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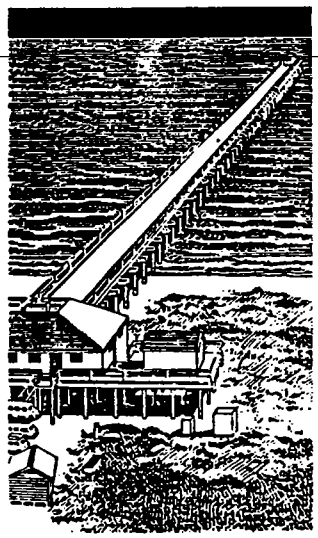

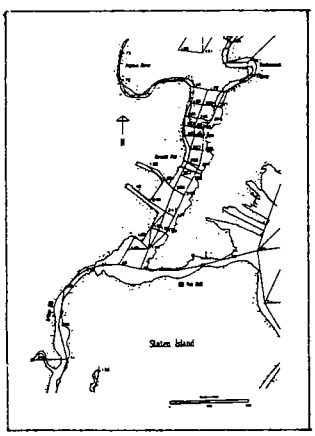

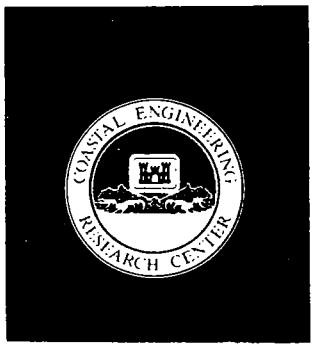

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PASSAIC RIVER BASIN FLOOD PROTECTION PROJECT, STORM SURGE ANALYSIS

by

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The US Army Corps of Engineers, New York District, Passaic River Division (PRD) has been working on plans to reduce flooding in the Passaic River Basin since 1939, but none of those plans was authorized. Congress then authorized the Corps to conduct a new study of the basin for the state of New Jersey in the Water Resources Development Act of 1976. The Corps evaluated more than 150 plans, presented an array of plans to the state of New Jersey, and the state selected a dual-inlet water diversion tunnel system as the centerpiece of its comprehensive flood protection program for the basin. In November 1990, Congress authorized construction of the $1.2 billion Passaic River Flood Protection in the Water Resources Development Act of 1990; the project cost to the state is $310 million.

The major elements of the project are two underground tunnels, a 20.1-mile-long main tunnel about 40 ft in diameter and a 1.2-mile spur tunnel about 22 ft in diameter that convey central basin flood waters to an outlet in the vicinity

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of Kearny Point in Newark Bay. The proposed diversion tunnel and surface works are generally designed to protect against the 100-year flood event, during which it is anticipated that a flood volume equal to that of Newark Bay will be discharged over a two-day period.

The Corps is studying the impact of discharging water from a diversion tunnel into Newark Bay and its tributaries, the Passaic and Hackensack Rivers. While a diversion tunnel discharge itself would not cause significant flooding, it is the combination of a storm surge generated by hurricanes and northeasters coincident with the diversion tunnel operation that the Corps is evaluating. The main purpose of this study is to determine the stage-frequency curves for various locations and conditions throughout Newark Bay and the tidally influenced portion of the Passaic and Hackensack Rivers. These curves can be used to determine the heights of storms in the vicinity of Kearny Point. Another objective of this study is to examine the likelihood that a significant diversion tunnel discharge could be coincident with a major storm surge, and to simulate such a combination, thereby determining the potential for additional flooding.

During the 1970's and 1980's, a two-dimensional hurricane surge model was used for the Newark Bay/Passaic/Hackensack River system as boundary forcing for an interior Dynamic Estuary Model (DEM) to estimate flood frequencies. The current study builds on previous models and revalidates and uses a modified DEM to accurately simulate tidal elevations in the system using recent data on system bathymetry, river cross sections, topography, and historical hurricane, northeaster, and rain flow data through 1991, in combination with a refined grid. The revalidated DEM is a valuable engineering tool more accurately simulating tidal and river flows than previous studies.

The coincidence analysis confirmed that large river flows are unlikely to coincide with large surges from New York Bight. Time history plots of several individual events show that there is a weak relationship between storm tides and river flows, and that the river flows lag the tides by several days; large storm tides with large Passaic River flows (lagged by 0-2 days) are extremely rare events. An increase in elevations due to sea level rise has been accounted for in the stage-frequency distribution curves. The bootstrap method, a modification of the joint probability method, was used to generate stage-frequency distributions with 33 synthetic storms approximating the entire population of historical storms. Results of coincidence analysis show that large storm tides together with large river flows is an extremely unlikely combination, and they can be treated as essentially independent events. However, the analysis indicates that the likelihood of elevated river flows following storm tides (by 0-2 days) is quite strong.

The effect of tunnel discharges to Newark Bay will have little effect (less than 0.1 foot) on tidal elevations in the lower Passaic River, Hackensack River, and Newark Bay where flood-prone areas are located. The inclusion of future project conditions, such as control levees in the vicinity of Kearny Point, changes the future unimproved stage-frequency distributions by less than 0.2 ft in the lower parts of the Passaic and Hackensack Rivers and in Newark Bay. However, the effect of tunnel diversion into Newark Bay will be to reduce river flooding in the upper tidal Passaic River by several feet.

PREFACE

The investigation described in this report was authorized by the US Army Corps of Engineers, New York District, Passaic River Division (CENAN-PR-C). Work was performed at the Coastal Engineering Research Center (CERC), US Army Engineer Waterways Experiment Station (WES) and at Ebasco Environmental, Bellevue, WA.

The study was conducted from 1 October 1991 through September 1992 by Dr. Zeki Demirbilek, Research Division (RD), Coastal Oceanography Branch (COB), CERC, and Dr. Raymond Walton, Manager of Water Resources Modeling Group, Ebasco Environmental, under Contract No. DACW39-90-D-0007.

This study was conducted under the general supervision of Dr. James R. Houston and Mr. Charles C. Calhoun, Jr., Director and Assistant Director, CERC, respectively; Mr. H. Lee Butler, Chief, RD, CERC; and under the direct supervision of Dr. Martin C. Miller, Chief, COB, CERC.

Project Managers during the conduct of this study and the publication of this report were Mr. John Bianco and Mr. Ray Schembri for CENAN-PR-C, Dr. Demirbilek for WES, and Dr. Walton for Ebasco Environmental.

At the time of publication of this report, Director of WES was Dr. Robert W. Whalin. Commander and Deputy Director was COL Leonard G. Hassell, EN.

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CONTENTS

	Page
PREFACE	1
CONVERSION FACTORS, NON-SI TO SI (METRIC) UNITS OF MEASUREMENT	8
PART I: INTRODUCTION	9
Passaic River Flood Protection Project	9
Study Objectives	9
The Study Area	10
Previous Studies	10
Approach	11
Findings and Recommendations	12
PART II: MODEL MODIFICATIONS	17
Description of Model	17
Data Sources	23
Pre-1980 Grid Refinements	24
1991 Grid Refinements	25
Future Project Grid Refinements	25
PART III: MODEL VALIDATION	30
Introduction	30
Astronomic Tide of October 1976	30
Historical Hurricanes	31
Historical Northeasters	32
"Halloween" Northeaster of 1991	32
PART IV: COINCIDENCE ANALYSIS	75
Introduction	75
Approach and Data Preparation	75
Comparison of Water Surface Elevations at Kearny Point and The Battery	76
Surge Height and River Flow Cross Correlation	77
Coincidence Between Surge Height and River Flow	77
Scatter Diagram of Surge Height and River Flow Values	78
Stage Frequency Statistics for Surge Heights	79
Boundary Conditions for River Flow Models	80
River Flows for Storm Tide Simulations	81
PART V: STATISTICAL PROCEDURE	96
Joint Probability Analysis	96
Modified Bootstrap Method	97
Storm Selection	97
PART VI: SEA LEVEL RISE	103
PART VII: SENSITIVITY ANALYSIS	105
Events Selected	105
River Flow Conditions	105
Analysis of Simulations	106
PART VIII: STAGE-FREQUENCY DISTRIBUTIONS FOR FUTURE CONDITIONS	135
PART IX: SUMMARY AND CONCLUSIONS	145
Summary	145
Conclusions	146
Summary Conclusions	148

Page

REFERENCES 150

APPENDIX A: USERS GUIDE FOR NEWARK BAY VERSION OF THE DYNAMIC ESTUARY MODEL -- DEMNEWARK A1
User Considerations A1
Data Input Description A2
Output Description A2

APPENDIX B: SAMPLE INPUT FILES B1

APPENDIX C: SAMPLE OUTPUT FILES C1

APPENDIX D: FACT SHEET D1

APPENDIX E: MODELING PROCEDURES E1
Coincidence Analysis E1
Identify New Storms E2
Develop Synthetic Storm Tide Events E2
Link-Node Model Simulations E3
Stage-Frequency Curves E4

LIST OF TABLES

Number		Page
1	Comparison of Observed and Simulated Tidal Elevations for the "Halloween" Storm of October 1991	34
2	Coincidence Analysis	82
3	Average Surges Coincident with Given Passaic River Flows	83
4a	Average Passaic River Flows for Given Surge Heights	84
4b	Passaic River Flows for Selected Storm Events	84
5	Selected Storm Events	99
6	Maximum Predicted Water Elevations (feet) at Selected Nodes October 1976 Tides and Four Project Scenarios	108
7	Maximum Predicted Water Elevations (feet) at Selected Nodes for Synthetic Hurricane 135 and Four Project Scenarios	109
8	Maximum Predicted Water Elevations (feet) at Selected Nodes for Synthetic Hurricane 249 and Four Project Scnearios	110
A1	DEMNEWARK Input Card Groups	A3
A2	Basic Input Data Descriptions	A5
A3	Grid File Description	A12
E1	Magnetic Tapes and Their Hurricane/Northeaster Surge Contents	E5
E2	Hurricane Astronomic Tides	E6
E3	Northeaster Astronomic Tides	E7

LIST OF FIGURES

Number		Page
1	Pompton River/Passaic River Dual Inlet Tunnel	16
2	Pseudo-Two-Dimensional Geometric Representation for Estuary Systems	27
3	Link-Node Grid of Study Area	28
4	Detail of Link-Node Grid Newark Bay Area	29
5	Gage Locations for October 1976 Tidal Elevation Study	35
6	Observed Tidal Heights at Sandy Hook for Tide of 11-13 October 1976	36
7	Observed Tidal Heights at the Battery for Tide of 11-13 October 1976	37
8	Tidal Heights at Point No Point for Tide of 11-13 October 1976	38
9	Tidal Heights at Belleville for Tide of 11-13 October 1976	39
10	Tidal Heights at East Rutherford for Tide of 11-13 October 1976	40
11	Tidal Heights at Garfield for Tide of 11-13 October 1976	41
12	Tidal Heights at Kearny Point for Tide of 11-13 October 1976	42
13	Tidal Heights at Belleville Tpke for Tide of 11-13 October 1976	43
14	Tidal Heights at Carlstadt for Tide of 11-13 October 1976	44
15	Tidal Heights at Mill Creek for Tide of 11-13 October 1976	45
16	Tidal Heights at Cromakill Creek for Tide of 11-13 October 1976	46
17	Tidal Heights at Ridgefield Park for Tide of 11-13 October 1976	47
18	Tidal Heights at Hackensack for Tide of 11-13 October 1976	48
19	Tidal Heights at Port Ivory for Tide of 11-13 October 1976	49
20	Tidal Heights at South Amboy for Tide of 11-13 October 1976	50
21	Tidal Heights at Sayreville for Tide of 11-13 October 1976	51
22	Tidal Heights at Keasbey for Tide of 11-13 October 1976	52
23	Tidal Heights at New Brunswick for Tide of 11-13 October 1976	53
24	Observed Tidal Heights at Sandy Hook for Hurricane of 21 September 1938	54
25	Observed Tidal Heights at The Battery for Hurricane of 21 September 1938	55
26	Tidal Heights at Elm Park for Hurricane of 21 September 1938	56
27	Tidal Heights at East Newark for Hurricane of 21 September 1938	57
28	Observed Tidal Heights at Sandy Hook for Hurricane of 12 September 1960	58
29	Observed Tidal Heights at The Battery for Hurricane of 12 September 1960	59
30	Tidal Heights at Elm Park for Hurricane of 12 September 1960	60
31	Tidal Heights at Fort Hamilton for Hurricane of 12 September 1960	61
32	Tidal Heights at Carteret for Hurricane of 12 September 1960	62
33	Tidal heights at Kearny Point for Hurricane of September 1960	63
34	Observed Tidal Heights at Sandy Hook for Northeaster of 24-26 November 1950	64
35	Observed Tidal Heights at The Battery for Northeaster of 24-26 November 1950	65
36	Tidal Heights at Elm Park for Northeaster of 24-26 November 1950	66
37	Observed Tidal Heights at Sandy Hook for Northeaster of 6-8 November 1953	67
38	Observed Tidal Heights at The Battery for Northeaster of 6-8 November 1953	68
39	Tidal Heights at Elm Park for Northeaster of 6-8 November 1953	69
40	Tidal Heights at East Newark for Northeaster of 6-8 November 1953	70
41	Tidal Heights at Fort Hamilton for Northeaster of 6-8 November 1953	71
42	Observed Tidal Heights at Sandy Hook for the "Halloween" Storm of October 1991	72
43	Observed Tidal Heights at The Battery for the "Halloween" Storm of October 1991	73

44 Tidal Heights at Ridgefield Park for the "Halloween" Storm of October 1991 74
45 Tidal Heights at Kearny Point and The Battery for Northeaster of 24-26 November 1950 85
46 Tidal Heights at Kearny Point and The Battery for Hurricane of 12 September 1960 86
47 Tidal Heights at Kearny Point and The Battery for Tide of 11-13 October 1976 87
48 Cross-Correlation Between Surge Height at The Battery and Passaic River Flow Measured at the Little Falls, New Jersey Gage 88
49 Predicted Tide Height and Observed Water Level at The Battery and Flow of the Passaic River Measured at the Little Falls, New Jersey Gage During the 21 September 1938 Storm Event 89
50 Predicted Tide Height and Observed Water Level at The Battery and Flow of the Passaic River Measured at the Little Falls, New Jersey Gage During the 25 November 1950 Storm Event 90
51 Predicted Tide Height and Observed Water Level at The Battery and Flow of the Passaic River Measured at the Little Falls, New Jersey Gage During the 12 September 1960 Storm Event 91
52 Predicted Tide Height and Observed Water Level at The Battery and Flow of the Passaic River Measured at the Little Falls, New Jersey Gage During the 10 November 1977 Storm Event 92
53 Predicted Tide Height and Observed Water Level at The Battery and Flow of the Passaic River Measured at the Little Falls, New Jersey Gage During the 7 April 1984 Storm Event 93
54 Values of Surge Height Greater than 0.5 Feet and Maximum River Flow Greater than 1,000 cfs Within the Following 72 Hours 94
55 Stage Frequency Curve and Return Period for Water Surface Elevation at The Battery and Passaic River Flow Greater than 6,000 cfs at the Little Falls Gage 95
56 Return Period for Peak Surge at Node 172 100
57 Stage Frequency Curve at Entrance to Newark Bay 101
58 Range of Elevation vs. Size of Sample for Return Periods of 10 to 100 Years 102
59 Mean Sea Level 1921-1990 at The Battery, New York 103
60 Passaic River Hydrographs 111
61 Predicted Water Level Elevations at Newark Airport for Year 2050 Conditions and October 1976 Tides 112
62 Predicted Water Level Elevations at Kearny Point for Year 2050 Conditions and October 1976 Tides 113
63 Predicted Water Level Elevations at East Newark for Year 2050 Conditions and October 1976 Tides 114
64 Predicted Water Level Elevations at Third River for Year 2050 Conditions and October 1976 Tides 115
65 Predicted Water Level Elevations at Garfield for Year 2050 Conditions and October 1976 Tides 116
66 Predicted Water Level Elevations at Snake Hill for Year 2050 Conditions and October 1976 Tides 117
67 Predicted Water Level Elevations at Barry's Creek for Year 2050 Conditions and October 1976 Tides 118
68 Predicted Water Level Elevations at New Milford for Year 2050 Conditions and October 1976 Tides 119
69 Predicted Water Level Elevations at Newark Airport for Year 2050 Conditions and Synthetic Hurricane 135 120
70 Predicted Water Level Elevations at Kearny Point for Year 2050 Conditions and Synthetic Hurricane 135 121
71 Predicted Water Level Elevations at East Newark for Year 2050 Conditions and Synthetic Hurricane 135 122
72 Predicted Water Level Elevations at Third River for Year 2050 Conditions and Synthetic Hurricane 135 123
73 Predicted Water Level Elevations at Garfield for Year 2050 Conditions and Synthetic Hurricane 135 124

74	Predicted Water Level Elevations at Snake Hill for Year 2050 Conditions and Synthetic Hurricane 135	125
75	Predicted Water Level Elevations at Barry's Creek for Year 2050 Conditions and Synthetic Hurricane 135	126
76	Predicted Water Level Elevations at New Milford for Year 2050 Conditions and Synthetic Hurricane 135	127
77	Predicted Water Level Elevations at Newark Airport for Year 2050 Conditions and Synthetic Hurricane 249	128
78	Predicted Water Level Elevations at Kearny Point for Year 2050 Conditions and Synthetic Hurricane 249	129
79	Predicted Water Level Elevations at East Newark for Year 2050 Conditions and Synthetic Hurricane 249	130
80	Predicted Water Level Elevations at Third River for Year 2050 Conditions and Synthetic Hurricane 249	131
81	Predicted Water Level Elevations at Garfield for Year 2050 Conditions and Synthetic Hurricane 249	132
82	Predicted Water Level Elevations at Snake Hill for Year 2050 Conditions and Synthetic Hurricane 249	133
83	Predicted Water Level Elevations at Barry's Creek for Year 2050 Conditions and Synthetic Hurricane 249	134
84	Predicted Water Level Elevations at New Milford for Year 2050 Conditions and Synthetic Hurricane 249	136
85	Stage-Frequency Curve for Node 49 (Newark Airport) in Newark Bay for 33 Synthetic Storms	137
86	Stage-Frequency Curve for Node 262 (Kearny Point) in Newark Bay for 33 Synthetic Storms	138
87	Stage-Frequency Curve for Node 173 (East Newark) on the Passaic River for 33 Synthetic Storms	139
88	Stage-Frequency Curve for Node 217 (Third River) on the Passaic River for 33 Synthetic Storms	140
89	Stage-Frequency Curve for Node 226 (Garfield) on the Passaic River for 33 Synthetic Storms	141
90	Stage-Frequency Curve for Node 182 (Snake Hill) on the Hackensack River for 33 Synthetic Storms	142
91	Stage-Frequency Curve for Node 190 (Barry's Creek) on the Hackensack River for 33 Synthetic Storms	143
92	Stage-Frequency Curve for Node 213 (New Milford) on the Hackensack River for 33 Synthetic Storms	144
A1	Flow Chart of DEMNEWARK	A4
A2	Schematic of Junction Surface Areas Using Double Trapezoid	A13
A3	Schematic of Link Cross-Section	A15

CONVERSION FACTORS, NON-SI TO SI (METRIC)
UNITS OF MEASUREMENT

Non-SI units of measurement used in this report can be converted to SI (metric) units as follows:

Multiply	By	To Obtain
cubic feet	0.028317	cubic meters
cubic feet per second	0.028317	cubic meters per second
feet	0.3048	meters
feet per second	0.3048	meters per second
feet per second per second	0.3048	meters per second per second
inches	25.4	millimeters
miles (U.S. statute)	1.609347	kilometers
nautical miles	1.853187	kilometers
knots (international)	0.514444	meters per second
square feet	0.09290304	square meters
square feet per second	0.09290304	square meters per second

PASSAIC RIVER BASIN FLOOD PROTECTION PROJECT

STORM SURGE ANALYSIS

PART I: INTRODUCTION

Passaic River Flood Protection Project

1. The 935-square-mile Passaic River Basin in New Jersey has seen serious flooding during the last century. This is due to the fact that it lies in the East Coast storm belt, and over the years has become more urbanized, with about 30,000 structures in the flood-prone areas (Fact Sheet 1992, Appendix D). Damages average about $100 million per year, and the system has been declared a national disaster area on a number of occasions.

2. The U.S. Army Corps of Engineers, after evaluating more than 150 alternatives, proposed in December 1987 to reduce the upstream flooding threat by constructing a dual inlet diversion tunnel system as the key to a Passaic River Flood Protection Project. The Water Resources Development Act of 1990 authorized funds for construction. The major elements of the project are two underground tunnels, a 20.1-mile-long main tunnel about 40 feet in diameter and a 1.2-mile spur tunnel about 22 feet in diameter (Figure 1) that convey Central Basin flood waters to an outlet in the vicinity of Kearny Point in Newark Bay. The overall Passaic River Flood Protection Project includes the purchase of natural water storage areas, including wetlands, continued protection for flood-threatened (but protected) areas, and the preservation of fish and wildlife. The proposed diversion tunnel and surface works are generally designed to protect against the 100-year-flood event. During such an event, it is anticipated that a flood volume equal to that of Newark Bay will be discharged over a two-day period. The Fact Sheet (Appendix D) provides an overview of the project.

Study Objectives

3. As stated in the Fact Sheet, the U.S. Army Corps is studying the impacts of discharging water from a diversion tunnel into Newark Bay and its tributaries, the Passaic and Hackensack Rivers. In particular, the Hackensack River has been the scene of previous flooding due to storm surges entering the

system from New York Bight. As recently as October 1991, the "Halloween" Northeaster created flooding in the low-lying areas along the banks of the Hackensack, including the Meadowlands. At this time, no damages were reported for this event.

4. While a diversion tunnel discharge by itself would not cause significant flooding in these areas, it is the combination of a storm surge (hurricane or northeaster generated) coincident with the diversion tunnel operation that the Corps is evaluating. The main purpose of this study is to determine the stage-frequency curves for various locations and conditions throughout Newark Bay and the tidally-influenced portion of the Passaic and Hackensack Rivers. These curves can be used to determine the heights of storm tide levees in the vicinity of Kearny Point. Another objective of this study is to examine the likelihood that a significant diversion tunnel discharge could be coincident with a major storm surge, and to simulate such combinations, thereby determining the potential for additional flooding.

The Study Area

5. The study area for the storm surge analysis includes Newark Bay and the tidal portions of its tributaries, the Passaic and Hackensack Rivers. The Passaic River is tidal as far upstream as Dundee Dam, a distance of 17.7 river miles. Upstream of Dundee Dam, the Passaic River Basin has a drainage area of 809.9 square miles. The Hackensack River is tidal as far as the Oradell Reservoir, a distance of 23 river miles. The tributary area above the New Milford gage (at Oradell Dam) is 113 square miles. Beyond Newark Bay, water enters the system through Kill Van Kull and Arthur Kill, on each side of Staten Island. In recent years these areas have been dredged to deepen and maintain the navigation channel.

Previous Studies

6. During the late 1970s, Camp Dresser & McKee Inc. (CDM) performed a storm surge study for FEMA (CDM 1983a). The FEMA study used a two-dimensional, hurricane surge model to generate boundary conditions at four interior points, which in turn were used as boundary forcing for an interior model of the Newark Bay/Passaic River/Hackensack River system. The interior

model was an earlier version of the Dynamic Estuary Model (DEM). That version, with some minor modifications, was used for this study. The CDM (1983a) study was based on the Joint Probability Method, in which 295 synthetic storms (both hurricanes and northeasters) were generated assuming independence of individual storm parameters. Assigning probabilities of occurrence to each storm parameter, frequency distributions of surge elevations were developed for key locations in the study area.

7. The study was extended by the Corps to look at flood frequencies on the Passaic River (CDM 1983b). The DEM grid was modified to provide improved resolution in Newark Bay, the Hackensack River, and particularly the Passaic River.

8. In 1988, another study examined the cost and benefit of constructing a storm surge barrier on the Hackensack River to protect flood-prone areas in the tidal reach. In that study (CDM 1988), the DEM grid was refined along the Hackensack River, and a subset of 24 synthetic storm events was used to simulate surge elevations with varying proposed tidal barrier heights.

Approach

9. This current study builds on previous models described above, and now simulates the interaction of storm surges and coincident diversion tunnel discharges. Using recent data on system bathymetry and topography, the Hackensack River version of the DEM grid (CDM 1988) was modified to: (1) incorporate the most recent information on bathymetry and river cross sections, and (2) provide increased resolution in parts of Kill Van Kull, Arthur Kill, Newark Bay, and the lower parts of the Passaic and Hackensack Rivers. This information was used to create three grids: (1) a pre-1980 condition, (2) an October 1991 condition, and (3) a future (2050) condition.

10. The "pre-1980" grid was used to revalidate the DEM model using the historical conditions from the Passaic study (CDM 1983b). This consisted of: (1) an astronomical tide of 11-13 October 1976; (2) a hurricane of 21 September 1938; (3) Hurricane Donna of 12 September 1960; (4) a northeaster of 24-26 November 1950; and (5) a northeaster of 6-8 November 1953. The "October 1991" grid was then used to validate the model to the "Halloween" northeaster

of October 1991. The updated 1991 grid included partial dredging that has occurred in Kill Van Kull and Arthur Kill.

11. During the Hackensack River study (CDM 1988), the coincidence of storm surges and river flows was investigated by examining flow and tide gage records around the time of observed peak surge elevations. In this study, we reviewed the analysis, and extended its scope to determine whether a relationship exists between storm surges and proposed diversion tunnel flows.

12. The Hackensack River study (CDM 1988) used a modification of the joint probability method to identify a limited number of storm surge events capable of providing stage frequency distributions that would approximate the distribution of the entire population of synthetic events. Twenty-four storms were selected for the CDM (1988) study. The modified "bootstrap" method was further examined to determine whether the 24 events were adequate to develop accurate stage frequency distributions for the purposes of this study.

13. Several project alternatives were identified for detailed investigation using the newly revalidated storm surge model. Options included various tunnel discharge locations and the inclusion or exclusion of other flood protection works (i.e., storm surge levee system). These various design conditions, and the diversion tunnel discharging to Newark Bay without a coincident storm surge, were simulated with the suite of storm surges and stage frequency distributions developed. Simulations were performed both with and without project conditions to examine the project impacts on storm surges and frequency distributions.

Findings and Recommendations

14. The revalidated DEM model more accurately simulated tidal elevations in the Passaic/Hackensack/Newark Bay system than previous studies. This was due to inclusion of more recent system geometry data. The model, therefore, is a valuable tool for simulating tidal and river flow scenarios in the system.

15. The coincidence analysis confirmed that large river flows are unlikely to coincide with large storm surges from New York Bight. Time-history plots of several individual events show that there is a weak relationship between storm tides and river flows, and that the river flows lag the tides by several days. In general, for a relatively small surge (say,

less than four feet), a wide range of river flows is possible. For a relatively small (less than one-year) river flow, a wide range of storm surges is possible. However, large storm tides with large Passaic River flows (lagged by 0-2 days) are extremely rare events. The data were further analyzed to determine the average surge condition that might occur within 72-hours of specific significant river flows. The results indicated that over the range of river flows observed, an average storm surge is on the order of 1.5-2 feet. In a similar fashion, the data were also analyzed to determine the average Passaic River flow that might occur within 72 hours of storm surges of different elevations. The results showed that for all storm surge elevations observed, an average Passaic River flow of 1000-2000 cfs would be found, which is approximately the average daily river flow (1150 cfs).

16. The National Oceanic Service (NOS) concluded that sea level is rising at an approximate rate of 2.7 mm/yr (0.0089 ft/yr). Based on the previous model studies, we estimated a sea level rise of 0.89 feet in the 100 years from 1950 to 2050. Using this value of sea level rise, a sensitivity analysis performed for future (year 2050) conditions, for three tide events and four river flow conditions, demonstrated that the distribution and magnitude of river and tunnel discharges has a very small effect (less than 0.1 ft) on tidal elevations in the lower part of the system, including the lower tidal parts of the Passaic and Hackensack Rivers and Newark Bay. The placement of flood protection levees around Kearny Point also has a small effect (less than 0.2 ft in the vicinity of Kearny Point and 0.4 ft in the vicinity of Newark Airport) on tidal elevations. Upstream in the Passaic River, toward Dundee Dam, the effect of the Diversion Tunnel is to lower water elevations during major river flow events. For the 100-year flow, for example, even though the peak fresh water discharge at the mouth of the Passaic may increase (from 33,645 cfs to 48,544 cfs), flood elevations will be lowered by several feet as a result of the tunnel bypassing the upper part of the tidal river. The flood characteristics of the Hackensack should remain essentially the same, due to comparatively larger cross-sectional areas.

17. Stage-frequency distribution curves for various locations in the system were developed using 33 synthetic storm events and the one-year river flows in the Passaic and Hackensack. The new distribution curves are similar to the distributions developed previously (CDM 1983a, 1988), except that an increase in elevations due to sea level rise has been accounted for in these

new curves. These distributions permit the selection of appropriate flood protection levees around Kearny Point to protect against a given return period storm surge event.

18. From the analyses in this study, the following conclusions are drawn:

1. The inclusion of future project conditions, including flood control levees in the vicinity of Kearny Point, changes the future unimproved stage-frequency distributions by less than 0.2 foot in the lower parts of the Passaic and Hackensack Rivers and in Newark Bay.
2. The stage-frequency distributions developed for the vicinity of Kearny Point, will allow the selection of flood protection levee elevations to protect against storm tides with a given return period. The distributions in the upper tidal Passaic and Hackensack Rivers, do not include the effect of significant river flows, and therefore reflect only tidal conditions.
3. The coincidence of large storm tides and large river flows is an extremely unlikely combination, and can be treated as essentially independent events. However, the likelihood that elevated river flows occur following storm tides (by 0-2 days) is quite strong.
4. Sea level rise is estimated to be on the order of 2.7 mm/yr (0.0089 ft/yr), or 0.89 feet from 1950 to 2050.
5. The magnitude and distribution of significant river and tunnel discharges has a very small effect (less than 0.1 ft) on tidal elevations in the lower Passaic River, Hackensack River, and Newark Bay.
6. The effect of tunnel discharges to Newark bay will have little effect (less than 0.1 ft) on the existing characteristics of flood-prone areas along the Hackensack River, such as the Meadowlands.
7. The effect of tunnel diversions into Newark Bay will be to reduce river flooding in the upper tidal Passaic River by several feet.
8. The tidal boundary condition for a river flow model of the Passaic River system should be the superposition of an average tide and a storm surge of 1.5-2 feet.

9. The coincidence analysis indicated that a Passaic River flow of 1000-2000 cfs may occur during a typical storm tide. The add "conservatism" to the storm tide analysis in this report, we specified the one-year river flows in each of the major tributaries. This results in a flow in excess of 5000 cfs in the Passaic River, or nearly three times the average flow expected. However, this flow will occur relatively infrequently with significant storm tides.

10. The coincidence analysis was used to develop a storm tide stage-frequency distributions of events in which the Passaic River flow exceeded 6000 cfs. This analysis can be used to determine appropriate tidal heights for design of tunnel outlet works.

11. Dredging operations in the Kills and Newark Bay will have little effect on circulation and water levels in the study area. Water levels may change by less than 0.15 feet, and the tidal phase may be altered by less than one-half hour.

model was an earlier version of the Dynamic Estuary Model (DEM). That version, with some minor modifications, was used for this study. The CDM (1983a) study was based on the Joint Probability Method, in which 295 synthetic storms (both hurricanes and northeasters) were generated assuming independence of individual storm parameters. Assigning probabilities of occurrence to each storm parameter, frequency distributions of surge elevations were developed for key locations in the study area.

7. The study was extended by the Corps to look at flood frequencies on the Passaic River (CDM 1983b). The DEM grid was modified to provide improved resolution in Newark Bay, the Hackensack River, and particularly the Passaic River.

8. In 1988, another study examined the cost and benefit of constructing a storm surge barrier on the Hackensack River to protect flood-prone areas in the tidal reach. In that study (CDM 1988), the DEM grid was refined along the Hackensack River, and a subset of 24 synthetic storm events was used to simulate surge elevations with varying proposed tidal barrier heights.

Approach

9. This current study builds on previous models described above, and now simulates the interaction of storm surges and coincident diversion tunnel discharges. Using recent data on system bathymetry and topography, the Hackensack River version of the DEM grid (CDM 1988) was modified to: (1) incorporate the most recent information on bathymetry and river cross sections, and (2) provide increased resolution in parts of Kill Van Kull, Arthur Kill, Newark Bay, and the lower parts of the Passaic and Hackensack Rivers. This information was used to create three grids: (1) a pre-1980 condition, (2) an October 1991 condition, and (3) a future (2050) condition.

10. The "pre-1980" grid was used to revalidate the DEM model using the historical conditions from the Passaic study (CDM 1983b). This consisted of: (1) an astronomical tide of 11-13 October 1976; (2) a hurricane of 21 September 1938; (3) Hurricane Donna of 12 September 1960; (4) a northeaster of 24-26 November 1950; and (5) a northeaster of 6-8 November 1953. The "October 1991" grid was then used to validate the model to the "Halloween" northeaster

of October 1991. The updated 1991 grid included partial dredging that has occurred in Kill Van Kull and Arthur Kill.

11. During the Hackensack River study (CDM 1988), the coincidence of storm surges and river flows was investigated by examining flow and tide gage records around the time of observed peak surge elevations. In this study, we reviewed the analysis, and extended its scope to determine whether a relationship exists between storm surges and proposed diversion tunnel flows.

12. The Hackensack River study (CDM 1988) used a modification of the joint probability method to identify a limited number of storm surge events capable of providing stage frequency distributions that would approximate the distribution of the entire population of synthetic events. Twenty-four storms were selected for the CDM (1988) study. The modified "bootstrap" method was further examined to determine whether the 24 events were adequate to develop accurate stage frequency distributions for the purposes of this study.

13. Several project alternatives were identified for detailed investigation using the newly revalidated storm surge model. Options included various tunnel discharge locations and the inclusion or exclusion of other flood protection works (i.e., storm surge levee system). These various design conditions, and the diversion tunnel discharging to Newark Bay without a coincident storm surge, were simulated with the suite of storm surges and stage frequency distributions developed. Simulations were performed both with and without project conditions to examine the project impacts on storm surges and frequency distributions.

Findings and Recommendations

14. The revalidated DEM model more accurately simulated tidal elevations in the Passaic/Hackensack/Newark Bay system than previous studies. This was due to inclusion of more recent system geometry data. The model, therefore, is a valuable tool for simulating tidal and river flow scenarios in the system.

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PASSAIC RIVER FLOOD PROTECTION PROJECT

AUTHORIZED PLAN

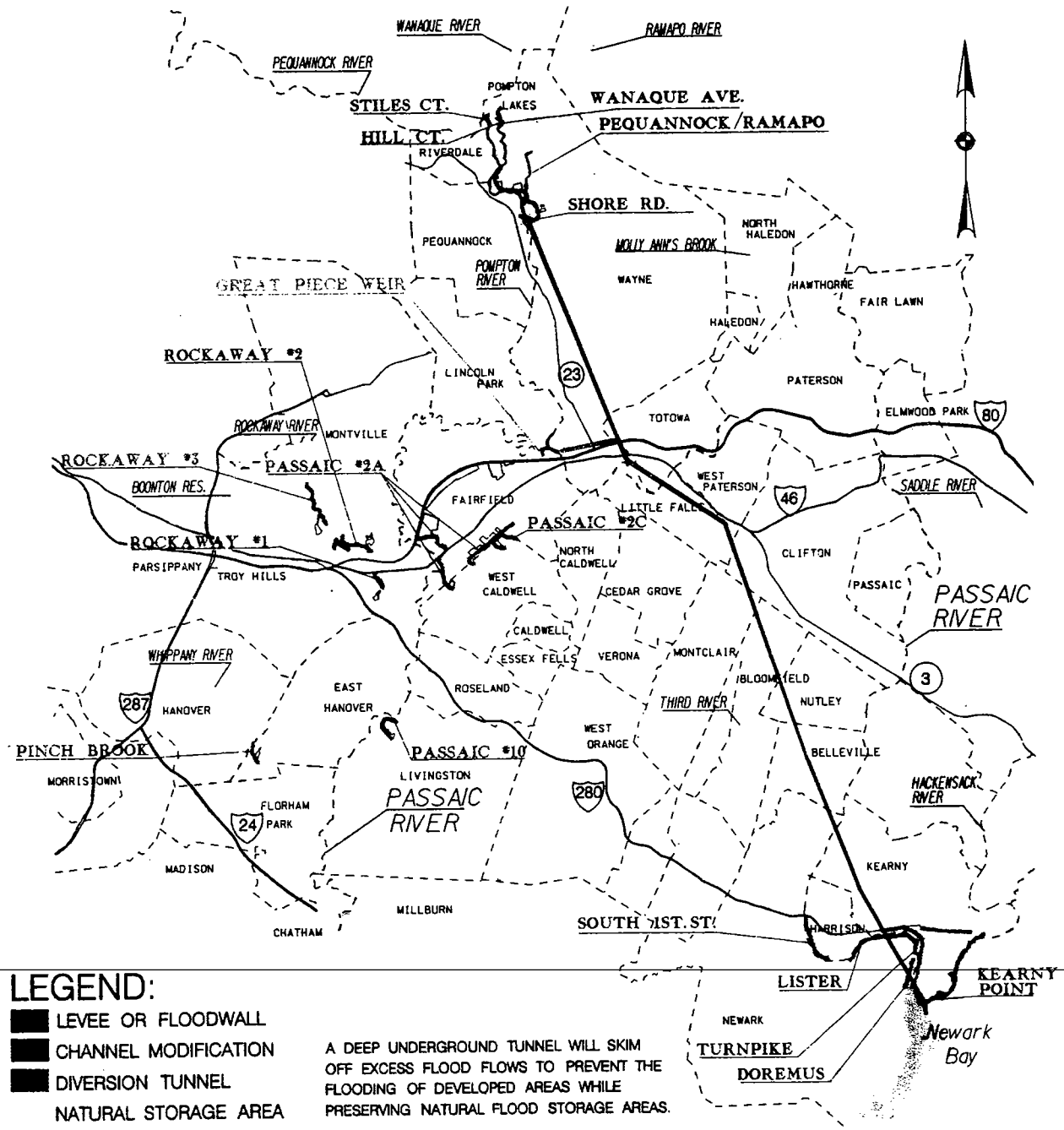


Figure 1. Pompton River/Passaic River dual inlet tunnel

PART II: MODEL MODIFICATIONS

Description of Model

19. The study area is characterized by a large number of bays, embayments, interconnecting channels, waterways, and rivers. The offshore surge model developed for the FEMA study (CDM 1983a) used a spatial resolution of five nautical miles for the computational grid. Due to the grid size and the lack of geometric flexibility of its finite-difference scheme, it became necessary to select a different model for the nearshore portion of the study area. The Dynamic Estuary Model (DEM) was selected for this purpose. DEM (WRE 1977) is a two-dimensional, vertically integrated, hydrodynamic model based on a link-node computational method. The fundamental feature of the DEM model is its very efficient integration of the one-dimensional and two-dimensional domains of flow. This model is ideally suited to modeling the one-dimensional Passaic River and its complex connection with the New York Bight through Newark Bay, and Arthur Kill and Kill Van Kull through the Lower New York Harbor. The model was modified during the FEMA study (CDM 1983a) to run directly using a binary sequential output file from the surge generation model, which transfers the surge heights at four boundary nodes and also storm information.

20. The hydrodynamic behavior of a water body influenced by external forces is governed by two fundamental equations; namely, the continuity equation and the momentum equation. A complete description of the movement of water requires a simultaneous solution of the two equations. In order to solve these two coupled equations, the DEM program uses a link and node discretization of the prototype water body (Figure 2).

21. A reach (or link) is defined as a channel where water flows from one end to the other. The ends of the reach are further defined as nodes (or junctions) in which water volumes are stored. If the heads at the end nodes at any given time are known, the hydraulic gradient along the channel and thus the flow rate may be calculated. By the transfer of water from one end to the other according to the computed flow, the head at the node will subsequently be altered, defining a stepwise hydraulic computation on the discretized system representing the water body.

22. The nodes are defined by the surface area, depth, and a starting water surface elevation. The nodal surface area (which can vary with depth) is defined as the area enclosed by the perpendicular bisectors (Figure 2) of its connecting links and the coastline for nodes near the shoreline. To assure mass conservation, the sum of the surface areas for all nodes must equal the total surface area of the water body. For areas in which the surface area varies greatly with water elevation, the program has an option to vary the surface area with depth. This option becomes very important when modeling the storm surge elevations in flat areas such as the Meadowlands. The depth of the node is defined as the average depth of the area that the node represents. Depths on charts are referenced to some datum, usually Mean Low Water (MLW). A correction factor is included to correct this to other datum planes. In this study, all elevations are referenced to the National Geodetic Vertical Datum of 1929 (NGVD) since this is the one standard datum that does not change with time or space. The nodes are also identified by an X and Y coordinate. Although not strictly needed by the computational scheme, this information is used to compute link lengths if desired, and to compute the northeaster and hurricane wind and pressure effects.

23. The hydraulic computation requires the following information for links: the width, length, depth or hydraulic radius and friction coefficient (Manning's "n"). Values for these parameters are selected to represent the conveyance characteristics of the water body between the nodes. For a two-dimensional water body, the appropriate width is often difficult to assess. For consistency, the width is defined by the length of the perpendicular bisector of the channels between their intersections with adjacent bisectors. The depth of the link represents the controlling depth for the link or channel. Often this is the average of the depths of the two end nodes and DEM will compute it if unspecified. The length of the link is also computed from the X and Y coordinates of the end nodes if it is unspecified. The Manning's "n" friction coefficient is the only calibration parameter of the model assuming a correct spatial geometric-discretization of the water body, although experience has found that a correct geometric description is the most important factor for accurate model simulations. The range of hydraulically plausible values for Manning's "n" is usually between 0.015 and 0.08, although a range of 0.025 - 0.04 is more typical of open water. Values greater than 0.04 may be found in very shallow or overbank vegetated areas. Finally,

identification of the nodes at the ends of the link are also needed in order to define the connectivity of the network.

24. The one-dimensional momentum equation is written for each link as:

$$\frac{\partial V}{\partial t} = -V \frac{\partial V}{\partial x} - g\frac{\partial H}{\partial x} - gS_f + gS_w \qquad (1)$$

where:

V = Horizontal velocity,

t = Time,

x = Distance,

H = Water surface elevation from the datum plane,

g = Gravitational acceleration,

S_f = Energy gradient, and

S_w = Wind stress.

The energy gradient, S_f, of turbulent flow is proportional to the square of the mean velocity according to Manning's equation:

$$S_f = \frac{n^2 V |V|}{2.2 R^{4/3}} \qquad (2)$$

where:

n = Friction coefficient (Manning's "n"), and

R = Hydraulic radius of the channel (or link).

The wind stress term is given by:

$$S_w = \frac{K}{d} \cdot \frac{\rho_a}{g\rho_w} U^2 \cos \psi \qquad (3)$$

where:

K = Dimensionless coefficient varying with U

= $(0.8 + 0.0475\ U) \times 2.63\ 10^{-6}$

d = Depth of flow,

ρ_a = Air density,

ρ_w = Water density,

U = Wind velocity in mph, and

Ψ = Angle between the wind direction and the axis of the channel.

This wind stress formulation was modified from the original program (WRE 1977) to provide a more accurate determination of the water surface wind stress under gale force winds. It is used to compute the surface stress from the simulated hurricane winds. For northeasters, a planetary boundary layer model was used to compute the surface stress terms.

25. The second equation is the continuity equation, which states that the rate of water flowing into a node through links or specified inflows affects the rate of change in the water surface elevation at the node:

$$A_{sj} \frac{\partial H_j}{\partial t} = \sum_{i=1}^{k} Q_i + Q_j \tag{4}$$

where:

A_{sj} = Surface area of node j,

Q_i = Flow of a connecting channel,

Q_j = Water inflow rate to node j, and

k = Number of links entering node j.

26. The numerical solution of Equations 1 and 4 entails rewriting both equations in finite difference form. Two types of integration are necessary for their solution; namely, a space integration and a time integration. A stepwise procedure is used for the spatial integration of Equations 1 and 4, whereby the momentum equation is used to solve for link flow and the continuity equation is used to solve for the nodal head. Both equations are explicitly solved for the unknown variables. The hydraulic computations within a given time interval proceed as follows:

1. Compute the flow rate in each link according to the hydraulic gradient and other hydraulic conditions existing at the beginning of a time interval.
2. Compute the rise or fall of the water surface (head) at each node based on the link flow and the importation or withdrawal of water at the node.
3. Update the geometric and hydraulic conditions for the computation of the next time interval.

27. Time integration is performed numerically by using a modified Euler technique. Each computational time-step is subdivided into two parts, whereby

the time rate of change of a variable calculated at the half time-step is used to project the variable from one time-step to the next full time-step. The intermediate time-step computations improve the stability and accuracy of the model. Stability of the scheme for each link is governed by the Courant-Friederichs-Levy condition:

$$\Delta t \leq \frac{\Delta x}{\sqrt{gh}} \tag{5}$$

where:

Δt = Computation time-step,

Δx = Length of link,

g = Gravitational acceleration,

h = Depth of water, and

$\sqrt{gh}$ = Celerity of the free gravity wave.

An efficient discretization has an equal maximum allowable (stable) time-step for all links. Therefore, shallow links should have shorter lengths and deep areas should have longer links. The stability of the entire model is governed by the time-step of the most critical link. The above stability condition provides a guide to the link lengths to be used but may often be exceeded without producing stability problems in the DEM model.

28. Two types of boundary conditions are used in the DEM model, namely flow (or discharge) boundary conditions and tidal (or water surface elevation) boundary conditions. Flow boundary conditions are used for the headwaters of rivers, whereas tidal boundary conditions are used at the mouth of estuaries. The tidal boundary conditions can be fitted astronomic tides, measured tidal elevations, or direct input from the offshore surge generation model.

29. The version of the Dynamic Estuary Model (DEM) applied for the FEMA surge study of New York Bight (CDM 1983a), and the Corps study of the Passaic River (CDM 1983b) included only open channels (using a double trapezoid) as flow conveyances. In the Hackensack River study (CDM 1988) there were two types of physical structures that needed to be included in the model, culverts and tidal barriers.

30. The Hackensack River basin is crossed by a number of roads and railways. A number of culverts have been built to allow the uninterrupted flows of many of the creeks in the area. From experience with culvert dynamics, we know that they can cause dramatic changes in local hydrodynamics,

6. Hackensack River (Overbank) from Newark Bay to Oradell Reservoir. Prepared by Aerial Data Reduction Associates, Inc., Pennsauken, NJ, for the Department of the Army, New York District Corps of Engineers, New York, NY. Survey photography (March 1985).

7. Passaic River Flood Control Project (DACW54-90-C-003) with UNET Cross Section Locations. Prepared by Aerial Data Reduction Associates, Inc., Pennsauken, NJ, for the Department of the Army, New York District Corps of Engineers, New York, NY. Survey photography (January 1990).

Pre-1980 Grid Refinements

35. The additional data sources were used to refine the model grid used for previous simulations of water level elevations in the Kills, Newark Bay, Passaic River, and Hackensack River. Refinements included adding nodes and links in some areas and modifying some node and link parameters. Figure 3 shows the modified link-node grid used for this study.

36. Additional nodes were added in Kill Van Kull and Arthur Kill in order to fit the geographical shape more closely and increase resolution. Five nodes were inserted between the eastern end of Kill Van Kull and the confluence of the Rahway River with Arthur Kill (Figure 4). The link-node description of Newark Bay (Figure 4) was significantly refined with the new model using about twice as many nodes in that area as in the previous studies. Nodes were added to distinguish shallow areas from the main channel, and provided pathways for lateral water exchanges to occur. Nodes were also added near Kearny Point to provide additional resolution for improved condition simulations that included the proposed diversion tunnel outflows. The increased resolution allowed for a finer level of detail in the examination of effects on Newark Bay water levels of possible future modifications to the existing waterways. One additional node was added in both the Passaic and Hackensack Rivers slightly north of Kearny Point. These nodes were placed in the existing sharp bends, which both rivers make, before resuming general northward directions. Finally, two nodes were added to include the Saddle River in the model system. The Saddle River flows into the Passaic River approximately one-half mile south of Garfield.

37. Soundings and contour maps of the Kills, Newark Bay, and Passaic and Hackensack Rivers provided the source for refining the physical parameterizations of nodes and links. Physical parameters for the newly-added nodes and links were taken from the maps.

1991 Grid Refinements

38. Refinements to the grid to represent October 1991 conditions, for simulation of the "Halloween Storm", consisted of revising node and link physical parameters. These changes were made to the pre-1980 grid. Revisions reflected depth and area changes due to the ongoing dredging project in the Kills and Newark Bay. Generally the main channels, except for Arthur Kill, were deepened, and in some cases slightly widened. However, the depth of Arthur Kill remained at 35 feet. The authorized project depth for other areas of the system was 40 feet, although actual depths were up to one foot deeper. Extraction of the rock substrate was not included at this time, since the dredging removed only the covering sediment layer using a suction dredge. The major change in the Newark Bay area was the removal of a large shoal off the Port Elizabeth Marine Terminal. The appropriate nodes and links were modified. Other physical changes resulted in model modifications at corners of connecting waterways. Only slight changes to channel widths resulted.

39. There were no new nodes added to the 1991 grid. The additional resolution and enhanced physical representation were purposefully added to the pre-1980 grid in anticipation of the needs of subsequent simulations, including model validation.

Future Project Grid Refinements

40. Prior to the October 1991 storm, mainly sediment overburden had been removed from the waterways, and removal of the rock substrate had not begun. Underlying rock substrate removal began after October 1991. According to dredging plans, rock substrate removal was to be performed in very localized areas rather than uniformly over the waterways. Removal thicknesses were generally small. Because model predictions are insensitive to small changes in waterway depth and volume, and because revisions of the 1991 grid to account for rock substrate removal would not necessarily be accurate enough

to reflect the actual changes, watering geometry and parameterization for the future project grid were taken to be the same as the 1991 grid. At present, no other plans are known for future projects to modify the waterways. However, some simulations of future conditions included modification of overbank links and nodes, thereby reflecting the proposed flood-protection levees at Kearny Point. Waterway parameters were not affected.

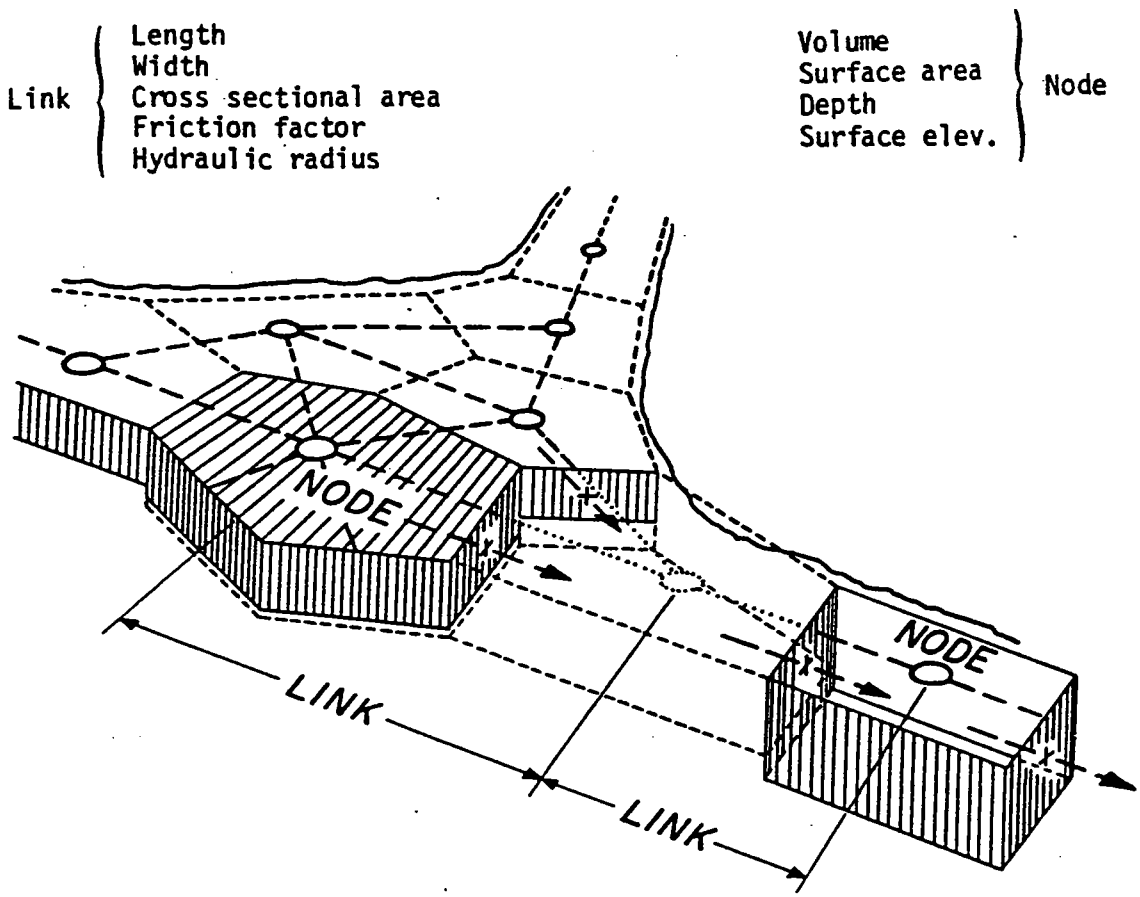
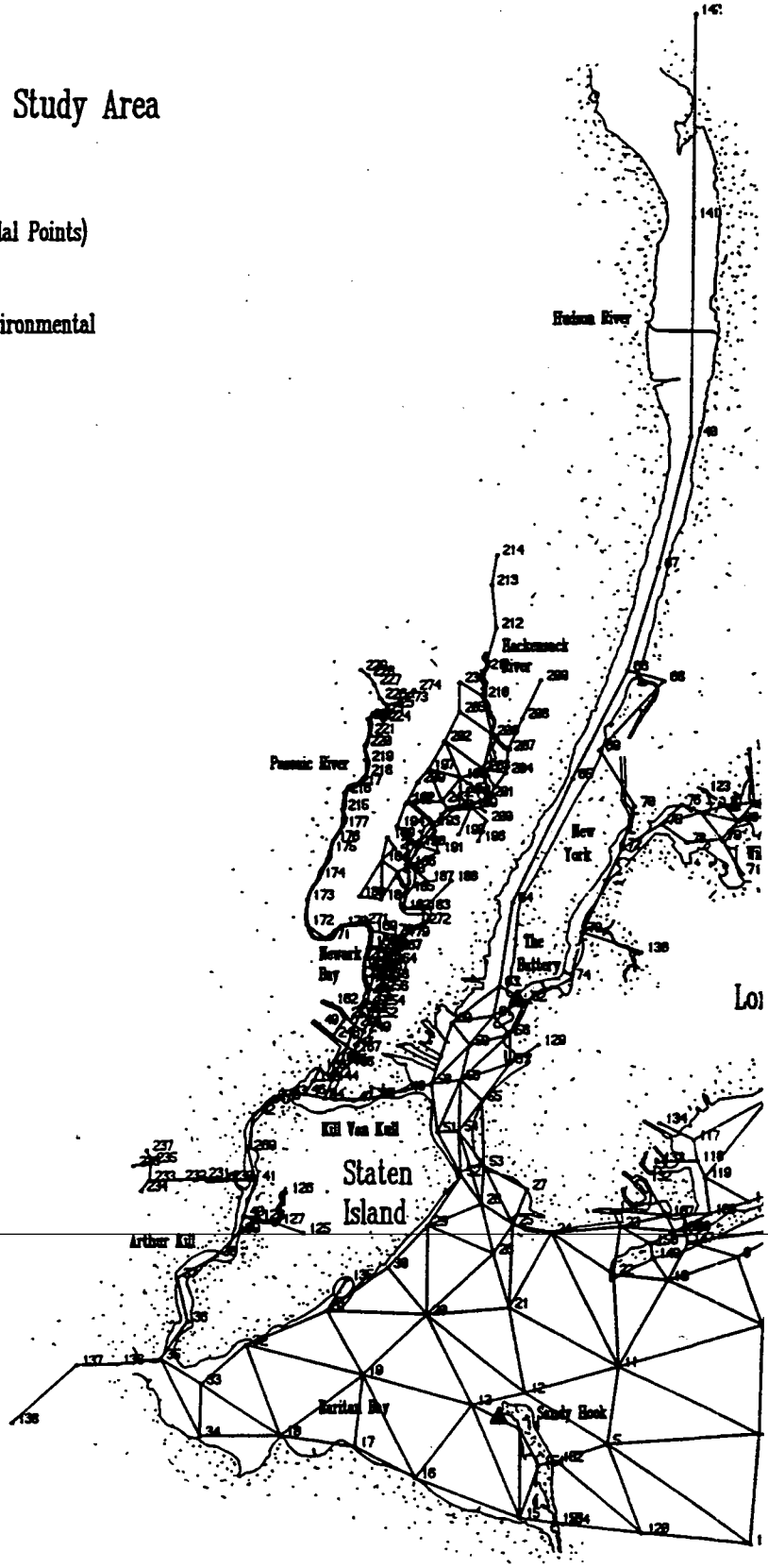


Figure 2. Pseudo-two-dimensional geometric representation for estuary systems

Figure 3.
Link–Node Grid of Study Area

(Note: Numbers Identify Nodal Points)

Cartography by EBASCO Environmental
May 1992



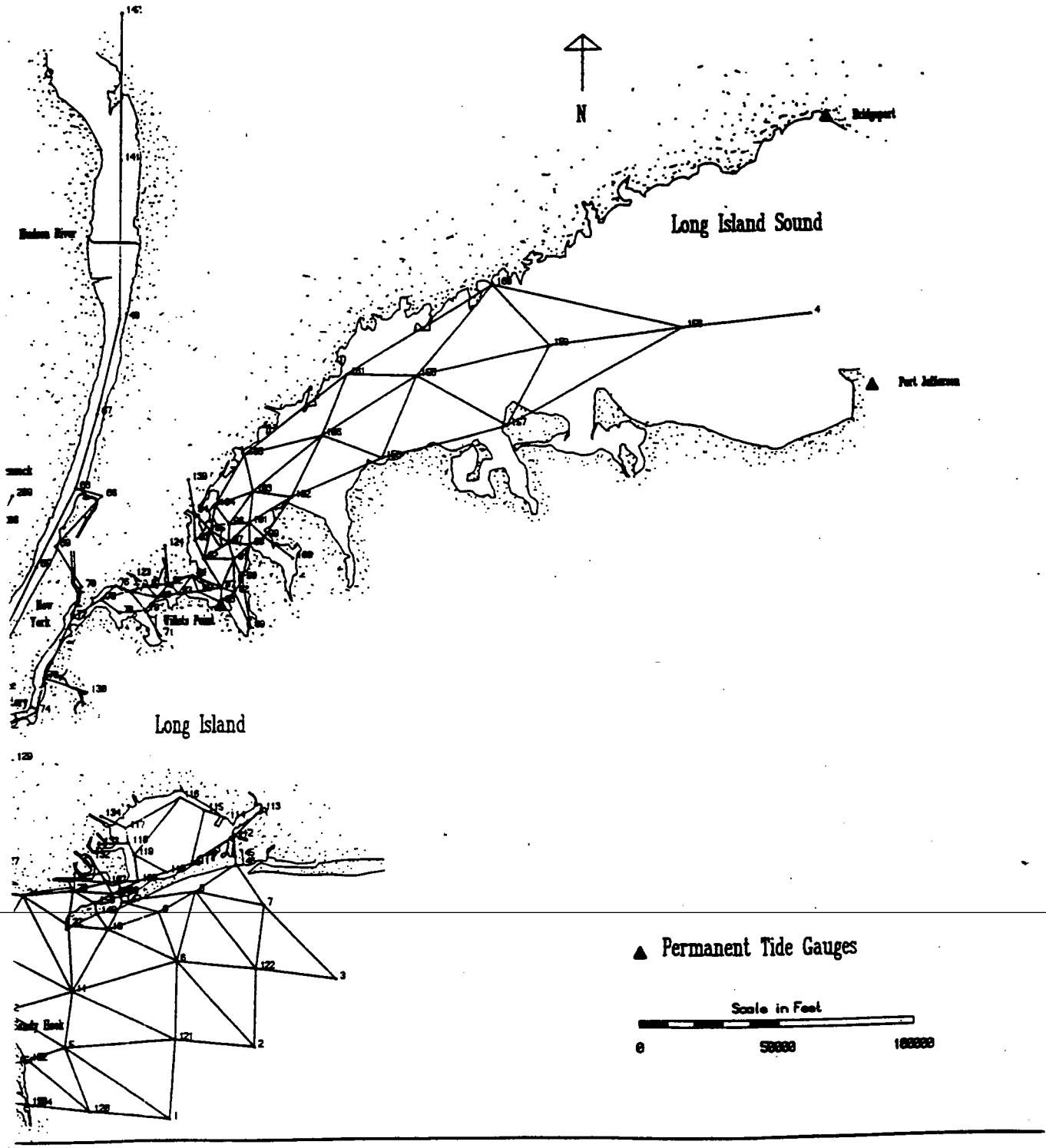
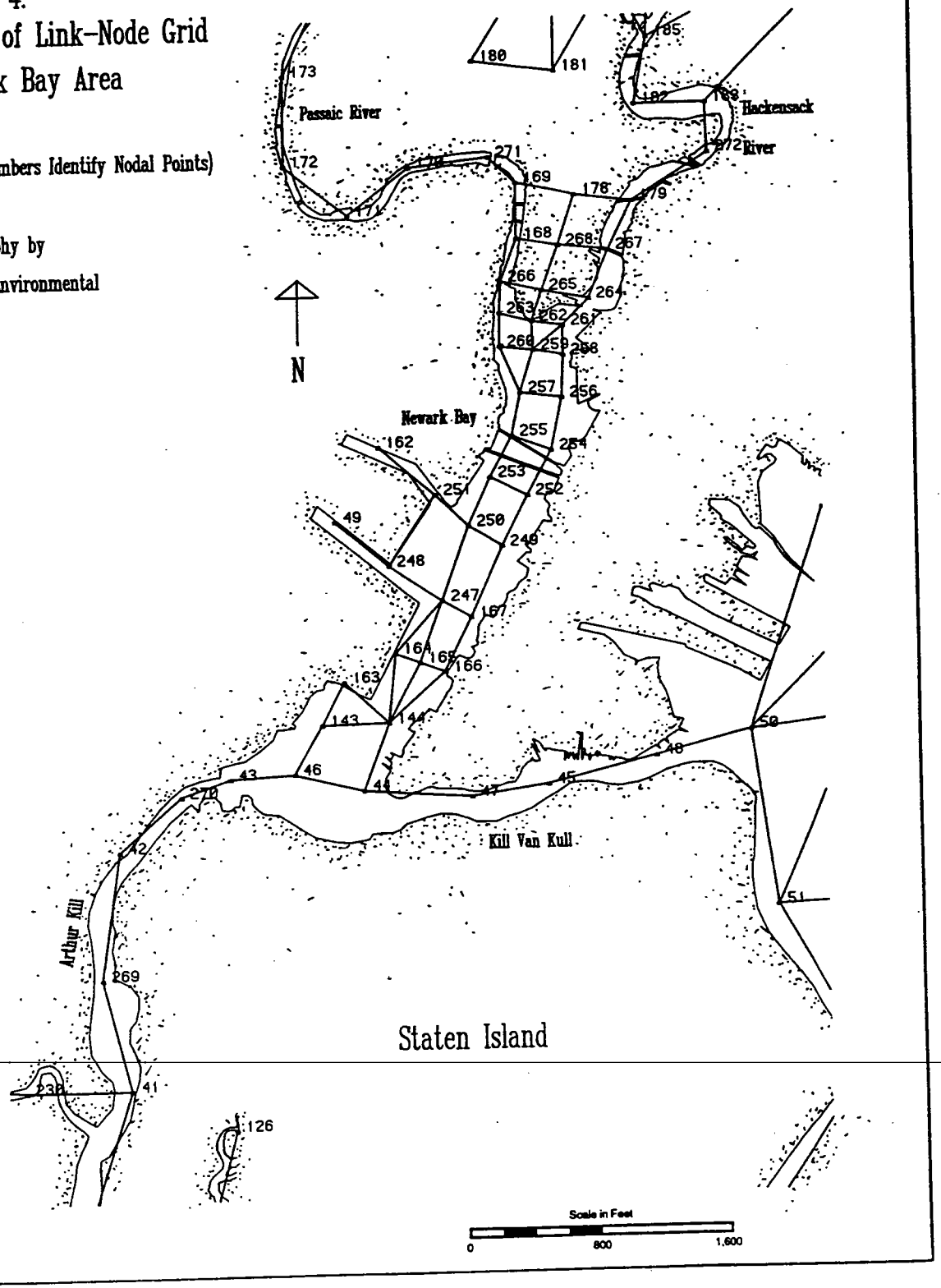

N
Long Island Sound
Long Island
Permanent Tide Gauges
Scale in Feet
0
50000
100000

Figure 4.
Detail of Link-Node Grid
Newark Bay Area

(Note: Numbers Identify Nodal Points)

Cartography by
EBASCO Environmental
May 1992



PART III: MODEL VALIDATION

Introduction

41. Once the model refinements were completed (see Figures 3 and 4), the model was revalidated against six events:

1. The astronomic tide of 11-13 October 1976
2. The hurricane of 21 September 1938
3. The hurricane (Donna) of 12 September 1960
4. The northeaster of 24-26 November 1950
5. The northeaster of 6-7 November 1953
6. The "Halloween Storm" of 29-31 October 1991

42. In a previous study of the area (CDM 1983b) the two hurricanes, and the 1950 and 1953 northeasters, were simulated first using the offshore model, and then transferred to the interior link-node model at exterior boundary nodes 1-4. Nodes 1-3 are located in New York Bight, approximately two miles east of Sandy Hook. Node 4 is located in Long Island Sound in the vicinity of Bridgeport, Connecticut. However, in this study we chose to force the link-node model with direct observations at Sandy Hook (node 12) and The Battery (node 62) in Figure 3. Therefore, we developed a smaller version of the link-node grid containing 176 nodes and 263 links. The two hurricanes and three northeaster events were simulated using this grid, and the astronomical tide was simulated using the entire grid, with forcing at the exterior boundary nodes 1-4 and at the interior nodes at Sandy Hook and The Battery.

Astronomic Tide of October 1976

43. The astronomic tide of 11-13 October 1976 was used to calibrate the original model of the Passaic River (CDM 1983b). This tide was also used to validate the changes made to the grid for the Hackensack River Surge Barrier study (CDM 1988). The full modified grid was used to simulate this event, with interior forcing from observations at Sandy Hook (node 12) and The Battery (node 62), and forcing at boundary nodes 1-4 developed from extrapolated readings from tide gages in the area. Since the interior boundary conditions were also specified, forcing at these nodes dominates the interior solution in Newark Bay and its tributaries.

44. Figure 5 shows the locations of observation points. Figures 6 and 7 show the observed and predicted tides at Sandy Hook and The Battery. Figures 8 through 23 each show: a) observed tidal heights; b) the results of simulations using the modified grid for this study; and c) the results from the Hackensack River Surge Barrier Study (CDM 1988). These figures show that the model agrees well with observations, and that at most locations the agreement is at least as good as, if not better than, the results of the Hackensack River Surge Barrier study. From this comparison, we conclude that the model is accurately simulating tidal conditions in the Newark Bay system. Sensitivity of forcing from observations at Sandy Hook (node 12) and The Battery (node 62) was tested by rerunning the larger grid of the system with forcing at only the exterior nodes 1-4. The results of this simulation are shown in Figures 6 and 7, respectively, and demonstrate that the interior region can be accurately forced using boundary conditions specified at either sets of locations.

45. One additional simulation was performed in which friction values along the Hackensack River were reduced by about 25 percent to determine whether significant changes in predicted tidal elevations along that river would be seen. The results indicated that little change (less than 0.1 ft) was found, confirming that system geometry often plays a more important role in defining the model than does bottom friction.

Historical Hurricanes

46. In the Passaic River study (CDM 1983b) two hurricanes were simulated to validate the model. These events were not simulated in the Hackensack River Surge Barrier study, as it was a reconnaissance study of limited scope. For the current study, we resimulated these two events using the smaller grid of the system, and direct forcing at nodes 12, 24 and 25 using observations at Sandy Hook, and at nodes 62 and 63 using observations at The Battery.

47. The hurricane of 21 September 1938 was simulated using 50 hours of observations from 0000 hours, 20 September 1938. Figure 24 and 25 show the observed storm tides at Sandy Hook at The Battery, respectively. Figures 26 and 27 show comparisons with observed high and low tides at Elm Park and East

Newark, respectively. These figures show that the model predicts this event accurately.

48. The hurricane of 12 September 1960 was simulated using 48 hours of observations from 0000 hours, 11 September 1960. Figures 28 and 29 show the observed tides at Sandy Hook and The Battery, respectively. Figures 30 through 32 show comparisons with observed tides at Elm Park, Fort Hamilton and Carteret, respectively. Figure 33 shows predicted and observed tidal heights at Kearny Point. These figures demonstrate that the model predicts storm tide heights accurately during this event.

Historical Northeasters

49. The northeaster of 24-26 November 1950 was simulated using the smaller grid, and direct forcing at the Sandy Hook and The Battery boundary nodes. The event was simulated from 0000 hours, 24 November 1950 for 52 hours. Figures 34 and 35 show the observed tides at Sandy Hook and The Battery, respectively. Figure 36 shows a comparison with observed tidal heights at Elm Park, and the agreement is generally very good. However, it appears from Figure 36 that the gage at Elm Park topped out and missed two consecutive peak tides.

50. The northeaster of 6-7 November 1953 was simulated from 0000 hours, 6 November 1953 for 48 hours. Figure 37 and 38 show the observed storm tide at Sandy Hook and The Battery, respectively. Figures 39 through 41 show comparisons with observations at Elm Park, East Newark and Fort Hamilton, respectively. These figures further validate that the model accurately simulates this northeaster event.

"Halloween" Northeaster of 1991

51. During 30-31 October 1991, the "Halloween" storm hit the Newark Bay area. The New York District of the Corps of Engineers recorded, as accurately as possible in the circumstances, high water levels in the afternoon of Wednesday, 30 October and the morning of Thursday, 31 October 1991. We simulated this event for 71 hours from 0000 hours, 29 October 1991, using a grid that reflected the partial dredging in the Kills and Newark Bay to this date.

52. Figures 42 and 43 show the observed tides at Sandy Hook and The Battery, respectively. Figure 44 shows predicted and observed tidal heights at Ridgefield Park (Bergen Generating Station). Table 1 compares observations throughout the Newark Bay/Passaic/Hackensack River system with simulation results. The table shows generally agreement throughout the system. However, there are two locations along the Hackensack River where observed heads are more than a foot lower than predicted. It is interesting to note the close agreement at either end of the Hackensack River, and both higher predicted and observed tidal elevations than at these two more central locations. Therefore, either: a) there is some systematic error in the readings at these observation points, b) the readings represent overbank observations where obstructions in the flood plain reduce water levels from those seen in the main river, or c) the model does not predict the storm tide correctly. Other simulations suggest that the model accurately predicts storm surge events, and it is unlikely that flood plain obstructions close to the main channel would produce the differences in water surface "observed". We therefore suspect that the differences are produced by some systematic error in the readings at locations near nodes 206 and 210.

53. Finally, to determine the effect of dredging on tidal heights in the Newark Bay system, the "Halloween" Storm was simulated using the "pre-1980" grid. The results showed that, at most, predicted tidal heights for this extreme event changed by less than 0.02 feet. In addition, we simulated the observed hurricanes of September 1938 and 1960, and the northeasters of 1950 and 1953, using the "1991" grid without sea level rise. The results showed that peak surge elevations compared within 0.15 feet, and that the effect of the dredging was to slightly alter the phasing of the peak elevations, but by less than 1/2 hour. Therefore, we conclude that the dredging operations in the Kills and Newark Bay has, and will have, little effect on circulation and water levels in the study area.

Table 1

Comparison of Observed and Simulated Tidal Elevations
For the "Halloween" Storm of October 1991

Location	Node	Observed Height[1]	Observed Time[2]	Predicted Height[1]	Predicted Time
New York Harbor					
Caven Point, New York Harbor	60	6.2	W (2pm)	6.02	W (2 pm)
Passaic River					
BASF Plant, Kearny	262	7.62-7.94	T (debris)	7.23	T (3:45 am)
4th St., Newark	171	6.83 7.43	W (3 pm) T (debris)	6.66 7.29	W (3 pm) T (4 am)
Fire Pier, Newark	172	7.75	T (debris)	7.31	T (4 am)
Page St., Lyndhurst	216	5.72-6.22 6.25-7.6	W (3:30 pm) T (debris)	6.78 7.37	W (3:30 pm) T (3:45 am)
Old Boat House, East Rutherford	219	6.34	T (debris)	7.39	T (3:45 am)
Hackensack River					
Daily News, Kearny	264	> 7.1	T (??)	7.22	T (3:30 am)
Fence Outlet, Ridgefield Park	207	5.34 5.94	W (3 pm) T (7-8 am)	5.74 5.79	W (3 pm) T (7:30 am)
Gas Station, South Hackensack	206	4.95	T (7 am)	6.06	T (7 am)
Marina, South Hackensack	210	5.79	T (debris)	6.91	T (5:15 am)
Hess, Bogota	211	7.2	T (debris)	6.94	T (5:15 am)

[1] Feet NGVD
[2] W = Wednesday afternoon, 30 October 1991
T = Thursday morning, 31 October 1991

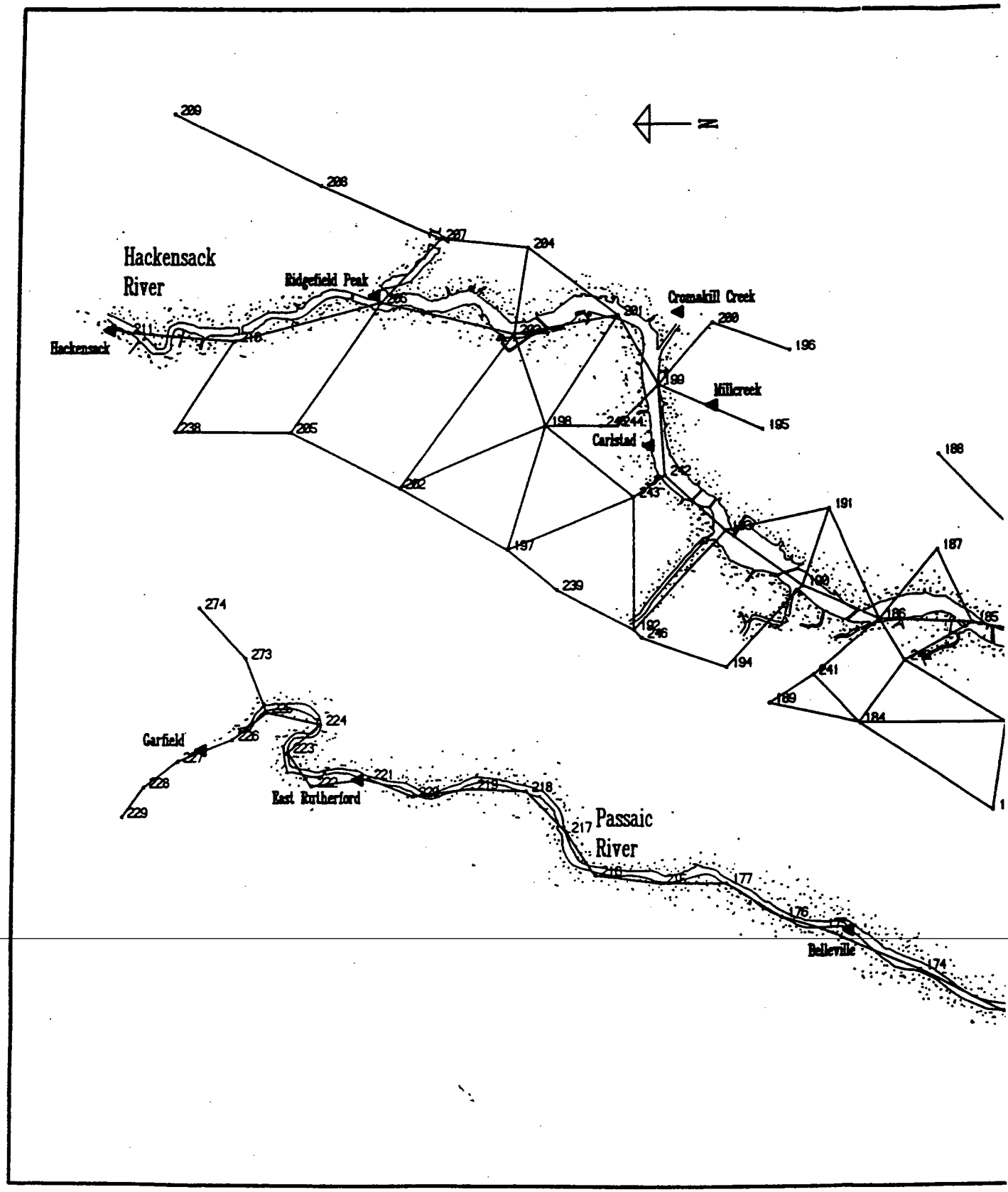

N
Hackensack River
Hackensack
Ridgefield Peak
Cromakill Creek
Millcreek
Carlstad
Garfield
East Rutherford
Passaic River
Belleville

Figure 5.
Gage Locations for
October 1976 Tidal
Elevation Study

(Note: Numbers Identify
Nodal Points)

Cartography by
EBASCO Environmental
May 1992

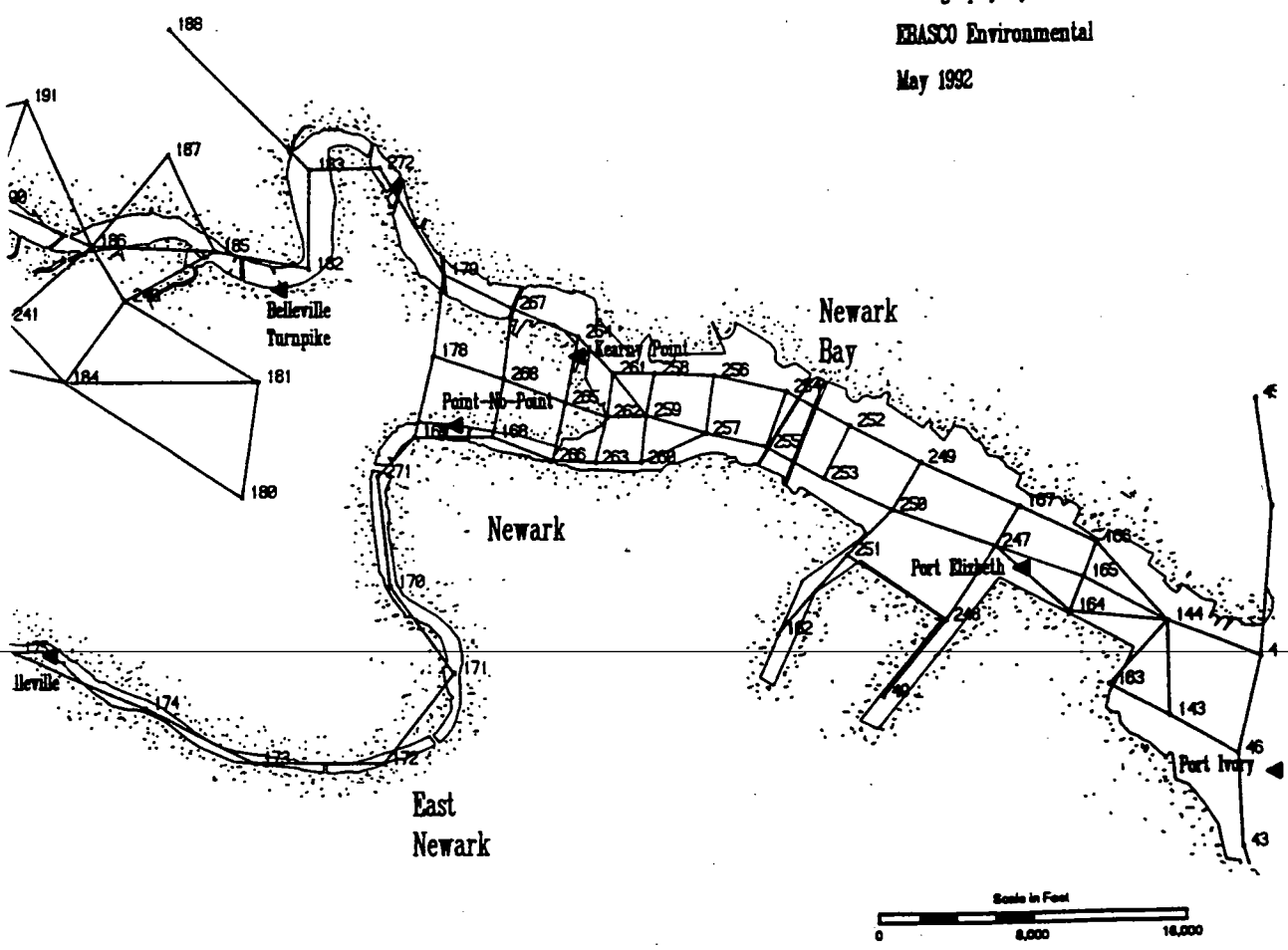


Figure 6. Tidal heights at Sandy Hook
for tide of 11–13 October 1976

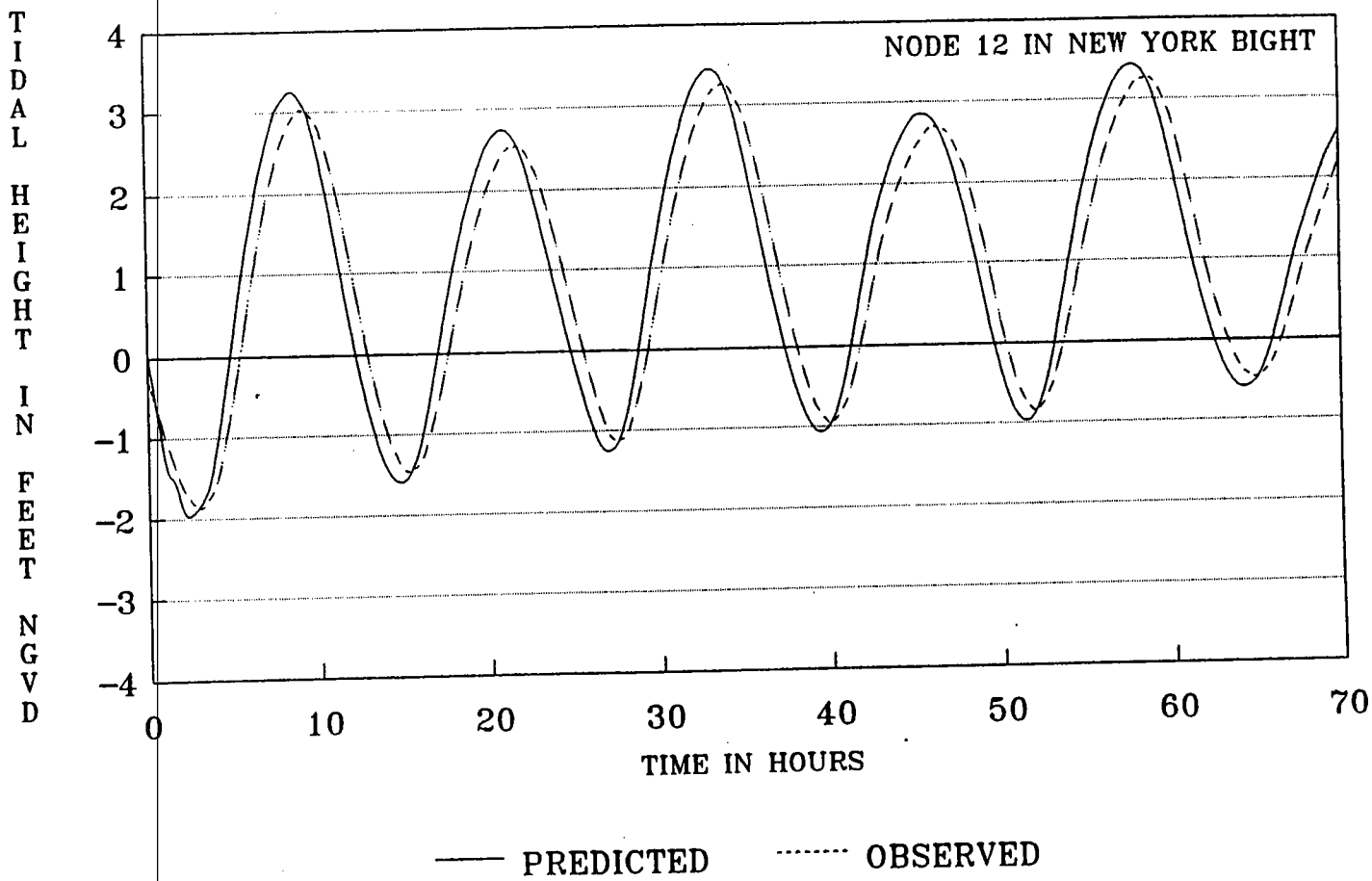


Figure 7. Tidal heights at the Battery
for tide of 11–13 October 1976

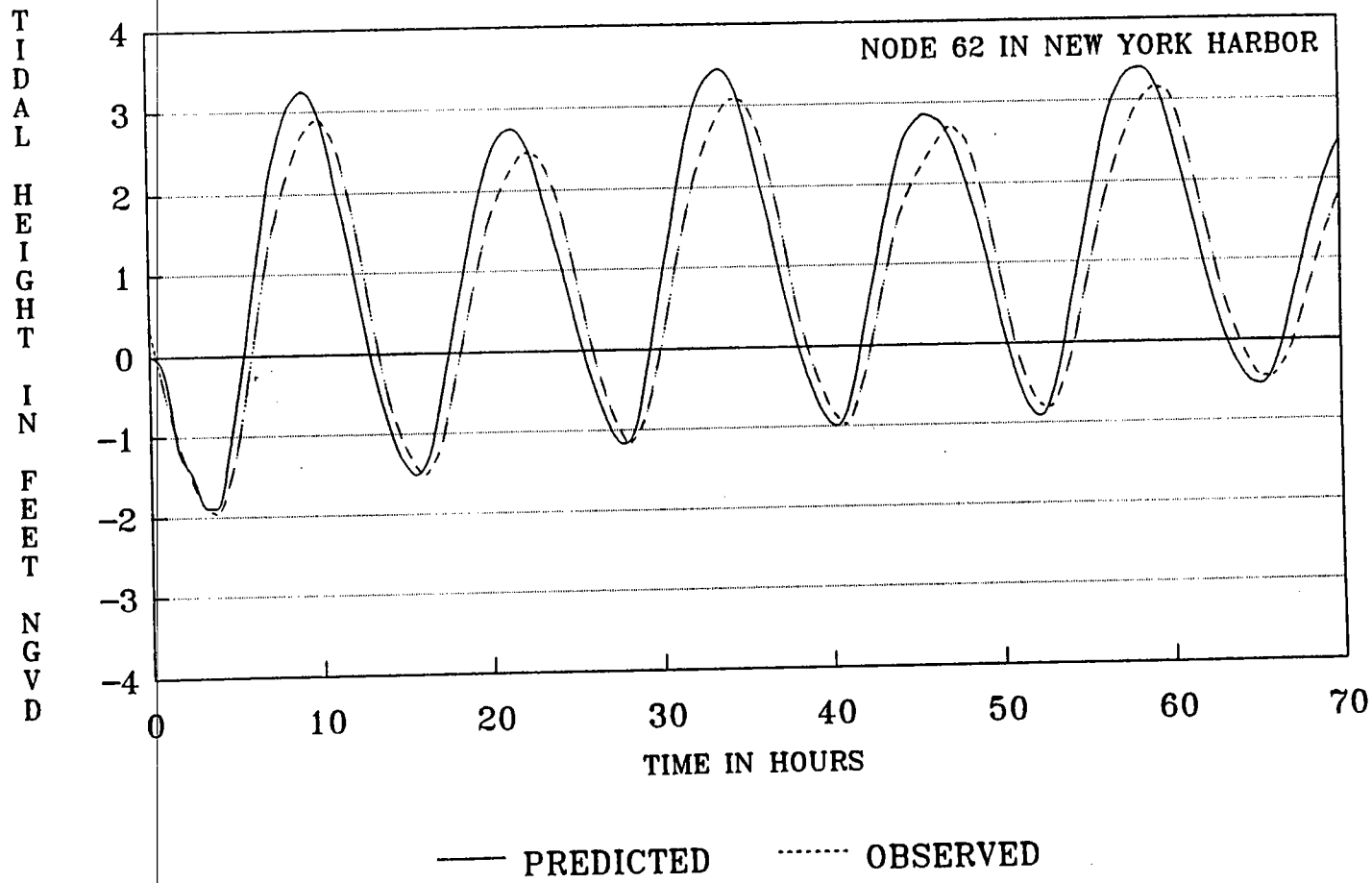


Figure 8. Tidal heights at Point No Point for tide of 11-13 October 1976

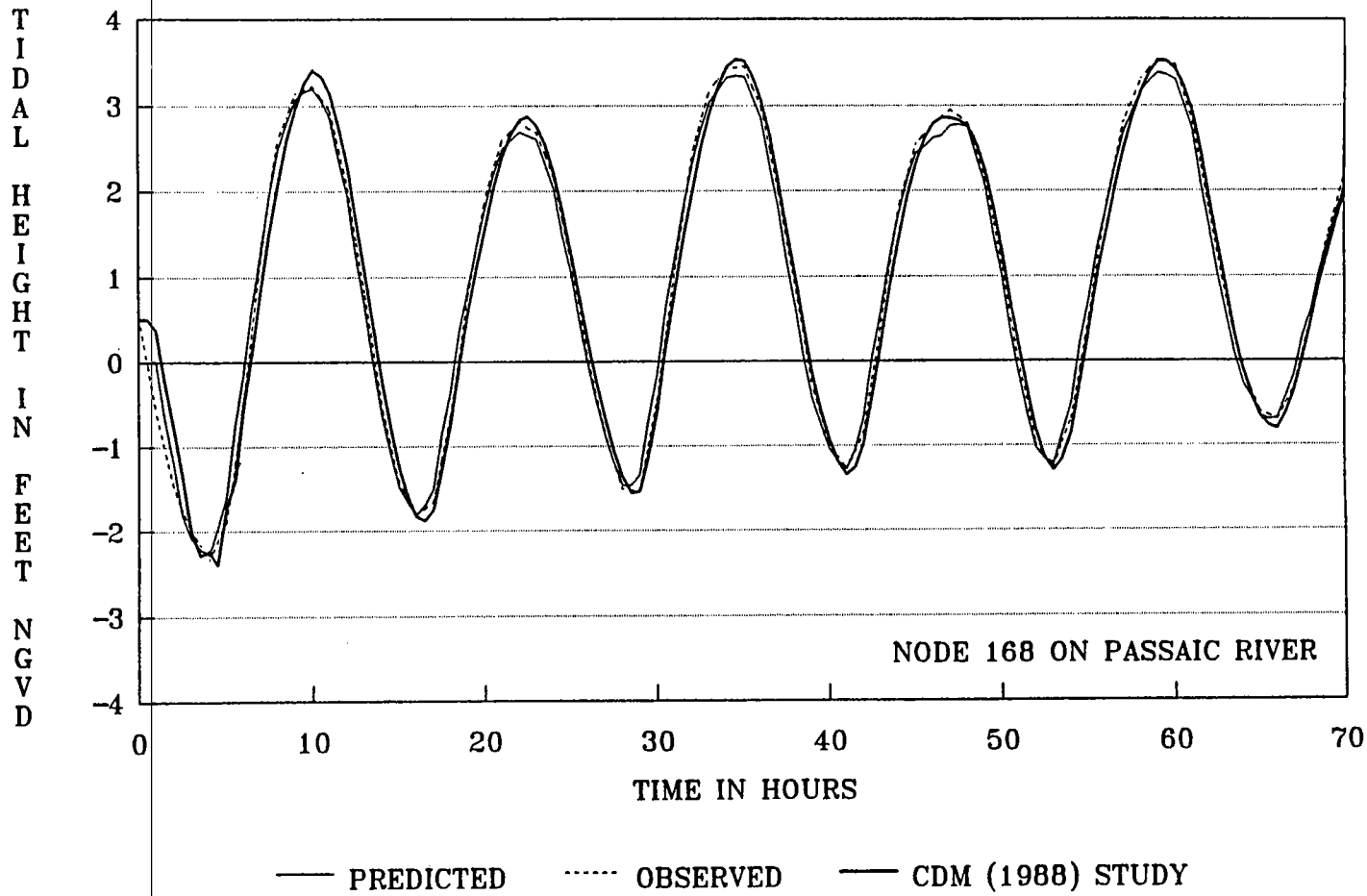


Figure 9. Tidal heights at Belleville
for tide of 11-13 October 1976

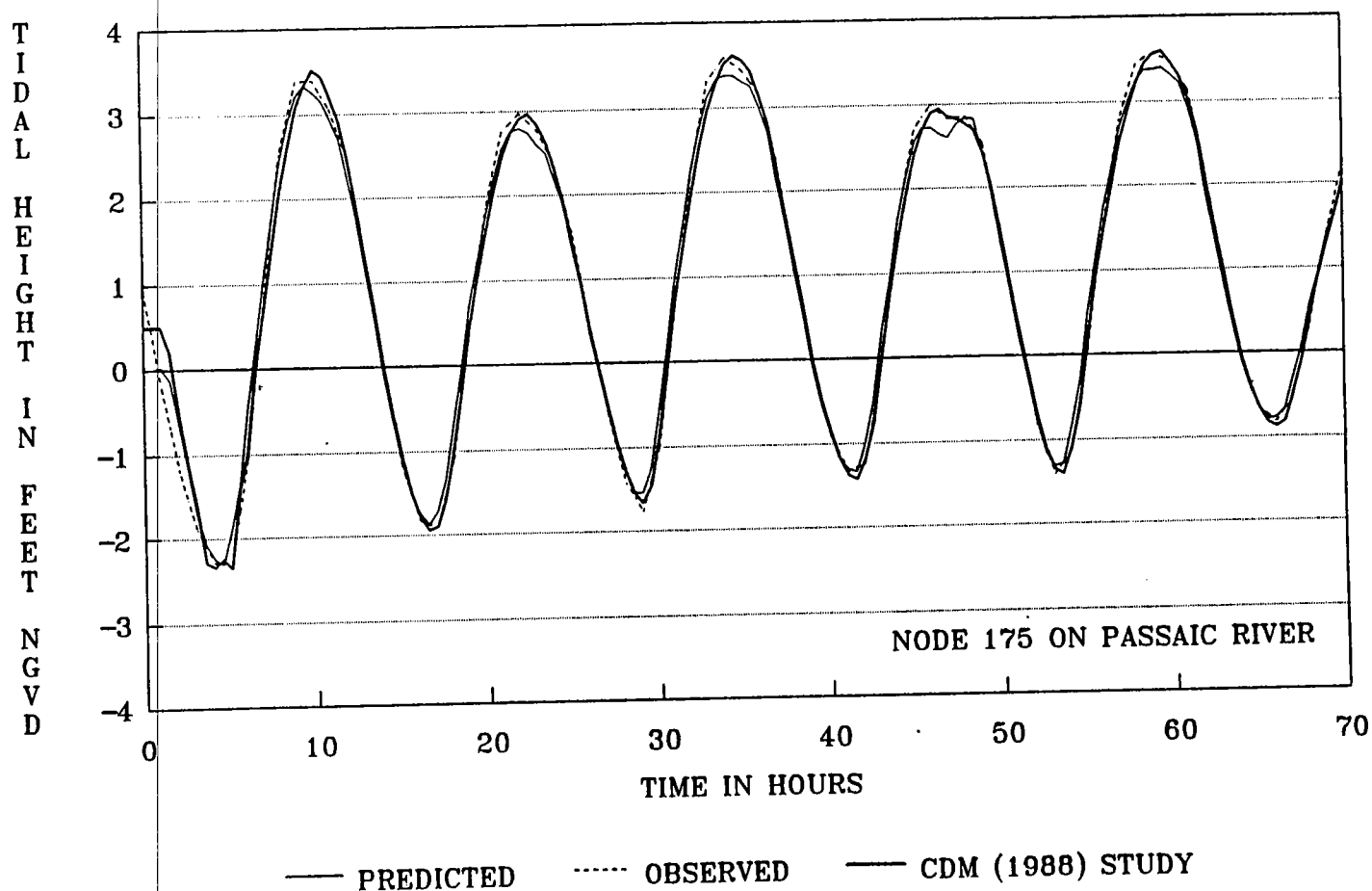


Figure 10. Tidal heights at East Rutherford for tide of 11-13 October 1976

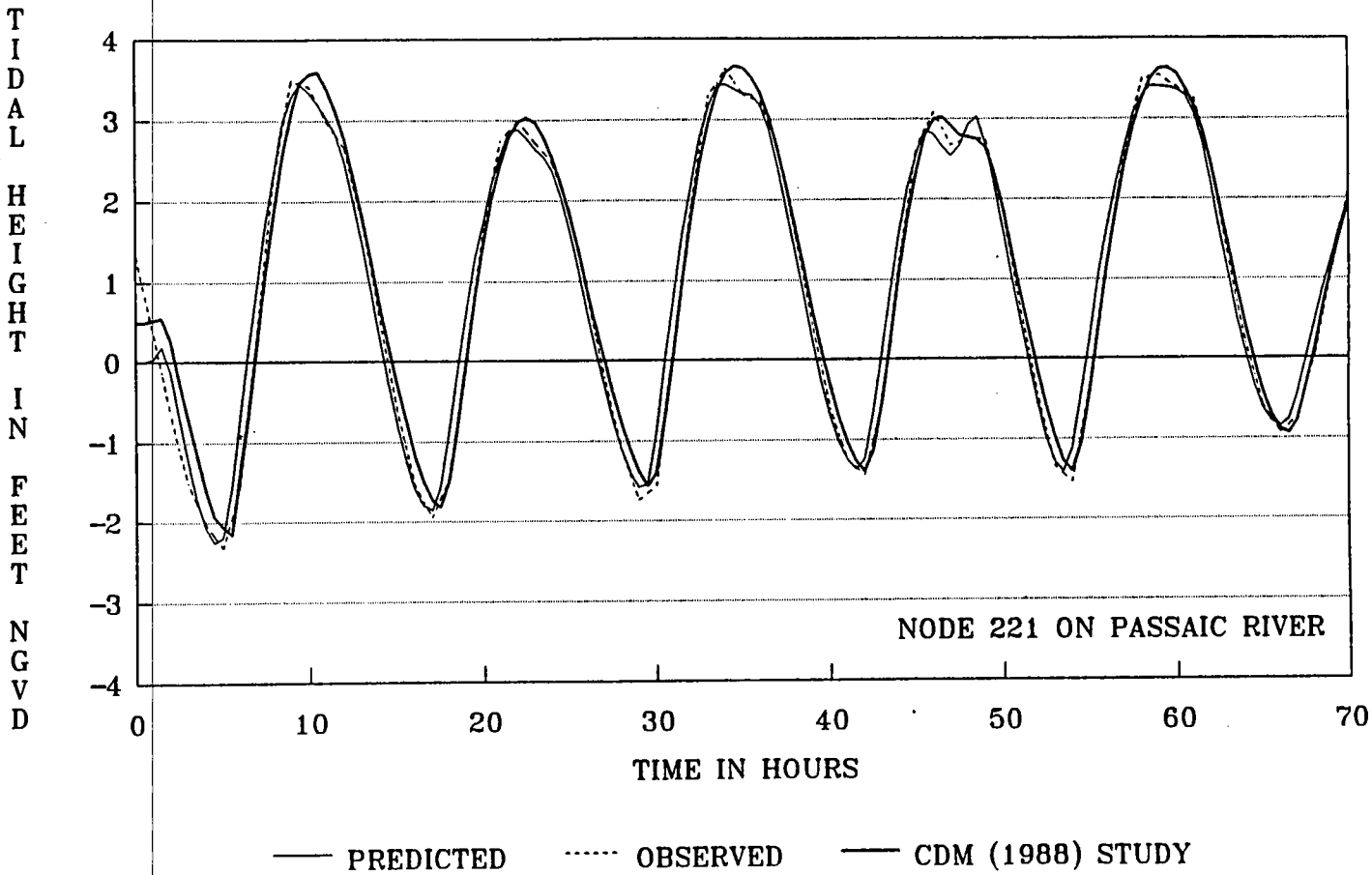


Figure 11. Tidal heights at Garfield
for tide of 11-13 October 1976

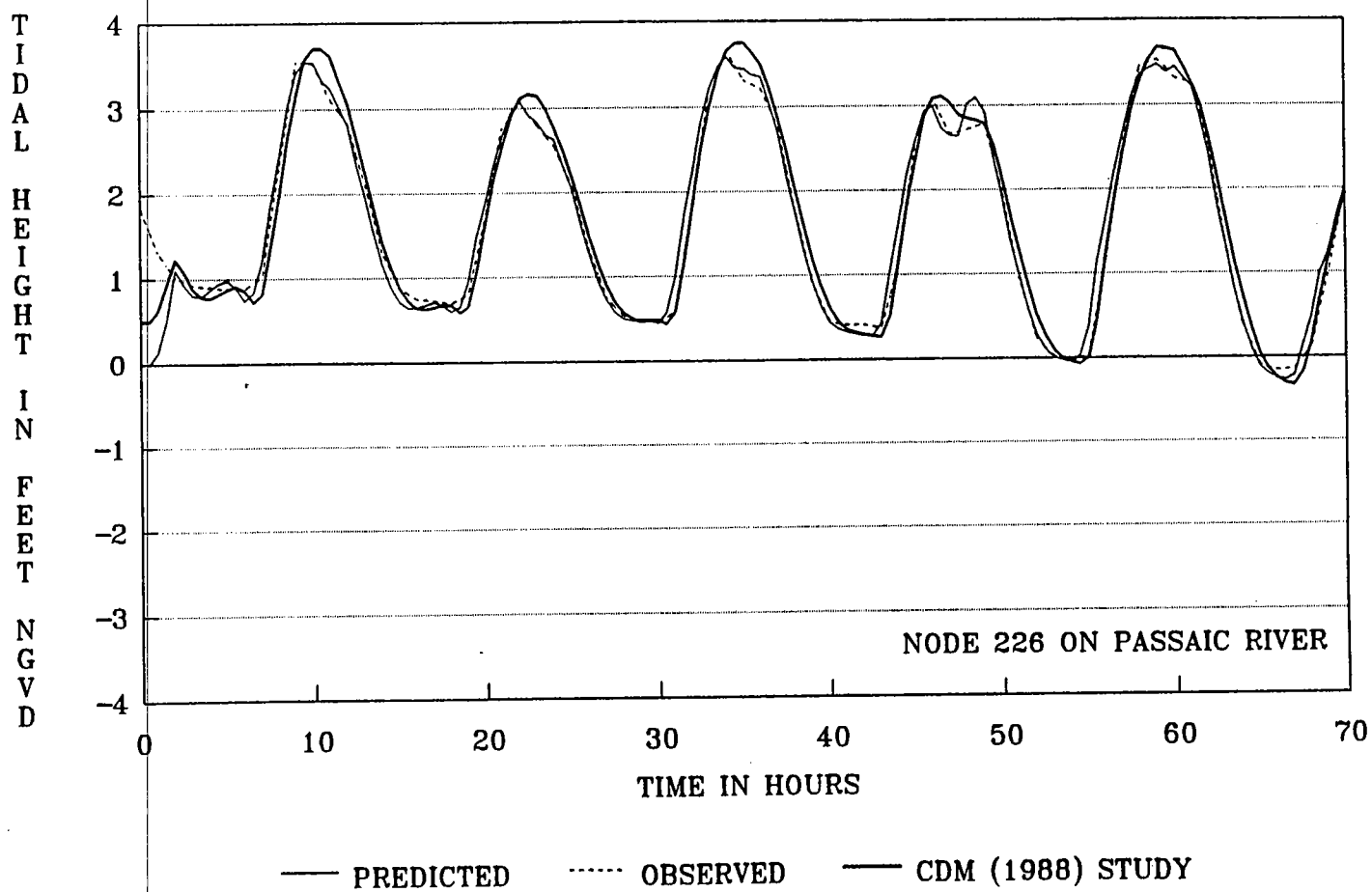


Figure 12. Tidal heights at Kearny Point for tide of 11-13 October 1976

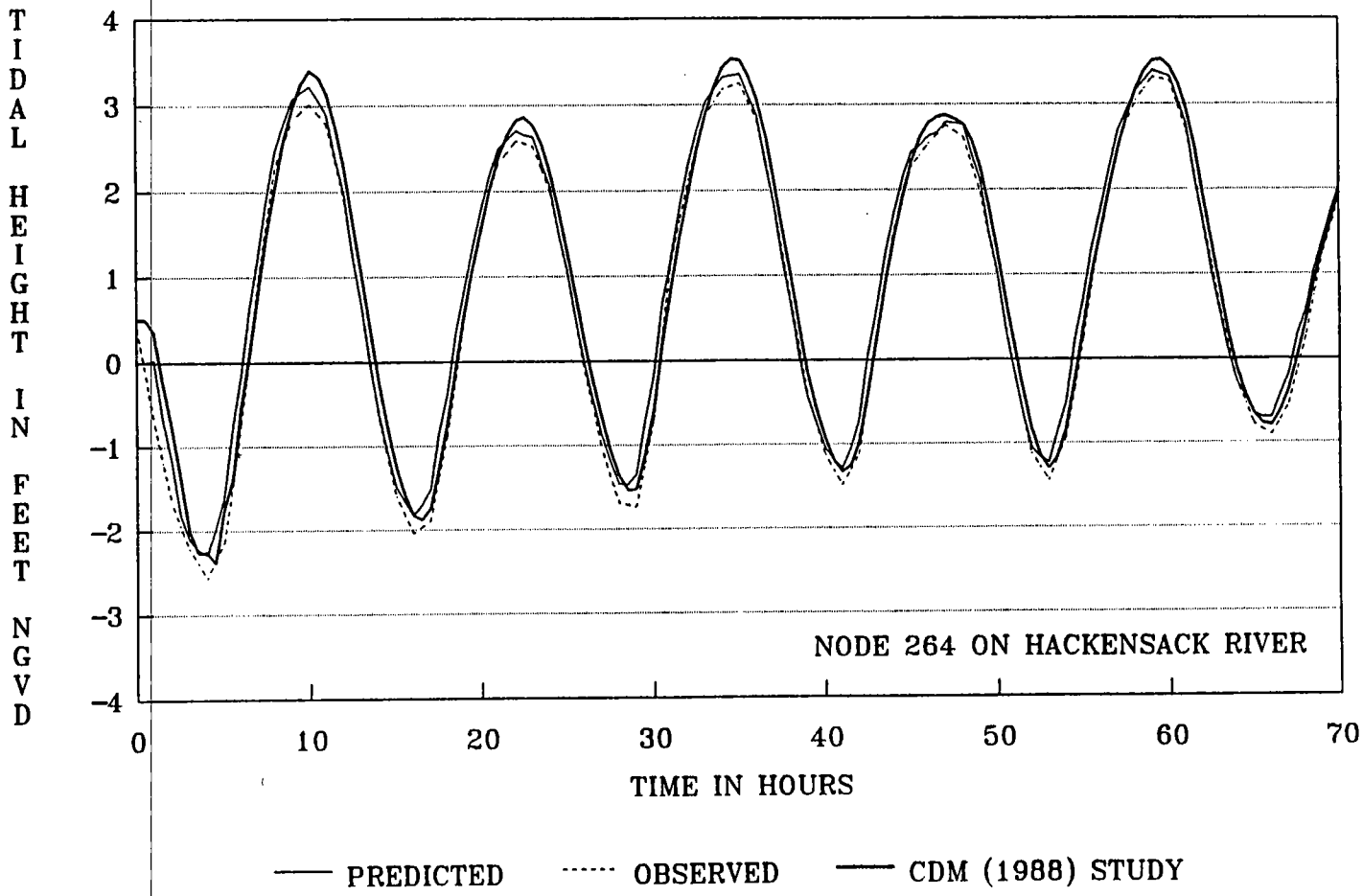


Figure 13. Tidal heights at Belleville
Tpke for tide of 11-13 October 1976

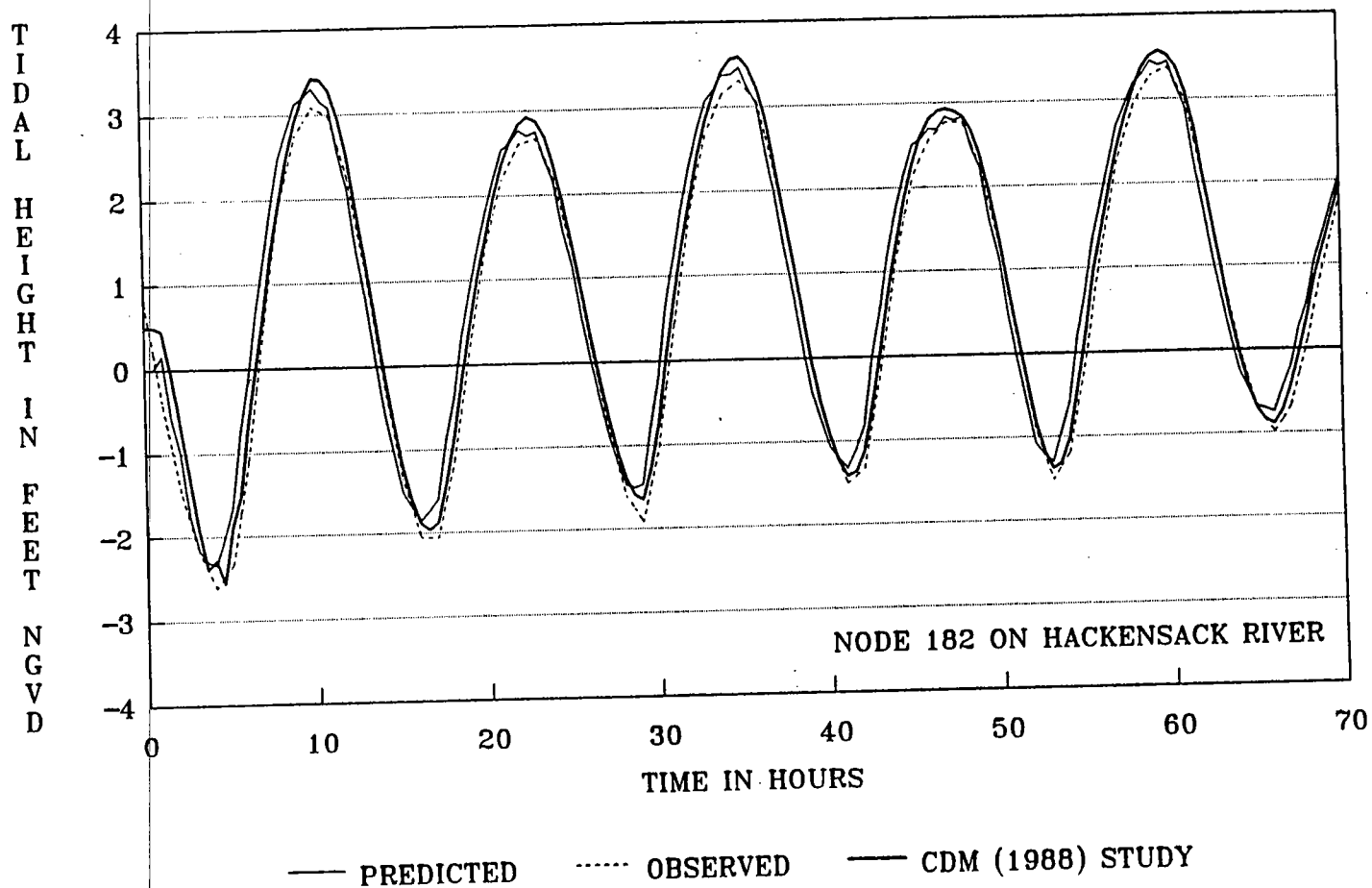


Figure 14. Tidal heights at Carlstadt
for tide of 11–13 October 1976

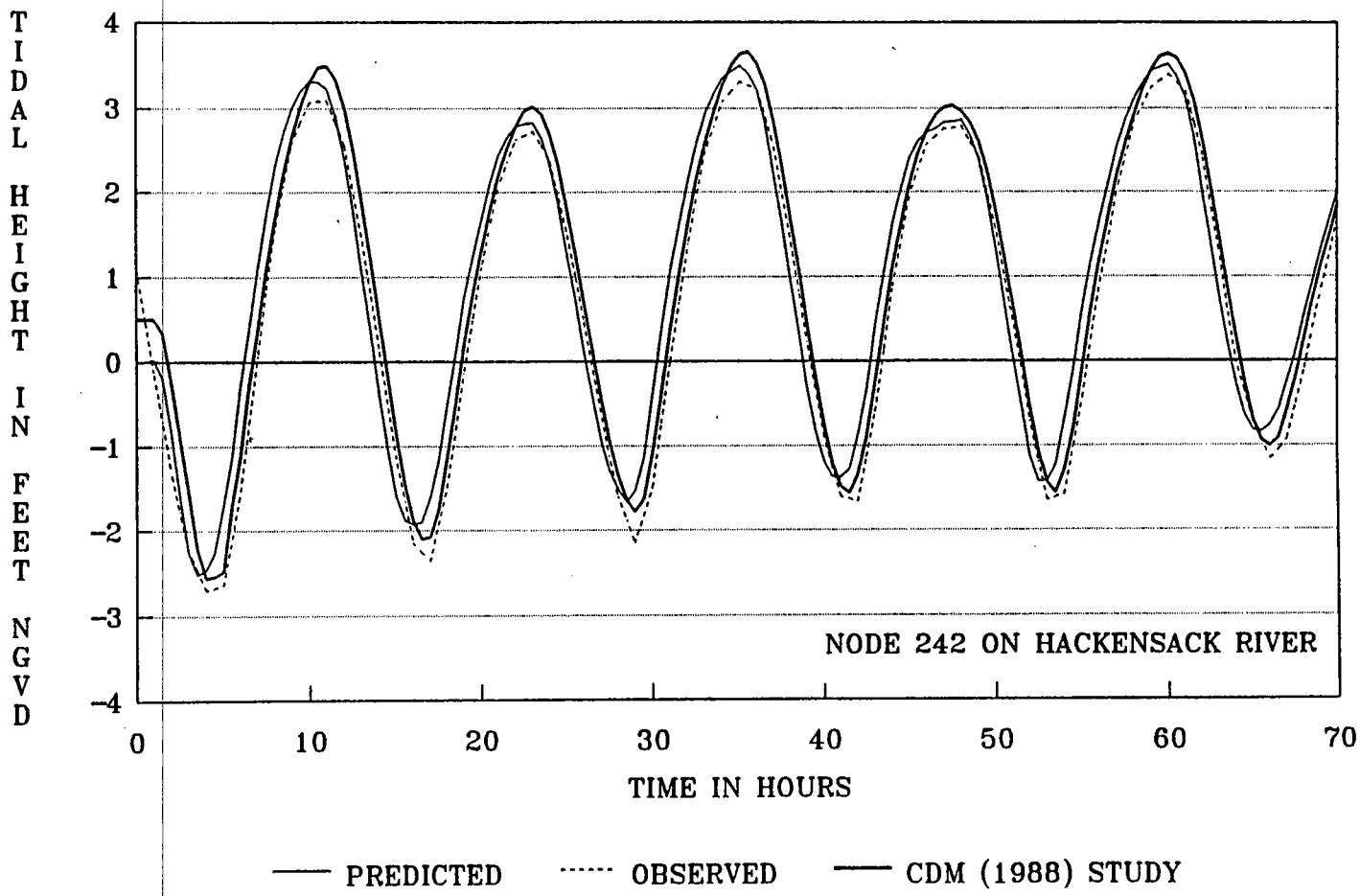


Figure 15. Tidal heights at Mill Creek
for tide of 11-13 October 1976

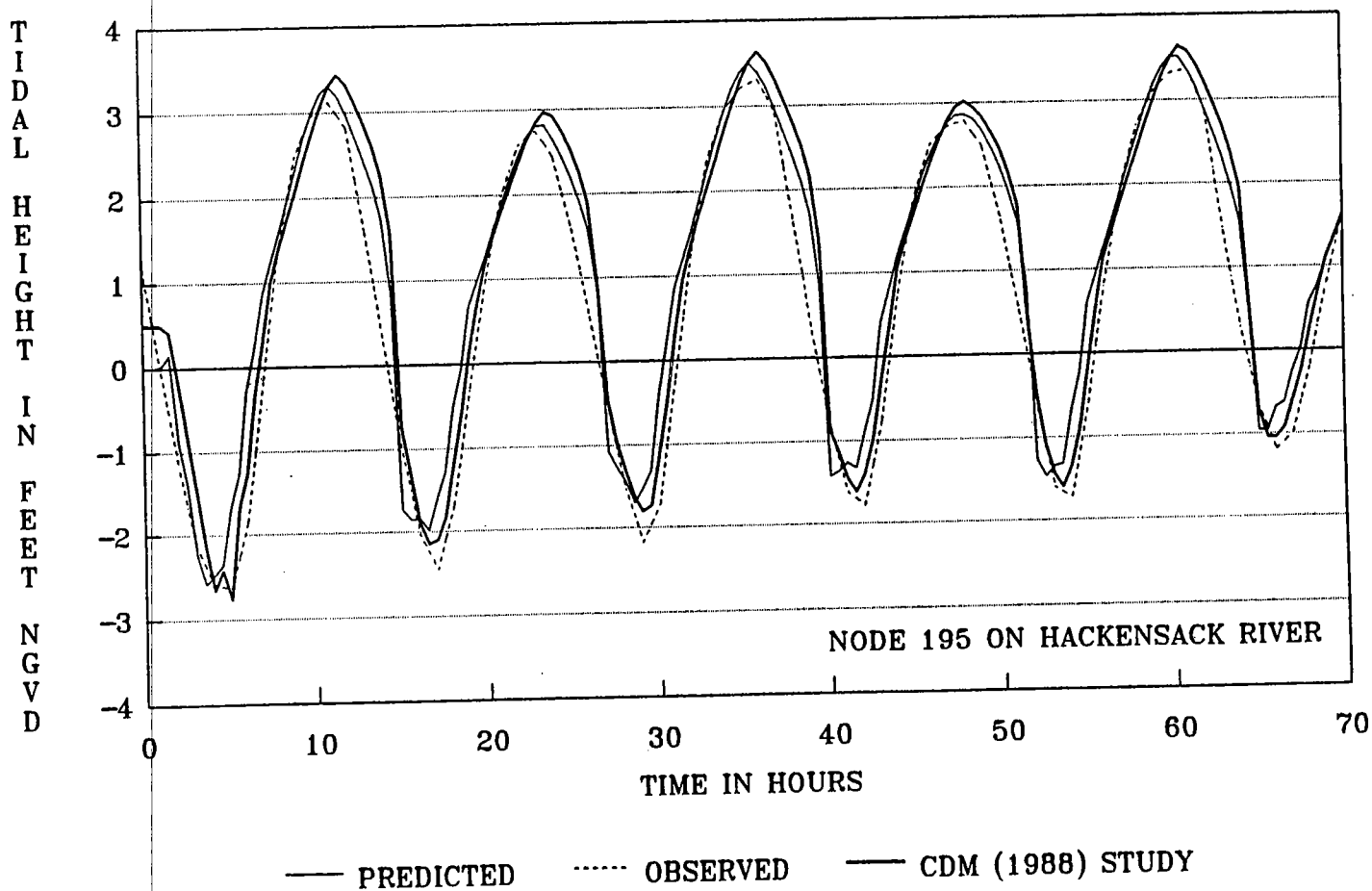


Figure 16. Tidal heights at Cromakill Creek for tide of 11–13 October 1976

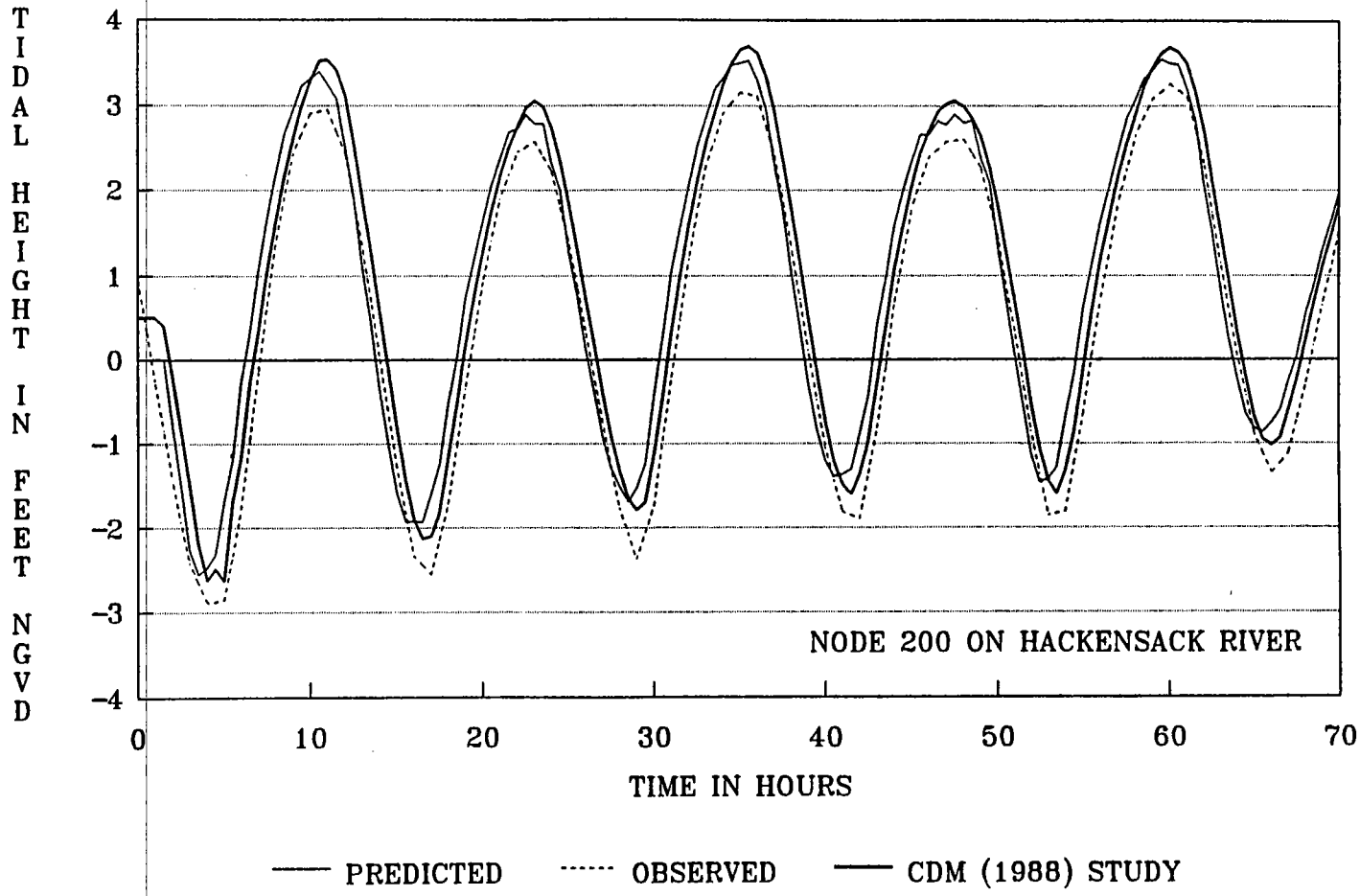


Figure 17. Tidal heights at Ridgefield Park for tide of 11-13 October 1976

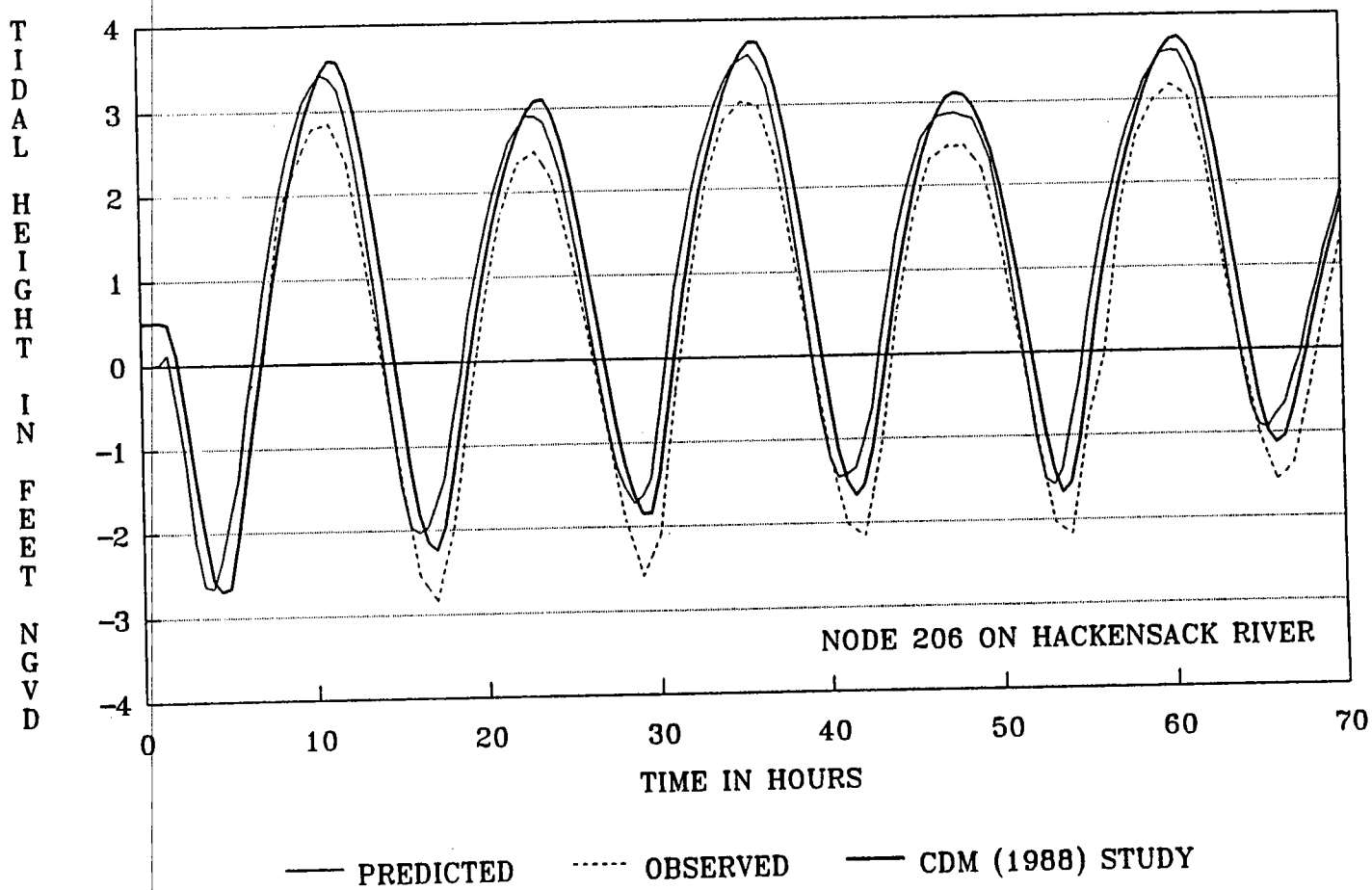


Figure 18. Tidal heights at Hackensack
for tide of 11-13 October 1976

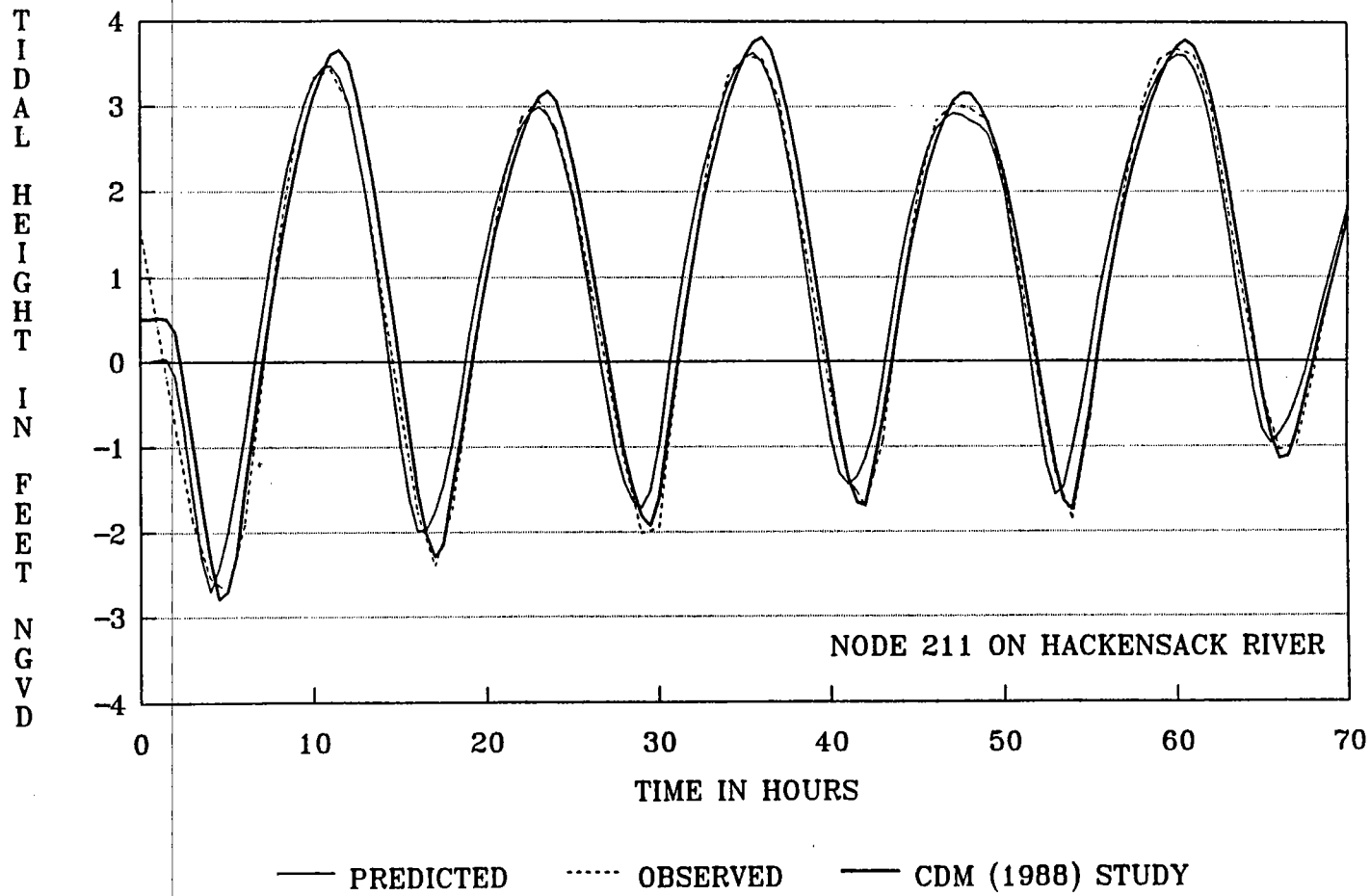


Figure 19. Tidal heights at Port Ivory
for tide of 11–13 October 1976

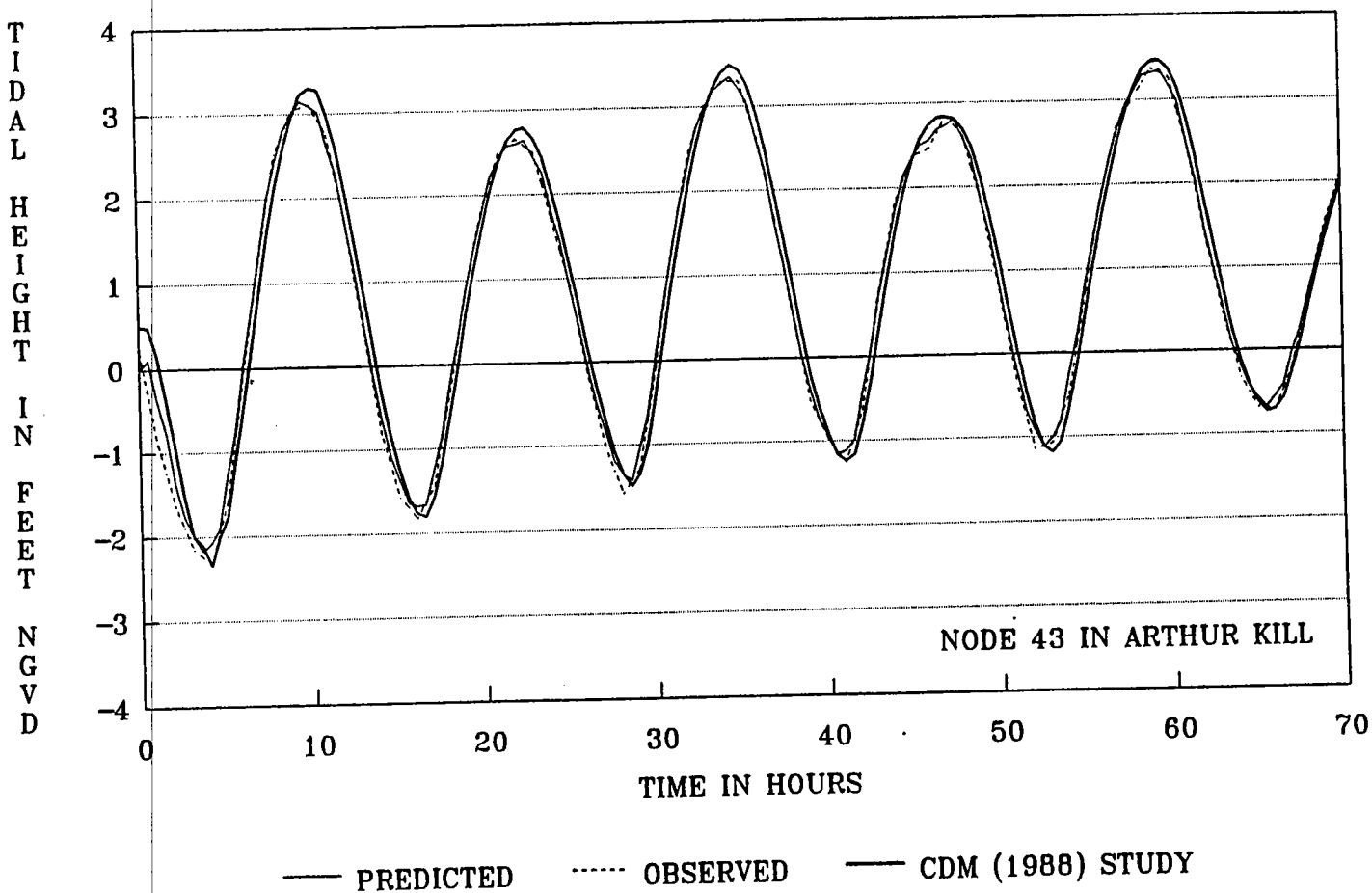


Figure 20. Tidal heights at South Amboy
for tide of 11-13 October 1976

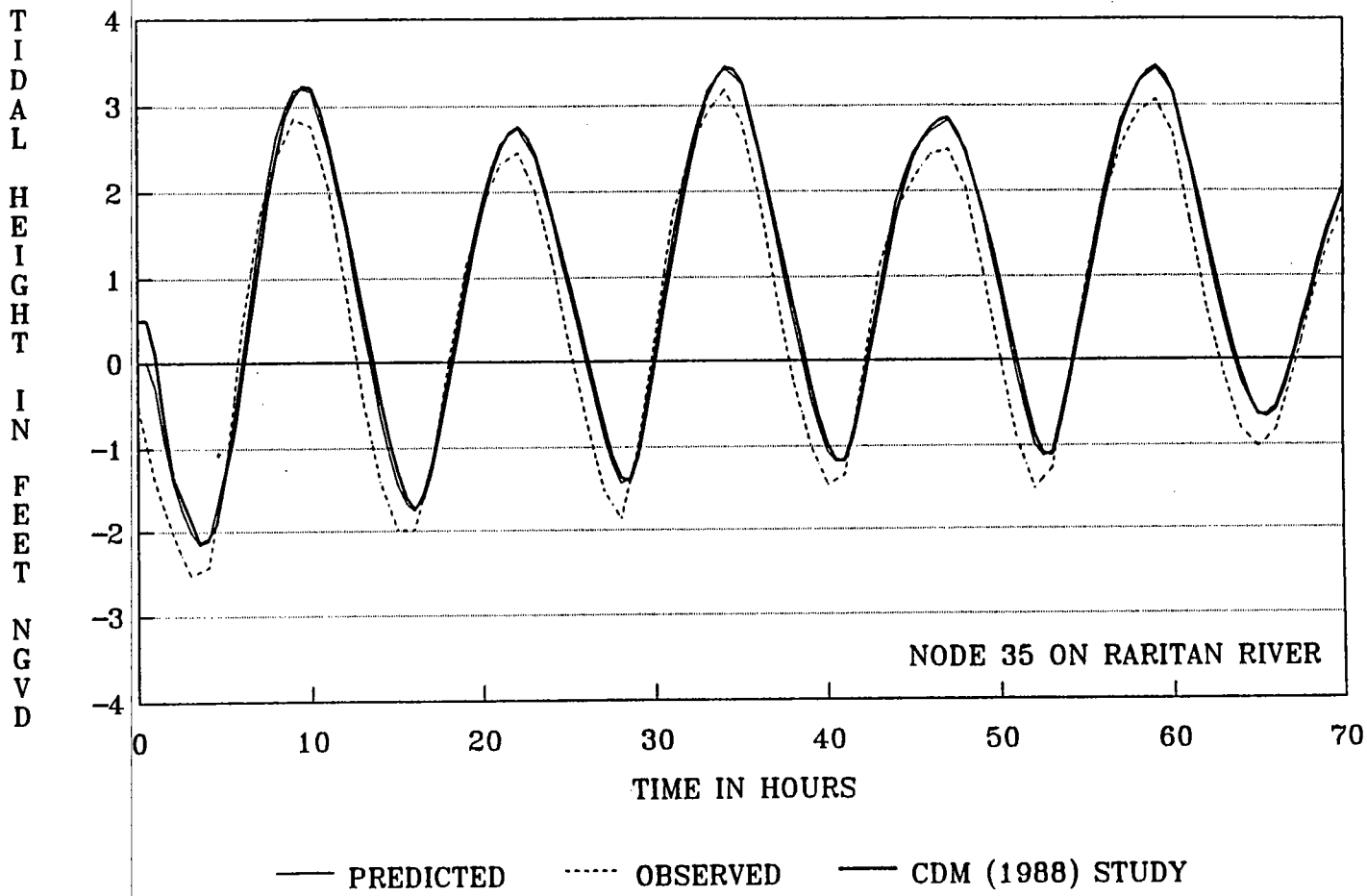


Figure 21. Tidal heights at Sayreville
for tide of 11-13 October 1976

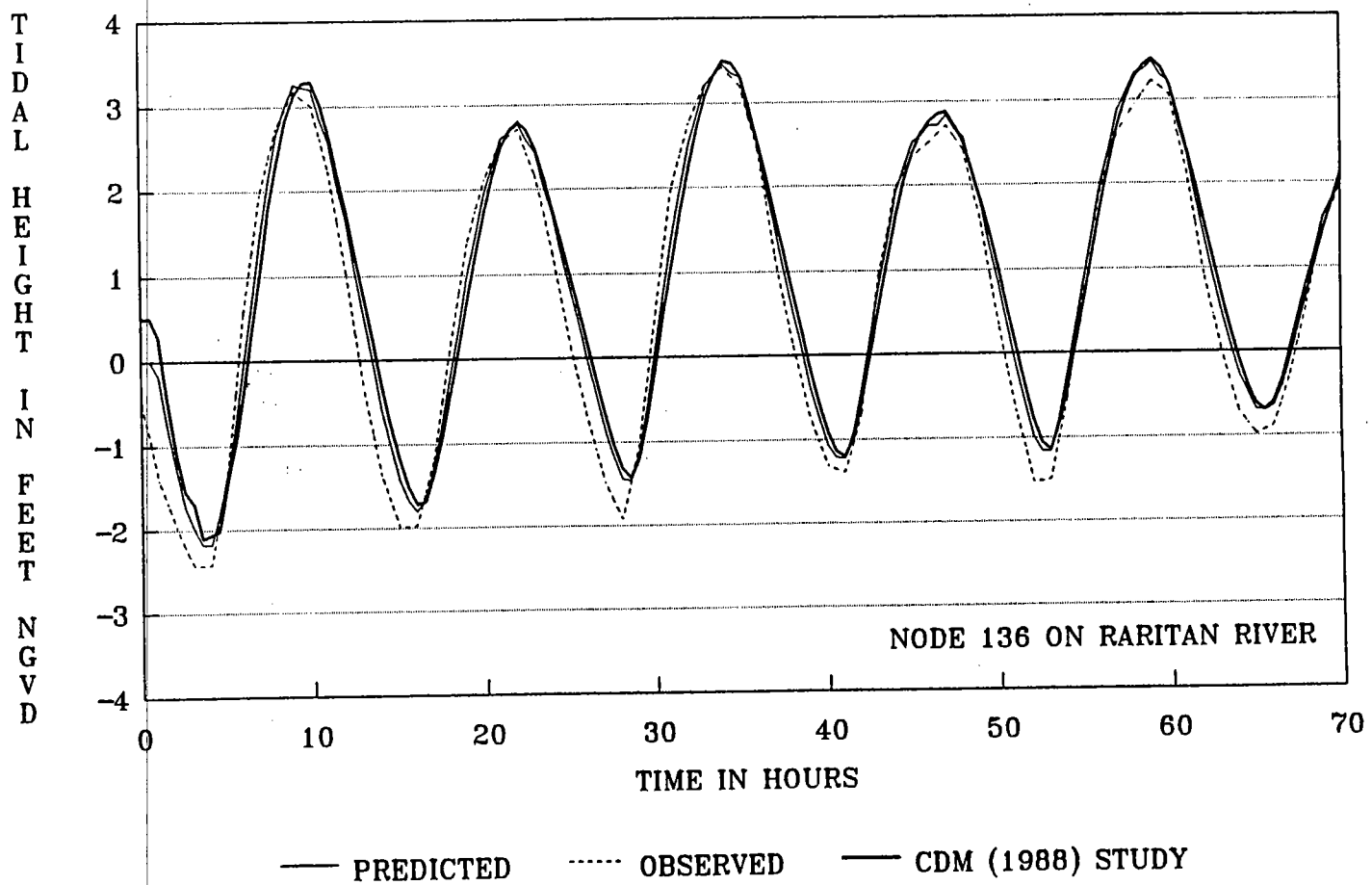


Figure 22. Tidal heights at Keasbey
for tide of 11–13 October 1976

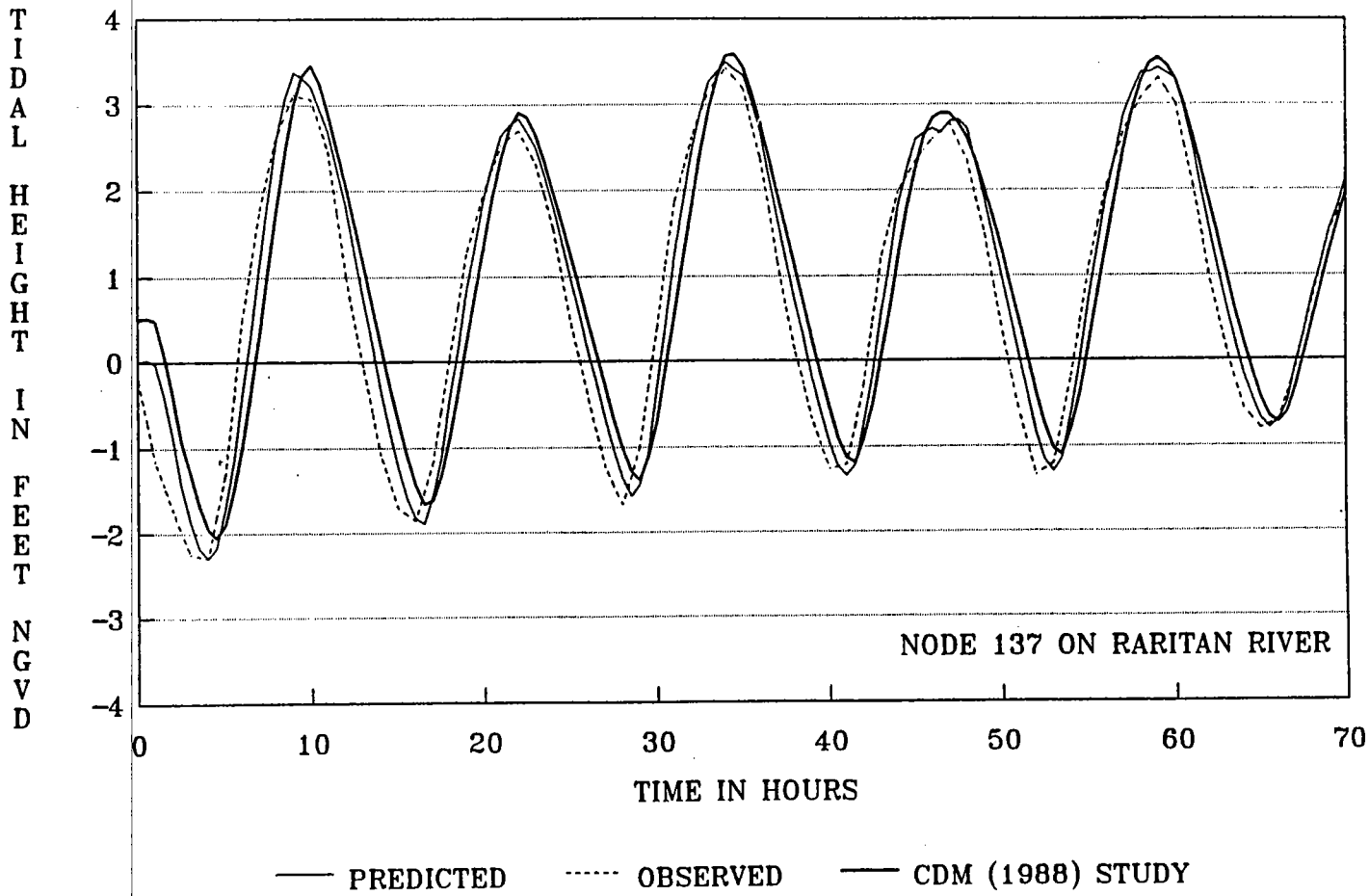


Figure 23. Tidal heights at New Brunswick for tide of 11-13 October 1976

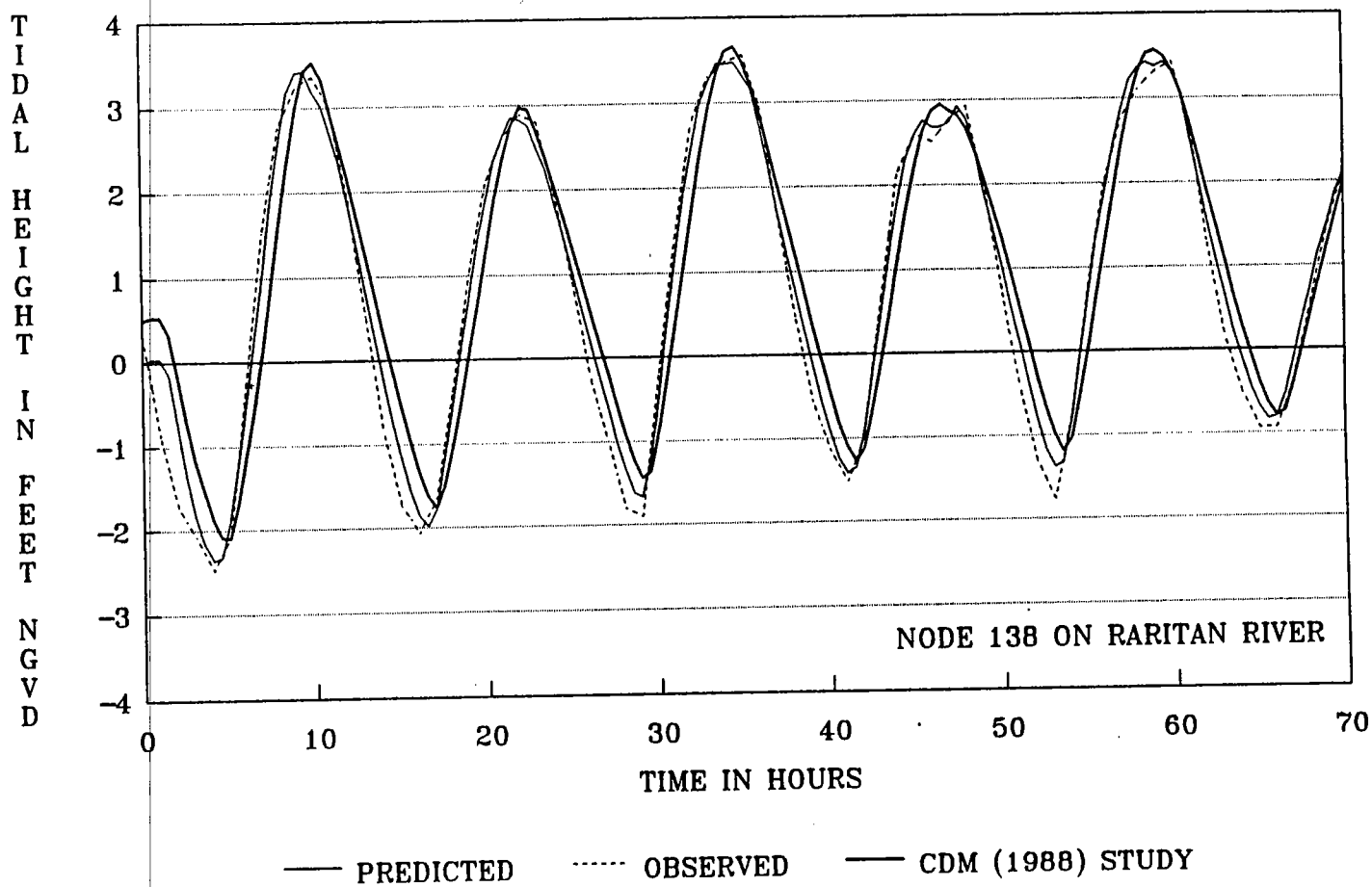


Figure 24. Observed tidal heights at Sandy Hook for hurricane of 21 September 1938

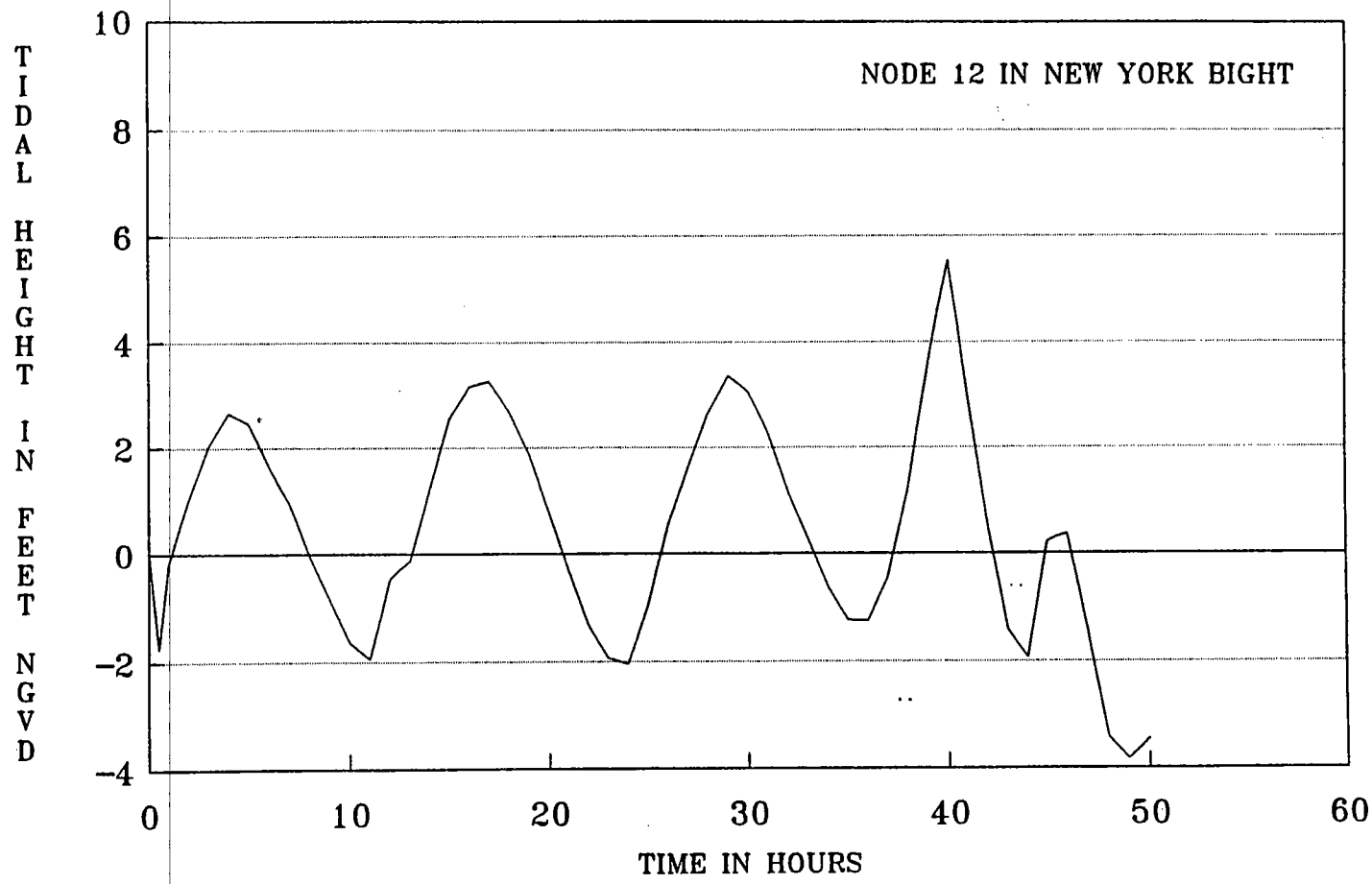


Figure 27. Tidal heights at East Newark
for hurricane of 21 September 1938

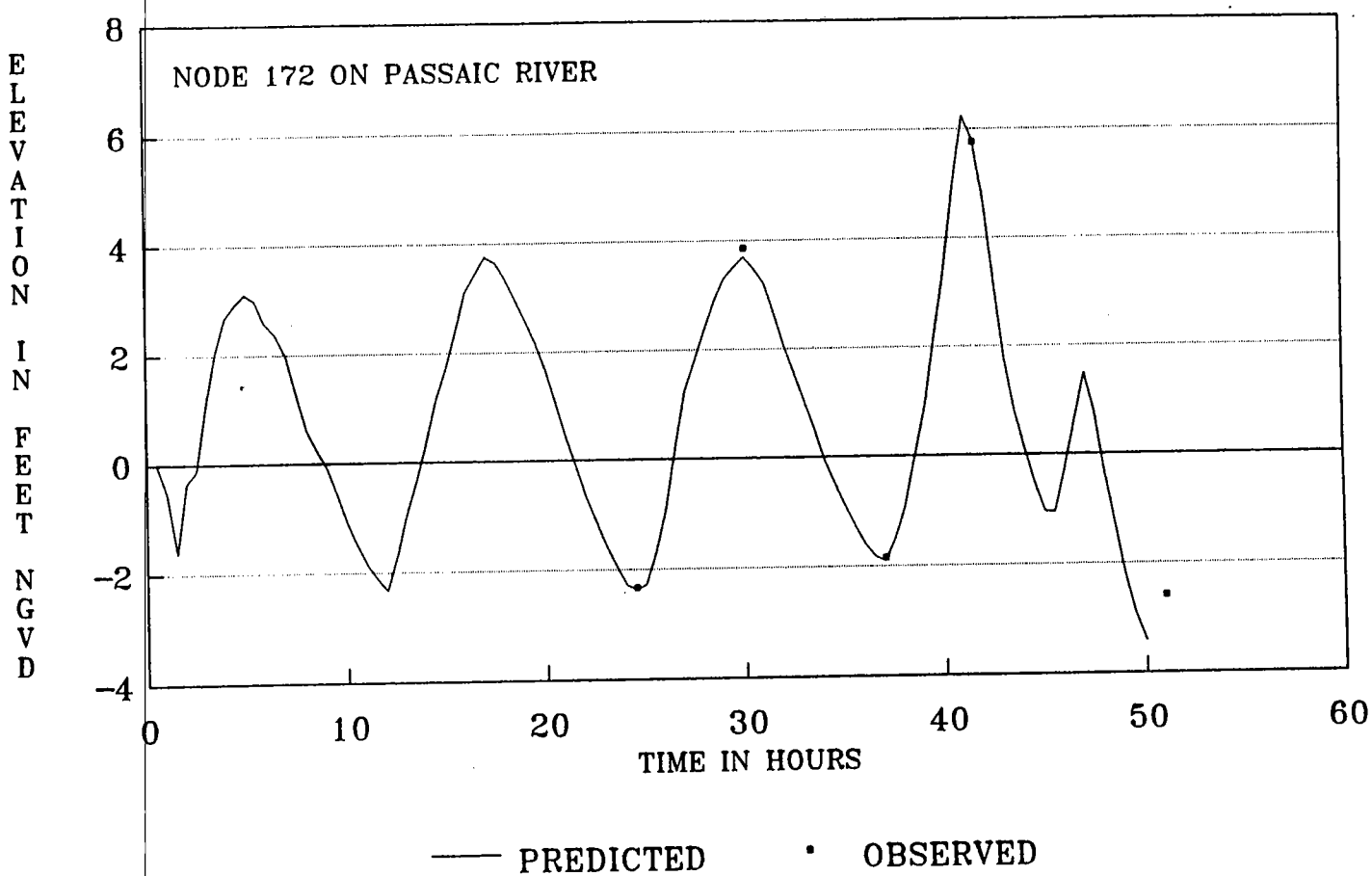


Figure 28. Observed tidal heights at Sandy Hook for hurricane of 12 September 1960

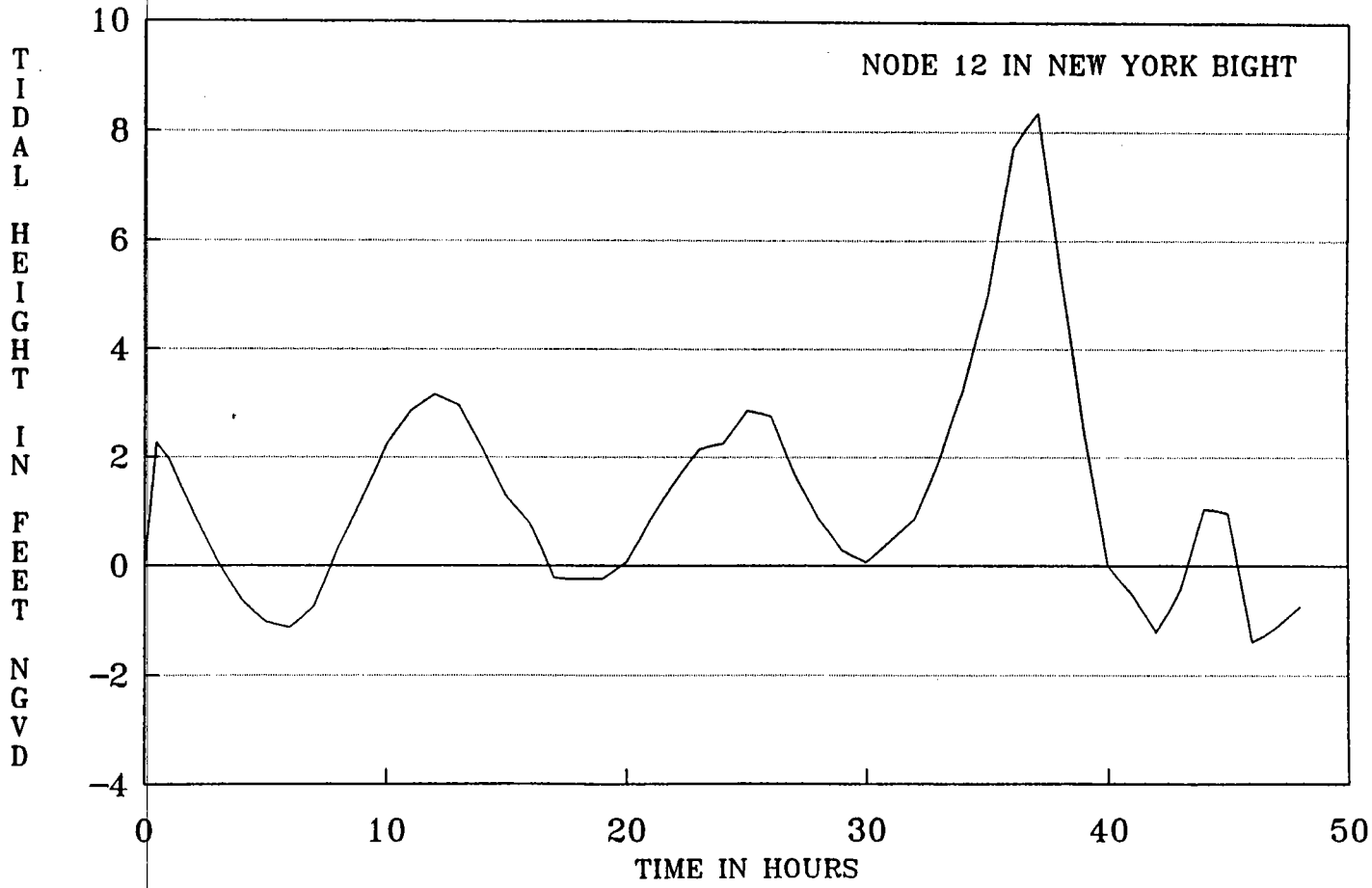


Figure 29. Observed tidal heights at The Battery for hurricane of 12 September 1960

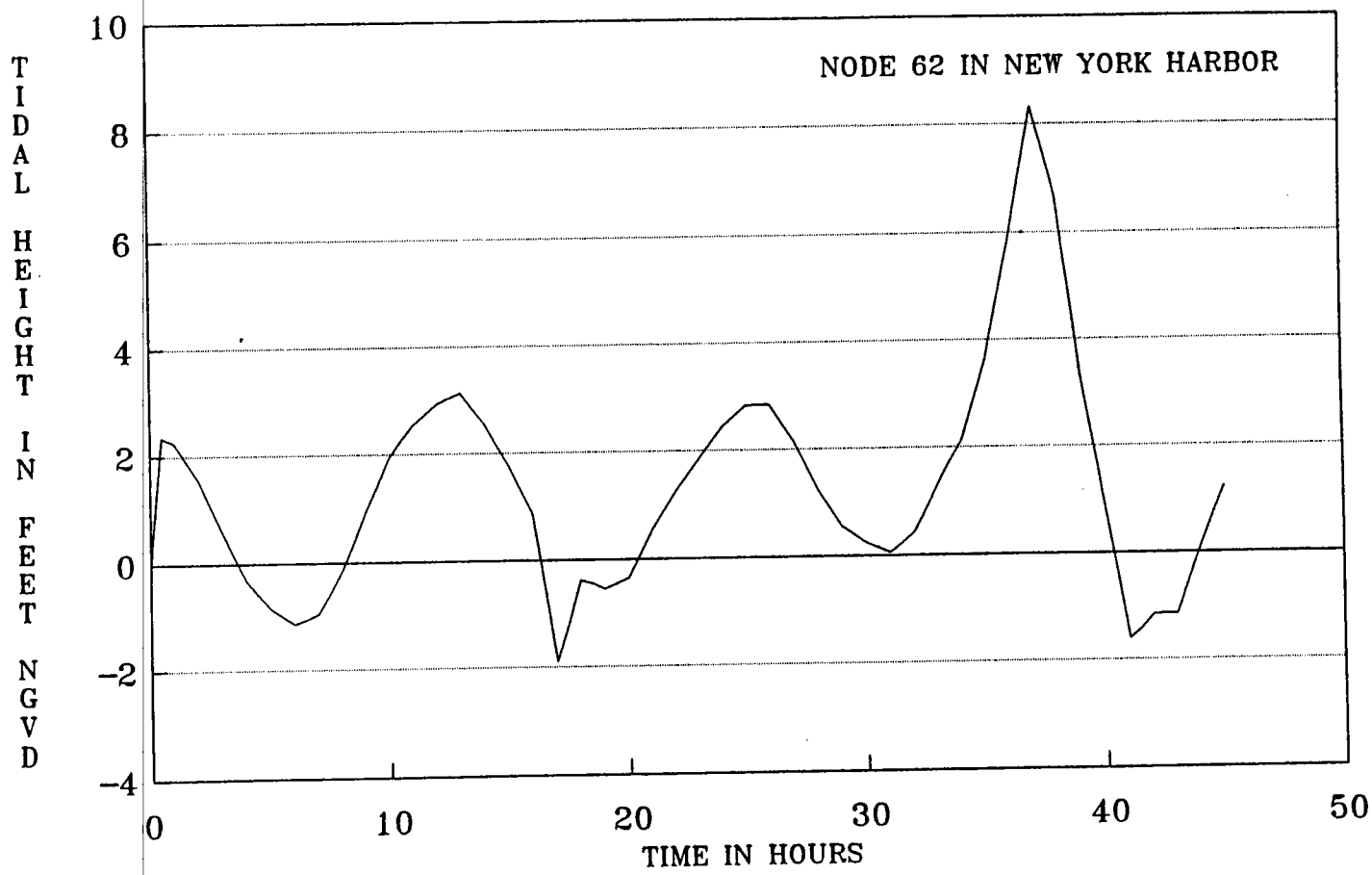


Figure 32. Tidal heights at Carteret
for hurricane of 12 September 1960

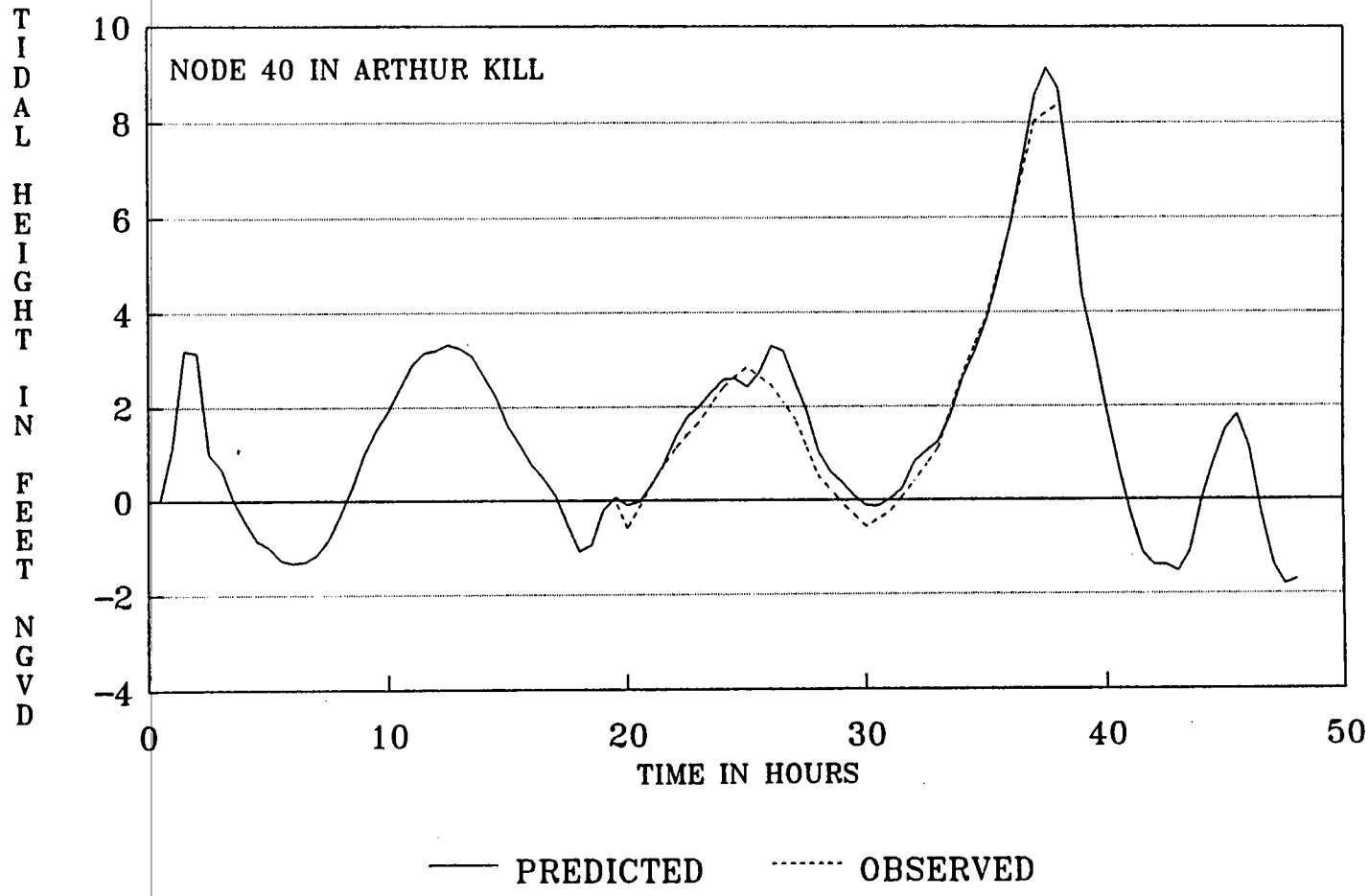
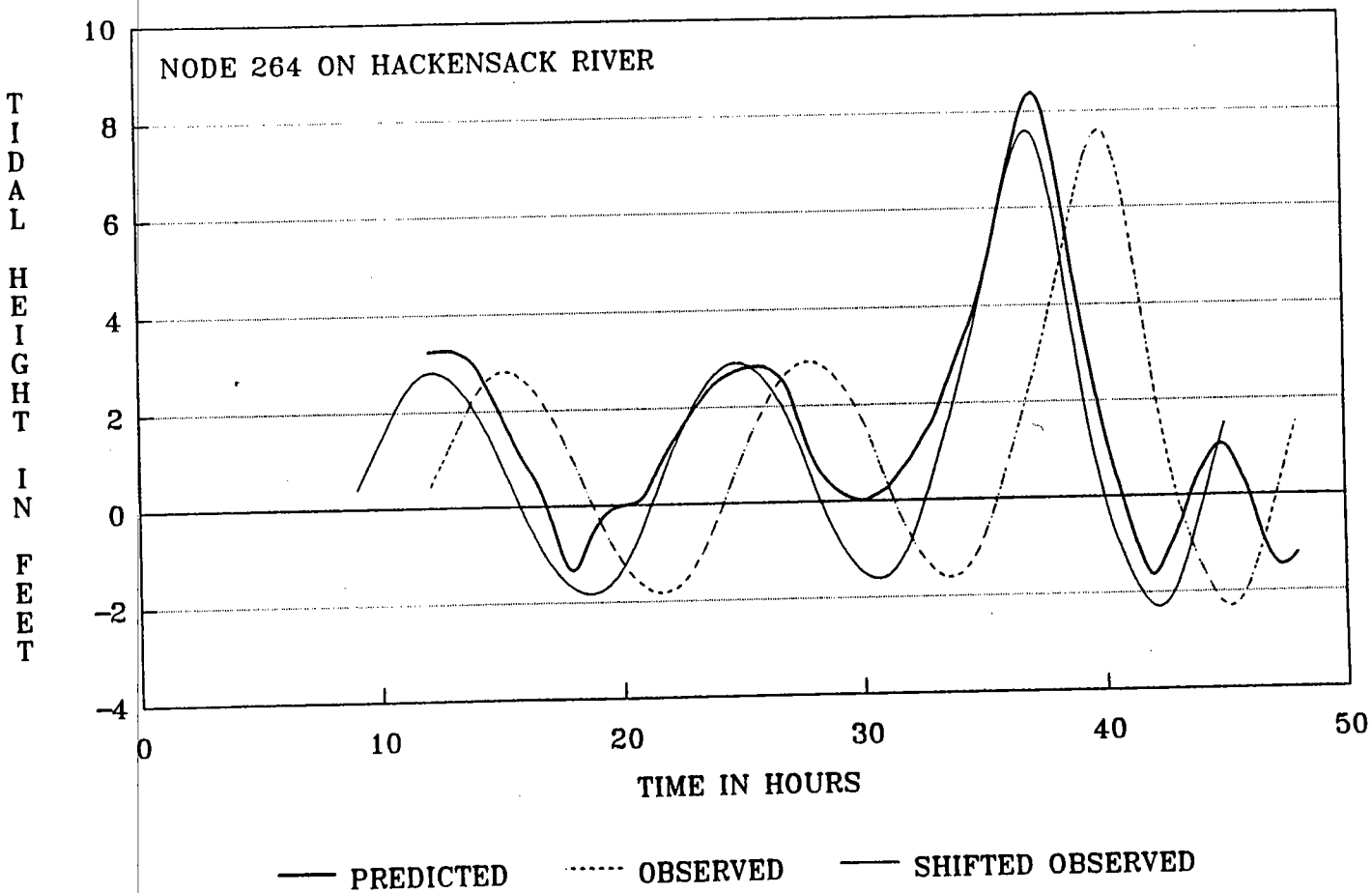


Figure 33. Tidal heights at Kearny Point for hurricane of September 1960



Note: Observational values were obtained from a tidal height curve measured at the mouth of the Hackensack River. The time origin for the observations was not specified in terms of time-of-day. The SHIFTED OBSERVED line is the curve obtained by shifting the time index of the observations by 3 hours so that the peaks at approximately hour 37 coincide.

Figure 34. Observed tidal heights at Sandy Hook for northeaster of 24–26 November 1950

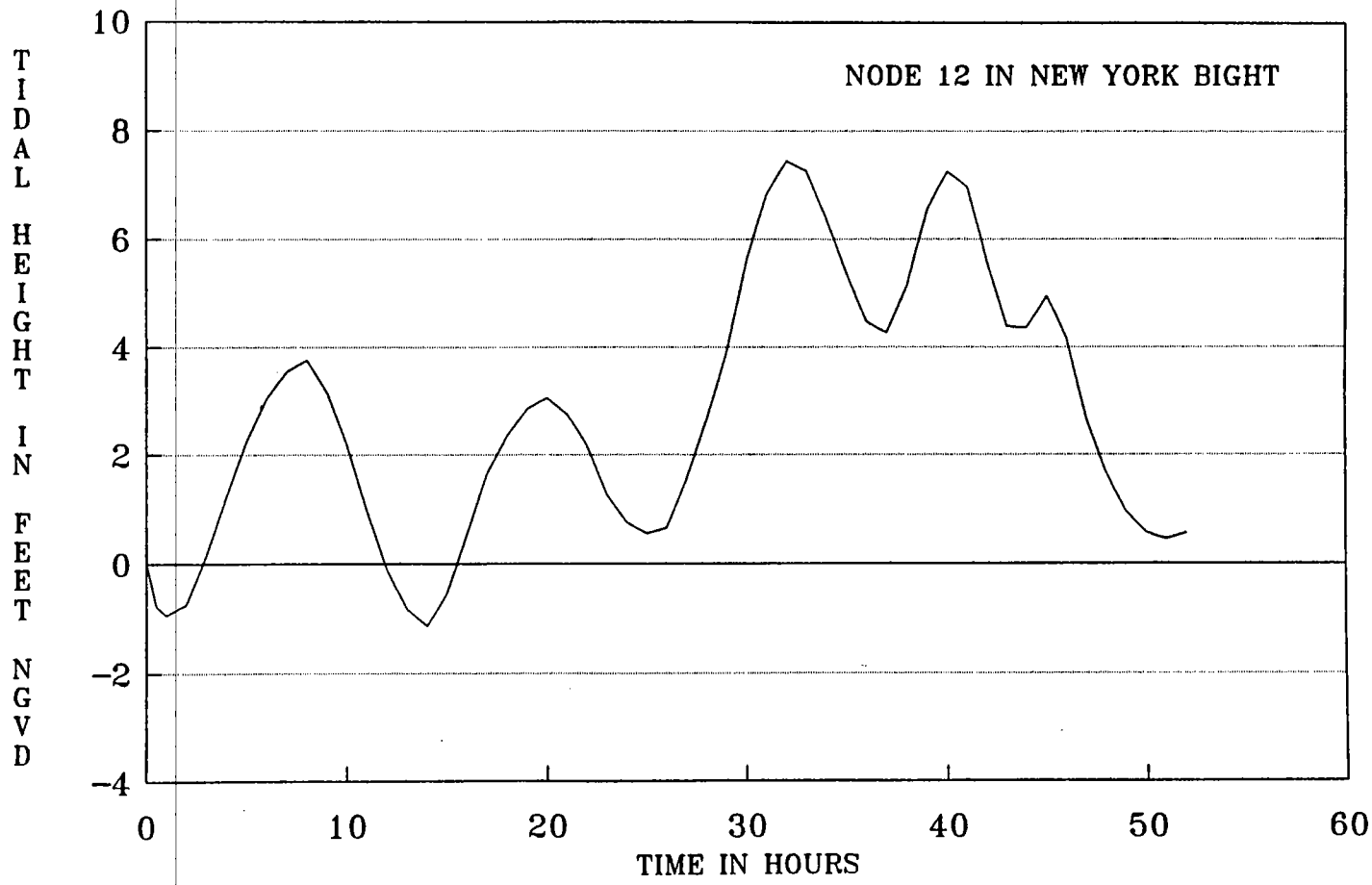


Figure 35. Observed tidal heights at The Battery for northeaster of 24–26 November 1950

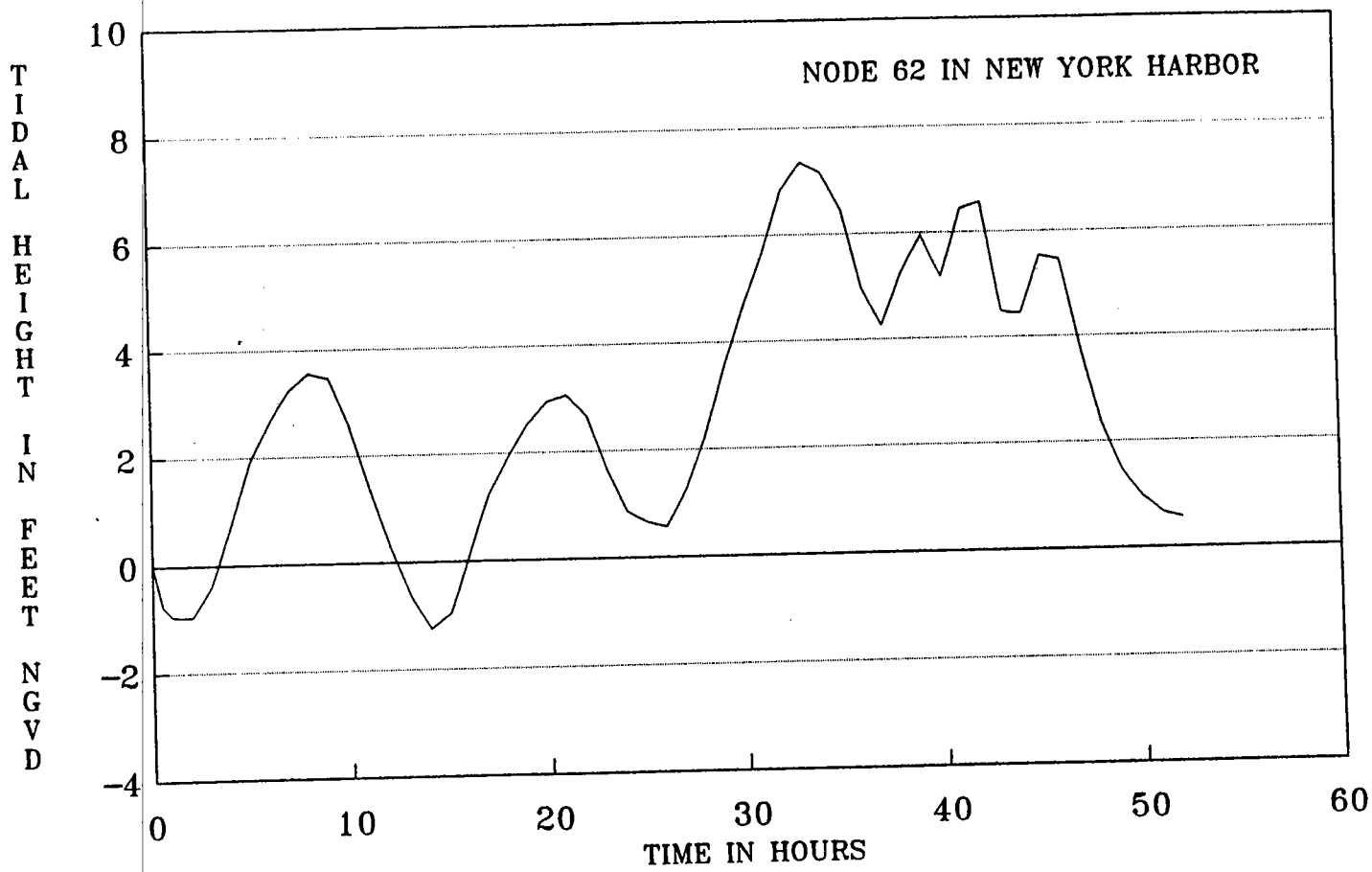


Figure 36. Tidal heights at Elm Park
for northeaster of 24–26 November 1950

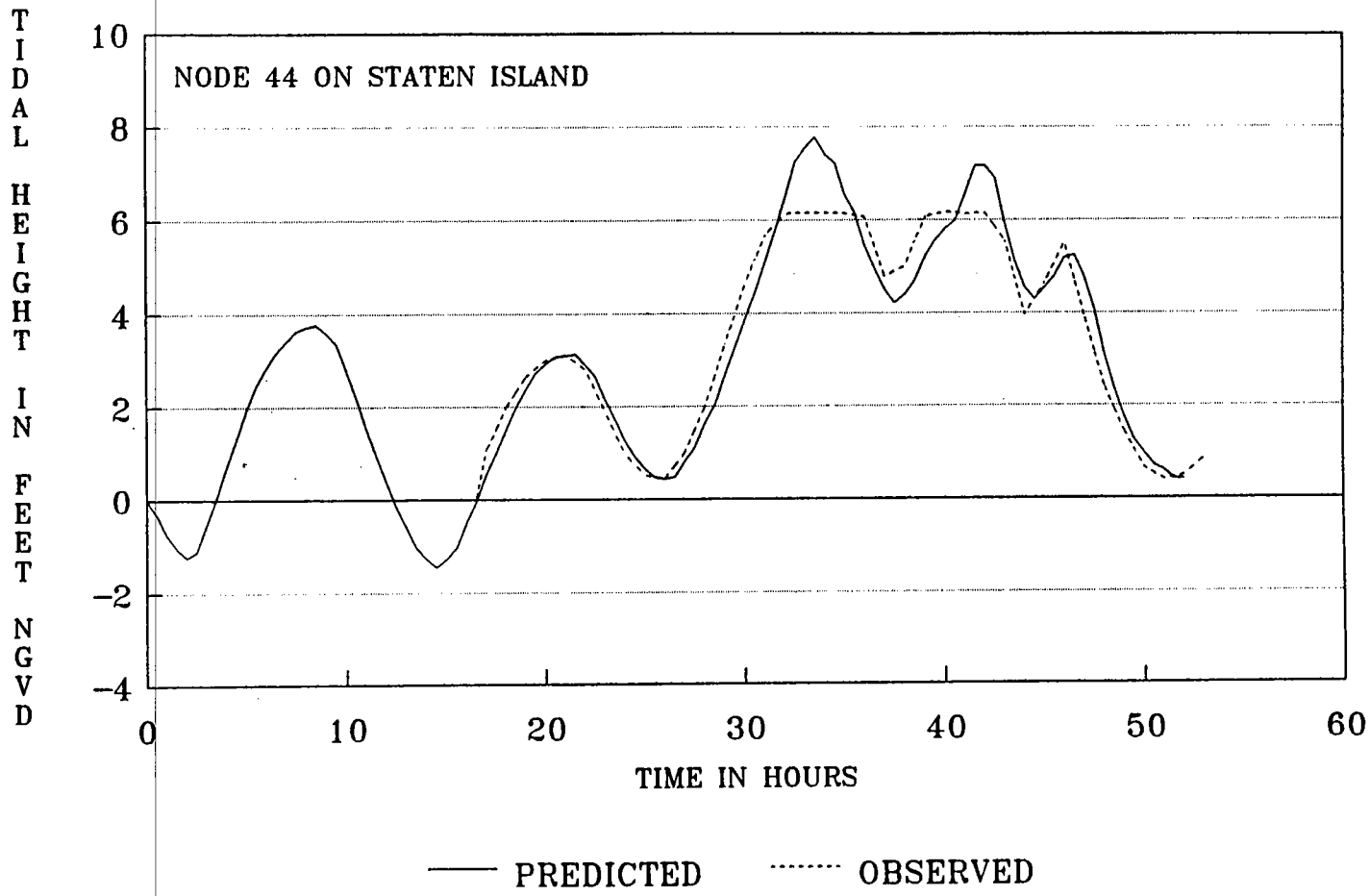


Figure 37. Observed tidal heights at Sandy Hook for northeaster of 6-8 November 1953

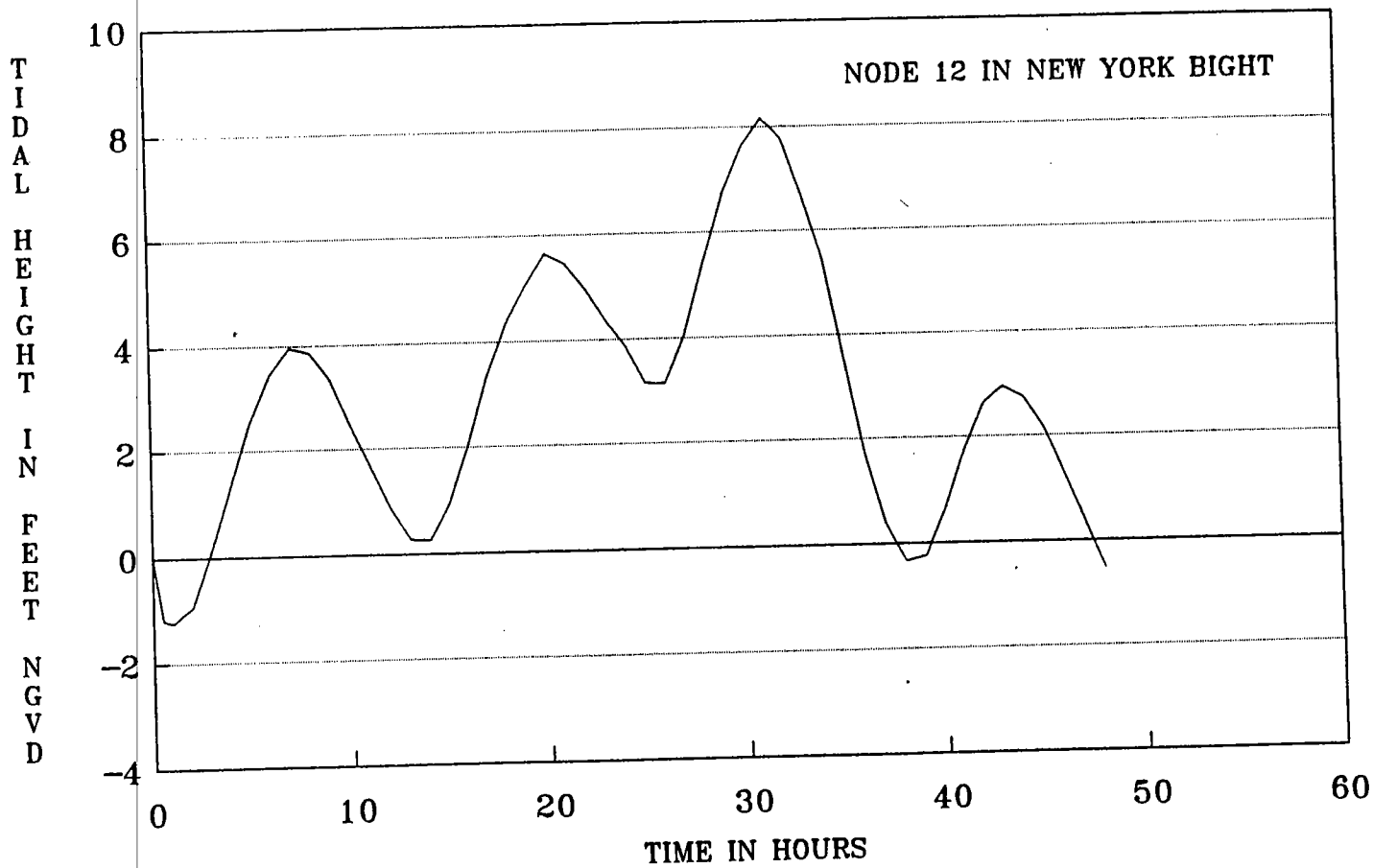


Figure 38. Observed tidal heights at The Battery for northeaster of 6–8 November 1953

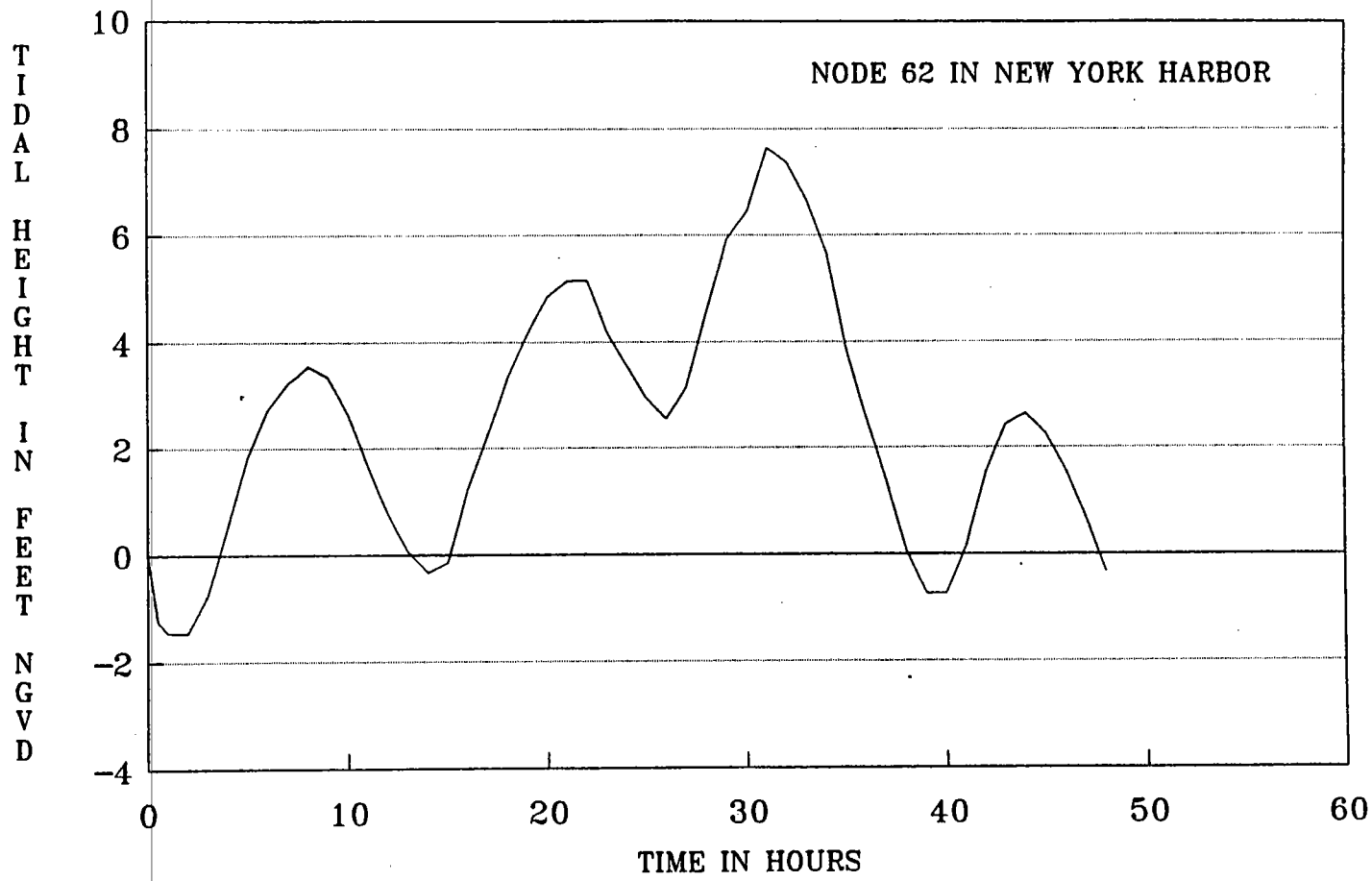


Figure 39. Tidal heights at Elm Park
for northeaster of 6–8 November 1953

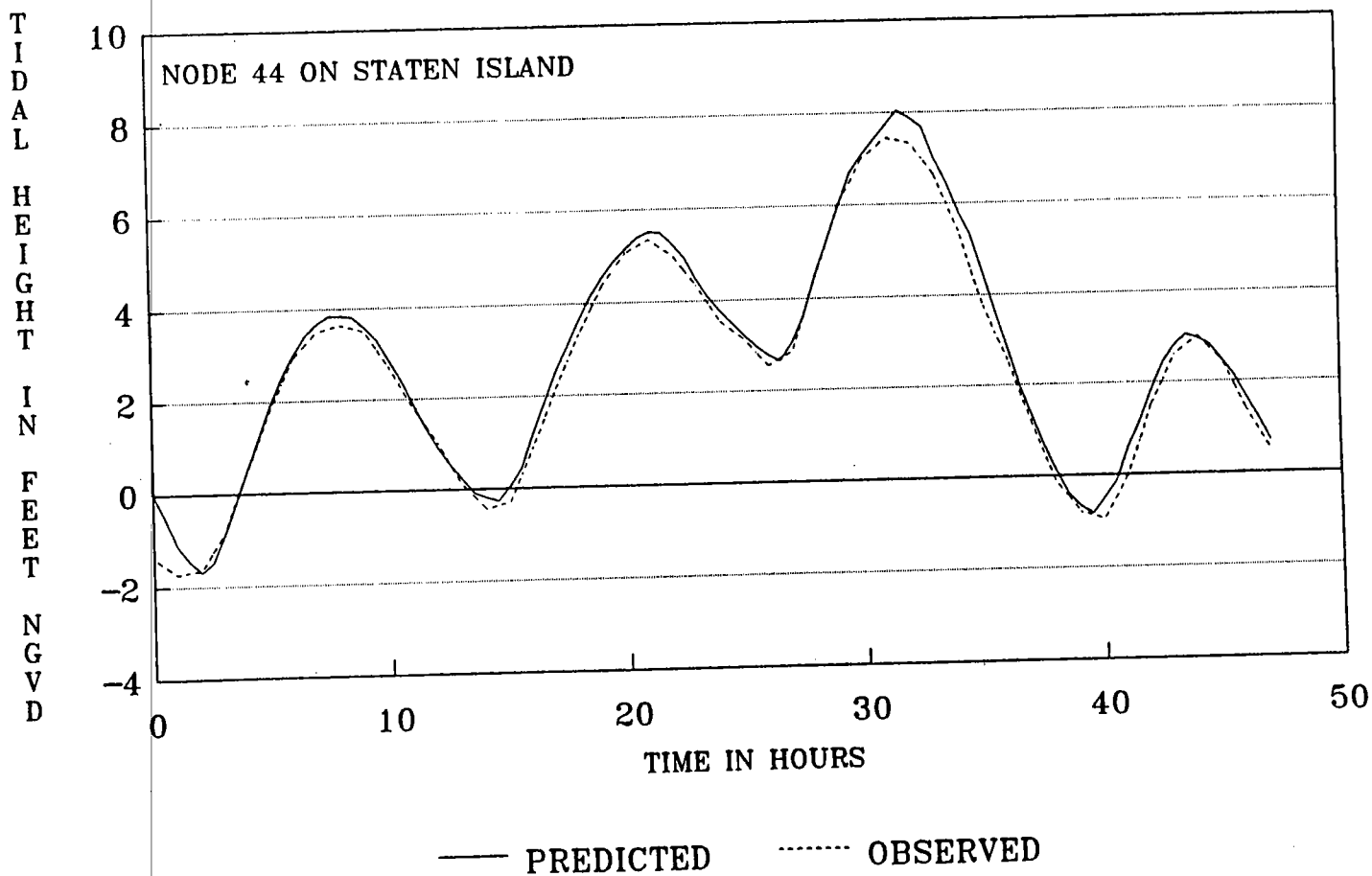


Figure 40. Tidal heights at East Newark
for northeaster of 6–8 November 1953

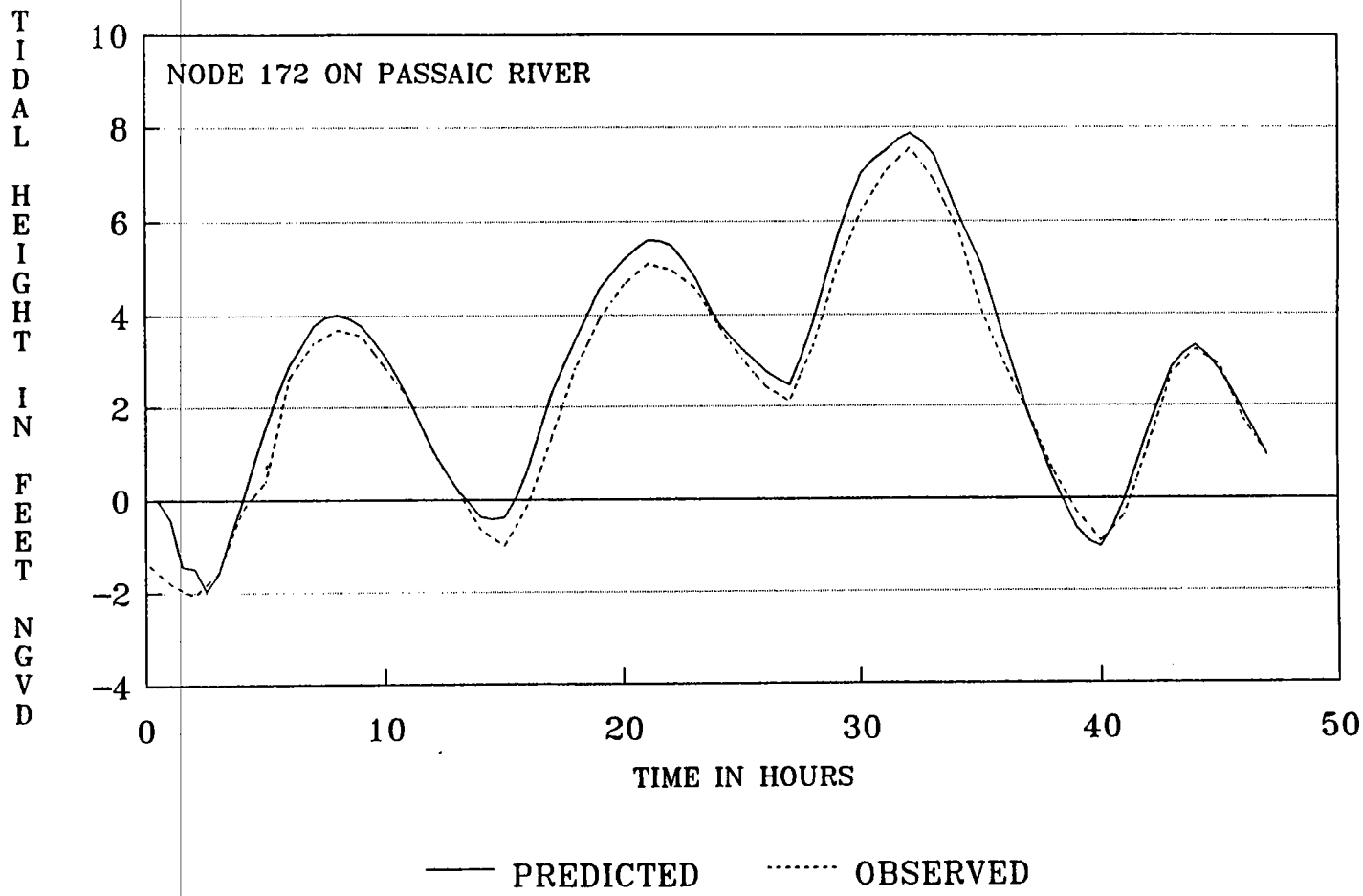


Figure 41. Tidal heights at Fort Hamilton for northeaster of 6–8 November 1953

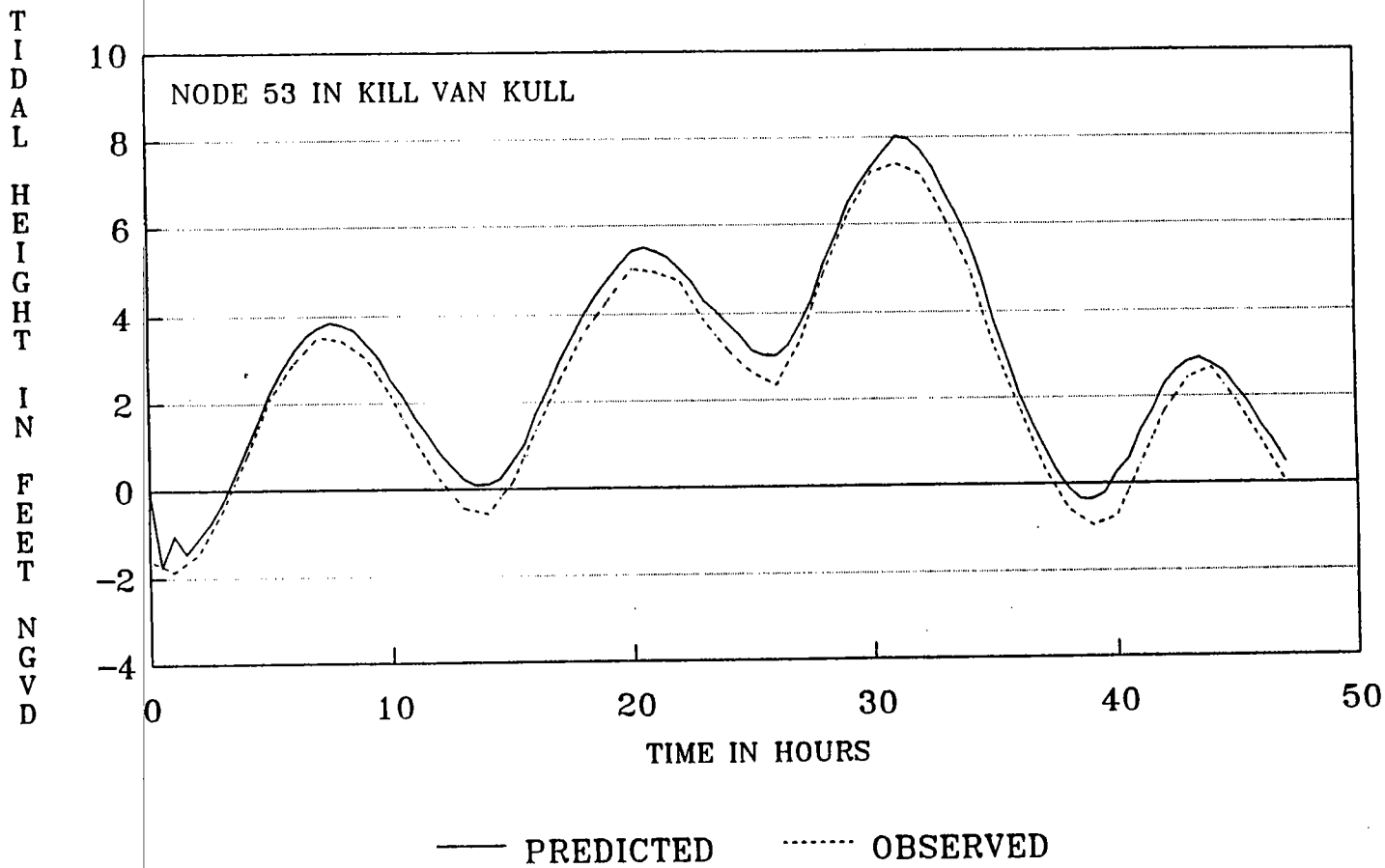


Figure 42. Observed tidal heights at Sandy Hook for the "Halloween" storm of October 1991

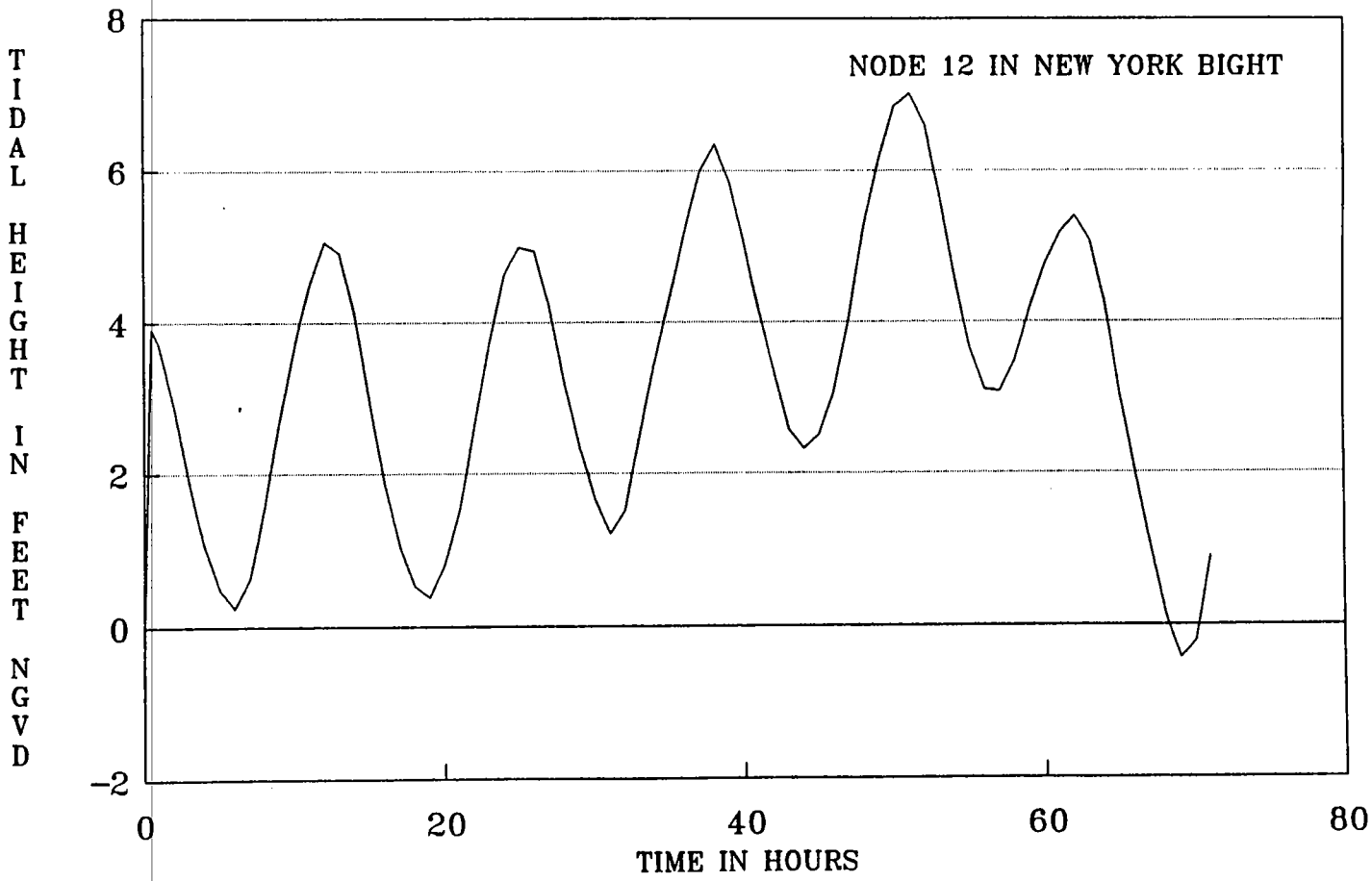


Figure 43. Observed tidal heights at
The Battery for the "Halloween" storm
of October 1991

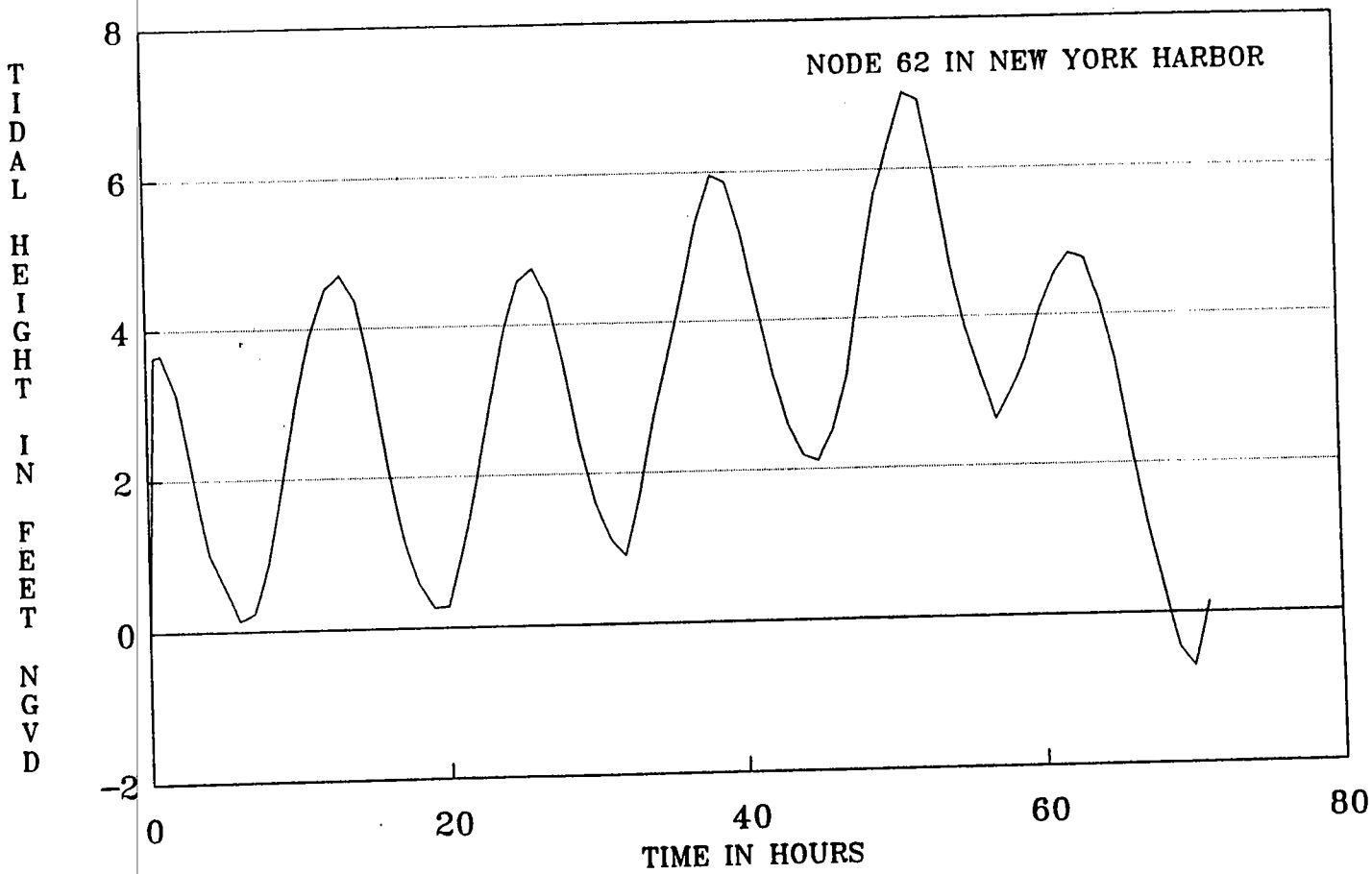
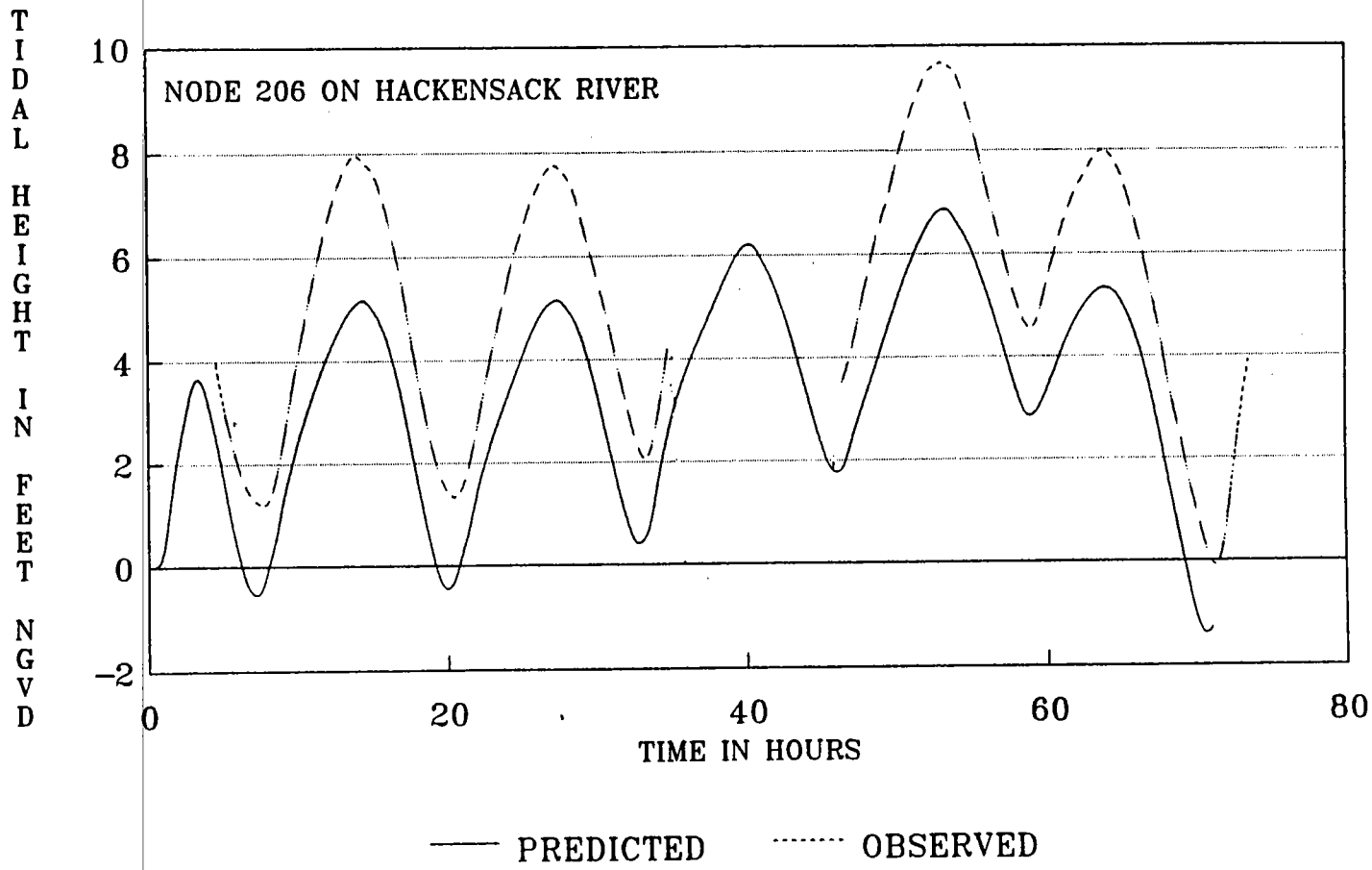


Figure 44. Tidal heights at Ridgefield Park for the "Halloween" storm of October 1991



Note: Observations were obtained from near the Bergen Power Generation Station near the intersection of Overpeck Creek and the Hackensack River. The observed curve is plotted relative to the provided datum.

PART IV: COINCIDENCE ANALYSIS

Introduction

54. Astronomic tides, meteorological conditions, and river flows cause fluctuations of water level in the modeled system. Astronomical tides are independent of the other two, although tidally-induced water surface elevations can combine with either or both meteorological and fluvial events to cause very high water elevations. Since the greatest effect would occur when meteorological and fluvial events reinforce each other, information regarding their joint relationship is useful in examining the potential occurrence of high water levels.

Approach and Data Preparation

55. Several approaches were taken to investigate the relation between river flows and storm surges (storm tide minus astronomic tide). The approaches were based on observed water surface elevations and predicted tides at The Battery in New York Harbor used in conjunction with Passaic River flows measured at Little Falls, New Jersey (785 square miles). Approaches included cross correlations and linear regressions between the data series, examination of the frequency of joint occurrence of large flow volume and surge height events, and scatter plots of corresponding flow and surge events.

56. Time series of hourly observed water level at The Battery were obtained through WES from the National Ocean Service (NOS) office in Rockville, Maryland. A standard tidal prediction model and ancillary data files were obtained directly from the same office. Daily river flow data measurements were obtained from the New Jersey USGS office. River flow data spanned the interval of 1898 to 1990, and observed water level data extended from 1920 to 1991.

57. Daily values of water level elevations caused by influences other than tides (which will be referred to as surge heights) were obtained in the following way. The tide prediction package was used to produce time series of hourly predicted tide heights. Predicted tides took into account the increase in mean sea level from 1920 to the present using Epoch values provided by NOS. Predicted tide values were subtracted from the corresponding hourly observed

values to obtain hourly surge heights, and the maximum daily surge heights were extracted from the respective 24-hour values for each day of the time series.

58. Time series of yearly maximum values of river flow and surge height were extracted from the respective time series of daily maximum values. The smallest value in each of the time series of annual maximum values was taken as an indication of the magnitude of the respective one-year event. The values were 1.85 feet for surge height and 3040 cubic feet per second (cfs) for river flow. Since 1.85 feet was 0.5 feet less than the next-larger yearly maximum of 2.35 feet, and because there were nearly 2,600 values larger than 1.85 feet, the value of 2.35 feet was taken as an estimate of the one-year surge event.

59. The time series of observed water levels at the Battery contained several gaps, which produced corresponding gaps in the surge height time series. Surge height time series gaps of five days or less were bridged by inserting a linear fit between values at the ends of the gaps. No attempt was made to bridge larger gaps. Gaps were from 1921 to 1927, January 1958 to May 1958, May 1973 to May 1977, and September 1981 to October 1981. Six time series resulted after considering gaps and start/end dates for tidal epochs: 1927-1952, 1953-1958, 1958-1961, 1962-1973, 1977-1980, and 1981-1991. This resulted in 21,171 daily observations for the analysis.

Comparison of Water Surface Elevations at Kearny Point and The Battery

60. The time series of observed water elevations is from measurements at The Battery, which is close to the area of interest, namely Newark Bay and the Passaic and Hackensack rivers. In order to establish that both the timing and magnitude of water surface elevation at The Battery were representative of conditions at Kearny Point, water surface elevations at these two locations were plotted against the same time axis for three historical cases: (1) the northeaster of 24-26 November 1950 (Figure 45), (2) the hurricane of 12 September 1960 (Figure 46), and (3) tides during 11-13 October 1976 (Figure 47).

61. For these three types of events, the three figures show close agreement between timing and magnitude of water surface elevation at The Battery and Kearny Point. Therefore, using water surface elevations obtained

at The Battery for examining coincidence between surges and Passaic River flows will yield results applicable to the vicinity of Kearny Point.

Surge Height and River Flow Cross Correlation

62. Lagged cross correlation between surge height and river flow showed that peak correlation (+0.22) occurred between surge height on a given day and river flow measured two days later (Figure 48). That is, changes in river flow tended to lag surge-caused changes in water surface elevation by about two days. Positive correlation means that increases in surge height are accompanied by increases (rather than decreases) in river flow. The cross correlation coefficient of 0.22 represents a weak correlation (where a value of 1.0 implies complete dependence and a value of 0.0 implies complete independence).

63. The degree of correlation begins to increase when river flow leads surge height by one day. The correlation peaks when surge height leads by two days, and shows a slow decline thereafter. This indicates that river flow events tend to occur later than surge events and to decrease more slowly.

64. Linear regression was calculated between surge height values and river flows two days later, which represents the timing that would yield the best fit. The resulting regression relation could explain only 4.4 percent of the variance of the river flow when using the surge height time series as the independent variable. Surge height is therefore a poor predictor of river flow, which is to be expected in view of the relatively weak correlation between the two.

Coincidence Between Surge Height and River Flow

65. Coincidence was examined by comparing daily values of surge height and river flow with respective threshold values of 2.35 feet and 3040 cfs. Counted were the number of times (1) both daily values exceeded their thresholds, (2) neither exceeded its threshold, (3) surge height exceeded its threshold, but river flow did not, and (4) river flow exceeded its threshold, but surge height did not. Comparisons were made for seven cases that ranged from surge height leading river flow by three days to river flow leading surge height by three days.

66. The results (Table 2) indicate greater coincidence when surge leads river flow, which reflects the findings of the correlation analysis. Coincidence with surge height leading was approximately double that with river flow leading. The largest count of both series exceeding thresholds, 192, occurred with surge height leading by two days. A count of 192 represents only 0.9 percent. In contrast, both series were jointly less than threshold approximately 89 percent of the time. The analysis shows that, given relatively moderate event threshold values, surge height and river flow events coincide only a small fraction of the time.

67. The relation between water level and river flow was further examined for five historical storm events by plotting predicted tide height and observed water level at The Battery, along with Passaic River flow, for the time interval from three days preceding the event to seven days after. The selected storm events were 21 September 1938 (Figure 49), 25 November 1950 (Figure 50), 12 September 1960 (Figure 51), 10 November 1977 (Figure 52), and 7 April 1984 (Figure 53). Maximum surge heights range from approximately four to eight feet, and maximum river flows from approximately 4,000 to 17,000 cfs. The plots show that, for these selected events, the river flow peaks within about one to three days after a peak surge. However, the plots also show that the magnitudes of surge and flow peaks are not necessarily directly related. That is, a large surge peak may be accompanied by either large or small flow peaks, and vice-versa. For example, a surge of about seven feet and flow of 4,000 cfs occurred during the 1950 storm, while a surge of four feet and flow of 17,000 cfs occurred during the 1984 storm. The indication is that, for major events, peaks in surge and flow tend to accompany each other within approximately 72 hours, but that there is no consistent relation between their magnitudes.

Scatter Diagram of Surge Height and River Flow Values

68. In order to investigate the relation between surge height and river flow visually, a scatter diagram was plotted with surge height values on the horizontal axis and river flow values on the vertical axis. Only those points for which surge height exceeded 0.5 feet and river flow exceeded 1,000 cfs jointly were plotted. Note that for each identified surge height value, only the single maximum river flow within the succeeding 72 hours was selected.

69. The scatter diagram (Figure 54) shows the absence of any strong connection between surge height and river flow. Points tend to be distributed primarily along the vertical axis of the diagram. This pattern indicates that, for a given surge height, there is a wide range of possible river flows, with most of them being relatively small. To a lesser extent, there is a range of surge heights for a given river flow. Close relationship between surge height and river flow would have been indicated by points being distributed about some diagonal from the origin.

70. The scatter plot reinforces the results of correlation and regression calculations and the findings of the coincidence analysis. When only moderate thresholds are specified, surge height events and river flow events are only weakly related, and the occurrence of one is not a conclusive predictor of either the occurrence or the magnitude of the other. However, there is some indication (based upon plots of the five selected storm events) of greater likelihood of joint occurrence of surge and flow increases during major storm events, even though their magnitudes may not be directly related.

Stage Frequency Statistics for Surge Heights

71. The distribution of water surface elevations at The Battery was examined for peak values occurring within 72 hours prior to Passaic River flows exceeding 6,000 cfs. This is the threshold flow when the proposed diversion tunnel begins to function. The analysis was performed to examine what magnitude of storm tide might occur when the diversion tunnel was operating.

72. According to the record at the Little Falls gage on the Passaic River, 230 of the 21,174 days examined had flows that exceeded 6000 cfs. For each of these 230 records, the maximum tidal height in the previous 72 hours was identified from the tide gage record at The Battery. These maximum tidal heights were then ranked and plotted in Figure 55 as a cumulative frequency distribution. The plot is a conditional cumulative frequency (or exceedance) distribution. The plot presents both the percent daily exceedance and the return period for storm tides that are coincident with river flows exceeding 6000 cfs. Also plotted on Figure 55 is the stage frequency distribution for all river flows. Comparison between these two distributions shows that a given tidal elevation coincident with Passaic River flow greater than 6000 cfs

occurs much less frequently than when no river flow condition is included. For example, a tidal elevation of six feet independent of river flow has a return period of 2.6 years. However, a tidal elevation of six feet coincident with flow greater than 6000 cfs has a return period of 19.3 years, which corresponds to only 13.5 percent as often. Examination of Figure 55 shows that the elevation of 6.15 feet (the maximum), in combination with flow greater than 6000 cfs, is equalled or exceeded once in the 21,174 days of record, or 0.005 percent of days (return period of 58 years). An elevation of 2.15 feet (a typical high tide elevation) is exceeded only 1.1 percent of the days (return period of 0.25 years). Tidal heights of 4.2 feet and 5.9 feet are coincident with Passaic River flows exceeding 6000 cfs for return intervals of one year and 10 years, respectively. It is possible to estimate longer return period events (say, 100 years) by extrapolating the conditional distribution in Figure 55.

Boundary Conditions for River Flow Models

73. The weak coincidence between river flow and storm surges may at first suggest that the two "events" be considered to be independent. However, the results of the analysis also shows that, while the coincidence is weak, the events are not completely independent. One question that is asked is what type of tidal boundary condition should be specified when using a river model to simulate significant flow events.

74. If the probability of a specific river flow can be statistically determined, then the overall statistic is not altered by selecting the average downstream tidal boundary condition for that flow condition. Consequently, the daily-maximum surge elevations within 72 hours of observed river flows were averaged for specified ranges of river flows, and the results summarized in Table 3. Table 3 lists the average surge (without tide) elevation; (1) on the same day as the river flow, (2) one day prior, (3) two days prior, and (4) the maximum of the 72 hours prior to the river flow.

75. Table 3 shows that a storm surge of 1.5- to 2-feet will occur on average within 72 hours of various flow ranges in the Passaic River. However, it is very difficult to analyze the shape of the storm (duration and "peakiness") that would occur. Overall, we recommend that a river discharge

model of the Passaic River specify a tidal boundary that is the combination of an average tide plus a 1.5-2.0 feet surge.

River Flows for Storm Tide Simulations

76. The weak coincidence between river flows and storm surges also leads to the question of what river flow to specify when simulating a storm tide event. This question was addressed in a similar fashion as before by investigating the river flows that occurred within the 72 hours following an observed storm surge. The data were analyzed to determine the average flow observed for a surge of a specified height. The results are presented in Table 4a. In Table 4b, Passaic River flows associated with historical storm tide events are tabulated to illustrate flows observed during these events.

77. Table 4 lists the average flows; (1) on the same day as the storm surge, (2) one day following, (3) two days following, and (4) the maximum of the 72 hours following the surge event. The results show little variation in average flows between surge heights, and indicate that when a surge event occurs, a river flow in the range 1000-2000 cfs might be expected.

78. To add "conservatism" to the subsequent storm tide analyses, we decided to the specify the one-year flows in each of the major tributaries. On the Passaic River, this results in a flow in excess of 5000 cfs, or nearly three times the average flow that might be expected. Additional coincidence analyses have shown that this flow will occur relatively infrequently with storm tide events.

Table 2

Tallies of coincidence between surge height and river flow events

```
********************** COINCIDENCE ANALYSIS **********************

THE TOTAL NUMBER OF POINTS USED WAS 21171
  TIME SERIES SURGE.DLY   : MEAN =      .95  STD. DEV. =      .72
  TIME SERIES RIVER.DLY   : MEAN =  1096.90  STD. DEV. =  1330.02

SURGE HEIGHT THRESHOLD VALUE IS    2.35 FEET
RIVER  FLOW  THRESHOLD VALUE IS 3040.00 CFS

THRESHOLD VALUES WERE SPECIFIED BY USER

WHEN COMPARING SURGE HEIGHT WITH RIVER FLOW 3 DAYS LATER:
  BOTH SERIES EXCEED THRESHOLDS                              179 TIMES
  SURGE EXCEEDS THRESHOLD AND FLOW IS LESS THAN THRESHOLD    640 TIMES
  SURGE IS LESS THAN THRESHOLD AND FLOW EXCEEDS THRESHOLD   1432 TIMES
  BOTH SERIES ARE LESS THAN THRESHOLDS                     18917 TIMES

WHEN COMPARING SURGE HEIGHT WITH RIVER FLOW 2 DAYS LATER:
  BOTH SERIES EXCEED THRESHOLDS                              192 TIMES
  SURGE EXCEEDS THRESHOLD AND FLOW IS LESS THAN THRESHOLD    627 TIMES
  SURGE IS LESS THAN THRESHOLD AND FLOW EXCEEDS THRESHOLD   1419 TIMES
  BOTH SERIES ARE LESS THAN THRESHOLDS                     18930 TIMES

WHEN COMPARING SURGE HEIGHT WITH RIVER FLOW 1 DAY LATER:
  BOTH SERIES EXCEED THRESHOLDS                              191 TIMES
  SURGE EXCEEDS THRESHOLD AND FLOW IS LESS THAN THRESHOLD    628 TIMES
  SURGE IS LESS THAN THRESHOLD AND FLOW EXCEEDS THRESHOLD   1420 TIMES
  BOTH SERIES ARE LESS THAN THRESHOLDS                     18929 TIMES

WHEN COMPARING SURGE HEIGHT WITH RIVER FLOW ON THE SAME DAY:
  BOTH SERIES EXCEED THRESHOLDS                              137 TIMES
  SURGE EXCEEDS THRESHOLD AND FLOW IS LESS THAN THRESHOLD    682 TIMES
  SURGE IS LESS THAN THRESHOLD AND FLOW EXCEEDS THRESHOLD   1474 TIMES
  BOTH SERIES ARE LESS THAN THRESHOLDS                     18875 TIMES

WHEN COMPARING RIVER FLOW WITH SURGE HEIGHT 1 DAY LATER:
  BOTH SERIES EXCEED THRESHOLDS                               91 TIMES
  SURGE EXCEEDS THRESHOLD AND FLOW IS LESS THAN THRESHOLD    728 TIMES
  SURGE IS LESS THAN THRESHOLD AND FLOW EXCEEDS THRESHOLD   1520 TIMES
  BOTH SERIES ARE LESS THAN THRESHOLDS                     18829 TIMES

WHEN COMPARING RIVER FLOW WITH SURGE HEIGHT 2 DAYS LATER:
  BOTH SERIES EXCEED THRESHOLDS                               94 TIMES
  SURGE EXCEEDS THRESHOLD AND FLOW IS LESS THAN THRESHOLD    725 TIMES
  SURGE IS LESS THAN THRESHOLD AND FLOW EXCEEDS THRESHOLD   1517 TIMES
  BOTH SERIES ARE LESS THAN THRESHOLDS                     18832 TIMES

WHEN COMPARING RIVER FLOW WITH SURGE HEIGHT 3 DAYS LATER:
  BOTH SERIES EXCEED THRESHOLDS                               88 TIMES
  SURGE EXCEEDS THRESHOLD AND FLOW IS LESS THAN THRESHOLD    731 TIMES
  SURGE IS LESS THAN THRESHOLD AND FLOW EXCEEDS THRESHOLD   1523 TIMES
  BOTH SERIES ARE LESS THAN THRESHOLDS                     18826 TIMES
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Table 3

Average Surges[1] Coincident with Given Passaic River Flows

Flow Range (cfs)	Surge (feet) 2 days Prior	1 day Prior	Same Day	Maximum 72 Hours
0.- 1000.	.90	.90	.88	1.19
1000.- 2000.	.99	1.00	1.02	1.38
2000.- 3000.	1.05	1.04	1.06	1.46
3000.- 4000.	1.04	1.02	1.12	1.46
4000.- 5000.	1.01	.98	1.16	1.47
5000.- 6000.	1.07	1.16	1.21	1.55
6000.- 7000.	1.28	1.21	1.25	1.61
7000.- 8000.	1.15	1.03	1.16	1.44
8000.- 9000.	1.13	1.27	1.40	1.64
9000.- 10000.	1.18	1.33	1.42	1.65
10000.- 11000.	1.65	1.61	1.51	1.85
11000.- 12000.	1.36	1.63	1.64	1.91
12000.- 13000.	1.42	1.32	1.27	1.42
13000.- 14000.	1.60	1.40	1.64	1.75
14000.- 15000.	1.91	1.32	1.49	2.04
15000.- 16000.	--- no flows in record ---			
16000.- 17000.	2.16	2.23	1.91	2.23
17000.- 18000.	--- no flows in record ---			
18000.- 19000.	1.32	1.11	1.05	1.32
> 19000.	--- no flows in record ---			

Note: [1]Surge in storm tide minus astronomic tide.

Table 4a

Average Passaic River Flows for Given Surge Heights

Surge[1] height (ft)	Passaic River Flow (cfs) 2 days Later	1 day Later	Same Day	Maximum 72 Hours
-2.50	101.	116.	108.	116.
-2.00	1522.	1751.	1836.	1858.
-1.50	1335.	1351.	990.	1459.
-1.00	1213.	1247.	1095.	1400.
-.50	1126.	1207.	1174.	1339.
.00	888.	942.	938.	1053.
.50	889.	931.	946.	1053.
1.00	1193.	1195.	1194.	1373.
1.50	1145.	1125.	1123.	1307.
2.00	1356.	1293.	1276.	1527.
2.50	1673.	1507.	1507.	1855.
3.00	1876.	1518.	1449.	2013.
3.50	1717.	1324.	1286.	1837.
4.00	1715.	1187.	1150.	1805.
4.50	901.	919.	910.	1002.
5.00	1782.	1561.	1534.	1818.
5.50	2602.	1002.	1018.	2629.
6.00	1356.	363.	387.	1356.
6.50	943.	148.	161.	943.
7.00	--- no surges in record ---			
7.50	--- no surges in record ---			
8.00	--- no surges in record ---			
8.50	1000.	296.	348.	1000.

Note: [1] Surge in storm tide minus astronomic tide.

Table 4b.

Passaic River Flows for Selected Storm Events

Storm Event	Passaic River Flow (cfs) 2 days Later	1 day Later	Same Day	Maximum 72 Hours
21 Sept 1938	9,140	7,020	4,590	9,140
25 Nov 1950	3,920	4,130	1,000	4,130
12 Sept 1960	5,040	4,910	2,190	5,040
10 Nov 1977	5,310	7,130	8,960	8,960
7 Apr 1984	13,200	16,000	18,000	18,000

Figure 45. Tidal heights at Kearny Point and The Battery for northeaster of 24–26 November 1950

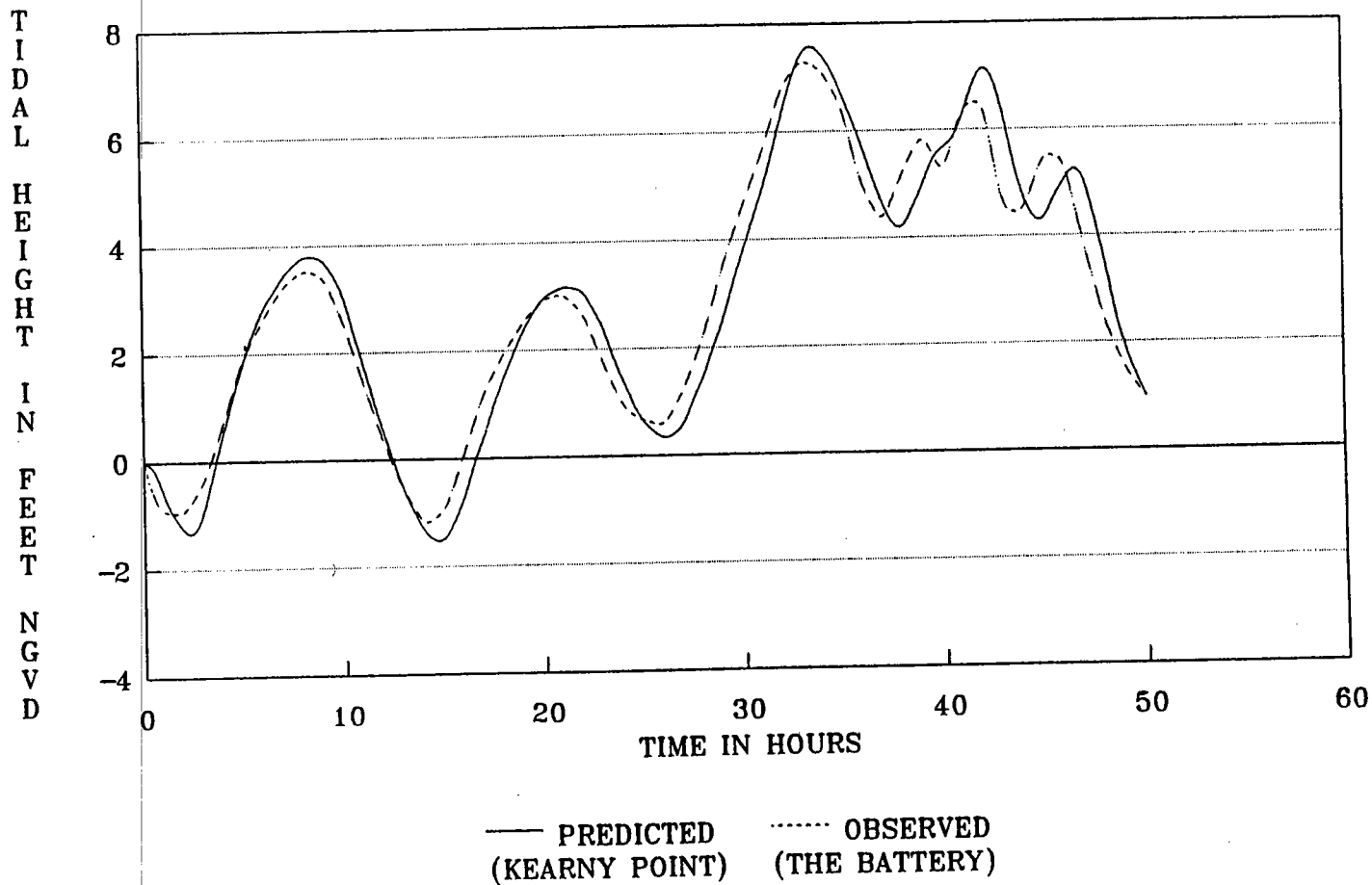


Figure 46. Tidal heights at Kearny Point and The Battery for hurricane of 12 September 1960

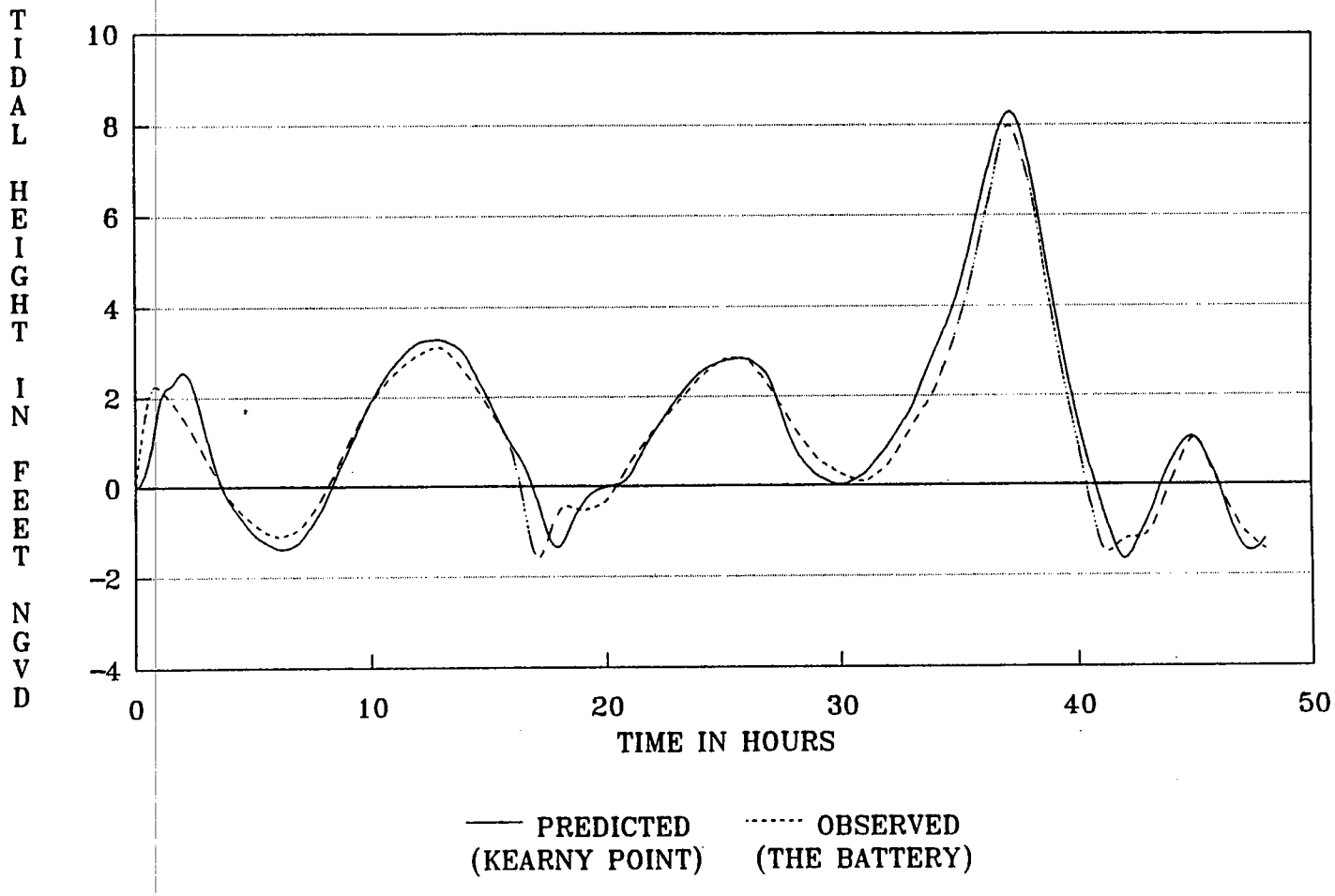
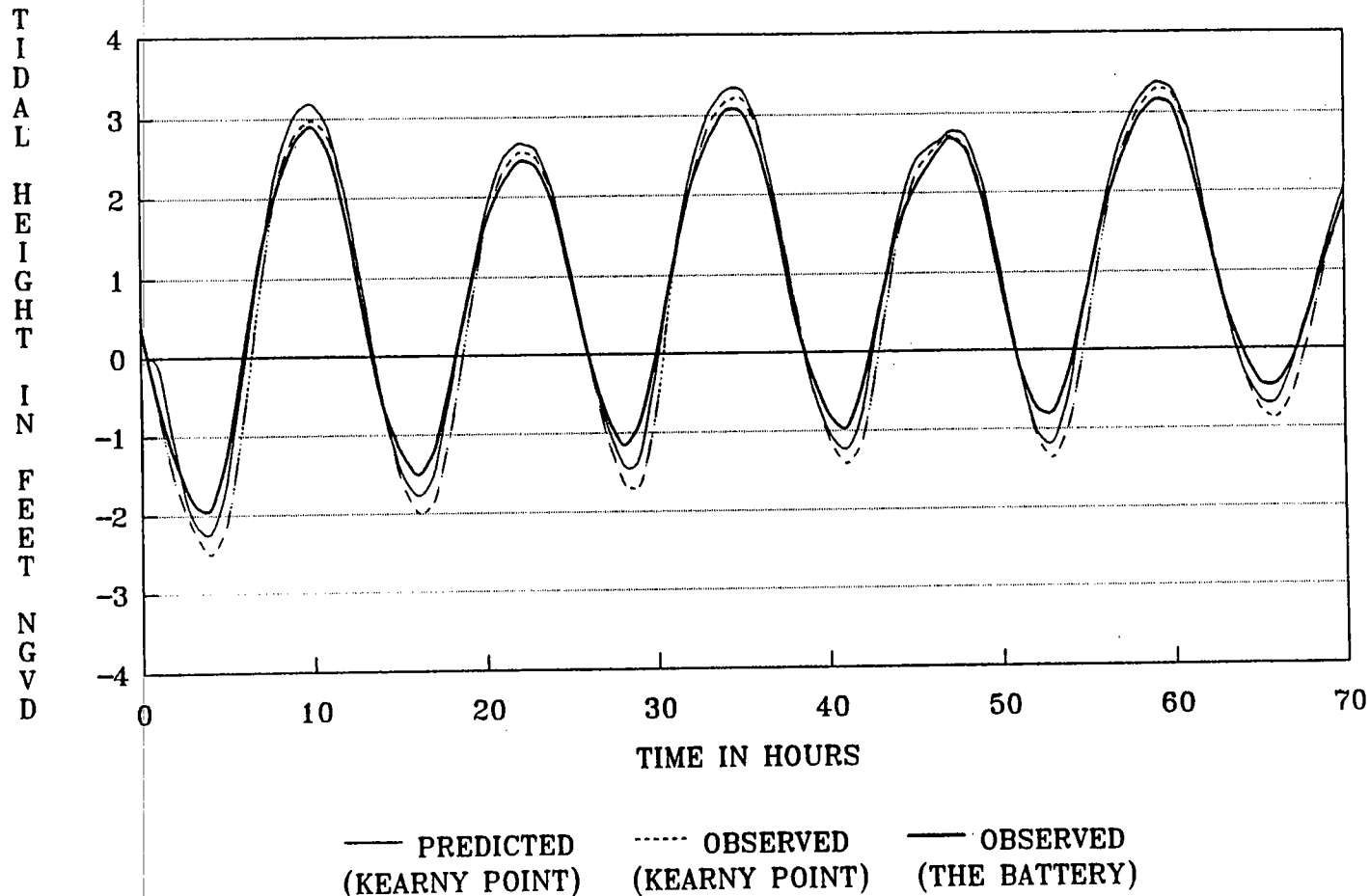


Figure 47. Tidal heights at Kearny Point and The Battery for tide of 11-13 October 1976



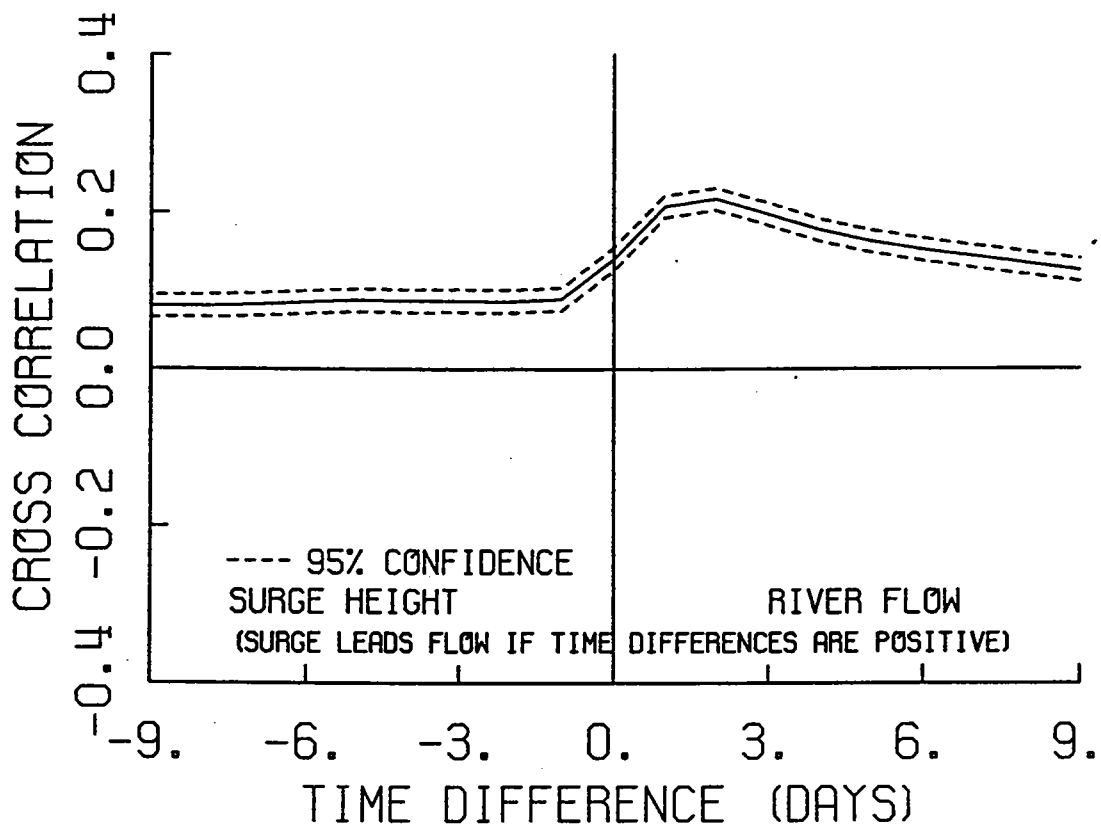


Figure 48. Cross correlation between surge height at The Battery and Passaic River flow measured at the Little Falls, New Jersey gage.

Figure 49. Predicted tide height and observed water level at The Battery and flow of the Passaic River measured at the Little Falls, New Jersey gage during the 21 September 1938 storm event

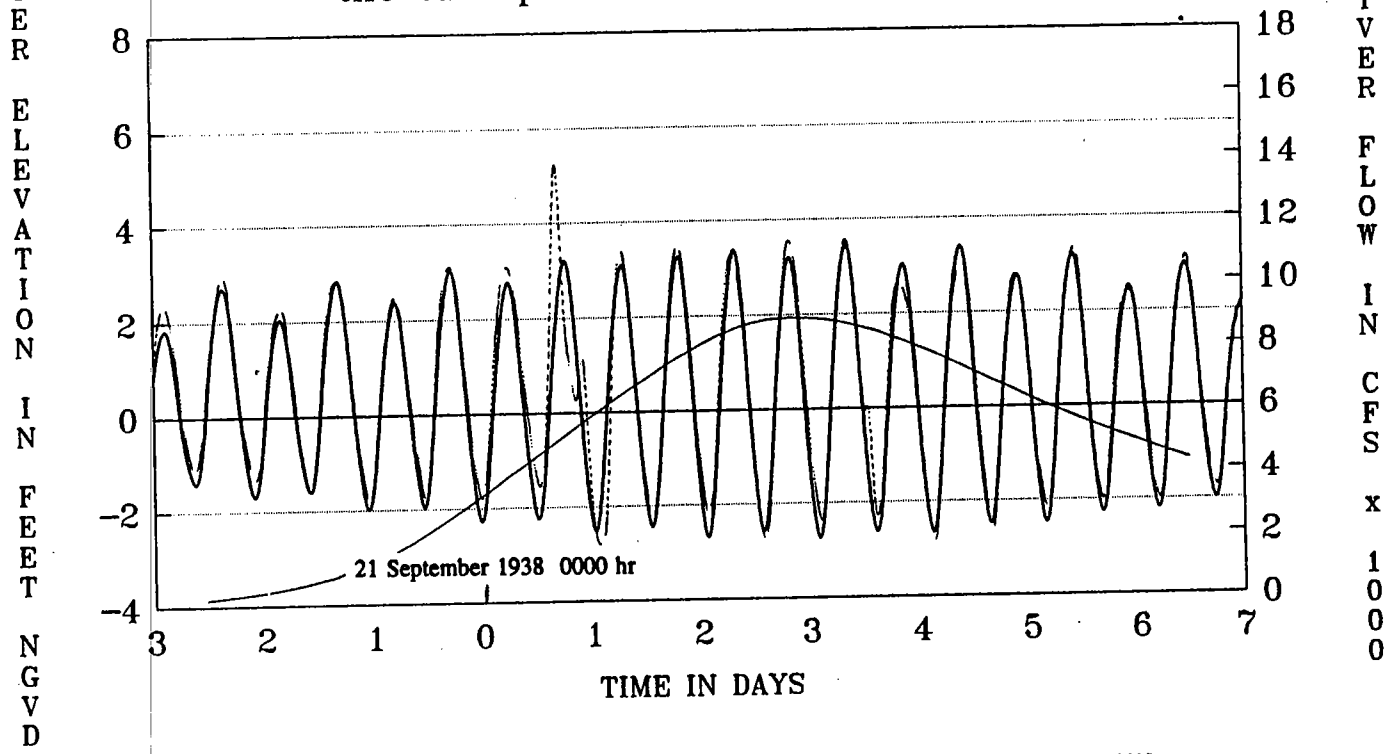


Figure 50. Predicted tide height and observed water level at The Battery and flow of the Passaic River measured at the Little Falls, New Jersey gage during the 25 November 1950 storm event

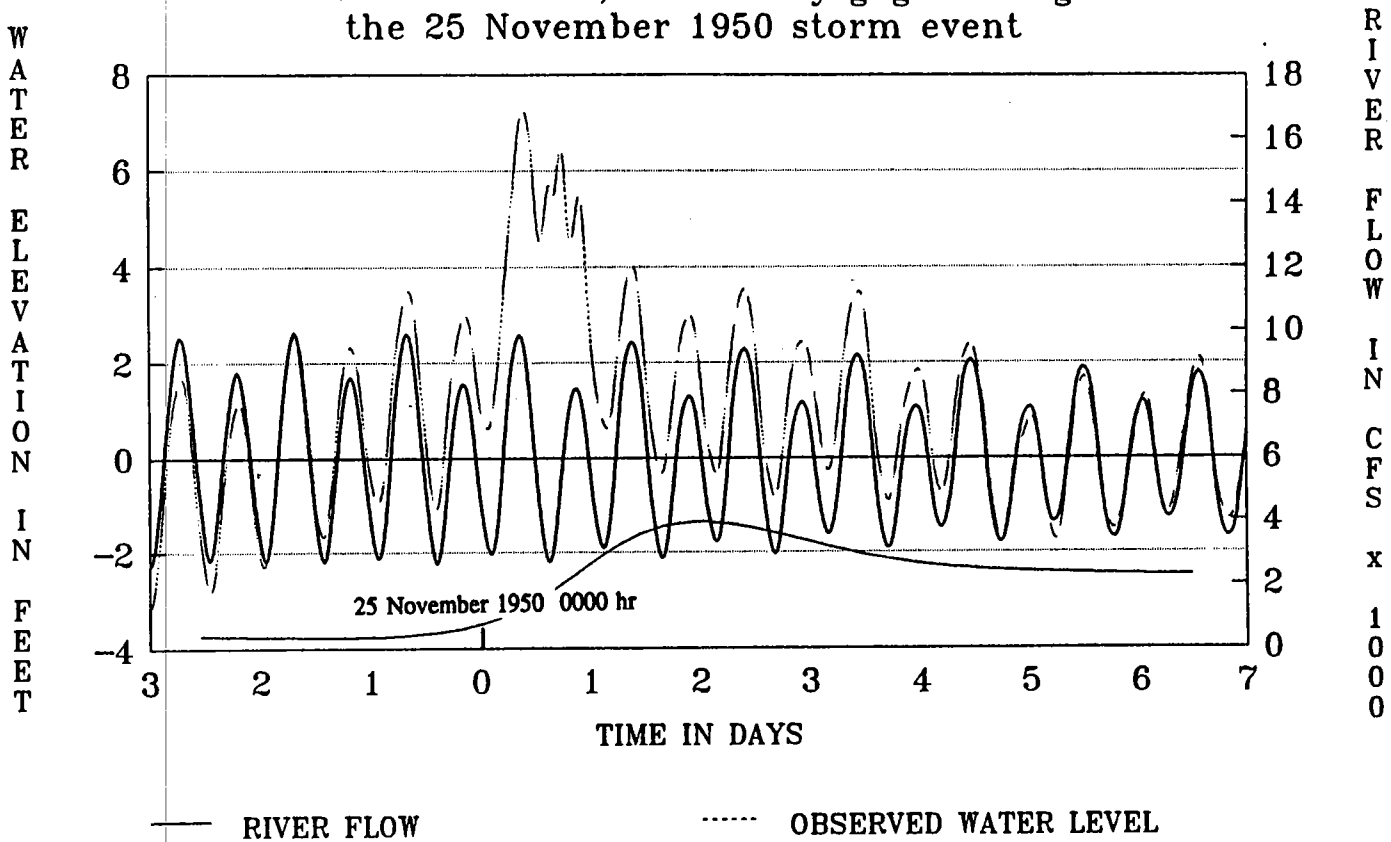


Figure 51. Predicted tide height and observed water level at The Battery and flow of the Passaic River measured at the Little Falls, New Jersey gage during the 12 September 1960 storm event

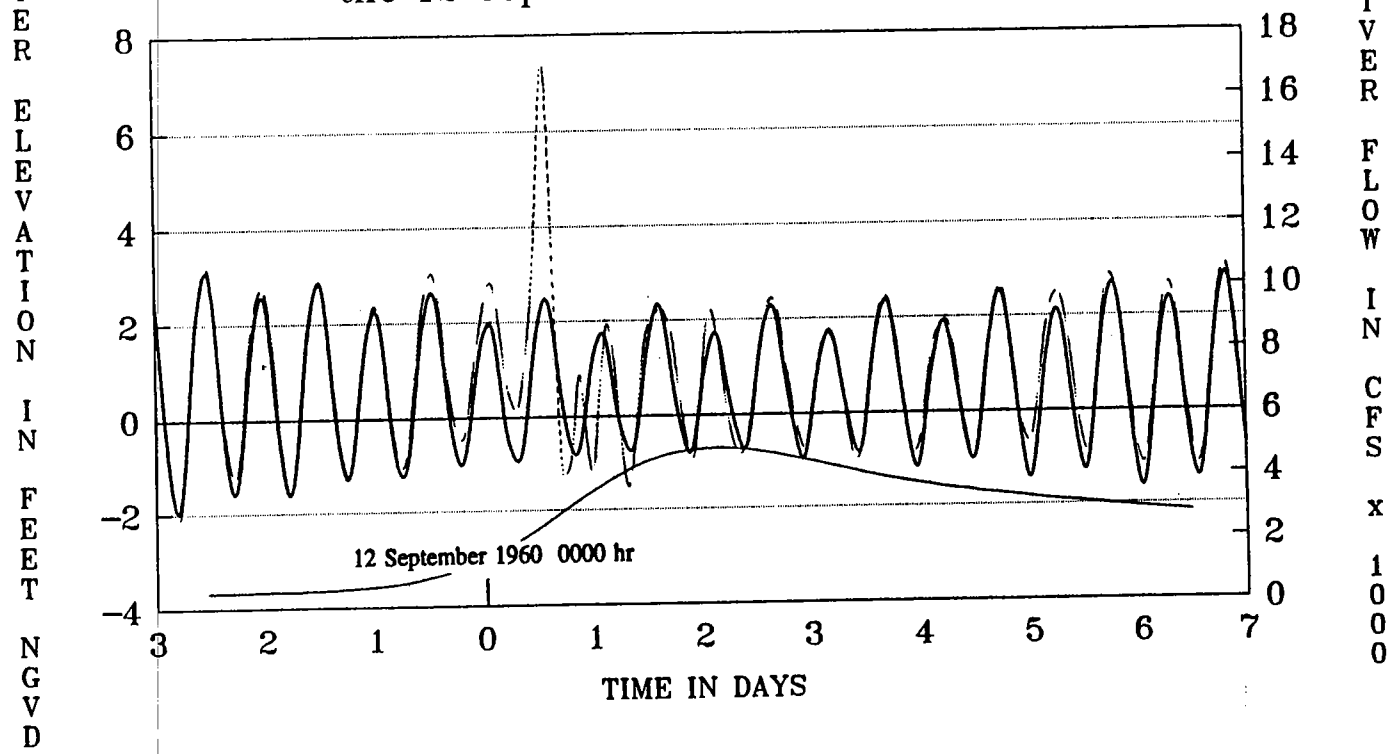


Figure 52. Predicted tide height and observed water level at The Battery and flow of the Passaic River measured at the Little Falls, New Jersey gage during the 10 November 1977 storm event

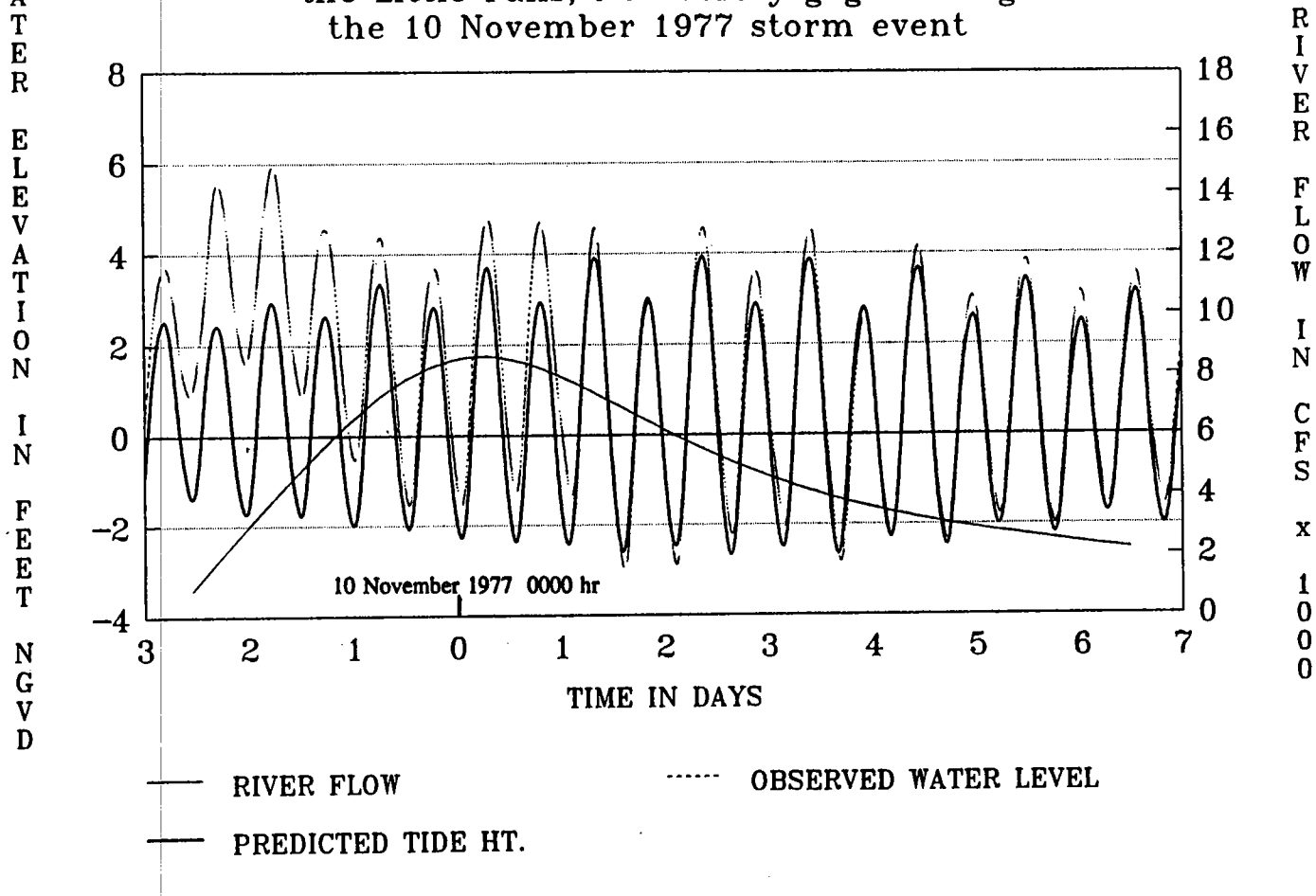
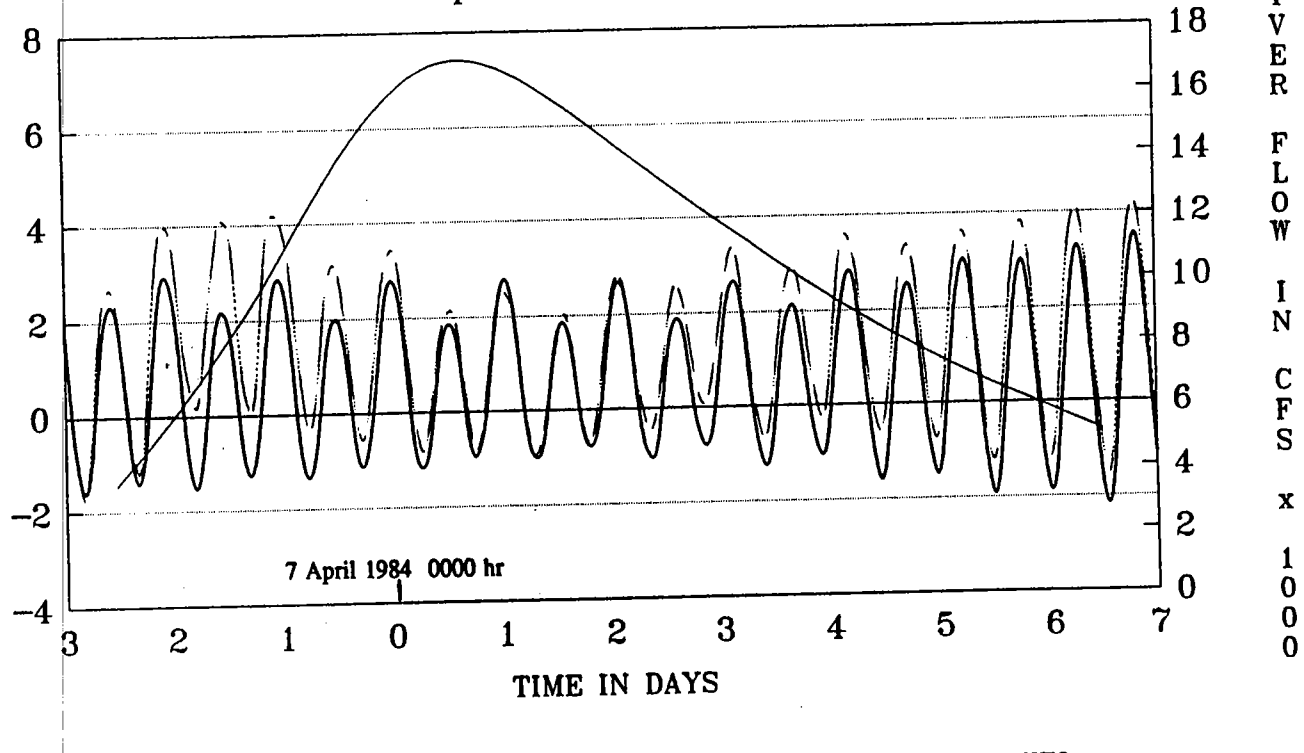


Figure 53. Predicted tide height and observed water level at The Battery and flow of the Passaic River measured at the Little Falls, New Jersey gage during the 7 April 1984 storm event



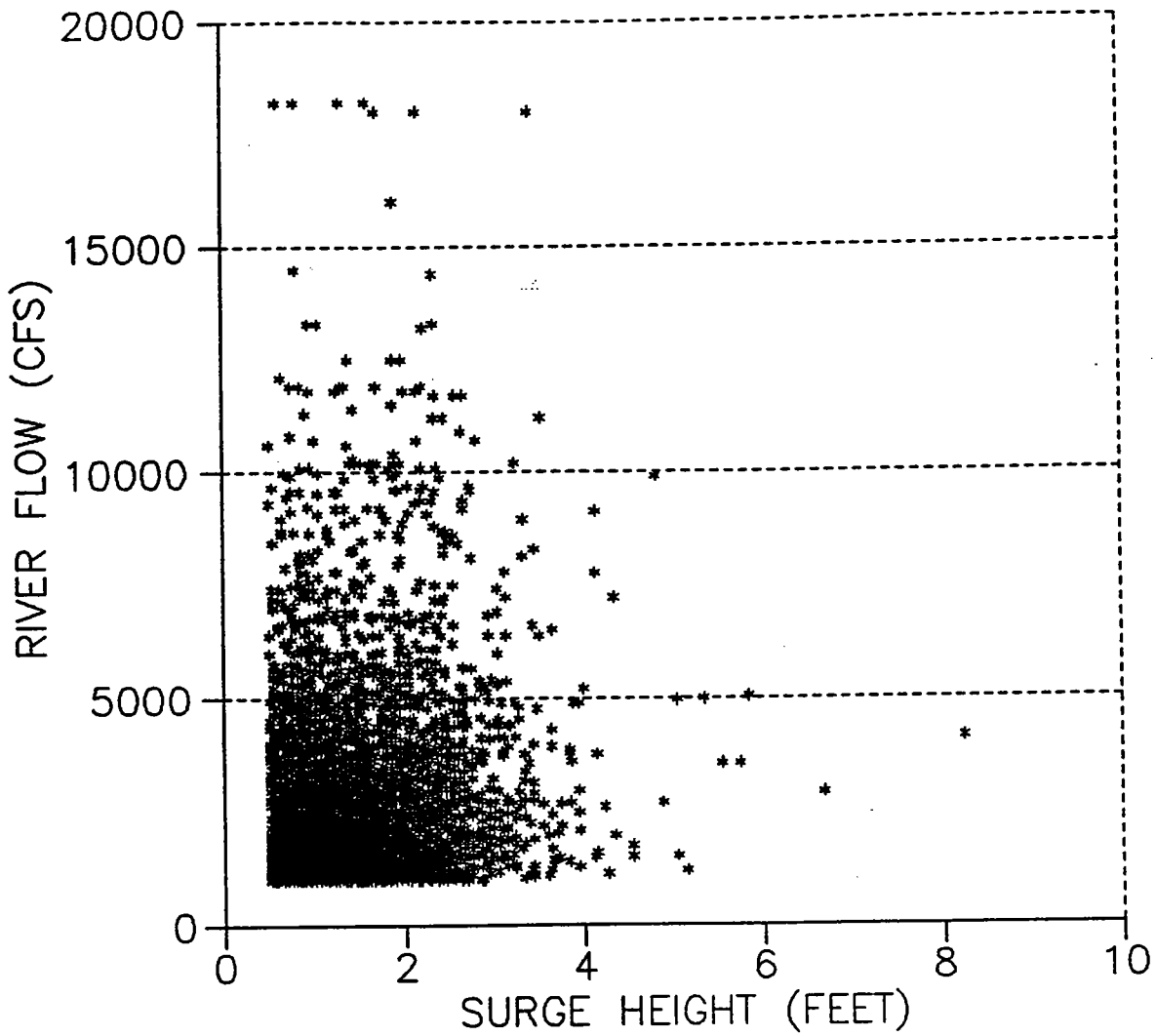
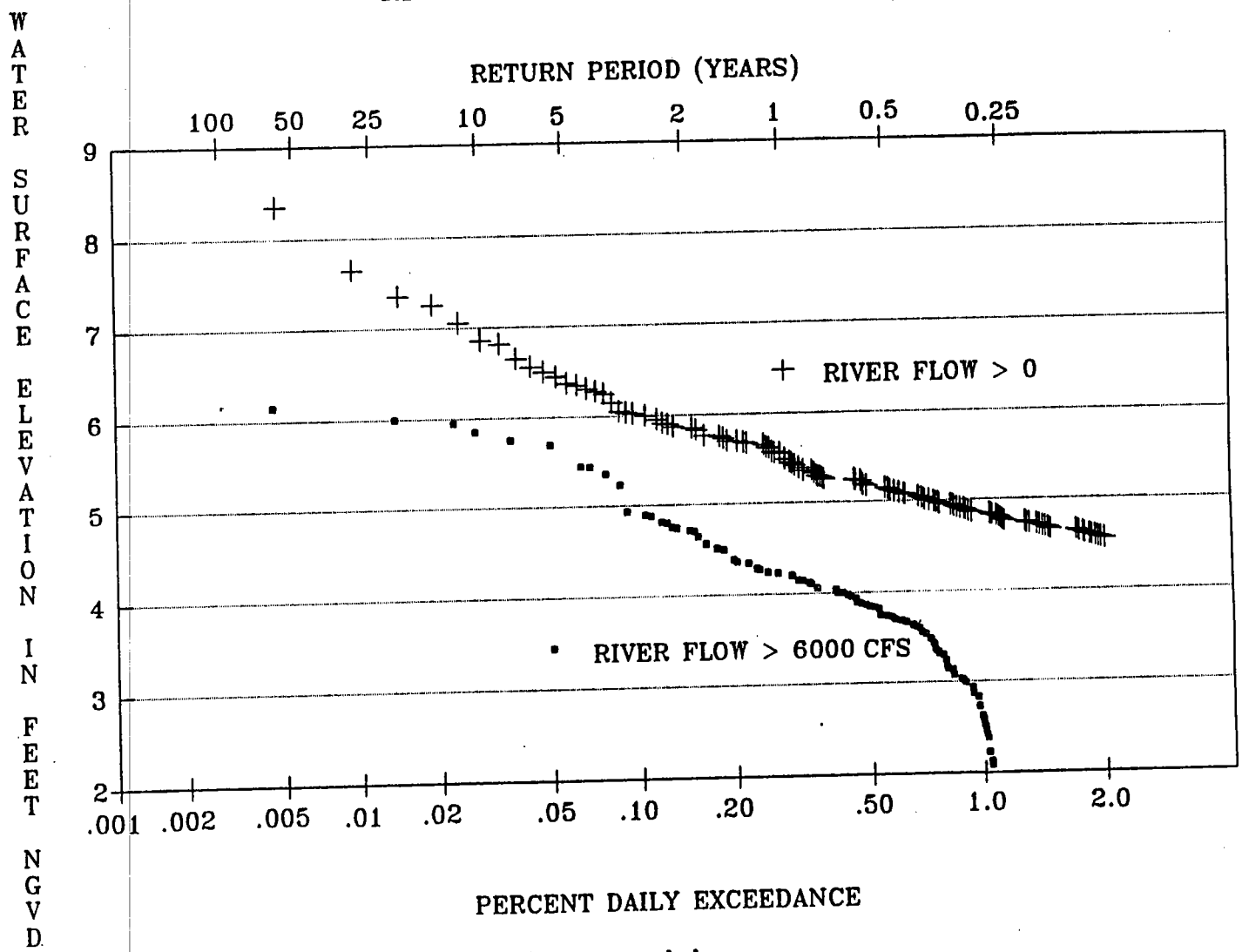


Figure 54. Values of surge height greater than 0.5 feet and maximum river flow greater than 1,000 cfs within the following 72 hours.

Figure 55. Stage-frequency curves and return periods for water surface elevation at The Battery and Passaic River flows at the Little Falls gage



Note: Tabulated river flow values exceeded 6,000 CFS on 230 out of 21,174 days.

Part V: STATISTICAL PROCEDURE

Joint Probability Analysis

79. The Joint Probability Method (JPM) was used to develop hurricane and northeaster surge frequencies for previous studies of the area (CDM 1983a, 1983b, and 1988). The method involves the parameterization of the storm characteristics relevant to surge formation, which includes: (1) central pressure deficit, (2) radius to maximum winds, (3) forward speed, (4) travel direction, and (5) latitude at which the storm meets the coast. The probability distribution of each of these parameters is derived from the observations of historical hurricanes and northeasters. Other factors which might influence peak surge elevation are the tidal amplitude, and the temporal relationship (lag) between tidal periodicity and storm occurrence. Assuming that the storm characteristics are statistically independent, and that the observed distributions are accurate indicators of the underlying parameter frequency distributions, the frequency of occurrence of a given storm is the product of the probability of occurrence of each of its defining parameter values.

80. Three models were used to estimate the surge elevation along the length of the Passaic and Hackensack Rivers, which would occur in response to a synthetic storm defined by some combination of parameter values. These models are:

1. Wind Field Models - simulation of hurricane or northeaster forcing on the ocean surface.
2. Offshore Surge Model - two-dimensional, hydrodynamic model of surge generation over the continental shelf.
3. Inshore Surge Model (DEM) - hydrodynamic model of surge propagation within bays, harbors and waterways.

81. The JPM was used to develop 252 synthetic hurricanes and 43 synthetic northeasters. These 295 total synthetic storm events were then convolved with five tide types and 50 half-hour lags. This produced over 70,000 combinations, each with a probability of occurrence, which were used to develop stage-frequency curves at various locations in the study area. Details of the method can be found in CDM (1983a and 1983b).

Modified Bootstrap Method

82. Rather than simulate the 295 synthetic storm events, and then convolve the results with the five tidal types and 50 half-hour lags (to produce 295x5x50 = 73,750 "events"), the approach used for the Hackensack River Surge Barrier Study (CDM 1988) was selected. The Hackensack study used a smaller subset of the combinations which approximated the original stage-frequency distributions (Prater and Butler 1986). A modified version of the "Bootstrap" method (Efron 1982) was used to estimate the error introduced by simulating the more than 70,000 events, which were used to generate the stage-frequency distributions in the Passaic River Study (CDM 1983b).

83. The modification to the "Bootstrap" method was to "select" a few events over the range of return periods of interest, rather than to choose many at random. The range of interest in CDM (1988) was return periods of 10-100 years. The method involves the selection of a set of events representative of the population frequency distribution (Prater et al. 1988). The percent probability of occurrence of a given peak surge elevation may be obtained from a stage-frequency distribution plot. If a set of elevations is selected from a stage-frequency distribution curve, the horizontal axis (the probability of exceedance) may be divided into ranges that equal the probability of occurrence for each specified elevation.

Storm Selection

84. In the Hackensack Surge Barrier Study (CDM 1988), 24 synthetic storm events were selected from the stage-frequency curve at node 44 at the mouth of Newark Bay, with the majority selected for return periods of 10-100 years. The adequacy of this number of events was tested by choosing, from the 24 events originally selected, three sets of eight events and two sets of 12 events, and examining how the sample number matched the stage-frequency distributions at various locations in the system developed from the full set of events. The results (an example is shown in Figure 56) showed that convergence to the complete distribution was obtained as more events were included in the sample. When all 24 selected events were used, the agreement between the full distribution and the bootstrap distribution was acceptable.

85. For the Passaic River Basin Flood Protection study, however, we decided to use more events to fill in the distribution for return periods of less than 10 years and for return periods of greater than 100 years. The additional events were selected by specifying storm tide elevations from the stage-frequency distribution for node 44 at the mouth of Newark Bay, and identifying the surge/tide/lag combinations from the more than 70,000 events that produced total maximum tidal surge elevations within 0.001 feet of the specified value. From the number of events available at each specified elevation, a single event combination was selected for the study. The events were selected to provide a mix of hurricanes and northeasters, and to distribute these two types of storm events over the range of surge elevations specified. Table 5 lists the storm events selected. The nine new storms selected for this study are indicated with an asterisk. Figure 57 shows the stage-frequency distributions at node 44 at the mouth of Newark Bay, and the 33 event combinations selected.

86. The observed range of elevation differences, from the full stage-frequency distribution, for a given return period, may be used as an estimate of error. If so, one might expect that the range would be a function of the form (Leon Borgman, personal communication, 1988):

$$R = k\, n^c \qquad (9)$$

where: R = the range,

n = sample size, and

k and c = function parameters.

Figure 58 shows the range plotted as a function of sample size for the 24 events selected for the Surge Barrier Study (CDM 1988), whose analysis yielded an error of approximately 0.24 feet. With the inclusion of nine additional storm events from this study (i.e., a total of 33 storm events) reduces the estimated error to 0.15 feet. This error value is well within the accuracy of numerical models used herein and in similar flooding projects.

Table 5

Selected Storm Events

Storm[1]	Lag (Hours)	Tide No.	Peak Surge (Ft. NGVD)	Incremental Probability of Occurrence	Cumulative Probability
N017	4.5	3	12.25	0.0013	0.0013
H242*	11.5	2	11.75	0.0007	0.0020
H135	15.0	1	11.25	0.0006	0.0026
H203*	8.5	3	11.00	0.0006	0.0032
H144	16.0	5	10.75	0.0007	0.0039
H196*	14.5	1	10.5	0.0008	0.0047
H117	14.5	3	10.25	0.0009	0.0056
N014*	4.5	4	10.0	0.0010	0.0066
H192	20.5	4	9.75	0.0017	0.0083
H200	10.5	4	9.50	0.0021	0.0104
H090	18.5	4	9.25	0.0024	0.0128
N015	10.5	4	9.08	0.0027	0.0155
N001	4.0	3	8.92	0.0027	0.0182
H184	20.5	5	8.75	0.0041	0.0223
H225	2.0	2	8.58	0.0053	0.0276
H151	13.0	1	8.42	0.0053	0.0329
N020	3.5	3	8.25	0.0075	0.0404
H027	13.0	2	8.08	0.0093	0.0497
H191	10.5	5	7.92	0.0093	0.0590
H235	15.0	5	7.75	0.0120	0.0710
H025	5.0	5	7.58	0.0140	0.0850
H041	10.5	5	7.42	0.0140	0.0990
H250	7.0	3	7.25	0.0210	0.1200
N041*	17.5	1	7.125	0.0200	0.1400
H078	21.5	2	7.00	0.0300	0.1700
H008*	22.5	4	6.875	0.0200	0.1900
N028	2.5	3	6.75	0.0600	0.2500
H066*	21.5	3	6.25	0.0700	0.3200
N009	6.5	1	6.25	0.1400	0.4600
H166*	8.5	2	6	0.1300	0.5900
H249	1.5	4	5.75	0.2700	0.8600
N018*	16.0	2	5.5	0.1310	0.9910
H001	1.5	5	5.25	0.0090	1.0000

Note: Hxxx = refers to a hurricane
Nxxx = refers to a northeaster
"*" refers to new storm event for this study

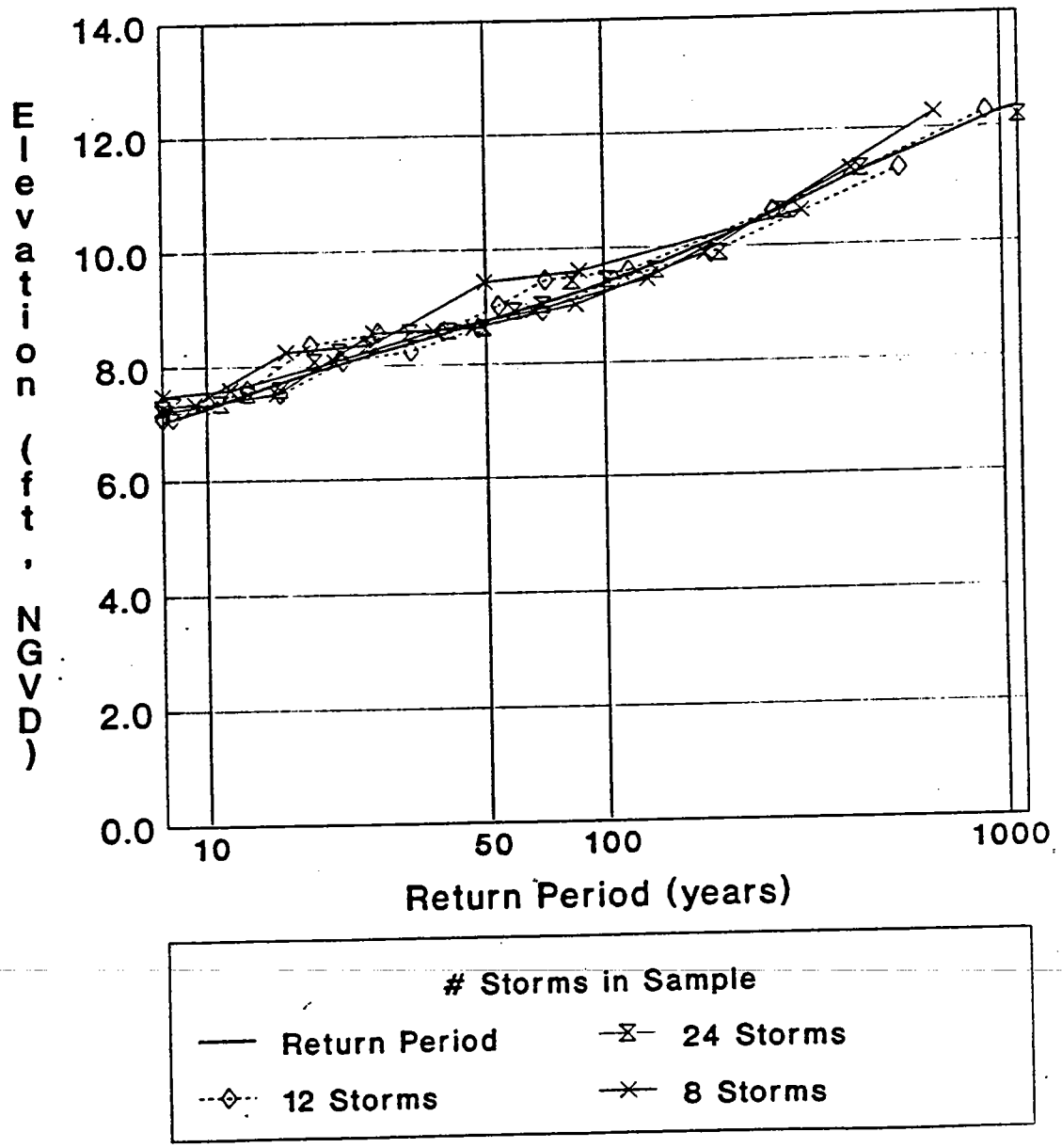


Figure 56. Return period for peak surge at Node 172.

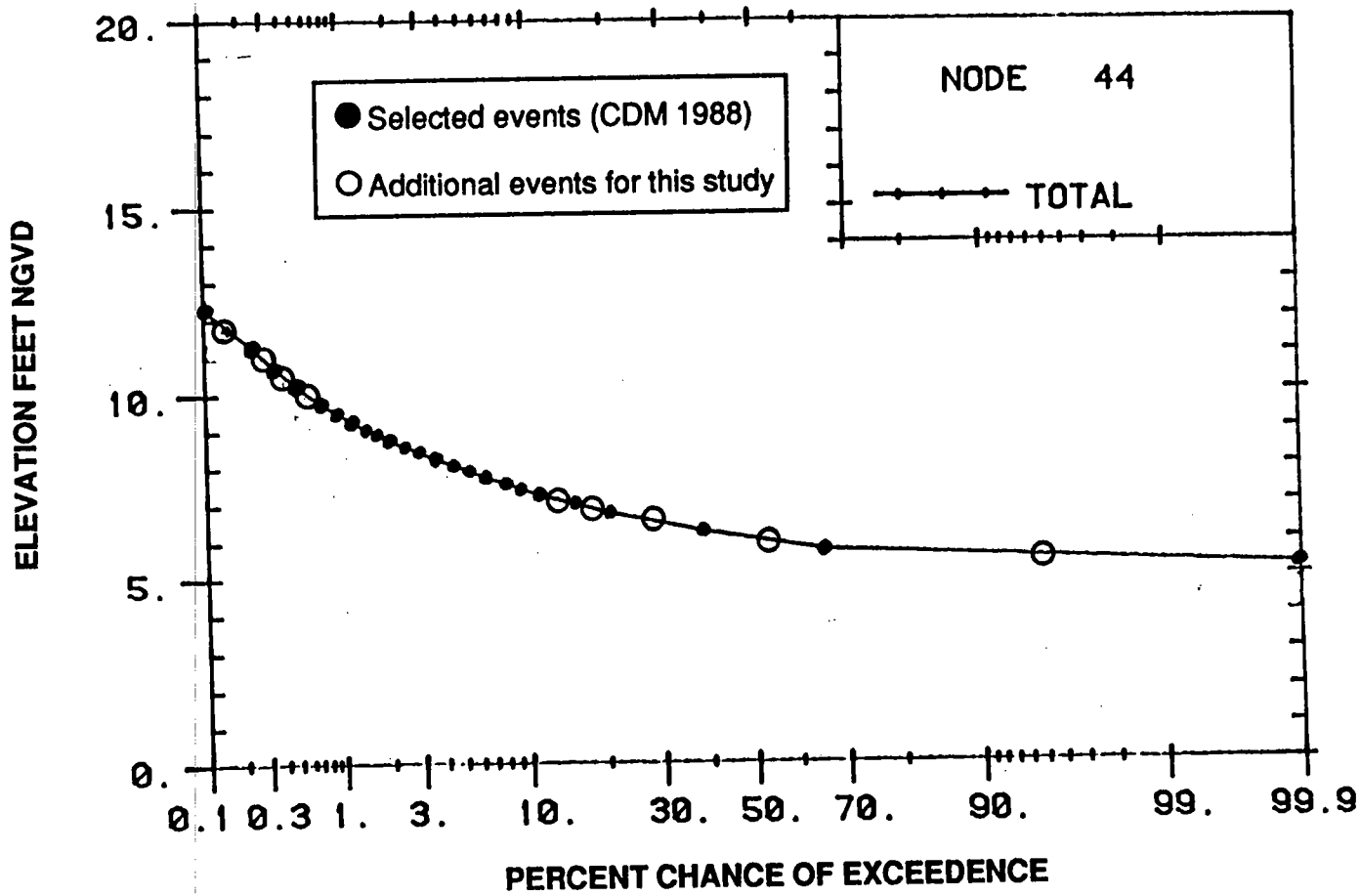


Figure 57. Stage frequency curve at entrance to Newark Bay (source: CDM 1988)

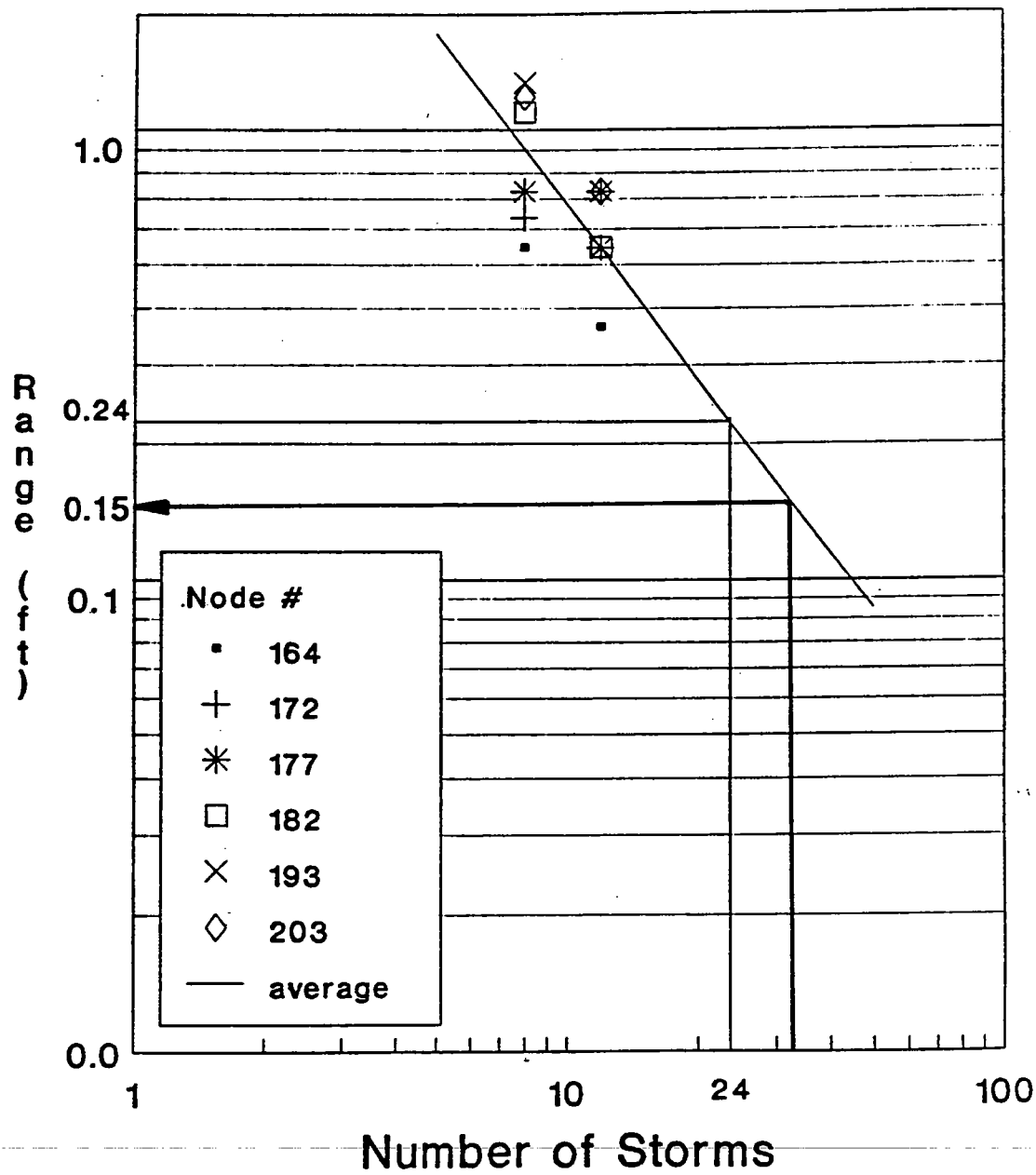


Figure 58. Range of elevation vs size of sample for return periods of 10 to 100 years

PART VI: SEA LEVEL RISE

87. Marine water level records in the vicinity of New York indicate a long-term rise in mean sea level since at least the 1920s. Because sea level influences surge elevations in the modeled system, sea level rise must be taken into account in order to provide accurate simulations of surge elevations under future conditions.

88. Figure 59 shows mean annual and 19-year averages of sea level at The Battery. Mean sea level fluctuates substantially from year to year, but the long-term trend becomes apparent when a 19-year moving average is applied to the annual means. Nineteen years is approximately the period of one of the lowest-frequency tidal components, so that averaging over 19 years smooths all signals with periods less than 19 years. According to calculations made by the National Ocean Survey (NOAA 1988), mean sea level rise at The Battery since 1920 has been 2.7 millimeters (0.00886 feet) per year. This estimate is based upon historical observations.

89. Previous simulations (CDM 1983b) assumed a value of 0.5 feet for mean sea level above NGVD. This value is approximately correct for the year 1950, when the long-term average was about 5.48 feet (0.53 feet NGVD), on the tide staff. From Figure 59, long-term mean sea level in 1950 was approximately 0.3 feet higher than that in 1929.

90. Simulations of surge elevations under future conditions in the year 2050 incorporated an estimated sea level rise of 0.89 feet at The Battery. This estimate assumes that sea level rise continues at the constant historical rate of 0.00886 feet per year over the next 100 years from 1950.

91. Figure 59 shows that there can be large interannual variability in annual mean sea level. One large fluctuation was in the early 1980s when sea level appeared to increase by approximately 0.3 feet in one year. Such irregular changes cannot be anticipated in simulations of surge elevations under future conditions.

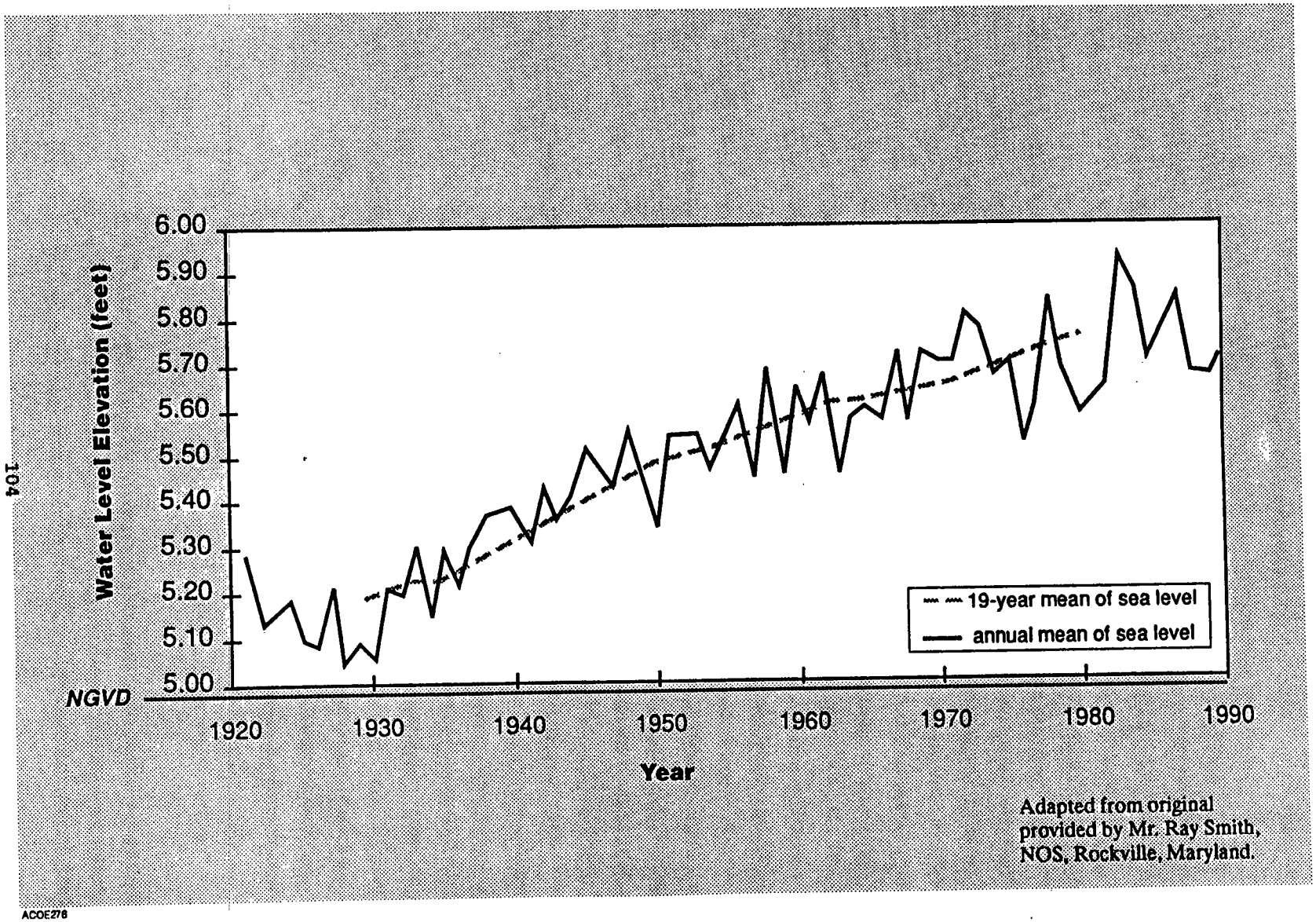


Figure 59. Mean sea level 1921–1990 at the Battery, New York

PART VII: SENSITIVITY ANALYSIS

Events Selected

92. The purpose of the sensitivity analysis was to complement the coincidence analysis by determining the order of magnitude of coincident tidal surge and river flow events, both with and without the proposed improvements. In this analysis, we postulated that the effect of large river flows in increasing tidal elevation near Kearny Point will be small. This postulate was based on the previous analysis of CDM (1983b), in which storm surges and river flows were assumed to be independent events. The superimposed stage-frequency distributions in that study showed that the distribution produced by river flows alone was small for locations well downstream in the Passaic and Hackensack Rivers, and in Newark Bay. Based on this analysis, we modeled the river flows in the majority of the sensitivity simulations as being constant because, if the effects are small in the region of interest, then the effects produced by an actual hydrograph will be smaller still.

93. From the available storm and non-storm events, we selected three that cover the range of surge elevations expected from the complete set of storms. The three events selected were:

1. The tide of 11-13 October 1976 - this represents a non-surge condition.
2. Synthetic hurricane H249 - this represents a small hurricane/tide combination that produced a small maximum tidal elevation of 5.75 feet at the mouth of Newark Bay.
3. Synthetic hurricane H135 - this represents a large hurricane/tide combination that produced a large maximum tidal elevation of 11.25 feet at the mouth of Newark Bay.

94. Each of these three events was simulated, with various coincident river flows, for year 2050 conditions. Consequently, a datum plane shift of 0.89 feet was used to include the effect of sea level rise from 1950-2050.

River Flow Conditions

95. The New York Corps has analyzed the hydrology of the Passaic River Basin above the Dundee Dam, and has developed flow hydrographs for the 100-year river flood event. Figure 60 shows the Phase 1 General Design Memorandum

100-year flow hydrographs for the year 2050, with and without the effect of the diversion tunnel. Without the diversion tunnel, the 100-year hydrograph is double peaked, with a maximum flow of 33,645 cfs. The effect of the diversion tunnel is to decrease the time of travel of the flood wave, and gives a maximum flow of 48,544 cfs, with approximately 30,000 cfs through the diversion tunnel and 20,000 cfs in the Passaic River.

96. In the sensitivity analysis, the three events were simulated for the following four conditions:

1. Future unimproved conditions with low river flows - for the tide of 11-13 October 1976, the observed river flows were used; for the two synthetic hurricanes, the one-year flow of 5,285 cfs in the Passaic River and 1,630 cfs in the Hackensack River were used.
2. Future unimproved conditions with high river flows - the 100-year flows of 33,645 cfs in the Passaic River, and 7,135 cfs in the Hackensack River, were used.
3. Future improved conditions with no flood levees - the 100-year flows of 30,000 cfs through the diversion tunnel, 20,000 cfs in the upper Passaic River, and 7,135 cfs in the Hackensack River were used.
4. Future improved conditions with flood levees - the same as condition 3, except that overbank links in the vicinity of proposed flood protection levees were removed, to simulate the elimination of overbank flooding due to the construction of levees of sufficient height.

Analysis of Simulations

97. The four conditions were simulated for each of the three events, and the results plotted at various locations along the Passaic and Hackensack Rivers, and in Newark Bay. The results are plotted in Figures 61 through 84 for several sites selected in consultation with the PRD. The peak tidal surge elevations at these sites are compared in Tables 6 through 8, for the three different events.

98. The results show that for those stations in the lower Passaic and Hackensack Rivers, and in Newark Bay, the magnitude of the river flow (low versus 100-year event), and the distribution of flows (future unimproved

versus future improved) have little effect on the resulting tidal surge elevations. From Tables 6 through 8, it can be seen that the difference is only a few tenths of a foot, and we conclude that inflow distributions and magnitudes and flood protection levees have a negligible effect on tidal elevations in the lower part of the system. Certainly the variability is within the accuracy of the model, and within the factor of safety normally designed into this type of project.

99. For those stations farther up the Passaic River, the effect of the diversion tunnel is to reduce the magnitude of the 100-year flood by several feet. Thus in the tidal portion of the system, below the river dams, the overall effect of the tunnel diversion, with or without flood protection levees, is to reduce the river flood elevations in the upper portion of the tidal Passaic River, while not significantly increasing flood elevations in the remaining tidal system. The benefit of the diversion tunnel may by itself warrant considering a diversion tunnel for the project area.

Figure 71. Predicted water level elevations at East Newark for year 2050 conditions and synthetic hurricane 135

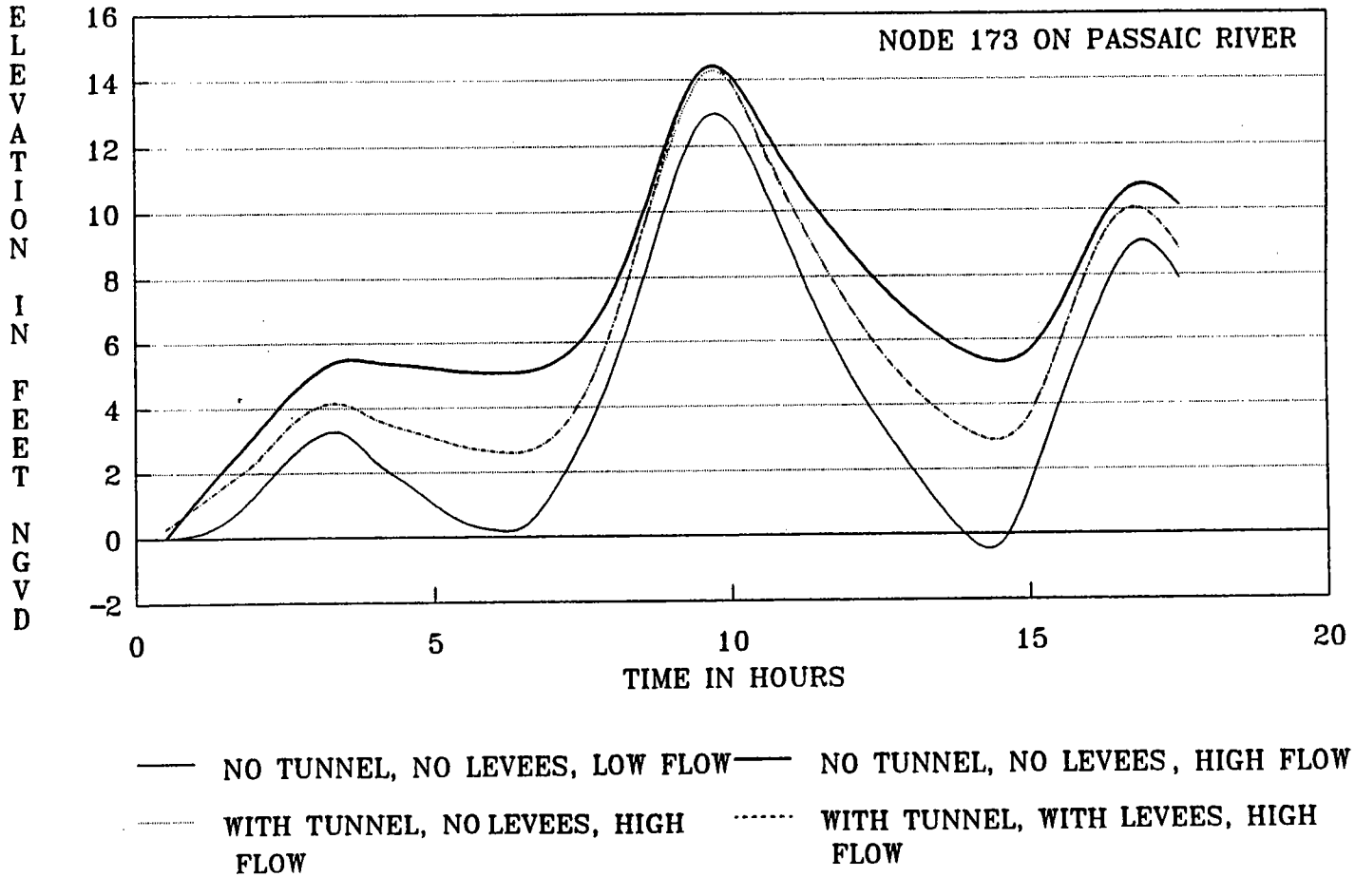


Figure 72. Predicted water level elevations at Third River for year 2050 conditions and synthetic hurricane 135

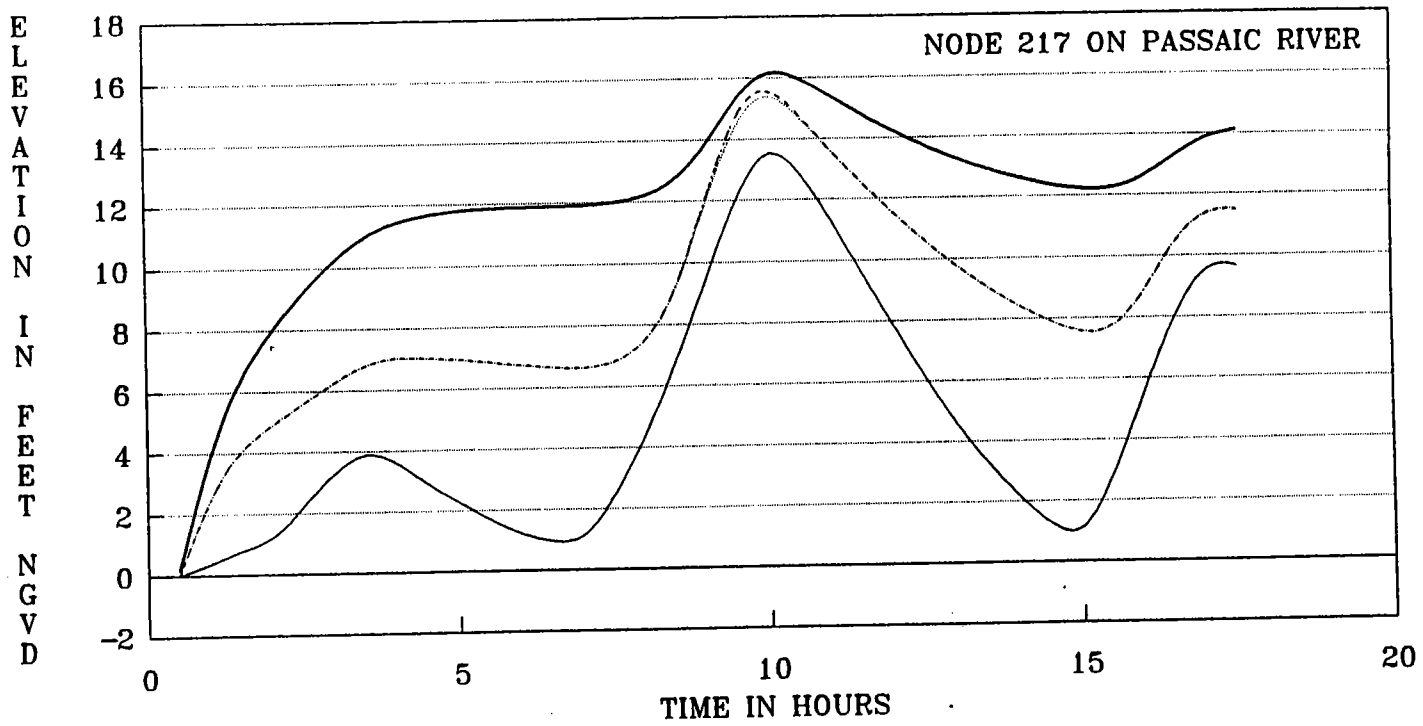


Figure 73. Predicted water level elevations at Garfield for year 2050 conditions and synthetic hurricane 135

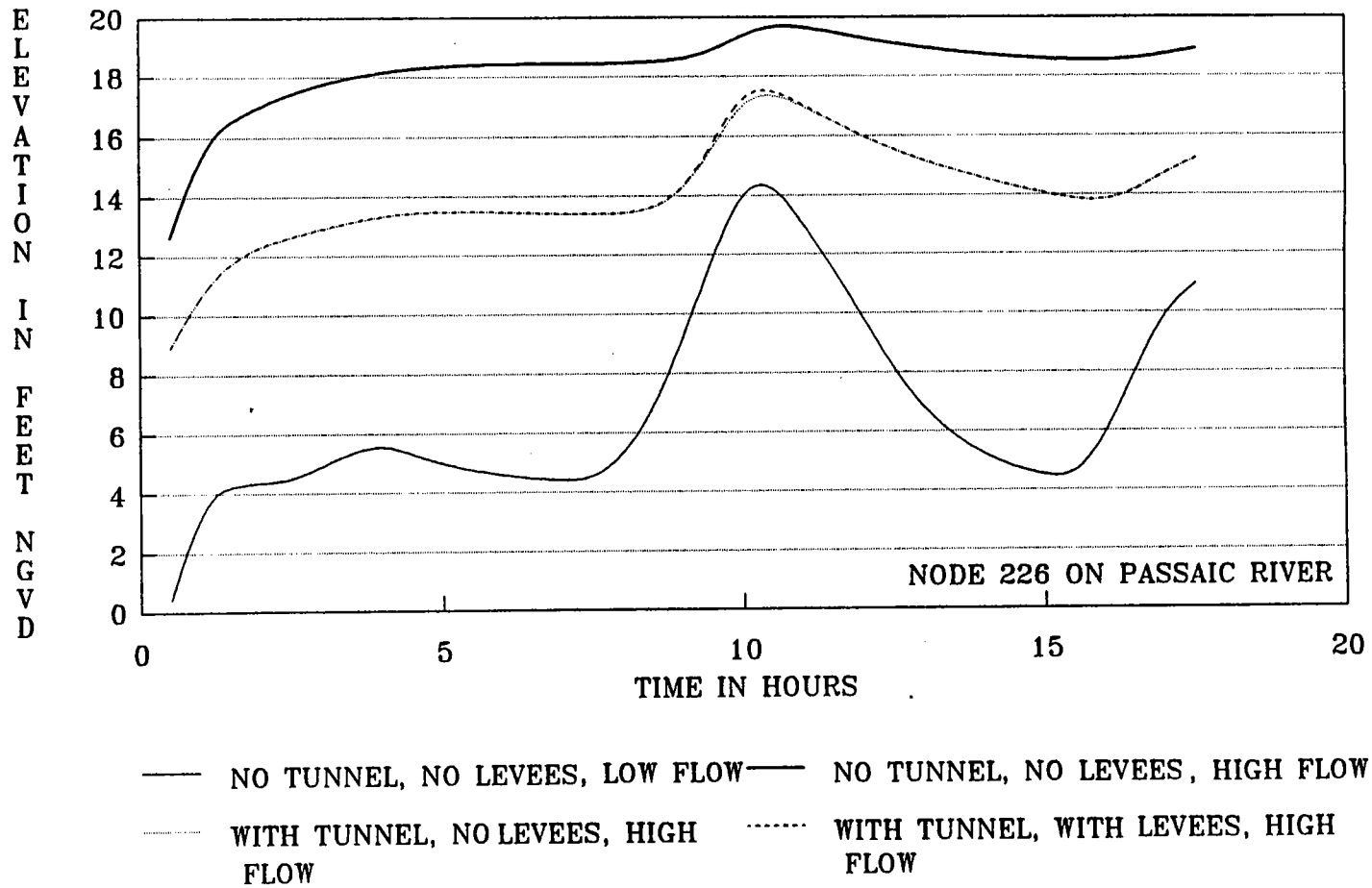


Figure 74. Predicted water level elevations at Snake Hill for year 2050 conditions and synthetic hurricane 135

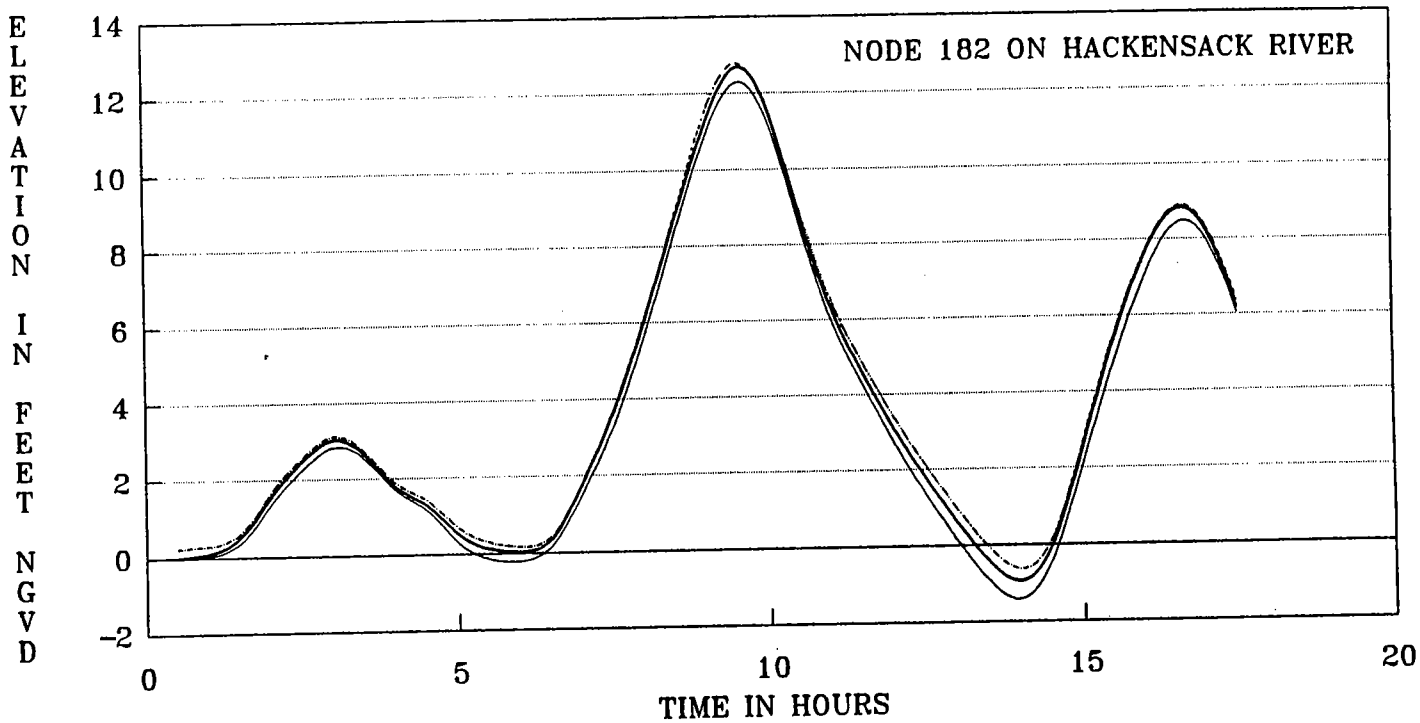


Figure 75. Predicted water level elevations at Berry's Creek for year 2050 conditions and synthetic hurricane 135

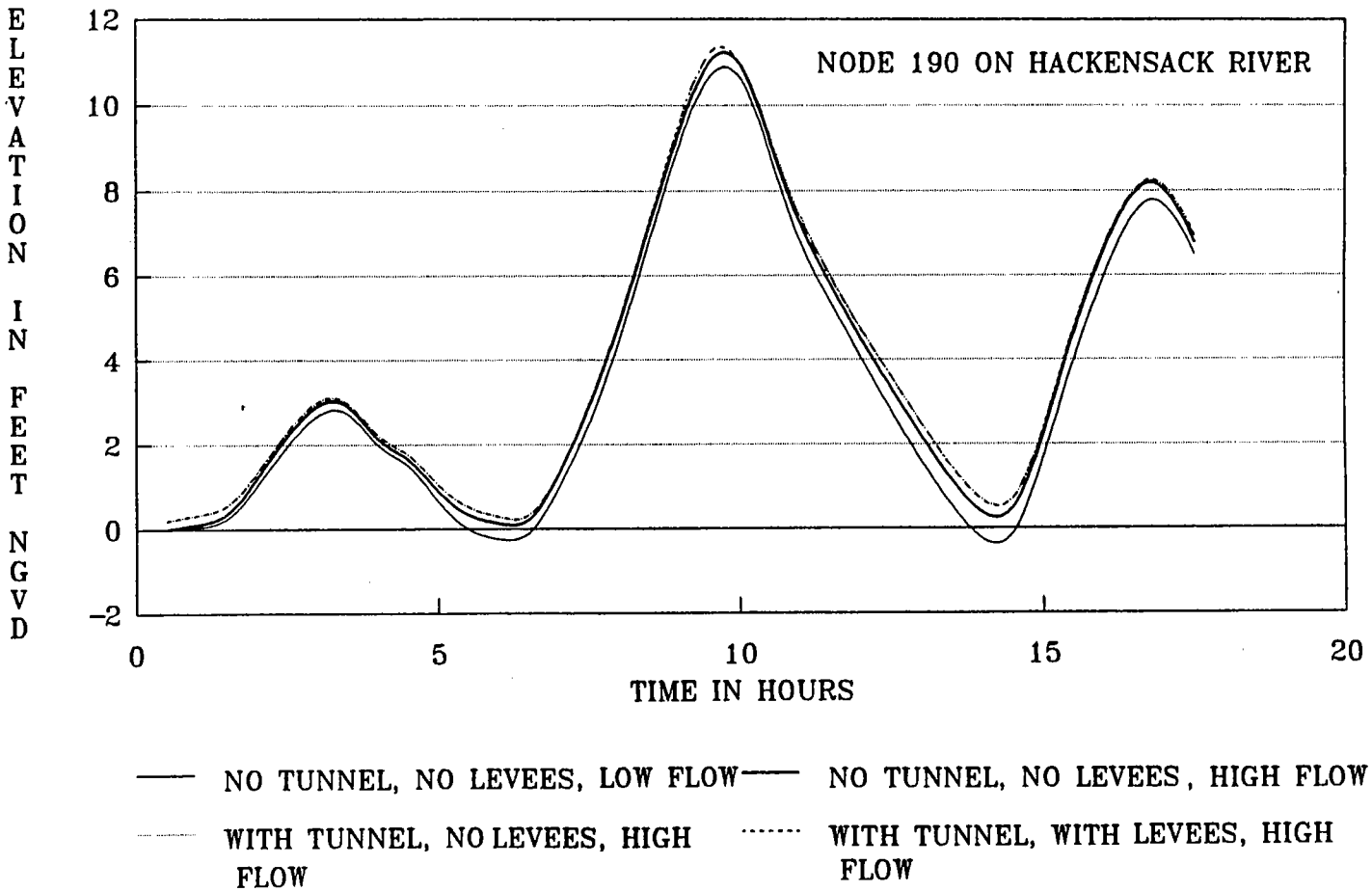


Figure 76. Predicted water level elevations at New Milford for year 2050 conditions and synthetic hurricane 135

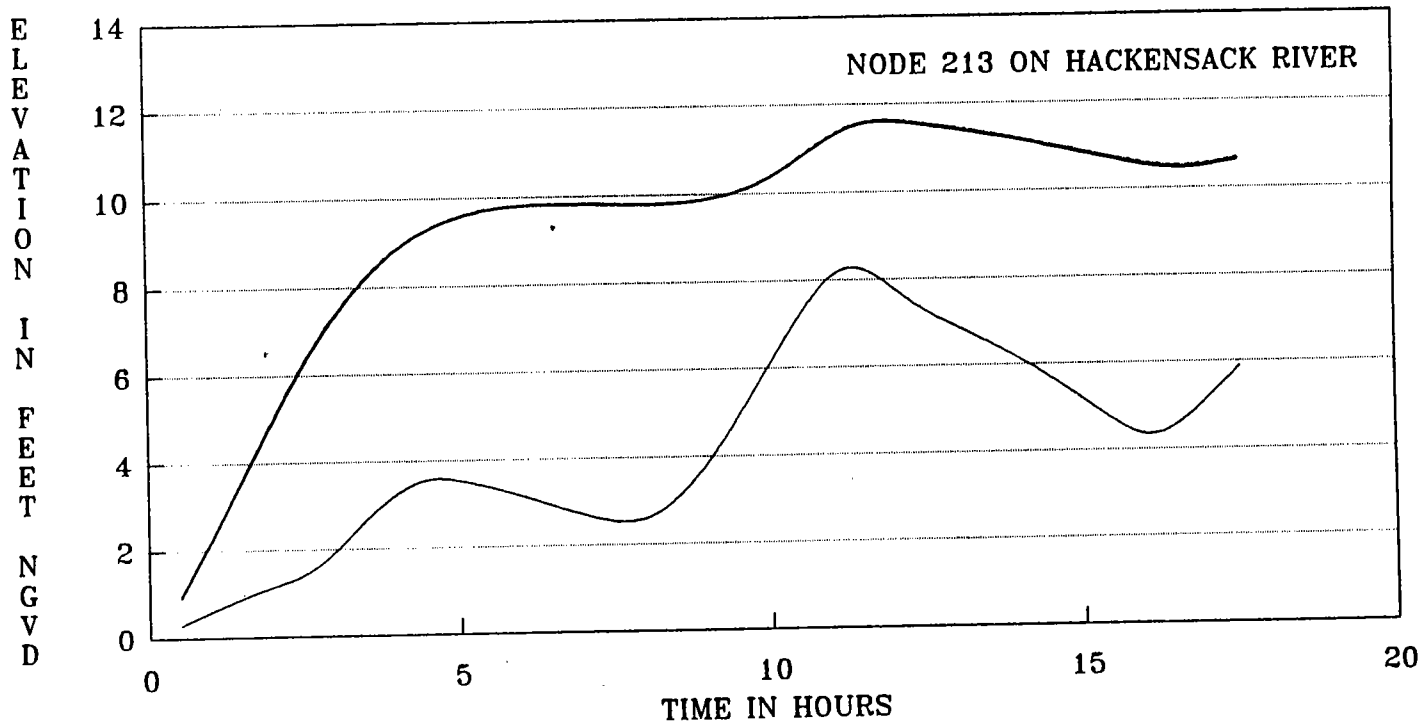


Figure 77. Predicted water level elevations at Newark Airport for year 2050 conditions and synthetic hurricane 249

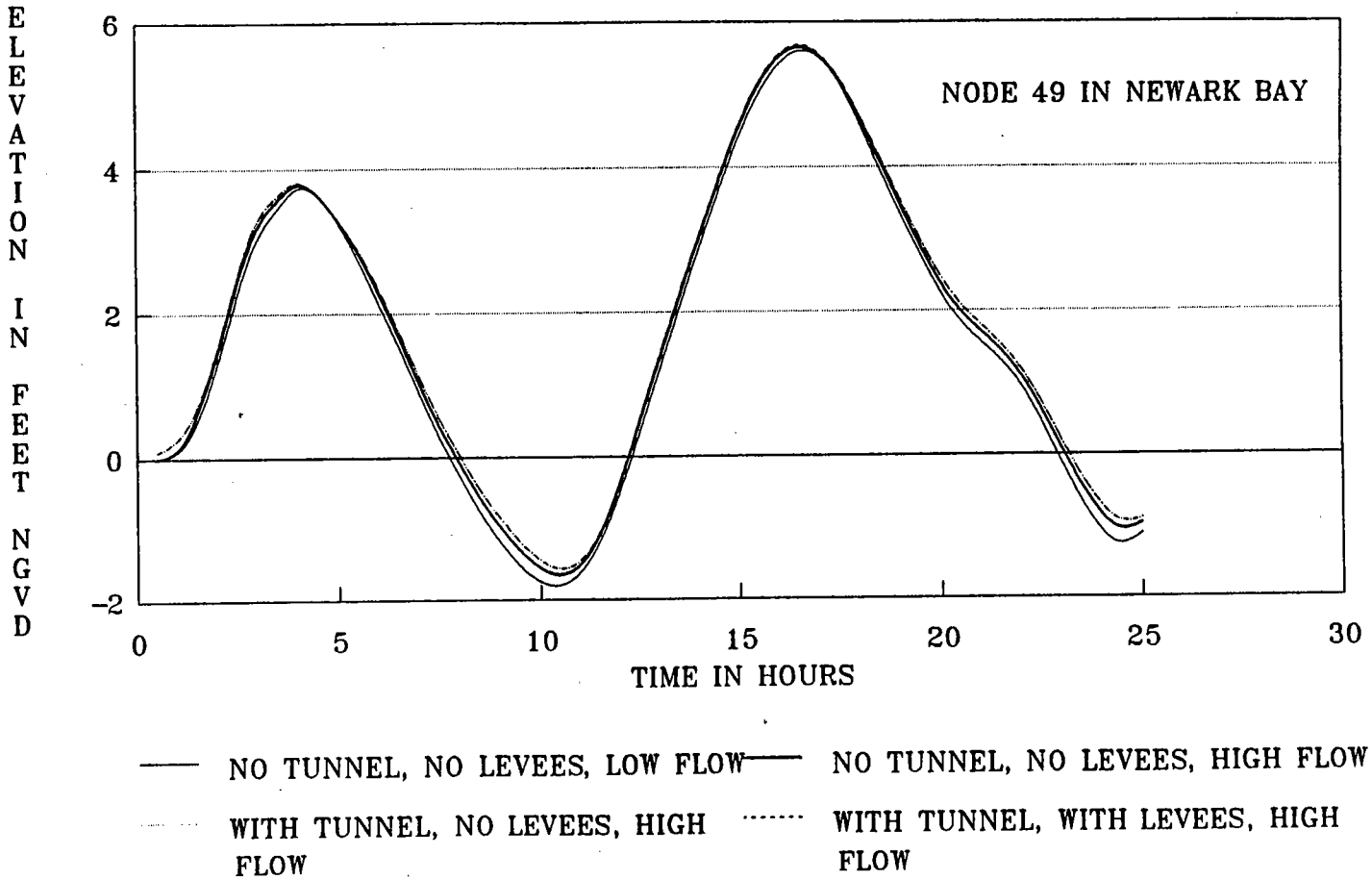


Figure 78. Predicted water level elevations at Kearny Point for year 2050 conditions and synthetic hurricane 249

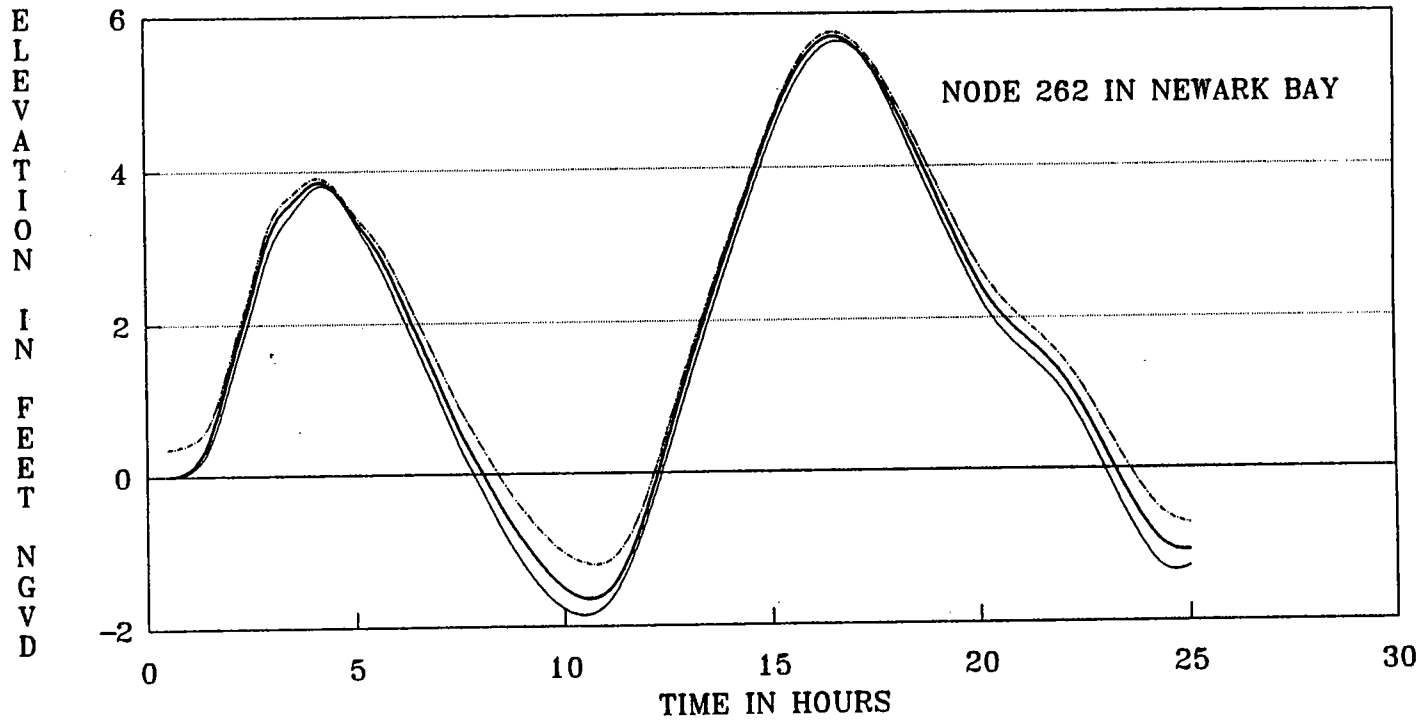


Figure 79. Predicted water level elevations at East Newark for year 2050 conditions and synthetic hurricane 249

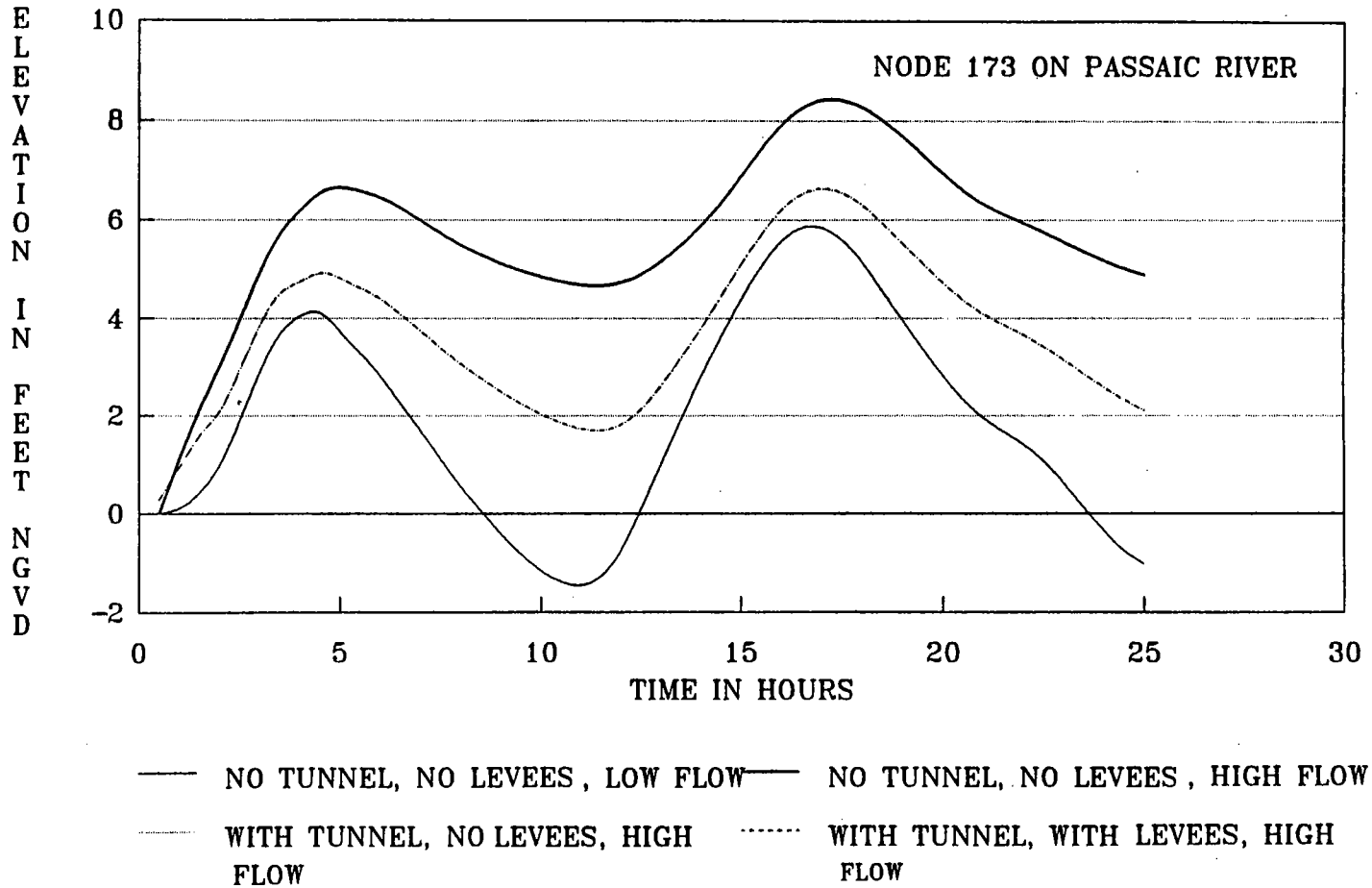


Figure 80. Predicted water level elevations at Third River for year 2050 conditions and synthetic hurricane 249

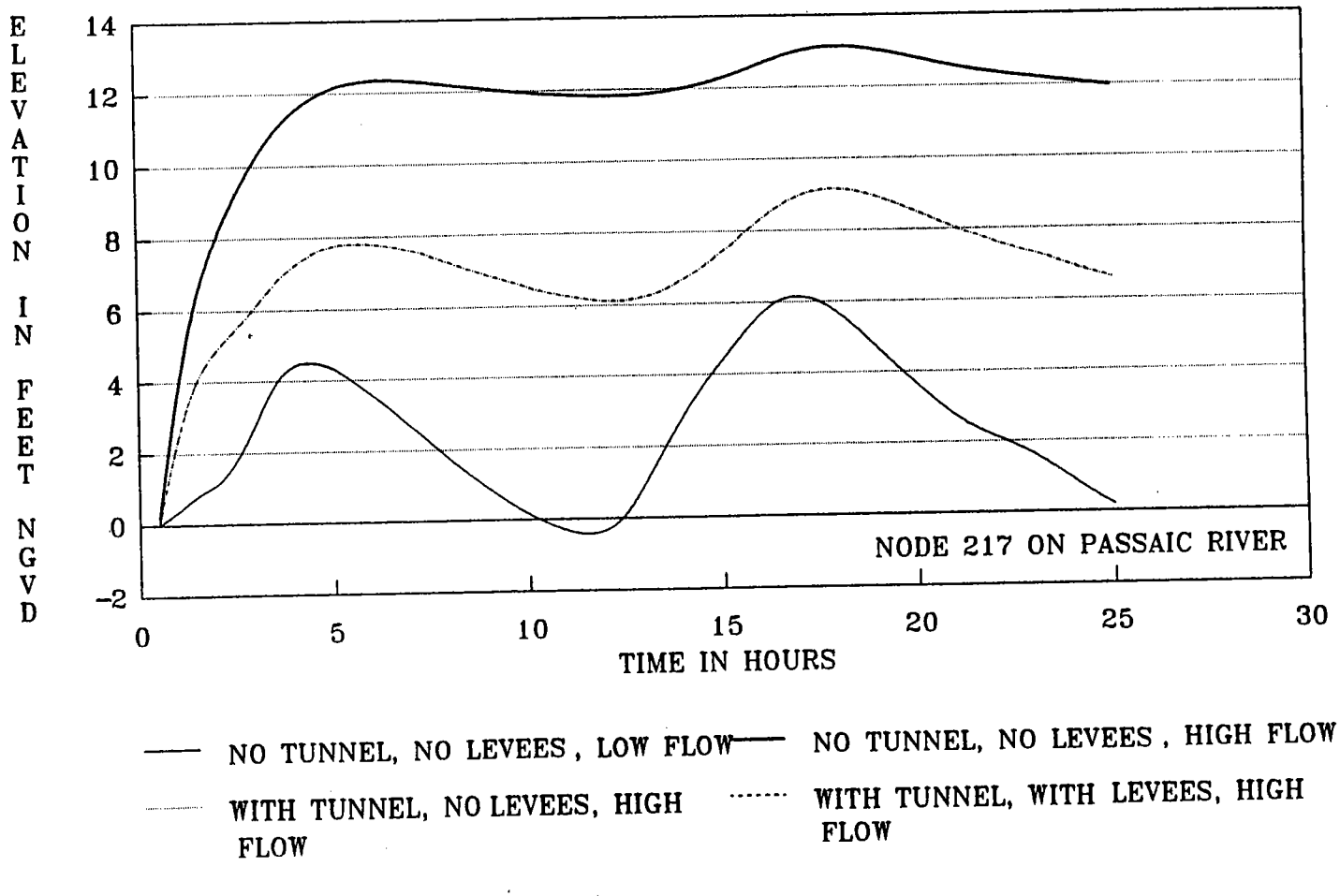


Figure 81. Predicted water l l elevations at Garfield for year 2050 conditions and synthetic hurricane 249

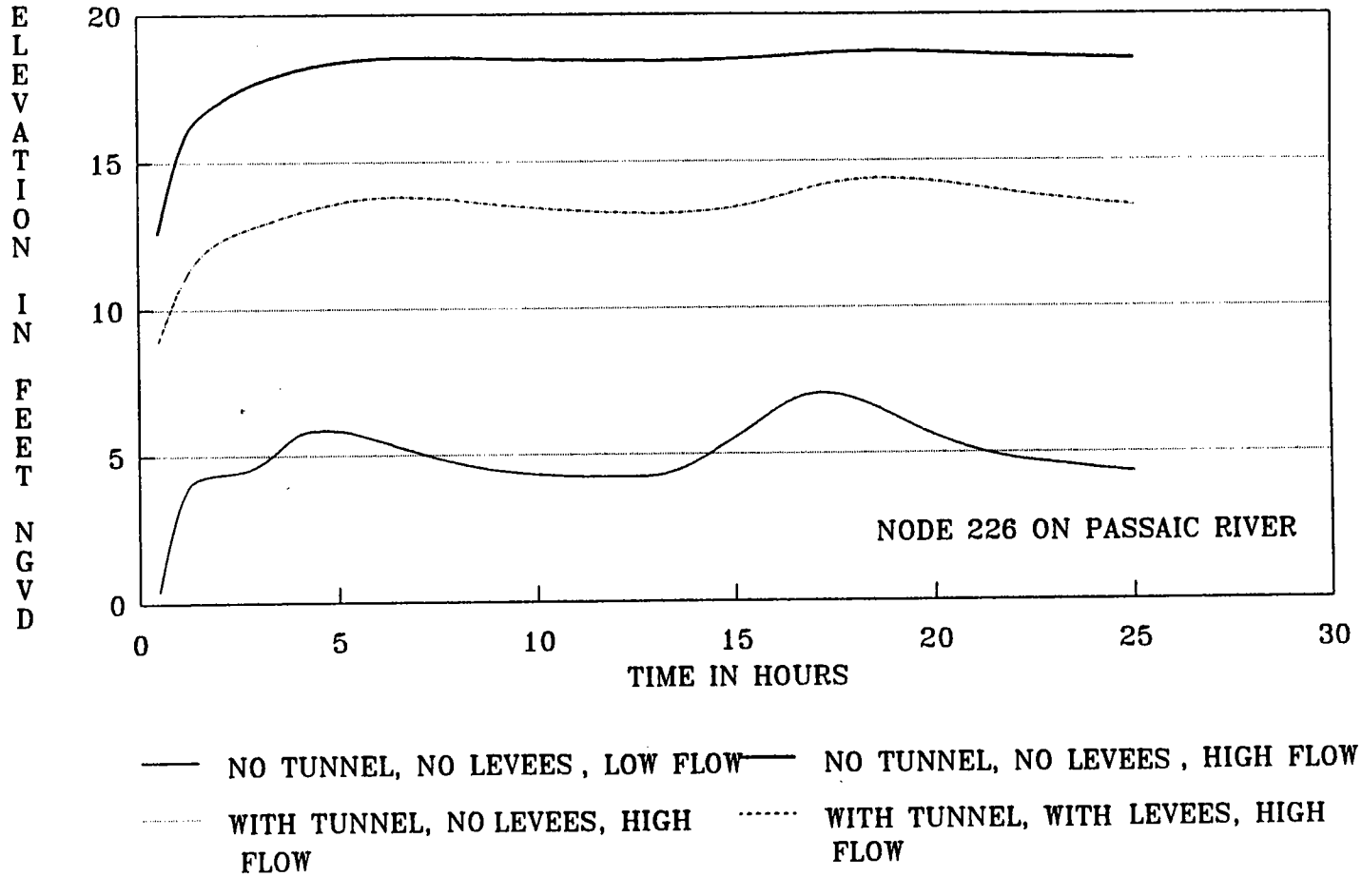


Figure 82. Predicted water level elevations at Snake Hill for year 2050 conditions and synthetic hurricane 249

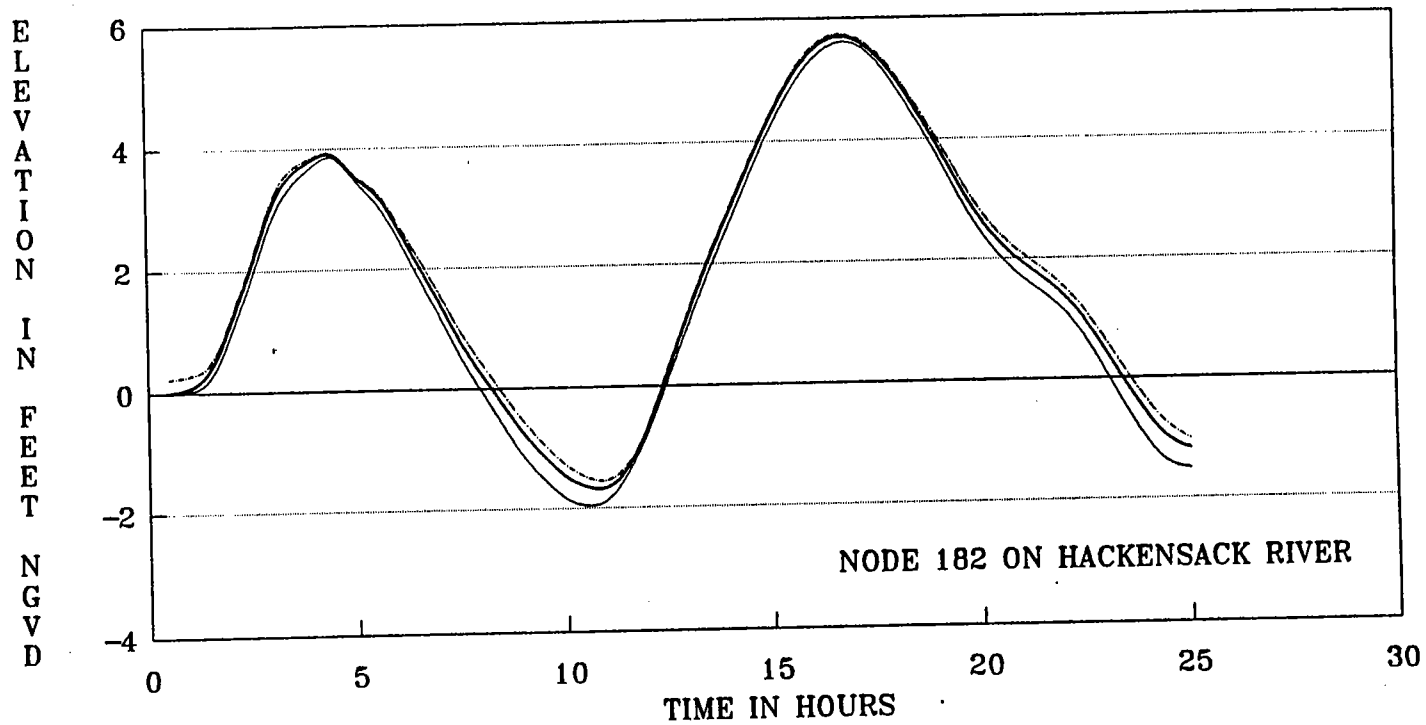
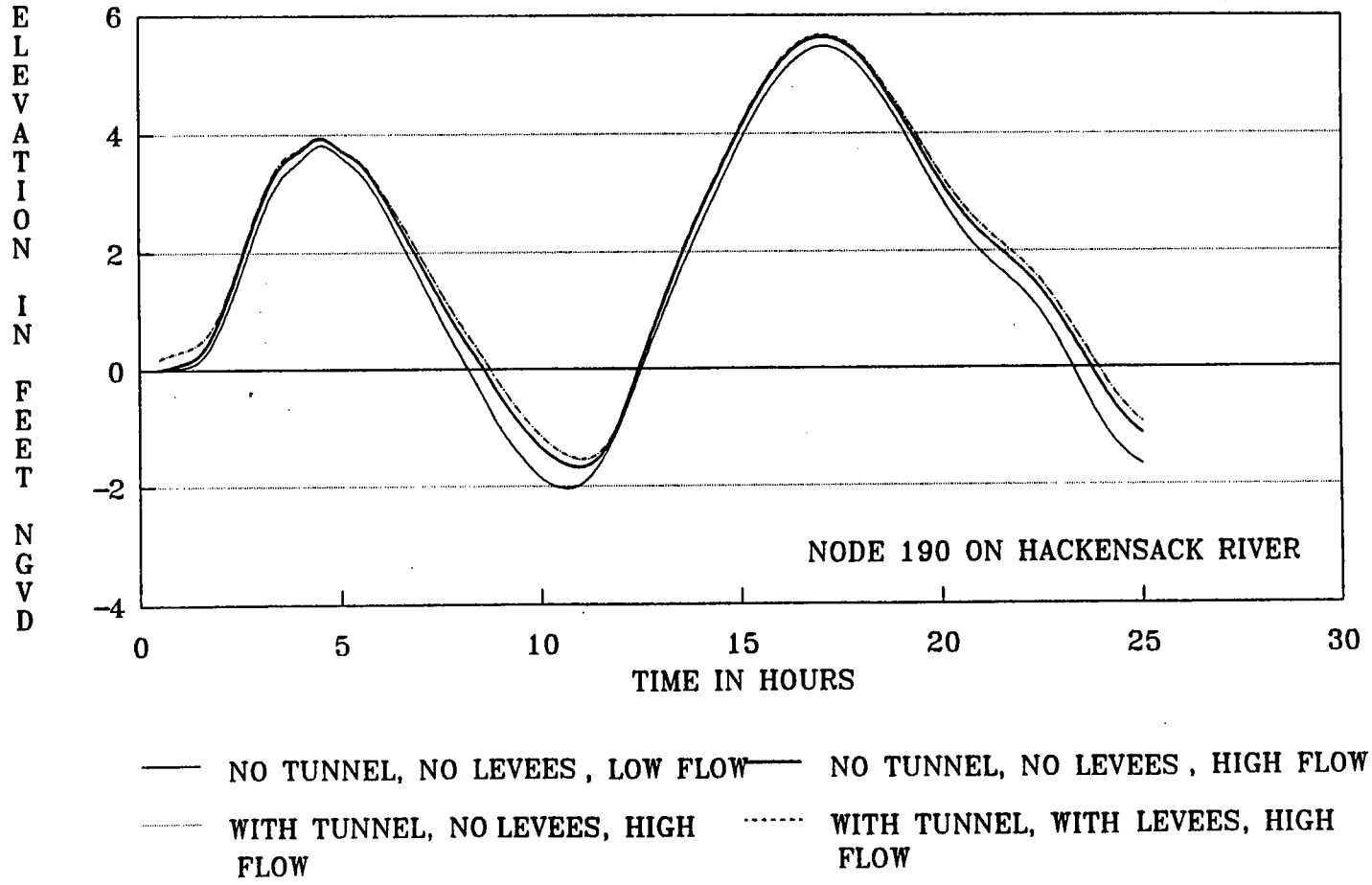


Figure 83. Predicted water level elevations at Berry's Creek for year 2050 conditions and synthetic hurricane 249



PART VIII: STAGE-FREQUENCY DISTRIBUTIONS FOR FUTURE CONDITIONS

100. The results of the sensitivity analysis demonstrate that the magnitude and distribution of river/diversion tunnel flows have little effect (less than 0.1 ft) on tidal elevations in the lower parts of the Passaic and Hackensack Rivers, and in Newark Bay. The effect of including flood protection levees in the vicinity of Kearny Point is to increase storm tide heights by less than 0.2 foot over future unimproved conditions in this vicinity and by less than 0.4 foot adjacent to Newark Airport. Consequently, once stage-frequency distributions have been developed for the future unimproved condition, the effects of future improvements, such as the tunnel and levee construction, will be small. The effect of the improvements on tidal elevations is within the accuracy of the development of the stage-frequency distributions, and it is standard practice to include an appropriate factor of safety in any design.

101. The 33 synthetic storms selected for a "modified bootstrap" of the underlying joint probability analysis, were simulated with a datum shift of 0.89 feet, which represents the estimated sea level rise from 1950-2050. Two scenarios were simulated: (1) future unimproved, with no levees or tunnel discharge, and one-year river flows in Passaic (5,285 cfs) and Hackensack (1,630 cfs) rivers; and (2) future improved, with levees, one-year river flows in the Passaic River (1,000 cfs in the river channel and 6,000 cfs in the tunnel, and one-year flow of 1,630 cfs in the Hackensack River. The resulting distributions at various locations in the system are shown on Figures 85 through 92.

102. It is important to recognize that the resulting stage-frequency distributions in these figures do not include the joint probabilities of significant river flows. As the effect of river flows in the lower part of the system is small, the stage-frequency distributions in these areas will be accurate. However, in the upper tidal portions of the Passaic and Hackensack Rivers, where the effects of river flows are significant, the stage-frequency curves represent purely coastal processes. For the primary aim of this study, we are focussing on the lower system, namely around Kearny Point, and have shown clearly that upstream flooding will not be significantly worsened by the discharges from the proposed diversion tunnel.

Figure 84. Predicted water level elevations at New Milford for year 2050 conditions and synthetic hurricane 249

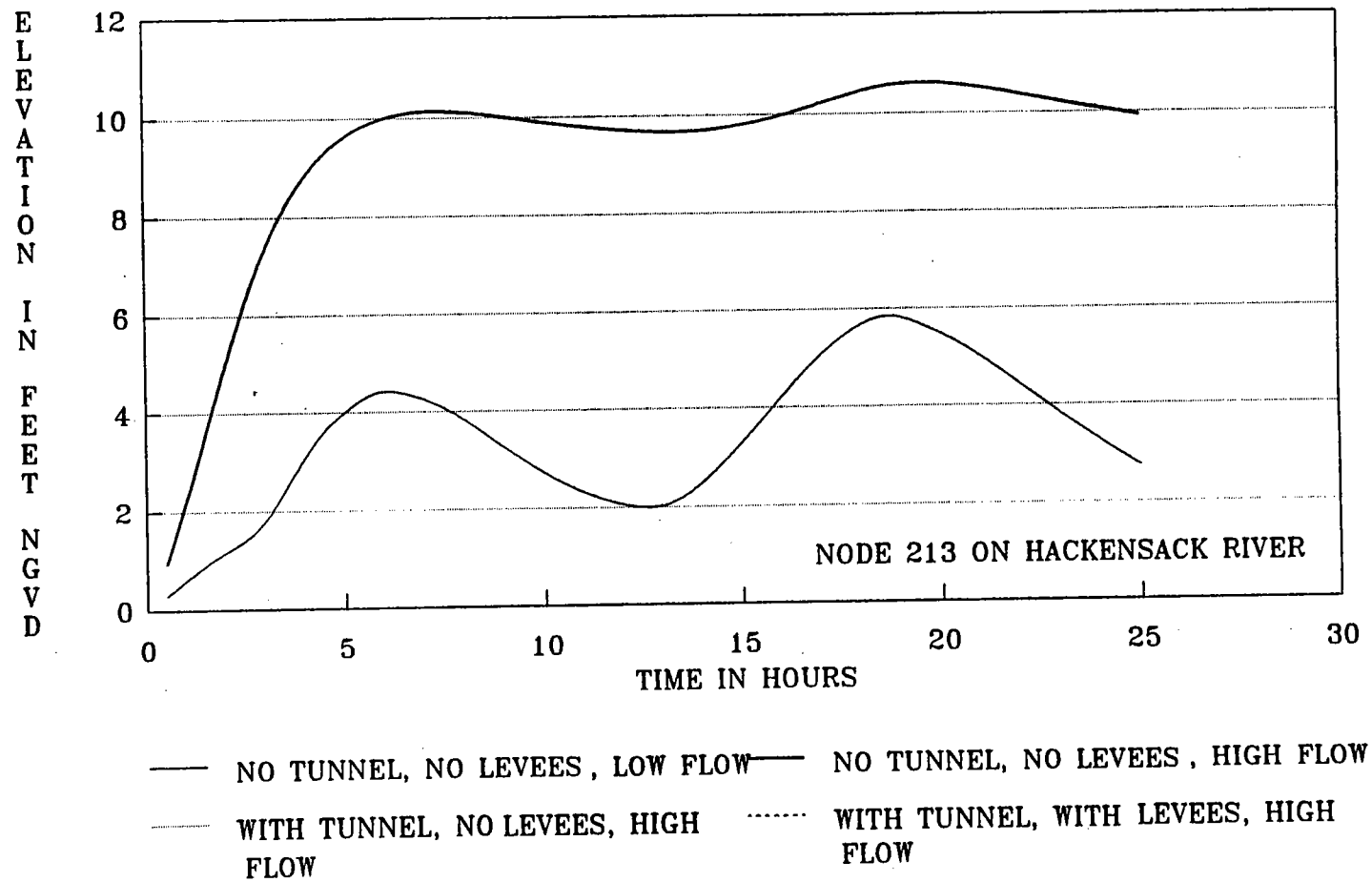


Figure 85. Stage-frequency curves for node 49 (Newark Airport) in Newark Bay for 33 synthetic storms

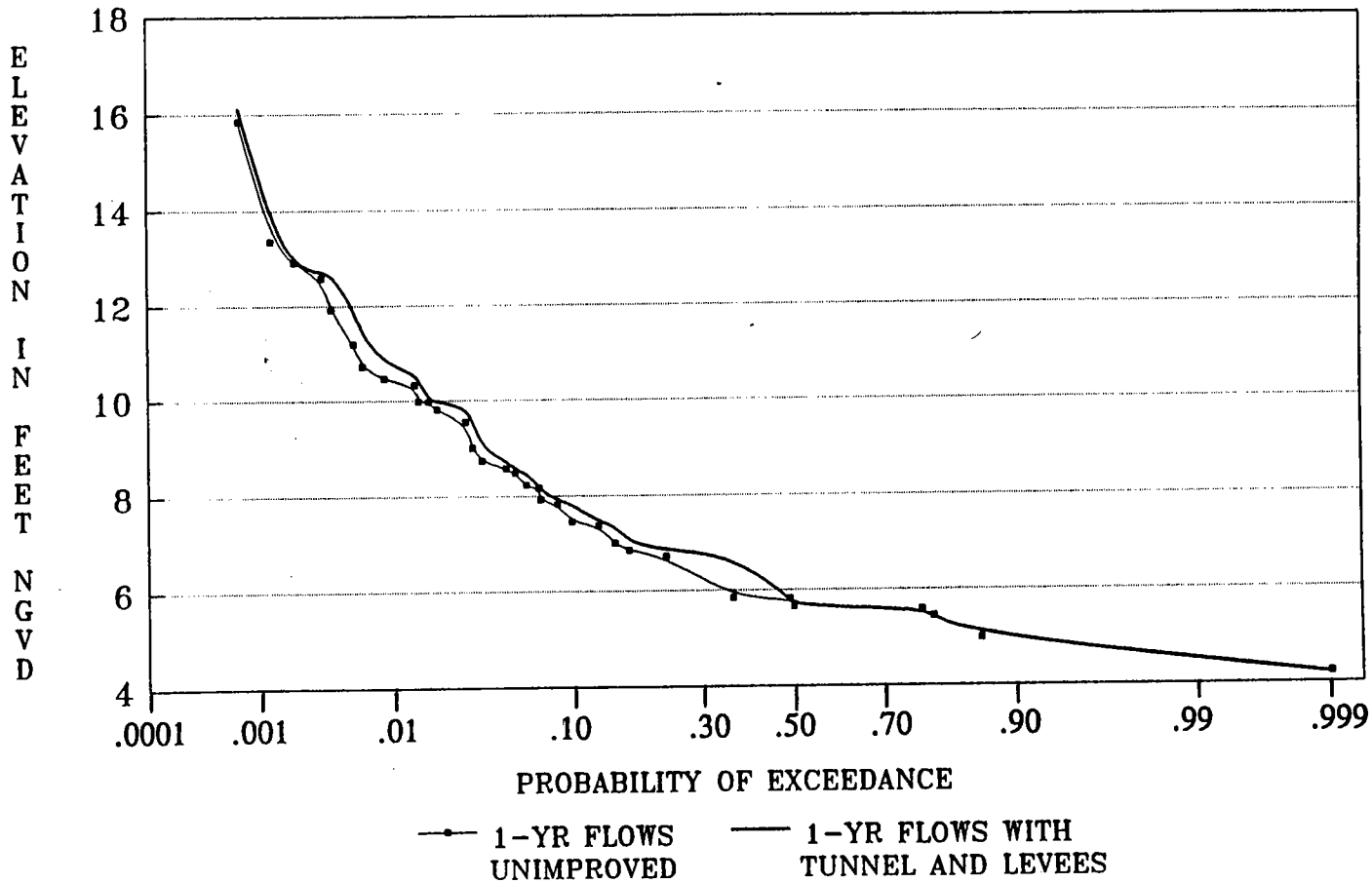


Figure 86. Stage-frequency curves for node 262 (Kearny Point) in Newark Bay for 33 synthetic storms

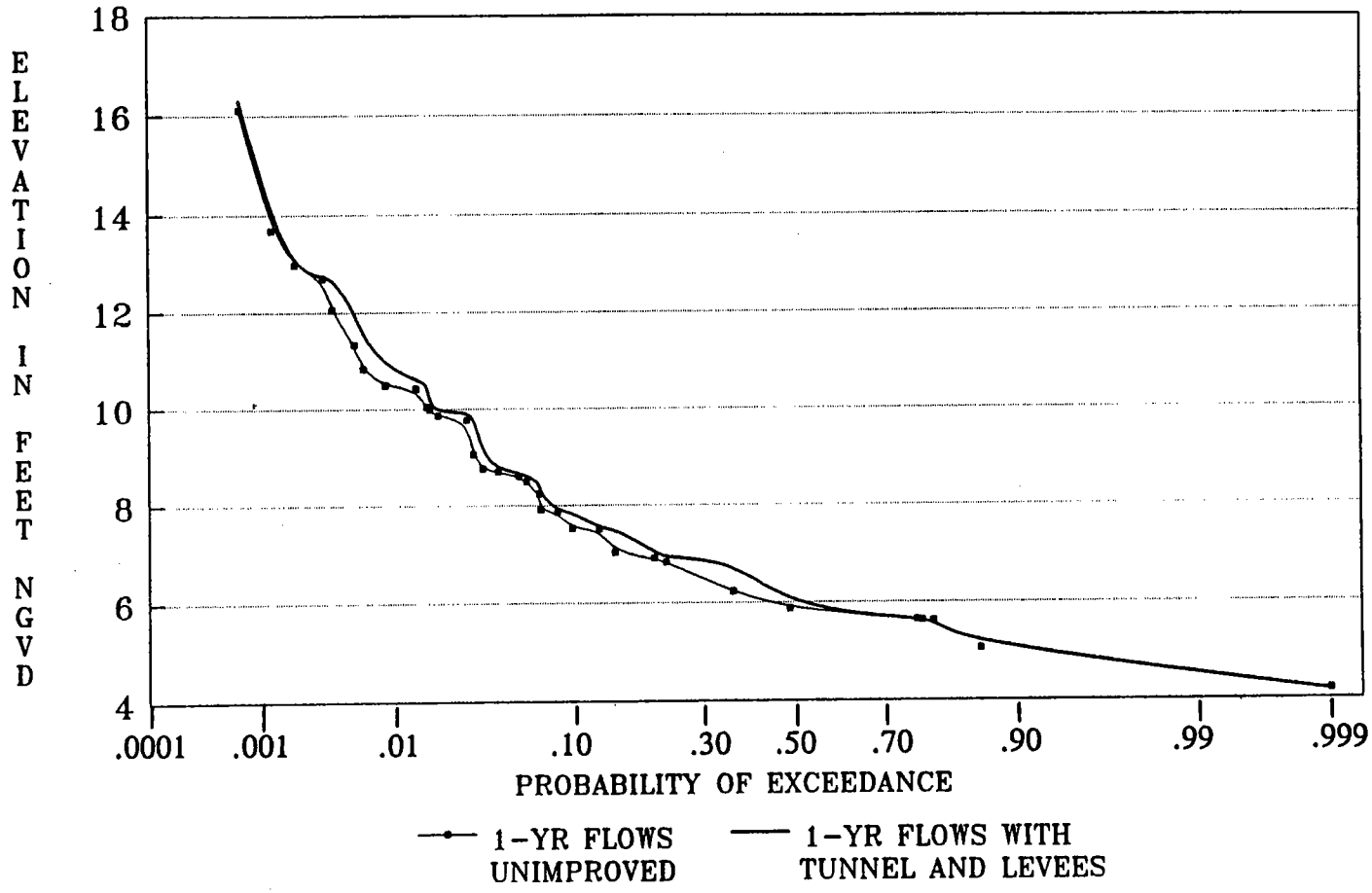


Figure 87. Stage-frequency curves for node 173 (East Newark) on the Passaic River for 33 synthetic storms

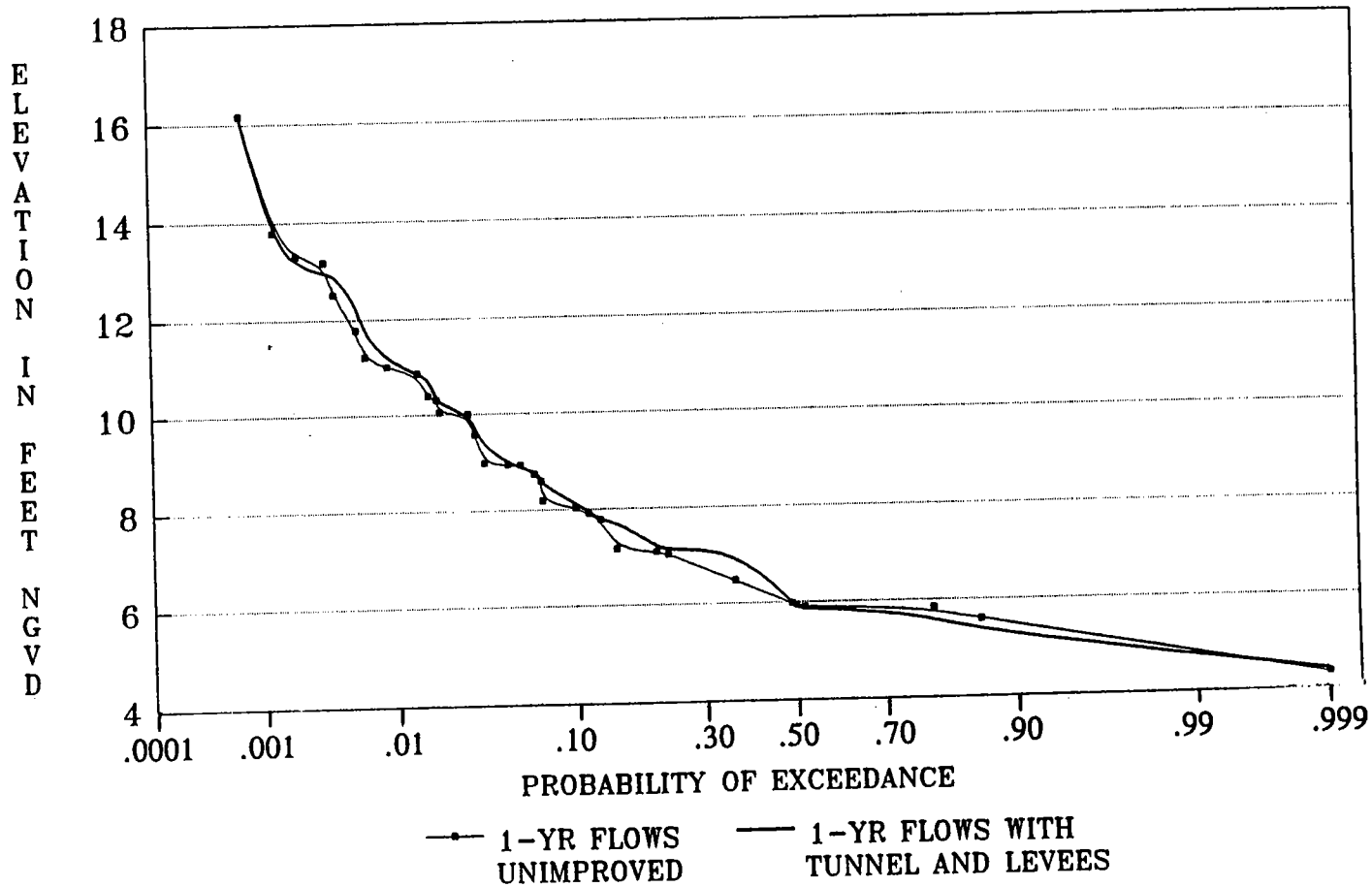


Figure 88. Stage-frequency curves for node 217 (Third River) on the Passaic River for 33 synthetic storms

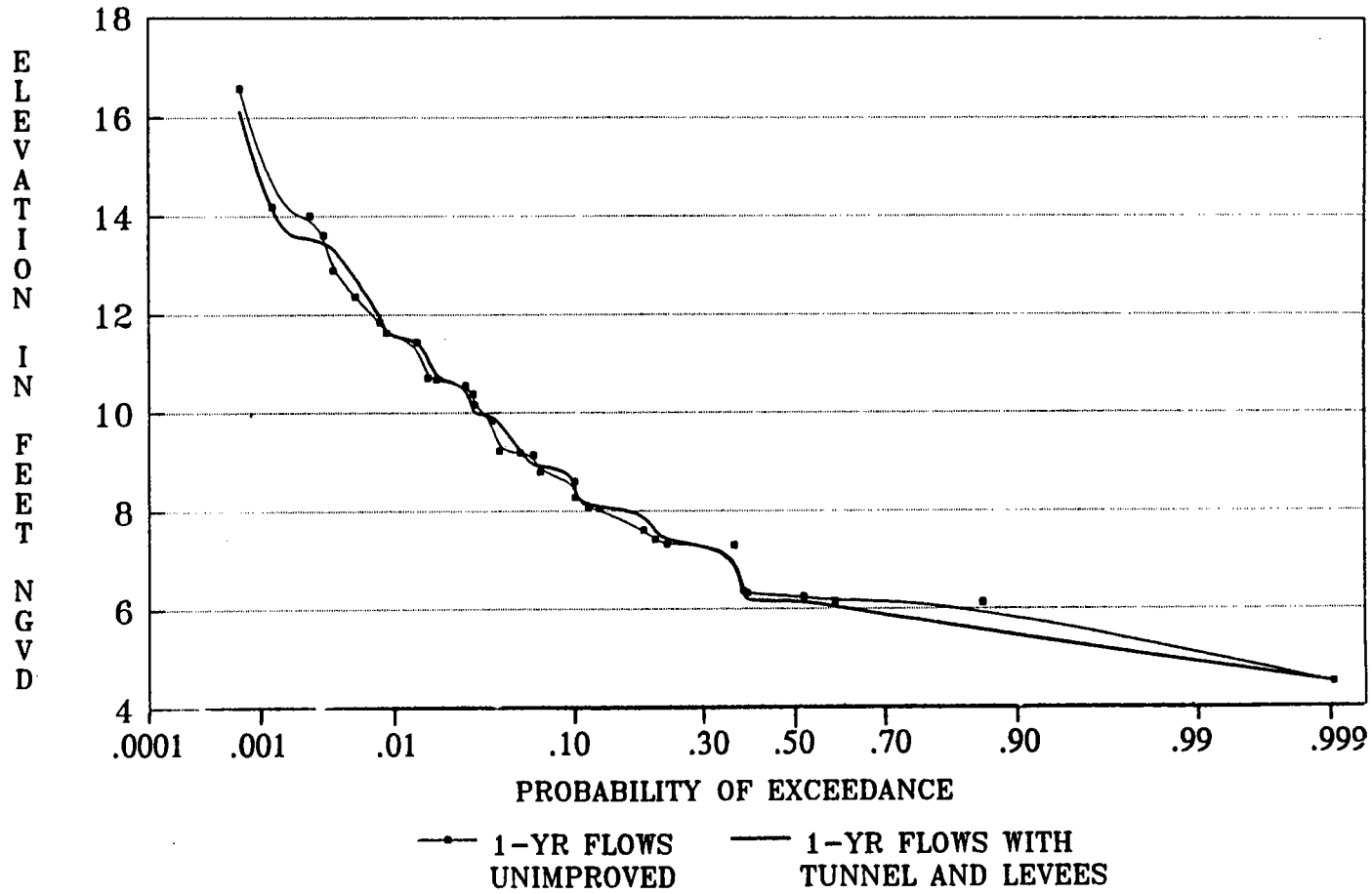


Figure 89. Stage-frequency curves for node 226 (Garfield) on the Passaic River for 33 synthetic storms

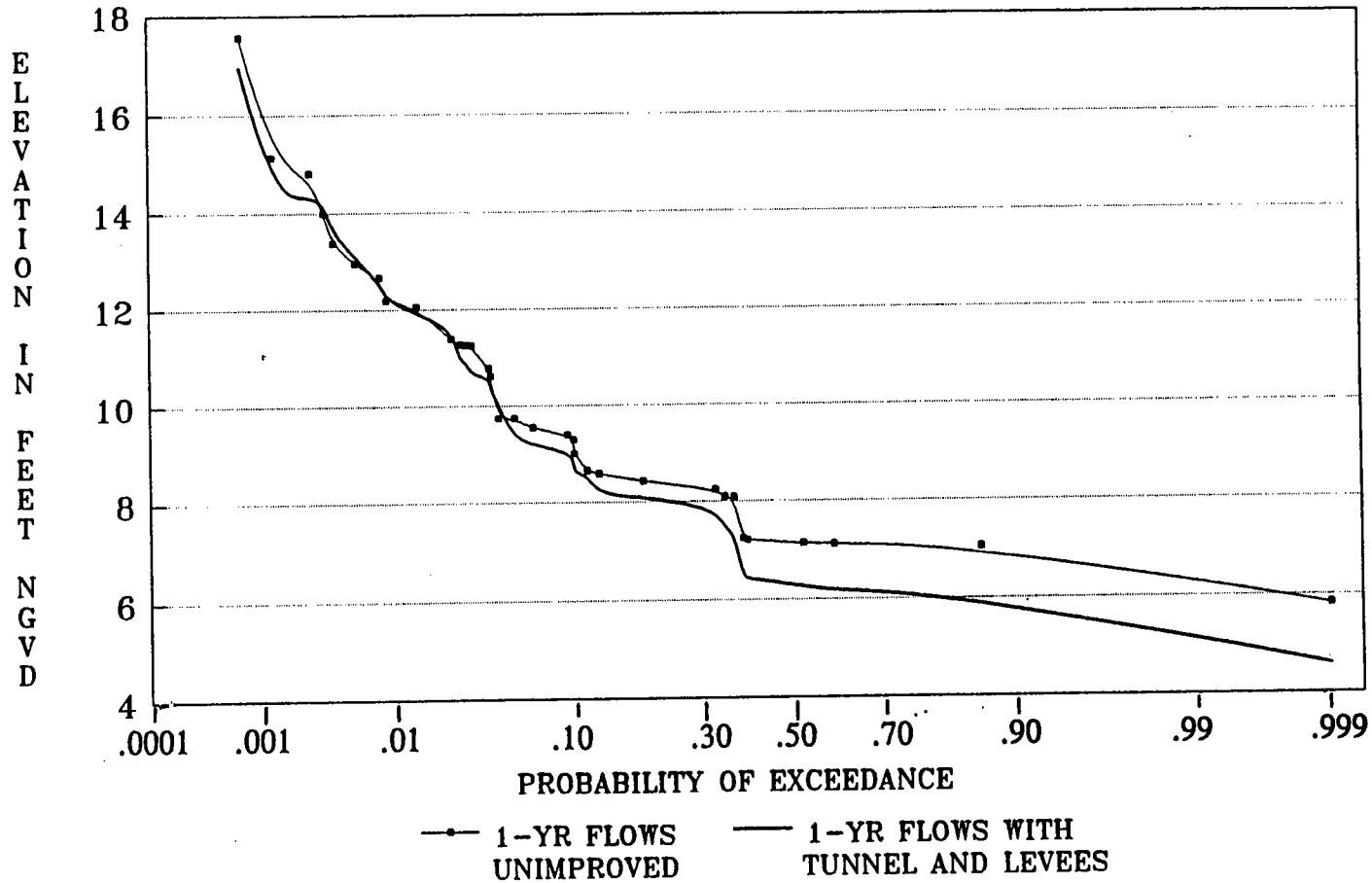


Figure 90. Stage-frequency curves for node 182 (Snake Hill) on the Hackensack River for 33 synthetic storms

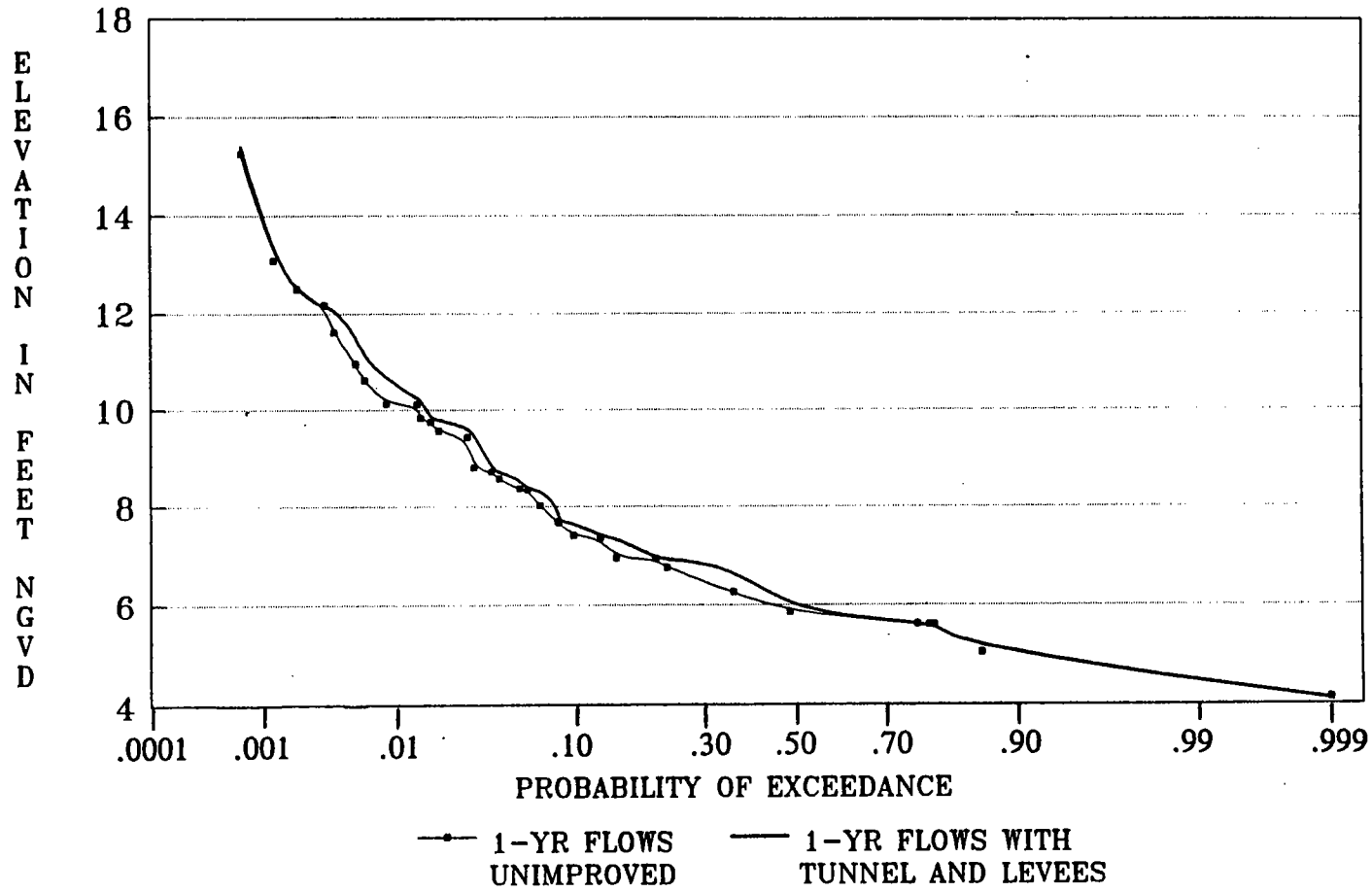


Figure 91. Stage-frequency curves for node 190 (Berry's Creek) on the Hackensack River for 33 synthetic storms

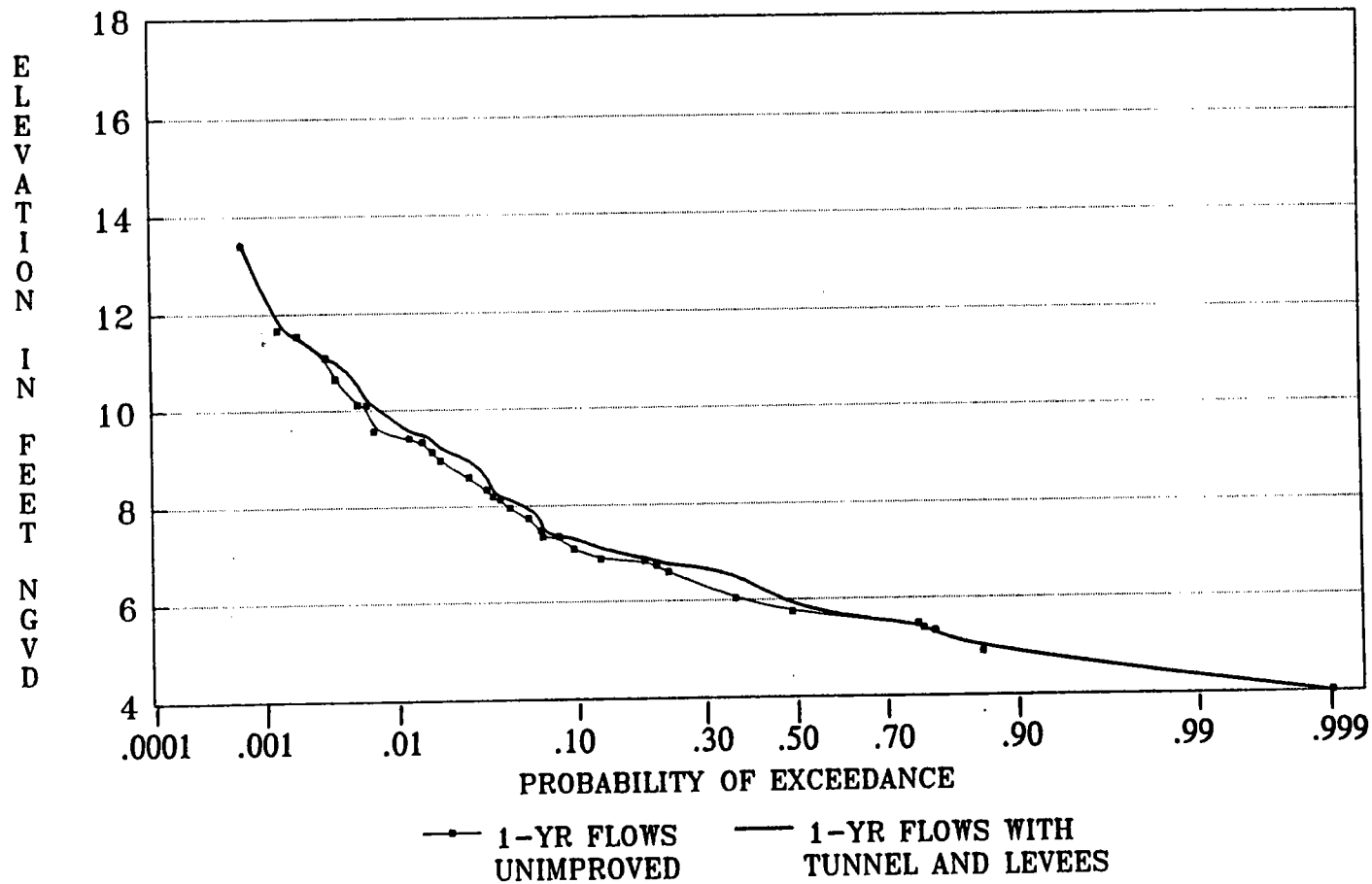
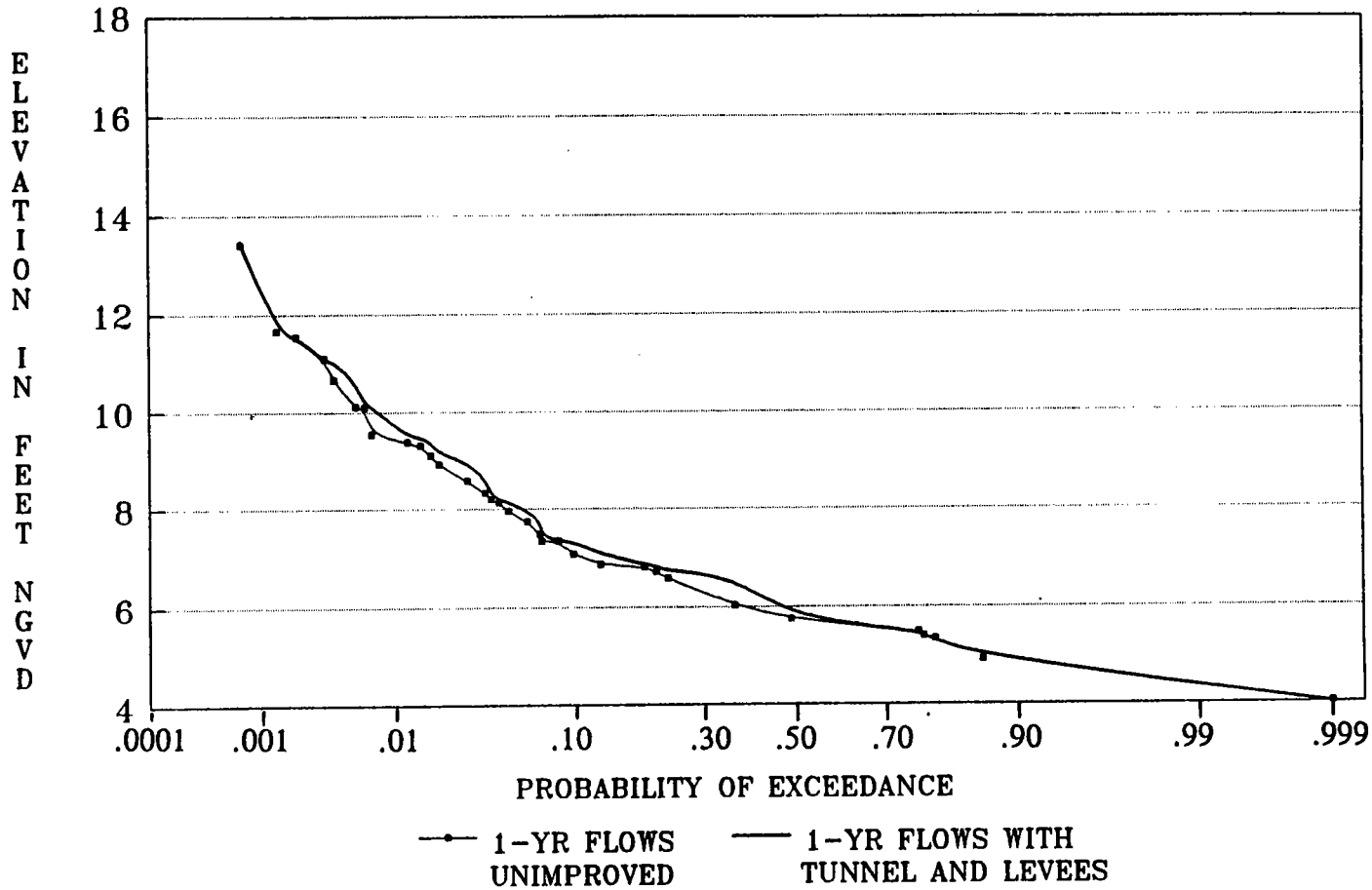


Figure 92. Stage-frequency curves for node 213 (New Milford) on the Hackensack River for 33 synthetic storms



PART IX: SUMMARY AND CONCLUSIONS

Summary

103. The New York Corps is proposing to build a 20-mile long, deep rock tunnel about 40 feet in diameter, to divert flood waters from the upper Passaic River Basin to Newark Bay. One objective of this study was to examine the effect that discharges from the diversion tunnel might have on tidal elevations in Newark Bay, and the lower tidal parts of the Passaic and Hackensack Rivers. Another objective was to develop stage-frequency curves at strategic locations for the design of storm tide levees. A particular concern was whether tunnel flows might be coincident with storm tide surges from New York Bight, and possibly lead to increased flooding in the downstream areas, such as the Meadowlands and Newark Airport.

104. To examine this possibility, a version of the Dynamic Estuary Model (DEM), previously applied to the system (CDM 1983a, 1983b, 1988), was revalidated for this study using recent hydrographic data. The revalidation, having increased resolution built into the model and incorporating more recent data, showed better agreement than previous studies.

105. A coincidence analysis was performed to examine the distributions of river flows and storm surges (the predicted tidal effect was removed). This analysis showed that there is a weak relationship between river flows and tidal elevations. Coincidences of large surges and large river flows were found to be extremely rare occurrences.

106. The statistical procedure used in the Hackensack River Surge Barrier Study (CDM 1988) was based on a "modified bootstrap" method. This method was applied to the underlying joint probability method analysis (CDM 1983a, 1983b). From the more than 70,000 surge/tide/lag combinations, 24 events were selected to provide a reasonable approximation of the stage-frequency distribution. For this study, we included an additional nine storms, for a total of 33 storm events. These events were selected to fill out the frequency distribution for return periods of less than 10 years and greater than 100 years.

107. As the future project conditions were developed for the year 2050, we examined the difference between mean sea level (MSL) and NGVD, and concluded that the previous studies (CDM 1983b, 1988) were based on a

correction appropriate for about 1950. Using an estimate of 2.7 mm/yr (0.0089 ft/yr) for sea level rise (NOAA 1988), we estimated a sea level rise of 0.89 feet between 1950 and 2050. This value was used to adjust the specified datum for future condition simulations in this study.

108. To reinforce the conclusions of the coincidence analysis, a sensitivity analysis was performed in which three tidal events [(1) a typical tide, (2) a small hurricane, and (3) a large hurricane] were simulated for four future conditions [(1) unimproved with a small river flow, (2) unimproved with a 100-year river flow, (3) improved with 100-year river and tunnel flows, and (4) improved with flood protection levees and 100-year river and tunnel flows]. The results showed that the magnitude and distribution of river and tunnel flows had a very small effect (less than 0.2 ft) on tidal elevations in the lower parts of the Passaic and Hackensack Rivers, and in Newark Bay.

109. Having concluded that the magnitude and distribution of river and tunnel flows had little effect on tidal elevations in the lower system, stage-frequency distributions for future unimproved conditions were developed at various locations using the 33 selected synthetic storm events and the one-year river flows in the Passaic and Hackensack Rivers. The effect on these stage-frequency distributions due to large river and/or tunnel flows will be small, generally on the order of a few tenths of a foot, which is within the accuracy of the model used in this study.

Conclusions

110. The revalidated DEM model more accurately simulated tidal elevations in the Passaic/Hackensack/Newark Bay system than previous studies. This was due to the updating and inclusion of more recent system geometry data. The model is therefore a valuable tool for simulating tidal and river flow scenarios in the system.

111. The coincidence analysis confirmed the findings of the Hackensack River Surge Barrier Study (CDM 1988) that large river flows are unlikely to coincide with large storm surges from New York Bight. Time-history plots of several individual events suggest that there is a relationship between storm tides and river flows, with the river flows lagged by several days, but they also serve to further demonstrate that the relationship is weak. In general, for a relative small surge, a wide range of river flows is possible. For a

relatively small (less than one-year) river flow, a wide range of storm surges is possible. However, large storm tides with large Passaic River flows (lagged by 0 to 2 days) are extremely rare events.

112. The data were further analyzed to determine the average surge condition that might occur within 72 hours of specific significant river flows. The results suggested that over the range of river flows observed, an average storm surge is on the order of 1.5 to 2 feet. Therefore, we conclude that, if a Passaic River flow model is to be developed to simulate significant flow events, the downstream boundary condition could be the superposition of an average tide plus a storm surge of 1.5 to 2 feet.

113. In a similar fashion, the data were also analyzed to determine the average Passaic River flow that might occur within 72 hours of storm surges of different elevations. The results showed that for all storm surge elevations observed, an average Passaic River flow of 1000-2000 cfs would be found. From this finding, we recommended (and used for this study) that the one-year river flows in the major tributaries of the system should be used for storm tide simulations. In the Passaic River, the one-year flow is in excess of 5000 cfs, or about three times the average flow coincident with a storm surge.

114. NOS concludes that sea level is rising at an approximate rate of 2.7 mm/yr (0.0089 ft/yr). Based on the previous model studies, we estimated a sea level rise of 0.89 feet in the 100 years from 1950 to 2050.

115. The sensitivity analysis performed for future conditions (including sea level rise) for three tide events and four river flow conditions, demonstrated that the distribution and magnitude of river and tunnel discharges has a very small effect (less than 0.1 ft) on tidal elevations in the lower part of the system, including the lower tidal parts of the Passaic and Hackensack Rivers and Newark Bay. The placement of flood protection levees around Kearny Point also has a small effect (less than 0.2 ft) on tidal elevations. Upstream in the tidal Passaic River, the effect of the Diversion Tunnel is to lower water elevations during significant river flow events. For example, even though the peak fresh water discharge to the lower Passaic may increase (from 33,645 cfs to 48,544 cfs) for the 100-year flow, flood elevations will be lowered by several feet as a result of the tunnel bypassing the upper part of the tidal river. The flood characteristics of the Hackensack remain essentially the same.

116. Finally, stage-frequency curves for various location in the system were developed using 33 synthetic storm events and the one-year river flows in the Passaic and Hackensack. The distributions are similar to the distributions developed previously (CDM 1983a, 1988) with an increase in overall elevations due to sea level rise. These distributions permit the selection of appropriate flood protection levees around Kearny Point to protect against a given return period storm surge event.

Summary Conclusions

117. From the analyses in this study, the following conclusions are drawn:

1. The coincidence of large storm tides and large river flows is an extremely unlikely combination, and can be treated as essentially independent events. However, the likelihood that somewhat elevated river flows occur following storm tides (by 0-2 days) is quite strong.
2. The tidal boundary condition for a river flow model of the Passaic River system could be the superposition of an average tide and a storm surge of 1.5 to 2 feet.
3. From the coincidence analysis, we concluded that it is reasonable to assume, as a conservative condition, that the one-year river flows in the Passaic and Hackensack, can occur with significant surge events. This conclusion is consistent with CDM (1988).
4. The coincidence analysis was used to develop a storm tide stage-frequency distribution of events in which the Passaic River flow exceeded 6000 cfs. This analysis can be used to determine appropriate tidal heights for design of tunnel outlet works.
5. Sea level rise is taken to be 2.7 mm/yr (0.0089 ft/yr), or 0.89 feet between 1950 and 2050.
6. The magnitude and distribution of significant river and tunnel discharges have a very small effect (less than 0.2 ft) on tidal elevation in the lower Passaic River, Hackensack River, and Newark Bay.
7. The effect of tunnel discharges to Newark Bay will have little effect (less than 0.1 ft) on the existing flood characteristics of

the Hackensack River, including the flood-prone areas in the vicinity of the Meadowlands.

8. The effect of tunnel discharges to Newark Bay will reduce river flood elevations in the upper tidal Passaic River by several feet.

9. The stage-frequency distributions developed for the vicinity of Kearny Point will assist in the selection of flood protection levee heights. The levees will be designed to protect against tidal surges with a given return period. The distributions in the upper tidal Passaic and Hackensack Rivers do not include the effect of significant river flows, and therefore reflect only tidal conditions.

10. The inclusion of future project conditions, including flood control levees in the vicinity of Kearny Point, changes the future unimproved stage-frequency distributions by less than 0.2 feet in the lower part of the Passaic and Hackensack Rivers, and in Newark Bay.

11. Dredging operation in the Kills and Newark Bay will have little effect on circulation and water levels in the study area. Water levels may change by less than 0.15 feet, and the tidal phase may be altered by less than 1/2 hour.

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APPENDIX A:

USERS GUIDE FOR NEWARK BAY VERSION OF THE DYNAMIC ESTUARY MODEL -- DEMNEWARK

APPENDIX A: USERS GUIDE FOR NEWARK BAY VERSION OF THE DYNAMIC ESTUARY MODEL -- DEMNEWARK

User Considerations

A1. An early version of the Dynamic Estuary Model (DEM) was developed by Water Resources Engineers (1977). It was the first version to incorporate wetting and drying. The code was substantially modified for a hurricane surge study of the New York Bight area (CDM 1983a) and was used in this form for the Passaic River surge study (CDM 1983b). For the Hackensack River surge barrier study (CDM 1988), the code was further modified to include culverts and broad-crested weirs (to simulate barrier overtopping). This version was called DEMHACK. For the Passaic River Flood Control Study, described in this report, the Hackensack River study version was again modified somewhat, to be compatible with Ebasco's graphics system. However, the input formats are unchanged. This version is called DEMNEWARK.

A2. The program is written in FORTRAN and compiled using a FORTRAN-77 compiler. However, the code uses no conventions for specific computers and should run on any computer using FORTRAN-77 with minor changes.

A3. The memory required by the program should be tailored to the specific study being performed using the PARAMETER statements located in the main program and each subroutine. The maximum number of nodes or junctions (MXJ) and links or channels (MXC) and the maximum number of channels entering a junction (MCH) are set in these statements and used to dimension the various arrays.

A4. The memory use and run time requirements vary with the size of the network being simulated and the computer used. To provide guidance for the user, the small-scale grid of the Newark Bay area has 176 nodes and 263 links. Using a time step of 60 seconds, one hour of simulated time required 41 seconds on an AST 386/33 with a math coprocessor (or about 0.7 seconds per time step). The source and executable codes require approximately 150 KB and 200 KB of memory each.

Data Input Description

A5. The program inputs are supplied on 14 card groups, A through N, as summarized on Table A1. The actual input descriptions are given in Tables A2 and A3. In this table, the variable types A, F and I are used for alphanumeric, floating point real, and integer, respectively.

A6. There are three input files and two output files (see Figure A1). The three input files are:

1. The basic input information (as described below except card groups J and K);
2. The grid file of node and link information (card groups J and K); and
3. Hurricane or northeaster boundary condition data from the Tetra Tech model of New York Bight [if ISWCH(3) = 2 or 3, respectively].

A7. The first two files are described in Tables A1 and A2. The third file (the hurricane or northeaster file) is a binary file created from the Tetra Tech model of New York Bight and is not described here. Example input files are listed in Appendix B.

Output Description

A8. The program creates two output files (see Figure A1). The first is a tabular output file in which input data is echoed, if the appropriate options are specified, and velocities/flows and heads are printed as time histories at each link or node for each day of the simulation. The second file is a "heads" output file which contains heads at specified nodes every half hour for the simulation period. This file is the basis of all the time-history plots in this report, and is created by editing the file and reading it into an appropriate graphics package. The output for the input file listed in Appendix B is listed in Appendix C.

Table A1

DEMNEWARK Input Card Groups

Card Group	Brief Description
A	Alphanumeric run description
B	Job control switches
C	Grid printout control
D	Job control information
E	Rain input cards
F	Head plot junction numbers
G	Tidal boundary cards
H	Wind speed and direction cards
I	Map scale and input datum reference
J	Junction cards (nodes)
K	Channel cards (links)
L	Junctions for plotting elevations
M	Inflow hydrographs
N	Historical tidal boundary inputs

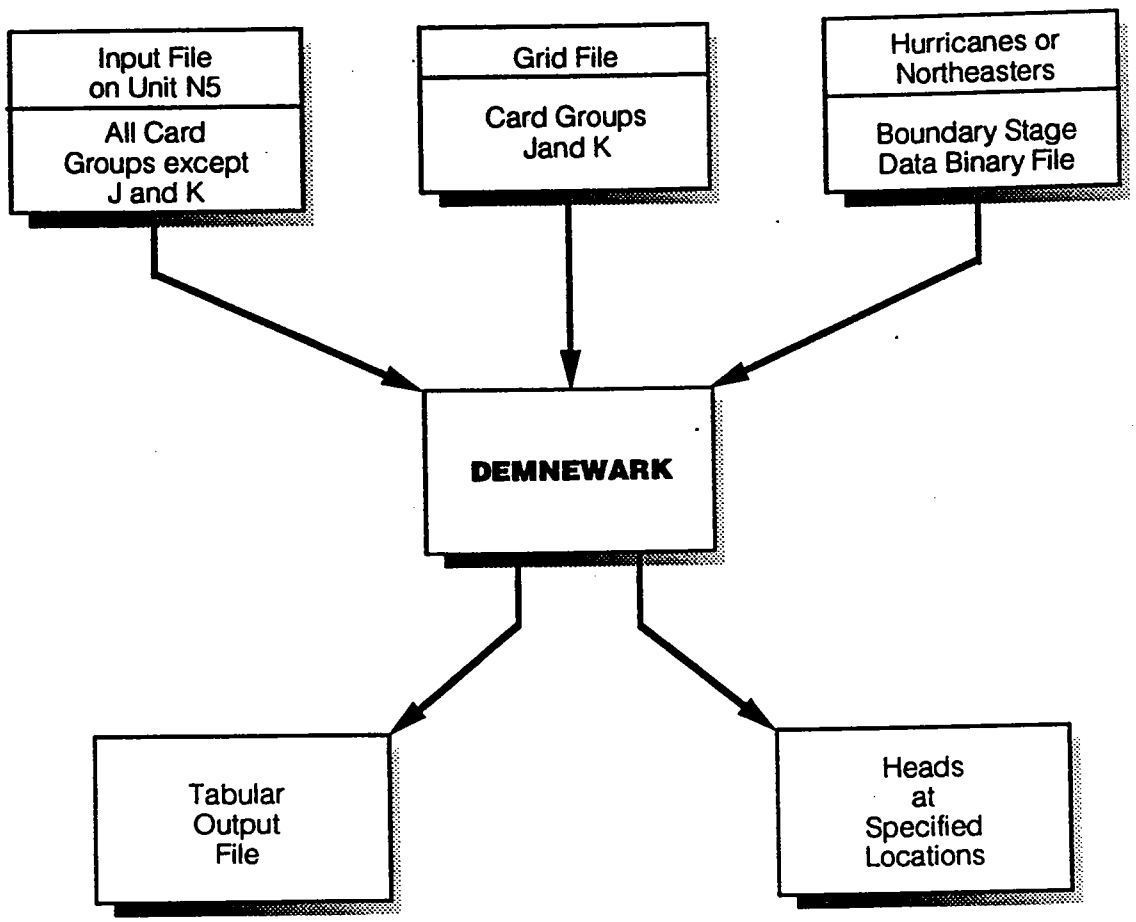

Figure A1. Flow chart of DEMNEWARK

TABLE A2
BASIC INPUT DATA DESCRIPTION

Card Group Card Number	Card Columns	Variable Name	Variable Type	Variable Description
A: ALPHANUMERIC RUN DESCRIPTION				
A 1	1-80	ALPHA	A	User Identification Information
A 2	1-80	ALPHA	A	User Identification Information
A 3	1-80	TITLE	A	Simulation Title
A 4	1-80	TITLE	A	Simulation Title
B: JOB CONTROL SWITCHES				
B 1	1-5	ISWCH(1)	I	1 - Tidal system 2 - Non-tidal system (e.g., lake)
	6-10	ISWCH(2)	I	0 - No action 1 - Suppresses printout of channel and nodal parameters
	11-15	ISWCH(3)	I	0 - No time series elevation boundary condition data used 1 - Read elevation boundary condition data from this file 2 - Read hurricane data from separate file 3 - Read northeaster data from separate file
	16-20	ISWCH(4)	I	0 - Not used
	21-25	ISWCH(5)	I	0 - Print channel velocities and flows 1 - Skip channel printout
	26-30	ISWCH(6)	I	0 - Not used
	31-35	ISWCH(7)	I	0 - Not used
	36-40	ISWCH(8)	I	0 - No action 1 - Prints first wind and pressure information and terminates program (used for diagnostic checking)
	41-45	ISWCH(9)	I	0 - Wind forcing not imposed 1 - Wind forcing included
	46-50	ISWCH(10)	I	0 - No action 1 - Surge elevations saved at 1/2 hour intervals -1 - Maximum surge elevation and time of occurrence saved

TABLE A2, continued
BASIC INPUT DATA DESCRIPTION

Card Group Card Number	Card Columns	Variable Name	Type	Variable Description
C: GRID PRINTOUT CONTROL				
C 1	1-5	ICHAR	I	0 - No action 1 - Produces line printer "map" of link-node grid network
	6-10	XMIN	F	Minimum X for grid
	11-15	XMAX	F	Maximum X for grid
	16-20	YMIN	F	Minimum Y for grid
	21-25	YMAX	F	Maximum Y for grid
D: JOB CONTROL INFORMATION				
D 1	1-5	NDAYS	I	Number of printout days (or cycles) simulated
	6-10	NPRNT	I	Number of printout timesteps per day (< 26). Usually equal to 25.
	11-15	PSTP	F	Printout timestep (hours). Usually equal to one hour.
	16-20	DELT	F	Hydraulic timestep (seconds).
	21-25	TZERO	F	Initial time of simulation (hours).
	26-30	NPLT	I	Number of stage plots (<51) (Card group F)
	31-35	EVAP	F	Evaporation rate (inches per month).
	36-40	AVGHEA	F	Average head used when finding high and low tides. Set to 0.
	46-50	NPSWRT	I	Day cycle when printed output will start.
	51-55	NQSWRT	I	Number of day cycle when switching from curve fit to measured tidal stages.
	56-60	NJSW	I	Number of junctions of hydrograph input from cards (<21) (Card group M)
	61-65	INRAIN	I	Number of points of rain information (<51) (Card group E)
	66-70	NBOUND	I	Number of tidal boundary nodes (<51) (Card group G)

TABLE A2, continued
BASIC INPUT DATA DESCRIPTION

Card Group Card Number	Card Columns	Variable Name	Variable Type	Variable Description
E: RAIN INPUT CARDS				
	If INRAIN = 0 Skip Card Group E			
	INRAIN pairs of values with four per card			
E 1	1-10	RAIN(1)	F	Rate of precipitation (inches per hour)
	11-20	INTIME(1)	F	Time from start of simulation (minutes)
	.		.	
	.		.	
	.		.	
	61-70	RAIN(4)	F	Etc., up to INRAIN pairs
	71-80	INTIME(4)	F	
F: HEAD PLOT FUNCTION NUMBERS				
	If NPLT = 0 Skip Card Group F *(note: If ISWCH(10) ≠ 0, plots are also sent to unit 41)*			
	Junction Numbers to be Plotted, NPLT values with eight per card.			
F 1	1-10	JPLT(1)	I	Junction number to be plotted
	.		.	
	.		.	
	.		.	
	71-80	JPLT(8)	I	Junction number to be plotted

TABLE A2, continued
BASIC INPUT DATA DESCRIPTION

Card Group Card Number	Card Columns	Variable Name	Type	Variable Description
G: TIDAL BOUNDARY CARDS				
		If ISWCH(1) = 2, Skip Card Group G		
This card group is repeated for each of the NBOUND tidal boundary nodes. If NQSWRT = 1, only the boundary junction number (JGW) need be specified using only the first card. Otherwise this card group supplies the information required to perform a curve fitting through the specified points to be subsequently used as the boundary condition.				
G 1	1-5	KO	I	1 - Only two maximum and two minimum tide elevations will be used for curve fitting. NI must equal 4. 0 - Additional points are read in.
	6-10	NI	I	Number of tidal stage data points (<50).
	11-15	MAXIT	I	Maximum number of iterations for curve fitting (<50).
	16-20	NCHTID	I	0 - Skips tidal curve fitting printout. 1 - Provides printout of curve fitting calculations
	21-25	JGW	I	Junction number of boundary
	26-35	PERDT	F	Length of tidal day (hours)
G 2	1-10	TT(1)	F	Time (hours) from beginning of simulation of tidal stage, first point.
	11-20	YY(1)	F	Tidal stage (feet), first point
	.		.	
	.		.	
	.		.	
	.	TT(NI)	F	Time (hours from beginning of simulation of tidal stage, last point)
	.	YY(NI)	F	Tidal stage (feet), last point (use additional cards if needed)

TABLE A2, continued
BASIC INPUT DATA DESCRIPTION

Card Group Card Number	Card Columns	Variable Name	Variable Type	Variable Description
H: WIND SPEED AND DIRECTION CARDS				
	If ISWCH(3) = 0, Skip Card Group H			
	Three Values per Card with up to 50 Cards			
H1	1-10	TIMW(1)	F	Time of wind change (hours). TIMW ≥ 99999 terminates wind input.
	11-20	TWIND(1)	F	Wind magnitude (mph).
	21-30	TWDIR(1)	F	Wind direction, degrees measured counter-clockwise from north to direction in which wind is blowing.
I: MAP SCALE AND INPUT DATUM REFERENCE				
I1	1-10	ISCALE	I	Scale of map used to measure x and y locations, and channel lengths. Program converts input in inches, on map, to feet. If input is in feet, ISCALE = 12.
	21-30	WRFACT	F	Wind reduction factor.
	31-40	DATUM	F	Datum correction in feet (positive upward).
	41-50	FACTN	F	Manning's n reduction factor.
L: JUNCTIONS FOR PLOTTING ELEVATIONS				
	If ISWCH(10) = 0, Skip Card Group L			
L1	1-5	NPTS	I	Number of plotting locations
L2	1-5	NODES(1)	I	First plotting location
	.			
	.			
	.			
	75-80	NODES(16)	I	Sixteenth plotting location
	(use extra L2 cards as needed)			

TABLE A2, continued
BASIC INPUT DATA DESCRIPTION

Card Group Card Number	Card Columns	Variable Name	Type	Variable Description
M: INFLOW HYDROGRAPHS				
	If NJSW = 0, Skip Card Group M			
	Nodes where inflow will occur - 16 values per card up to the maximum of NJSW or 20 nodes.			
M1	1-5	JSW(1)	I	Node for inflow number 1.
	.			
	.			
	.			
	75-80	JSW(16)	I	Node for inflow number 16.
M2: INFLOW TIME HISTORY				
	If NJSW = 0, Skip Card Group M2			
M2*	1-10	TEP	F	Time (hours) of following inflows.
	11-20	QE(1)	F	Inflow (ft^3/sec) for first inflow point.
	.	.	.	
	.	.	.	
	.	.	.	
	71-80	QE(7)	F	Inflow (ft^3/sec) for seventh input point.
	(use additional cards if NJSW>7)			

Note: *M2 and N1 cards are ordered together through time with M2 cards first if TEP = TEB.

TABLE A2, continued
BASIC INPUT DATA DESCRIPTION

Card Group Card Number	Card Columns	Variable Name	Variable Type	Variable Description
N: HISTORICAL BOUNDARY STAGE DATA				
Data for boundary nodes are entered in the same order as in card group G. Time and heads (feet) referenced to output datum for NBOUND boundary junctions with seven values on first card and eight values on subsequent cards as needed if NBOUND is greater than seven.				
N1*	1-10	TEB	F	Time (hours) of following head inputs when switching from curve fit to historical inputs. TEB must be ≥ the start of first day as specified by NQSWRT. The time of final changes must be ≥ end of simulation.
	11-20	HEB(1,2)	F	Head for first boundary.
	21-30	HEB(2,2)	F	Head for second boundary.
	31-40	HEB(3,2)	F	Head for third boundary.
	.		.	
	.		.	
	.		.	
	71-80	HEB(7,2)	F	Head for seventh boundary.

Note: *M2 and N1 cards are ordered together through time with M2 cards first if TEP = TEB.

TABLE A3
GRID FILE DESCRIPTION

Card Group Card Number	Card Columns	Variable Name	Variable Type	Variable Description
J: JUNCTION CARDS				
(Note: Junction surface area is based on triple trapezoid shown in Figure A2)				
J1	1-5	J	I	Junction number; 99999 terminates junction input. Numbers need not be continuous.
	6-10	HEAD	F	Initial or starting water surface elevation (feet) referenced to output datum plane, also used as a minimum elevation reference for continuous Manning's n, and nodal area calculations (upward from datum plane is positive).
	11-20	SURF	F	Junction bottom surface area (ft^2x10^6)
	21-30	QF1	F	Constant diversion (flow) into junction (1000 cfs).
	31-40	DT	F	Depth of junction (feet) referenced to input datum.
	41-50	SH0	F	Height to first area breakpoint (feet - see Figure A2).
	51-60	SAN	F	Increase in surface area (ft^2x10^6) per foot of head over first interval (see Figure A2).
	61-65	SH1	F	Height to second breakpoint (feet - see Figure A2).
	66-70	SAN1	F	Increase in surface area (ft^2x10^6) per foot of head above second breakpoint (see Figure A2).
	71-75	X1	F	x - coordinate (inches) (converted to feet using ISCALE).
	76-80	Y1	F	y - coordinate (inches) (converted to feet using ISCALE).

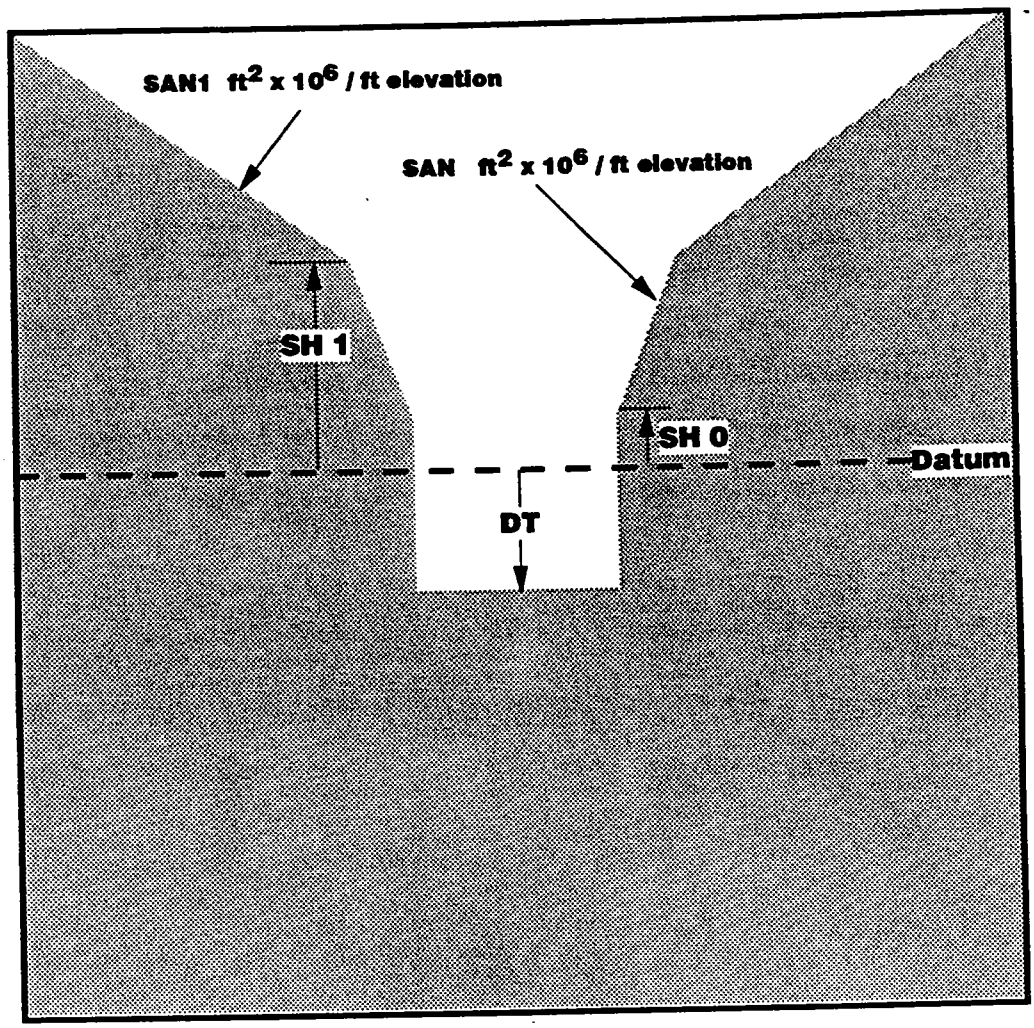

Figure A2. Schematic of junction surface areas

TABLE A3, continued
GRID FILE DESCRIPTION

Card Group Card Number	Card Columns	Variable Name	Type	Variable Description
K: CHANNEL CARDS				
(Note: Channel area based on double trapezoid shown in Figure A-3.)				
K1	1-5	N	I	Channel number (99999 terminates input). Numbers need not be continuous.
	6-10	N1	I	Junction at one end of channel (order not important).
	11-15	N2	I	Junction at other end of channel.
	16-20	ZZ1	F	Inverse side slope over first interval (see Figure A3).
	21-25	ZZ2	F	Inverse side slope over second interval (see Figure A3).
	26-35	ALEN	F	Length of channel (feet). If unspecified or zero, program will compute from coordinates of end junctions.
	36-45	WIDTH	F	Bottom width of channel (feet). Diameter of circular culvert (INDIC8=3).
	46-55	DEPTH	F	Depth from input datum to channel bottom (feet - positive downward). Depth to invert of culvert (INDIC8=2 or 3).
	56-65	COEF	F	Manning's coefficient.
	66-70	CHCA	F	Height to cross-section breakpoint (feet - see Figure A-3). Elevation of weir crest (INDIC8=1). Height of box culvert (INDIC8=2).
	71-75	VEL	F	Initial velocity (ft/sec). Flow ($10^3 ft^3/s$) of pumping across weir structure (INDIC8=1).
	80	INDIC8	I	0 - regular channel 1 - broad-crested weir 2 - box culvert 3 - circular culvert

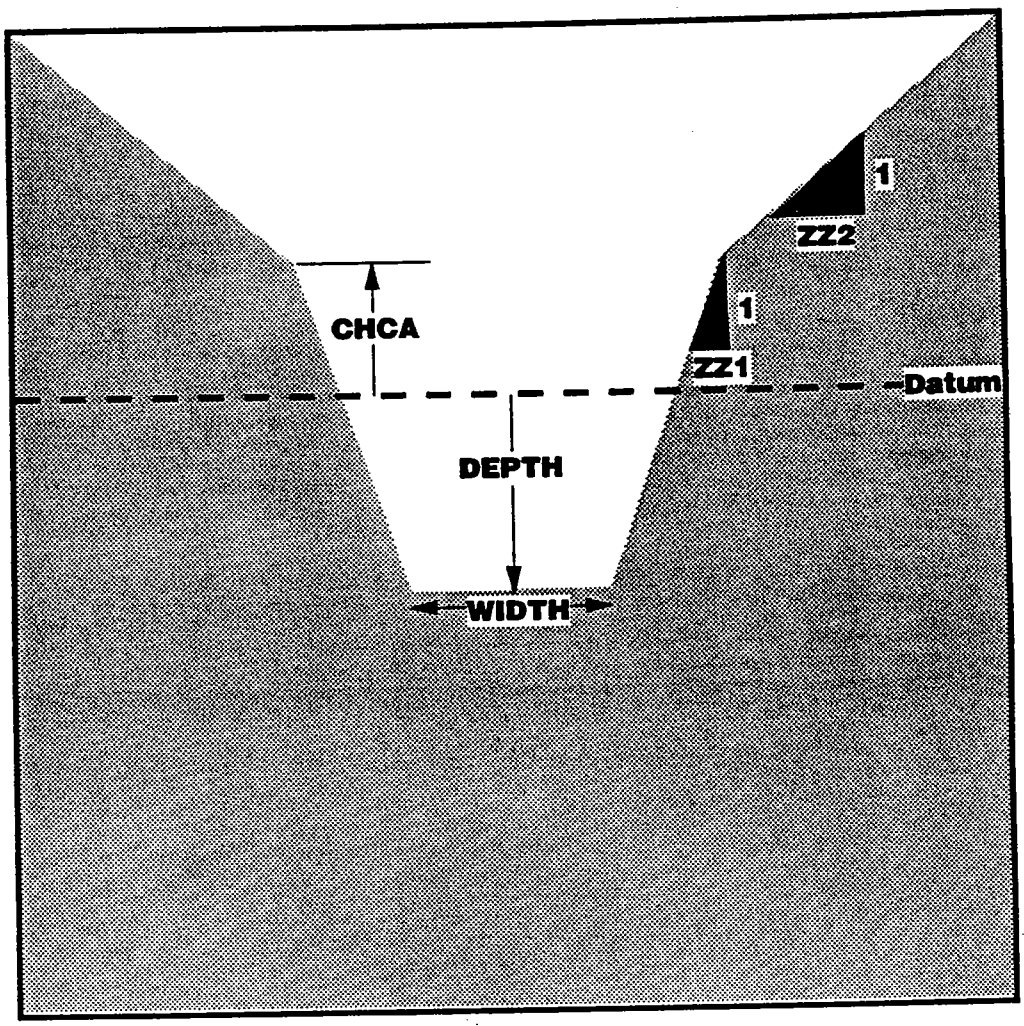

Figure A3. Schematic of link cross-section

APPENDIX B:

SAMPLE INPUT FILES

B1: CONTROL FILE

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PASSAIC RIVER FLOOD PROTECTION STUDY
 OCTOBER TIDE 11-13 1976   RAN  FEBRUARY 1992
 FORCING AT NODES 1, 2, 3, AND 4.
    APPROXIMATE ACTUAL FLOWS IN RIVERS
   1    0    0    0    1    1    0    0    0    1
 C 0  2.3 14.2  7.3 24.9
 D 3   25   1.  60.  0.0    0                   1    1    3         4
 O 1    4   50    1    1       25.
   1    4   50    1    2       25.
   1    4   50    1    3       25.
   1    4   50    1    4       25.
 I 125000       0.25         0.       1.00
  19
  12   62  168  175  221  226  167  182  242  195  200  206  211  213   43   35
 136  137  138
 229  214  209
        0.      1000.       100.        30.
       0.0     -0.28      -0.28      -0.28       2.67
      40.1      744.        74.        25.
       1.0    -1.020     -1.020     -1.020      2.62
       2.0    -1.650     -1.650     -1.650      1.85
       3.0     -1.92      -1.920     -1.920      0.56
       4.0    -1.570     -1.570     -1.570     -0.84
       5.0    -0.510     -0.510     -0.510     -1.97
       6.0     0.840      0.840      0.840     -2.68
       7.0     1.970      1.970      1.970     -2.65
       8.0     2.720      2.720      2.720     -1.63
       9.0     3.070      3.070      3.070     -0.23
      10.0     2.890      2.890      2.890      1.44
      11.0     2.160      2.160      2.160      2.96
      12.0     0.990      0.990      0.990      3.91
      13.0    -0.160     -0.160     -0.160      4.04
      14.0    -1.040     -1.040     -1.040      3.23
      15.0    -1.490     -1.490     -1.490      1.88
      16.0    -1.360     -1.360     -1.360      0.29
      17.0    -0.640     -0.640     -0.640     -1.18
      18.0     0.400      0.400      0.400     -2.29
      19.0     1.350      1.350      1.350     -2.73
      20.0     2.080      2.080      2.080     -2.28
      21.0     2.510      2.510      2.510     -1.07
      22.0     2.550      2.550      2.550      0.38
      23.0     2.120      2.120      2.120      1.90
       24.     1.300      1.300      1.300      3.11
       25.     0.420      0.420      0.420      3.71
       26.    -0.450     -0.450     -0.450      3.46
       27.    -1.110     -1.110     -1.110      2.41
       28.    -1.110     -1.110     -1.110      1.05
       29.    -0.360     -0.360     -0.360     -0.35
       30.     0.810      0.810      0.810     -1.41
       31.     1.870      1.870      1.870     -1.96
       32.     2.660      2.660      2.660     -1.70
       33.     3.160      3.160      3.160     -0.57
       34.     3.310      3.310      3.310      0.82
       35.     2.920      2.920      2.920      2.32
       36.     2.070      2.070      2.070      3.52
       37.     1.010      1.010      1.010      4.20
       38.     0.060      0.060      0.060      4.03
       39.    -0.690     -0.690     -0.690      3.08
       40.    -1.000     -1.000     -1.000      1.65
       41.    -0.680     -0.680     -0.680      0.10
       73.      300.        30.        10.
       42.     0.240      0.240      0.240     -1.20
       43.     1.260      1.260      1.260     -2.01
       44.     1.970      1.970      1.970     -2.15
       45.     2.420      2.420      2.420     -1.37
       46.     2.720      2.720      2.720     -0.17
       47.     2.650      2.650      2.650      1.31
       48.     2.170      2.170      2.170      2.59
      49.0     1.300      1.300      1.300      3.55
      50.0     0.240      0.240      0.240      3.83
      51.0    -0.590     -0.590     -0.590      3.13
      52.0    -0.900     -0.900     -0.900      1.94
      53.0    -0.530     -0.530     -0.530      0.57
      54.0     0.320      0.320      0.320     -0.76
      55.0     1.370      1.370      1.370     -1.64
      56.0     2.270      2.270      2.270     -1.91
```

57.0	2.880	2.880	2.880	-1.27
58.0	3.250	3.250	3.250	-0.07
59.0	3.280	3.280	3.280	1.34
60.0	2.800	2.800	2.800	2.71
61.0	1.910	1.910	1.910	3.74
62.0	0.930	0.930	0.930	4.21
63.0	0.160	0.160	0.160	3.86
64.0	-0.360	-0.360	-0.360	2.72
65.0	-0.500	-0.500	-0.500	1.31
66.0	-0.270	-0.270	-0.270	-0.08
67.0	0.320	0.320	0.320	-1.14
68.0	1.060	1.060	1.060	-1.84
69.0	1.650	1.650	1.650	-1.73
70.0	2.210	2.210	2.210	-0.97

B2: GRID FILE

1	990.	104.30	-1.8			11.48	5.66
2	863.	95.30	-1.8			13.78	7.58
3	1184.	59.30	-1.8			15.99	9.38
4	2548.	105.65	-3.15			28.66	27.16
5	381.	44.30	-1.8			8.68	7.60
6	457.	53.30	-1.8			11.69	9.90
7	496.	42.30	-2.30	34.040		14.05	11.36
8	217.	29.30	-2.30	0.620		12.21	11.75
9	115.	27.30	-1.8			11.19	11.20
10	200.	26.30	-1.8			9.81	10.75
11	446.	44.30	-1.8			8.88	9.10
12	225.	26.29	-1.79			7.08	8.61
13	302.	20.29	-1.79			6.05	8.39
14	21.7	14.29	-1.79			6.99	7.90
15	133.	14.29	-1.79			7.00	6.21
16	185.	14.29	-1.79			4.96	7.00
17	112.	8.28	-1.78			3.79	7.60
18	208.	11.28	-1.78			2.37	7.81
19	266.	22.28	-1.78			3.94	8.98
20	266.	20.30	-1.8			5.15	10.13
21	284.	29.30	-1.8			6.77	10.25
22	101.	17.30	-2.30	1.290		8.77	10.87
23	56.42	14.31	-2.31	0.440		8.89	11.79
24	156.	20.31	-2.31	1.720		7.57	11.68
25	59.6	22.31	-2.31	0.640		6.83	11.85
26	100.	29.31	-1.81			6.45	11.29
27	43.4	17.34	-2.34	1.810		7.09	12.52
28	68.3	44.20	-1.7			6.21	12.25
29	99.	9.20	-2.20	3.760		5.16	11.84
30	78.	7.24	-2.24	2.400		4.40	11.03
31	133.	12.28	-2.28	0.620		3.22	10.21
32	146.	20.32	-2.32	0.870		1.73	9.55
33	104.	20.37	-1.87			0.88	8.78
34	114.	7.37	-1.87			0.86	7.78
35	91.	14.43	-1.93			0.08	9.25
36	23.8	20.44	-1.94			0.60	9.98
37	30.4	20.46	-1.96			0.39	10.82
38	14.1	20.48	-2.48	1.450		1.15	11.25
39	7.8	20.49	-2.49	0.540		1.57	11.70
40	10.	20.49	-2.49	1.520		1.65	12.02
41	4.08	35.	-25.	0.14	-10.	1.87	12.70
42	4.14	35.				1.82	13.97
43	2.13	35.	-15.	0.11		2.41	14.35
44	10.78	42.	-32.00	0.33	-10.	3.13	14.28
45	5.94	42.	-20.00	0.108	-5.	4.11	14.30
46	4.41	42.	-27.00	0.27	-5.	2.76	14.37
47	5.2	42.	-20.00	0.104	-5.	3.70	14.24
48	6.0	42.	-20.00	0.12	-5.	4.69	14.44
49	2.34	35.		9.524	9.50.256	2.99	15.72
50	40.	23.31	-2.31	0.999		5.20	14.57
51	35.	54.33	-1.83			5.33	13.63
52	41.	54.35	-1.85			5.80	12.79
53	26.	23.39	-2.39	0.460		6.25	12.98
54	38.	37.35	-1.85			5.74	13.65
55	28.	34.33	-2.33	0.410		6.20	14.23
56	58.6	44.31	-1.81			5.77	14.64
57	34.6	34.31	-2.31	0.850		6.74	14.95
58	26.	32.31	-2.31	1.260		6.73	15.51
59	44.4	39.31	-1.81			5.94	15.31
60	63.	11.31	-2.31	2.300		5.59	15.75
61	32.5	39.31	-1.81			6.40	15.87
62	29.2	39.31	-2.31	0.850		7.03	16.15
63	58.6	39.27	-1.77			6.52	16.45
64	94.4	32.14	-2.14	7.640		6.76	18.06
65	114.	28.95	-1.95	5.050		7.89	20.47
66	108.	25.76	-1.26			8.93	22.56
67	166.	25.72	-1.22			9.50	24.56
68	13.	7.87	-1.37			9.63	22.35
69	8.7	4.98	-1.48			8.41	21.02
70	9.7	5.09	-2.09	0.700		9.09	19.92
71	32.5	6.50	-3.13	2.680		11.22	18.59
72	33.6	17.30	-2.30	1.330		8.85	19.08
73	44.5	20.30	-1.8			8.11	17.47
74	21.7	23.31	-2.31	1.260		7.89	16.56
75	33.6	21.10	-3.10	0.540		9.61	19.56
76	6.5	18.11	-3.11	0.390		9.99	19.95

77	20.6		18.12	-3.12	0.640	10.3719.79
78	22.		18.11	-3.11	1.140	10.0919.20
79	58.6		18.13	-3.13	1.120	10.8019.26
80	22.8		18.13	-2.63		11.1319.61
81	17.4		15.13	-3.13	0.630	10.8619.92
82	26.		15.26	-3.26	1.270	11.4519.99
83	21.7		18.26	-3.26	0.340	11.7219.72
84	18.4		18.39	-3.39	0.470	12.1120.21
85	11.9		18.39	-3.39	0.270	12.2719.77
86	8.7		12.52	-3.52	0.240	12.8919.47
87	41.2		21.52	-3.52	0.110	12.9019.88
88	30.4		15.52	-3.52	0.360	13.2619.74
89	29.3		6.57	-3.57	3.380	13.6918.80
90	28.2		12.57	-3.07		13.4620.11
91	42.3		39.57	-3.07		13.2320.64
92	41.2		12.57	-3.57	0.400	12.4220.66
93	18.4		12.57	-3.57	0.290	12.1821.16
94	19.5		9.57	-3.57	1.890	12.1521.91
95	29.3		12.57	-3.57	0.400	12.6121.41
96	31.5		27.57	-3.07		13.1121.59
97	30.4		45.57	-3.07		13.0921.09
98	29.3		48.57	-3.07		13.6621.03
99	48.8		15.57	-3.07		14.0621.24
100	60.7		15.59	-3.09		14.8420.66
101	52.1		66.57	-3.07		13.6421.62
102	264.		39.68	-3.18		14.7922.30
103	120.		57.65	-3.15		13.7422.46
104	45.5		27.57	-3.07		12.7322.09
105	145.		45.62	-3.12		13.5023.45
106	369.		45.66	-3.16		15.6023.96
107	31.5		14.45	-2.45	1.350	9.7812.00
108	26.04		17.45	-2.45	1.220	9.9311.70
109	35.81		17.55	-2.55	0.970	10.6312.03
110	49.9		14.60	-2.60	0.670	11.4112.27
111	69.4		11.63	-2.63	2.350	12.1012.49
112	33.6		14.58	-2.58	6.490	13.2513.21
113	16.		14.57	-2.57	11.820	13.9913.92
114	13.		14.59	-2.59	4.240	13.0313.70
115	40.2		17.60	-2.60	3.310	12.4613.91
116	84.6		14.61	-2.61	8.040	11.7914.26
117	60.7		14.59	-2.59	3.250	10.2913.45
118	35.8		14.58	-2.58	0.370	10.3713.05
119	46.6		14.57	-2.57	1.080	10.5312.73
120	571.		50.30	-1.8		9.34 5.90
121	553.		80.30	-1.8		11.64 7.80
122	431.		71.30	-1.8		13.83 9.67
123	3.260	0.1740	6.50	-3.13	0.570	10.4420.22
124	5.43		6.50	-3.26	0.600	11.3421.03
125	6.5		4.49	-2.49	1.490	2.7511.70
126	4.3		4.49	-2.49	1.450	2.4212.48
127	7.6		6.49	-2.49	0.500	2.2611.88
128	6.5		13.49	-2.49	0.660	1.9011.96
129	5.4		27.31	-2.31	0.710	7.2915.31
130	14.1		10.30	-1.8		9.2417.08
131	6.5		17.45	-2.45	1.910	8.7512.10
132	14.1		10.59	-2.59	1.640	9.3512.67
133	15.2		14.58	-2.58	3.080	9.5913.03
134	3.3		14.59	-2.59	1.320	9.6313.78
135	16.3		12.28	-1.78		3.6010.80
136	33.6		17.43	-2.43	0.410	-0.77 9.15
137	30.4		14.55	-2.05		-1.56 9.13
138	46.700		14.70	-2.2		-2.80 8.00
139	3.300	0.0230	5.57	-3.57	1.040	11.9922.79
140	239.		25.50	-1.		10.0927.11
141	543.		25.50	-1.		10.0931.41
142	300.	13.5800	25.50	-1.		10.0935.41
143	8.80		8.0			2.9114.63
144	6.04		42.00	-2.	-10.	3.2714.64
145	7.3		-9.06	0.06	2.550	13.2812.68
146	56.42		-9.00		1.540	13.3012.46
147	43.4		-5.00		1.680	10.1911.48
148	8.68		-5.10	0.10	2.660	10.1211.70
149	19.53		-5.00		0.920	9.5211.19
150	10.85		-4.90	-0.10	1.160	9.4811.45
151	18.45		-5.10	0.6		7.35 7.20
152	66.19		-5.00	0.5		7.70 7.28

153	22.79	-5.15	0.65					7.70	6.11
154	75.95	-5.00	0.5					7.82	6.09
155	718.	63.65	-3.15					18.14	25.56
156	258.	39.66	-3.16					17.22	23.35
157	524.	48.65	-3.15					20.59	24.20
158	2680.	105.65	-3.15					25.29	26.82
159	972.	81.65	-3.15					21.70	26.35
160	812.	45.65	-3.15					20.19	28.00
161	379.	33.63	-3.13					16.26	25.60
162	2.06	35.						3.23	16.12
163	5.27	17.3						3.03	14.86
164	4.5	22.6						3.31	15.01
165	4.61	30.3						3.44	14.96
166	4.22	12.3						3.57	14.91
167	6.09	12.3						3.71	15.20
168	0.88	21.	-15.	0.044	-5.			3.98	17.23
169	0.59	15.	-10.	0.063	-3.			3.98	17.53
170	0.89	32.70	-9.	0.062	-1.			3.41	17.62
171	1.10	32.70	-9.	0.054	0.			3.08	17.37
172	1.18	23.00	-9.	0.058	0.			2.74	17.64
173	1.15	22.60	-9.	0.057	0.			2.74	18.13
174	1.11	18.60	-8.	0.079	-1.			2.95	18.56
175	0.935	12.70	-8.	0.053	-1.			3.16	19.07
176	0.598	12.70	-8.	0.026	0.			3.22	19.27
177	0.531	12.70	-10.	0.027	-2.			3.39	19.55
178	6.42	-9.00	999.					4.29	17.46
179	1.87	32.	-20.	0.097	-5.			4.60	17.42
180	14.	1.50	0.50	2.500	2.50	0.240		3.75	18.19
181	0.1	1.50	0.50	3.	5.5			4.19	18.13
182	2.52	35.	-15.	0.075	-1.	1.		4.62	17.94
183	1.47	43.	-30.	0.025	-5.	1.160		5.00	17.94
184	0.1	5.50	-1.50	0.100	1.5	1.660		4.19	18.88
185	1.61	32.	-25.	0.037	-3.	0.750		4.69	18.30
186	1.73	30.	-15.	0.067	-2.	0.640		4.71	18.78
187	5.	1.00		1.100	6.5	0.400		5.06	18.49
188	0.3	3.50	-0.50	1.440	4.5	0.250		5.54	18.49
189	4.	0.50	0.50	0.250	4.5	0.270		4.29	19.34
190	2.60	22.	-15.	0.064	-2.	1.310		4.88	19.18
191	26.04	-4.00	999.					5.27	19.05
192	0.94	15.50	1.50	5.010	6.5	0.380		4.66	20.03
193	2.10	30.	-15.	0.063	-2.	0.970		5.16	19.57
194	0.2	8.50	-1.50	1.350	6.5	2.450		4.47	19.56
195	0.15	8.50	-1.50	0.080	0.5	1.340		5.67	19.39
196	0.13	5.50	2.50	0.190	4.5	4.770		6.07	19.26
197	0.48	10.50	-0.50	0.210	2.5	3.320		5.06	20.67
198	0.13	0.50	-0.50	4.960	2.5	0.290		5.69	20.49
199	1.24	24.	-15.	0.060	0	0.960		5.90	19.92
200	0.4	10.50	-0.50	0.180	1.5	2.280		6.21	19.65
201	1.14	20.	-15.	0.10	0	1.640		6.25	20.13
202	53.	-2.00	4.50	0.140				5.37	21.22
203	1.20	20.	-5.50	0.410	2.5	2.740		6.15	20.65
204	0.26	5.50	0.50	2.550	5.5	0.780		6.59	20.59
205	12.8	-3.50	7.		9.5	6.400		5.65	21.78
206	1.12	15.	-2.50	1.	1.5	2.900		6.31	21.33
207	1.48	18.50	-1.50	0.740	6.5	1.450		6.63	21.03
208	2.8	10.50	-1.50	0.700	4.5	2.300		6.90	21.65
209	0.900	2.50	-0.50	0.900	1.5	2.400		7.26	22.39
210	1.04	14.	-10.	0.11	0	1.200		6.11	22.07
211	0.88	10.	-7.	0.10	0	0.550		6.15	22.61
212	0.97	7.	-4.	0.19	0	1.140		6.36	23.41
213	0.76	5.	-3.	0.20	0	0.780		6.26	24.25
214	0.29	4.	-2.	0.12	0	0.340		6.36	24.83
215	0.53	12.	-8.	0.03	-1.			3.39	19.88
216	0.47	12.	-6.	0.027	-1.			3.43	20.21
217	0.45	12.	-6.	0.025	-2.			3.65	20.36
218	0.453	13.	-8.	0.030	-4.			3.85	20.56
219	0.465	13.	-8.	0.062	-6.			3.86	20.83
220	0.45	13.	-8.	0.04	-5.			3.82	21.13
221	0.435	10.	-4.	0.044	-2.			3.91	21.36
222	0.363	12.	-7.	0.022	-3.			3.87	21.65
223	0.338	12.	-7.	0.027	-4.			4.04	21.77
224	0.405	12.						4.18	21.61
225	0.73	4.41	9.50	0.278				4.24	21.88
226	0.621	1.50	9.50	0.192				4.10	22.05
227	0.695	-1.50	9.50	0.085				3.99	22.32
228	0.933	-3.50						3.86	22.49

229		0.461		-5.50				3.7122.60
230		1.819		10.50		2.270		1.3112.70
231		1.99		8.90		0.960		0.8712.75
232		1.87		6.90		1.430		0.4112.70
233		0.979		6.40		0.930		-0.1912.68
234		0.77		2.70		0.760		-0.3412.49
235		0.26		2.70		0.350		-0.1613.04
236		0.25		1.50		0.180		-0.5012.97
237		0.200	0.0717	-4.50		0.150		-0.2413.27
238		7.		-4.00	9.50	0.100		5.6522.36
239		0.5		12.50	-1.50	0.110	2.52.110	4.8620.42
240		0.2		9.50	-1.50	0.080	1.51.430	4.5018.65
241		0.1		8.50	-0.50	1.350	3.5	4.4319.12
242		1.65		22.	-15.	0.063	0	5.4419.88
243		0.25		1.50	2.50	0.150	7.52.710	5.3320.04
244		0.12		5.50	-0.50	2.380	4.5	5.6920.13
245		0.04		5.50	-0.50	3.	2.5	5.6920.21
246		0.06		5.50	-0.50	0.030	1.50.450	4.6219.99
247		9.22		22.4				3.5615.29
248		6.14		20.2				3.2815.48
249		8.43		12.3				3.8815.58
250		8.16		24.4				3.7015.69
251		5.		23.2				3.5315.86
252		6.80		10.0				4.0215.85
253		5.84		15.5				3.8215.95
254		6.91		9.0				4.1516.09
255		5.16		15.7				3.9416.17
256		7.22		7.0				4.2116.37
257		5.00		21.8				3.9916.40
258		3.75		10.0				4.2216.60
259		3.25		16.8				4.0616.63
260		0.89		28.0	-10.	0.09	-2.	3.8816.65
261		0.89		34.0	-10.	0.287	-4.	4.2216.76
262		1.89		4.0	-3.	0.395	-0.1	4.0616.81
263		0.89		28.0	-10.	0.09	-2.	3.8816.83
264		1.27		35.0	-20.	0.098	-5.	4.3616.90
265		8.94		-9.0				4.1116.95
266		0.88		23.0	-20.	0.037	-5.	3.8917.00
267		1.58		33.0	-20.	0.074	-5.	4.4717.16.
268		11.25		-9.0				4.2017.19
269		4.07		35.0	-20.	0.19	-5.	1.7213.29
270		2.36		35.0				2.1514.26
271		0.66		14.0	-9.	0.061	-3.	3.8317.67
272		1.65		48.0	-30.	0.030	-5.	5.0117.67
273		0.23		-2.				4.5121.99
274		0.17		-7.				4.7622.22
99999								
1	5	120		19375.	7118.		.03	
2	5	121		30833.	11458.		.03	
3	6	121		21875.	17188.		.03	
4	6	122		22917.	14063.		.03	
5	8	122		27604.	9547.		.03	
6	7	122		17708.	13889.		.03	
7	7	8		19792.	7292.		.03	
8	6	8		19792.	10590.		.03	
9	6	9		14583.	9201.		.03	
10	6	10		21354.	9896.		.03	
11	6	11		30729.	1458.		.03	
12	11	121		32083.	1806.		.03	
13	5	11		15625.	15972.		.03	
14	5	12		19375.	8681.		.03	
15	11	12		19271.	10590.		.03	
16	11	21		25000.	411.		.03	
17	11	24		29688.	7292.		.03	
18	11	22		18229.	7639.		.03	
19	10	11		19792.	764.		.03	
20	10	22		11458.	7813.		.03	
21	9	10		15104.	6424.		.03	
22	22	23		9375.	5208.		.04	
23	23	24		13542.	4688.		.04	
24	23	107		9375.	2431.		.04	
25	23	108		10417.	2100.		.04	
26	107	109		7813.	1042.		.04	
27	108	109		8125.	1736.		.04	
28	109	110		8437.	3125.		.04	
29	110	111		6250.	2604.		.04	

30	111	112		14063.	2604.		.04
31	112	113		10938.	1562.		.04
32	111	115		15104.	2604.		.06
33	114	115		6250.	3646.		.04
34	115	116		7813.	4167.		.04
35	116	117		19792.	4167.		.04
36	116	119		25000.	1563.		.06
37	117	118		4167.	3125.		.04
38	118	119		4167.	3125.		.04
39	110	119		10417.	3646.		.04
40	109	119		7292.	4167.		.04
41	22	24		15104.	8160.		.04
42	21	24		17708.	10417.		.04
43	24	25		8333.	6071.		.04
44	21	25		16667.	3819.		.04
45	21	26		11458.	7118.		.03
46	20	21		16667.	9375.		.04
47	12	21		11979.	11806.		.04
48	12	20		15521.	6597.		.04
49	12	13		10938.	7292.		.03
50	13	20		20313.	9028.		.04
51	13	19		22917.	764.		.03
52	13	16		18750.	42708.		.04
53	13	15		24479.	7813.		.04
54	13	14		10417.	3125.		.04
55	14	15		17708.	4167.		.04
56	15	16		22917.	6250.		.04
57	16	19		22917.	8333.		.04
58	16	17		13542.	4792.		.04
59	17	19		14580.	9375.		.04
60	17	18		14792.	5208.		.04
61	18	19		20313.	9549.		.04
62	19	20		17708.	11458.		.04
63	20	26		18229.	7813.		.04
64	25	26		7292.	5208.		.04
65	25	28		7292.	4688.		.04
66	26	28		10417.	5556.		.03
67	26	29		14583.	8160.		.04
68	20	29		17708.	7118.		.04
69	20	30		11979.	8681.		.04
70	20	31		20000.	7292.		.04
71	19	31		15104.	11458.		.04
72	19	32		23750.	9028.		.03
73	18	32		19271.	10417.		.04
74	18	33		18750.	6944.		.04
75	18	34		15625.	6771.		.04
76	33	34		10417.	8160.		.04
77	34	35		17708.	3438.		.04
78	33	35		9896.	5208.	30.5	.04
79	32	33		11979.	8160.		.04
80	31	32		17188.	7292.		.04
81	30	31		14792.	4167.		.04
82	29	30		11458.	5208.		.04
83	29	52		11979.	3125.		.04
84	28	29		11979.	5729.		.04
85	28	52		6875.	5382.		.04
86	28	54		15625.	1736.		.03
87	28	53		7813.	4167.		.04
88	25	53		13021.	3125.		.04
89	25	27		7500.	3646.		.04
90	27	53		9896.	3125.		.04
91	53	55		14063.	85.		.06
92	53	54		8333.	2604.		.04
93	52	54		9583.	3472.		.04
94	51	52		9896.	2803.		.04
95	51	54		5208.	6597.		.04
96	54	56		10417.	3125.		.03
97	54	55		7292.	3125.		.04
98	55	56		6250.	5556.		.04
99	51	56		11458.	3299.		.03
100	50	51		10000.	2604.		.03
101	45	48	10.	6400.	1563.	40.	.03
102	44	47	10.	6200.	1563.	40.	.03
103	43	46			2500.	35.	.03
104	42	270			900.	35.	.03
105	41	269		6300.	1000.	35.	.03

106	40	41		7292.	1563.	35.	.03
107	39	40		3643.	1563.	35.	.03
108	38	39		6250.	2083.	35.	.03
109	37	38		7292.	2604.	35.	.03
110	36	37		9167.	2604.	35.	.03
111	35	36		9167.	2604.	35.	.03
112	253	255	5.		1000.	37.	.03
113	254	255			2600.	9.	.035
114	254	256			2600.	8.	.035
115	256	257			2600.	7.	.035
116	50	60		13021.	4688.		.04
117	50	59		10938.	2951.		.04
118	50	56		6146.	5729.		.03
119	56	59		7292.	3819.		.03
120	56	58		12604.	2778.		.04
121	56	57		10417.	3646.		.04
122	55	57		9271.	3646.		.04
123	57	58		5730.	3438.		.04
124	58	59		7604.	3438.		.04
125	59	61		7292.	3438.		.03
126	59	60		6250.	6076.		.04
127	60	61		8437.	3819.		.04
128	60	63		12500.	3531.		.04
129	61	63		6250.	4514.		.03
130	61	62		7292.	3125.		.03
131	58	62		7813.	2292.		.06
132	62	63		5729.	85.		.04
133	62	74		10938.	2604.		.04
134	73	74		9896.	2604.		.04
135	72	73		18750.	2604.		.04
136	63	64		17188.	5208.		.03
137	64	65		28646.	5208.		.03
138	65	66		23750.	5208.		.03
139	66	67		21667.	5208.		.03
140	66	68		8542.	521.		.06
141	68	69		16667.	833.		.06
142	69	70		12500.	833.		.06
143	70	72		10417.	1250.		.06
144	71	79		8333.	1250.		.04
145	72	75		9375.	3125.		.04
146	81	123		52800.	1042.		.04
147	82	124		6667.	1562.		.04
148	75	76		5625.	3125.		.04
149	75	77		9375.	1042.		.04
150	75	78		6771.	2604.		.06
151	76	77		4167.	2604.		.04
152	78	79		7292.	2083.		.04
153	79	80		5208.	3125.		.04
154	77	79		7292.	2083.		.04
155	77	80		8333.	1562.		.04
156	77	81		5208.	1562.		.04
157	81	82		6250.	1562.		.04
158	80	81		4167.	3125.		.04
159	80	82		5104.	2604.		.04
160	80	83		6250.	2083.		.04
161	82	83		4062.	4062.		.04
162	82	84		7292.	1563.		.04
163	83	84		6771.	2604.		.04
164	83	85		5729.	2083.		.04
165	84	85		4792.	4062.		.04
166	84	87		8958.	1736.		.04
167	85	87		6771.	3125.		.03
168	85	86		7292.	1250.		.04
169	86	87		4167.	3438.		.04
170	86	88		5208.	1042.		.04
171	88	89		10729.	2604.		.04
172	89	90		13542.	3125.		.04
173	88	90		4688.	5282.		.05
174	88	91		9580.	2257.		.05
175	87	88		4167.	4167.		.04
176	87	91		8437.	3993.		.04
177	87	92		9167.	3472.		.05
178	91	92		8333.	4167.		.05
179	91	97		5104.	4861.		.04
180	91	98		6667.	3646.		.05
181	90	91		6563.	3438.		.05

182	90	98		9896.	2427.		.05
183	98	99		4688.	2083.		.05
184	98	101		6250.	3819.		.05
185	97	98		6771.	3438.		.05
186	97	101		8750.	2778.		.05
187	96	97		5208.	3125.		.04
188	95	97		6249.	2604.		.05
189	92	97		8334.	3438.		.05
190	92	95		7812.	3125.		.05
191	92	93		6458.	3125.		.05
192	93	95		5729.	4167.		.05
193	93	94		7812.	2604.		.05
194	94	95		7187.	1979.		.05
195	95	104		6770.	2083.		.05
196	96	104		6250.	5104.		.05
197	96	103		11979.	3438.		.04
198	96	101		6250.	4514.		.05
199	101	103		8854.	5903.		.05
200	101	102		14583.	4167.		.05
201	99	101		6146.	5903.		.05
202	99	102		15104.	2083.		.05
203	99	100		10312.	4896.		.05
204	102	103		11146.	9028.		.05
205	103	104		11250.	5556.		.05
206	104	105		16146.	2257.		.05
207	103	105		10416.	11111.		.05
208	105	106		22500.	8681.		.05
209	103	106		25104.	5729.		.04
210	102	106		19479.	9375.		.05
211	106	155		31250.	8333.		.04
212	107	108		3646.	6250.		.04
213	8	9		11979.	4500.		.03
214	1	120		22083.	10416.		.03
215	1	5		35937.	9896.		.03
216	1	121		22916.	17708.		.03
217	2	121		22396.	11111.		.03
218	2	6		34375.	10243.		.03
219	2	122		21875.	14931.		.03
220	3	122		22396.	10764.		.03
221	3	7		29167.	12500.		.03
222	94	139		31680.	1042.		.04
223	40	128		2604.	1042.		.05
224	39	128		4688.	1042.		.05
225	127	128		3646.	729.		.05
226	126	127		7292.	625.		.05
227	125	127		6771.	625.		.05
228	31	135		6771.	2604.		.04
229	57	129		7813.	1042.		.05
230	73	130		15625.	729.		.05
231	23	131		8333.	2431.		.04
232	107	131		10833.	2083.		.06
233	107	132		9375.	2083.		.06
234	118	133		8542.	2083.		.06
235	117	134		8333.	1042.		.06
236	35	136		19622.	5208.		.04
237	136	137		24102.	2083.		.04
238	137	138		30352.	3125.		.04
239	67	140		176000.	5729.		.03
240	140	141		176000.	10417.		.03
241	141	142		176000.	13021.		.03
242	261	262			1300.	7.0	.035
243	263	266	12.		600.	35.0	.03
244	145	146		2396.	3646.		.06
245	112	145		5521.	1875.		.04
246	7	146		13542.	6944.		.03
247	8	146		14063.	5556.		.03
248	8	147		17188.	2292.		.03
249	9	147		6875.	7292.		.03
250	10	147		7083.	4167.		.03
251	147	148		2396.	2083.		.06
252	109	148		3854.	2083.		.04
253	108	148		6250.	1042.		.04
254	10	149		6146.	3125.		.03
255	149	150		2917.	3125.		.06
256	108	150		6250.	1736.		.04
257	23	150		6250.	1736.		.04

258	5	152				11042.	10243.		.03		
259	120	152				22708.	7292.		.03		
260	120	154				16250.	8854.		.03		
261	153	154				1354.	5208.		.06		
262	15	153				6875.	3125.		.04		
263	151	152				3750.	3125.		.06		
264	14	151				8333.	1000.		.04		
265	15	151				10833.	2000.		.04		
266	255	257	5.				1500.	37.	.03		
267	256	258					2200.	6.	.035		
268	258	259					1200.	8.	.035		
269	257	260					700.	35.	.03		
270	257	259	10.				1000.	35.	.03		
271	258	261					1000.	7.	.035		
272	259	260					1400.	8.	.035		
273	260	263	12.				700.	35.	.03		
274	259	262					1500.	6.	.035		
275	262	265					2100.	-9.	.05		
276	261	264	10.				700.	33.	.03		
277	262	263					1600.	-9.	.05		
278	259	261	10.				800.	35.	.03		
279	264	265					2100.	-9.	.03		
280	102	156				27604.	6944.		.05		
281	105	161				36458.	4167.		.05		
282	106	161				19271.	12500.		.05		
283	106	156				17708.	14931.		.05		
284	156	157				36458.	6250.		.05		
285	155	156				24479.	15451.		.05		
286	155	161				19792.	15972.		.05		
287	160	161				46875.	6250.		.05		
288	155	160				33333.	13542.		.05		
289	155	159				38021.	13368.		.04		
290	155	157				29167.	16677.		.05		
291	157	159				26042.	19965.		.05		
292	159	160				23958.	21528.		.05		
293	158	160				54688.	10417.		.05		
294	158	159				37500.	13542.		.04		
295	157	158				62500.	7292.		.05		
296	4	158				34896.	41667.		.04		
297	213	214	0.32	14.3		10000.	50.		.04	5.5	
298	58	61				4583.	1563.		.04		
299	265	266					2150.	-9.	.05		
300	264	267	10.				800.	33.	.03		
301	252	254					2300.	8.	.035		
302	267	268					2850.	-9.	.05		
303	168	169	15.0	50.0		3100.	400.	23.4	.03	5.5	
304	169	271	16.3			2800.	300.	17.8	.03		
305	170	171	15.0	119.0		4800.	270.	16.4	.03	6.0	
306	171	172	11.7	110.0		5400.	250.	17.0	.03	6.0	
307	172	173	11.8	87.6		5100.	230.	16.4	.03	6.0	
308	173	174	15.4	67.4		5100.	235.	18.7	.03	8.0	
309	174	175	13.1	72.5		6000.	215.	14.8	.03	9.5	
310	175	176	11.0	95.6			205.	14.2	.035	8.0	
311	265	268					2500.	-9.	.05		
312	168	268					2850.	-9.	.05		
313	179	267	10.				800.	33.	.03		
314	168	266	15.				600.	35.	.03		
315	178	268					2700.	-9.	.05		
316	178	179					1000.	-8.5	.055		
317	179	272	12.8			5400.	700.	40.5	.03		
318	252	253					2600.	9.	.035		
319	250	253	5.				1000.	37.	.03		
320	249	252					2100.	8.	.035		
321	169	178					1000.	-11.5	.05		
322	162	251				4300.	600.	35.	.03		
323	250	251	5.				1200.	37.	.03		
324	180	181					100.	-5.5	.055		
325	249	250					3500.	9.	.035		
326	182	183	9.3	103.		4400.	500.	38.3	.03	2.5	
327	180	184					600.	-8.0	.055		
328	181	184					100.	-8.0	.055		
329	248	251	5.				1400.	35.	.03		
330	182	185	4.6	5.0		4000.	480.	31.5	.03	1.5	
331	183	188				6000.	10.	3.5	.025	7.0	2
332	184	189					800.	-1.5	.055		
333	240	186					2000.	-0.5	.055		

334	184	240	8.6	2.2	4000.	20.	5.5	.035	1.5	
335	185	186	7.4	120.	5200.	520.	29.1	.03	1.5	
336	185	187				900.	-7.5	.055		
337	186	241	5.56	2.14	5300.	20.	8.5	.03	0.5	
338	186	187				1000.	-9.5	.055		
339	247	250	5.			1000.	40.	.03		
340	186	190	6.0	11.0	4700.	440.	27.5	.03	1.5	
341	186	191				1000.	-9.0	.055		
342	167	249				2200.	8.	.035		
343	49	248	5.			600.	35.	.03		
344	247	248				1200.	37.	.03		
345	190	194	2.31	0.0	6000.	50.	11.5	.035	1.5	
346	190	193	14.0	15.4		450.	24.3	.03	1.5	
347	191	193				1000.	-9.5	.055		
348	167	247				3900.	9.	.035		
349	164	247	5.		4100.	1000.	35.	.03		
350	165	247	5.			1000.	40.	.03		
351	192	239	8.28	36.0	5300.	80.	12.5	.035	2.0	
352	166	167				1200.	8.	.035		
353	193	242	9.0	50.0	4600.	450.	22.5	.03	1.5	
354	242	199	12.0	163.		450.	22.7	.03	1.5	
355	195	199	3.33	245.	8000.	30.	8.5	.04	0.5	
356	196	200	6.31	360.	5500.	40.		.04	1.5	
357	197	198	300.	40.0	10000.	800.	-8.5	.055	9.5	
358	244	245			100.	20.	5.5	.025	10.0	2
359	198	201	900.	0.0		600.	-9.0	.055	10.5	
360	199	201	11.1	630.	4250.	300.	22.8	.03	2.5	
361	199	200	6.4	300.	4800.	30.	15.1	.035	8.5	
362	197	202	0.0	100.	10000.	20.	2.5	.055	5.0	
363	198	202			9000.	1000.	-6.5	.055		
364	202	203				2000.	-6.5	.055		
365	198	203				1100.	-4.5	.055		
366	201	203	12.0	247.	5900.	225.	20.5	.03	1.5	
367	201	204	6.67	0.0	7400.	40.	5.5	.035	0.5	
368	192	193	4.0	0.0	6500.	30.	18.5	.03	19.5	
369	202	205				100.		.055		
370	203	206	12.0	200.	7800.	300.	18.3	.035	2.5	
371	204	207	0.0	120.	6000.	40.		.035	7.0	
372	203	204				100.	-5.5	.055		
373	164	165				3000.	20.	.03		
374	205	206				1000.	-7.5	.055		
375	206	207	3.22	233.	7900.	200.		.03	11.5	
376	207	208	6.25	7.7	6900.	200.		.03	1.5	
377	208	209	7.0	37.5	7100.	100.	15.3	.03	4.0	
378	206	210	13.3	100.	8200.	200.	12.3	.035	4.5	
379	210	211	0.0	970.	6800.	130.	12.3	.035	12.0	
380	211	212	25.0	14.0	12550.	100.		.04	4.5	
381	212	213	5.0	6.25	10000.	100.		.04	4.5	
382	176	177	14.7	121.9		165.	13.6	.035	6.5	
383	177	215	11.0	131.1	3600.	175.	15.7	.035	6.5	
384	215	216	15.0	121.8		200.	13.6	.035	6.0	
385	216	217	16.0	153.8	2800.	165.	12.3	.03	6.5	
386	217	218	18.0	115.8	3140.	190.	13.6	.03	7.5	
387	218	219	18.0	73.8	2900.	150.	13.9	.03	9.0	
388	219	220	12.0	92.5	3300.	150.	15.5	.03	9.5	
389	220	221	19.0	108.5	2700.	150.	13.6	.03	9.5	
390	221	222	15.0	122.0	3100.	150.	11.1	.04	9.5	
391	222	223	16.0	139.5	2700.	150.	14.2	.04	10.0	
392	223	224	12.0	141.6	2300.	140.	14.2	.04	10.0	
393	224	225	9.5	111.5	3100.	165.		.04	9.5	
394	225	226	10.5	83.5	2600.	135.		.03	10.0	
395	226	227	0.	50.	3050.	250.		.03	10.	
396	227	228	16.	24.	2100.	200.		.03	10.	
397	228	229	16.	24.	2050.	200.		.03	10.	
398	41	230	0.0	400.	6400.	466.	14.0	.04	0.5	
399	230	231	0.0	350.	5417.	387.	12.3	.04	0.5	
400	231	232	0.0	250.	5200.	365.	7.3	.04	0.5	
401	232	233	0.0	150.	6990.	252.	4.6	.04	0.5	
402	233	234	0.0	100.	3199.	97.	2.7	.04	0.5	
403	233	235	0.0	100.	4202.	97.	2.7	.04	0.5	
404	235	236	0.0	50.	4197.	50.	2.5	.04	0.5	
405	235	237	0.0	50.	3000.	50.	-1.6	.04	2.0	
406	190	191				100.	-6.5	.055		
407	241	189				2000.	-7.5	.055		
408	184	241				2000.	-7.5	.055		
409	240	185	7.8	220.	5000.	10.	9.5	.035	-0.5	

410	246	192			600.	10.	5.5	.025	9.0	2
411	239	197	8.6	47.2	4000.	80.		.055	-0.5	
412	205	238				100.		.055		
413	238	210	350.	900.	0.	300.	-8.5	.055	-0.5	
414	240	181	800.	0.1	0.	2000.	-7.0	.055	9.5	
415	242	243			600.	7.	5.0	.025	7.0	2
416	243	198				100.	-9.5	.055		
417	243	197				200.	-9.5	.055		
418	243	192				50.	-9.5	.055		
419	199	244	0.0	300.	3000.	40.	2.5	.04	2.0	
420	245	198	0.0	300.	4200.	40.	2.5	.055	2.0	
421	194	246	14.3	66.2	5900.	40.	5.5	.04	1.5	
422	165	166				3200.	14.	.035		
423	144	164	5.		4065.	500.	35.	.03		
424	144	165	5.			1500.	40.	.03		
425	144	166	30.			1100.	12.	.035		
426	144	163	20.			2000.	30.	.03		
427	143	163				2200.	8.	.035		
428	143	144				2000.	7.	.035		
429	46	143				3300.	6.	.035		
430	44	144	7.			2700.	40.	.03		
431	42	269			7260.	900.	35.	.03		
432	43	270			2900.	900.	35.	.03		
433	44	46			6200.	2500.	37.	.03		
434	45	47	15.		4200.	1563.	40.	.03		
435	48	50	10.		5600.	1563.	40.	.03		
436	170	271	18.6			240.	17.2	.035		
437	183	272	9.6		4000.	400.	39.6	.03		
438	225	273			4880.	30.	-2.	.04		
439	273	274			4880.	53.	-6.	.04		
99999										

APPENDIX C:

SAMPLE OUTPUT FILES

C1: HEADS FILE

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19

TIME	NODE 12	NODE 62	NODE168	NODE175	NODE221	NODE226	NODE167	NODE182	NODE242	NODE195
NODE200	NODE206	NODE211	NODE213	NODE 43	NODE 35	NODE136	NODE137	NODE138	NODE	
.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
.00	.00	.00	.00	.00	.00	.00	.00	.00		
.50	-.22	.00	.00	.00	.00	.00	.00	.00	.00	.00
.00	.00	.00	.04	.00	.00	.00	.00	.00		
1.00	-.74	-.09	.00	.00	.03	.14	-.01	.00	.00	.00
.00	.01	.02	.05	-.02	-.02	.00	.00	.00		
1.50	-1.00	-.63	-.12	.03	.08	.51	-.24	-.04	.00	.01
.01	.01	.01	.05	-.30	-.32	-.21	-.06	-.01		
2.00	-1.47	-.85	-.64	-.14	.13	1.03	-.72	-.49	-.23	-.13
-.17	-.04	.00	.02	-.78	-.93	-.81	-.44	-.22		
2.50	-1.77	-1.07	-1.17	-.62	-.17	1.05	-1.23	-1.07	-.84	-.77
-.79	-.49	-.25	.00	-1.29	-1.39	-1.31	-.94	-.83		
3.00	-1.88	-1.51	-1.67	-1.13	-.69	.87	-1.67	-1.65	-1.51	-1.44
-1.47	-1.21	-.84	-.21	-1.65	-1.75	-1.71	-1.49	-1.43		
3.50	-2.03	-1.80	-1.99	-1.64	-1.21	.77	-1.95	-2.07	-2.11	-2.09
-2.11	-2.00	-1.58	-.55	-1.95	-2.04	-2.04	-1.92	-1.90		
4.00	-1.87	-2.10	-2.23	-1.99	-1.67	.78	-2.23	-2.28	-2.40	-2.45
-2.43	-2.48	-2.23	-.94	-2.22	-2.18	-2.20	-2.22	-2.25		
4.50	-1.65	-2.08	-2.45	-2.28	-2.01	.85	-2.35	-2.50	-2.54	-2.52
-2.54	-2.62	-2.58	-1.32	-2.28	-2.24	-2.29	-2.37	-2.43		
5.00	-1.09	-1.84	-2.26	-2.49	-2.29	.92	-2.13	-2.41	-2.58	-2.64
-2.61	-2.60	-2.63	-1.66	-2.08	-1.97	-2.09	-2.35	-2.44		
5.50	-.39	-1.44	-1.81	-2.20	-2.44	1.00	-1.70	-1.89	-2.08	-2.17
-2.14	-2.35	-2.49	-1.94	-1.61	-1.47	-1.57	-1.95	-2.16		
6.00	.29	-.63	-1.10	-1.68	-1.94	1.01	-.96	-1.26	-1.47	-1.52
-1.51	-1.73	-1.97	-2.10	-.88	-.79	-.94	-1.43	-1.54		
6.50	1.06	.03	-.21	-.88	-1.11	.79	-.15	-.32	-.58	-.73
-.64	-.93	-1.25	-1.80	-.12	-.03	-.13	-.64	-.83		
7.00	1.61	.86	.59	.08	-.17	.73	.66	.52	.34	.26
.30	-.01	-.39	-1.20	.70	.74	.61	.14	.03		
7.50	2.22	1.45	1.40	.97	.79	1.12	1.41	1.33	1.12	.83
1.07	.78	.43	-.53	1.42	1.55	1.48	1.04	.90		
8.00	2.60	2.15	2.04	1.82	1.70	1.81	2.08	1.98	1.83	1.23
1.76	1.51	1.19	.17	2.12	2.22	2.15	1.87	1.83		
8.50	2.98	2.61	2.69	2.52	2.48	2.55	2.70	2.61	2.39	1.62
2.30	2.07	1.84	.93	2.70	2.83	2.83	2.67	2.64		
9.00	3.18	2.95	3.18	3.18	3.14	3.17	3.16	3.13	2.94	2.03
2.82	2.58	2.37	1.66	3.16	3.22	3.23	3.26	3.33		
9.50	3.27	3.19	3.50	3.59	3.70	3.76	3.45	3.47	3.34	2.48
3.27	3.01	2.86	2.32	3.42	3.52	3.58	3.67	3.70		
10.00	3.19	3.30	3.62	3.87	3.96	4.05	3.56	3.65	3.61	2.91
3.57	3.35	3.25	2.91	3.54	3.54	3.60	3.76	3.85		
10.50	2.97	3.30	3.59	3.79	3.96	4.10	3.53	3.65	3.70	3.29
3.75	3.61	3.58	3.39	3.47	3.40	3.46	3.58	3.64		
11.00	2.55	3.03	3.38	3.57	3.68	3.86	3.28	3.53	3.70	3.57
3.73	3.76	3.79	3.76	3.23	3.03	3.07	3.20	3.24		
11.50	2.02	2.66	2.97	3.21	3.36	3.55	2.86	3.18	3.51	3.67
3.62	3.77	3.87	3.96	2.77	2.57	2.61	2.73	2.76		
12.00	1.42	2.12	2.42	2.76	2.96	3.22	2.29	2.67	3.10	3.49
3.29	3.55	3.71	3.93	2.22	2.02	2.08	2.24	2.27		
12.50	.78	1.57	1.78	2.21	2.50	2.82	1.70	1.96	2.44	3.23
2.66	3.16	3.33	3.63	1.65	1.48	1.53	1.69	1.76		
13.00	.21	.93	1.16	1.62	1.93	2.36	1.07	1.33	1.75	2.93
1.79	2.50	2.80	3.25	1.01	.93	.99	1.18	1.22		
13.50	-.37	.40	.49	1.02	1.36	1.88	.44	.62	1.03	2.63
1.15	1.76	2.13	2.80	.41	.37	.42	.62	.70		
14.00	-.81	-.14	-.11	.39	.77	1.46	-.15	-.04	.25	2.32
.33	.94	1.40	2.28	-.17	-.17	-.10	.11	.16		
14.50	-1.20	-.60	-.66	-.18	.19	1.09	-.67	-.62	-.41	1.96
-.35	.09	.61	1.73	-.67	-.69	-.63	-.42	-.35		
15.00	-1.47	-1.01	-1.10	-.72	-.35	.84	-1.10	-1.13	-1.03	1.26
-1.00	-.77	-.17	1.17	-1.11	-1.13	-1.09	-.90	-.85		
15.50	-1.61	-1.33	-1.51	-1.16	-.84	.69	-1.49	-1.55	-1.58	-1.15
-1.59	-1.51	-.95	.62	-1.48	-1.50	-1.48	-1.33	-1.30		
16.00	-1.61	-1.52	-1.81	-1.57	-1.26	.64	-1.76	-1.89	-1.95	-1.83
-1.96	-1.96	-1.60	.09	-1.73	-1.78	-1.78	-1.70	-1.68		
16.50	-1.43	-1.64	-1.93	-1.87	-1.64	.64	-1.89	-2.00	-2.10	-2.20
-2.13	-2.19	-2.02	-.41	-1.87	-1.89	-1.93	-1.96	-1.99		
17.00	-1.11	-1.50	-1.90	-2.00	-1.91	.69	-1.79	-1.98	-2.07	-2.12
-2.09	-2.16	-2.17	-.86	-1.75	-1.77	-1.88	-2.06	-2.14		
17.50	-.58	-1.25	-1.58	-1.91	-2.02	.73	-1.51	-1.66	-1.83	-1.86
-1.87	-1.96	-2.04	-1.24	-1.46	-1.34	-1.45	-1.81	-2.02		
18.00	.00	-.68	-1.10	-1.49	-1.73	.73	-.96	-1.21	-1.33	-1.34

	-1.35	-1.49	-1.63	-1.50	-.87	-.80	-.93	-1.34	-1.47		
18.50	.60	-.14	-.33	-.88	-1.04	.61	-.28	-.42	-.66	-.78	
	-.72	-.92	-1.10	-1.44	-.25	-.13	-.22	-.66	-.79		
19.00	1.09	.53	.37	-.02	-.25	.60	.42	.29	.15	.09	
	.12	-.14	-.44	-.93	.46	.52	.43	.07	-.02		
19.50	1.60	1.04	1.04	.74	.61	.95	1.05	1.00	.84	.69	
	.81	.57	.29	-.39	1.06	1.17	1.13	.82	.74		
20.00	1.99	1.62	1.59	1.45	1.39	1.54	1.61	1.56	1.46	1.07	
	1.44	1.23	.98	.19	1.63	1.69	1.65	1.50	1.49		
20.50	2.33	2.06	2.12	2.04	2.04	2.13	2.11	2.08	1.96	1.41	
	1.90	1.75	1.56	.84	2.11	2.19	2.20	2.12	2.10		
21.00	2.58	2.44	2.53	2.55	2.56	2.62	2.52	2.50	2.39	1.75	
	2.35	2.19	2.04	1.48	2.53	2.56	2.57	2.57	2.61		
21.50	2.72	2.68	2.87	2.91	2.97	3.05	2.85	2.84	2.75	2.10	
	2.71	2.57	2.46	2.05	2.84	2.86	2.89	2.93	2.94		
22.00	2.76	2.76	3.07	3.21	3.23	3.31	3.01	3.09	3.05	2.45	
	3.01	2.88	2.81	2.55	2.99	3.00	3.03	3.10	3.15		
22.50	2.66	2.82	3.07	3.25	3.39	3.49	3.02	3.12	3.19	2.77	
	3.23	3.14	3.11	2.96	2.99	2.99	3.03	3.13	3.17		
23.00	2.42	2.69	2.96	3.13	3.25	3.43	2.89	3.07	3.21	3.03	
	3.23	3.28	3.31	3.29	2.86	2.77	2.82	2.94	3.00		
23.50	2.05	2.46	2.71	2.87	2.99	3.17	2.64	2.86	3.09	3.17	
	3.16	3.30	3.38	3.47	2.58	2.44	2.48	2.60	2.64		
24.00	1.60	2.05	2.34	2.55	2.68	2.90	2.23	2.53	2.82	3.08	
	2.93	3.13	3.25	3.43	2.17	2.01	2.05	2.17	2.20		
24.50	1.12	1.68	1.82	2.14	2.33	2.59	1.75	1.97	2.32	2.87	
	2.45	2.79	2.94	3.18	1.70	1.56	1.59	1.70	1.75		
25.00	.67	1.21	1.29	1.64	1.90	2.25	1.24	1.40	1.70	2.62	
	1.73	2.24	2.47	2.86	1.20	1.10	1.15	1.27	1.29		
25.50	.21	.77	.77	1.13	1.39	1.84	.74	.82	1.06	2.34	
	1.14	1.57	1.88	2.45	.73	.65	.67	.80	.86		
26.00	-.23	.31	.30	.62	.89	1.44	.27	.33	.48	2.04	
	.53	.88	1.23	1.98	.25	.24	.28	.40	.41		
26.50	-.64	-.08	-.17	.15	.40	1.10	-.17	-.15	-.04	1.68	
	-.01	.22	.58	1.49	-.16	-.18	-.15	-.03	.02		
27.00	-.98	-.46	-.54	-.29	-.04	.84	-.54	-.57	-.55	.93	
	-.54	-.41	-.07	.98	-.55	-.59	-.55	-.42	-.38		
27.50	-1.23	-.81	-.92	-.67	-.45	.66	-.91	-.93	-.97	-1.17	
	-.99	-.94	-.65	.49	-.91	-.97	-.94	-.81	-.77		
28.00	-1.28	-1.10	-1.26	-1.03	-.81	.55	-1.24	-1.28	-1.29	-1.21	
	-1.29	-1.28	-1.10	.02	-1.24	-1.29	-1.27	-1.17	-1.14		
28.50	-1.18	-1.28	-1.51	-1.36	-1.14	.49	-1.49	-1.53	-1.55	-1.48	
	-1.55	-1.54	-1.41	-.41	-1.47	-1.52	-1.53	-1.48	-1.48		
29.00	-.87	-1.26	-1.61	-1.60	-1.44	.48	-1.53	-1.68	-1.73	-1.75	
	-1.74	-1.73	-1.65	-.79	-1.50	-1.53	-1.61	-1.70	-1.73		
29.50	-.34	-1.04	-1.45	-1.67	-1.67	.49	-1.36	-1.54	-1.70	-1.78	
	-1.74	-1.83	-1.84	-1.12	-1.30	-1.20	-1.30	-1.61	-1.81		
30.00	.31	-.43	-1.01	-1.43	-1.65	.51	-.83	-1.18	-1.38	-1.43	
	-1.42	-1.59	-1.74	-1.39	-.74	-.64	-.80	-1.24	-1.40		
30.50	1.01	.12	-.22	-.84	-1.14	.46	-.12	-.36	-.69	-.83	
	-.76	-1.03	-1.28	-1.52	-.06	.09	-.02	-.53	-.71		
31.00	1.55	.87	.60	.01	-.26	.46	.68	.49	.25	.15	
	.20	-.14	-.50	-1.10	.73	.84	.71	.25	.14		
31.50	2.12	1.42	1.39	.93	.68	.90	1.40	1.34	1.12	.81	
	1.07	.72	.35	-.51	1.42	1.58	1.52	1.13	1.01		
32.00	2.53	2.08	2.03	1.76	1.63	1.69	2.06	1.97	1.82	1.22	
	1.76	1.50	1.17	.14	2.09	2.18	2.13	1.91	1.90		
32.50	2.92	2.59	2.64	2.47	2.42	2.45	2.64	2.57	2.37	1.61	
	2.29	2.06	1.82	.90	2.64	2.74	2.75	2.65	2.63		
33.00	3.21	3.03	3.11	3.10	3.08	3.10	3.10	3.06	2.89	2.02	
	2.79	2.56	2.36	1.63	3.12	3.14	3.15	3.17	3.23		
33.50	3.40	3.31	3.50	3.53	3.60	3.66	3.48	3.45	3.29	2.45	
	3.22	2.97	2.83	2.29	3.46	3.49	3.53	3.57	3.58		
34.00	3.49	3.41	3.73	3.89	3.92	3.95	3.68	3.74	3.64	2.88	
	3.56	3.32	3.22	2.87	3.66	3.68	3.70	3.76	3.80		
34.50	3.43	3.53	3.77	3.95	4.10	4.17	3.73	3.80	3.81	3.30	
	3.83	3.63	3.57	3.34	3.71	3.72	3.76	3.84	3.87		
35.00	3.23	3.47	3.72	3.86	3.95	4.08	3.66	3.80	3.88	3.63	
	3.89	3.83	3.83	3.74	3.63	3.57	3.61	3.71	3.77		
35.50	2.88	3.28	3.53	3.64	3.72	3.83	3.46	3.65	3.82	3.84	
	3.87	3.94	3.98	4.01	3.41	3.28	3.33	3.43	3.48		
36.00	2.40	2.89	3.20	3.36	3.45	3.60	3.10	3.40	3.69	3.83	
	3.76	3.91	4.00	4.13	3.04	2.84	2.89	3.02	3.07		
36.50	1.89	2.47	2.73	3.00	3.15	3.31	2.62	2.92	3.30	3.65	
	3.49	3.72	3.84	3.99	2.55	2.37	2.41	2.54	2.58		
37.00	1.35	1.99	2.16	2.52	2.75	2.98	2.07	2.34	2.74	3.38	

	2.94	3.35	3.50	3.73	2.03	1.86	1.91	2.05	2.08		
37.50	.80	1.49	1.59	1.97	2.24	2.53	1.53	1.72	2.11	3.09	
	2.23	2.80	3.03	3.39	1.49	1.37	1.40	1.54	1.59		
38.00	.33	.94	1.04	1.41	1.68	2.04	.98	1.15	1.49	2.79	
	1.52	2.14	2.43	2.97	.94	.88	.93	1.07	1.10		
38.50	-.14	.49	.47	.86	1.13	1.58	.45	.54	.83	2.49	
	.89	1.41	1.78	2.49	.44	.39	.43	.58	.64		
39.00	-.53	.06	-.01	.33	.61	1.17	-.03	.01	.19	2.18	
	.22	.66	1.08	1.97	-.04	-.06	-.02	.14	.17		
39.50	-.84	-.34	-.45	-.15	.10	.83	-.45	-.44	-.34	1.79	
	-.32	-.07	.36	1.44	-.45	-.49	-.46	-.31	-.27		
40.00	-1.04	-.67	-.82	-.58	-.34	.59	-.80	-.86	-.86	.98	
	-.84	-.73	-.33	.90	-.80	-.86	-.83	-.72	-.69		
40.50	-1.10	-.93	-1.13	-.94	-.74	.44	-1.11	-1.18	-1.25	-1.42	
	-1.27	-1.24	-.94	.38	-1.10	-1.15	-1.14	-1.07	-1.06		
41.00	-1.00	-1.07	-1.36	-1.25	-1.08	.35	-1.30	-1.41	-1.48	-1.37	
	-1.49	-1.51	-1.36	-.11	-1.27	-1.33	-1.35	-1.35	-1.36		
41.50	-.73	-1.10	-1.39	-1.46	-1.36	.32	-1.34	-1.45	-1.56	-1.51	
	-1.58	-1.63	-1.59	-.56	-1.31	-1.31	-1.37	-1.49	-1.56		
42.00	-.26	-.84	-1.24	-1.47	-1.52	.31	-1.13	-1.33	-1.44	-1.47	
	-1.46	-1.53	-1.60	-.94	-1.07	-1.01	-1.14	-1.40	-1.54		
42.50	.36	-.44	-.80	-1.18	-1.43	.29	-.71	-.90	-1.08	-1.19	
	-1.12	-1.26	-1.38	-1.21	-.64	-.47	-.57	-.97	-1.14		
43.00	.90	.23	-.15	-.65	-.86	.25	-.02	-.29	-.49	-.54	
	-.52	-.72	-.91	-1.24	.06	.17	.05	-.36	-.46		
43.50	1.46	.79	.66	.15	-.11	.37	.70	.58	.32	.18	
	.26	-.04	-.31	-.77	.72	.88	.82	.42	.29		
44.00	1.85	1.43	1.33	.98	.77	.88	1.37	1.27	1.11	.85	
	1.09	.79	.46	-.27	1.41	1.49	1.42	1.15	1.12		
44.50	2.22	1.88	1.97	1.72	1.62	1.68	1.96	1.93	1.76	1.22	
	1.70	1.46	1.19	.32	1.96	2.06	2.06	1.90	1.85		
45.00	2.48	2.34	2.43	2.39	2.34	2.34	2.42	2.40	2.29	1.59	
	2.24	2.03	1.81	1.01	2.43	2.45	2.45	2.44	2.50		
45.50	2.67	2.66	2.81	2.83	2.91	2.97	2.78	2.78	2.67	1.96	
	2.62	2.46	2.31	1.68	2.76	2.77	2.80	2.87	2.89		
46.00	2.85	2.80	3.04	3.20	3.25	3.29	2.99	3.05	3.00	2.33	
	2.96	2.81	2.70	2.28	2.97	2.93	2.96	3.04	3.11		
46.50	2.87	2.90	3.12	3.29	3.42	3.49	3.08	3.15	3.18	2.68	
	3.21	3.09	3.04	2.78	3.06	3.03	3.05	3.09	3.10		
47.00	2.83	2.86	3.10	3.22	3.30	3.42	3.05	3.19	3.27	2.97	
	3.27	3.27	3.27	3.17	3.02	3.05	3.06	3.05	3.03		
47.50	2.66	2.84	2.97	3.04	3.10	3.20	2.94	3.06	3.22	3.18	
	3.29	3.36	3.40	3.43	2.93	2.91	2.93	2.97	2.99		
48.00	2.39	2.65	2.84	2.84	2.88	3.00	2.78	2.97	3.14	3.24	
	3.16	3.30	3.40	3.53	2.74	2.64	2.69	2.80	2.87		
48.50	2.04	2.40	2.60	2.70	2.71	2.80	2.53	2.70	2.90	3.11	
	2.99	3.15	3.23	3.38	2.48	2.34	2.38	2.49	2.54		
49.00	1.59	2.11	2.22	2.42	2.56	2.70	2.15	2.33	2.54	2.93	
	2.62	2.85	2.95	3.14	2.11	1.98	2.02	2.11	2.12		
49.50	1.12	1.71	1.78	2.06	2.24	2.44	1.74	1.85	2.07	2.70	
	2.14	2.43	2.58	2.85	1.70	1.58	1.60	1.68	1.72		
50.00	.60	1.22	1.33	1.62	1.81	2.06	1.27	1.40	1.57	2.45	
	1.58	1.93	2.13	2.51	1.24	1.14	1.18	1.30	1.31		
50.50	.06	.76	.81	1.13	1.34	1.64	.78	.87	1.05	2.18	
	1.09	1.37	1.61	2.11	.75	.68	.72	.85	.92		
51.00	-.36	.27	.30	.63	.86	1.23	.25	.35	.50	1.88	
	.53	.77	1.05	1.68	.23	.20	.26	.43	.47		
51.50	-.74	-.14	-.22	.13	.37	.84	-.23	-.19	-.07	1.48	
	-.04	.15	.47	1.23	-.24	-.30	-.25	-.06	.02		
52.00	-.93	-.56	-.65	-.36	-.11	.51	-.65	-.66	-.61	.30	
	-.60	-.46	-.13	.77	-.67	-.71	-.67	-.51	-.47		
52.50	-1.01	-.85	-1.05	-.78	-.57	.25	-1.03	-1.08	-1.08	-1.16	
	-1.08	-1.01	-.72	.30	-1.01	-1.05	-1.04	-.93	-.90		
53.00	-.89	-1.01	-1.30	-1.18	-.98	.09	-1.25	-1.37	-1.43	-1.51	
	-1.44	-1.42	-1.21	-.16	-1.22	-1.25	-1.28	-1.26	-1.27		
53.50	-.60	-1.03	-1.37	-1.42	-1.34	.00	-1.31	-1.45	-1.56	-1.58	
	-1.59	-1.67	-1.58	-.59	-1.26	-1.25	-1.31	-1.44	-1.51		
54.00	-.17	-.69	-1.20	-1.48	-1.54	-.04	-1.06	-1.33	-1.48	-1.48	
	-1.52	-1.62	-1.68	-.97	-.99	-.92	-1.07	-1.36	-1.50		
54.50	.45	-.30	-.69	-1.16	-1.48	-.06	-.59	-.81	-1.05	-1.15	
	-1.11	-1.29	-1.45	-1.28	-.52	-.34	-.44	-.89	-1.09		
55.00	1.01	.36	-.01	-.56	-.83	-.09	.13	-.14	-.34	-.41	
	-.38	-.62	-.88	-1.31	.20	.29	.16	-.26	-.35		
55.50	1.60	.90	.82	.27	-.02	.18	.84	.75	.50	.35	
	.43	.13	-.18	-.80	.85	.99	.93	.54	.42		
56.00	2.07	1.55	1.45	1.12	.88	.89	1.49	1.41	1.28	.93	

1.25	.96	.61	-.26	1.53	1.62	1.54	1.28	1.25		
56.50	2.53	2.07	2.09	1.82	1.73	1.74	2.09	2.04	1.87	1.30
1.80	1.59	1.33	.39	2.10	2.23	2.22	2.04	1.98		
57.00	2.86	2.60	2.60	2.50	2.41	2.40	2.61	2.55	2.40	1.67
2.33	2.13	1.91	1.10	2.63	2.70	2.68	2.62	2.67		
57.50	3.14	2.98	3.07	3.01	3.02	3.06	3.07	3.01	2.85	2.06
2.77	2.57	2.41	1.77	3.07	3.13	3.15	3.16	3.15		
58.00	3.35	3.22	3.42	3.48	3.48	3.48	3.40	3.40	3.26	2.46
3.18	2.96	2.82	2.37	3.39	3.40	3.41	3.47	3.53		
58.50	3.44	3.40	3.64	3.75	3.82	3.85	3.60	3.63	3.55	2.88
3.52	3.30	3.21	2.88	3.58	3.60	3.63	3.68	3.69		
59.00	3.46	3.44	3.71	3.87	3.95	4.00	3.66	3.75	3.74	3.26
3.73	3.57	3.53	3.33	3.64	3.66	3.68	3.73	3.76		
59.50	3.33	3.49	3.66	3.79	3.88	3.94	3.62	3.71	3.80	3.58
3.84	3.78	3.77	3.69	3.60	3.57	3.61	3.67	3.70		
60.00	3.07	3.36	3.55	3.60	3.65	3.73	3.50	3.66	3.79	3.77
3.80	3.87	3.92	3.94	3.46	3.38	3.41	3.48	3.52		
60.50	2.71	3.10	3.34	3.41	3.42	3.47	3.27	3.47	3.69	3.80
3.75	3.87	3.94	4.04	3.21	3.08	3.11	3.19	3.22		
61.00	2.23	2.72	2.99	3.14	3.23	3.30	2.90	3.17	3.44	3.66
3.57	3.73	3.82	3.95	2.84	2.65	2.70	2.82	2.85		
61.50	1.73	2.33	2.51	2.79	2.94	3.05	2.43	2.66	2.99	3.44
3.16	3.45	3.55	3.72	2.37	2.21	2.24	2.36	2.42		
62.00	1.23	1.84	1.97	2.31	2.51	2.67	1.90	2.11	2.45	3.17
2.58	3.00	3.17	3.42	1.86	1.72	1.77	1.91	1.93		
62.50	.74	1.37	1.43	1.76	1.99	2.18	1.38	1.53	1.86	2.88
1.93	2.44	2.67	3.06	1.35	1.24	1.27	1.40	1.46		
63.00	.34	.87	.91	1.22	1.43	1.66	.86	.99	1.25	2.59
1.31	1.79	2.09	2.63	.84	.79	.83	.96	.98		
63.50	-.02	.49	.39	.70	.90	1.16	.38	.43	.63	2.30
.67	1.10	1.43	2.15	.39	.33	.36	.49	.54		
64.00	-.31	.11	-.02	.20	.40	.71	-.02	-.02	.08	1.97
.10	.40	.77	1.63	-.02	-.05	-.02	.09	.11		
64.50	-.50	-.20	-.37	-.20	-.07	.31	-.36	-.40	-.37	1.50
-.37	-.27	.11	1.11	-.35	-.38	-.37	-.30	-.28		
65.00	-.62	-.43	-.64	-.56	-.45	.02	-.60	-.71	-.77	.01
-.78	-.76	-.47	.59	-.59	-.64	-.64	-.61	-.61		
65.50	-.60	-.60	-.81	-.81	-.76	-.16	-.78	-.87	-.98	-1.04
-.99	-1.05	-.93	.10	-.76	-.80	-.82	-.84	-.86		
66.00	-.53	-.65	-.90	-.96	-.96	-.28	-.83	-.95	-1.01	-1.13
-1.02	-1.10	-1.11	-.35	-.80	-.83	-.89	-.97	-1.01		
66.50	-.31	-.64	-.81	-.98	-1.05	-.35	-.76	-.85	-.94	-.95
-.95	-1.01	-1.07	-.72	-.74	-.67	-.72	-.90	-1.00		
67.00	.02	-.41	-.62	-.80	-.93	-.39	-.54	-.67	-.72	-.69
-.73	-.78	-.84	-.93	-.50	-.41	-.48	-.66	-.72		
67.50	.43	-.11	-.24	-.50	-.58	-.29	-.19	-.29	-.40	-.47
-.43	-.52	-.59	-.76	-.15	.00	-.04	-.23	-.30		
68.00	.83	.39	.23	.00	-.13	-.02	.29	.15	.04	.01
.02	-.10	-.24	-.48	.33	.44	.38	.23	.20		
68.50	1.24	.83	.77	.53	.41	.46	.79	.72	.57	.50
.54	.37	.21	-.17	.81	.92	.91	.76	.70		
69.00	1.57	1.30	1.26	1.08	.99	.98	1.29	1.22	1.12	.90
1.10	.93	.74	.24	1.31	1.35	1.31	1.21	1.22		
69.50	1.88	1.65	1.73	1.61	1.54	1.53	1.72	1.71	1.61	1.21
1.58	1.42	1.25	.72	1.72	1.77	1.78	1.71	1.67		
70.00	2.19	2.00	2.08	2.06	2.04	2.04	2.07	2.07	2.01	1.52
2.00	1.88	1.74	1.24	2.07	2.09	2.09	2.07	2.11		

C2: TABULAR OUTPUT FILE

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1PASSAIC RIVER FLOOD PROTECTION STUDY
  OCTOBER TIDE 11-13 1976   RAN  FEBRUARY 1992
 FORCING AT NODES 1, 2, 3, AND 4.
     APPROXIMATE ACTUAL FLOWS IN RIVERS


 SWITCH INFORMATION
   (1)  (2)  (3)  (4)  (5)  (6)  (7)  (8)  (9) (10)
    1    0    0    0    1    1    0    0    0    1
 TIDALLY INFLUENCED SYSTEM ISWCH(1)
 CHANNEL VELOCITY AND FLOWS ARE NOT PRINTED ISWCH(5)
     3   25  1.000000 60.000000   .000000    0       .00       .00              1    1    3    0    4
0DAYS SIMULATED   3
0PRINTOUT CYCLES PER DAY  25
0INTEGRATION CYCLES PER PRINTOUT CYCLE  60
0LENGTH OF INTEGRATION STEP IS 60.000000 SECONDS
0INITIAL TIME    .00 HOURS
 EVAPORATION RATE    .0 INCHES PER MONTH
0WRITE CYCLE STARTS AT THE    1 TIME CYCLE


0NO PRECIPITATION INPUT
          1         4        50         1         1    25.000
          1         4        50         1         2    25.000
          1         4        50         1         3    25.000
          1         4        50         1         4    25.000

 MAP SCALE IS        1:     125000

 WIND REDUCTION FACTOR =       .250

 DATUM CORRECTION IS        .000 FEET  MANNINGS N FACTOR =       1.000
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1 JUNCTION NUMBER	HEAD (FT)	DEPTH (FT)	INFLOW (CFS)	REFERENCE HEAD H0 (FT)	H1 (FT)	SURFACE AREA (FT**2)	AREA SLOPES (FT**2/FT) SLOPE1	SLOPE2	CHANNELS ENTERING JUNCTION								COORDINATES (FT) (X)	(Y)
1	.00	104.30	0.00E+00	-1.80	999.00	9.90E+08	0.00E+00	0.00E+00	214	215	216	0	0	0	0	0	119583.30	58958.33
2	.00	95.30	0.00E+00	-1.80	999.00	8.63E+08	0.00E+00	0.00E+00	217	218	219	0	0	0	0	0	143541.70	78958.34
3	.00	59.30	0.00E+00	-1.80	999.00	1.18E+09	0.00E+00	0.00E+00	220	221	0	0	0	0	0	0	166562.50	97708.34
4	.00	105.65	0.00E+00	-3.15	999.00	2.55E+09	0.00E+00	0.00E+00	296	0	0	0	0	0	0	0	298541.70	282916.70
5	.00	44.30	0.00E+00	-1.80	999.00	3.81E+08	0.00E+00	0.00E+00	1	2	13	14	215	258	0	0	90416.67	79166.67
6	.00	53.30	0.00E+00	-1.80	999.00	4.57E+08	0.00E+00	0.00E+00	3	4	8	9	10	11	218	0	121770.80	103125.00
7	.00	42.30	0.00E+00	-2.30	999.00	4.96E+08	3.40E+07	0.00E+00	6	7	221	246	0	0	0	0	146354.20	118333.30
8	.00	29.30	0.00E+00	-2.30	999.00	2.17E+08	6.20E+05	0.00E+00	5	7	8	213	247	248	0	0	127187.50	122395.80
9	.00	27.30	0.00E+00	-1.80	999.00	1.15E+08	0.00E+00	0.00E+00	9	21	213	249	0	0	0	0	116562.50	116666.70
10	.00	26.30	0.00E+00	-1.80	999.00	2.00E+08	0.00E+00	0.00E+00	10	19	20	21	250	254	0	0	102187.50	111979.20
11	.00	44.30	0.00E+00	-1.80	999.00	4.46E+08	0.00E+00	0.00E+00	11	12	13	15	16	17	18	19	92500.01	94791.67
12	.00	26.29	0.00E+00	-1.79	999.00	2.25E+08	0.00E+00	0.00E+00	14	15	47	48	49	0	0	0	73750.00	89687.50
13	.00	20.29	0.00E+00	-1.79	999.00	3.02E+08	0.00E+00	0.00E+00	49	50	51	52	53	54	0	0	63020.84	87395.84
14	.00	14.29	0.00E+00	-1.79	999.00	2.17E+07	0.00E+00	0.00E+00	54	55	264	0	0	0	0	0	72812.50	82291.67
15	.00	14.29	0.00E+00	-1.79	999.00	1.33E+08	0.00E+00	0.00E+00	53	55	56	262	265	0	0	0	72916.67	64687.50
16	.00	14.29	0.00E+00	-1.79	999.00	1.85E+08	0.00E+00	0.00E+00	52	56	57	58	0	0	0	0	51666.67	72916.67
17	.00	8.28	0.00E+00	-1.78	999.00	1.12E+08	0.00E+00	0.00E+00	58	59	60	0	0	0	0	0	39479.17	79166.67

18	.00	11.28	0.00E+00	-1.78	999.00	2.08E+08	0.00E+00	0.00E+00	60	61	73	74	75	0	0	0	24687.50	81354.17
19	.00	22.28	0.00E+00	-1.78	999.00	2.66E+08	0.00E+00	0.00E+00	51	57	59	61	62	71	72	0	41041.67	93541.66
20	.00	20.30	0.00E+00	-1.80	999.00	2.66E+08	0.00E+00	0.00E+00	46	48	50	62	63	68	69	70	53645.84	105520.80
21	.00	29.30	0.00E+00	-1.80	999.00	2.84E+08	0.00E+00	0.00E+00	16	42	44	45	46	47	0	0	70520.84	106770.80
22	.00	17.30	0.00E+00	-2.30	999.00	1.01E+08	1.29E+06	0.00E+00	18	20	22	41	0	0	0	0	91354.17	113229.20
23	.00	14.31	0.00E+00	-2.31	999.00	5.64E+07	4.40E+05	0.00E+00	22	23	24	25	231	257	0	0	92604.17	122812.50
24	.00	20.31	0.00E+00	-2.31	999.00	1.56E+08	1.72E+06	0.00E+00	17	23	41	42	43	0	0	0	78854.17	121666.70
25	.00	22.31	0.00E+00	-2.31	999.00	5.96E+07	6.40E+05	0.00E+00	43	44	64	65	88	89	0	0	71145.84	123437.50
26	.00	29.31	0.00E+00	-1.81	999.00	1.00E+08	0.00E+00	0.00E+00	45	63	64	66	67	0	0	0	67187.50	117604.20
27	.00	17.34	0.00E+00	-2.34	999.00	4.34E+07	1.81E+06	0.00E+00	89	90	0	0	0	0	0	0	73854.17	130416.70
28	.00	44.20	0.00E+00	-1.70	999.00	6.83E+07	0.00E+00	0.00E+00	65	66	84	85	86	87	0	0	64687.50	127604.20
29	.00	9.20	0.00E+00	-2.20	999.00	9.90E+07	3.76E+06	0.00E+00	67	68	82	83	84	0	0	0	53750.00	123333.30
30	.00	7.24	0.00E+00	-2.24	999.00	7.80E+07	2.40E+06	0.00E+00	69	81	82	0	0	0	0	0	45833.34	114895.80
31	.00	12.28	0.00E+00	-2.28	999.00	1.33E+08	6.20E+05	0.00E+00	70	71	80	81	228	0	0	0	33541.67	106354.20
32	.00	20.32	0.00E+00	-2.32	999.00	1.46E+08	8.70E+05	0.00E+00	72	73	79	80	0	0	0	0	18020.83	99479.17
33	.00	20.37	0.00E+00	-1.87	999.00	1.04E+08	0.00E+00	0.00E+00	74	76	78	79	0	0	0	0	9166.67	91458.34
34	.00	7.37	0.00E+00	-1.87	999.00	1.14E+08	0.00E+00	0.00E+00	75	76	77	0	0	0	0	0	8958.33	81041.67
35	.00	14.43	0.00E+00	-1.93	999.00	9.10E+07	0.00E+00	0.00E+00	77	78	111	236	0	0	0	0	833.33	96354.17
36	.00	20.44	0.00E+00	-1.94	999.00	2.38E+07	0.00E+00	0.00E+00	110	111	0	0	0	0	0	0	6250.00	103958.30
37	.00	20.46	0.00E+00	-1.96	999.00	3.04E+07	0.00E+00	0.00E+00	109	110	0	0	0	0	0	0	4062.50	112708.30
38	.00	20.48	0.00E+00	-2.48	999.00	1.41E+07	1.45E+06	0.00E+00	108	109	0	0	0	0	0	0	11979.17	117187.50
39	.00	20.49	0.00E+00	-2.49	999.00	7.80E+06	5.40E+05	0.00E+00	107	108	224	0	0	0	0	0	16354.17	121875.00
40	.00	20.49	0.00E+00	-2.49	999.00	1.00E+07	1.52E+06	0.00E+00	106	107	223	0	0	0	0	0	17187.50	125208.30
41	.00	35.00	0.00E+00	-25.00	999.00	4.08E+06	1.40E+05	0.00E+00	105	106	398	0	0	0	0	0	19479.17	132291.70
42	.00	35.00	0.00E+00	.00	999.00	4.14E+06	0.00E+00	0.00E+00	104	431	0	0	0	0	0	0	18958.33	145520.80
43	.00	35.00	0.00E+00	-15.00	999.00	2.13E+06	1.10E+05	0.00E+00	103	432	0	0	0	0	0	0	25104.17	149479.20
44	.00	42.00	0.00E+00	-32.00	999.00	1.08E+07	3.30E+05	0.00E+00	102	430	433	0	0	0	0	0	32604.17	148750.00
45	.00	42.00	0.00E+00	-20.00	999.00	5.94E+06	1.08E+05	0.00E+00	101	434	0	0	0	0	0	0	42812.50	148958.30
46	.00	42.00	0.00E+00	-27.00	999.00	4.41E+06	2.70E+05	0.00E+00	103	429	433	0	0	0	0	0	28750.00	149687.50
47	.00	42.00	0.00E+00	-20.00	999.00	5.20E+06	1.04E+05	0.00E+00	102	434	0	0	0	0	0	0	38541.67	148333.30
48	.00	42.00	0.00E+00	-20.00	999.00	6.00E+06	1.20E+05	0.00E+00	101	435	0	0	0	0	0	0	48854.17	150416.70
49	.00	35.00	0.00E+00	.00	9.50	2.34E+06	9.52E+06	2.56E+05	343	0	0	0	0	0	0	0	31145.83	163750.00
50	.00	23.31	0.00E+00	-2.31	999.00	4.00E+07	9.99E+05	0.00E+00	100	116	117	118	435	0	0	0	54166.67	151770.80
51	.00	54.33	0.00E+00	-1.83	999.00	3.50E+07	0.00E+00	0.00E+00	94	95	99	100	0	0	0	0	55520.84	141979.20
52	.00	54.35	0.00E+00	-1.85	999.00	4.10E+07	0.00E+00	0.00E+00	83	85	93	94	0	0	0	0	60416.67	133229.20
53	.00	23.39	0.00E+00	-2.39	999.00	2.60E+07	4.60E+05	0.00E+00	87	88	90	91	92	0	0	0	65104.17	135208.30
54	.00	37.35	0.00E+00	-1.85	999.00	3.80E+07	0.00E+00	0.00E+00	86	92	93	95	96	97	0	0	59791.67	142187.50
55	.00	34.33	0.00E+00	-2.33	999.00	2.80E+07	4.10E+05	0.00E+00	91	97	98	122	0	0	0	0	64583.33	148229.20
56	.00	44.31	0.00E+00	-1.81	999.00	5.86E+07	0.00E+00	0.00E+00	96	98	99	118	119	120	121	0	60104.17	152500.00
57	.00	34.31	0.00E+00	-2.31	999.00	3.46E+07	8.50E+05	0.00E+00	121	122	123	229	0	0	0	0	70208.34	155729.20
58	.00	32.31	0.00E+00	-2.31	999.00	2.60E+07	1.26E+06	0.00E+00	120	123	124	131	298	0	0	0	70104.17	161562.50
59	.00	39.31	0.00E+00	-1.81	999.00	4.44E+07	0.00E+00	0.00E+00	117	119	124	125	126	0	0	0	61875.00	159479.20
60	.00	11.31	0.00E+00	-2.31	999.00	6.30E+07	2.30E+06	0.00E+00	116	126	127	128	0	0	0	0	58229.17	164062.50
61	.00	39.31	0.00E+00	-1.81	999.00	3.25E+07	0.00E+00	0.00E+00	125	127	129	130	298	0	0	0	66666.67	165312.50
62	.00	39.31	0.00E+00	-2.31	999.00	2.92E+07	8.50E+05	0.00E+00	130	131	132	133	0	0	0	0	73229.17	168229.20
63	.00	39.27	0.00E+00	-1.77	999.00	5.86E+07	0.00E+00	0.00E+00	128	129	132	136	0	0	0	0	67916.67	171354.20
64	.00	32.14	0.00E+00	-2.14	999.00	9.44E+07	7.64E+06	0.00E+00	136	137	0	0	0	0	0	0	70416.67	188125.00
65	.00	28.95	0.00E+00	-1.95	999.00	1.14E+08	5.05E+06	0.00E+00	137	138	0	0	0	0	0	0	82187.50	213229.20
66	.00	25.76	0.00E+00	-1.26	999.00	1.08E+08	0.00E+00	0.00E+00	138	139	140	0	0	0	0	0	93020.84	235000.00
67	.00	25.72	0.00E+00	-1.22	999.00	1.66E+08	0.00E+00	0.00E+00	139	239	0	0	0	0	0	0	98958.34	255833.30
68	.00	7.87	0.00E+00	-1.37	999.00	1.30E+07	0.00E+00	0.00E+00	140	141	0	0	0	0	0	0	100312.50	232812.50
69	.00	4.98	0.00E+00	-1.48	999.00	8.70E+06	0.00E+00	0.00E+00	141	142	0	0	0	0	0	0	87604.16	218958.30
70	.00	5.09	0.00E+00	-2.09	999.00	9.70E+06	7.00E+05	0.00E+00	142	143	0	0	0	0	0	0	94687.51	207500.00
71	.00	6.50	0.00E+00	-3.13	999.00	3.25E+07	2.68E+06	0.00E+00	144	0	0	0	0	0	0	0	116875.00	193645.80

72	.00	17.30	0.00E+00	-2.30	999.00	3.36E+07	1.33E+06	0.00E+00	135	143	145	0	0	0	0	0	92187.51	198750.00
73	.00	20.30	0.00E+00	-1.80	999.00	4.45E+07	0.00E+00	0.00E+00	134	135	230	0	0	0	0	0	84479.16	181979.20
74	.00	23.31	0.00E+00	-2.31	999.00	2.17E+07	1.26E+06	0.00E+00	133	134	0	0	0	0	0	0	82187.50	172500.00
75	.00	21.10	0.00E+00	-3.10	999.00	3.36E+07	5.40E+05	0.00E+00	145	148	149	150	0	0	0	0	100104.20	203750.00
76	.00	18.11	0.00E+00	-3.11	999.00	6.50E+06	3.90E+05	0.00E+00	148	151	0	0	0	0	0	0	104062.50	207812.50
77	.00	18.12	0.00E+00	-3.12	999.00	2.06E+07	6.40E+05	0.00E+00	149	151	154	155	156	0	0	0	108020.80	206145.80
78	.00	18.11	0.00E+00	-3.11	999.00	2.20E+07	1.14E+06	0.00E+00	150	152	0	0	0	0	0	0	105104.20	200000.00
79	.00	18.13	0.00E+00	-3.13	999.00	5.86E+07	1.12E+06	0.00E+00	144	152	153	154	0	0	0	0	112500.00	200625.00
80	.00	18.13	0.00E+00	-2.63	999.00	2.28E+07	0.00E+00	0.00E+00	153	155	158	159	160	0	0	0	115937.50	204270.80
81	.00	15.13	0.00E+00	-3.13	999.00	1.74E+07	6.30E+05	0.00E+00	146	156	157	158	0	0	0	0	113125.00	207500.00
82	.00	15.26	0.00E+00	-3.26	999.00	2.60E+07	1.27E+06	0.00E+00	147	157	159	161	162	0	0	0	119270.80	208229.20
83	.00	18.26	0.00E+00	-3.26	999.00	2.17E+07	3.40E+05	0.00E+00	160	161	163	164	0	0	0	0	122083.30	205416.70
84	.00	18.39	0.00E+00	-3.39	999.00	1.84E+07	4.70E+05	0.00E+00	162	163	165	166	0	0	0	0	126145.80	210520.80
85	.00	18.39	0.00E+00	-3.39	999.00	1.19E+07	2.70E+05	0.00E+00	164	165	167	168	0	0	0	0	127812.50	205937.50
86	.00	12.52	0.00E+00	-3.52	999.00	8.70E+06	2.40E+05	0.00E+00	168	169	170	0	0	0	0	0	134270.80	202812.50
87	.00	21.52	0.00E+00	-3.52	999.00	4.12E+07	1.10E+05	0.00E+00	166	167	169	175	176	177	0	0	134375.00	207083.30
88	.00	15.52	0.00E+00	-3.52	999.00	3.04E+07	3.60E+05	0.00E+00	170	171	173	174	175	0	0	0	138125.00	205625.00
89	.00	6.57	0.00E+00	-3.57	999.00	2.93E+07	3.38E+06	0.00E+00	171	172	0	0	0	0	0	0	142604.20	195833.30
90	.00	12.57	0.00E+00	-3.07	999.00	2.82E+07	0.00E+00	0.00E+00	172	173	181	182	0	0	0	0	140208.30	209479.20
91	.00	39.57	0.00E+00	-3.07	999.00	4.23E+07	0.00E+00	0.00E+00	174	176	178	179	180	181	0	0	137812.50	215000.00
92	.00	12.57	0.00E+00	-3.57	999.00	4.12E+07	4.00E+05	0.00E+00	177	178	189	190	191	0	0	0	129375.00	215208.30
93	.00	12.57	0.00E+00	-3.57	999.00	1.84E+07	2.90E+05	0.00E+00	191	192	193	0	0	0	0	0	126875.00	220416.70
94	.00	9.57	0.00E+00	-3.57	999.00	1.95E+07	1.89E+06	0.00E+00	193	194	222	0	0	0	0	0	126562.50	228229.20
95	.00	12.57	0.00E+00	-3.57	999.00	2.93E+07	4.00E+05	0.00E+00	188	190	192	194	195	0	0	0	131354.20	223020.80
96	.00	27.57	0.00E+00	-3.07	999.00	3.15E+07	0.00E+00	0.00E+00	187	196	197	198	0	0	0	0	136562.50	224895.80
97	.00	45.57	0.00E+00	-3.07	999.00	3.04E+07	0.00E+00	0.00E+00	179	185	186	187	188	189	0	0	136354.20	219687.50
98	.00	48.57	0.00E+00	-3.07	999.00	2.93E+07	0.00E+00	0.00E+00	180	182	183	184	185	0	0	0	142291.70	219062.50
99	.00	15.57	0.00E+00	-3.07	999.00	4.88E+07	0.00E+00	0.00E+00	183	201	202	203	0	0	0	0	146458.30	221250.00
100	.00	15.59	0.00E+00	-3.09	999.00	6.07E+07	0.00E+00	0.00E+00	203	0	0	0	0	0	0	0	154583.30	215208.30
101	.00	66.57	0.00E+00	-3.07	999.00	5.21E+07	0.00E+00	0.00E+00	184	186	198	199	200	201	0	0	142083.30	225208.30
102	.00	39.68	0.00E+00	-3.18	999.00	2.64E+08	0.00E+00	0.00E+00	200	202	204	210	280	0	0	0	154062.50	232291.70
103	.00	57.65	0.00E+00	-3.15	999.00	1.20E+08	0.00E+00	0.00E+00	197	199	204	205	207	209	0	0	143125.00	233958.30
104	.00	27.57	0.00E+00	-3.07	999.00	4.55E+07	0.00E+00	0.00E+00	195	196	205	206	0	0	0	0	132604.20	230104.20
105	.00	45.62	0.00E+00	-3.12	999.00	1.45E+08	0.00E+00	0.00E+00	206	207	208	281	0	0	0	0	140625.00	244270.80
106	.00	45.66	0.00E+00	-3.16	999.00	3.69E+08	0.00E+00	0.00E+00	208	209	210	211	282	283	0	0	162500.00	249583.30
107	.00	14.45	0.00E+00	-2.45	999.00	3.15E+07	1.35E+06	0.00E+00	24	26	212	232	233	0	0	0	101875.00	125000.00
108	.00	17.45	0.00E+00	-2.45	999.00	2.60E+07	1.22E+06	0.00E+00	25	27	212	253	256	0	0	0	103437.50	121875.00
109	.00	17.55	0.00E+00	-2.55	999.00	3.58E+07	9.70E+05	0.00E+00	26	27	28	40	252	0	0	0	110729.20	125312.50
110	.00	14.60	0.00E+00	-2.60	999.00	4.99E+07	6.70E+05	0.00E+00	28	29	39	0	0	0	0	0	118854.20	127812.50
111	.00	11.63	0.00E+00	-2.63	999.00	6.94E+07	2.35E+06	0.00E+00	29	30	32	0	0	0	0	0	126041.70	130104.20
112	.00	14.58	0.00E+00	-2.58	999.00	3.36E+07	6.49E+06	0.00E+00	30	31	245	0	0	0	0	0	138020.80	137604.20
113	.00	14.57	0.00E+00	-2.57	999.00	1.60E+07	1.18E+07	0.00E+00	31	0	0	0	0	0	0	0	145729.20	145000.00
114	.00	14.59	0.00E+00	-2.59	999.00	1.30E+07	4.24E+06	0.00E+00	33	0	0	0	0	0	0	0	135729.20	142708.30
115	.00	17.60	0.00E+00	-2.60	999.00	4.02E+07	3.31E+06	0.00E+00	32	33	34	0	0	0	0	0	129791.70	144895.80
116	.00	14.61	0.00E+00	-2.61	999.00	8.46E+07	8.04E+06	0.00E+00	34	35	36	0	0	0	0	0	122812.50	148541.70
117	.00	14.59	0.00E+00	-2.59	999.00	6.07E+07	3.25E+06	0.00E+00	35	37	235	0	0	0	0	0	107187.50	140104.20
118	.00	14.58	0.00E+00	-2.58	999.00	3.58E+07	3.70E+05	0.00E+00	37	38	234	0	0	0	0	0	108020.80	135937.50
119	.00	14.57	0.00E+00	-2.57	999.00	4.66E+07	1.08E+06	0.00E+00	36	38	39	40	0	0	0	0	109687.50	132604.20
120	.00	50.30	0.00E+00	-1.80	999.00	5.71E+08	0.00E+00	0.00E+00	1	214	259	260	0	0	0	0	97291.67	61458.34
121	.00	80.30	0.00E+00	-1.80	999.00	5.53E+08	0.00E+00	0.00E+00	2	3	12	216	217	0	0	0	121250.00	81250.01
122	.00	71.30	0.00E+00	-1.80	999.00	4.31E+08	0.00E+00	0.00E+00	4	5	6	219	220	0	0	0	144062.50	100729.20
123	.00	6.50	1.74E+02	-3.13	999.00	3.26E+06	5.70E+05	0.00E+00	146	0	0	0	0	0	0	0	108750.00	210625.00
124	.00	6.50	0.00E+00	-3.26	999.00	5.43E+06	6.00E+05	0.00E+00	147	0	0	0	0	0	0	0	118125.00	219062.50
125	.00	4.49	0.00E+00	-2.49	999.00	6.50E+06	1.49E+06	0.00E+00	227	0	0	0	0	0	0	0	28645.83	121875.00

126	.00	4.49	0.00E+00	-2.49	999.00	4.30E+06	1.45E+06	0.00E+00	226	0	0	0	0	0	0	0	25208.33	130000.00
127	.00	6.49	0.00E+00	-2.49	999.00	7.60E+06	5.00E+05	0.00E+00	225	226	227	0	0	0	0	0	23541.67	123750.00
128	.00	13.49	0.00E+00	-2.49	999.00	6.50E+06	6.60E+05	0.00E+00	223	224	225	0	0	0	0	0	19791.67	124583.30
129	.00	27.31	0.00E+00	-2.31	999.00	5.40E+06	7.10E+05	0.00E+00	229	0	0	0	0	0	0	0	75937.50	159479.20
130	.00	10.30	0.00E+00	-1.80	999.00	1.41E+07	0.00E+00	0.00E+00	230	0	0	0	0	0	0	0	96250.00	177916.70
131	.00	17.45	0.00E+00	-2.45	999.00	6.50E+06	1.91E+06	0.00E+00	231	232	0	0	0	0	0	0	91145.84	126041.70
132	.00	10.59	0.00E+00	-2.59	999.00	1.41E+07	1.64E+06	0.00E+00	233	0	0	0	0	0	0	0	97395.84	131979.20
133	.00	14.58	0.00E+00	-2.58	999.00	1.52E+07	3.08E+06	0.00E+00	234	0	0	0	0	0	0	0	99895.84	135729.20
134	.00	14.59	0.00E+00	-2.59	999.00	3.30E+06	1.32E+06	0.00E+00	235	0	0	0	0	0	0	0	100312.50	143541.70
135	.00	12.28	0.00E+00	-1.78	999.00	1.63E+07	0.00E+00	0.00E+00	228	0	0	0	0	0	0	0	37500.00	112500.00
136	.00	17.43	0.00E+00	-2.43	999.00	3.36E+07	4.10E+05	0.00E+00	236	237	0	0	0	0	0	0	-8020.83	95312.50
137	.00	14.55	0.00E+00	-2.05	999.00	3.04E+07	0.00E+00	0.00E+00	237	238	0	0	0	0	0	0	-16250.00	95104.17
138	.00	14.70	0.00E+00	-2.20	999.00	4.67E+07	0.00E+00	0.00E+00	238	0	0	0	0	0	0	0	-29166.67	83333.34
139	.00	5.57	2.30E+01	-3.57	999.00	3.30E+06	1.04E+06	0.00E+00	222	0	0	0	0	0	0	0	124895.80	237395.80
140	.00	25.50	0.00E+00	-1.00	999.00	2.39E+08	0.00E+00	0.00E+00	239	240	0	0	0	0	0	0	105104.20	282395.80
141	.00	25.50	0.00E+00	-1.00	999.00	5.43E+08	0.00E+00	0.00E+00	240	241	0	0	0	0	0	0	105104.20	327187.50
142	.00	25.50	1.36E+04	-1.00	999.00	3.00E+08	0.00E+00	0.00E+00	241	0	0	0	0	0	0	0	105104.20	368854.20
143	.00	8.00	0.00E+00	.00	999.00	8.80E+06	0.00E+00	0.00E+00	427	428	429	0	0	0	0	0	30312.50	152395.80
144	.00	42.00	0.00E+00	-2.00	999.00	6.04E+06	0.00E+00	0.00E+00	423	424	425	426	428	430	0	0	34062.50	152500.00
145	.00	-9.06	0.00E+00	.06	999.00	7.30E+06	2.55E+06	0.00E+00	244	245	0	0	0	0	0	0	138333.30	132083.30
146	.00	-9.00	0.00E+00	.00	999.00	5.64E+07	1.54E+06	0.00E+00	244	246	247	0	0	0	0	0	138541.70	129791.70
147	.00	-5.00	0.00E+00	.00	999.00	4.34E+07	1.68E+06	0.00E+00	248	249	250	251	0	0	0	0	106145.80	119583.30
148	.00	-5.10	0.00E+00	.10	999.00	8.68E+06	2.66E+06	0.00E+00	251	252	253	0	0	0	0	0	105416.70	121875.00
149	.00	-5.00	0.00E+00	.00	999.00	1.95E+07	9.20E+05	0.00E+00	254	255	0	0	0	0	0	0	99166.67	116562.50
150	.00	-4.90	0.00E+00	-.10	999.00	1.09E+07	1.16E+06	0.00E+00	255	256	257	0	0	0	0	0	98750.00	119270.80
151	.00	-5.10	0.00E+00	.60	999.00	1.85E+07	0.00E+00	0.00E+00	263	264	265	0	0	0	0	0	76562.50	75000.00
152	.00	-5.00	0.00E+00	.50	999.00	6.62E+07	0.00E+00	0.00E+00	258	259	263	0	0	0	0	0	80208.34	75833.34
153	.00	-5.15	0.00E+00	.65	999.00	2.28E+07	0.00E+00	0.00E+00	261	262	0	0	0	0	0	0	80208.34	63645.84
154	.00	-5.00	0.00E+00	.50	999.00	7.60E+07	0.00E+00	0.00E+00	260	261	0	0	0	0	0	0	81458.34	63437.50
155	.00	63.65	0.00E+00	-3.15	999.00	7.18E+08	0.00E+00	0.00E+00	211	285	286	288	289	290	0	0	188958.30	266250.00
156	.00	39.66	0.00E+00	-3.16	999.00	2.58E+08	0.00E+00	0.00E+00	280	283	284	285	0	0	0	0	179375.00	243229.20
157	.00	48.65	0.00E+00	-3.15	999.00	5.24E+08	0.00E+00	0.00E+00	284	290	291	295	0	0	0	0	214479.20	252083.30
158	.00	105.65	0.00E+00	-3.15	999.00	2.68E+09	0.00E+00	0.00E+00	293	294	295	296	0	0	0	0	263437.50	279375.00
159	.00	81.65	0.00E+00	-3.15	999.00	9.72E+08	0.00E+00	0.00E+00	289	291	292	294	0	0	0	0	226041.70	274479.20
160	.00	45.65	0.00E+00	-3.15	999.00	8.12E+08	0.00E+00	0.00E+00	287	288	292	293	0	0	0	0	210312.50	291666.70
161	.00	33.63	0.00E+00	-3.13	999.00	3.79E+08	0.00E+00	0.00E+00	281	282	286	287	0	0	0	0	169375.00	266666.70
162	.00	35.00	0.00E+00	.00	999.00	2.06E+06	0.00E+00	0.00E+00	322	0	0	0	0	0	0	0	33645.84	167916.70
163	.00	17.30	0.00E+00	.00	999.00	5.27E+06	0.00E+00	0.00E+00	426	427	0	0	0	0	0	0	31562.50	154791.70
164	.00	22.60	0.00E+00	.00	999.00	4.50E+06	0.00E+00	0.00E+00	349	373	423	0	0	0	0	0	34479.17	156354.20
165	.00	30.30	0.00E+00	.00	999.00	4.61E+06	0.00E+00	0.00E+00	350	373	422	424	0	0	0	0	35833.34	155833.30
166	.00	12.30	0.00E+00	.00	999.00	4.22E+06	0.00E+00	0.00E+00	352	422	425	0	0	0	0	0	37187.50	155312.50
167	.00	12.30	0.00E+00	.00	999.00	6.09E+06	0.00E+00	0.00E+00	342	348	352	0	0	0	0	0	38645.84	158333.30
168	.00	21.00	0.00E+00	-15.00	999.00	8.80E+05	4.40E+04	0.00E+00	303	312	314	0	0	0	0	0	41458.34	179479.20
169	.00	15.00	0.00E+00	-10.00	999.00	5.90E+05	6.30E+04	0.00E+00	303	304	321	0	0	0	0	0	41458.34	182604.20
170	.00	32.70	0.00E+00	-9.00	999.00	8.90E+05	6.20E+04	0.00E+00	305	436	0	0	0	0	0	0	35520.84	183541.70
171	.00	32.70	0.00E+00	-9.00	999.00	1.10E+06	5.40E+04	0.00E+00	305	306	0	0	0	0	0	0	32083.33	180937.50
172	.00	23.00	0.00E+00	-9.00	999.00	1.18E+06	5.80E+04	0.00E+00	306	307	0	0	0	0	0	0	28541.67	183750.00
173	.00	22.60	0.00E+00	-9.00	999.00	1.15E+06	5.70E+04	0.00E+00	307	308	0	0	0	0	0	0	28541.67	188854.20
174	.00	18.60	0.00E+00	-8.00	999.00	1.11E+06	7.90E+04	0.00E+00	308	309	0	0	0	0	0	0	30729.17	193333.30
175	.00	12.70	0.00E+00	-8.00	999.00	9.35E+05	5.30E+04	0.00E+00	309	310	0	0	0	0	0	0	32916.67	198645.80
176	.00	12.70	0.00E+00	-8.00	999.00	5.98E+05	2.60E+04	0.00E+00	310	382	0	0	0	0	0	0	33541.67	200729.20
177	.00	12.70	0.00E+00	-10.00	999.00	5.31E+05	2.70E+04	0.00E+00	382	383	0	0	0	0	0	0	35312.50	203645.80
178	.00	-9.00	0.00E+00	999.00	999.00	6.42E+06	0.00E+00	0.00E+00	315	316	321	0	0	0	0	0	44687.50	181875.00
179	.00	32.00	0.00E+00	-20.00	999.00	1.87E+06	9.70E+04	0.00E+00	313	316	317	0	0	0	0	0	47916.67	181458.30

180	.00	1.50	0.00E+00	.50	2.50	1.40E+07	2.50E+06	2.40E+05	324	327	0	0	0	0	0	0	39062.50	189479.20
181	.00	1.50	0.00E+00	.50	5.50	1.00E+05	3.00E+06	0.00E+00	324	328	414	0	0	0	0	0	43645.84	188854.20
182	.00	35.00	0.00E+00	-15.00	999.00	2.52E+06	7.50E+04	1.00E+06	326	330	0	0	0	0	0	0	48125.00	186875.00
183	.00	43.00	0.00E+00	-30.00	999.00	1.47E+06	2.50E+04	1.16E+06	326	331	437	0	0	0	0	0	52083.34	186875.00
184	.00	5.50	0.00E+00	-1.50	1.50	1.00E+05	1.00E+05	1.66E+06	327	328	332	334	408	0	0	0	43645.84	196666.70
185	.00	32.00	0.00E+00	-25.00	999.00	1.61E+06	3.70E+04	7.50E+05	330	335	336	409	0	0	0	0	48854.17	190625.00
186	.00	30.00	0.00E+00	-15.00	999.00	1.73E+06	6.70E+04	6.40E+05	333	335	337	338	340	341	0	0	49062.50	195625.00
187	.00	1.00	0.00E+00	.00	6.50	5.00E+06	1.10E+06	4.00E+05	336	338	0	0	0	0	0	0	52708.34	192604.20
188	.00	3.50	0.00E+00	-.50	4.50	3.00E+05	1.44E+06	2.50E+05	331	0	0	0	0	0	0	0	57708.34	192604.20
189	.00	.50	0.00E+00	.50	4.50	4.00E+06	2.50E+05	2.70E+05	332	407	0	0	0	0	0	0	44687.50	201458.30
190	.00	22.00	0.00E+00	-15.00	999.00	2.60E+06	6.40E+04	1.31E+06	340	345	346	406	0	0	0	0	50833.34	199791.70
191	.00	-4.00	0.00E+00	999.00	999.00	2.60E+07	0.00E+00	0.00E+00	341	347	406	0	0	0	0	0	54895.84	198437.50
192	.00	15.50	0.00E+00	1.50	6.50	9.40E+05	5.01E+06	3.80E+05	351	368	410	418	0	0	0	0	48541.67	208645.80
193	.00	30.00	0.00E+00	-15.00	999.00	2.10E+06	6.30E+04	9.70E+05	346	347	353	368	0	0	0	0	53750.00	203854.20
194	.00	8.50	0.00E+00	-1.50	6.50	2.00E+05	1.35E+06	2.45E+06	345	421	0	0	0	0	0	0	46562.50	203750.00
195	.00	8.50	0.00E+00	-1.50	.50	1.50E+05	8.00E+04	1.34E+06	355	0	0	0	0	0	0	0	59062.50	201979.20
196	.00	5.50	0.00E+00	2.50	4.50	1.30E+05	1.90E+05	4.77E+06	356	0	0	0	0	0	0	0	63229.17	200625.00
197	.00	10.50	0.00E+00	-.50	2.50	4.80E+05	2.10E+05	3.32E+06	357	362	411	417	0	0	0	0	52708.34	215312.50
198	.00	.50	0.00E+00	-.50	2.50	1.30E+05	4.96E+06	2.90E+05	357	359	363	365	416	420	0	0	59270.84	213437.50
199	.00	24.00	0.00E+00	-15.00	999.00	1.24E+06	6.00E+04	9.60E+05	354	355	360	361	419	0	0	0	61458.34	207500.00
200	.00	10.50	0.00E+00	-.50	1.50	4.00E+05	1.80E+05	2.28E+06	356	361	0	0	0	0	0	0	64687.50	204687.50
201	.00	20.00	0.00E+00	-15.00	999.00	1.14E+06	1.00E+05	1.64E+06	359	360	366	367	0	0	0	0	65104.17	209687.50
202	.00	-2.00	0.00E+00	4.50	999.00	5.30E+07	1.40E+05	0.00E+00	362	363	364	369	0	0	0	0	55937.50	221041.70
203	.00	20.00	0.00E+00	-5.50	2.50	1.20E+06	4.10E+05	2.74E+06	364	365	366	370	372	0	0	0	64062.50	215104.20
204	.00	5.50	0.00E+00	.50	5.50	2.60E+05	2.55E+06	7.80E+05	367	371	372	0	0	0	0	0	68645.84	214479.20
205	.00	-3.50	0.00E+00	7.00	9.50	1.28E+07	0.00E+00	6.40E+06	369	374	412	0	0	0	0	0	58854.17	226875.00
206	.00	15.00	0.00E+00	-2.50	1.50	1.12E+06	1.00E+06	2.90E+06	370	374	375	378	0	0	0	0	65729.17	222187.50
207	.00	18.50	0.00E+00	-1.50	6.50	1.48E+06	7.40E+05	1.45E+06	371	375	376	0	0	0	0	0	69062.50	219062.50
208	.00	10.50	0.00E+00	-1.50	4.50	2.80E+06	7.00E+05	2.30E+06	376	377	0	0	0	0	0	0	71875.00	225520.80
209	.00	2.50	0.00E+00	-.50	1.50	9.00E+05	9.00E+05	2.40E+06	377	0	0	0	0	0	0	0	75625.01	233229.20
210	.00	14.00	0.00E+00	-10.00	999.00	1.04E+06	1.10E+05	1.20E+06	378	379	413	0	0	0	0	0	63645.84	229895.80
211	.00	10.00	0.00E+00	-7.00	999.00	8.80E+05	1.00E+05	5.50E+05	379	380	0	0	0	0	0	0	64062.50	235520.80
212	.00	7.00	0.00E+00	-4.00	999.00	9.70E+05	1.90E+05	1.14E+06	380	381	0	0	0	0	0	0	66250.00	243854.20
213	.00	5.00	0.00E+00	-3.00	999.00	7.60E+05	2.00E+05	7.80E+05	297	381	0	0	0	0	0	0	65208.34	252604.20
214	.00	4.00	0.00E+00	-2.00	999.00	2.90E+05	1.20E+05	3.40E+05	297	0	0	0	0	0	0	0	66250.00	258645.80
215	.00	12.00	0.00E+00	-8.00	999.00	5.30E+05	3.00E+04	0.00E+00	383	384	0	0	0	0	0	0	35312.50	207083.30
216	.00	12.00	0.00E+00	-6.00	999.00	4.70E+05	2.70E+04	0.00E+00	384	385	0	0	0	0	0	0	35729.17	210520.80
217	.00	12.00	0.00E+00	-6.00	999.00	4.50E+05	2.50E+04	0.00E+00	385	386	0	0	0	0	0	0	38020.84	212083.30
218	.00	13.00	0.00E+00	-8.00	999.00	4.53E+05	3.00E+04	0.00E+00	386	387	0	0	0	0	0	0	40104.17	214166.70
219	.00	13.00	0.00E+00	-8.00	999.00	4.65E+05	6.20E+04	0.00E+00	387	388	0	0	0	0	0	0	40208.33	216979.20
220	.00	13.00	0.00E+00	-8.00	999.00	4.50E+05	4.00E+04	0.00E+00	388	389	0	0	0	0	0	0	39791.67	220104.20
221	.00	10.00	0.00E+00	-4.00	999.00	4.35E+05	4.40E+04	0.00E+00	389	390	0	0	0	0	0	0	40729.17	222500.00
222	.00	12.00	0.00E+00	-7.00	999.00	3.63E+05	2.20E+04	0.00E+00	390	391	0	0	0	0	0	0	40312.50	225520.80
223	.00	12.00	0.00E+00	-7.00	999.00	3.38E+05	2.70E+04	0.00E+00	391	392	0	0	0	0	0	0	42083.34	226770.80
224	.00	12.00	0.00E+00	.00	999.00	4.05E+05	0.00E+00	0.00E+00	392	393	0	0	0	0	0	0	43541.67	225104.20
225	.00	4.41	0.00E+00	9.50	999.00	7.30E+05	2.78E+05	0.00E+00	393	394	438	0	0	0	0	0	44166.66	227916.70
226	.00	1.50	0.00E+00	9.50	999.00	6.21E+05	1.92E+05	0.00E+00	394	395	0	0	0	0	0	0	42708.33	229687.50
227	.00	-1.50	0.00E+00	9.50	999.00	6.95E+05	8.50E+04	0.00E+00	395	396	0	0	0	0	0	0	41562.50	232500.00
228	.00	-3.50	0.00E+00	.00	999.00	9.33E+05	0.00E+00	0.00E+00	396	397	0	0	0	0	0	0	40208.33	234270.80
229	.00	-5.50	0.00E+00	.00	999.00	4.61E+05	0.00E+00	0.00E+00	397	0	0	0	0	0	0	0	38645.84	235416.70
230	.00	10.50	0.00E+00	.00	999.00	1.82E+06	2.27E+06	0.00E+00	398	399	0	0	0	0	0	0	13645.83	132291.70
231	.00	8.90	0.00E+00	.00	999.00	1.99E+06	9.60E+05	0.00E+00	399	400	0	0	0	0	0	0	9062.50	132812.50
232	.00	6.90	0.00E+00	.00	999.00	1.87E+06	1.43E+06	0.00E+00	400	401	0	0	0	0	0	0	4270.83	132291.70
233	.00	6.40	0.00E+00	.00	999.00	9.79E+05	9.30E+05	0.00E+00	401	402	403	0	0	0	0	0	-1979.17	132083.30

234	.00	2.70	0.00E+00	.00	999.00	7.70E+05	7.60E+05	0.00E+00	402	0	0	0	0	0	0	0	-3541.67	130104.20
235	.00	2.70	0.00E+00	.00	999.00	2.60E+05	3.50E+05	0.00E+00	403	404	405	0	0	0	0	0	-1666.67	135833.30
236	.00	1.50	0.00E+00	.00	999.00	2.50E+05	1.80E+05	0.00E+00	404	0	0	0	0	0	0	0	-5208.33	135104.20
237	.00	-4.50	7.17E+01	.00	999.00	2.00E+05	1.50E+05	0.00E+00	405	0	0	0	0	0	0	0	-2500.00	138229.20
238	.00	-4.00	0.00E+00	9.50	999.00	7.00E+06	1.00E+05	0.00E+00	412	413	0	0	0	0	0	0	58854.17	232916.70
239	.00	12.50	0.00E+00	-1.50	2.50	5.00E+05	1.10E+05	2.11E+06	351	411	0	0	0	0	0	0	50625.00	212708.30
240	.00	9.50	0.00E+00	-1.50	1.50	2.00E+05	8.00E+04	1.43E+06	333	334	409	414	0	0	0	0	46875.00	194270.80
241	.00	8.50	0.00E+00	-.50	3.50	1.00E+05	1.35E+06	0.00E+00	337	407	408	0	0	0	0	0	46145.83	199166.70
242	.00	22.00	0.00E+00	-15.00	999.00	1.65E+06	6.30E+04	0.00E+00	353	354	415	0	0	0	0	0	56666.67	207083.30
243	.00	1.50	0.00E+00	2.50	7.50	2.50E+05	1.50E+05	2.71E+06	415	416	417	418	0	0	0	0	55520.84	208750.00
244	.00	5.50	0.00E+00	-.50	4.50	1.20E+05	2.38E+06	0.00E+00	358	419	0	0	0	0	0	0	59270.84	209687.50
245	.00	5.50	0.00E+00	-.50	2.50	4.00E+04	3.00E+06	0.00E+00	358	420	0	0	0	0	0	0	59270.84	210520.80
246	.00	5.50	0.00E+00	-.50	1.50	6.00E+04	3.00E+04	4.50E+05	410	421	0	0	0	0	0	0	48125.00	208229.20
247	.00	22.40	0.00E+00	.00	999.00	9.22E+06	0.00E+00	0.00E+00	339	344	348	349	350	0	0	0	37083.33	159270.80
248	.00	20.20	0.00E+00	.00	999.00	6.14E+06	0.00E+00	0.00E+00	329	343	344	0	0	0	0	0	34166.67	161250.00
249	.00	12.30	0.00E+00	.00	999.00	8.43E+06	0.00E+00	0.00E+00	320	325	342	0	0	0	0	0	40416.67	162291.70
250	.00	24.40	0.00E+00	.00	999.00	8.16E+06	0.00E+00	0.00E+00	319	323	325	339	0	0	0	0	38541.67	163437.50
251	.00	23.20	0.00E+00	.00	999.00	5.00E+06	0.00E+00	0.00E+00	322	323	329	0	0	0	0	0	36770.84	165208.30
252	.00	10.00	0.00E+00	.00	999.00	6.80E+06	0.00E+00	0.00E+00	301	318	320	0	0	0	0	0	41875.00	165104.20
253	.00	15.50	0.00E+00	.00	999.00	5.84E+06	0.00E+00	0.00E+00	112	318	319	0	0	0	0	0	39791.67	166145.80
254	.00	9.00	0.00E+00	.00	999.00	6.91E+06	0.00E+00	0.00E+00	113	114	301	0	0	0	0	0	43229.17	167604.20
255	.00	15.70	0.00E+00	.00	999.00	5.16E+06	0.00E+00	0.00E+00	112	113	266	0	0	0	0	0	41041.67	168437.50
256	.00	7.00	0.00E+00	.00	999.00	7.22E+06	0.00E+00	0.00E+00	114	115	267	0	0	0	0	0	43854.17	170520.80
257	.00	21.80	0.00E+00	.00	999.00	5.00E+06	0.00E+00	0.00E+00	115	266	269	270	0	0	0	0	41562.50	170833.30
258	.00	10.00	0.00E+00	.00	999.00	3.75E+06	0.00E+00	0.00E+00	267	268	271	0	0	0	0	0	43958.33	172916.70
259	.00	16.80	0.00E+00	.00	999.00	3.25E+06	0.00E+00	0.00E+00	268	270	272	274	278	0	0	0	42291.67	173229.20
260	.00	28.00	0.00E+00	-10.00	999.00	8.90E+05	9.00E+04	0.00E+00	269	272	273	0	0	0	0	0	40416.67	173437.50
261	.00	34.00	0.00E+00	-10.00	999.00	8.90E+05	2.87E+05	0.00E+00	242	271	276	278	0	0	0	0	43958.33	174583.30
262	.00	4.00	0.00E+00	-3.00	999.00	1.89E+06	3.95E+05	0.00E+00	242	274	275	277	0	0	0	0	42291.67	175104.20
263	.00	28.00	0.00E+00	-10.00	999.00	8.90E+05	9.00E+04	0.00E+00	243	273	277	0	0	0	0	0	40416.67	175312.50
264	.00	35.00	0.00E+00	-20.00	999.00	1.27E+06	9.80E+04	0.00E+00	276	279	300	0	0	0	0	0	45416.67	176041.70
265	.00	-9.00	0.00E+00	.00	999.00	8.94E+06	0.00E+00	0.00E+00	275	279	299	311	0	0	0	0	42812.50	176562.50
266	.00	23.00	0.00E+00	-20.00	999.00	8.80E+05	3.70E+04	0.00E+00	243	299	314	0	0	0	0	0	40520.84	177083.30
267	.00	33.00	0.00E+00	-20.00	999.00	1.58E+06	7.40E+04	0.00E+00	300	302	313	0	0	0	0	0	46562.50	178750.00
268	.00	-9.00	0.00E+00	.00	999.00	1.13E+07	0.00E+00	0.00E+00	302	311	312	315	0	0	0	0	43750.00	179062.50
269	.00	35.00	0.00E+00	-20.00	999.00	4.07E+06	1.90E+05	0.00E+00	105	431	0	0	0	0	0	0	17916.67	138437.50
270	.00	35.00	0.00E+00	.00	999.00	2.36E+06	0.00E+00	0.00E+00	104	432	0	0	0	0	0	0	22395.84	148541.70
271	.00	14.00	0.00E+00	-9.00	999.00	6.60E+05	6.10E+04	0.00E+00	304	436	0	0	0	0	0	0	39895.83	184062.50
272	.00	48.00	0.00E+00	-30.00	999.00	1.65E+06	3.00E+04	0.00E+00	317	437	0	0	0	0	0	0	52187.50	184062.50
273	.00	-2.00	0.00E+00	.00	999.00	2.30E+05	0.00E+00	0.00E+00	438	439	0	0	0	0	0	0	46979.17	229062.50
274	.00	-7.00	0.00E+00	.00	999.00	1.70E+05	0.00E+00	0.00E+00	439	0	0	0	0	0	0	0	49583.34	231458.30

TOTAL SURFACE AREA = 2.4748E+10 SQ.FT.

1 CHANNEL NUMBER	LENGTH (FT)	WIDTH (FT)	AREA (SQ FT)	MANNING COEF	VELOCITY (FPS)	DEPTH (FT)	JUNCTIONS AT ENDS		MINIMUM TIME STEP	REFERENCE HEAD	Z1 (FT/FT)	Z2 (FT/FT)	IND
1	19375.0	7118.0	336681.4	.030	.00	47.3	5	120	496.46	47.300	0.000E+00	0.000E+00	CHAN
2	30833.0	11458.0	713833.4	.030	.00	62.3	5	121	688.40	62.300	0.000E+00	0.000E+00	CHAN
3	21875.0	17188.0	1148159.0	.030	.00	66.8	6	121	471.66	66.800	0.000E+00	0.000E+00	CHAN
4	22917.0	14063.0	876124.9	.030	.00	62.3	6	122	511.67	62.300	0.000E+00	0.000E+00	CHAN
5	27604.0	9547.0	480214.1	.030	.00	50.3	8	122	685.90	50.300	0.000E+00	0.000E+00	CHAN

6	17708.0	13889.0	788895.3	.030	.00	56.8	7	122	414.06	56.800	0.000E+00 0.000E+00CHAN
7	19792.0	7292.0	261053.6	.030	.00	35.8	7	8	582.94	35.800	0.000E+00 0.000E+00CHAN
8	19792.0	10590.0	437367.0	.030	.00	41.3	6	8	542.73	41.300	0.000E+00 0.000E+00CHAN
9	14583.0	9201.0	370800.3	.030	.00	40.3	6	9	404.82	40.300	0.000E+00 0.000E+00CHAN
10	21354.0	9896.0	393860.8	.030	.00	39.8	6	10	596.50	39.800	0.000E+00 0.000E+00CHAN
11	30729.0	1458.0	71150.4	.030	.00	48.8	6	11	775.19	48.800	0.000E+00 0.000E+00CHAN
12	32083.0	1806.0	112513.8	.030	.00	62.3	11	121	716.31	62.300	0.000E+00 0.000E+00CHAN
13	15625.0	15972.0	707559.6	.030	.00	44.3	5	11	413.70	44.300	0.000E+00 0.000E+00CHAN
14	19375.0	8681.0	306395.9	.030	.00	35.3	5	12	574.72	35.295	0.000E+00 0.000E+00CHAN
15	19271.0	10590.0	373774.0	.030	.00	35.3	11	12	571.64	35.295	0.000E+00 0.000E+00CHAN
16	25000.0	411.0	15124.8	.030	.00	36.8	11	21	726.25	36.800	0.000E+00 0.000E+00CHAN
17	29688.0	7292.0	235568.1	.030	.00	32.3	11	24	920.49	32.305	0.000E+00 0.000E+00CHAN
18	18229.0	7639.0	235281.2	.030	.00	30.8	11	22	578.84	30.800	0.000E+00 0.000E+00CHAN
19	19792.0	764.0	26969.2	.030	.00	35.3	10	11	587.05	35.300	0.000E+00 0.000E+00CHAN
20	11458.0	7813.0	170323.4	.030	.00	21.8	10	22	432.47	21.800	0.000E+00 0.000E+00CHAN
21	15104.0	6424.0	172163.2	.030	.00	26.8	9	10	514.16	26.800	0.000E+00 0.000E+00CHAN
22	9375.0	5208.0	82312.4	.040	.00	15.8	22	23	415.57	15.805	0.000E+00 0.000E+00CHAN
23	13542.0	4688.0	81149.3	.040	.00	17.3	23	24	573.60	17.310	0.000E+00 0.000E+00CHAN
24	9375.0	2431.0	34957.8	.040	.00	14.4	23	107	435.68	14.380	0.000E+00 0.000E+00CHAN
25	10417.0	2100.0	33348.0	.040	.00	15.9	23	108	460.67	15.880	0.000E+00 0.000E+00CHAN
26	7813.0	1042.0	16672.0	.040	.00	16.0	107	109	344.22	16.000	0.000E+00 0.000E+00CHAN
27	8125.0	1736.0	30380.0	.040	.00	17.5	108	109	342.28	17.500	0.000E+00 0.000E+00CHAN
28	8437.0	3125.0	50234.4	.040	.00	16.1	109	110	370.84	16.075	0.000E+00 0.000E+00CHAN
29	6250.0	2604.0	34151.5	.040	.00	13.1	110	111	304.14	13.115	0.000E+00 0.000E+00CHAN
30	14063.0	2604.0	34125.4	.040	.00	13.1	111	112	684.59	13.105	0.000E+00 0.000E+00CHAN
31	10938.0	1562.0	22766.2	.040	.00	14.6	112	113	504.90	14.575	0.000E+00 0.000E+00CHAN
32	15104.0	2604.0	38057.5	.060	.00	14.6	111	115	696.25	14.615	0.000E+00 0.000E+00CHAN
33	6250.0	3646.0	58682.4	.040	.00	16.1	114	115	274.54	16.095	0.000E+00 0.000E+00CHAN
34	7813.0	4167.0	67109.5	.040	.00	16.1	115	116	343.09	16.105	0.000E+00 0.000E+00CHAN
35	19792.0	4167.0	60838.2	.040	.00	14.6	116	117	912.82	14.600	0.000E+00 0.000E+00CHAN
36	25000.0	1563.0	22804.2	.060	.00	14.6	116	119	1153.41	14.590	0.000E+00 0.000E+00CHAN
37	4167.0	3125.0	45578.1	.040	.00	14.6	117	118	192.28	14.585	0.000E+00 0.000E+00CHAN
38	4167.0	3125.0	45546.9	.040	.00	14.6	118	119	192.35	14.575	0.000E+00 0.000E+00CHAN
39	10417.0	3646.0	53176.9	.040	.00	14.6	110	119	480.69	14.585	0.000E+00 0.000E+00CHAN
40	7292.0	4167.0	66922.0	.040	.00	16.1	109	119	320.66	16.060	0.000E+00 0.000E+00CHAN
41	15104.0	8160.0	153448.8	.040	.00	18.8	22	24	613.80	18.805	0.000E+00 0.000E+00CHAN
42	17708.0	10417.0	258393.7	.040	.00	24.8	21	24	626.57	24.805	0.000E+00 0.000E+00CHAN
43	8333.0	6071.0	129373.0	.040	.00	21.3	24	25	318.11	21.310	0.000E+00 0.000E+00CHAN
44	16667.0	3819.0	98549.3	.040	.00	25.8	21	25	578.20	25.805	0.000E+00 0.000E+00CHAN
45	11458.0	7118.0	208593.0	.030	.00	29.3	21	26	373.00	29.305	0.000E+00 0.000E+00CHAN
46	16667.0	9375.0	232500.0	.040	.00	24.8	20	21	589.80	24.800	0.000E+00 0.000E+00CHAN
47	11979.0	11806.0	328147.8	.040	.00	27.8	12	21	400.41	27.795	0.000E+00 0.000E+00CHAN
48	15521.0	6597.0	153677.1	.040	.00	23.3	12	20	566.71	23.295	0.000E+00 0.000E+00CHAN
49	10938.0	7292.0	169830.7	.030	.00	23.3	12	13	399.42	23.290	0.000E+00 0.000E+00CHAN
50	20313.0	9028.0	183223.3	.040	.00	20.3	13	20	794.61	20.295	0.000E+00 0.000E+00CHAN
51	22917.0	764.0	16261.7	.030	.00	21.3	13	19	875.37	21.285	0.000E+00 0.000E+00CHAN
52	18750.0	42708.0	738421.4	.040	.00	17.3	13	16	794.65	17.290	0.000E+00 0.000E+00CHAN
53	24479.0	7813.0	135086.8	.040	.00	17.3	13	15	1037.45	17.290	0.000E+00 0.000E+00CHAN
54	10417.0	3125.0	54031.3	.040	.00	17.3	13	14	441.49	17.290	0.000E+00 0.000E+00CHAN
55	17708.0	4167.0	59546.4	.040	.00	14.3	14	15	825.52	14.290	0.000E+00 0.000E+00CHAN
56	22917.0	6250.0	89312.5	.040	.00	14.3	15	16	1068.35	14.290	0.000E+00 0.000E+00CHAN
57	22917.0	8333.0	152368.9	.040	.00	18.3	16	19	944.46	18.285	0.000E+00 0.000E+00CHAN
58	13542.0	4792.0	54077.7	.040	.00	11.3	16	17	710.40	11.285	0.000E+00 0.000E+00CHAN
59	14580.0	9375.0	143250.0	.040	.00	15.3	17	19	657.31	15.280	0.000E+00 0.000E+00CHAN

60	14792.0	5208.0	50934.2	.040	.00	9.8	17	18	833.55	9.780	0.000E+00 0.000E+00CHAN
61	20313.0	9549.0	160232.2	.040	.00	16.8	18	19	873.88	16.780	0.000E+00 0.000E+00CHAN
62	17708.0	11458.0	243940.8	.040	.00	21.3	19	20	676.32	21.290	0.000E+00 0.000E+00CHAN
63	18229.0	7813.0	193801.5	.040	.00	24.8	20	26	645.01	24.805	0.000E+00 0.000E+00CHAN
64	7292.0	5208.0	134418.5	.040	.00	25.8	25	26	252.94	25.810	0.000E+00 0.000E+00CHAN
65	7292.0	4688.0	155899.4	.040	.00	33.3	25	28	222.84	33.255	0.000E+00 0.000E+00CHAN
66	10417.0	5556.0	204210.8	.030	.00	36.8	26	28	302.80	36.755	0.000E+00 0.000E+00CHAN
67	14583.0	8160.0	157120.8	.040	.00	19.3	26	29	585.66	19.255	0.000E+00 0.000E+00CHAN
68	17708.0	7118.0	104990.5	.040	.00	14.8	20	29	812.54	14.750	0.000E+00 0.000E+00CHAN
69	11979.0	8681.0	119537.4	.040	.00	13.8	20	30	568.89	13.770	0.000E+00 0.000E+00CHAN
70	20000.0	7292.0	118786.7	.040	.00	16.3	20	31	873.26	16.290	0.000E+00 0.000E+00CHAN
71	15104.0	11458.0	197994.3	.040	.00	17.3	19	31	640.31	17.280	0.000E+00 0.000E+00CHAN
72	23750.0	9028.0	192296.4	.030	.00	21.3	19	32	906.87	21.300	0.000E+00 0.000E+00CHAN
73	19271.0	10417.0	164588.6	.040	.00	15.8	18	32	854.37	15.800	0.000E+00 0.000E+00CHAN
74	18750.0	6944.0	109888.8	.040	.00	15.8	18	33	830.62	15.825	0.000E+00 0.000E+00CHAN
75	15625.0	6771.0	63139.6	.040	.00	9.3	18	34	901.71	9.325	0.000E+00 0.000E+00CHAN
76	10417.0	8160.0	113179.2	.040	.00	13.9	33	34	492.92	13.870	0.000E+00 0.000E+00CHAN
77	17708.0	3438.0	37474.2	.040	.00	10.9	34	35	945.21	10.900	0.000E+00 0.000E+00CHAN
78	9896.0	5208.0	158844.0	.040	.00	30.5	33	35	315.78	30.500	0.000E+00 0.000E+00CHAN
79	11979.0	8160.0	166015.2	.040	.00	20.3	32	33	468.02	20.345	0.000E+00 0.000E+00CHAN
80	17188.0	7292.0	118859.6	.040	.00	16.3	31	32	750.25	16.300	0.000E+00 0.000E+00CHAN
81	14792.0	4167.0	40669.9	.040	.00	9.8	30	31	834.40	9.760	0.000E+00 0.000E+00CHAN
82	11458.0	5208.0	42809.8	.040	.00	8.2	29	30	704.28	8.220	0.000E+00 0.000E+00CHAN
83	11979.0	3125.0	99296.9	.040	.00	31.8	29	52	374.50	31.775	0.000E+00 0.000E+00CHAN
84	11979.0	5729.0	152964.3	.040	.00	26.7	28	29	408.54	26.700	0.000E+00 0.000E+00CHAN
85	6875.0	5382.0	265198.1	.040	.00	49.3	28	52	172.60	49.275	0.000E+00 0.000E+00CHAN
86	15625.0	1736.0	70785.4	.030	.00	40.8	28	54	431.22	40.775	0.000E+00 0.000E+00CHAN
87	7813.0	4167.0	140823.8	.040	.00	33.8	28	53	236.84	33.795	0.000E+00 0.000E+00CHAN
88	13021.0	3125.0	71406.2	.040	.00	22.8	25	53	480.04	22.850	0.000E+00 0.000E+00CHAN
89	7500.0	3646.0	72282.0	.040	.00	19.8	25	27	296.84	19.825	0.000E+00 0.000E+00CHAN
90	9896.0	3125.0	63640.6	.040	.00	20.4	27	53	386.45	20.365	0.000E+00 0.000E+00CHAN
91	14063.0	85.0	2453.1	.060	.00	28.9	53	55	461.32	28.860	0.000E+00 0.000E+00CHAN
92	8333.0	2604.0	79083.5	.040	.00	30.4	53	54	266.47	30.370	0.000E+00 0.000E+00CHAN
93	9583.0	3472.0	159191.2	.040	.00	45.8	52	54	249.40	45.850	0.000E+00 0.000E+00CHAN
94	9896.0	2803.0	152315.0	.040	.00	54.3	51	52	236.58	54.340	0.000E+00 0.000E+00CHAN
95	5208.0	6597.0	302406.5	.040	.00	45.8	51	54	135.56	45.840	0.000E+00 0.000E+00CHAN
96	10417.0	3125.0	127593.8	.030	.00	40.8	54	56	287.29	40.830	0.000E+00 0.000E+00CHAN
97	7292.0	3125.0	112000.0	.040	.00	35.8	54	55	214.65	35.840	0.000E+00 0.000E+00CHAN
98	6250.0	5556.0	218461.9	.040	.00	39.3	55	56	175.65	39.320	0.000E+00 0.000E+00CHAN
99	11458.0	3299.0	162706.7	.030	.00	49.3	51	56	287.52	49.320	0.000E+00 0.000E+00CHAN
100	10000.0	2604.0	101087.3	.030	.00	38.8	50	51	282.84	38.820	0.000E+00 0.000E+00CHAN
101	6400.0	1563.0	70520.0	.030	.00	40.0	45	48	178.33	40.000	1.000E+01 0.000E+00CHAN
102	6200.0	1563.0	70520.0	.030	.00	40.0	44	47	172.76	40.000	1.000E+01 0.000E+00CHAN
103	3651.8	2500.0	87500.0	.030	.00	35.0	43	46	108.78	35.000	0.000E+00 0.000E+00CHAN
104	4576.2	900.0	31500.0	.030	.00	35.0	42	270	136.32	35.000	0.000E+00 0.000E+00CHAN
105	6300.0	1000.0	35000.0	.030	.00	35.0	41	269	187.66	35.000	0.000E+00 0.000E+00CHAN
106	7292.0	1563.0	54705.0	.030	.00	35.0	40	41	217.21	35.000	0.000E+00 0.000E+00CHAN
107	3643.0	1563.0	54705.0	.030	.00	35.0	39	40	108.52	35.000	0.000E+00 0.000E+00CHAN
108	6250.0	2083.0	72905.0	.030	.00	35.0	38	39	186.17	35.000	0.000E+00 0.000E+00CHAN
109	7292.0	2604.0	91140.0	.030	.00	35.0	37	38	217.21	35.000	0.000E+00 0.000E+00CHAN
110	9167.0	2604.0	91140.0	.030	.00	35.0	36	37	273.06	35.000	0.000E+00 0.000E+00CHAN
111	9167.0	2604.0	91140.0	.030	.00	35.0	35	36	273.06	35.000	0.000E+00 0.000E+00CHAN
112	2610.4	1000.0	40422.5	.030	.00	37.0	253	255	75.63	37.000	5.000E+00 0.000E+00CHAN
113	2340.9	2600.0	23400.0	.035	.00	9.0	254	255	137.51	9.000	0.000E+00 0.000E+00CHAN

114	2982.9	2600.0	20800.0	.035	.00	8.0	254	256	185.85	8.000	0.000E+00 0.000E+00CHAN
115	2312.9	2600.0	18200.0	.035	.00	7.0	256	257	154.05	7.000	0.000E+00 0.000E+00CHAN
116	13021.0	4688.0	81149.3	.040	.00	17.3	50	60	551.53	17.310	0.000E+00 0.000E+00CHAN
117	10938.0	2951.0	92395.8	.040	.00	31.3	50	59	344.48	31.310	0.000E+00 0.000E+00CHAN
118	6146.0	5729.0	193697.5	.030	.00	33.8	50	56	186.27	33.810	0.000E+00 0.000E+00CHAN
119	7292.0	3819.0	159672.4	.030	.00	41.8	56	59	198.74	41.810	0.000E+00 0.000E+00CHAN
120	12604.0	2778.0	106425.2	.040	.00	38.3	56	58	358.86	38.310	0.000E+00 0.000E+00CHAN
121	10417.0	3646.0	143324.3	.040	.00	39.3	56	57	292.79	39.310	0.000E+00 0.000E+00CHAN
122	9271.0	3646.0	125130.7	.040	.00	34.3	55	57	278.88	34.320	0.000E+00 0.000E+00CHAN
123	5730.0	3438.0	114519.8	.040	.00	33.3	57	58	174.96	33.310	0.000E+00 0.000E+00CHAN
124	7604.0	3438.0	123114.8	.040	.00	35.8	58	59	223.93	35.810	0.000E+00 0.000E+00CHAN
125	7292.0	3438.0	135147.8	.030	.00	39.3	59	61	204.96	39.310	0.000E+00 0.000E+00CHAN
126	6250.0	6076.0	153783.6	.040	.00	25.3	59	60	218.93	25.310	0.000E+00 0.000E+00CHAN
127	8437.0	3819.0	96658.9	.040	.00	25.3	60	61	295.54	25.310	0.000E+00 0.000E+00CHAN
128	12500.0	3531.0	89299.0	.040	.00	25.3	60	63	438.03	25.290	0.000E+00 0.000E+00CHAN
129	6250.0	4514.0	177355.1	.030	.00	39.3	61	63	175.72	39.290	0.000E+00 0.000E+00CHAN
130	7292.0	3125.0	122843.8	.030	.00	39.3	61	62	204.96	39.310	0.000E+00 0.000E+00CHAN
131	7813.0	2292.0	82076.5	.060	.00	35.8	58	62	230.08	35.810	0.000E+00 0.000E+00CHAN
132	5729.0	85.0	3339.7	.040	.00	39.3	62	63	161.07	39.290	0.000E+00 0.000E+00CHAN
133	10938.0	2604.0	81531.2	.040	.00	31.3	62	74	344.48	31.310	0.000E+00 0.000E+00CHAN
134	9896.0	2604.0	56780.2	.040	.00	21.8	73	74	373.47	21.805	0.000E+00 0.000E+00CHAN
135	18750.0	2604.0	48955.2	.040	.00	18.8	72	73	762.07	18.800	0.000E+00 0.000E+00CHAN
136	17188.0	5208.0	185951.7	.030	.00	35.7	63	64	506.91	35.705	0.000E+00 0.000E+00CHAN
137	28646.0	5208.0	159078.4	.030	.00	30.5	64	65	913.41	30.545	0.000E+00 0.000E+00CHAN
138	23750.0	5208.0	142464.8	.030	.00	27.4	65	66	800.23	27.355	0.000E+00 0.000E+00CHAN
139	21667.0	5208.0	134053.9	.030	.00	25.7	66	67	752.60	25.740	0.000E+00 0.000E+00CHAN
140	8542.0	521.0	8760.6	.060	.00	16.8	66	68	367.10	16.815	0.000E+00 0.000E+00CHAN
141	16667.0	833.0	5352.0	.060	.00	6.4	68	69	1158.76	6.425	0.000E+00 0.000E+00CHAN
142	12500.0	833.0	4194.2	.060	.00	5.0	69	70	981.71	5.035	0.000E+00 0.000E+00CHAN
143	10417.0	1250.0	13993.8	.060	.00	11.2	70	72	548.66	11.195	0.000E+00 0.000E+00CHAN
144	8333.0	1250.0	15393.7	.040	.00	12.3	71	79	418.46	12.315	0.000E+00 0.000E+00CHAN
145	9375.0	3125.0	60000.0	.040	.00	19.2	72	75	377.04	19.200	0.000E+00 0.000E+00CHAN
146	52800.0	1042.0	11269.2	.040	.00	10.8	81	123	2829.39	10.815	0.000E+00 0.000E+00CHAN
147	6667.0	1562.0	16994.6	.040	.00	10.9	82	124	356.20	10.880	0.000E+00 0.000E+00CHAN
148	5625.0	3125.0	61265.6	.040	.00	19.6	75	76	223.88	19.605	0.000E+00 0.000E+00CHAN
149	9375.0	1042.0	20433.6	.040	.00	19.6	75	77	373.08	19.610	0.000E+00 0.000E+00CHAN
150	6771.0	2604.0	51051.4	.060	.00	19.6	75	78	269.49	19.605	0.000E+00 0.000E+00CHAN
151	4167.0	2604.0	47171.5	.040	.00	18.1	76	77	172.53	18.115	0.000E+00 0.000E+00CHAN
152	7292.0	2083.0	37744.0	.040	.00	18.1	78	79	301.88	18.120	0.000E+00 0.000E+00CHAN
153	5208.0	3125.0	56656.2	.040	.00	18.1	79	80	215.55	18.130	0.000E+00 0.000E+00CHAN
154	7292.0	2083.0	37754.4	.040	.00	18.1	77	79	301.84	18.125	0.000E+00 0.000E+00CHAN
155	8333.0	1562.0	28311.3	.040	.00	18.1	77	80	344.93	18.125	0.000E+00 0.000E+00CHAN
156	5208.0	1562.0	25968.3	.040	.00	16.6	77	81	225.09	16.625	0.000E+00 0.000E+00CHAN
157	6250.0	1562.0	23734.6	.040	.00	15.2	81	82	282.55	15.195	0.000E+00 0.000E+00CHAN
158	4167.0	3125.0	51968.7	.040	.00	16.6	80	81	180.07	16.630	0.000E+00 0.000E+00CHAN
159	5104.0	2604.0	43473.8	.040	.00	16.7	80	82	220.14	16.695	0.000E+00 0.000E+00CHAN
160	6250.0	2083.0	37900.2	.040	.00	18.2	80	83	258.21	18.195	0.000E+00 0.000E+00CHAN
161	4062.0	4062.0	68079.1	.040	.00	16.8	82	83	174.85	16.760	0.000E+00 0.000E+00CHAN
162	7292.0	1563.0	26297.5	.040	.00	16.8	82	84	313.29	16.825	0.000E+00 0.000E+00CHAN
163	6771.0	2604.0	47718.3	.040	.00	18.3	83	84	278.74	18.325	0.000E+00 0.000E+00CHAN
164	5729.0	2083.0	38171.0	.040	.00	18.3	83	85	235.85	18.325	0.000E+00 0.000E+00CHAN
165	4792.0	4062.0	74700.2	.040	.00	18.4	84	85	196.92	18.390	0.000E+00 0.000E+00CHAN
166	8958.0	1736.0	34641.9	.040	.00	20.0	84	87	353.39	19.955	0.000E+00 0.000E+00CHAN
167	6771.0	3125.0	62359.4	.030	.00	20.0	85	87	267.12	19.955	0.000E+00 0.000E+00CHAN

168	7292.0	1250.0	19318.8	.040	.00	15.5	85	86	326.88	15.455	0.000E+00 0.000E+00CHAN
169	4167.0	3438.0	58514.8	.040	.00	17.0	86	87	178.00	17.020	0.000E+00 0.000E+00CHAN
170	5208.0	1042.0	14608.8	.040	.00	14.0	86	88	245.11	14.020	0.000E+00 0.000E+00CHAN
171	10729.0	2604.0	28761.2	.040	.00	11.0	88	89	568.92	11.045	0.000E+00 0.000E+00CHAN
172	13542.0	3125.0	29906.3	.040	.00	9.6	89	90	771.43	9.570	0.000E+00 0.000E+00CHAN
173	4688.0	5282.0	74185.7	.050	.00	14.0	88	90	220.44	14.045	0.000E+00 0.000E+00CHAN
174	9580.0	2257.0	62169.1	.050	.00	27.5	88	91	321.67	27.545	0.000E+00 0.000E+00CHAN
175	4167.0	4167.0	77172.8	.040	.00	18.5	87	88	170.64	18.520	0.000E+00 0.000E+00CHAN
176	8437.0	3993.0	121966.2	.040	.00	30.5	87	91	269.02	30.545	0.000E+00 0.000E+00CHAN
177	9167.0	3472.0	59180.2	.050	.00	17.0	87	92	391.29	17.045	0.000E+00 0.000E+00CHAN
178	8333.0	4167.0	108633.7	.050	.00	26.1	91	92	287.61	26.070	0.000E+00 0.000E+00CHAN
179	5104.0	4861.0	206932.8	.040	.00	42.6	91	97	137.86	42.570	0.000E+00 0.000E+00CHAN
180	6667.0	3646.0	160679.2	.050	.00	44.1	91	98	176.98	44.070	0.000E+00 0.000E+00CHAN
181	6563.0	3438.0	89628.7	.050	.00	26.1	90	91	226.52	26.070	0.000E+00 0.000E+00CHAN
182	9896.0	2427.0	74193.4	.050	.00	30.6	90	98	315.42	30.570	0.000E+00 0.000E+00CHAN
183	4688.0	2083.0	66801.8	.050	.00	32.1	98	99	145.88	32.070	0.000E+00 0.000E+00CHAN
184	6250.0	3819.0	219859.8	.050	.00	57.6	98	101	145.16	57.570	0.000E+00 0.000E+00CHAN
185	6771.0	3438.0	161826.7	.050	.00	47.1	97	98	173.92	47.070	0.000E+00 0.000E+00CHAN
186	8750.0	2778.0	155762.5	.050	.00	56.1	97	101	205.93	56.070	0.000E+00 0.000E+00CHAN
187	5208.0	3125.0	114281.3	.040	.00	36.6	96	97	151.77	36.570	0.000E+00 0.000E+00CHAN
188	6249.0	2604.0	75698.3	.050	.00	29.1	95	97	204.25	29.070	0.000E+00 0.000E+00CHAN
189	8334.0	3438.0	99942.7	.050	.00	29.1	92	97	272.40	29.070	0.000E+00 0.000E+00CHAN
190	7812.0	3125.0	39281.3	.050	.00	12.6	92	95	388.30	12.570	0.000E+00 0.000E+00CHAN
191	6458.0	3125.0	39281.3	.050	.00	12.6	92	93	321.00	12.570	0.000E+00 0.000E+00CHAN
192	5729.0	4167.0	52379.2	.050	.00	12.6	93	95	284.76	12.570	0.000E+00 0.000E+00CHAN
193	7812.0	2604.0	28826.3	.050	.00	11.1	93	94	413.77	11.070	0.000E+00 0.000E+00CHAN
194	7187.0	1979.0	21907.5	.050	.00	11.1	94	95	380.67	11.070	0.000E+00 0.000E+00CHAN
195	6770.0	2083.0	41805.8	.050	.00	20.1	95	104	266.31	20.070	0.000E+00 0.000E+00CHAN
196	6250.0	5104.0	140717.3	.050	.00	27.6	96	104	209.77	27.570	0.000E+00 0.000E+00CHAN
197	11979.0	3438.0	146493.2	.040	.00	42.6	96	103	323.40	42.610	0.000E+00 0.000E+00CHAN
198	6250.0	4514.0	212474.0	.050	.00	47.1	96	101	160.54	47.070	0.000E+00 0.000E+00CHAN
199	8854.0	5903.0	366635.3	.050	.00	62.1	101	103	197.98	62.110	0.000E+00 0.000E+00CHAN
200	14583.0	4167.0	221371.9	.050	.00	53.1	101	102	352.59	53.125	0.000E+00 0.000E+00CHAN
201	6146.0	5903.0	242436.2	.050	.00	41.1	99	101	169.01	41.070	0.000E+00 0.000E+00CHAN
202	15104.0	2083.0	57542.9	.050	.00	27.6	99	102	506.42	27.625	0.000E+00 0.000E+00CHAN
203	10312.0	4896.0	76279.7	.050	.00	15.6	99	100	460.40	15.580	0.000E+00 0.000E+00CHAN
204	11146.0	9028.0	439347.6	.050	.00	48.7	102	103	281.57	48.665	0.000E+00 0.000E+00CHAN
205	11250.0	5556.0	236741.2	.050	.00	42.6	103	104	303.72	42.610	0.000E+00 0.000E+00CHAN
206	16146.0	2257.0	82594.9	.050	.00	36.6	104	105	470.36	36.595	0.000E+00 0.000E+00CHAN
207	10416.0	11111.0	573716.5	.050	.00	51.6	103	105	255.45	51.635	0.000E+00 0.000E+00CHAN
208	22500.0	8681.0	396200.8	.050	.00	45.6	105	106	586.92	45.640	0.000E+00 0.000E+00CHAN
209	25104.0	5729.0	295931.5	.040	.00	51.7	103	106	615.54	51.655	0.000E+00 0.000E+00CHAN
210	19479.0	9375.0	400031.2	.050	.00	42.7	102	106	525.51	42.670	0.000E+00 0.000E+00CHAN
211	31250.0	8333.0	455440.1	.040	.00	54.7	106	155	744.92	54.655	0.000E+00 0.000E+00CHAN
212	3646.0	6250.0	99687.5	.040	.00	16.0	107	108	160.88	15.950	0.000E+00 0.000E+00CHAN
213	11979.0	4500.0	127350.0	.030	.00	28.3	8	9	396.83	28.300	0.000E+00 0.000E+00CHAN
214	22083.0	10416.0	805156.8	.030	.00	77.3	1	120	442.63	77.300	0.000E+00 0.000E+00CHAN
215	35937.0	9896.0	735272.8	.030	.00	74.3	1	5	734.72	74.300	0.000E+00 0.000E+00CHAN
216	22916.0	17708.0	1634449.0	.030	.00	92.3	1	121	420.35	92.300	0.000E+00 0.000E+00CHAN
217	22396.0	11111.0	975545.8	.030	.00	87.8	2	121	421.21	87.800	0.000E+00 0.000E+00CHAN
218	34375.0	10243.0	761054.9	.030	.00	74.3	2	6	702.78	74.300	0.000E+00 0.000E+00CHAN
219	21875.0	14931.0	1243752.0	.030	.00	83.3	2	122	422.37	83.300	0.000E+00 0.000E+00CHAN
220	22396.0	10764.0	702889.3	.030	.00	65.3	3	122	488.41	65.300	0.000E+00 0.000E+00CHAN
221	29167.0	12500.0	635000.0	.030	.00	50.8	3	7	721.16	50.800	0.000E+00 0.000E+00CHAN

222	31680.0	1042.0	7887.9	.040	.00	7.6	94	139	2029.13	7.570	0.000E+00	0.000E+00CHAN
223	2604.0	1042.0	17703.6	.050	.00	17.0	40	128	111.33	16.990	0.000E+00	0.000E+00CHAN
224	4688.0	1042.0	17703.6	.050	.00	17.0	39	128	200.43	16.990	0.000E+00	0.000E+00CHAN
225	3646.0	729.0	7282.7	.050	.00	10.0	127	128	203.29	9.990	0.000E+00	0.000E+00CHAN
226	7292.0	625.0	3431.2	.050	.00	5.5	126	127	548.44	5.490	0.000E+00	0.000E+00CHAN
227	6771.0	625.0	3431.2	.050	.00	5.5	125	127	509.26	5.490	0.000E+00	0.000E+00CHAN
228	6771.0	2604.0	31977.1	.040	.00	12.3	31	135	340.51	12.280	0.000E+00	0.000E+00CHAN
229	7813.0	1042.0	32104.0	.050	.00	30.8	57	129	248.05	30.810	0.000E+00	0.000E+00CHAN
230	15625.0	729.0	11153.7	.050	.00	15.3	73	130	703.96	15.300	0.000E+00	0.000E+00CHAN
231	8333.0	2431.0	38604.3	.040	.00	15.9	23	131	368.51	15.880	0.000E+00	0.000E+00CHAN
232	10833.0	2083.0	33223.9	.060	.00	16.0	107	131	478.01	15.950	0.000E+00	0.000E+00CHAN
233	9375.0	2083.0	26079.2	.060	.00	12.5	107	132	466.92	12.520	0.000E+00	0.000E+00CHAN
234	8542.0	2083.0	30370.1	.060	.00	14.6	118	133	394.23	14.580	0.000E+00	0.000E+00CHAN
235	8333.0	1042.0	15202.8	.060	.00	14.6	117	134	384.46	14.590	0.000E+00	0.000E+00CHAN
236	19622.0	5208.0	82963.4	.040	.00	15.9	35	136	866.38	15.930	0.000E+00	0.000E+00CHAN
237	24102.0	2083.0	33307.2	.040	.00	16.0	136	137	1062.19	15.990	0.000E+00	0.000E+00CHAN
238	30352.0	3125.0	45703.1	.040	.00	14.6	137	138	1398.66	14.625	0.000E+00	0.000E+00CHAN
239	176000.0	5729.0	146719.7	.030	.00	25.6	67	140	6128.86	25.610	0.000E+00	0.000E+00CHAN
240	176000.0	10417.0	265633.5	.030	.00	25.5	140	141	6142.07	25.500	0.000E+00	0.000E+00CHAN
241	176000.0	13021.0	332035.5	.030	.00	25.5	141	142	6142.07	25.500	0.000E+00	0.000E+00CHAN
242	1746.1	1300.0	9100.0	.035	.00	7.0	261	262	116.31	7.000	0.000E+00	0.000E+00CHAN
243	1773.9	600.0	28350.0	.030	.00	35.0	263	266	52.84****	35.000	1.200E+01	0.000E+00CHAN
244	2396.0	3646.0	.1	.060	.00	-9.0	145	146	.00-DRY	-9.030	0.000E+00	0.000E+00CHAN
245	5521.0	1875.0	5175.0	.040	.00	2.8	112	145	585.65	2.760	0.000E+00	0.000E+00CHAN
246	13542.0	6944.0	115617.6	.030	.00	16.6	7	146	584.85	16.650	0.000E+00	0.000E+00CHAN
247	14063.0	5556.0	56393.4	.030	.00	10.1	8	146	777.89	10.150	0.000E+00	0.000E+00CHAN
248	17188.0	2292.0	27847.8	.030	.00	12.1	8	147	868.98	12.150	0.000E+00	0.000E+00CHAN
249	6875.0	7292.0	81305.8	.030	.00	11.1	9	147	362.83	11.150	0.000E+00	0.000E+00CHAN
250	7083.0	4167.0	44378.5	.030	.00	10.6	10	147	382.49	10.650	0.000E+00	0.000E+00CHAN
251	2396.0	2083.0	.1	.060	.00	-5.1	147	148	.00-DRY	-5.050	0.000E+00	0.000E+00CHAN
252	3854.0	2083.0	12966.7	.040	.00	6.2	109	148	272.22	6.225	0.000E+00	0.000E+00CHAN
253	6250.0	1042.0	6434.4	.040	.00	6.2	108	148	443.23	6.175	0.000E+00	0.000E+00CHAN
254	6146.0	3125.0	33281.3	.030	.00	10.6	10	149	331.89	10.650	0.000E+00	0.000E+00CHAN
255	2917.0	3125.0	.1	.060	.00	-4.9	149	150	.00-DRY	-4.950	0.000E+00	0.000E+00CHAN
256	6250.0	1736.0	10893.4	.040	.00	6.3	108	150	439.69	6.275	0.000E+00	0.000E+00CHAN
257	6250.0	1736.0	8167.9	.040	.00	4.7	23	150	507.78	4.705	0.000E+00	0.000E+00CHAN
258	11042.0	10243.0	201275.0	.030	.00	19.6	5	152	438.97	19.650	0.000E+00	0.000E+00CHAN
259	22708.0	7292.0	165163.8	.030	.00	22.6	120	152	840.85	22.650	0.000E+00	0.000E+00CHAN
260	16250.0	8854.0	200543.1	.030	.00	22.6	120	154	601.72	22.650	0.000E+00	0.000E+00CHAN
261	1354.0	5208.0	.1	.060	.00	-5.1	153	154	.00-DRY	-5.075	0.000E+00	0.000E+00CHAN
262	6875.0	3125.0	14281.2	.040	.00	4.6	15	153	566.74	4.570	0.000E+00	0.000E+00CHAN
263	3750.0	3125.0	.1	.060	.00	-5.1	151	152	.00-DRY	-5.050	0.000E+00	0.000E+00CHAN
264	8333.0	1000.0	4595.0	.040	.00	4.6	14	151	685.06	4.595	0.000E+00	0.000E+00CHAN
265	10833.0	2000.0	9190.0	.040	.00	4.6	15	151	890.59	4.595	0.000E+00	0.000E+00CHAN
266	2451.8	1500.0	58922.5	.030	.00	37.0	255	257	71.03	37.000	5.000E+00	0.000E+00CHAN
267	2398.1	2200.0	13200.0	.035	.00	6.0	256	258	172.53	6.000	0.000E+00	0.000E+00CHAN
268	1695.7	1200.0	9600.0	.035	.00	8.0	258	259	105.65	8.000	0.000E+00	0.000E+00CHAN
269	2845.1	700.0	24500.0	.030	.00	35.0	257	260	84.75	35.000	0.000E+00	0.000E+00CHAN
270	2504.3	1000.0	41125.0	.030	.00	35.0	257	259	74.60	35.000	1.000E+01	0.000E+00CHAN
271	1666.7	1000.0	7000.0	.035	.00	7.0	258	261	111.01	7.000	0.000E+00	0.000E+00CHAN
272	1886.5	1400.0	11200.0	.035	.00	8.0	259	260	117.54	8.000	0.000E+00	0.000E+00CHAN
273	1875.0	700.0	31850.0	.030	.00	35.0	260	263	55.85****	35.000	1.200E+01	0.000E+00CHAN
274	1875.0	1500.0	9000.0	.035	.00	6.0	259	262	134.90	6.000	0.000E+00	0.000E+00CHAN
275	1548.6	2100.0	.1	.050	.00	-9.0	262	265	.00-DRY	-9.000	0.000E+00	0.000E+00CHAN

276	2062.4	700.0	28545.0	.030	.00	33.0	261	264	63.27	33.000	1.000E+01	0.000E+00CHAN
277	1886.5	1600.0	.1	.050	.00	-9.0	262	263	.00-DRY	-9.000	0.000E+00	0.000E+00CHAN
278	2147.5	800.0	34125.0	.030	.00	35.0	259	261	63.97	35.000	1.000E+01	0.000E+00CHAN
279	2655.7	2100.0	.1	.030	.00	-9.0	264	265	.00-DRY	-9.000	0.000E+00	0.000E+00CHAN
280	27604.0	6944.0	275468.5	.050	.00	39.7	102	156	772.35	39.670	0.000E+00	0.000E+00CHAN
281	36458.0	4167.0	165117.4	.050	.00	39.6	105	161	1020.66	39.625	0.000E+00	0.000E+00CHAN
282	19271.0	12500.0	495562.5	.050	.00	39.6	106	161	539.36	39.645	0.000E+00	0.000E+00CHAN
283	17708.0	14931.0	636956.4	.050	.00	42.7	106	156	477.78	42.660	0.000E+00	0.000E+00CHAN
284	36458.0	6250.0	275968.8	.050	.00	44.2	156	157	966.89	44.155	0.000E+00	0.000E+00CHAN
285	24479.0	15451.0	798121.4	.050	.00	51.7	155	156	600.22	51.655	0.000E+00	0.000E+00CHAN
286	19792.0	15972.0	776878.1	.050	.00	48.6	155	161	500.11	48.640	0.000E+00	0.000E+00CHAN
287	46875.0	6250.0	247750.0	.050	.00	39.6	160	161	1312.04	39.640	0.000E+00	0.000E+00CHAN
288	33333.0	13542.0	740070.3	.050	.00	54.7	155	160	794.61	54.650	0.000E+00	0.000E+00CHAN
289	38021.0	13368.0	971185.3	.040	.00	72.7	155	159	786.10	72.650	0.000E+00	0.000E+00CHAN
290	29167.0	16677.0	936413.6	.050	.00	56.2	155	157	685.94	56.150	0.000E+00	0.000E+00CHAN
291	26042.0	19965.0	1300720.0	.050	.00	65.2	157	159	568.58	65.150	0.000E+00	0.000E+00CHAN
292	23958.0	21528.0	1370257.0	.050	.00	63.7	159	160	529.20	63.650	0.000E+00	0.000E+00CHAN
293	54688.0	10417.0	788046.1	.050	.00	75.7	158	160	1108.05	75.650	0.000E+00	0.000E+00CHAN
294	37500.0	13542.0	1268208.0	.040	.00	93.7	158	159	682.89	93.650	0.000E+00	0.000E+00CHAN
295	62500.0	7292.0	562577.8	.050	.00	77.2	157	158	1253.96	77.150	0.000E+00	0.000E+00CHAN
296	34896.0	41667.0	4402119.0	.040	.00	105.7	4	158	598.29	105.650	0.000E+00	0.000E+00CHAN
297	10000.0	50.0	228.2	.040	.00	4.5	213	214	830.74	10.000	3.200E-01	1.430E+01CHAN
298	4583.0	1563.0	55971.0	.040	.00	35.8	58	61	134.96	35.810	0.000E+00	0.000E+00CHAN
299	2350.1	2150.0	.1	.050	.00	-9.0	265	266	.00-DRY	-9.000	0.000E+00	0.000E+00CHAN
300	2940.7	800.0	31845.0	.030	.00	33.0	264	267	90.21	33.000	1.000E+01	0.000E+00CHAN
301	2843.2	2300.0	18400.0	.035	.00	8.0	252	254	177.15	8.000	0.000E+00	0.000E+00CHAN
302	2829.8	2850.0	.1	.050	.00	-9.0	267	268	.00-DRY	-9.000	0.000E+00	0.000E+00CHAN
303	3100.0	400.0	13466.7	.030	.00	23.4	168	169	112.93	28.900	1.500E+01	5.000E+01CHAN
304	2800.0	300.0	7922.2	.030	.00	17.8	169	271	116.96	17.800	1.630E+01	0.000E+00CHAN
305	4800.0	270.0	6445.2	.030	.00	16.4	170	171	208.88	22.400	1.500E+01	1.190E+02CHAN
306	5400.0	250.0	5940.6	.030	.00	17.0	171	172	230.80	23.000	1.170E+01	1.100E+02CHAN
307	5100.0	230.0	5358.9	.030	.00	16.4	172	173	221.93	22.400	1.180E+01	8.760E+01CHAN
308	5100.0	235.0	7087.1	.030	.00	18.7	173	174	207.84	26.700	1.540E+01	6.740E+01CHAN
309	6000.0	215.0	4616.7	.030	.00	14.8	174	175	274.85	24.300	1.310E+01	7.250E+01CHAN
310	2175.1	205.0	4020.0	.035	.00	14.2	175	176	101.72	22.200	1.100E+01	9.560E+01CHAN
311	2670.0	2500.0	.1	.050	.00	-9.0	265	268	.00-DRY	-9.000	0.000E+00	0.000E+00CHAN
312	2329.2	2850.0	.1	.050	.00	-9.0	168	268	.00-DRY	-9.000	0.000E+00	0.000E+00CHAN
313	3028.0	800.0	31845.0	.030	.00	33.0	179	267	92.89	33.000	1.000E+01	0.000E+00CHAN
314	2572.7	600.0	30187.5	.030	.00	35.0	168	266	76.64	35.000	1.500E+01	0.000E+00CHAN
315	2964.6	2700.0	.1	.050	.00	-9.0	178	268	.00-DRY	-9.000	0.000E+00	0.000E+00CHAN
316	3255.9	1000.0	.1	.055	.00	-8.5	178	179	.00-DRY	-8.500	0.000E+00	0.000E+00CHAN
317	5400.0	700.0	38847.6	.030	.00	40.5	179	272	149.53	40.500	1.280E+01	0.000E+00CHAN
318	2329.2	2600.0	23400.0	.035	.00	9.0	252	253	136.82	9.000	0.000E+00	0.000E+00CHAN
319	2982.9	1000.0	40422.5	.030	.00	37.0	250	253	86.42	37.000	5.000E+00	0.000E+00CHAN
320	3168.1	2100.0	16800.0	.035	.00	8.0	249	252	197.39	8.000	0.000E+00	0.000E+00CHAN
321	3310.5	1000.0	.1	.050	.00	-11.5	169	178	.00-DRY	-11.500	0.000E+00	0.000E+00CHAN
322	4300.0	600.0	21000.0	.030	.00	35.0	162	251	128.09	35.000	0.000E+00	0.000E+00CHAN
323	2504.3	1200.0	47822.5	.030	.00	37.0	250	251	72.55	37.000	5.000E+00	0.000E+00CHAN
324	4625.8	100.0	.1	.055	.00	-5.5	180	181	.00-DRY	-5.500	0.000E+00	0.000E+00CHAN
325	2197.4	3500.0	31500.0	.035	.00	9.0	249	250	129.08	9.000	0.000E+00	0.000E+00CHAN
326	4400.0	500.0	25971.0	.030	.00	38.3	182	183	125.29	40.800	9.300E+00	1.030E+02CHAN
327	8524.5	600.0	.1	.055	.00	-8.0	180	184	.00-DRY	-8.000	0.000E+00	0.000E+00CHAN
328	7812.5	100.0	.1	.055	.00	-8.0	181	184	.00-DRY	-8.000	0.000E+00	0.000E+00CHAN
329	4738.1	1400.0	52062.5	.030	.00	35.0	248	251	141.14	35.000	5.000E+00	0.000E+00CHAN

330	4000.0	480.0	17402.2	.030	.00	31.5	182	185	125.60	33.000	4.600E+00	5.000E+00CHAN
331	6000.0	10.0	35.0	.025	.00	3.5	183	188	565.18	7.000	3.500E+00	0.000E+00BOX
332	4903.6	800.0	.1	.055	.00	-1.5	184	189	.00-DRY	-1.500	0.000E+00	0.000E+00CHAN
333	2572.7	2000.0	.1	.055	.00	-.5	186	240	.00-DRY	-.500	0.000E+00	0.000E+00CHAN
334	4000.0	20.0	240.1	.035	.00	5.5	184	240	300.57	7.000	8.600E+00	2.200E+00CHAN
335	5200.0	520.0	18265.2	.030	.00	29.1	185	186	169.87	30.600	7.400E+00	1.200E+02CHAN
336	4332.6	900.0	.1	.055	.00	-7.5	185	187	.00-DRY	-7.500	0.000E+00	0.000E+00CHAN
337	5300.0	20.0	370.9	.030	.00	8.5	186	241	320.36	9.000	5.560E+00	2.140E+00CHAN
338	4734.7	1000.0	.1	.055	.00	-9.5	186	187	.00-DRY	-9.500	0.000E+00	0.000E+00CHAN
339	4414.5	1000.0	44000.0	.030	.00	40.0	247	250	123.01	40.000	5.000E+00	0.000E+00CHAN
340	4700.0	440.0	14368.8	.030	.00	27.5	186	190	157.94	29.000	6.000E+00	1.100E+01CHAN
341	6475.9	1000.0	.1	.055	.00	-9.0	186	191	.00-DRY	-9.000	0.000E+00	0.000E+00CHAN
342	4336.4	2200.0	17600.0	.035	.00	8.0	167	249	270.18	8.000	0.000E+00	0.000E+00CHAN
343	3921.2	600.0	24062.5	.030	.00	35.0	49	248	116.80	35.000	5.000E+00	0.000E+00CHAN
344	3524.8	1200.0	44400.0	.030	.00	37.0	247	248	102.12	37.000	0.000E+00	0.000E+00CHAN
345	6000.0	50.0	727.7	.035	.00	11.5	190	194	311.80	13.000	2.310E+00	0.000E+00CHAN
346	5001.1	450.0	15068.4	.030	.00	24.3	190	193	178.79	25.800	1.400E+01	1.540E+01CHAN
347	5536.5	1000.0	.1	.055	.00	-9.5	191	193	.00-DRY	-9.500	0.000E+00	0.000E+00CHAN
348	1822.2	3900.0	35100.0	.035	.00	9.0	167	247	107.04	9.000	0.000E+00	0.000E+00CHAN
349	4100.0	1000.0	38062.5	.030	.00	35.0	164	247	122.13	35.000	5.000E+00	0.000E+00CHAN
350	3657.7	1000.0	44000.0	.030	.00	40.0	165	247	101.92	40.000	5.000E+00	0.000E+00CHAN
351	5300.0	80.0	1646.9	.035	.00	12.5	192	239	264.18	14.500	8.280E+00	3.600E+01CHAN
352	3354.4	1200.0	9600.0	.035	.00	8.0	166	167	209.00	8.000	0.000E+00	0.000E+00CHAN
353	4600.0	450.0	12403.1	.030	.00	22.5	193	242	170.90	24.000	9.000E+00	5.000E+01CHAN
354	4809.8	450.0	13306.7.	.030	.00	22.7	199	242	177.90	24.200	1.200E+01	1.630E+02CHAN
355	8000.0	30.0	375.3	.040	.00	8.5	195	199	483.56	9.000	3.330E+00	2.450E+02CHAN
356	5500.0	40.0	521.9	.040	.00	8.0	196	200	342.68	9.500	6.310E+00	3.600E+02CHAN
357	10000.0	800.0	.1	.055	.00	-8.5	197	198	.00-DRY	1.000	3.000E+02	4.000E+01CHAN
358	844.3	20.0	110.0	.009	.00	5.5	244	245	63.44	10.000	5.500E+00	0.000E+00BOX
359	6934.7	600.0	.1	.055	.00	-9.0	198	201	.00-DRY	1.500	9.000E+02	0.000E+00CHAN
360	4250.0	300.0	9725.1	.030	.00	22.8	199	201	156.85	25.300	1.110E+01	6.300E+02CHAN
361	4800.0	30.0	1182.6	.035	.00	15.1	199	200	217.68	23.600	6.400E+00	3.000E+02CHAN
362	10000.0	20.0	50.0	.055	.00	2.5	197	202	1114.56	7.500	0.000E+00	1.000E+02CHAN
363	9000.0	1000.0	.1	.055	.00	-6.5	198	202	.00-DRY	-6.500	0.000E+00	0.000E+00CHAN
364	10063.3	2000.0	.1	.055	.00	-6.5	202	203	.00-DRY	-6.500	0.000E+00	0.000E+00CHAN
365	5073.3	1100.0	.1	.055	.00	-4.5	198	203	.00-DRY	-4.500	0.000E+00	0.000E+00CHAN
366	5900.0	225.0	7134.0	.030	.00	20.5	201	203	229.64	22.000	1.200E+01	2.470E+02CHAN
367	7400.0	40.0	320.9	.035	.00	5.5	201	204	556.06	6.000	6.670E+00	0.000E+00CHAN
368	6500.0	30.0	1239.5	.030	.00	18.5	192	193	266.32	38.000	4.000E+00	0.000E+00CHAN
369	6521.9	100.0	.1	.055	.00	-2.8	202	205	.00-DRY	-2.750	0.000E+00	0.000E+00CHAN
370	7800.0	300.0	7499.3	.035	.00	18.3	203	206	321.32	20.800	1.200E+01	2.000E+02CHAN
371	6000.0	40.0	480.0	.035	.00	12.0	204	207	305.23	19.000	0.000E+00	1.200E+02CHAN
372	4625.7	100.0	.1	.055	.00	-5.5	203	204	.00-DRY	-5.500	0.000E+00	0.000E+00CHAN
373	1450.9	3000.0	60000.0	.030	.00	20.0	164	165	57.17****	20.000	0.000E+00	0.000E+00CHAN
374	8321.0	1000.0	.1	.055	.00	-7.5	205	206	.00-DRY	-7.500	0.000E+00	0.000E+00CHAN
375	7900.0	200.0	3801.7	.030	.00	16.8	206	207	340.17	28.250	3.220E+00	2.330E+02CHAN
376	6900.0	200.0	3557.0	.030	.00	14.5	207	208	319.33	16.000	6.250E+00	7.700E+00CHAN
377	7100.0	100.0	2349.3	.030	.00	15.3	208	209	319.88	19.300	7.000E+00	3.750E+01CHAN
378	8200.0	200.0	3466.1	.035	.00	12.3	206	210	412.03	16.800	1.330E+01	1.000E+02CHAN
379	6800.0	130.0	1599.0	.035	.00	12.3	210	211	341.69	24.300	0.000E+00	9.700E+02CHAN
380	12550.0	100.0	1753.1	.040	.00	8.5	211	212	758.59	13.000	2.500E+01	1.400E+01CHAN
381	10000.0	100.0	690.0	.040	.00	6.0	212	213	719.44	10.500	5.000E+00	6.250E+00CHAN
382	3412.1	165.0	3603.5	.035	.00	13.6	176	177	163.05	20.100	1.470E+01	1.219E+02CHAN
383	3600.0	175.0	4103.2	.035	.00	15.7	177	215	160.11	22.200	1.100E+01	1.311E+02CHAN

384	3462.7	200.0	4107.2	.035	.00	13.6	215	216	165.47	19.600	1.500E+01 1.218E+02CHAN
385	2800.0	165.0	3239.8	.030	.00	12.3	216	217	140.69	18.800	1.600E+01 1.538E+02CHAN
386	3140.0	190.0	4248.6	.030	.00	13.6	217	218	150.05	21.100	1.800E+01 1.158E+02CHAN
387	2900.0	150.0	3823.9	.030	.00	13.9	218	219	137.08	22.900	1.800E+01 7.380E+01CHAN
388	3300.0	150.0	3766.5	.030	.00	15.5	219	220	147.71	25.000	1.200E+01 9.250E+01CHAN
389	2700.0	150.0	3797.1	.030	.00	13.6	220	221	129.02	23.100	1.900E+01 1.085E+02CHAN
390	3100.0	150.0	2589.1	.040	.00	11.1	221	222	163.97	20.600	1.500E+01 1.220E+02CHAN
391	2700.0	150.0	3743.1	.040	.00	14.2	222	223	126.27	24.200	1.600E+01 1.395E+02CHAN
392	2300.0	140.0	3197.8	.040	.00	14.2	223	224	107.56	24.200	1.200E+01 1.416E+02CHAN
393	3100.0	165.0	1673.6	.040	.00	8.2	224	225	190.72	17.705	9.500E+00 1.115E+02CHAN
394	2600.0	135.0	444.8	.030	.00	3.0	225	226	266.54	12.955	1.050E+01 8.350E+01CHAN
395	3050.0	250.0	.1	.030	.00	.0	226	227	.00-DRY	10.000	0.000E+00 5.000E+01CHAN
396	2100.0	200.0	.1	.030	.00	-2.5	227	228	.00-DRY	7.500	1.600E+01 2.400E+01CHAN
397	2050.0	200.0	.1	.030	.00	-4.5	228	229	.00-DRY	5.500	1.600E+01 2.400E+01CHAN
398	6400.0	466.0	6524.0	.040	.00	14.0	41	230	301.43	14.500	0.000E+00 4.000E+02CHAN
399	5417.0	387.0	4760.1	.040	.00	12.3	230	231	272.19	12.800	0.000E+00 3.500E+02CHAN
400	5200.0	365.0	2664.5	.040	.00	7.3	231	232	339.17	7.800	0.000E+00 2.500E+02CHAN
401	6990.0	252.0	1159.2	.040	.00	4.6	232	233	574.34	5.100	0.000E+00 1.500E+02CHAN
402	3199.0	97.0	261.9	.040	.00	2.7	233	234	343.09	3.200	0.000E+00 1.000E+02CHAN
403	4202.0	97.0	261.9	.040	.00	2.7	233	235	450.66	3.200	0.000E+00 1.000E+02CHAN
404	4197.0	50.0	125.0	.040	.00	2.5	235	236	467.78	3.000	0.000E+00 5.000E+01CHAN
405	3000.0	50.0	.1	.040	.00	-1.6	235	237	.00-DRY	.400	0.000E+00 5.000E+01CHAN
406	4282.3	100.0	.1	.055	.00	-6.5	190	191	.00-DRY	-6.500	0.000E+00 0.000E+00CHAN
407	2716.3	2000.0	.1	.055	.00	-7.5	189	241	.00-DRY	-7.500	0.000E+00 0.000E+00CHAN
408	3535.5	2000.0	.1	.055	.00	-7.5	184	241	.00-DRY	-7.500	0.000E+00 0.000E+00CHAN
409	5000.0	10.0	473.5	.035	.00	9.5	185	240	285.88	9.000	7.800E+00 2.200E+02CHAN
410	844.3	10.0	55.0	.021	.00	5.5	192	246	63.44	9.000	5.500E+00 0.000E+00BOX
411	4000.0	80.0	1493.5	.055	.00	11.5	197	239	207.87	11.000	8.600E+00 4.720E+01CHAN
412	6041.7	100.0	.1	.055	.00	-3.8	205	238	.00-DRY	-3.750	0.000E+00 0.000E+00CHAN
413	5664.4	300.0	.1	.055	.00	-8.5	210	238	.00-DRY	-9.000	3.500E+02 9.000E+02CHAN
414	6306.2	2000.0	.1	.055	.00	-7.0	181	240	.00-DRY	2.500	8.000E+02 1.000E-01CHAN
415	805.0	7.0	35.0	.022	.00	5.0	242	243	63.44	7.000	5.000E+00 0.000E+00BOX
416	6002.9	100.0	.1	.055	.00	-9.5	198	243	.00-DRY	-9.500	0.000E+00 0.000E+00CHAN
417	7139.8	200.0	.1	.055	.00	-9.5	197	243	.00-DRY	-9.500	0.000E+00 0.000E+00CHAN
418	6979.9	50.0	.1	.055	.00	-9.5	192	243	.00-DRY	-9.500	0.000E+00 0.000E+00CHAN
419	3000.0	40.0	100.0	.040	.00	2.5	199	244	334.37	4.500	0.000E+00 3.000E+02CHAN
420	4200.0	40.0	100.0	.055	.00	2.5	198	245	468.11	4.500	0.000E+00 3.000E+02CHAN
421	5900.0	40.0	436.3	.040	.00	5.5	194	246	443.35	7.000	1.430E+01 6.620E+01CHAN
422	1450.9	3200.0	44800.0	.035	.00	14.0	165	166	68.33	14.000	0.000E+00 0.000E+00CHAN
423	4065.0	500.0	20562.5	.030	.00	35.0	144	164	121.09	35.000	5.000E+00 0.000E+00CHAN
424	3774.5	1500.0	64000.0	.030	.00	40.0	144	165	105.17	40.000	5.000E+00 0.000E+00CHAN
425	4204.2	1100.0	15360.0	.035	.00	12.0	144	166	213.88	12.000	3.000E+01 0.000E+00CHAN
426	3391.4	2000.0	69000.0	.030	.00	30.0	144	163	109.12	30.000	2.000E+01 0.000E+00CHAN
427	2702.3	2200.0	17600.0	.035	.00	8.0	143	163	168.37	8.000	0.000E+00 0.000E+00CHAN
428	3751.4	2000.0	14000.0	.035	.00	7.0	143	144	249.87	7.000	0.000E+00 0.000E+00CHAN
429	3126.7	3300.0	19800.0	.035	.00	6.0	46	143	224.95	6.000	0.000E+00 0.000E+00CHAN
430	4023.6	2700.0	113600.0	.030	.00	40.0	44	144	112.11	40.000	7.000E+00 0.000E+00CHAN
431	7260.0	900.0	31500.0	.030	.00	35.0	42	269	216.26	35.000	0.000E+00 0.000E+00CHAN
432	2900.0	900.0	31500.0	.030	.00	35.0	43	270	86.38	35.000	0.000E+00 0.000E+00CHAN
433	6200.0	2500.0	92500.0	.030	.00	37.0	44	46	179.62	37.000	0.000E+00 0.000E+00CHAN
434	4200.0	1563.0	74520.0	.030	.00	40.0	45	47	117.03	40.000	1.500E+01 0.000E+00CHAN
435	5600.0	1563.0	70520.0	.030	.00	40.0	48	50	156.04	40.000	1.000E+01 0.000E+00CHAN
436	4405.9	240.0	6879.3	.035	.00	17.2	170	271	187.22	17.200	1.860E+01 0.000E+00CHAN
437	4000.0	400.0	23367.2	.030	.00	39.6	183	272	112.02	39.600	9.600E+00 0.000E+00CHAN

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  438       4880.0   30.0        .1    .040     .00       -2.0       225       273          .00-DRY -2.000    0.000E+00 0.000E+00CHAN
  439       4880.0   53.0        .1    .040     .00       -6.0       273       274          .00-DRY -6.000    0.000E+00 0.000E+00CHAN
1PASSAIC RIVER FLOOD PROTECTION STUDY
 OCTOBER TIDE 11-13 1976   RAN  FEBRUARY 1992
 FORCING AT NODES 1, 2, 3, AND 4.
    APPROXIMATE ACTUAL FLOWS IN RIVERS


 THE SURGES AT THE FOLLOWING  19 NODES WILL BE SAVED ON TAPE 41
    12   62  168  175  221  226  167  182  242  195  200  206  211  213   43   35  136  137  138
1HYDROGRAPH INPUTS TO SYSTEM

 AT NODES                229       214       209
 AT TIME =     .00 HOURS -
 HYDROGRAPH INFLOWS (CFS) =     1000.0     100.0      30.0
 AT TIME =     .00HOURS -
 BOUNDARY HEADS =       -.28      -.28      -.28      2.67
1          AT DAY   1
 AT TIME =   40.10 HOURS -
 HYDROGRAPH INFLOWS (CFS) =      744.0      74.0      25.0
 AT TIME =    1.00HOURS -
 BOUNDARY HEADS =      -1.02     -1.02     -1.02      2.62
 AT TIME =    2.00HOURS -
 BOUNDARY HEADS =      -1.65     -1.65     -1.65      1.85
 AT TIME =    3.00HOURS -
 BOUNDARY HEADS =      -1.92     -1.92     -1.92       .56
 AT TIME =    4.00HOURS -
 BOUNDARY HEADS =      -1.57     -1.57     -1.57      -.84
 AT TIME =    5.00HOURS -
 BOUNDARY HEADS =       -.51      -.51      -.51     -1.97
 AT TIME =    6.00HOURS -
 BOUNDARY HEADS =        .84       .84       .84     -2.68
 AT TIME =    7.00HOURS -
 BOUNDARY HEADS =       1.97      1.97      1.97     -2.65
 AT TIME =    8.00HOURS -
 BOUNDARY HEADS =       2.72      2.72      2.72     -1.63
 AT TIME =    9.00HOURS -
 BOUNDARY HEADS =       3.07      3.07      3.07      -.23
 AT TIME =   10.00HOURS -
 BOUNDARY HEADS =       2.89      2.89      2.89      1.44
 AT TIME =   11.00HOURS -
 BOUNDARY HEADS =       2.16      2.16      2.16      2.96
 AT TIME =   12.00HOURS -
 BOUNDARY HEADS =        .99       .99       .99      3.91
 AT TIME =   13.00HOURS -
 BOUNDARY HEADS =       -.16      -.16      -.16      4.04
 AT TIME =   14.00HOURS -
 BOUNDARY HEADS =      -1.04     -1.04     -1.04      3.23
 AT TIME =   15.00HOURS -
 BOUNDARY HEADS =      -1.49     -1.49     -1.49      1.88
 AT TIME =   16.00HOURS -
 BOUNDARY HEADS =      -1.36     -1.36     -1.36       .29
 AT TIME =   17.00HOURS -
 BOUNDARY HEADS =       -.64      -.64      -.64     -1.18
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AT TIME =   18.00HOURS -
BOUNDARY HEADS =      .40       .40       .40     -2.29
AT TIME =   19.00HOURS -
BOUNDARY HEADS =     1.35      1.35      1.35     -2.73
AT TIME =   20.00HOURS -
BOUNDARY HEADS =     2.08      2.08      2.08     -2.28
AT TIME =   21.00HOURS -
BOUNDARY HEADS =     2.51      2.51      2.51     -1.07
AT TIME =   22.00HOURS -
BOUNDARY HEADS =     2.55      2.55      2.55       .38
AT TIME =   23.00HOURS -
BOUNDARY HEADS =     2.12      2.12      2.12      1.90
AT TIME =   24.00HOURS -
BOUNDARY HEADS =     1.30      1.30      1.30      3.11
AT TIME =   25.00HOURS -
BOUNDARY HEADS =      .42       .42       .42      3.71
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 PASSAIC RIVER FLOOD PROTECTION STUDY
  OCTOBER TIDE 11-13 1976   RAN  FEBRUARY 1992
ODAY IS   1
0 ********************  T I M E   H I S T O R Y   O F   S T A G E  ********************
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HEADS IN FEET - NGVD

0 HOUR	JUNCTION 1	JUNCTION 2	JUNCTION 3	JUNCTION 4	JUNCTION 5	JUNCTION 6
.00	.0000	.0000	.0000	.0000	.0000	.0000
1.00	-1.0200	-1.0200	-1.0200	2.6200	-.9857	-1.0029
2.00	-1.6500	-1.6500	-1.6500	1.8500	-1.7000	-1.7475
3.00	-1.9200	-1.9200	-1.9200	.5600	-1.9268	-1.9659
4.00	-1.5700	-1.5700	-1.5700	-.8400	-1.6087	-1.5284
5.00	-.5100	-.5100	-.5100	-1.9700	-.6153	-.4232
6.00	.8400	.8400	.8400	-2.6800	.7533	.9263
7.00	1.9700	1.9700	1.9700	-2.6500	1.9012	1.9840
8.00	2.7200	2.7200	2.7200	-1.6300	2.6957	2.6767
9.00	3.0700	3.0700	3.0700	-.2300	3.1083	3.0069
10.00	2.8900	2.8900	2.8900	1.4400	2.9725	2.8190
11.00	2.1600	2.1600	2.1600	2.9600	2.2547	2.0877
12.00	.9900	.9900	.9900	3.9100	1.0756	.9316
13.00	-.1600	-.1600	-.1600	4.0400	-.0919	-.1632
14.00	-1.0400	-1.0400	-1.0400	3.2300	-1.0045	-.9856
15.00	-1.4900	-1.4900	-1.4900	1.8800	-1.5058	-1.4057
16.00	-1.3600	-1.3600	-1.3600	.2900	-1.4325	-1.2652
17.00	-.6400	-.6400	-.6400	-1.1800	-.7717	-.5585
18.00	.4000	.4000	.4000	-2.2900	.3281	.4641
19.00	1.3500	1.3500	1.3500	-2.7300	1.3048	1.3537
20.00	2.0800	2.0800	2.0800	-2.2800	2.0722	2.0394
21.00	2.5100	2.5100	2.5100	-1.0700	2.5471	2.4544
22.00	2.5500	2.5500	2.5500	.3800	2.6218	2.4929
23.00	2.1200	2.1200	2.1200	1.9000	2.2064	2.0642
24.00	1.3000	1.3000	1.3000	3.1100	1.3629	1.2460
25.00	.4200	.4200	.4200	3.7100	.4671	.4034
OAVERAGE VALUE	.6320	.6320	.6320	.4190	.6318	.6281

0 ********** HIGH AND LOW TIDES **********

HEAD	TIME	HEAD	TIME	HEAD	TIME	HEAD	TIME	HEAD	TIME	HEAD	TIME
3.0700	9.00	3.0700	9.00	3.0700	9.00	4.0400	13.00	3.1579	9.32	3.1274	9.33

PASSAIC RIVER FLOOD PROTECTION STUDY
OCTOBER TIDE 11-13 1976 RAN FEBRUARY 1992
0DAY IS 1
0 ********** TIME HISTORY OF STAGE **********

HEADS IN FEET - NGVD

0 HOUR	JUNCTION 7	JUNCTION 8	JUNCTION 9	JUNCTION 10	JUNCTION 11	JUNCTION 12
.00	.0000	.0000	.0000	.0000	.0000	.0000
1.00	-.8941	-1.0195	-1.1110	-.9948	-.9385	-.7528
2.00	-1.7185	-1.6526	-1.7411	-1.8807	-1.6521	-1.4842
3.00	-1.9450	-1.9709	-1.9611	-1.9626	-1.9125	-1.8878
4.00	-1.5310	-1.5714	-1.5171	-1.5682	-1.6968	-1.8592
5.00	-.3863	-.4357	-.3876	-.4387	-.7583	-1.0637
6.00	.9674	.9642	.9655	.9115	.6224	.3174
7.00	2.0058	2.0250	1.9916	1.9588	1.8159	1.6267
8.00	2.6493	2.6824	2.6604	2.6597	2.6636	2.6107
9.00	2.9368	2.9772	2.9843	3.0165	3.1296	3.1869
10.00	2.7263	2.7706	2.7940	2.8591	3.0340	3.1828
11.00	2.0016	2.0455	2.0629	2.1321	2.3459	2.5303
12.00	.8765	.9090	.9154	.9734	1.1927	1.3942
13.00	-.1791	-.1675	-.1565	-.1200	.0108	.1945
14.00	-.9741	-.9817	-.9574	-.9362	-.9428	-.8259
15.00	-1.3812	-1.3892	-1.3644	-1.3715	-1.4957	-1.4794
16.00	-1.2321	-1.2365	-1.2143	-1.2492	-1.4750	-1.6035
17.00	-.5133	-.5234	-.5119	-.5831	-.8619	-1.0954
18.00	.4996	.4890	.4968	.4507	.2405	.0235
19.00	1.3554	1.3605	1.3525	1.3323.	1.2401	1.1096
20.00	1.9975	2.0236	2.0185	2.0263.	2.0452	1.9983
21.00	2.3825	2.4213	2.4318	2.4651	2.5608	2.5871
22.00	2.4109	2.4540	2.4730	2.5230	2.6675	2.7599
23.00	1.9881	2.0295	2.0464	2.1071	2.2735	2.4034
24.00	1.1953	1.2251	1.2301	1.2738	1.4397	1.5796
25.00	.3878	.3972	.4023	.4273	.5354	.6571
0AVERAGE VALUE	.6173	.6251	.6281	.6319	.6327	.6313

0 ********** HIGH AND LOW TIDES **********

HEAD	TIME	HEAD	TIME	HEAD	TIME	HEAD	TIME	HEAD	TIME	HEAD	TIME
3.2078	9.38	3.1917	9.40	3.1877	9.40	3.2295	9.45	3.2183	9.50	3.2744	9.57

<ETC. FOR ALL NODE IN SYSTEM ON DAY 1>

```
1          AT DAY   2
 AT TIME =   26.00HOURS -
 BOUNDARY HEADS =      -.45      -.45      -.45      3.46
 AT TIME =   27.00HOURS -
 BOUNDARY HEADS =     -1.11     -1.11     -1.11      2.41
 AT TIME =   28.00HOURS -
 BOUNDARY HEADS =     -1.11     -1.11     -1.11      1.05
 AT TIME =   29.00HOURS -
 BOUNDARY HEADS =      -.36      -.36      -.36      -.35
 AT TIME =   30.00HOURS -
 BOUNDARY HEADS =       .81       .81       .81     -1.41
 AT TIME =   31.00HOURS -
 BOUNDARY HEADS =      1.87      1.87      1.87     -1.96
 AT TIME =   32.00HOURS -
 BOUNDARY HEADS =      2.66      2.66      2.66     -1.70
 AT TIME =   33.00HOURS -
 BOUNDARY HEADS =      3.16      3.16      3.16      -.57
 AT TIME =   34.00HOURS -
 BOUNDARY HEADS =      3.31      3.31      3.31       .82
 AT TIME =   35.00HOURS -
 BOUNDARY HEADS =      2.92      2.92      2.92      2.32
 AT TIME =   36.00HOURS -
 BOUNDARY HEADS =      2.07      2.07      2.07      3.52
 AT TIME =   37.00HOURS -
 BOUNDARY HEADS =      1.01      1.01      1.01      4.20
 AT TIME =   38.00HOURS -
 BOUNDARY HEADS =       .06       .06       .06      4.03
 AT TIME =   39.00HOURS -
 BOUNDARY HEADS =      -.69      -.69      -.69      3.08
 AT TIME =   40.00HOURS -
 BOUNDARY HEADS =     -1.00     -1.00     -1.00      1.65
 AT TIME =   41.00HOURS -
 BOUNDARY HEADS =      -.68      -.68      -.68       .10
 AT TIME =   73.00 HOURS -
 HYDROGRAPH INFLOWS (CFS) =     300.0      30.0      10.0
 AT TIME =   42.00HOURS -
 BOUNDARY HEADS =       .24       .24       .24     -1.20
 AT TIME =   43.00HOURS -
 BOUNDARY HEADS =      1.26      1.26      1.26     -2.01
 AT TIME =   44.00HOURS -
 BOUNDARY HEADS =      1.97      1.97      1.97     -2.15
 AT TIME =   45.00HOURS -
 BOUNDARY HEADS =      2.42      2.42      2.42     -1.37
 AT TIME =   46.00HOURS -
 BOUNDARY HEADS =      2.72      2.72      2.72      -.17
 AT TIME =   47.00HOURS -
 BOUNDARY HEADS =      2.65      2.65      2.65      1.31
 AT TIME =   48.00HOURS -
 BOUNDARY HEADS =      2.17      2.17      2.17      2.59
 AT TIME =   49.00HOURS -
 BOUNDARY HEADS =      1.30      1.30      1.30      3.55
 AT TIME =   50.00HOURS -
 BOUNDARY HEADS =       .24       .24       .24      3.83
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PASSAIC RIVER FLOOD PROTECTION STUDY
OCTOBER TIDE 11-13 1976 RAN FEBRUARY 1992
ODAY IS 2
0 ********** TIME HISTORY OF STAGE **********

HEADS IN FEET - NGVD

0 HOUR	JUNCTION 1	JUNCTION 2	JUNCTION 3	JUNCTION 4	JUNCTION 5	JUNCTION 6
.00	.4200	.4200	.4200	3.7100	.4671	.4034
1.00	-.4500	-.4500	-.4500	3.4600	-.4141	-.4290
2.00	-1.1100	-1.1100	-1.1100	2.4100	-1.1012	-1.0616
3.00	-1.1100	-1.1100	-1.1100	1.0500	-1.1526	-1.0196
4.00	-.3600	-.3600	-.3600	-.3500	-.4844	-.2567
5.00	.8100	.8100	.8100	-1.4100	.7175	.9015
6.00	1.8700	1.8700	1.8700	-1.9600	1.8070	1.8830
7.00	2.6600	2.6600	2.6600	-1.7000	2.6380	2.6132
8.00	3.1600	3.1600	3.1600	-.5700	3.1910	3.0977
9.00	3.3100	3.3100	3.3100	.8200	3.3759	3.2528
10.00	2.9200	2.9200	2.9200	2.3200	3.0147	2.8669
11.00	2.0700	2.0700	2.0700	3.5200	2.1430	2.0121
12.00	1.0100	1.0100	1.0100	4.2000	1.0744	.9801
13.00	.0600	.0600	.0600	4.0300	.1076	.0841
14.00	-.6900	-.6900	-.6900	3.0800	-.6741	-.6356
15.00	-1.0000	-1.0000	-1.0000	1.6500	-1.0283	-.9247
16.00	-.6800	-.6800	-.6800	.1000	-.7613	-.5903
17.00	.2400	.2400	.2400	-1.2000	.1178	.3211
18.00	1.2600	1.2600	1.2600	-2.0100	1.1901	1.2980
19.00	1.9700	1.9700	1.9700	-2.1500	1.9487	1.9427
20.00	2.4200	2.4200	2.4200	-1.3700	2.4454	2.3632
21.00	2.7200	2.7200	2.7200	-.1700	2.7759	2.6737
22.00	2.6500	2.6500	2.6500	1.3100	2.7143	2.6082
23.00	2.1700	2.1700	2.1700	2.5900	2.2276	2.1260
24.00	1.3000	1.3000	1.3000	3.5500	1.3594	1.2561
25.00	.2400	.2400	.2400	3.8300	.3060	.2185
OAVERAGE VALUE	1.1012	1.1012	1.1012	.9988	1.1047	1.1069

0 ********** HIGH AND LOW TIDES **********

HEAD	TIME	HEAD	TIME	HEAD	TIME	HEAD	TIME	HEAD	TIME	HEAD	TIME
3.3100	34.00	3.3100	34.00	3.3100	34.00	4.2000	37.00	3.3884	33.82	3.3418	33.58

PASSAIC RIVER FLOOD PROTECTION STUDY
OCTOBER TIDE 11-13 1976 RAN FEBRUARY 1992
ODAY IS 2
0 ********** TIME HISTORY OF STAGE **********

HEADS IN FEET - NGVD

0 HOUR	JUNCTION 7	JUNCTION 8	JUNCTION 9	JUNCTION 10	JUNCTION 11	JUNCTION 12
.00	.3878	.3972	.4023	.4273	.5354	.6571

1.00	-.4222	-.4265	-.4164	-.3975	-.3553	-.2393
2.00	-1.0434	-1.0491	-1.0383	-1.0350	-1.0661	-.9932
3.00	-.9890	-1.0011	-.9762	-.9973	-1.1803	-1.2736
4.00	-.2039	-.2265	-.2047	-.2787	-.5788	-.8504
5.00	.9524	.9340	.9462	.8853	.6039	.3338
6.00	1.8983	1.9011	1.8859	1.8569	1.7258	1.5666
7.00	2.5722	2.6034	2.5903	2.5933	2.6034	2.5452
8.00	3.0182	3.0640	3.0752	3.1058	3.2016	3.2192
9.00	3.1651	3.2119	3.2348	3.2815	3.4155	3.4901
10.00	2.7805	2.8272	2.8493	2.9189	3.0836	3.2165
11.00	1.9502	1.9882	1.9953	2.0446	2.2260	2.3817
12.00	.9537	.9732	.9767	1.0110	1.1661	1.3305
13.00	.0892	.0889	.1011	.1235	.1794	.3105
14.00	-.6124	-.6236	-.6094	-.6035	-.6325	-.5420
15.00	-.8927	-.9035	-.8888	-.9054	-1.0313	-1.0432
16.00	-.5490	-.5625	-.5446	-.5912	-.8182	-.9866
17.00	.3728	.3516	.3619	.2905	.0121	-.2381
18.00	1.3286	1.3181	1.3148	1.2745	1.1015	.9227
19.00	1.9197	1.9416	1.9279	1.9302	1.9147	1.8604
20.00	2.2974	2.3402	2.3411	2.3675	2.4563	2.4826
21.00	2.6031	2.6408	2.6603	2.6950	2.8058	2.8471
22.00	2.5436	2.5736	2.5932	2.6407	2.7526	2.8296
23.00	2.0719	2.1016	2.1096	2.1520	2.2771	2.3785
24.00	1.2186	1.2420	1.2425	1.2810	1.4348	1.5747
25.00	.2001	.2143	.2167	.2495	.4003	.5774
0AVERAGE VALUE	1.0927	1.1046	1.1135	1.1193	1.1106	1.1096

C28

0 ********** HIGH AND LOW TIDES **********

HEAD	TIME	HEAD	TIME	HEAD	TIME	HEAD	TIME	HEAD	TIME	HEAD	TIME
3.4103	33.47	3.3989	33.48	3.3882	33.52	3.4182	33.55	3.4293	33.82	3.4929	33.93

<ETC. FOR ALL NODE IN SYSTEM ON DAY 2, AND SO ON.....>

APPENDIX D:

FACT SHEET

PASSAIC RIVER FLOOD PROTECTION PROJECT

Fact Sheet

PURPOSE/DESCRIPTION: Congress authorized the Passaic River Flood Protection Project for construction in November 1990. The project is to provide comprehensive and environmentally sound flood protection to 40 towns in the Passaic River Basin.

Flooding has long been a problem in the Passaic River Basin. Since Colonial times floods have claimed lives and damaged property. With the explosive growth of residential and industrial development in recent years, the threat of serious damage and loss of life from flooding has multiplied.

The most severe flood, the "flood of record," occurred in 1903, and more recent floods in 1968, 1971, 1972, two in 1975, and in 1984 were sufficiently devastating to warrant Federal flood declarations. The flood of April 5, 1984, caused such severe flooding in northern New Jersey that three people died and there was $410 million in damages (October 1991 dollars).

The Passaic River Basin, 935 square miles drained by the Passaic River and its tributaries, lies mostly in northern New Jersey. The basin hold s 132 municipalities in ten counties -- Bergen, Essex, Hudson, Morris, Passaic, Sussex, Somerset, and Union in New Jersey, and Orange and Rockland in New York State -- and has some of the most densely developed areas in the nation. More than 2.5 mill ion people live in the basin (1990 census), and a bout 30,000 homes and businesses lie in the basin's flood plain.

The basin extends from Newark in the east to Lake Hopatcong in the west, and from Monroe, N.Y., in the north to Somerset County, N.J., in the south. It is studded with rivers and streams including the Pompton, Pequannock, Wanaque, Ramapo, Mahwah, Saddle, Whippany, and Rockaway rivers -- major tributaries of the Passaic River.

STATUS: The U.S. Army Corps of Engineers has been working on plans to reduce flooding in the basin since 1939, but none of those plans was implemented. Congress then authorized the Corps to conduct a new study of the Passaic River Basin for the State of New Jersey in the Water Resources Development Act of 1976.

The Corps evaluated more than 150 plans, including a full range of non-structural alternatives such as buying out flood-prone homes. It presented an array of plans to the State of New Jersey. After a series of public hearings, the State selected a dual inlet water diversion tunnel system as the center piece of its comprehensive flood protection program for the basin. On May 8, 1987, the State formally announced its intention to act as the Passaic River Flood Protection Project's non-Federal sponsor, and the Corps recommended the project in its February 1988 General Design Memorandum.

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In November 1990, Congress authorized construction of the $1.2 billion Passaic River Flood Protection Project in the Water Resources Development Act of 1990 (Public Law 101-640). The Federal project cost is $890 million (October 1989 dollars); the State project cost is of $310 million.

The act changes the plan originally selected by the State, extending the tunnel to an outlet in Newark Bay and eliminating the need for nine levee-flood-wall systems in eastern Essex and southern Bergen counties. Eastern Essex and southern Bergen counties will now receive fluvial flood protection without having any surface structures along the lower Passaic River. The act also authorizes a $6 million stream-bank restoration project for the City of Newark.

The major elements of the project are two underground tunnels, a 20.1-mile-long main tunnel about 40 feet in diameter and a 1.2-mile spur tunnel about 22 feet in diameter. The main tunnel will carry flood waters from an inlet on the upper Pompton River down to an outlet in Newark Bay. The spur tunnel will convey Central Basin flood waters from an inlet just downstream of Two Bridges in Wayne to an underground connection with the main tunnel.

About 5.9 miles of channel modifications will be required to direct the flows into the tunnel inlets and 17.6 miles of levees and 6.2 miles of flood walls will increase flood protection. The diversion tunnels and associated surface works are generally designed to protect against floods, ranging up to the 100-year event. The project has a benefit-to-cost ratio of 1.1 to 1.

The Water Resources Act also recognizes New Jersey's earlier contribution of lands and project works by crediting these investments toward the State's share of the project's cost. It also establishes a wetlands bank to enable the State of New Jersey to purchase wetlands and watershed lands that can also be credited toward its share of the project's cost.

The Passaic River Flood Protection Project includes the acquisition of 5,350 acres of natural water storage areas, 5,200 acres of which are wetlands. Without the project, these lands could conceivably be developed, worsening existing flood problems. The State of New Jersey has an agreement with the Corps in which it promises to continue to protect 6,300 acres that are annually inundated by the river, thus avoiding any secondary development. About 9,500 acres of the Central Basin are already protected as designated parkland, bringing the total of natural storage areas that will be permanently protected with the project to 21,000 acres.

The Passaic River Flood Protection Project includes preservation measures for fish and wildlife and provision for wetlands mitigation. The project will also expand the opportunities for recreation along the river.

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APPENDIX E:

MODELING PROCEDURES

APPENDIX E:

MODELING PROCEDURES

Coincidence Analysis

E1. Files of daily values of Passaic River flow and maximum surge height at The Battery were used to investigate the coincidence between occurrences of flow and surge magnitudes that exceeded user-specified thresholds. Daily river flow values were from USGS data from the Little Falls, New Jersey gage. Daily maximum surge values were obtained by subtracting hourly predicted tide heights from observed water surface elevations at The Battery and selecting the maximum on each day. With some gaps, the data records extended from 1927 to 1992. The dates of river flow and surge height values corresponded on a line-by-line basis in their respective data files. The total number of record days was 21,174. Cross correlation calculations were first performed in order to determine if an average lead/lag relation existed between river flow and surge height. Other programs were then used to count the joint occurrences of particular combinations of river flow and surge height.

E2. The following procedure was used to examine the coincidence between river flow and surge height:

1. With the data files "SURGE.DLY" and "RIVER.DLY" as input, the program "COIN-BIG" was used to tally coincidences between values of river flow and surge height. The program queries for input and output file names and for threshold values. Threshold values can be specified directly by the user or can be calculated by the program by multiplying the respective data series standard deviations by a user-specified factor. COIN-BIG reads a surge height, and examines river flows on the same day and the three days before and after. The appropriate indexes(s) are incremented if the surge height and river flow on a given day both exceed their thresholds. Thus, seven counts are maintained. The program reads successive daily surge heights and accumulates counts until termination with the third-from-the-last value. Output is an ASCII file of pertinent parameters and counts for each of the seven lead/lag days.
2. A second program,"SURRIV", was used to select particular joint occurrences of surge height and river flow. The program queries for input (usually SURGE.DLY AND RIVER.DLY) and output file names and for threshold values. The program then reads a surge height. If surge height exceeds the specified threshold, the program compares river flows on the same day, the first day after, and the second day after against the specified river flow threshold. If river flow exceeds threshold on more than one of those three days, the program selects the maximum. If none of those three river flow values exceeds the threshold, the program reads the next surge height (next day) and examines the appropriate set of three river flow values. Output is a file of line-by-line surge height and river flow values that jointly exceed thresholds accompanied by their respective dates. On a given line, dates may differ by zero, one, or two days.

Identify New Storms

E3. In this study, nine new synthetic storm tide events were selected to add to the 24 events used in the Hackensack River Surge Barrier study (CDM 1988), for a total of 33 events. Each synthetic storm tide event is the combination of a synthetic storm surge (from 252 hurricanes and 43 northeasters), a tide (from five tidal marigrams), and a lag (from 50 1/2-hour lags). This resulted in 73,750 possible synthetic storm tide combinations to choose from.

E4. The following procedure was used to identify the nine additional events:

1. From the stage-frequency distribution developed for the mouth of Newark Bay (node 44) during the CDM (1983b) study (and reported in CDM 1988), determine what storm tide elevation each new event should have. For this study, we linearly interpolated between pairs of events at each end of the distribution.
2. Using the data files "HH.SUM" and "NE.SUM", which contain maximum storm tide heights at the mouth of Newark Bay (node 44) for the hurricane and northeaster combinations, respectively, run the program "PICKEM.EXE" for each tidal elevation identified and a small tolerance (say, 0.001 feet).
3. The output file produced, "PICKEM.OUT", contains storm tide combinations that produced maximum tidal elevations within the specified tolerance of the selected tidal elevation. From each group of candidate events, we selected <u>one</u> event. Each selection was made to provide an overall mix of hurricanes and northeasters, and to distribute the storm types over the range of storms available. The selected storm tide events are listed in the file "PICKEM1.OUT". The output files list the identification number of the synthetic storm surge, the identification number of the coincident tide, and the lag as the number of half-hour intervals (with "1" being zero lag).

Develop Synthetic Storm Tide Events

E5. Once a synthetic storm tide event had been selected, the next step was to create the storm tide boundary condition marigrams at nodes 1-4 of the link-node model of the interior system (including New York Harbor and Newark Bay). From the CDM (1983a and 1983b) studies of storm tides in the New York City area, boundary condition marigrams for the 252 synthetic hurricane surges and 43 synthetic northeaster surges, developed using the offshore surge model, were saved on 21 magnetic tapes. Table E1 gives the contents of each tape. These tapes reside at the Coastal Engineering Research Center (CERC), Waterways Experiment Station, in Vicksburg, Mississippi.

E6. The following procedure was used to create the boundary condition storm tide marigram file for the interior link-node model, for each storm tide combination identified:

1. A "combination" input file was created, with the "tidal day" (equal to 25.0 hours) and the identified lag (in hours) on the first line, and the times and tidal elevations of the two high tides and two low tides, for each link-node boundary junction 1-4, on lines 2-5. Nodes 1-3 were based on tides at Sandy Hook, and node 4 was based on tides at Bridgeport, Connecticut. Tides that were combined with hurricane and northeaster surges are shown in Tables E2 and E3, respectively.
2. The identified hurricane or northeaster surge file (the results from the offshore model saved at cells corresponding to the

interior model's boundary nodes 1-4), was downloaded to the VAX computer from the appropriate 9-track magnetic tape (see Table E1 for cross-reference).

3a. For hurricane surge tide combinations, the program "COMBINE.EXE" was run on the VAX to produce a binary output file on the VAX. Alternatively, the program "COMB15.EXE" was run on the VAX to produce an ASCII output file, with a time interval of 15 minutes (to reduce data storage), that could be transferred from the VAX to a PC. All hurricane storm tide simulations for this study were performed on a 386 PC.

3b. For northeaster storm tide combinations, the program NE_COMBINE2.EXE" was run to produce a binary output file on the VAX. All northeaster simulations were performed on the VAX.

3c. Each of the combination programs required an input control files (step #1) and an offshore surge results file (step #2). The models each output a binary tidal boundary conditions file (except an ASCII file from "COMB15.EXE"), and a results output file that echoes the steps the program took in performing the combination.

4. ASCII tidal boundary condition files were then transferred to a PC using standard transfer software, such as "KERMIT".

Link-Node Model Simulations

E7. The input files required for a simulation using the link-node model are described in detail in the users manual (Appendix A), and shown in Figure A1. The output files produced are also discussed in Appendix A and shown in Figure A1.

E8. The following procedure was used to perform a simulation using the link-node model:

1. The input (or "control") and "grid" files are prepared as described in the users manual (Appendix A). The tidal boundary conditions file is either prepared as discussed in the above section or specified as a blank (empty) file if tidal boundary data were included in the "Control" (or "Input") file on unit N5. If the tidal boundary conditions file is not empty (i.e., a synthetic hurricane or northeaster storm tide is being simulated), then the file should be a binary file if running on the VAX or an ASCII file if running on a PC.

2a. On the VAX, the link-node model is executed interactively by typing "R DEMNEWARK". The model then requests the names of the input and output files in the order described in step 2c. (A batch file can be set up on the VAX.)

2b. On the PC, the link-node model is executed by typing "DEMNEW". The model then requests the names of the input an output files in the order described in step 2c.

2c. The link-node model will ask for the following input and output file names:

- Control or input file name
- Tabular output file name
- Heads output file name
- Tidal boundary conditions file name
- Link-node grid file name

3. Once the model has executed, the computed heads in the "heads output" file can be plotted using a standard software package, such as "GRAPHER" or "HARVARD GRAPHICS".

Stage-Frequency Curves

E9. Once the 33 synthetic hurricane and northeaster storm tide conditions have been simulated, stage frequency curves at any nodes whose computed heads are output to the "heads output" file can be developed as follows:

1. The names of the 33 "heads output" files are listed in a "file names" input file. The order of the file names corresponds to the order of the probabilities of occurrence in the program "FREQ33.FOR".
2. A second input file is created that contains the number of nodes whose computed heads are contained in the "heads output" files, and the node numbers.
3. The program "FREQ33.EXE" is run using the two input files described in steps #1 and #2. An output file is specified, that contains the cumulative occurrences (stage-frequency) of storm tide elevations at each of the prescribed nodes.
4. The output file created is edited, and individual stage-frequency files created for each node.
5. The program "CUMP2.EXE" is run to rescale the x-axis in terms of probabilities.
6. The final stage-frequency distributions are plotted using a standard software package, such as "GRAPHER" or "HARVARD GRAPHICS".

Table E1
Magnetic Tapes and Their Hurricane/Northeaster Surge Contents

Tape ID	Contents	
A02806	Elevation histories for Northeasters	1- 2
A02807	Elevation histories for Northeaster	3
A05886	Elevation histories for Northeasters	4- 8
A00050	Elevation histories for Northeasters	9- 11
A05894	Elevation histories for Northeasters	12- 15
A05898	Elevation histories for Northeasters	16- 20
A00195	Elevation histories for Northeaster	21
A00201	Elevation histories for Northeaster	22
A00245	Elevation histories for Northeasters	23- 25
A00813	Elevation histories for Northeasters	26- 28
A00814	Elevation histories for Northeasters	29- 32
A00815	Elevation histories for Northeasters	33
A00865	Elevation histories for Northeasters	34, 36*
A00876	Elevation histories for Northeasters	37- 39
A00897	Elevation histories for Northeasters	40- 42
A00950	Elevation histories for Northeaster	43
A02809	Elevation histories for Hurricanes	1- 84
A02810	Elevation histories for Hurricanes	85-168
A02813	Elevation histories for Hurricanes	169-252
A00195	Statistics for Northeasters 1-43 and Hurricanes 1-218	*
A00247	Statistics for Hurricanes	219-252

*Note: The simulation for Northeaster 35 failed. There is no output for this event.

Table E2
Hurricane Astronomic Tides

I.D. No.	Date	Sandy Hook Time H.M.	Sandy Hook Height MLW	Sandy Hook Height NGVD[1]	Bridgeport Time H.M.	Bridgeport Height MLW	Bridgeport Height NGVD[2]
1	Oct 25, 1978	2:13	3.7	1.91	5:47	6.2	3.27
		8:30	1.0	-0.79	12:04	1.2	-1.73
		14:25	4.1	2.31	18:07	6.3	3.37
		21:13	0.6	-1.19	24:29	0.8	-2.13
2	Aug 25, 1978	0:39	4.3	2.51	4:22	6.1	3.17
		6:52	0.5	-1.29	10:34	0.5	-2.43
		13:07	4.7	2.91	16:46	6.7	3.77
		19:45	0.8	-0.99	23:15	0.4	-2.53
3	Sept 11, 1978	1:56	4.2	2.41	5:27	6.3	3.37
		8:23	0.5	-1.29	11:41	0.6	-2.33
		14:37	5.1	3.31	17:55	7.0	4.07
		21:14	0.3	-1.49	24:27	0.2	-2.73
4	Sept 13, 1978	4:20	4.6	2.81	1:30	-0.1	-3.03
		10:33	0.0	-1.79	7:38	6.8	3.87
		16:49	5.5	3.71	13:53	0.0	-2.93
		23:10	-0.4	-2.19	20:04	7.4	4.47
5	July 20, 1978	1:37	-1.0	-2.79	5:42	-1.4	-4.33
		7:37	5.3	3.51	11:51	7.5	4.57
		13:44	-0.7	-2.49	18:03	-0.9	-3.89
		19:59	6.4	4.61	24:12	7.9	4.97

[1] Sandy Hook - Mean low water is 1.79 ft below NGVD
[2] Bridgeport - Mean low water is 2.93 ft below NGVD

Table E3
Northeaster Astronomic Tides

I.D. No.	Date	Sandy Hook Time H.M.	Sandy Hook Height MLW	Sandy Hook Height NGVD[1]	Bridgeport Time H.M.	Bridgeport Height MLW	Bridgeport Height NGVD[2]
1	Jan 17, 1978	2:09	4.1	2.31	5:49	6.4	3.47
		8:43	0.3	-1.49	12:15	0.1	-2.83
		14:31	3.6	1.81	18:19	5.6	2.67
		20:52	0.0	-1.79	24:31	0.2	-2.73
2	Mar 2, 1978	0:59	4.6	2.81	4:17	6.6	3.67
		7:32	0.1	-1.69	10:49	-0.1	-3.03
		13:24	3.9	2.11	16:55	5.9	2.97
		19:48	0.1	-1.69	23:09	0.2	-2.73
3	Feb 4, 1978	4:38	5.0	3.21	1:37	-0.3	-3.23
		11:02	-0.7	-2.49	7:51	7.0	4.07
		17:07	4.2	2.41	14:20	-0.8	-3.73
		23:18	-0.7	-2.49	20:26	6.3	3.37
4	Dec 4, 1978	4:28	-0.5	-2.29	1:42	6.9	3.97
		10:45	5.3	3.51	7:52	-0.3	-3.23
		17:09	-0.8	-2.59	14:03	7.3	4.37
		23:19	4.4	2.61	20:29	-0.8	-3.73
5	Jan 8, 1978	0:29	-1.1	-2.89	3:47	-0.9	-3.83
		6:46	5.8	4.01	10:00	7.8	4.87
		13:12	-1.3	-3.09	16:27	-1.5	-4.43
		19:12	4.8	3.01	22:33	6.9	3.97

[1] Sandy Hook - mean low water is 1.79 ft below NGVD
[2] Bridgeport - mean low water is 2.93 ft below NGVD

Waterways Experiment Station Cataloging-in-Publication Data

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