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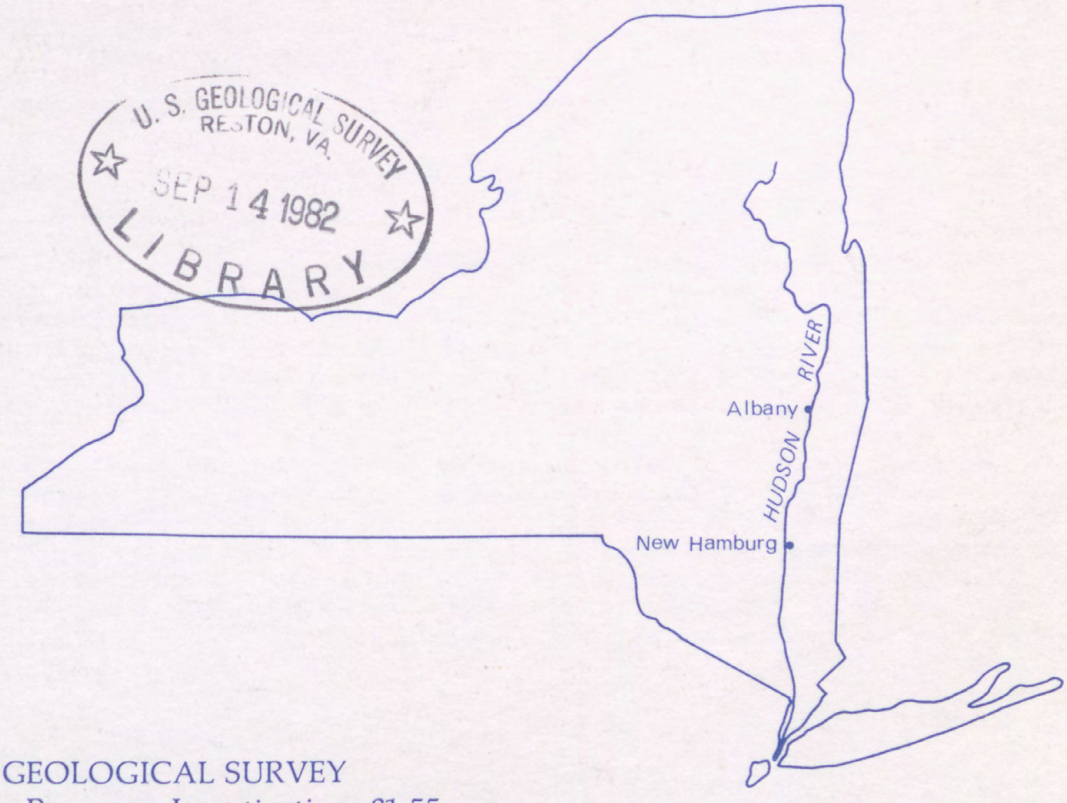
FLOW MODEL OF THE HUDSON RIVER ESTUARY FROM ALBANY TO NEW HAMBURG, NEW YORK



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This report includes all stage (water-level) and discharge data that were used to calibrate and verify the model and compares the model results with measured data. The model accurately simulated observed flows, but further calibration based upon additional flow measurements would improve simulation of the flow magnitude and phasing of the tide reversal under low-flow conditions. The model can be used to calculate instantaneous stage, velocity, and discharge for any location in the reach and can also be used to calculate net volume flux between tide reversals.

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CONVERSION FACTORS AND ABBREVIATIONS

The following factors may be used to convert units used in this report to the International System of Units (SI).

Multiply	By	To obtain SI units
foot (ft)	0.3048	meter (m)
mile (mi)	1.609	kilometer (km)
square foot (ft^2)	0.0929	square meter (m^2)
square mile (mi^2)	2.59	square kilometer (km^2)
cubic foot per second (ft^3/s)	0.02832	cubic meter per second (m^3/s)

FLOW MODEL OF THE HUDSON RIVER ESTUARY FROM ALBANY TO NEW HAMBURG, NEW YORK

By

David A. Stedfast

ABSTRACT

A one-dimensional transient-flow-simulation model was developed to represent a 76-mile reach of the tidal Hudson River between Albany and New Hamburg. In this reach, the direction of flow reverses four times daily as a result of tidal influence; this produces complex current patterns and retards the rate at which the river can flush out pollutants. In the model, the reach studied is treated as two subreaches to incorporate differences in channel conditions and to simplify model calibration.

This report includes all stage (water-level) and discharge data that were used to calibrate and verify the model and compares the model results with measured data. The model accurately simulated observed flows, but further calibration based upon additional flow measurements would improve simulation of the flow magnitude and phasing of the tide reversal under low-flow conditions. The model can be used to calculate instantaneous stage, velocity, and discharge for any location in the reach and can also be used to calculate net volume flux between tide reversals.

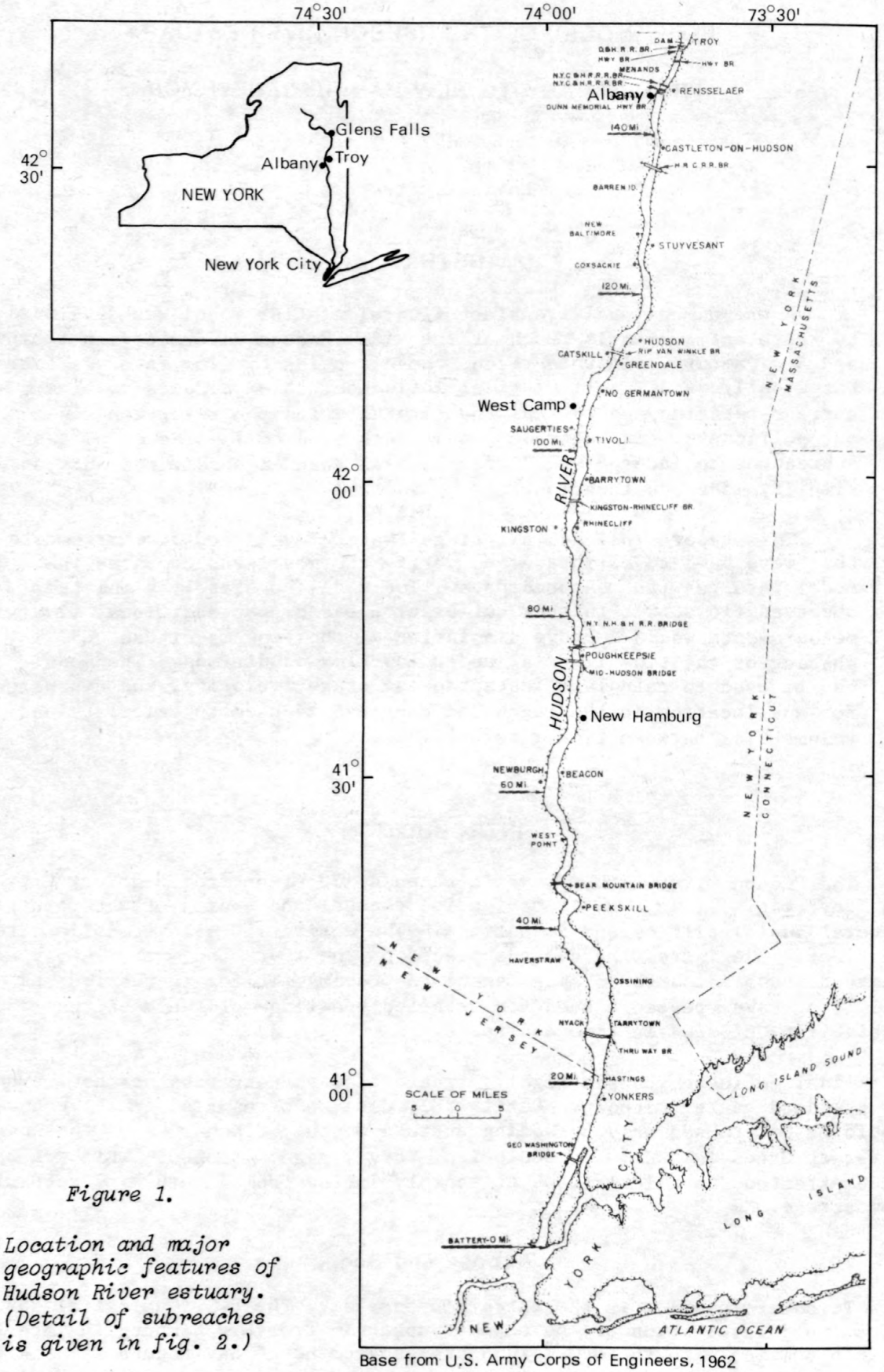
INTRODUCTION

The Hudson River estuary, which extends 150 miles from New York City north to Troy (fig. 1), is a major navigation channel and source of water supply for several municipalities and industries. The entire 150-mile reach is affected by tides. The increasing demands placed on the river for water supply and waste disposal, countered by a demand to preserve it for recreation and wildlife, have created a need for detailed knowledge of the magnitude and variability of flow in time and space.

Tidal influence causes highly erratic flow patterns that cannot be defined by standard gaging methods. Until 1981, data on streamflow in the estuary could be determined only by adding average monthly discharges of the Hudson River at Green Island (U.S. Geological Survey gage 01358000), which is not tide affected, to calculations of monthly inflow from intervening subbasins downstream.

Purpose and Scope

To determine flow in the estuary accurately, the U.S. Geological Survey began an investigation of the segment upstream from New Hamburg in late 1977, in cooperation with the New York State Department of Environmental Conservation and the New York City Department of Environmental Protection.



Base from U.S. Army Corps of Engineers, 1962

Figure 1.

Location and major geographic features of Hudson River estuary. (Detail of subreaches is given in fig. 2.)

The objective of the investigation was to implement, calibrate, and verify a computerized model that could provide the discharge, stage, and direction of flow at any specified time and cross section between Albany and New Hamburg. (New Hamburg is the approximate northern limit of the saltwater front.) This report describes the flow model and the two subreaches represented as well as the flow and stage data used for model calibration and verification.

Description of Estuary

The Hudson River flows south and east from its headwaters in the Adirondack Mountains to Glens Falls, where it begins its 180-mile southward course to the Battery in New York City (fig. 1). The Federal Dam at Troy, 30 miles south of Glens Falls and 7 miles north of Albany, marks the northern limit of the estuary. Major geographical features of the Hudson River basin and the reach studied are depicted in figure 1; the part studied is the 76-mile reach between Albany and New Hamburg.

The drainage basin of the Hudson River lies almost completely within the State of New York and encompasses a total area of 13,180 mi^2 at the Battery in New York City. At the Federal Dam in Troy, the total drainage area is 8,090 mi^2. The reach from Albany to New Hamburg (fig. 2) contributes 3,655 mi^2 of drainage area, of which approximately 45 percent is gaged. Major tributaries to the estuary in this reach include the Normanskill (gaged), Stockport Creek, Catskill Creek, Roeliff-Jansen Kill, Esopus Creek (gaged), and Roundout Creek (gaged).

The river channel varies considerably in width and cross-sectional area. At Troy the channel is 600 feet wide and has a typical cross-sectional area of 10,000 ft^2; both increase southward to the city of Hudson, where the channel is 3,000 ft wide and 64,000 ft^2 in cross section. A short distance downstream from Hudson, the channel narrows to 2,000 ft at Catskill and then widens rapidly to 6,000 ft. Just north of Kingston, the channel is still 6,000 ft wide, but the cross-sectional area exceeds 100,000 ft^2. In a 4-mile reach from Kingston to Hyde Park, the river narrows, expands, and then narrows again. From Hyde Park to Poughkeepsie, channel width and cross section remain approximately 2,000 ft wide and 125,000 ft^2 in area. At Newburgh, just south of Poughkeepsie, the channel expands to 8,000 ft wide and 170,000 ft^2 in cross-sectional area and continues to vary to its mouth at New York City.

Tidal influence in the estuary can be observed by the large variations in stage and discharge at a particular location over a complete tidal cycle. Mean range in stage at New York City is 4.5 ft, whereas upstream at Troy, just south of the Federal Dam, mean range is 4.7 ft. The smallest mean range among sites listed herein is 2.7 ft at West Point (National Oceanic and Atmospheric Administration and National Ocean Survey, 1980). These variations in mean-stage range are due to the effects of channel constrictions and expansions on the tide wave as it moves upstream.

Direction of flow in the estuary reverses four times daily as far north as Albany, except during high flows in spring, which overshadow the tidal influence. Maximum upstream (-) or downstream (+) flows during a tidal cycle

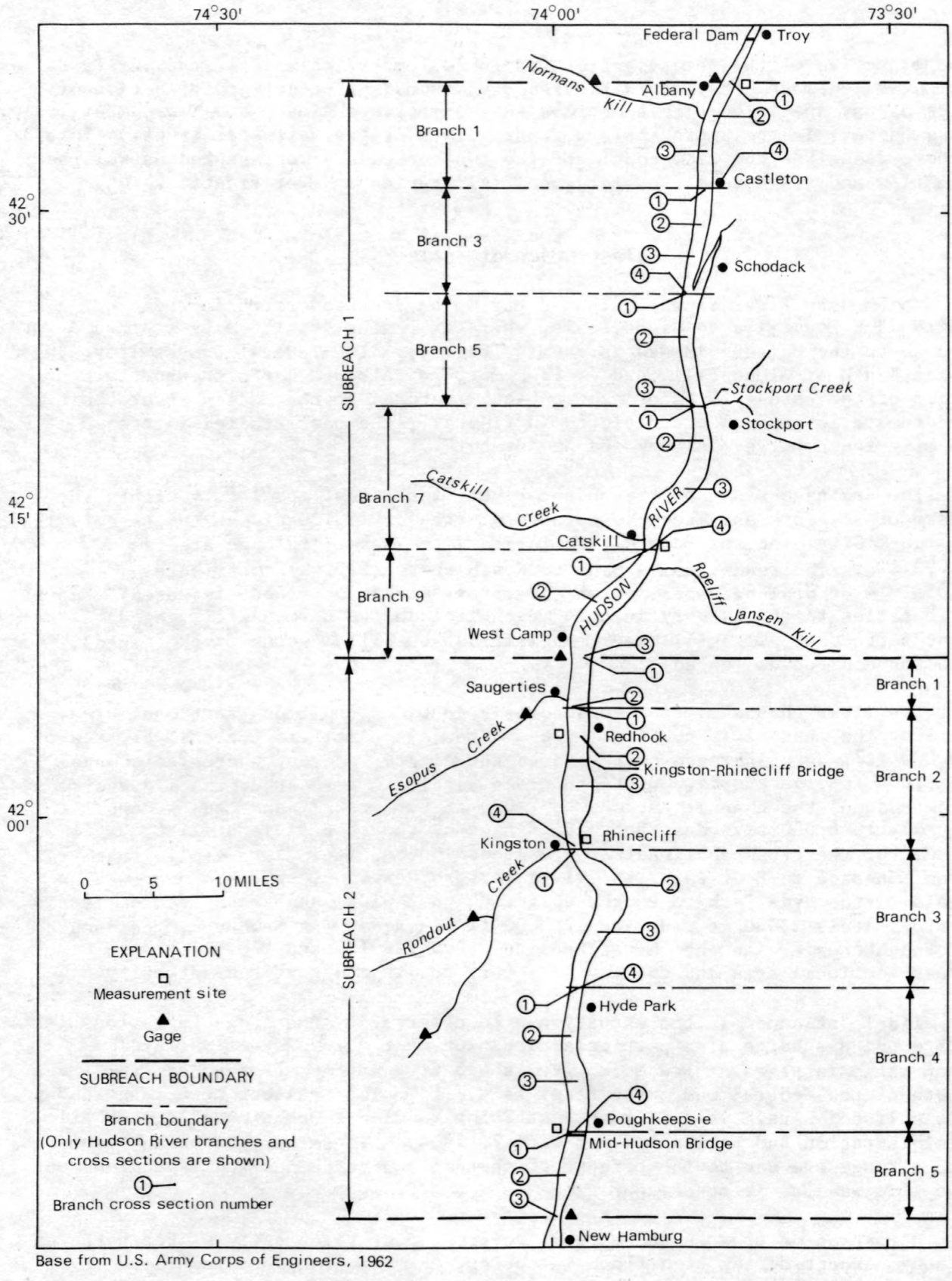


Figure 2.--Major geographical features of modeled reach of Hudson River, Albany to New Hamburg, N.Y.

typically range from ± 20,000 ft^3/s at Albany to ± 250,000 ft^3/s downstream at Poughkeepsie. Mean discharge at Green Island (not tide affected), based on 33 years of record (1946-79), is 13,900 ft^3/s. The largest flow on record at Green Island was 215,000 ft^3/s on March 19, 1936; the smallest was 882 ft^3/s on September 2, 1936 (U.S. Geological Survey, 1980). The geographical position of the salt front, defined as the northernmost location of 50 mg/L chloride concentration, is usually in the vicinity of Peekskill but ranges over several miles during a tidal cycle (Giese and Barr, 1967). During a period of extremely low flow in the mid-1960's, the salt front moved upriver as far as Poughkeepsie.

Acknowledgments

This study was done in cooperation with the New York State Department of Environmental Conservation and the New York City Department of Environmental Protection. The U.S. Army Corps of Engineers in Albany provided stage data for all discharge measurements made at Albany during the 1960's and permitted the Geological Survey to operate their Albany stage gage during the study. Roy Jacobsen in West Camp, and Lonestar Industries at New Hamburg, allowed the Survey to install and operate stage gages on their property. The Ulster County Park in Kingston, and the Red Hook Boat Club in Red Hook, gave permission to set targets on their property for the 1979 moving-boat measurement at Red Hook. Ray Schaffranek and Robert Baltzer of the U.S. Geological Survey assisted as modeling consultants.

Previous Studies

Reports by Giese and Barr (1967) and Busby and Darmer (1970) gave information that was used in planning and calibrating the models. A report by Stedfast (1980) provided the data on channel geometry for construction of the models. An annotated bibliography on the estuary by Embree and Wiltshire (1978) describes reports on the Hudson River estuary that were published during 1965-78.

FLOW-SIMULATION MODEL

The digital computer program developed by Schaffranek, Baltzer, and Goldberg (1981) and used in this study is a one-dimensional, implicit, finite-difference flow-simulation model that can be applied to single- or multiple-channel river systems for computing transient flow conditions. The program is capable of automatically incorporating boundary values from a data file and also explicitly accounts for the drag effect of wind on flow.

The model requires boundary-value data (stage or discharge at each end of the reach) as well as data on channel characteristics. The channel characteristics are defined for each "branch," or reach having relatively uniform channel properties; the river system is then represented by a series of branches, the number depending on the complexity of the channel. Each branch is defined by two to four cross sections in terms of area and width for given water-surface elevations, distance from adjacent cross section(s), and flow resistance (roughness coefficient) of the streambed between cross sections.

After the river system has been represented in this manner, appropriate series of boundary values (stage or discharge) at the upstream and downstream ends of the reach are applied.

Several programming features of the model were advantageous in this study. Boundary-value data (stage or discharge at upstream and downstream ends of the reach) can be either specified on punched computer cards, obtained from a special disk file, or determined by equation; in fact, all three techniques were used in the model-implementation process. Also, the maximum number of iterations, length of the time step, channel geometry, and finite-difference approximation can be adjusted to obtain a balance between precision and cost of model operation. Finally, the wind-drag factor described earlier and explicitly accounted for by the model proved to have a significant effect and will likely be important in future flow-modeling efforts on the Hudson River.

Computed results from this model were designed to accomodate a variety of uses. The type and format of results depends on the specific need and on certain economic considerations. The most comprehensive format is a printout for each iteration and (or) computational time step listing the stage, velocity, discharge, area, and width at each cross section, and the fall (change in water-surface elevation) between cross sections. This type of output is both voluminous and costly in machine requirements and is therefore used primarily for model calibration and verification or for a detailed investigation. An alternative that gives basic hydraulic data at minimal cost is a summary of the daily maximum, minimum, and mean flows at each cross section. A third possibility is a printout of the monthly accumulated flow volumes wherein the net daily total flow, as well as the accumulated volume of both the flood and ebb flows of the tidal cycle and the times of reversals, are tabulated for each day of the month. The model program also permits two types of plotting. One is a plot of computed and observed stage or discharge hydrographs that are useful in calibration and verification; the other is a stage or discharge hydrograph for each cross section that can indicate how the hydraulic and geometric characteristics of the channel affect the stage and discharge from one end of a reach to the other.

A more detailed description of the computer simulation model and the available input and output options are given in Schaffranek, Baltzer, and Goldberg (1981). As with all computer simulation models, parts of the program may be rewritten or subroutines added as needed.

COLLECTION OF DATA

Channel Characteristics

Channel roughness coefficient (flow resistance), reach length, and cross-sectional properties are the factors needed to describe the channel geometry in the model. The cross-sectional data, obtained from Stedfast (1980), were location, dimensions, and elevation of 125 cross sections of the estuary from Troy to the New York City limits. Perspective plots of cross sections from that report were used to determine which locations in the reach studied were

most representative and which contained major changes in channel configuration. A computer program by Schaffranek (1978) was then used to calculate the channel properties (stage, width, and area) for each cross section. Side channel and tributary storage areas at certain tributary junction sites were planimetered from 7-1/2 minute topographic maps and were added to the model. Finally, roughness coefficients were initially estimated from field reconnaissance and subsequently modified during the calibration.

Boundary Data

Stage data have been collected by the U.S. Geological Survey at three sites on the Hudson River since 1978. At the northern site, the foot of Maiden Lane in Albany at river mile 146.0, stage data are recorded at 15-minute intervals by an automatic digital recorder (ADR) situated on a stilling well and activated by a precision crystal timer. At the middle and southern sites, (Eves Point in West Camp at river mile 105.4 and Clinton Point in New Hamburg at river mile 70.3), stage is recorded at 15-minute intervals by bubble (gas-pressure, servo-manometer) gages that are equipped with a precision crystal timer, an ADR, and a strip-chart recorder. The graphic recorder is used to verify that the servo-manometer is working properly. All stage data used in model calibration and verification were stored for later extraction by the model in a special file designed for time-dependent data for flow-simulation models (Baltzer and Schaffranek, 1977). The datum for all three gages was established from U.S. Coast and Geodetic Survey and U.S. Geological Survey benchmarks as 10 feet below the National Geodetic Vertical Datum (NGVD) of 1929.

During the mid-1960's, discharge and stage measurements were made on four occasions. Stage data recorded at Albany were provided in the form of graphic recorder charts by the U.S. Army Corps of Engineers; stage data from Clinton Point were obtained from a Geological Survey gaging station. Some of these data were used as boundary-value data in the model. No data were collected at West Camp during the 1960's. The timers that operated the stage recorders during this period were neither synchronized nor as accurate as the present timers and could be a source of model error in computing flows of the 1960's.

The 76-mile reach from Albany to New Hamburg encompasses several tributaries whose inflow is significant and must therefore be included in the model. Approximately 45 percent of the drainage area between Albany and New Hamburg is gaged; about 10 percent of the drainage area of the 41-mile reach from Albany to West Camp is gaged, and 88 percent of drainage area of the 35-mile reach between West Camp and New Hamburg is gaged. Flows from the ungaged areas were estimated from drainage-area ratios (discharge per square mile) as determined from nearby gaging stations on unregulated streams.

Calibration Measurements

To calibrate and verify any flow model, a series of field measurements is needed for comparison with computed values. On August 21, 1979, continuous discharge measurements were made simultaneously at Albany, Red Hook, and Poughkeepsie for 13 hours (fig. 1). The measurements at Albany were made from

the Colonie Street railroad bridge by eight crews with current meters suspended from cranes to collect velocity readings at 0.2 and 0.8 of total depth below surface and depth soundings at 18 sections; velocity measurements at 0.1 depth intervals were taken at each section every 2 hours. At Red Hook, discharge was measured by the moving-boat method (Smoot and Novak, 1969). Simultaneously, velocity measurements at 0.1 depth intervals were made from another boat to determine the correct vertical-velocity coefficient. At Poughkeepsie, discharge was obtained from a correlation between the mean velocity at a specific station in the cross section and the mean velocity of the entire cross section. This correlation was developed from four tidal cycle discharge measurements in the mid-1960's at this same site. The coefficient of determination for this correlation was 0.98. Other discharge measurements were made at Albany on March 26, 1980 and at Catskill on April 18, 1980, both by the moving-boat method.

Five discharge measurements from the mid-1960's were used to verify the model. Four were made from the Mid-Hudson Bridge at Poughkeepsie and one by the moving-boat method at Rhinecliff. The four at Poughkeepsie (August 11, 1965, May 24-25, 1966, August 30, 1966, and June 21-22, 1967) were made by suspending several current meters 5 ft below water surface and collecting velocity data over one or more tidal cycles. Velocity measurements at 0.1 depth intervals were also taken so that the fixed-depth measured velocities could be converted to mean velocities. Cross-sectional areas were determined from soundings and stage data recorded at 15-minute intervals. The moving-boat discharge measurement at Rhinecliff (June 21-22, 1967) used the vertical-velocity coefficient measured at Poughkeepsie to convert the measured velocities to mean velocities.

All stage and discharge data collected during this study are listed in table 1 (at end of report). The field notes, original fathometer computations, graphs, notes on measurements, and other pertinent data are on file at the U.S. Geological Survey office in Albany, N.Y.

DISCUSSION OF RESULTS

The original reach from Albany to New Hamburg was divided into two subreaches to simplify model calibration.

Subreach 1--Albany to West Camp

The northern subreach, Albany to West Camp, contains several tributary and side-channel storage areas such as Schodack Creek (fig. 2). Channel characteristics of this subreach vary significantly from north to south, and only 8 percent of the contributing drainage area is gaged.

Calibration and Verification

Only three discharge measurements were available to calibrate and verify the model representing this subreach. The Albany measurement of August 21, 1979, was made during low flow and that of March 26, 1980, at high flow; the

third, at Catskill, was made during high flow on April 18, 1980. The Albany measurements were used to calibrate the model; the Catskill measurement was used to verify the model.

Calibration was done by adjusting the channel characteristics, storage, and roughness coefficient (η) values until the model results closely matched the observed data. During calibration it was found that the side-channel storage areas had a major effect on the accuracy of the results. The final model schematization and coefficient values for subreach 1 are given in table 2; a comparison of computed and observed flows for this subreach is shown in figure 3 (at end of report).

Because the West Camp gage was inoperable during the discharge measurement of March 26, 1980, these flows were simulated from the model of the entire reach, Albany to New Hamburg.

Accuracy of Results

The simulated maximum upstream and downstream flows for August 21, 1979, at Albany were within 5 percent of the observed values; the simulated net flow over a full tidal cycle for the same date was within 25 percent of the volume computed from the observed data. Simulated values for a period of low inflow at Green Island (August 21, 1979) differed considerably from the observed values near flow reversal and were 15 minutes out of phase. The simulated flows of March 26, 1980, and April 18, 1980, which represented high inflow at Green Island, were in phase and did not differ significantly from the observed values. All simulated flows of March 26, 1980, at Albany were within 13 percent of the observed values, and the net flow was within 2 percent of the volume computed from the observed data. Simulated maximum upstream and downstream flows of April 18, 1980, at Catskill were within 3 percent of the observed values, and the simulated net flow over a tidal cycle was within 4 percent of the volume computed from the observed data.

Model response to errant estimated initial conditions was tested to determine how long the model should be run to diminish the errors and provide accurate results. When the initial values were in error by as much as 100 percent, the model required up to 8 real-time hours to "warm up," or converge the values to within 5 percent of the long-term modeled values (11 hours were needed to converge to within 2 percent). These warmup times are conservative; if the model is started near the peak flow of the discharge hydrograph, significantly less warmup time is required. Therefore, when initial conditions are not accurately known, the model should run for 12 real-time hours to insure the accuracy of the computed results.

Past studies have indicated that strong north or south winds have a significant effect on the river stage (Busby and Darmer, 1970); such winds also affect the rate of surface flow by shear stress. Although the model described herein was not calibrated to account for this effect because no data were available, an evaluation of a hypothetical wind indicated that a sustained 10-mi/h north wind during a low-flow period could increase peak southward flow at Albany by as much as 25 percent and decrease the northward flow by 25 percent. Also, both the tidal phase and amplitude were significantly affected.

These indications suggest that wind could be a significant factor in flow simulation, but several additional flow measurements under wind and windless conditions would be needed to verify and improve the model calibration to accurately account for the effects of wind. Also, water temperatures change considerably from season to season, and the corresponding changes in viscosity could be a significant influence on flow.

Subreach 2--West Camp to New Hamburg

The model for subreach 2, West Camp to New Hamburg, differs significantly from subreach 1 in that the channel characteristics do not vary within subreach 2 significantly, and 88 percent of the contributing drainage area is gaged. Both factors made model calibration and verification of this subreach more successful.

Calibration and Verification

Four discharge measurements were available for model calibration and verification. Those used for calibration were made at Red Hook and Poughkeepsie on August 21, 1979; those used for verification were made at Rhinecliff and Poughkeepsie on June 21, 1967.

The West Camp to New Hamburg model was calibrated by making adjustments to the schematization of the channel characteristics (table 3) and by varying the roughness coefficient until the model results closely matched the observed data. A comparison of modeled and observed flows is given in figure 4. During calibration of this model, it was found that the tributaries and other side-channel storage areas along this subreach did not affect flow to the extent observed in subreach 1 and were therefore not represented in the final model. The final model schematization for subreach 2 is given in table 3.

After the model was satisfactorily calibrated from the 1979 data, it was verified by comparing simulated values of flow to the 1967 measured values. Because no boundary-value (stage) data were available for West Camp in 1967, stage data recorded at Rhinecliff were used. The model was verified by comparing simulated flows of June 21, 1967, at Rhinecliff and Poughkeepsie with observed values (figs. 5, 6).

Accuracy of Results

Maximum flows upstream and downstream at both Rhinecliff and Poughkeepsie were within 6 percent of the observed values, and mean simulated flood (northward) and ebb (southward) flows were within 9 percent of the mean of the observed values. However, the simulated net flows over a tidal cycle at these sites were in error by as much as 100 percent as a result of the small magnitude of net flow in relation to the large accumulative flood and ebb flows at these sites. Nevertheless, the values were within the limits of field-measurement accuracy. Maximum difference between computed and measured stages at Poughkeepsie was 0.09 foot; the difference between means was 0.03 foot.

Sensitivity of the West Camp to New Hamburg model (subreach 2) to estimated initial values and wind effects was also tested. The model-warmup time,

as described previously for 2-percent error in the initial conditions, was shown to be the same as for subreach 1. Therefore, the model for subreach 2 should also be run 12 hours before computation of flows if the initial conditions are not accurately known. The simulated effect of wind shear on model flows in subreach 2 was not as severe as in subreach 1; a simulated 10-mi/h north wind increased peak southward flow by 10 percent and decreased northward flow by the same amount, in contrast to the 25-percent increase and decrease in subreach 1. However, this further verifies that wind can be a significant factor on the flow regimen.

Suggestions for future model improvement are the same as for subreach 1. Additional discharge measurements during windless conditions are needed for better verification. After the model has been further verified, discharge measurements during windy periods are needed to evaluate wind effects. Also, water temperature should be measured concurrent with discharge to assess the influence of increased viscosity at low temperatures on the roughness coefficient.

Total Reach, Albany to New Hamburg

After the models for subreaches 1 and 2 were calibrated and verified, the channel schematizations for both were combined to form a model of the entire reach. Nine discharge measurements were available to verify this model--five from Poughkeepsie, two from Albany, and one each from Red Hook and Rhinecliff. A comparison of computed and observed values is given in figure 7 for all but the Albany measurement of March 26, 1980, which is shown in figure 3. Simulated stage values were verified for West Camp, Rhinecliff, Hyde Park, and Poughkeepsie; a comparison of observed and computed values is given in figure 8.

All simulated flows except the 1980 high flow at Albany were approximately 15 minutes out of phase. The model simulation of the 1979 and 1980 measurements at Albany produced maximum upstream and downstream flows within 6 percent of the observed flow and produced net flows over a tidal cycle within 2 percent of the volume computed from the observed data. Simulated maximum upstream and downstream flows at Red Hook, Rhinecliff, and Poughkeepsie were within 10 percent of the observed flows for all but the May 24, 1966, measurements. The simulated hydrographs of the 1967, 1966, and 1965 measurements at Rhinecliff and Poughkeepsie are shifted slightly above the observed values, even though they have the same amplitude. This could possibly be due to wind shear or to error in the Albany recorded stage data or gage datum.

The September 1978 flow at Poughkeepsie was simulated so that a comparison could be made between long-term computed outflow and the computed freshwater inflow from Green Island and intervening subbasin stations. The computed mean discharge at Poughkeepsie for the month was 7,510 ft^3/s, which is within 10 percent of the calculated freshwater inflow of 6,900 ft^3/s for the same site.

The largest mean difference between computed and measured stages was 0.09 foot at West Camp; the largest difference between computed and measured stage (0.22 foot), also at West Camp, is to be expected because West Camp is at the

midpoint of the modeled reach. The Albany to New Hamburg model could be improved by adjustment to reflect additional discharge measurements obtained to improve calibration of the two subreach models. Simulated discharges along the entire reach are given in figure 9.

When this model's sensitivity to both wind and initial conditions was tested, the required warmup time was the same as for subreaches 1 and 2, and the model's sensitivity to wind, as expected, was significant.

SUMMARY AND CONCLUSIONS

A transient-flow model was developed to simulate the rate and direction of flow in the Hudson River estuary at any location between Albany and New Hamburg. The reach was divided into two subreaches near the midpoint at West Camp to simplify the model calibration. A separate model was developed for each subreach as well as the entire reach. The model is a one-dimensional, implicit, finite-difference, network flow simulation model developed by Schaffranek, Baltzer, and Goldberg (1981).

Channel geometry, stage boundary, and calibration data were used in the development of the models. Cross-sectional properties that were used to represent the river's hydraulic characteristics were obtained from an earlier study by Stedfast (1980). Stage data for the upstream and downstream boundaries were collected at three continuous stage recorders in Albany, West Camp, and New Hamburg. The stage and discharge values used for calibrating and verifying the models were measured on several dates during 1978-80 and 1965-67 at various locations within the total reach.

All models accurately simulated the flood (northward) and ebb (southward) peak flows over a tidal cycle. Instantaneous flows were accurately simulated by the West Camp to New Hamburg model. Simulated flows were out of phase with the observed tidal cycle in both the Albany to West Camp and the Albany to New Hamburg models during low-flow periods. Also, in the Albany to West Camp model, instantaneous flows at Albany differed noticeably from the measured values at certain times during the tidal cycle. The Albany to New Hamburg model provided accurate net outflow values for the northern part of the reach, but less accurate values for the southern part, when outflow was only a small fraction of the mean northward and southward flows. However, the error in the simulated net flow of this reach was within the limit of accuracy of the field measurements. An analysis of these models for sensitivity to wind suggests that a north or south wind as low as 10 mi/h may retard or increase flow significantly.

Results of this study indicate that flows between Albany and New Hamburg can be accurately simulated by the three models. However, refined calibration based on additional measurements would improve accuracy of simulated flows in both magnitude and timing of the tide reversal. The models can be used to calculate instantaneous stage, velocity, and (or) discharge at any location within the reach, and net inflow or outflow volume over a tidal cycle may be determined within the limits of field-measurement accuracy.

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HYDROGRAPHS

Figures 3-9

3. Discharge hydrographs (calibration and verification), 1979-80, subreach 1

4. Discharge hydrographs (calibration), 1979, subreach 2

5. Discharge hydrographs (verification), 1967, subreach 2

6. Stage hydrographs (verification), 1967, Poughkeepsie

7. Discharge hydrographs (verification), 1965-79, entire reach

8. Stage hydrographs (verification), 1965-79, entire reach

9. Discharge hydrographs, 1979, entire reach

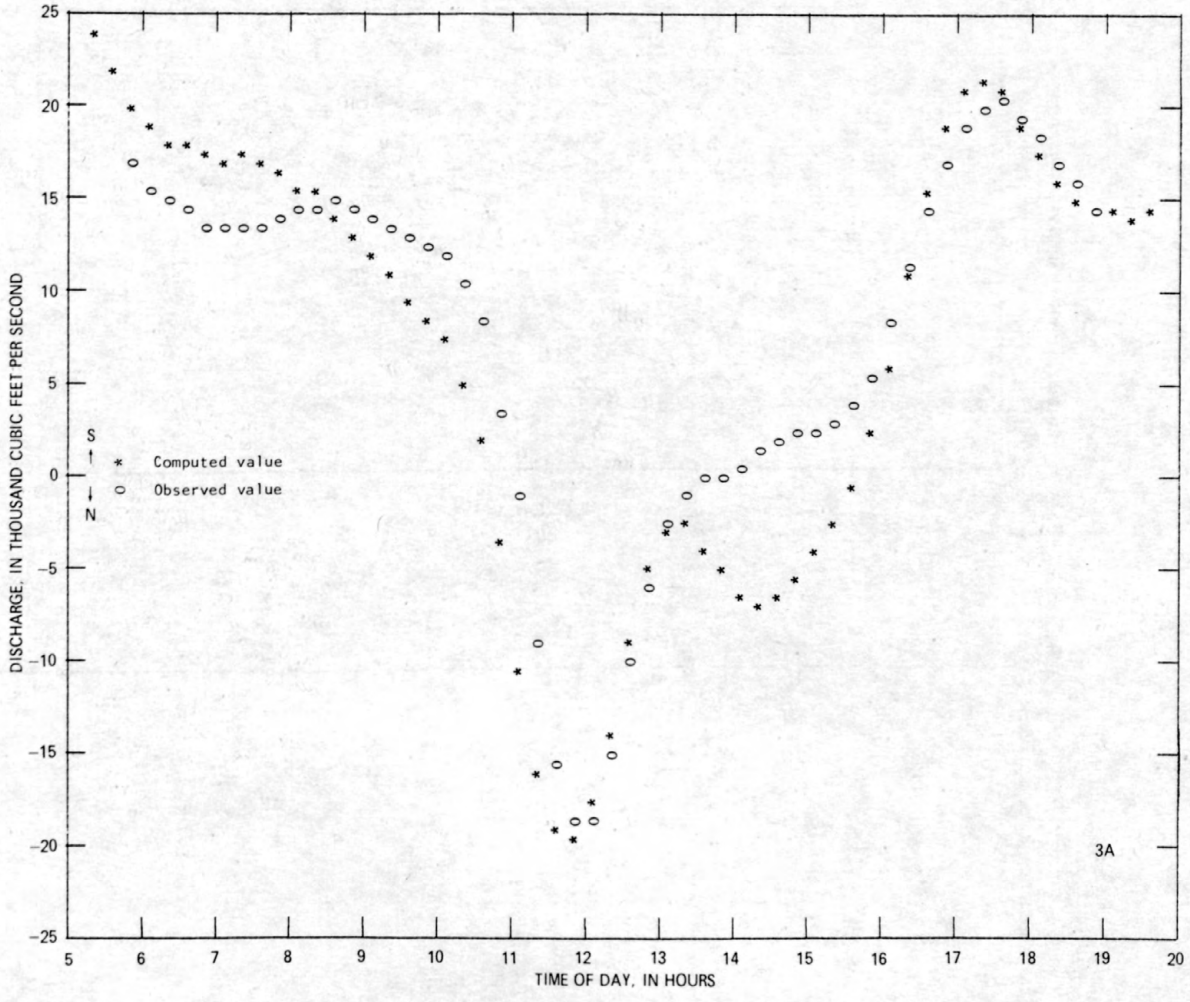
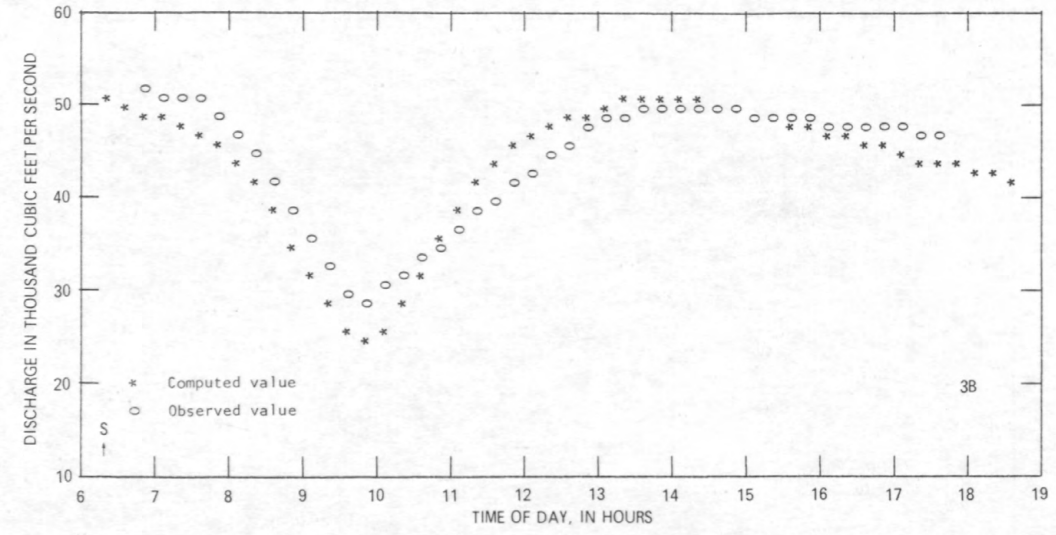


Figure 3A.--Comparison of observed and computed discharges at Colonie St. Bridge, Albany, August 21, 1979.



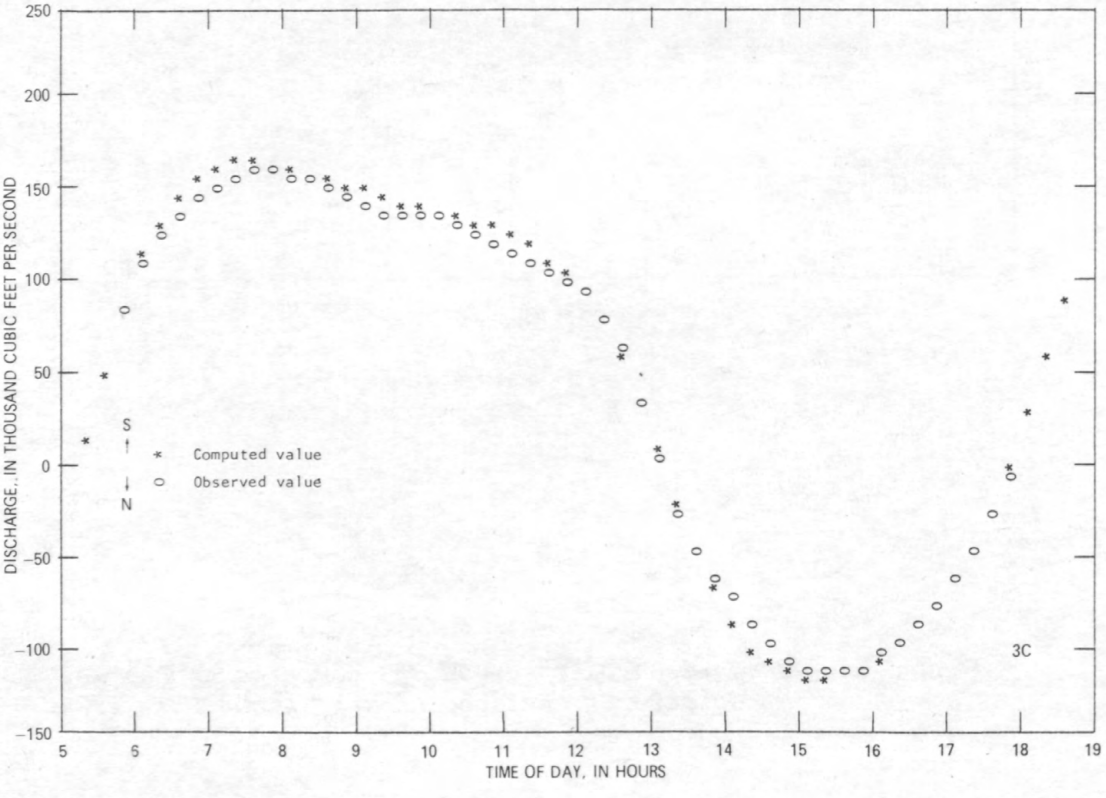
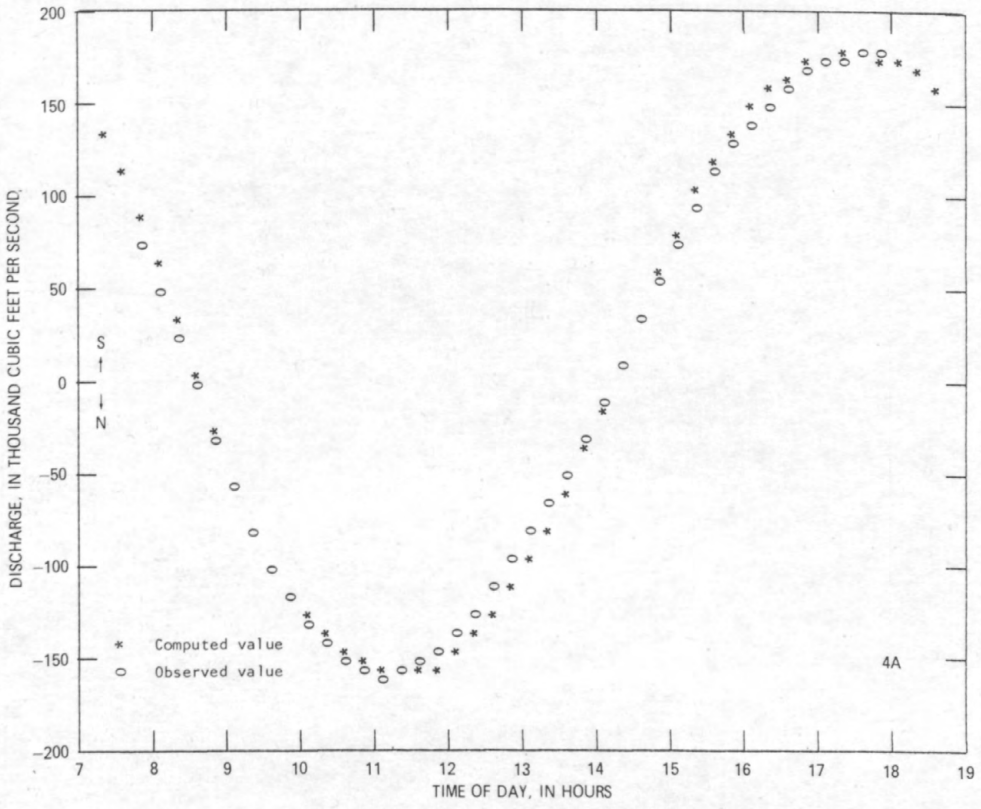


Figure 3B, 3C.--Comparison of observed and computed discharges: B, at foot of Maiden Lane, Albany, March 26, 1980; C, at a point 2.5 miles south of Rip Van Winkle Bridge, Catskill, April 18, 1980.



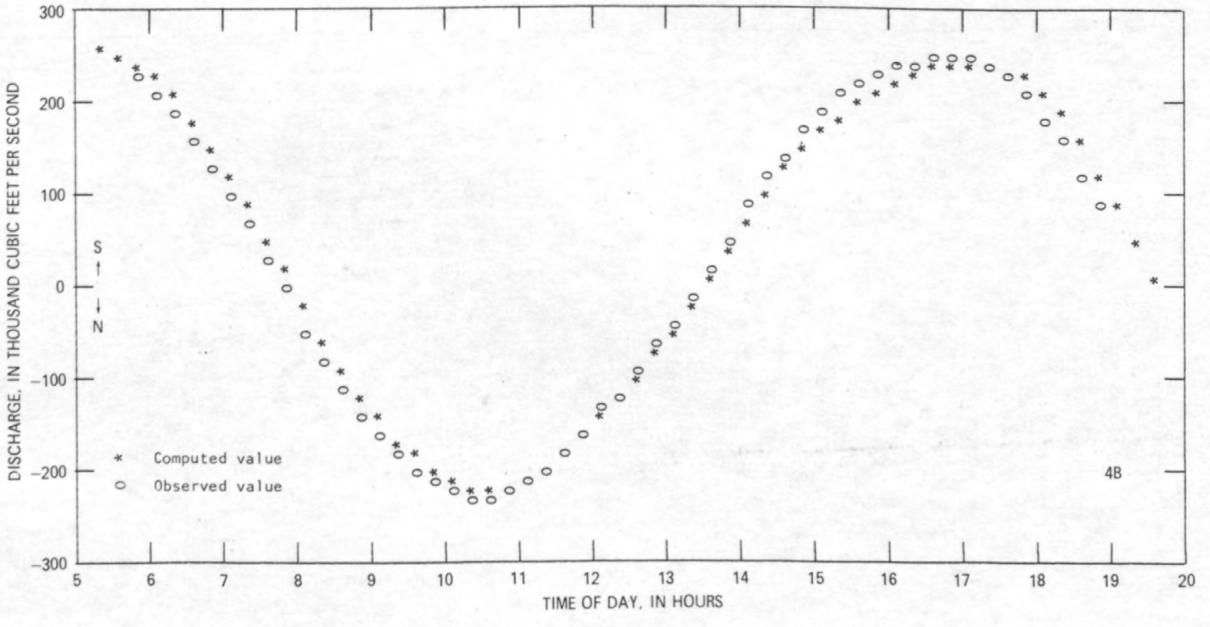
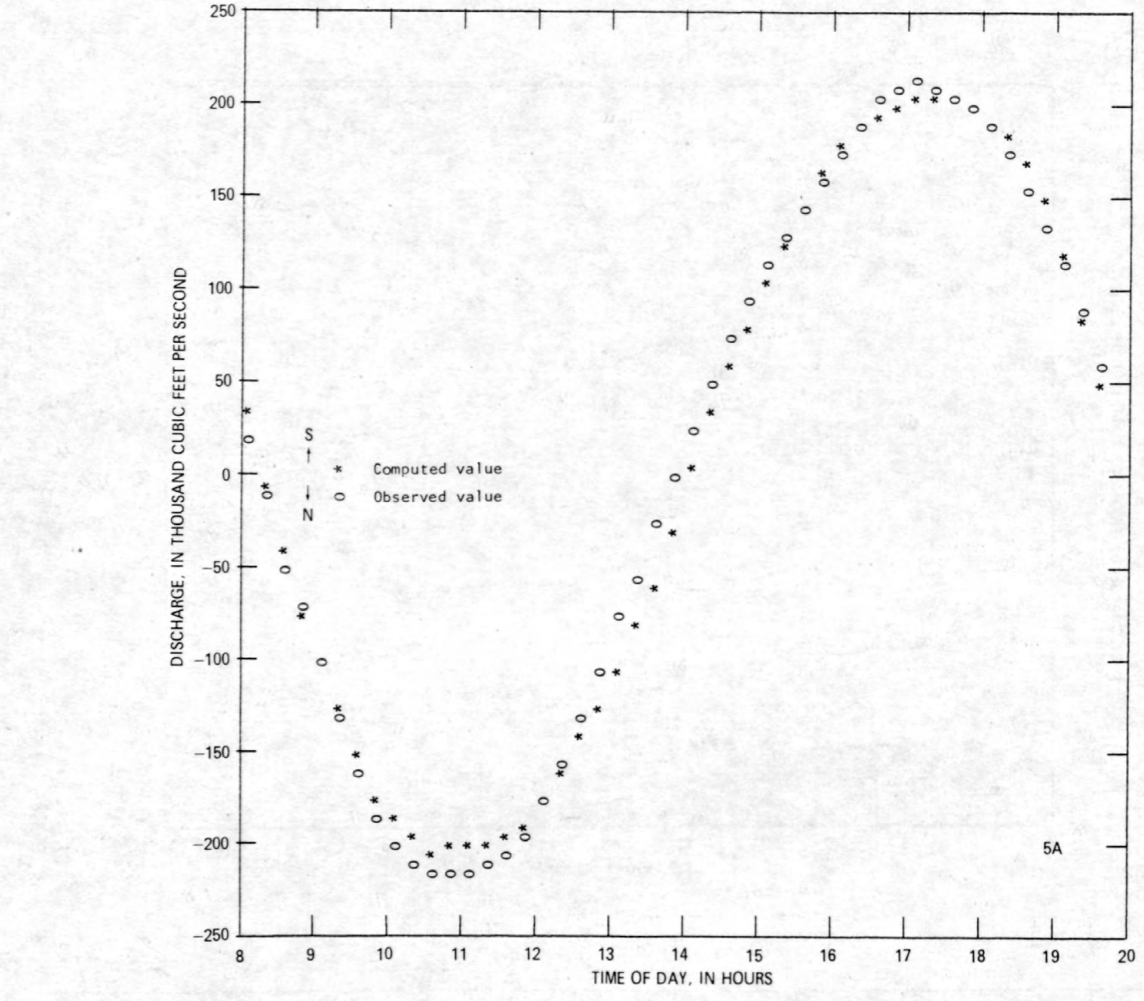


Figure 4A, 4B.--Comparison of observed discharges: A, 1.5 miles north of Kingston-Rhinecliff Bridge, August 21, 1979; B, at Mid-Hudson Bridge, Poughkeepsie, August 21, 1979.



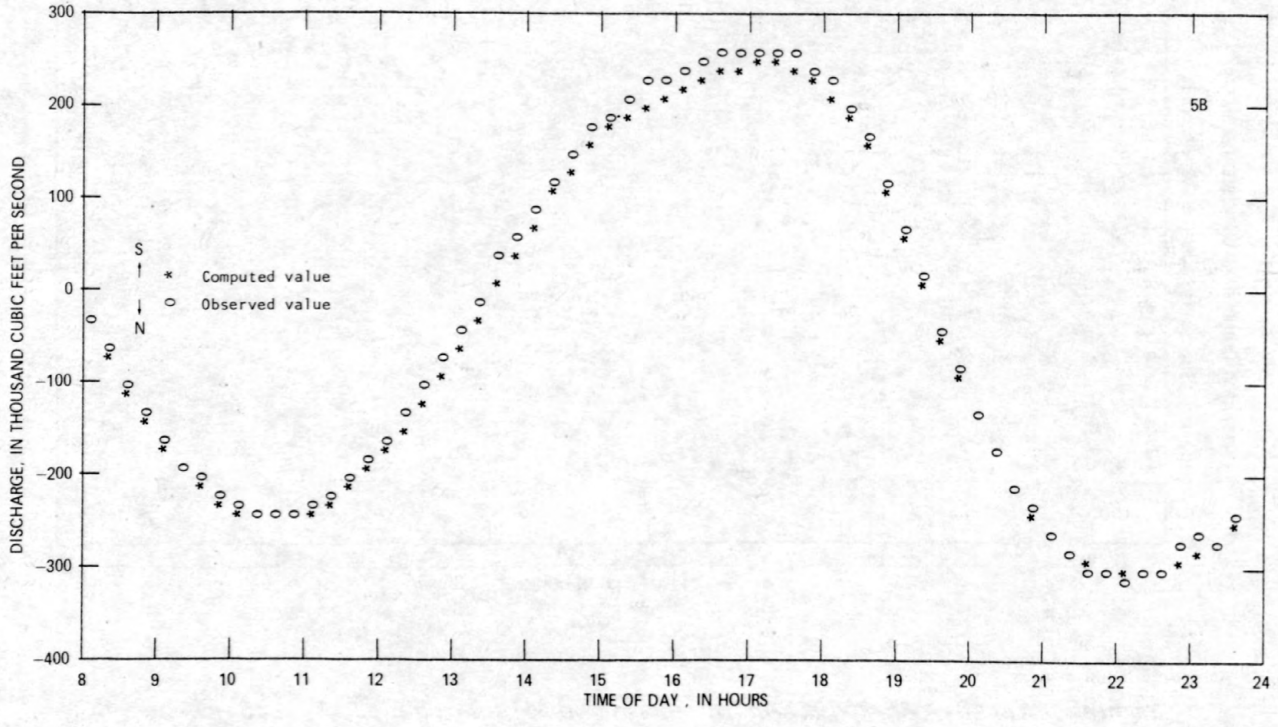


Figure 5A, 5B.--Comparison of observed and computed discharges: A, at Rhinecliff, June 21, 1967; B, at Mid-Hudson Bridge, Poughkeepsie, June 21, 1967.

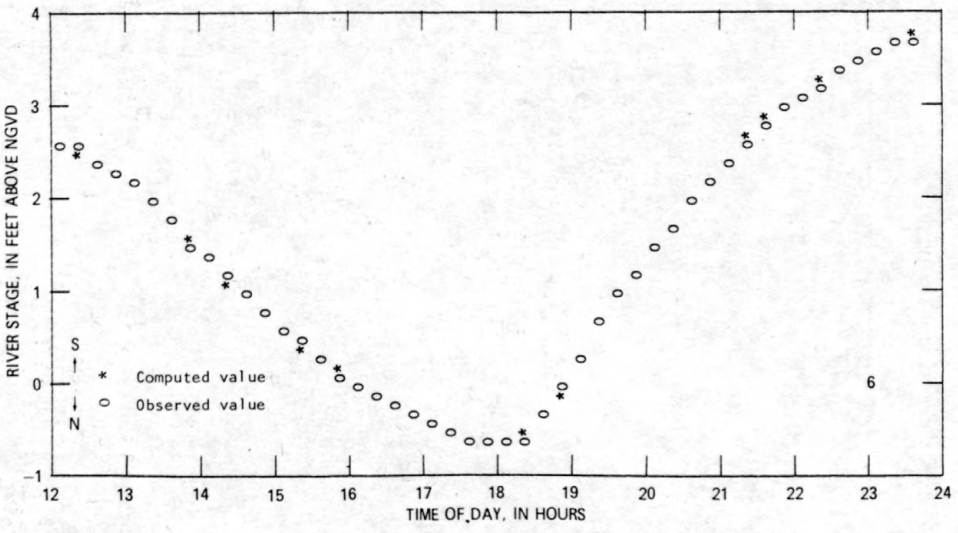


Figure 6.--Comparison of observed and computed stage at Mid-Hudson Bridge, Poughkeepsie, June 21, 1967.

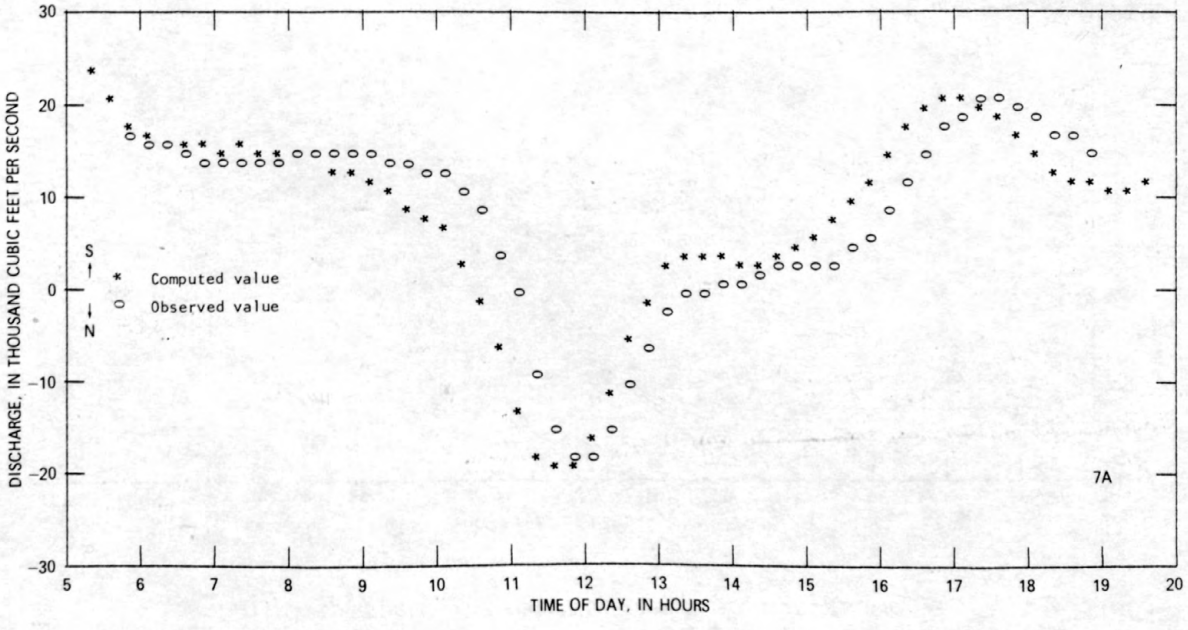
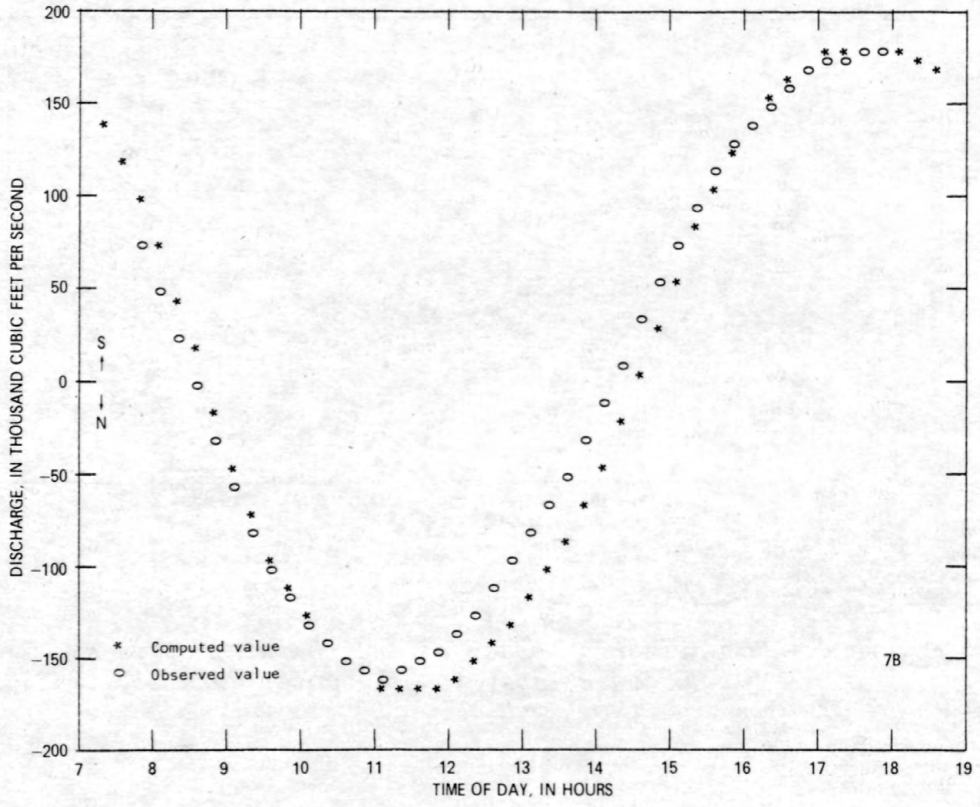


Figure 7A.--Comparison of observed and computed discharges at Colonie Street Bridge, Albany, August 21, 1979.



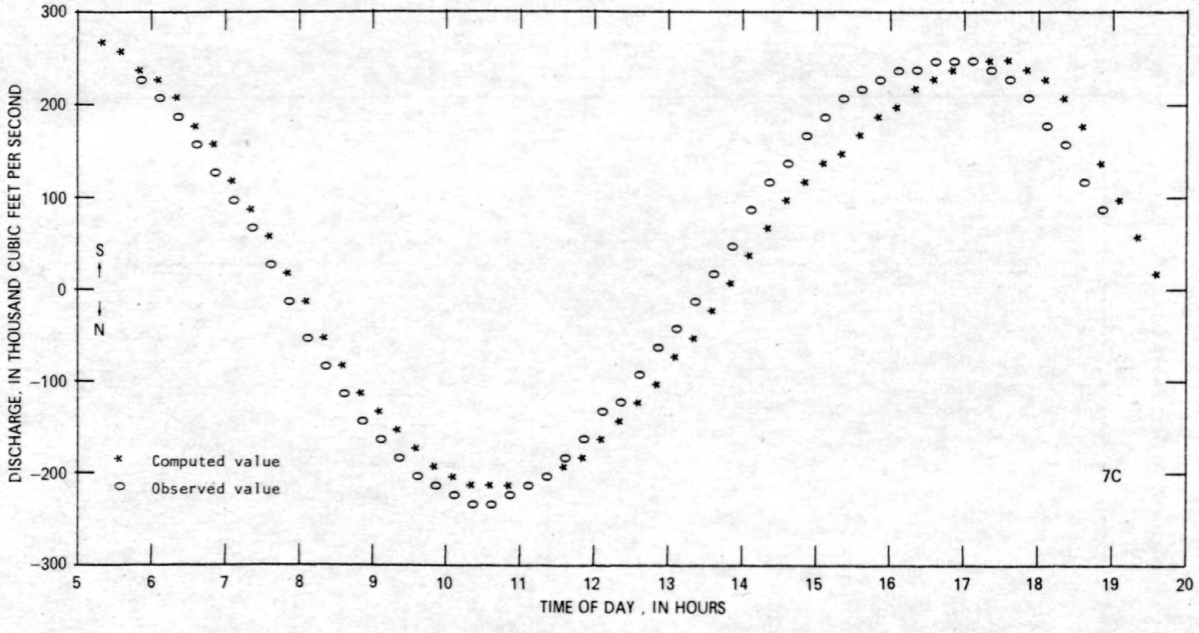


Figure 7B, 7C.--Comparison of observed and computed discharges: B, 1.5 miles north of Kingston-Rhinecliff Bridge, August 21, 1979; C, at Mid-Hudson Bridge, Poughkeepsie, August 21, 1979.

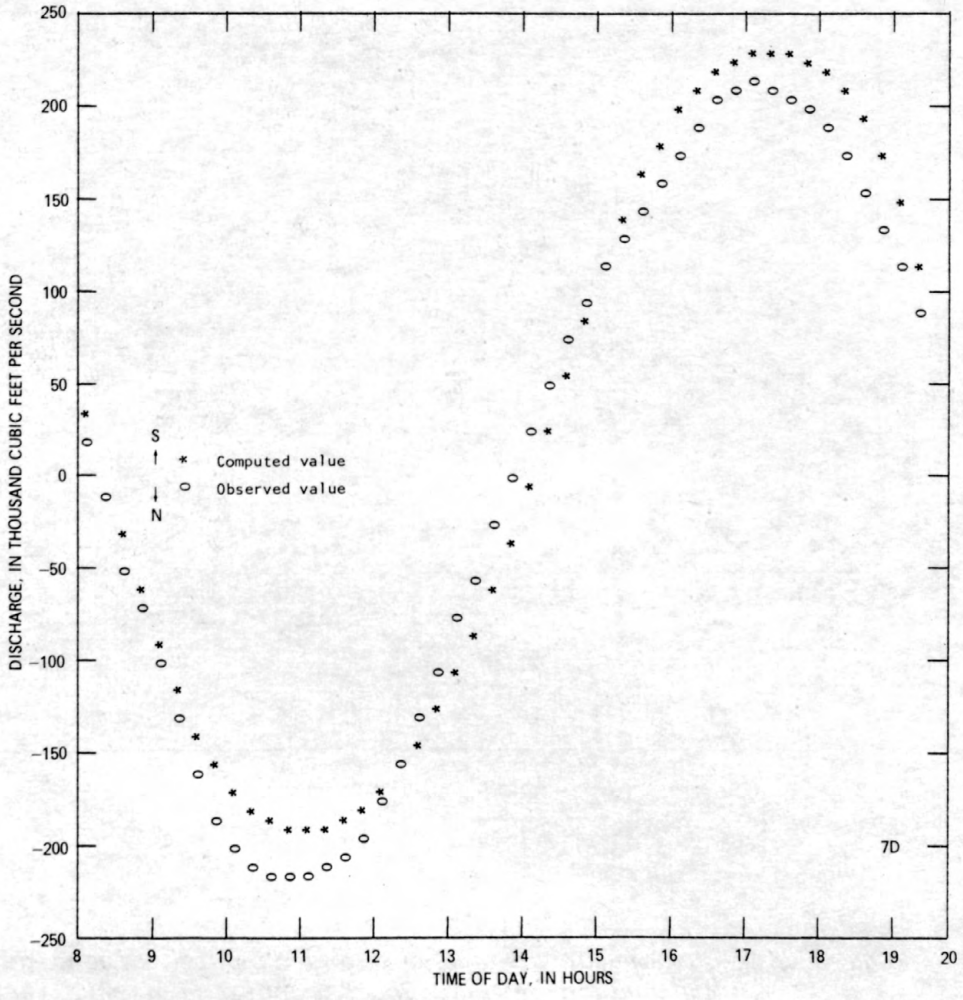


Figure 7D.--Comparison of observed and computed discharges at at Rhinecliff, June 21, 1967.

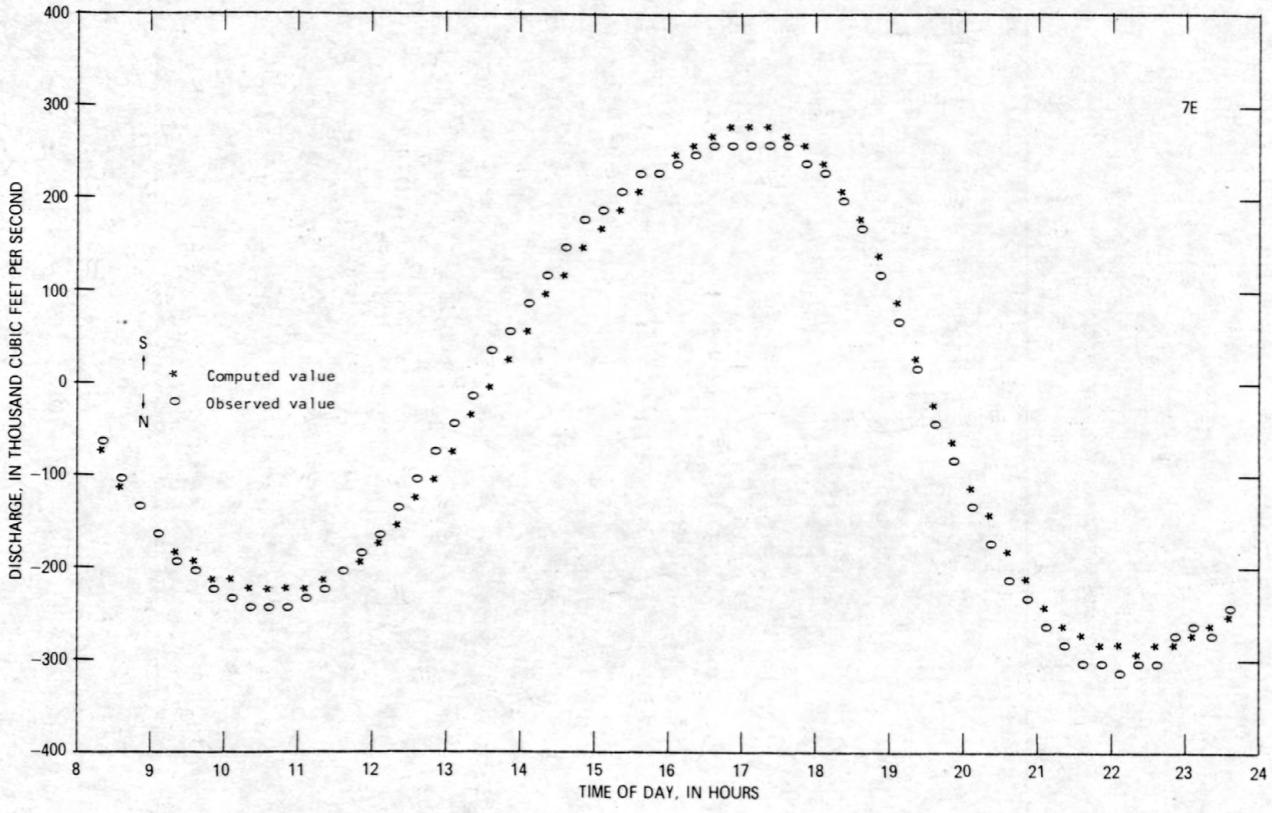


Figure 7E.--Comparison of observed and computed discharges at Mid-Hudson Bridge, Poughkeepsie, June 21, 1967.

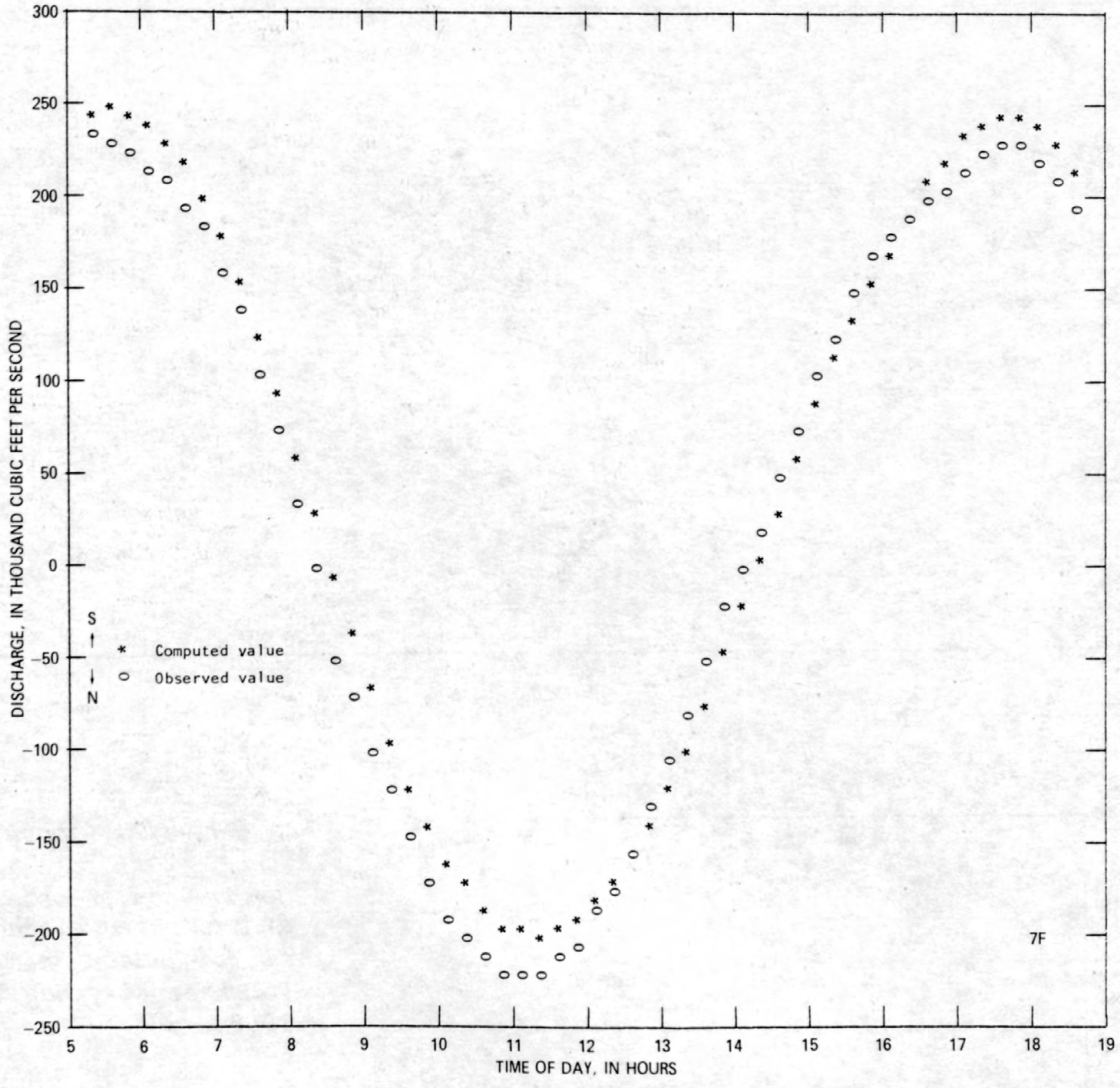


Figure 7F.--Comparison of observed and computed discharges at Mid-Hudson Bridge, Poughkeepsie, August 30, 1966.

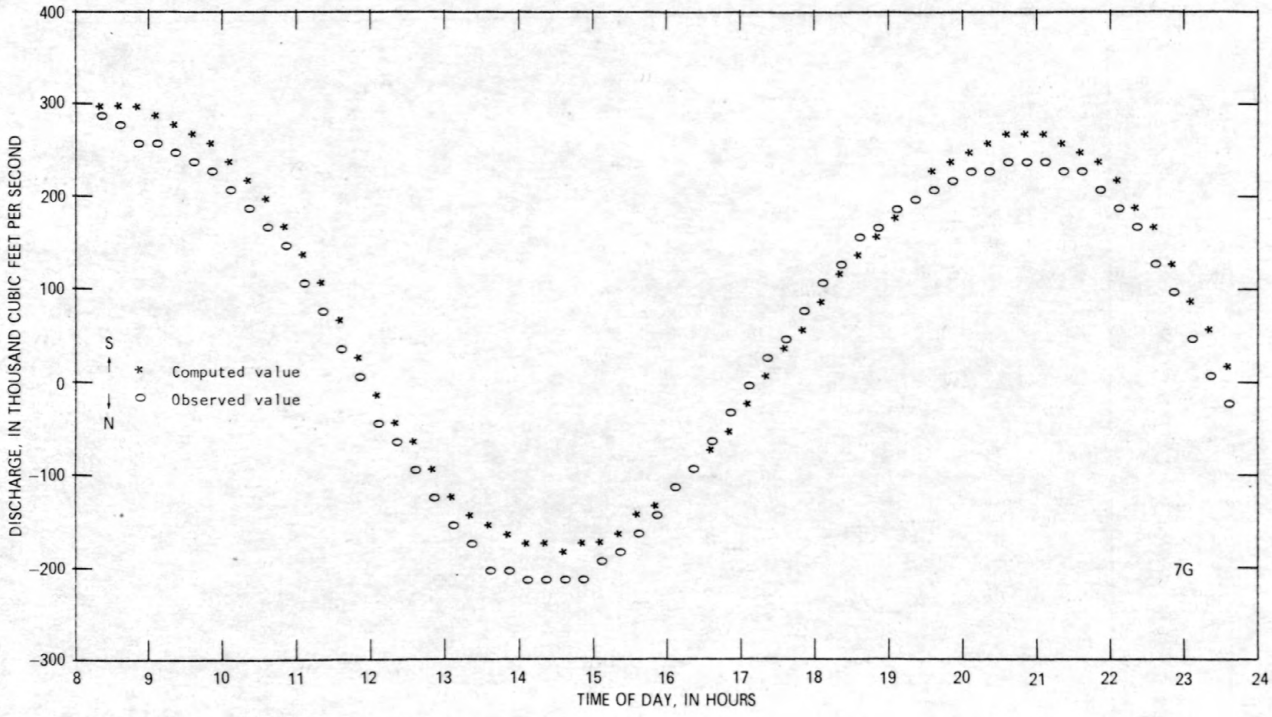


Figure 7G (above):

Comparison of observed and computed discharges at Mid-Hudson Bridge, Poughkeepsie, May 24, 1966.

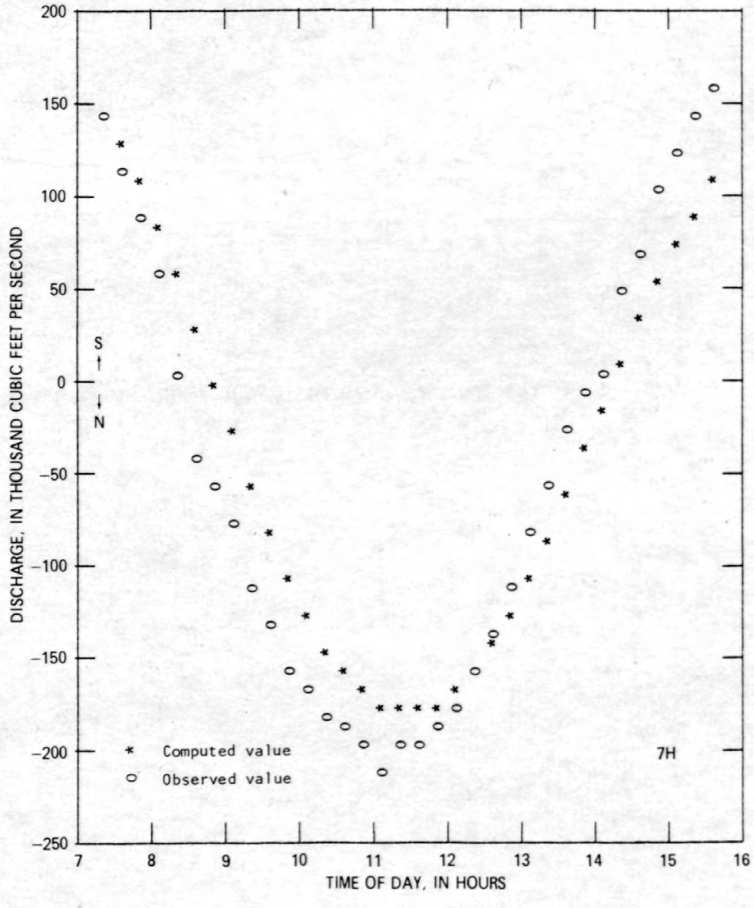
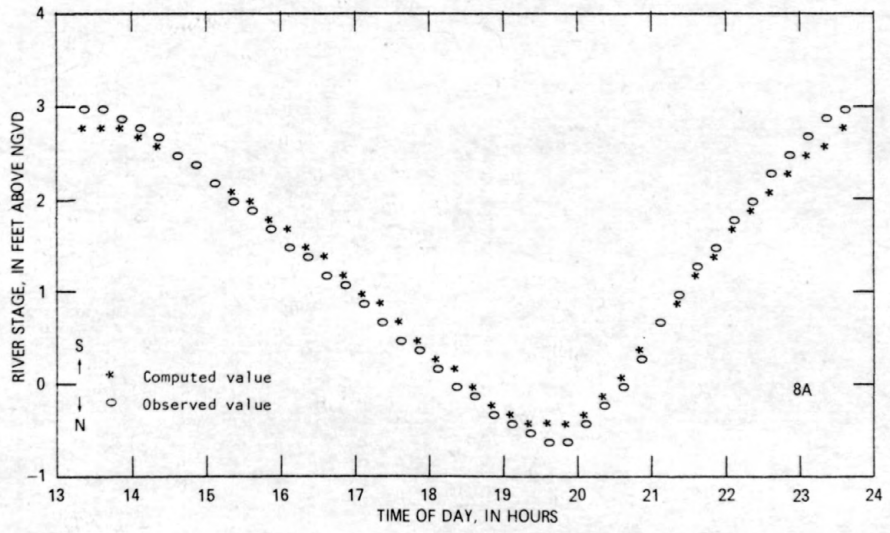


Figure 7H (left):

Comparison of observed and computed discharges at Mid-Hudson Bridge, Poughkeepsie, August 11, 1965.



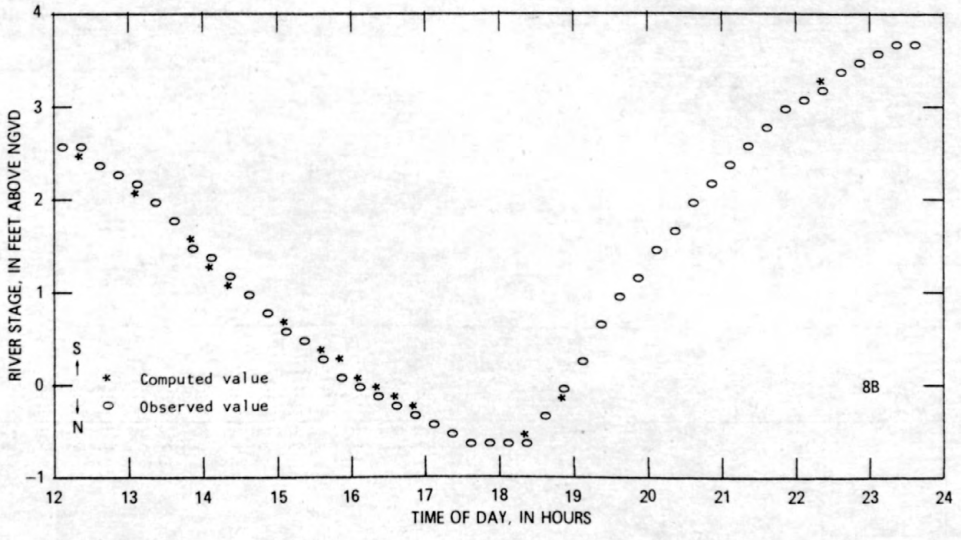


Figure 8A, 8B.--Comparison of observed and computed stage: A, at Eves Point, West Camp, August 21, 1979; B, at Mid-Hudson Bridge, Poughkeepsie, June 21, 1967.

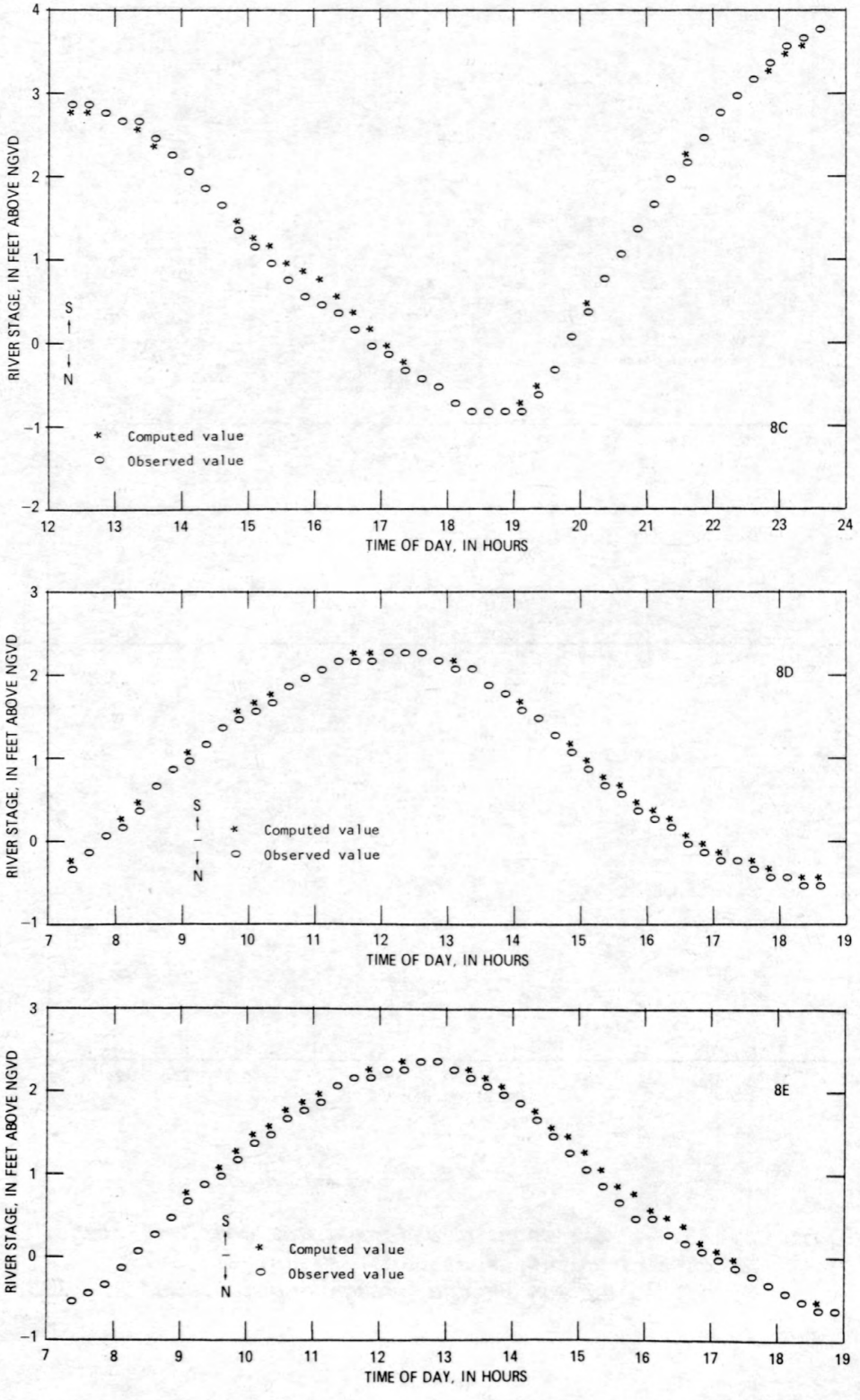
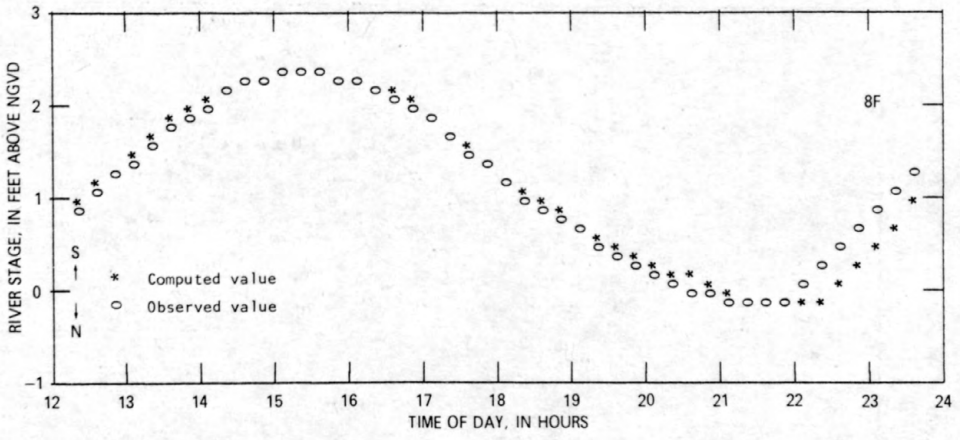
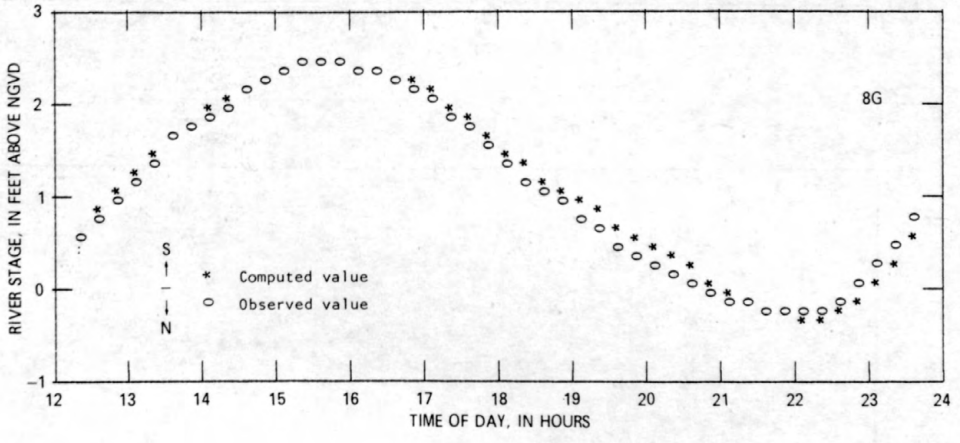


Figure 8C-8E.--Comparison of observed and computed stage:
C, at Rhinecliff, June 21, 1967;
D, at Mid-Hudson Bridge, Poughkeepsie, August 30, 1966.
E, at Hyde Park, August 30, 1966;





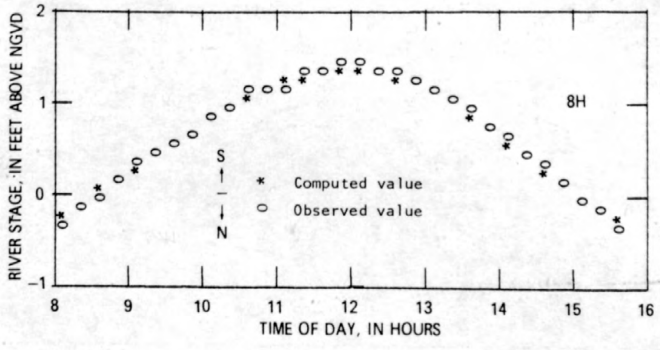
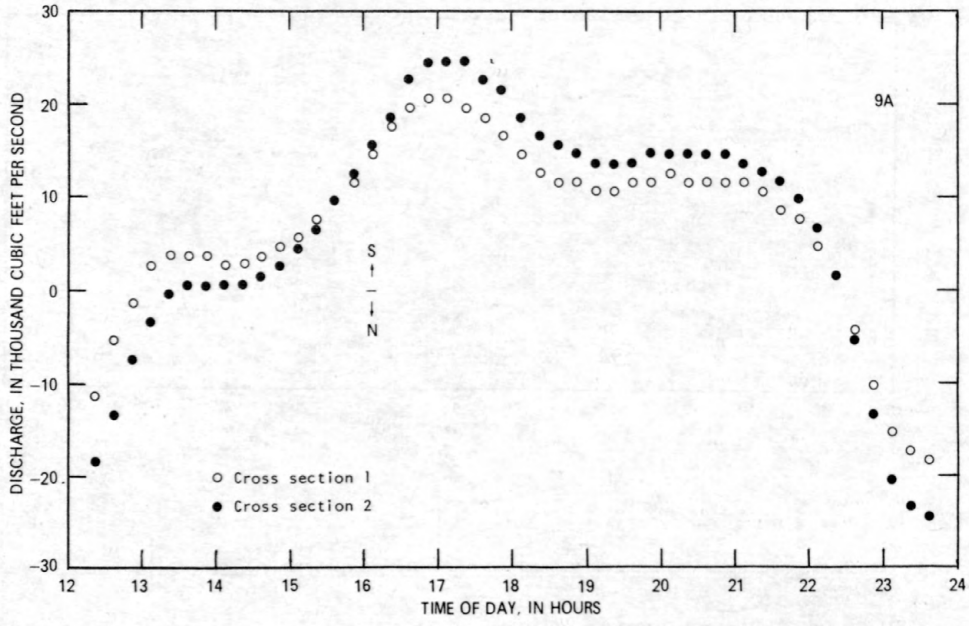


Figure 8F-8H.--Comparison of observed and computed stage:
F, at Mid-Hudson Bridge, Poughkeepsie, May 24, 1966.
G, at Hyde Park, May 24, 1966;
H, at Mid-Hudson Bridge, Poughkeepsie, August 11, 1965.



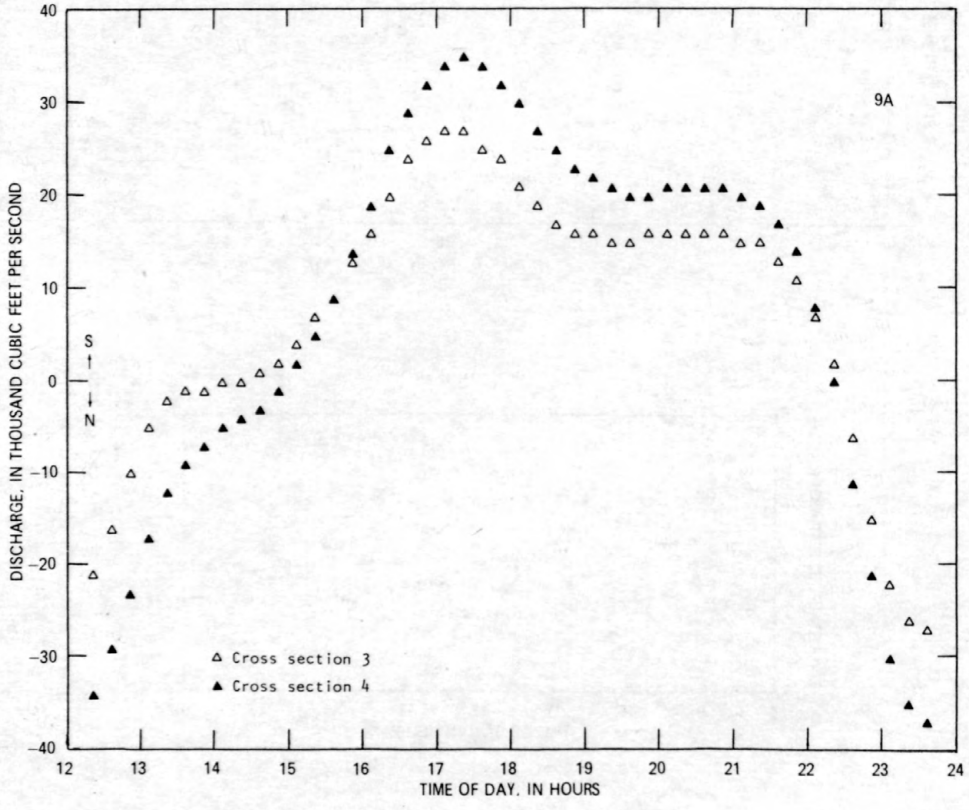
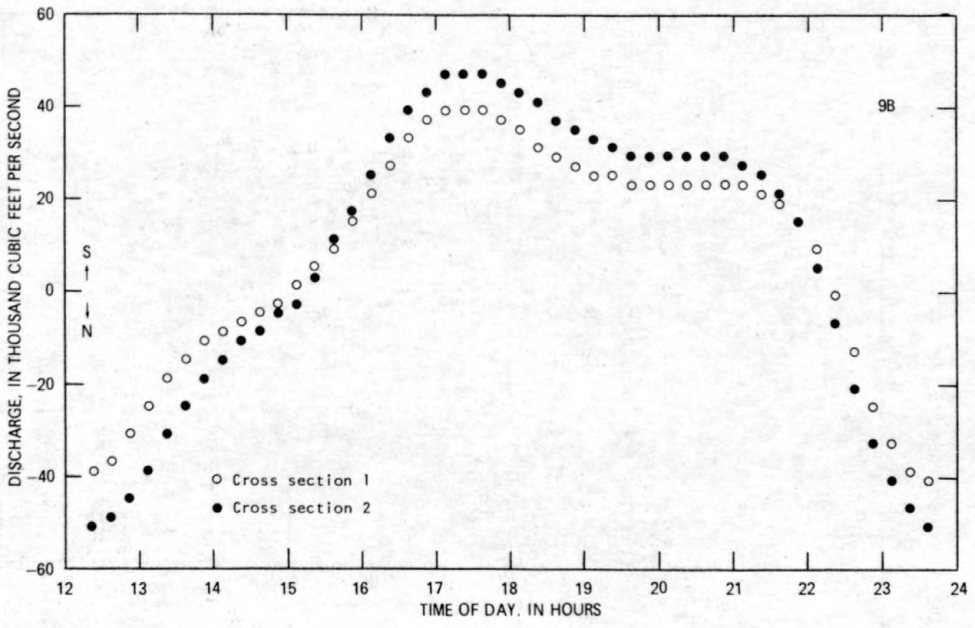


Figure 9A.--Computed discharges at cross sections from Albany to Castleton, August 21, 1979. (Locations are given in fig. 2.)



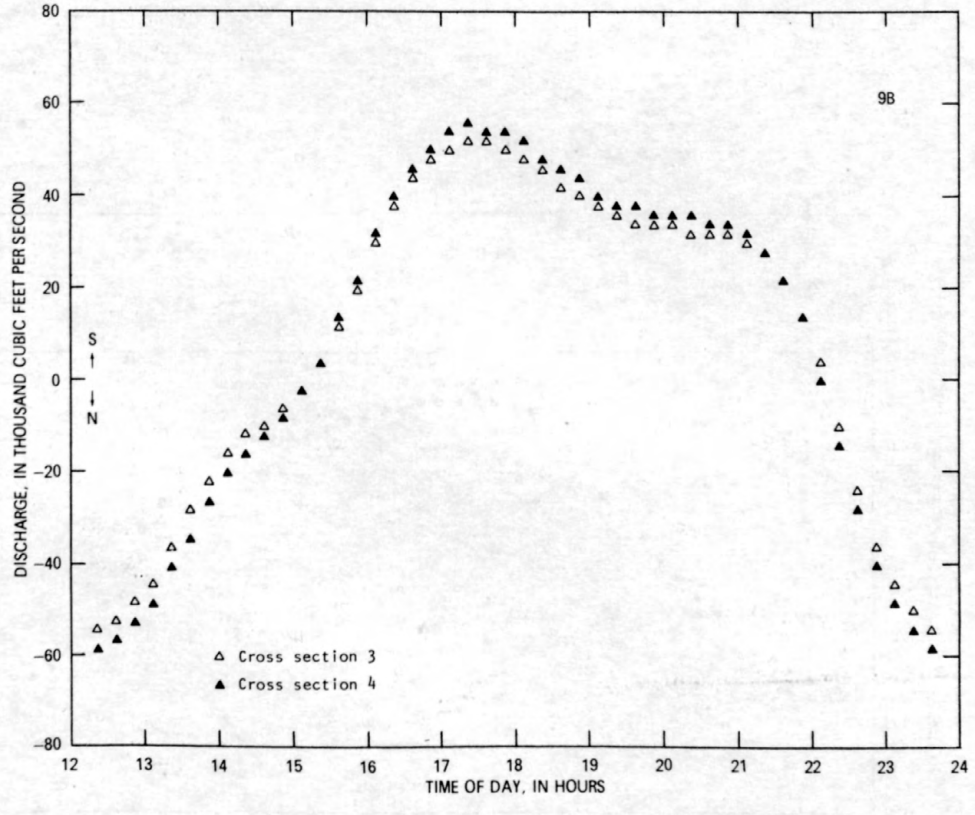


Figure 9B.--Computed discharges at cross sections from Castleton to Schodack, August 21, 1979. (Locations are given in fig. 2.)

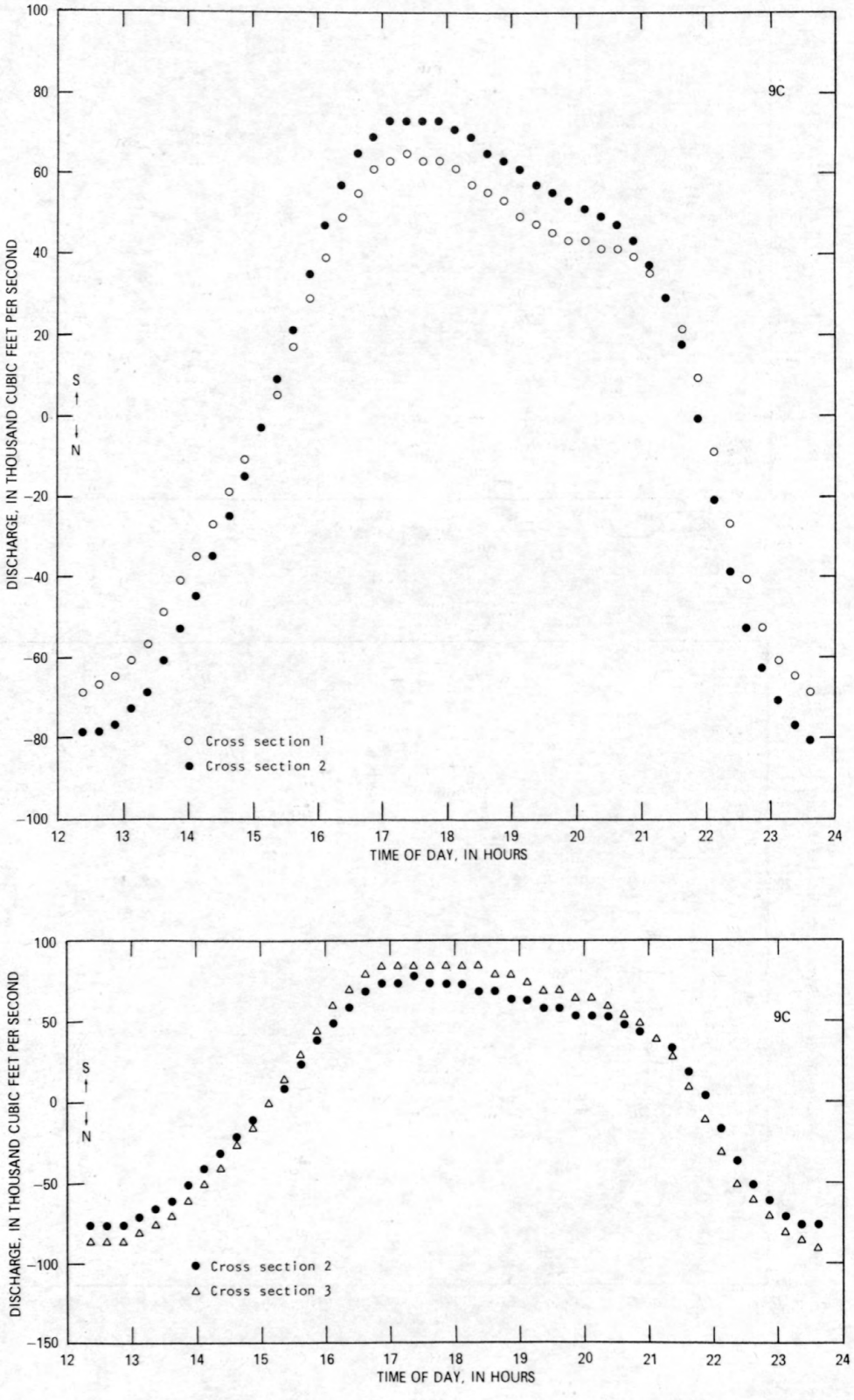


Figure 9C.--Computed discharges at cross sections from Schodack to Stockport, August 21, 1979. (Locations are given in fig. 2.)

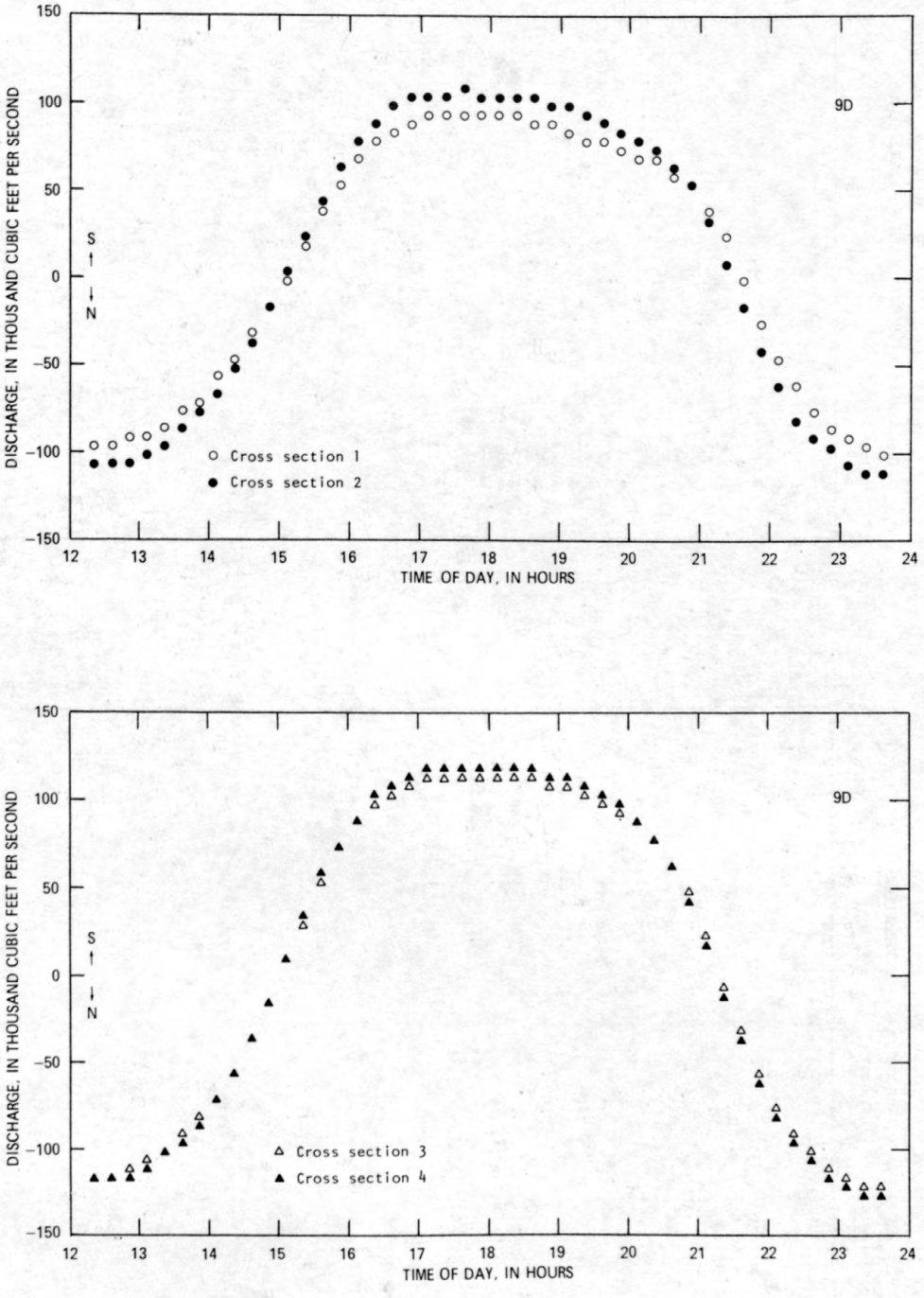
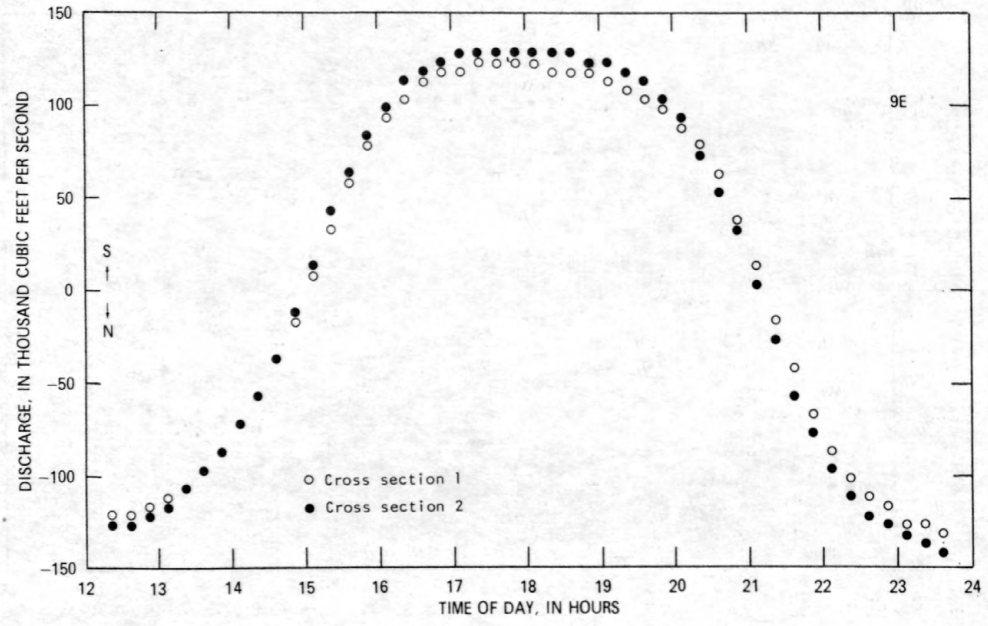


Figure 9D.--Computed discharges at cross sections from Stockport to Catskill, August 21, 1979. (Locations are given in fig. 2.)



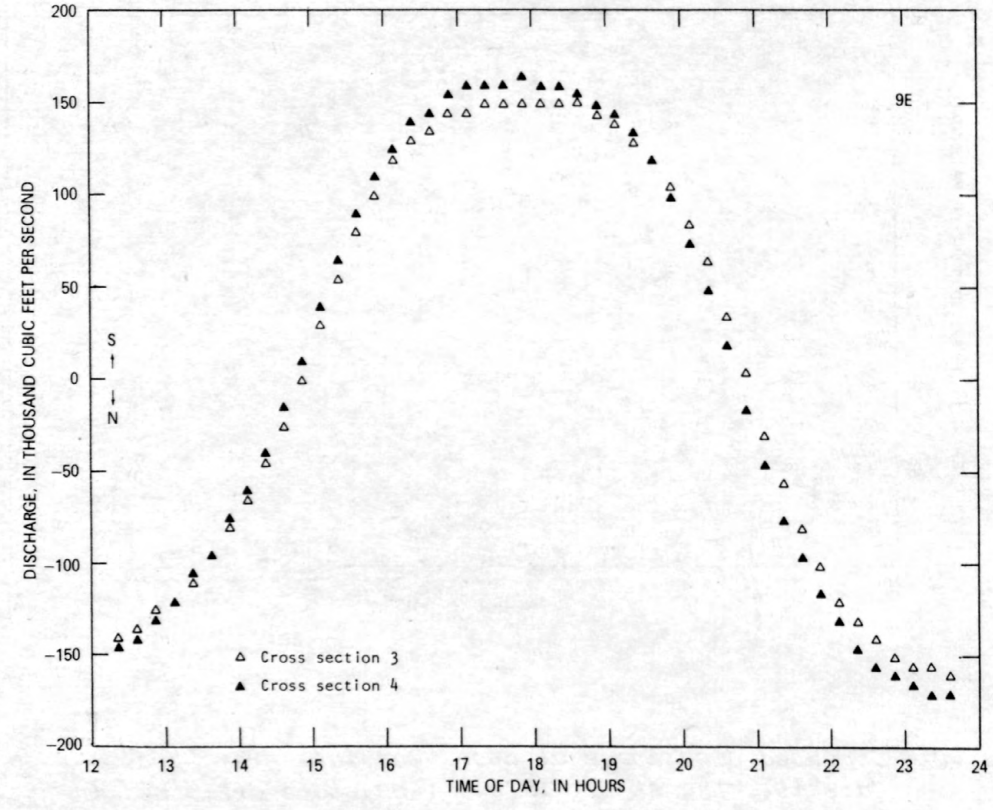
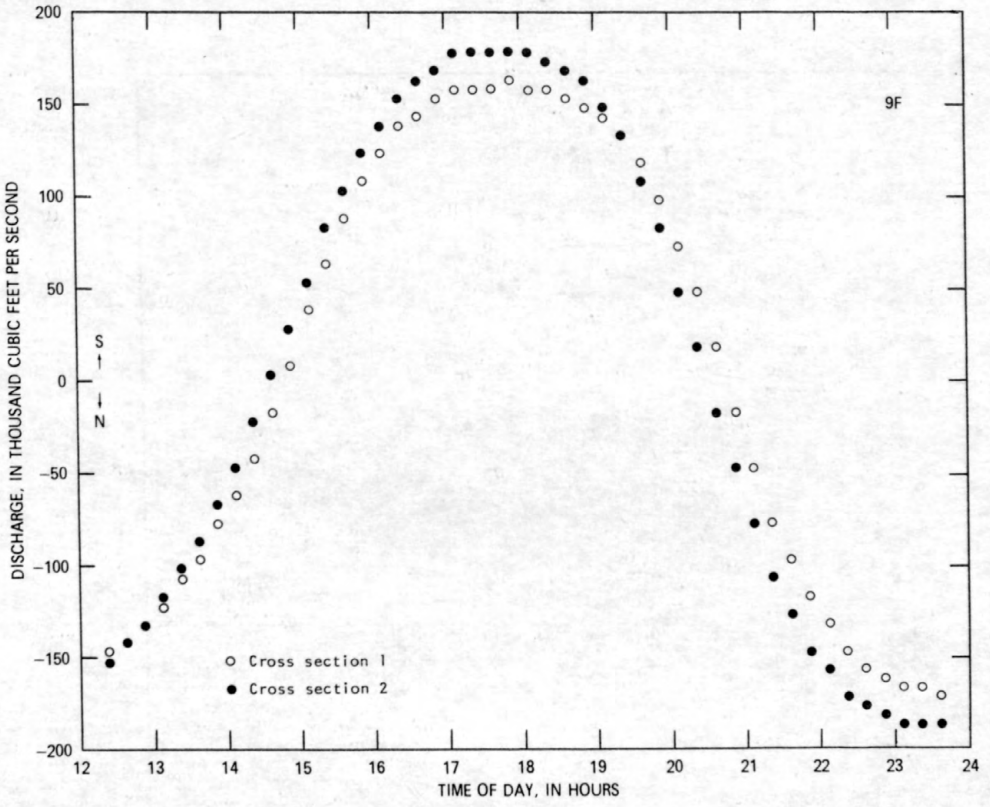


Figure 9E.--Computed discharges at cross sections from Catskill to Saugerties, August 21, 1979. (Locations are given in fig. 2.)



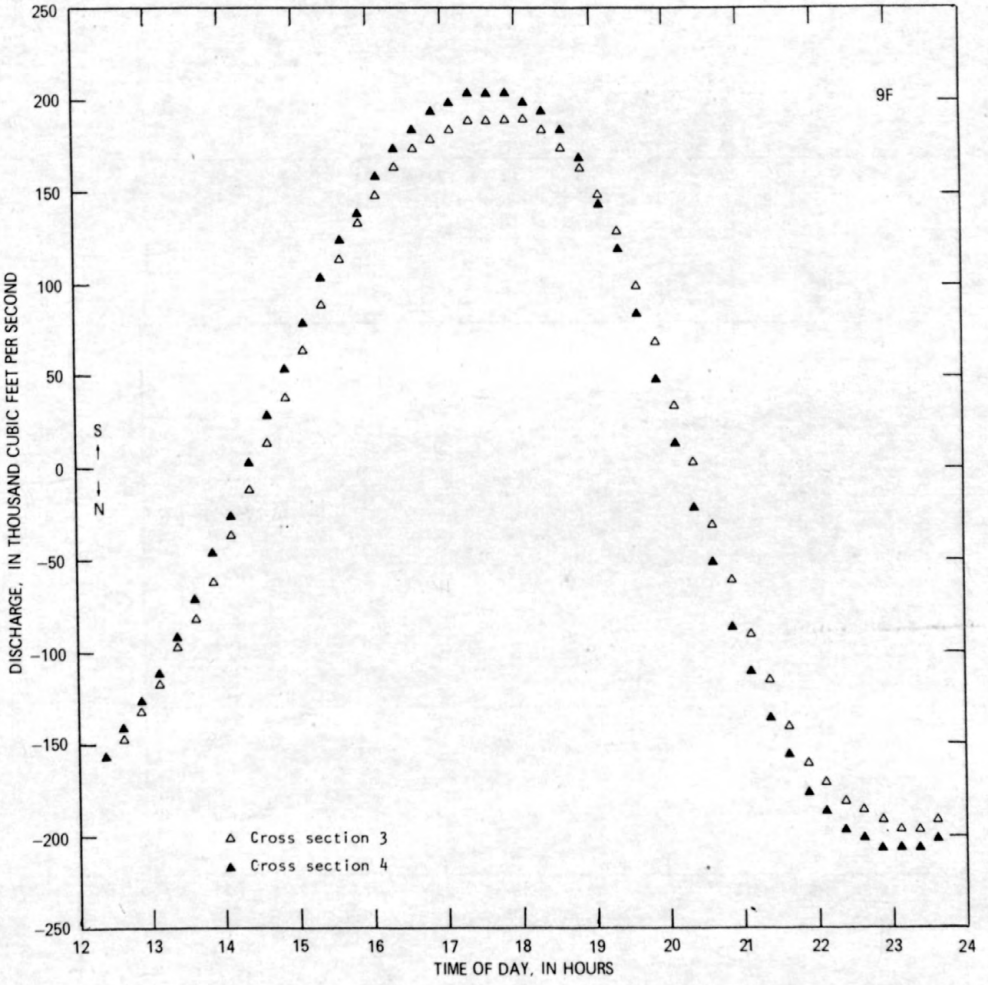
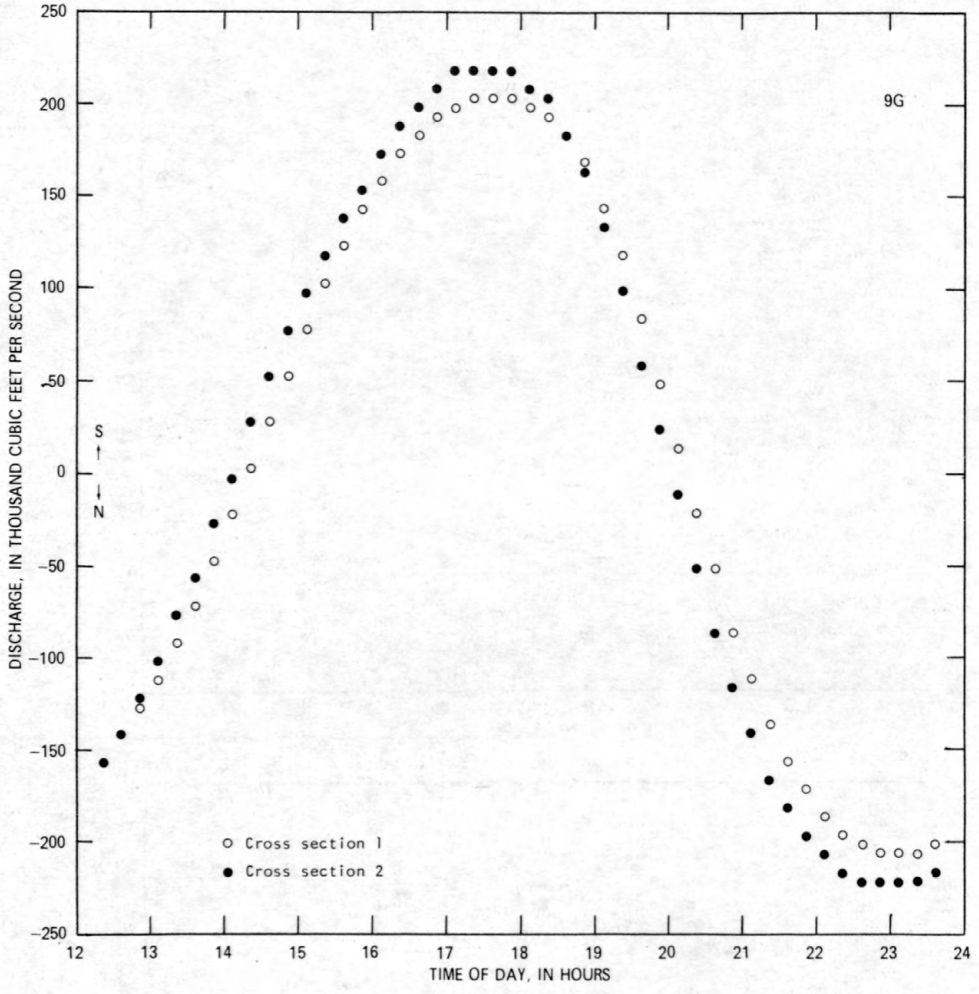
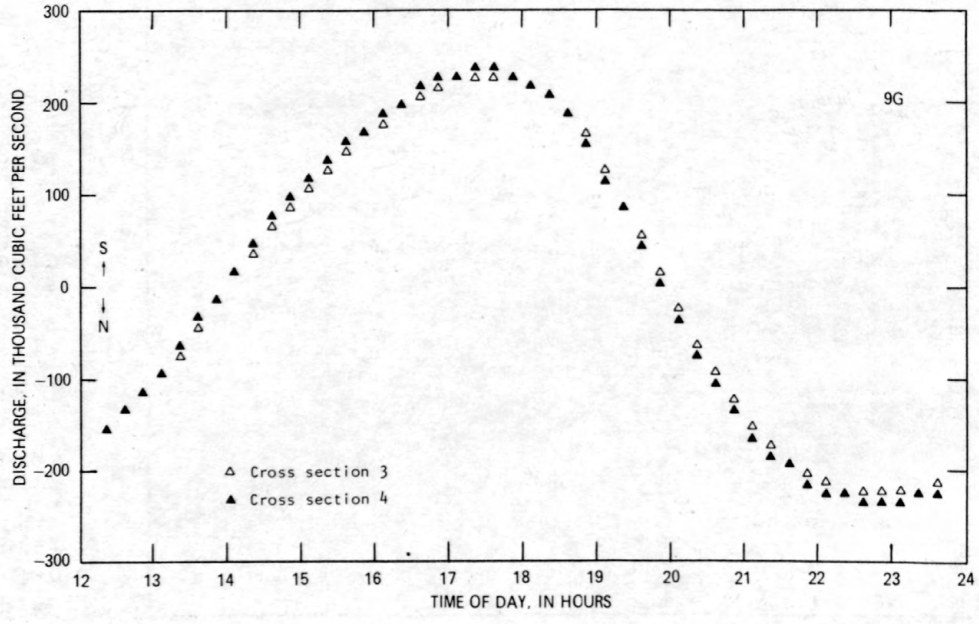


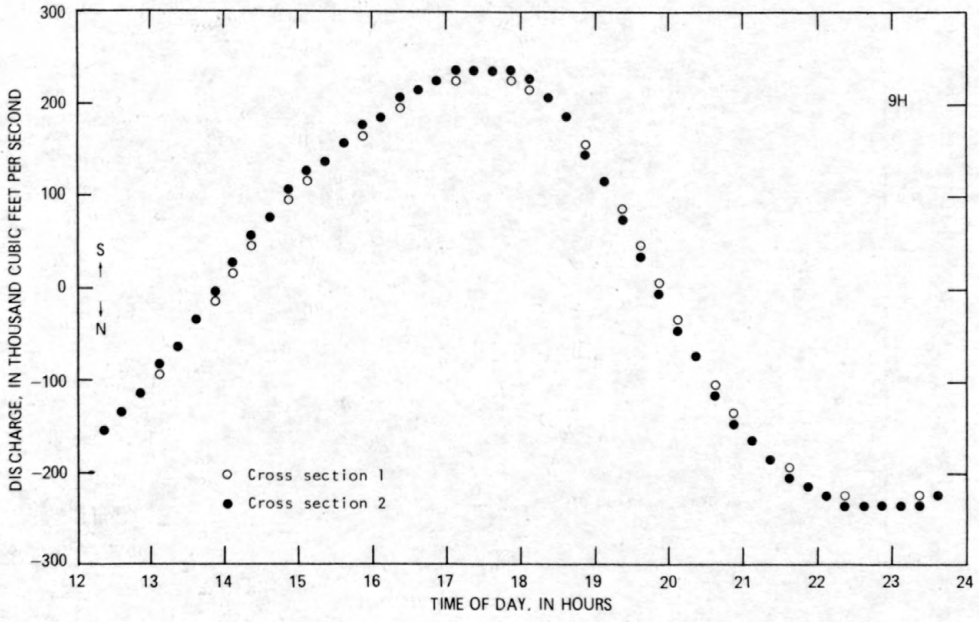
Figure 9F

Computed discharges at cross sections from Saugerties to Kingston, August 21, 1979.

(Locations are given in fig. 2.)


9G
DISCHARGE, IN THOUSAND CUBIC FEET PER SECOND
TIME OF DAY, IN HOURS
S
N
Cross section 1
Cross section 2
250
200
150
100
50
0
-50
-100
-150
-200
-250
12
13
14
15
16
17
18
19
20
21
22
23
24


9G
DISCHARGE, IN THOUSAND CUBIC FEET PER SECOND
TIME OF DAY, IN HOURS
S
N
Cross section 3
Cross section 4
300
200
100
0
-100
-200
-300
12
13
14
15
16
17
18
19
20
21
22
23
24



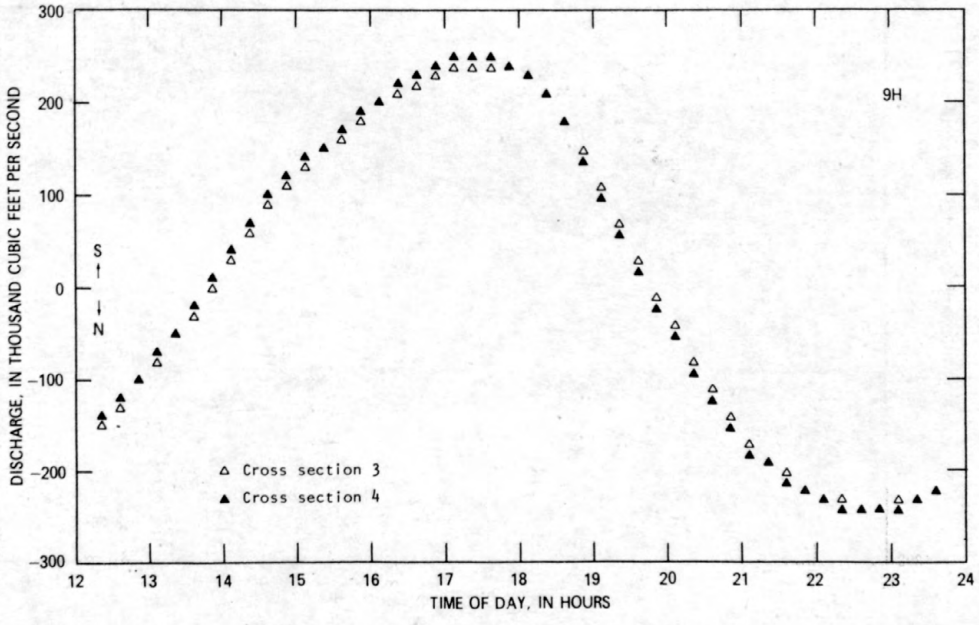


Figure 9H(above).--Computed discharges at cross sections from Hyde Park to Poughkeepsie, August 21, 1979. (Locations are given in fig. 2.)

Figure 9G(opposite).--Computed discharges at cross sections from Kingston to Hyde Park, August 21, 1979.

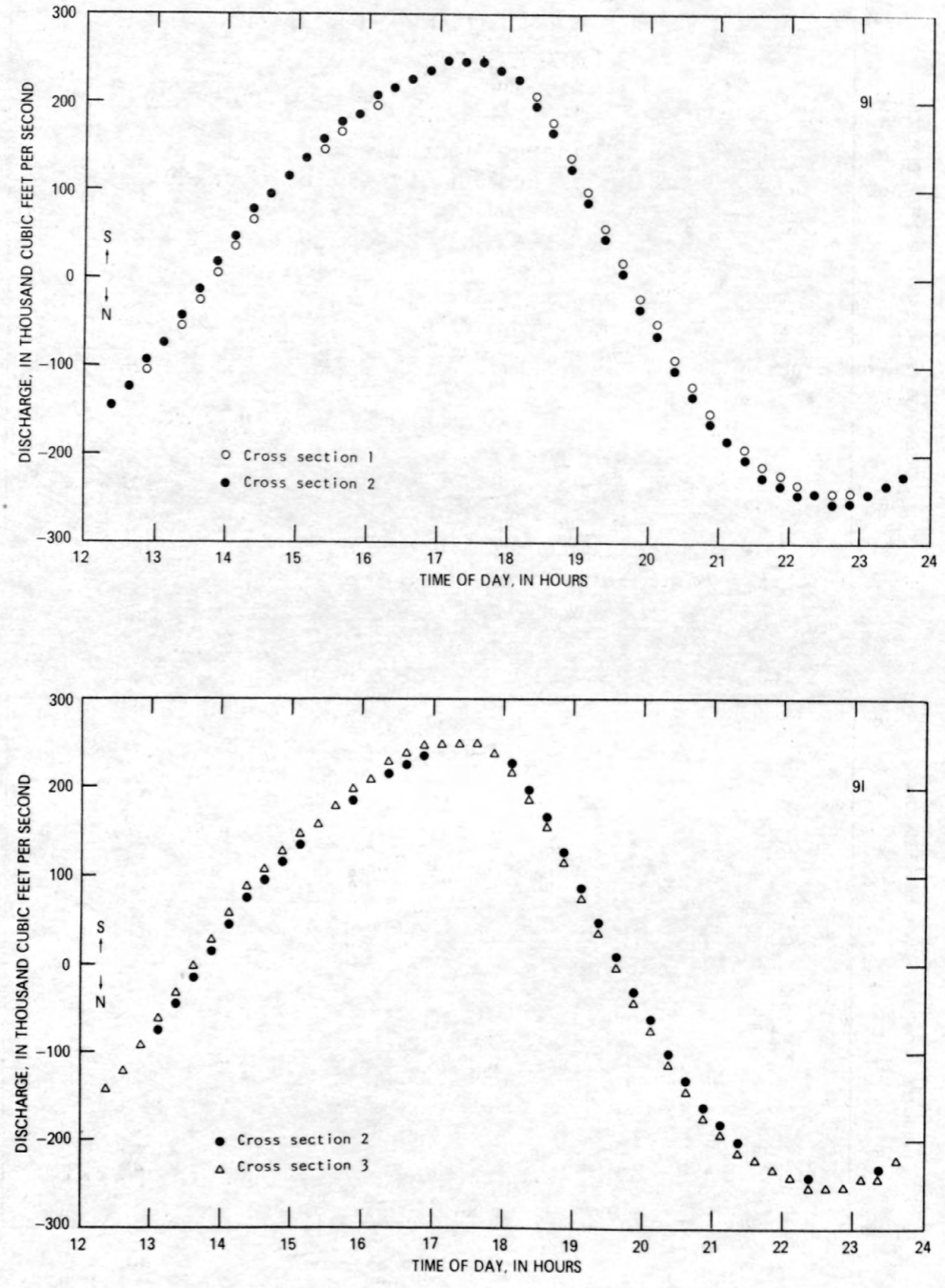


Figure 9I.--Computed discharges at cross sections from Poughkeepsie to New Hamburg, August 21, 1979. (Locations are given in fig. 2.)

TABLES 1-3

1. Stage and discharge data used in calibaration of Hudson River flow model:

   A. August 11, 1965
   B. May 24-25, 1966
   C. August 30, 1966
   D. June 21-22, 1967
   E. August 21, 1979
   F. March 26, 1980
   G. April 18, 1980

2. Model input data for subreach 1, Albany to West Camp

3. Model input data for subreach 2, West Camp to New Hamburg

Table 1.--Stage and discharge data used in calibration of Hudson River flow model
[Time is universal coordinated time minus 5 hours;
datum is 10 feet below NGVD of 1929]

A. August 11, 1965

Time	Discharge (cubic feet per second)		Stage (feet above datum)		
	Green Island	Poughkeepsie	Albany	Poughkeepsie	New Hamburg
0600	2360	237000	11.54	--	--
0615	--	224000	11.26	9.15	--
0630	--	212000	10.99	9.10	8.96
0645	--	198000	10.74	9.06	9.00
0700	--	185000	10.51	9.05	9.07
0715	--	162000	10.31	9.05	9.18
0730	--	138000	10.09	9.10	9.32
0745	--	112000	9.89	9.25	9.45
0800	2360	83400	9.68	9.38	9.65
0815	--	53300	9.51	9.55	9.85
0830	--	0	9.30	9.75	10.05
0845	--	-44800	9.11	9.95	10.22
0900	--	-61300	8.89	10.10	10.35
0915	--	-78200	8.73	10.25	10.46
0930	--	-114000	8.49	10.35	10.57
0945	--	-137000	8.26	10.50	10.69
1000	3070	-160000	8.11	10.63	10.82
1015	--	-171000	7.91	10.75	10.92
1030	--	-183000	7.78	10.90	11.00
1045	--	-192000	7.65	11.05	11.09
1100	--	-201000	7.58	11.10	11.16
1115	--	-214000	7.48	11.15	11.22
1130	--	-245000	7.53	11.25	11.25
1145	--	-201000	7.71	11.30	11.27
1200	3450	-189000	8.12	11.35	11.29
1215	--	-179000	8.53	11.36	11.25
1230	--	-160000	8.99	11.34	11.21
1245	--	-141000	9.37	11.27	11.15

Time	Discharge (cubic feet per second)		Stage (feet above datum)		
	Green Island	Poughkeepsie	Albany	Poughkeepsie	New Hamburg
1300	--	-117000	9.85	11.23	11.06
1315	--	-87000	10.31	11.11	10.93
1330	--	-61600	10.74	11.01	10.79
1345	--	-30500	11.02	10.88	10.64
1400	3470	-8730	11.30	10.73	10.49
1415	--	0	11.55	10.57	10.34
1430	--	44300	11.69	10.40	10.17
1445	--	63700	11.84	10.25	10.04
1500	--	102000	11.97	10.14	9.91
1515	--	121000	12.13	9.95	9.78
1530	--	139000	12.23	9.80	9.66
1545	--	156000	12.33	9.65	9.54
1600	3490	180000	12.40	9.55	9.39

B. May 24-25, 1966

Time	Discharge (cubic feet per second)		Stage (feet above datum)			
	Green Island	Poughkeepsie	Albany	Hyde Park	Poughkeepsie	New Hamburg
0800	22400	281000	14.35	10.40	10.24	10.13
0815	--	279000	14.11	10.22	10.15	10.04
0830	--	276000	13.85	10.04	9.98	9.96
0845	--	265000	13.62	9.95	9.88	9.86
0900	--	254000	13.36	9.82	9.73	9.78
0915	--	245000	13.10	9.70	9.64	9.70
0930	--	243000	12.88	9.56	9.56	9.62
0945	--	229000	12.65	9.48	9.48	9.58
1000	22800	217000	12.45	9.40	9.44	9.54
1015	--	203000	12.24	9.30	9.40	9.56
1030	--	182000	12.09	9.29	9.40	9.58
1045	--	160000	11.91	9.30	9.48	9.70

Table 1.--Stage and discharge data used in calibration of Hudson River flow model (contined)

B. May 24-25, 1966 (continued)

Time	Discharge (cubic feet per second)		Stage (feet above datum)			
	Green Island	Poughkeepsie	Albany	Hyde Park	Poughkeepsie	New Hamburg
1100	--	137000	11.74	9.35	9.56	9.84
1115	--	101000	11.59	9.46	9.71	10.02
1130	--	71500	11.41	9.61	9.94	10.28
1145	--	30500	11.26	9.79	10.18	10.54
1200	23700	-400	11.08	10.05	10.42	10.76
1215	--	-45200	10.92	10.26	10.62	10.94
1230	--	-74100	10.75	10.48	10.80	11.12
1245	--	-103000	10.59	10.70	10.98	11.26
1300	--	-133000	10.44	10.90	11.16	11.44
1315	--	-163000	10.31	11.11	11.34	11.62
1330	--	-185000	10.17	11.32	11.50	11.74
1345	--	-207000	10.03	11.55	11.68	11.88
1400	22600	-214000	9.93	11.66	11.84	11.98
1415	--	-224000	9.84	11.79	11.94	12.06
1430	--	-224000	9.79	11.95	12.05	12.12
1445	--	-221000	9.75	12.06	12.18	12.20
1500	--	-213000	9.78	12.21	12.22	12.24
1515	--	-204000	9.95	12.29	12.26	12.24
1530	--	-190000	10.27	12.35	12.28	12.20
1545	--	-174000	10.80	12.38	12.26	12.18
1600	21200	-147000	11.23	12.36	12.22	12.13
1615	--	-123000	11.73	12.31	12.16	12.08
1630	--	-96500	12.21	12.26	12.11	11.98
1645	--	-67300	12.67	12.21	12.04	11.90
1700	--	-39900	13.07	12.14	11.95	11.76
1715	--	-10500	13.45	12.02	11.78	11.58
1730	--	22500	13.71	11.84	11.60	11.40
1745	--	43700	13.91	11.68	11.42	11.23
1800	19900	72600	14.05	11.50	11.26	11.06

Time	Discharge (cubic feet per second)		Stage (feet above datum)			
	Green Island	Poughkeepsie	Albany	Hyde Park	Poughkeepsie	New Hamburg
1815	--	100000	14.18	11.32	11.08	10.90
1830	--	124000	14.25	11.15	10.94	10.80
1845	--	146000	14.31	10.99	10.78	10.68
1900	--	163000	14.32	10.86	10.68	10.56
1915	--	180000	14.32	10.72	10.56	10.42
1930	--	190000	14.28	10.55	10.38	10.28
1945	--	204000	14.20	10.40	10.26	10.16
2000	18900	214000	14.07	10.30	10.16	10.08
2015	--	218000	13.95	10.20	10.06	10.00
2030	--	223000	13.77	10.11	10.00	9.94
2045	--	229000	13.56	10.04	9.94	9.90
2100	--	228000	13.32	9.95	9.88	9.84
2115	--	231000	13.09	9.84	9.82	9.82
2130	--	224000	12.81	9.76	9.76	9.80
2145	--	215000	12.61	9.69	9.76	9.84
2200	18600	204000	12.38	9.66	9.76	9.90
2215	--	180000	12.17	9.66	9.82	10.04
2230	--	155000	11.96	9.70	9.97	10.20
2245	--	121000	11.78	9.82	10.16	10.46
2300	--	85600	11.58	9.98	10.36	10.68
2315	--	40800	11.39	10.17	10.58	10.94
2330	--	1100	11.21	10.40	10.82	11.18
2345	--	-32200	11.04	10.66	11.00	11.40
2400	18600	-75300	10.83	10.87	11.24	11.58
0015	--	-110000	10.66	11.11	11.44	11.76
0030	--	-142000	10.49	11.30	11.62	11.90
0045	--	-167000	10.33	11.53	11.78	12.04
0100	--	-191000	10.16	11.72	11.95	12.16
0115	--	-207000	10.02	11.86	12.10	12.30
0130	--	-219000	9.87	12.05	12.26	12.43
0145	--	-227000	9.73	12.20	12.40	12.54
0200	19500	-234000	9.63	12.36	12.52	12.66
0215	--	-238000	9.57	12.52	12.66	12.75
0230	--	-236000	9.57	12.66	12.76	12.84

Table 1.--Stage and discharge data used in calibration of Hudson River flow model (contined)

B. May 24-25, 1966 (continued)

Time	Discharge (cubic feet per second)		Stage (feet above datum)			
	Green Island	Poughkeepsie	Albany	Hyde Park	Poughkeepsie	New Hamburg
0245	--	-231000	9.66	12.80	12.87	12.92
0300	--	-226000	9.95	12.92	12.95	12.98
0315	--	-214000	10.49	13.04	13.03	13.02
0330	--	-201000	11.05	13.11	13.06	13.03
0345	--	-181000	11.61	13.15	13.06	12.99
0400	19400	-162000	12.11	13.15	13.00	12.94
0415	--	-138000	12.63	13.10	12.98	12.86
0430	--	-110000	13.11	13.08	12.91	12.76
0445	--	-80500	13.51	13.00	12.79	12.62
0500	--	-50000	13.81	12.85	12.64	12.46
0515	--	-19400	13.98	12.71	12.48	12.26
0530	--	7300	14.19	12.54	12.26	12.05
0545	--	49800	14.35	12.35	12.04	11.82
0600	19400	83400	14.45	12.09	11.80	11.60
0615	--	114000	14.55	11.88	11.60	11.41
0630	--	145000	14.65	11.68	11.44	11.23
0645	--	173000	13.76	11.50	11.26	11.08
0700	--	192000	14.81	11.31	11.10	10.94
0715	--	211000	14.85	11.13	10.94	10.78
0730	--	227000	14.82	10.96	10.76	10.67
0745	--	238000	14.79	10.82	10.66	10.54
0800	19200	253000	14.73	10.72	10.54	10.44
0815	--	259000	14.61	10.62	10.44	10.36
0830	--	268000	14.44	10.50	10.34	10.28
0845	--	270000	14.21	10.38	10.26	10.18
0900	--	271000	13.99	10.23	10.14	10.08
0915	--	268000	13.73	10.10	10.02	10.00
0930	--	268000	13.48	9.96	9.90	9.90
0945	--	261000	13.21	9.82	9.79	9.82

Time	Discharge (cubic feet per second)		Stage (feet above datum)			
	Green Island	Poughkeepsie	Albany	Hyde Park	Poughkeepsie	New Hamburg
1000	19800	255000	12.92	9.71	9.70	9.72
1015	--	244000	12.67	9.61	9.64	9.68
1030	--	232000	12.44	9.53	9.56	9.64
1045	--	223000	12.23	9.45	9.52	9.58
1100	--	210000	12.02	9.38	9.48	9.60
1115	--	--	--	--	--	--
1130	--	--	--	--	--	--
1145	--	--	--	--	--	--
1200	19700	--	--	--	--	--
			C. August 30, 1966			
0400	3080	--	--	--	--	--
0415	--	--	--	--	--	--
0430	--	--	--	--	--	--
0445	--	--	13.89	10.30	--	10.09
0500	--	--	13.64	10.12	--	9.99
0515	--	229000	13.31	9.98	9.92	9.89
0530	--	231000	13.00	9.86	9.79	9.81
0545	--	225000	12.62	9.72	9.71	9.72
0600	3270	220000	12.38	9.62	9.62	9.67
0615	--	211000	12.01	9.50	9.55	9.60
0630	--	205000	11.68	9.40	9.47	9.57
0645	--	190000	11.43	9.35	9.44	9.56
0700	3270	180000	11.20	9.30	9.44	9.61
0715	--	157000	10.99	9.30	9.49	9.72
0730	--	133000	10.82	9.36	9.61	9.86
0745	--	102000	10.61	9.47	9.76	10.04
0800	3620	71500	10.43	9.60	9.96	10.25
0815	--	31900	10.24	9.77	10.12	10.46
0830	--	-2840	10.10	9.96	10.34	10.65
0845	--	-52800	9.89	10.16	10.56	10.85
0900	--	-74900	9.69	10.36	10.76	11.04
0915	--	-103000	9.49	10.58	10.92	11.18
0930	--	-127000	9.32	10.79	11.08	11.35

Table 1.--Stage and discharge data used in calibration of Hudson River flow model (contined)

C. August 20, 1966 (continued)

Time	Discharge (cubic feet per second)		Stage (feet above datum)			
	Green Island	Poughkeepsie	Albany	Hyde Park	Poughkeepsie	New Hamburg
0945	--	-152000	9.15	10.95	11.25	11.49
1000	5070	-173000	8.97	11.12	11.38	11.62
1015	--	-194000	8.83	11.28	11.53	11.72
1030	--	-203000	8.68	11.45	11.65	11.84
1045	--	-217000	8.57	11.57	11.76	11.94
1100	--	-225000	8.47	11.70	11.90	12.02
1115	--	-224000	8.44	11.84	11.96	12.07
1130	--	-223000	8.52	11.97	12.06	12.13
1145	--	-214000	8.79	12.06	12.10	12.14
1200	6220	-208000	9.15	12.10	12.15	12.16
1215	--	-192000	9.60	12.16	12.20	12.12
1230	--	-179000	10.04	12.24	12.19	12.12
1245	--	-158000	10.56	12.26	12.17	12.06
1300	--	-135000	11.10	12.25	12.11	12.00
1315	--	-109000	11.65	12.16	12.04	11.92
1330	--	-83500	11.95	12.06	11.96	11.78
1345	--	-55800	12.26	11.96	11.82	11.64
1400	6750	-29300	12.51	11.88	11.68	11.53
1415	--	-5400	12.69	11.76	11.51	11.35
1430	--	17100	12.84	11.58	11.37	11.20
1445	--	42600	12.99	11.40	11.18	11.02
1500	--	72400	13.11	11.20	11.00	10.82
1515	--	98400	13.22	11.02	10.78	10.64
1530	--	120000	13.33	10.80	10.62	10.50
1545	--	146000	13.43	10.60	10.47	10.38
1600	6410	164000	13.53	10.44	10.34	10.25
1615	--	176000	13.61	10.35	10.24	10.10
1630	--	187000	13.52	10.20	10.09	9.98
1645	--	196000	13.51	10.08	9.95	9.88

Time	Discharge (cubic feet per second)		Stage (feet above datum)			
	Green Island	Poughkeepsie	Albany	Hyde Park	Poughkeepsie	New Hamburg
1700	--	201000	13.40	9.98	9.84	9.77
1715	--	209000	13.29	9.88	9.74	9.69
1730	--	218000	13.05	9.77	9.66	9.63
1745	--	223000	12.81	9.67	9.60	9.58
1800	5910	223000	12.46	9.56	9.51	9.52
1815	--	217000	12.13	9.46	9.46	9.51
1830	--	207000	11.86	9.36	9.42	9.51
1845	--	190000	11.55	9.30	9.42	9.58
1900	--	169000	11.31	9.30	9.50	9.72
1915	--	--	--	--	--	--
1930	--	--	--	--	--	--
1945	--	--	--	--	--	--
2000	4460	--	--	--	--	--

D. June 21-22,1967

Time	Discharge (cubic feet per second)			Stage (feet above datum			
	Green Island	Rhinecliff	Poughkeepsie	Albany	Rhinecliff	Poughkeepsie	New Hamburg
0730	6710	117000	--	10.39	9.17	--	--
0745	6720	83000	--	10.16	9.27	--	--
0800	6720	50000	--	9.92	9.47	10.45	10.84
0815	6700	16000	-37000	9.67	9.66	10.68	11.07
0830	6650	-15000	-70800	9.51	9.92	10.89	11.26
0845	6600	-55000	-106000	9.26	10.18	11.06	11.44
0900	6540	-76000	-142000	9.04	10.44	11.25	11.61
0915	6480	-107000	-168000	8.87	10.70	11.44	11.81
0930	6410	-136000	-196000	8.78	10.95	11.60	11.96
0945	6370	-164000	-213000	8.54	11.18	11.75	12.11
1000	6320	-189000	-232000	8.36	11.38	11.91	12.20

Table 1.--Stage and discharge data used in calibration of Hudson River flow model (continued)

D. June 21-22,1967 (continued)

Time	Discharge (cubic feet per second)			Stage (feet above datum			
	Green Island	Rhinecliff	Poughkeepsie	Albany	Rhinecliff	Poughkeepsie	New Hamburg
1015	6300	-203000	-241000	8.29	11.62	12.02	12.30
1030	6280	-213000	-247000	8.23	11.82	12.13	12.39
1045	6270	-218000	-252000	8.30	12.00	12.25	12.46
1100	6270	-220000	-250000	8.60	12.20	12.35	12.52
1115	6260	-219000	-243000	9.04	12.37	12.39	12.56
1130	6260	-217000	-231000	9.56	12.48	12.48	12.59
1145	6260	-209000	-211000	10.01	12.59	12.52	12.58
1200	6240	-198000	-190000	10.61	12.68	12.53	12.54
1215	6210	-182000	-166000	11.21	12.74	12.51	12.49
1230	6170	-159000	-140000	11.69	12.78	12.47	12.40
1245	6130	-133000	-113000	12.18	12.78	12.31	12.28
1300	6090	-108000	-83900	12.51	12.73	12.22	12.13
1315	6050	-82000	-48300	12.79	12.65	12.09	11.95
1330	6030	-58000	-16200	13.03	12.56	11.89	11.74
1345	6010	-30000	25100	13.21	12.39	11.66	11.56
1400	6000	-6000	52300	13.38	12.22	11.43	11.34
1415	6010	22000	80700	13.55	12.04	11.33	11.14
1430	6020	47000	113000	13.67	11.82	11.10	10.96
1445	6030	69000	143000	13.79	11.57	10.90	10.81
1500	6050	88000	168000	13.91	11.31	10.70	10.65
1515	6060	108000	184000	13.99	11.10	10.50	10.49
1530	6080	123000	202000	14.01	10.87	10.36	10.35
1545	6100	140000	215000	14.01	10.70	10.20	10.26
1600	6120	155000	223000	13.95	10.54	10.02	10.05
1615	6130	170000	231000	13.80	10.39	9.90	9.92
1630	6150	185000	243000	13.61	10.26	9.78	9.84
1645	6170	199000	251000	13.31	10.09	9.68	9.78
1700	6190	206000	250000	13.05	9.95	9.59	9.66

Time	Discharge (cubic feet per second)			Stage (feet above datum			
	Green Island	Rhinecliff	Poughkeepsie	Albany	Rhinecliff	Poughkeepsie	New Hamburg
1715	6210	208000	249000	12.68	9.79	9.50	9.55
1730	6220	206000	247000	12.35	9.64	9.40	9.52
1745	6240	202000	247000	11.98	9.50	9.33	9.52
1800	6250	195000	234000	11.67	9.36	9.31	9.52
1815	6250	184000	217000	11.39	9.20	9.31	9.62
1830	6240	170000	193000	11.18	9.11	9.34	9.79
1845	6230	152000	156000	10.92	9.06	9.58	10.05
1900	6210	131000	108000	10.74	9.06	9.85	10.39
1915	6200	108000	59800	10.52	9.11	10.20	10.80
1930	6190	84000	10500	10.30	9.29	10.59	11.12
1945	6190	56000	-50000	10.12	9.60	10.86	11.38
2000	6180	--	-88200	9.91	9.97	11.09	11.63
2015	6200	--	-137000	9.70	10.34	11.36	11.86
2030	6210	--	-178000	9.53	10.67	11.60	12.09
2045	6220	--	-219000	9.32	11.00	11.85	12.30
2100	6240	--	-243000	9.15	11.34	12.09	12.50
2115	6260	--	-272000	8.94	11.60	12.33	12.70
2130	6280	--	-289000	8.78	11.90	12.52	12.87
2145	6300	--	-306000	8.62	12.15	12.70	13.03
2200	6320	--	-315000	8.55	12.42	12.85	13.14
2215	6340	--	-318000	8.49	12.66	13.01	13.27
2230	6360	--	-312000	8.62	12.90	13.15	13.39
2245	6390	--	-306000	9.11	13.11	13.29	13.49
2300	6420	--	-283000	9.70	13.31	13.39	13.56
2315	6450	--	-275000	10.19	13.46	13.51	13.63
2330	6480	--	-279000	10.79	13.63	13.61	13.69
2345	6500	--	-247000	11.26	13.73	13.64	13.73
2400	6520	--	-227000	12.01	13.86	13.67	13.74
0015	6550	--	-204000	12.62	13.93	13.70	13.71
0030	6580	--	-158000	13.01	13.98	13.65	13.65
0045	6620	--	-157000	13.36	13.98	13.62	13.56
0100	6660	--	-124000	13.65	13.99	13.50	13.45
0115	6700	--	-88600	13.99	13.91	13.37	13.26

Table 1.--Stage and discharge data used in calibration of Hudson River flow model (contined)

D. June 21-22,1967 (continued)

Time	Discharge (cubic feet per second)			Stage (feet above datum			
	Green Island	Rhinecliff	Poughkeepsie	Albany	Rhinecliff	Poughkeepsie	New Hamburg
0130	6740	--	-65300	14.12	13.84	13.18	13.05
0145	6770	--	-22800	14.29	13.72	12.96	12.79
0200	6780	--	19100	14.52	13.60	12.71	12.55
0215	6780	--	57300	14.71	13.38	12.47	12.32
0230	6760	--	96100	14.90	13.16	12.22	12.07
0245	6710	--	136000	15.02	12.86	11.99	11.86
0300	6660	--	170000	15.13	12.62	11.78	11.68
0315	6620	--	196000	15.25	12.36	11.57	11.50
0330	6580	--	216000	15.34	12.07	11.39	11.34
0345	6540	--	232000	15.34	11.88	11.22	11.18
0400	6510	--	242000	15.34	11.70	11.05	11.02
0415	6500	--	258000	15.21	11.50	10.91	10.88
0430	6500	--	265000	15.09	11.34	10.71	10.76
0445	6500	--	280000	14.84	11.14	10.65	10.65
0500	6510	--	279000	14.56	10.97	10.51	10.53
0515	6520	--	279000	14.25	10.76	10.38	10.41
0530	6540	--	280000	13.91	10.61	10.23	10.29
0545	6550	--	277000	13.56	10.45	10.09	10.16
0600	6580	188000	274000	13.23	10.29	9.97	10.05
0615	6600	199000	267000	12.87	10.10	9.85	9.97
0630	6620	206000	247000	12.61	9.94	9.75	9.89
0645	6640	210000	245000	12.32	9.80	9.67	9.83
0700	6660	210000	231000	12.10	9.66	9.61	9.80
0715	6690	205000	217000	11.83	9.54	9.57	9.80
0730	6700	198000	201000	11.61	9.43	9.57	9.85
0745	6710	185000	180000	11.41	9.37	9.62	9.95
0800	6720	170000	150000	11.19	9.30	9.74	10.11
0815	6700	148000	119000	10.99	9.30	9.90	10.33

Time	Discharge (cubic feet per second)			Stage (feet above datum			
	Green Island	Rhinecliff	Poughkeepsie	Albany	Rhinecliff	Poughkeepsie	New Hamburg
0830	6670	123000	79400	10.81	9.35	10.12	10.57
0845	6620	96000	37800	10.57	9.45	10.36	10.83
0900	6570	64000	-88	10.39	9.64	10.62	11.06
0915	6510	26000	-41100	10.20	9.86	10.82	11.27
0930	6430	-21000	-80200	10.03	10.11	11.05	11.49
0945	6370	-66000	-123000	9.82	10.38	11.29	11.69
1000	6310	-144000	-153000	9.57	10.65	11.49	11.89
1015	6260	--	-180000	9.47	10.95	11.68	12.05
1030	6200	--	-204000	9.33	11.20	11.84	12.20
1045	6150	--	-228000	9.16	11.38	12.03	12.31
1100	6090	--	-247000	9.06	11.69	12.14	12.42

E. August 21,1979

Time	Discharge (cubic feet per second)			Stage (feet above datum)		
	Albany	Red Hook	Poughkeepsie	Albany	West Camp	New Hamburg
0600	16300	--	215000	12.14	10.21	9.82
0615	15200	--	198000	11.87	10.04	9.84
0630	14600	--	176000	11.61	9.87	9.94
0645	13900	--	151000	11.39	9.70	10.08
0700	13100	--	123000	11.18	9.56	10.24
0715	13100	--	91400	10.97	9.43	10.42
0730	13000	--	57200	10.78	9.32	10.61
0745	13200	--	19200	10.58	9.24	10.84
0800	13400	69000	-21900	10.38	9.22	11.04
0815	13800	46500	-59300	10.17	9.24	11.28
0830	14200	21500	-93600	9.98	9.34	11.50
0845	14400	-5500	-122000	9.75	9.54	11.66

Table 1.--Stage and discharge data used in calibration of Hudson River flow model (contined)

E. August 21, 1979 (continued)

Time	Discharge (cubic feet per second)			Stage (feet above datum)		
	Albany	Red Hook	Poughkeepsie	Albany	West Camp	New Hamburg
0900	14000	-34000	-147000	9.55	9.73	11.79
0915	13500	-61000	-168000	9.33	10.04	11.94
0930	13000	-83000	-190000	9.13	10.34	12.06
0945	12600	-106000	-207000	8.94	10.65	12.19
1000	12100	-120000	-220000	8.77	10.90	12.32
1015	11600	-135000	-233000	8.64	11.19	12.44
1030	9970	-147000	-238000	8.52	11.41	12.53
1045	7860	-155000	-239000	8.48	11.59	12.61
1100	3170	-160000	-233000	8.53	11.83	12.66
1115	-1320	-163000	-224000	8.69	12.02	12.69
1130	-9540	-162000	-212000	9.00	12.17	12.70
1145	-15800	-157000	-192000	9.42	12.36	12.69
1200	-19000	-148000	-172000	9.88	12.51	12.65
1215	-19100	-138000	-142000	10.38	12.63	12.58
1230	-15600	-128000	-126000	10.91	12.72	12.51
1245	-10600	-116000	-100500	11.45	12.79	12.41
1300	-6650	-102000	-74500	11.91	12.84	12.28
1315	-3250	-87000	-45200	12.29	12.84	12.15
1330	-1480	-71500	-18500	12.59	12.84	11.97
1345	-710	-54000	10600	12.82	12.84	11.78
1400	-390	-36500	41900	13.03	12.77	11.58
1415	200	-16000	76000	13.20	12.66	11.40
1430	1030	5500	106000	13.35	12.53	11.23
1445	1540	27500	133000	13.50	12.38	11.09
1500	1790	50000	157000	13.63	12.22	10.96
1515	1890	71000	178000	13.74	12.05	10.82
1530	2430	89500	196000	13.83	11.88	10.69
1545	3520	108000	209000	13.87	11.72	10.53

Time	Discharge (cubic feet per second)			Stage (feet above datum)		
	Albany	Red Hook	Poughkeepsie	Albany	West Camp	New Hamburg
1600	5140	124000	220000	13.88	11.54	10.40
1615	7800	137000	230000	13.82	11.38	10.27
1630	11200	147000	234000	13.72	11.22	10.15
1645	13900	156000	237000	13.54	11.05	10.06
1700	16600	163000	239000	13.31	10.90	9.98
1715	18300	168000	236000	13.03	10.71	9.92
1730	19600	172000	228000	12.72	10.53	9.86
1745	19800	174000	217000	12.41	10.36	9.82
1800	19000	173000	197000	12.08	10.19	9.82
1815	18100	--	174000	11.77	10.02	9.89
1830	16300	--	146000	11.48	9.85	10.06
1845	15600	--	114000	11.23	9.70	10.30
1900	13900	--	76200	11.00	9.56	10.54

F. March 26,1980

Time	Discharge (cubic feet per second)	Stage (feet above datum)		Time	Discharge (cubic feet per second)	Stage (feet above datum)	
	Albany	Albany	New Hamburg		Albany	Albany	New Hamburg
0600	--	12.35	12.22	1200	40900	14.77	11.37
0615	--	12.22	12.30	1215	42400	14.81	11.26
0630	--	12.11	12.42	1230	44000	14.81	11.16
0645	--	12.00	12.51	1245	45400	14.78	11.07
0700	50500	11.90	12.58	1300	46700	14.71	10.97
0715	50400	11.81	12.70	1315	47800	14.64	10.87
0730	50200	11.73	12.76	1330	48400	14.55	10.77
0745	49600	11.66	12.81	1345	48900	14.43	10.69

Table 1.--Stage and discharge data used in calibration of Hudson River flow model (Continued)

F. March 26, 1980 (continued)

Time	Discharge (cubic feet per second)	Stage (feet above datum)		Time	Discharge (cubic feet per second)	Stage (feet above datum)	
	Albany	Albany	New Hamburg		Albany	Albany	New Hamburg
0800	48100	11.62	12.85	1400	49100	14.29	10.59
0815	46000	11.59	12.89	1415	49100	14.14	10.48
0830	43700	11.61	12.90	1430	49000	13.99	10.44
0845	41300	11.68	12.90	1445	48900	13.83	10.34
0900	38400	11.81	12.90	1500	48700	13.66	10.26
0915	35200	12.03	12.85	1515	48400	13.50	10.23
0930	31600	12.32	12.75	1530	48100	13.33	10.17
0945	28700	12.65	12.64	1545	47800	13.16	10.11
1000	28200	12.99	12.52	1600	47600	12.99	10.08
1015	29600	13.34	12.42	1615	47400	12.83	10.07
1030	31100	13.68	12.29	1630	47200	12.66	10.14
1045	32600	13.98	12.14	1645	47000	12.50	10.22
1100	34200	14.23	11.98	1700	46800	12.34	10.29
1115	35800	14.44	11.80	1715	46600	12.18	10.45
1130	37600	14.60	11.63	1730	46400	12.02	10.62
1145	39300	14.71	11.49	1745	46200	11.87	10.80
				1800	--	11.72	10.98

G. April 18,1980

Time	Discharge (cubic feet per second)	Stage (feet above datum)		Time	Discharge (cubic feet per second)	Stage (feet above datum	
	Catskill	Albany	West Camp		Catskill	Albany	West Camp
0400	--	13.92	13.57	1115	112000	11.35	8.96
0415	--	14.20	13.56	1130	107000	11.16	8.95
0430	--	14.42	13.50	1145	102000	10.98	8.97
0445	--	14.62	13.38	1200	96000	10.80	9.09
0500	--	14.77	13.23	1215	88000	10.61	9.31
0515	--	14.89	13.06	1230	76000	10.44	9.62
0530	--	15.00	12.87	1245	58000	10.27	9.97
0545	--	15.09	12.70	1300	29000	10.11	10.31
0600	81000	15.15	12.54	1315	-2000	9.95	10.62
0615	105000	15.18	12.36	1330	-29000	9.82	10.93
0630	121000	15.16	12.17	1345	-48000	9.68	11.22
0645	131000	15.10	11.95	1400	-63000	9.57	11.51
0700	139000	15.00	11.73	1415	-76000	9.48	11.72
0715	146000	14.86	11.52	1430	-89000	9.44	11.94
0730	150000	14.67	11.32	1445	-100000	9.45	12.14
0745	153000	14.46	11.12	1500	-110000	9.61	12.33
0800	153000	14.24	10.91	1515	-114000	9.96	12.47
0815	151000	13.99	10.72	1530	-117000	10.45	12.59
0830	148000	13.74	10.55	1545	-116000	10.97	12.73
0845	145000	13.49	10.36	1600	-113000	11.50	12.77
0900	142000	13.25	10.18	1615	-107000	12.03	12.80
0915	136000	13.02	10.01	1630	-98000	12.57	12.80
0930	132000	12.80	9.83	1645	-88000	13.03	12.80
0945	132000	12.58	9.65	1700	-78000	13.41	12.72
1000	131000	12.36	9.50	1715	-65000	13.70	12.62
1015	130000	12.15	9.35	1730	-50000	13.93	12.49
1030	126000	11.95	9.21	1745	-32000	14.10	12.26
1045	122000	11.74	9.10	1800	-12000	14.22	12.06
1100	117000	11.54	9.02				

Table 2.--Model input data for subreach 1,
Albany to West Camp, N.Y.

UNITS OF INPUT (EN/ME)	=	EN
UNITS OF OUTPUT (EN/ME)	=	EN
BRANCHES (1<=N<=25)	=	9
JUNCTIONS (2<=N<=25)	=	10
BOUNDARY VALUES (1<=N<=10)	=	6
GEOMETRY INPUT UNIT (5/10)	=	5
PRINTOUT OPTION (0<=N<=4)	=	3
PLOT OPTION (0<=N<=4)	=	3
PLOTTER DEVICE (0<=N<=3)	=	0
PRINT MESSAGE OPTION (0/1)	=	0
PLOT MESSAGE OPTION (0/1)	=	0
EXTRAPOLATION OPTION (0/1)	=	0
PUNCH INITIAL COND. (0/1)	=	0
FRICTION TYPE (1<=N<=6)	=	1
MAXIMUM ITERATIONS	=	5
NUMBER OF STEPS	=	121
DERIVATIVE FACTOR (0<=N<=1)	=	0.60
GEOMETRY FACTOR (0<=N<=1)	=	0.60
TIME INCREMENT(MINUTES)	=	15
DISCHARGE CONVERGENCE	=	250.0
STAGE CONVERGENCE	=	0.0200
WIND SPEED(MPH/KPH)	=	0.0
SURFACE DRAG COEFFICIENT	=	0.0026
WATER DENSITY	=	1.9617
STAGE COMPUTATION DATUM	=	0.0
BVD(1) DATUM CORRECTION	=	-9.930
BVD(10) DATUM CORRECTION	=	-9.930

BRANCH 1 FROM JUNCTION 1 TO 3 : HUDSON RIVER - ALBANY TO CASTLETON :BR1

CROSS SECTION 1 :	STAGE (FT)	AREA (FT^2)	WIDTH (FT)
	-10.00	9200.0	900.0
	-8.00	11000.0	920.0
	-6.00	12900.0	980.0
	-4.00	14900.0	1010.0
	-2.00	17000.0	1060.0
	0.0	19100.0	1080.0
	2.00	21300.0	1100.0
	4.00	23500.0	1130.0
	6.00	25800.0	1170.0
	8.00	28200.0	1200.0
	10.00	30600.0	1230.0

LENGTH= 12140.0 FT; ETA= 0.250000E-01

Table 2.--Model input data for subreach 1,
Albany to West Camp, N.Y. (continued)

CROSS SECTION 2 :	STAGE (FT)	AREA (FT^2)	WIDTH (FT)
	-10.00	19600.0	980.0
	-8.00	21600.0	980.0
	-6.00	23500.0	980.0
	-4.00	25500.0	990.0
	-2.00	27500.0	990.0
	0.0	29500.0	1000.0
	2.00	31500.0	1000.0
	4.00	33500.0	1010.0
	6.00	35500.0	1010.0
	8.00	37500.0	1020.0
	10.00	39600.0	1030.0

LENGTH= 6340.0 FT; ETA= 0.240000E-01

CROSS SECTION 3 :	STAGE (FT)	AREA (FT^2)	WIDTH (FT)
	-10.00	14200.0	750.0
	-8.00	15700.0	770.0
	-6.00	17400.0	830.0
	-4.00	19000.0	840.0
	-2.00	20700.0	850.0
	0.0	22400.0	860.0
	2.00	24100.0	870.0
	4.00	25900.0	900.0
	6.00	27700.0	930.0
	8.00	29600.0	970.0
	10.00	31600.0	1000.0

LENGTH= 24800.0 FT; ETA= 0.240000E-01

CROSS SECTION 4 :	STAGE (FT)	AREA (FT^2)	WIDTH (FT)
	-10.00	14100.0	860.0
	-8.00	15900.0	980.0
	-6.00	18100.0	1160.0
	-4.00	20400.0	1170.0
	-2.00	22800.0	1180.0
	0.0	25100.0	1190.0
	2.00	27500.0	1200.0
	4.00	29900.0	1220.0
	6.00	32400.0	1250.0
	8.00	34900.0	1280.0
	10.00	37900.0	1700.0

Table 2.--Model input data for subreach 1,
Albany to West Camp, N.Y. (continued)

BRANCH 2 FROM JUNCTION 2 TO 3 : HUDSON RIVER-STORAGE NR CASTLETON

CROSS SECTION 1 :	STAGE (FT)	AREA (FT^2)	WIDTH (FT)
	-5.00	0.0	0.0
	0.0	5200.0	1200.0
	2.00	9200.0	1600.0
	10.00	30000.0	2400.0

LENGTH= 8000.0 FT; ETA= 0.250000E-01

CROSS SECTION 2 :	STAGE (FT)	AREA (FT^2)	WIDTH (FT)
	-10.00	1600.0	600.0
	0.0	20000.0	2000.0
	2.00	24800.0	2400.0
	10.00	50000.0	3200.0

BRANCH 3 FROM JUNCTION 3 TO 5 : HUDSON RIVER-CASTLETON TO SCHODACK

CROSS SECTION 1 :	STAGE (FT)	AREA (FT^2)	WIDTH (FT)
	-10.00	14100.0	860.0
	-8.00	15900.0	980.0
	-6.00	18100.0	1160.0
	-4.00	20400.0	1170.0
	-2.00	22800.0	1180.0
	0.0	25100.0	1190.0
	2.00	27500.0	1200.0
	4.00	29900.0	1220.0
	6.00	32400.0	1250.0
	8.00	34900.0	1280.0
	10.00	37900.0	1700.0

LENGTH= 22700.0 FT; ETA= 0.240000E-01

Table 2.--Model input data for subreach 1,
Albany to West Camp, N.Y. (continued)

CROSS SECTION 2 :	STAGE (FT)	AREA (FT^2)	WIDTH (FT)
	-10.00	15800.0	730.0
	-8.00	17300.0	770.0
	-6.00	18900.0	890.0
	-4.00	20800.0	990.0
	-2.00	22900.0	1170.0
	0.0	25500.0	1410.0
	2.00	28400.0	1460.0
	4.00	31400.0	1530.0
	6.00	34500.0	1620.0
	8.00	37800.0	1700.0
	10.00	41700.0	2150.0

LENGTH= 12150.0 FT; ETA= 0.230000E-01

CROSS SECTION 3 :	STAGE (FT)	AREA (FT^2)	WIDTH (FT)
	-10.00	18400.0	930.0
	-8.00	20300.0	950.0
	-6.00	22200.0	980.0
	-4.00	24200.0	1050.0
	-2.00	26400.0	1120.0
	0.0	28700.0	1160.0
	2.00	31000.0	1180.0
	4.00	33400.0	1230.0
	6.00	35900.0	1290.0
	8.00	38500.0	1350.0
	10.00	41600.0	1720.0

LENGTH= 7390.0 FT; ETA= 0.230000E-01

CROSS SECTION 4 :	STAGE (FT)	AREA (FT^2)	WIDTH (FT)
	-10.00	25600.0	1390.0
	-8.00	28400.0	1440.0
	-6.00	31600.0	1700.0
	-4.00	35300.0	1880.0
	-2.00	39100.0	1910.0
	0.0	43200.0	2160.0
	2.00	47600.0	2230.0
	4.00	52200.0	2310.0
	6.00	57100.0	2570.0
	8.00	62200.0	2570.0
	10.00	67400.0	2580.0

Table 2.--Model input data for subreach 1,
Albany to West Camp, N.Y. (continued)

BRANCH 4 FROM JUNCTION 4 TO 5 : HUDSON RIVER-STORAGE NR SCHODACK

CROSS SECTION 1 :	STAGE (FT)	AREA (FT^2)	WIDTH (FT)
	-10.00	0.0	0.0
	-2.00	600.0	450.0
	0.0	3300.0	1200.0
	2.00	6000.0	1500.0
	4.00	10800.0	2100.0
	6.00	21000.0	4800.0
	8.00	33000.0	5400.0
	10.00	45000.0	6000.0

LENGTH= 24000.0 FT; ETA= 0.250000E-01

CROSS SECTION 2 :	STAGE (FT)	AREA (FT^2)	WIDTH (FT)
	-10.00	2200.0	500.0
	-2.00	12600.0	1500.0
	0.0	15000.0	1800.0
	2.00	20000.0	2100.0
	4.00	24000.0	2500.0
	6.00	32000.0	3000.0
	8.00	37000.0	3600.0
	10.00	45000.0	3900.0

BRANCH 5 FROM JUNCTION 5 TO 7 : HUDSON RIVER - SCHODACK TO STOCKPORT

CROSS SECTION 1 :	STAGE (FT)	AREA (FT^2)	WIDTH (FT)
	-10.00	25600.0	1390.0
	-8.00	28400.0	1440.0
	-6.00	31600.0	1700.0
	-4.00	35300.0	1880.0
	-2.00	39100.0	1910.0
	0.0	43200.0	2160.0
	2.00	47600.0	2230.0
	4.00	52200.0	2310.0
	6.00	57100.0	2570.0
	8.00	62200.0	2570.0
	10.00	67400.0	2580.0

LENGTH= 20060.0 FT; ETA= 0.230000E-01

Table 2.--Model input data for subreach 1,
Albany to West Camp, N.Y. (continued)

CROSS SECTION 2 :	STAGE (FT)	AREA (FT^2)	WIDTH (FT)
	-10.00	22800.0	1440.0
	-8.00	25700.0	1480.0
	-6.00	28800.0	1600.0
	-4.00	32200.0	1820.0
	-2.00	36000.0	1910.0
	0.0	39900.0	1990.0
	2.00	43900.0	2080.0
	4.00	48200.0	2160.0
	6.00	52600.0	2250.0
	8.00	56700.0	2330.0
	10.00	62700.0	2770.0

LENGTH= 22710.0 FT; ETA= 0.220000E-01

CROSS SECTION 3 :	STAGE (FT)	AREA (FT^2)	WIDTH (FT)
	-10.00	31700.0	1580.0
	-8.00	34900.0	1680.0
	-6.00	38400.0	1790.0
	-4.00	42100.0	1930.0
	-2.00	46000.0	2020.0
	0.0	50300.0	2090.0
	2.00	54400.0	2150.0
	4.00	58800.0	2220.0
	6.00	63300.0	2280.0
	8.00	67400.0	2340.0
	10.00	74200.0	3150.0

BRANCH 6 FROM JUNCTION 6 TO 7 : HUDSON RIVER-STORAGE NR STOCKPORT

CROSS SECTION 1 :	STAGE (FT)	AREA (FT^2)	WIDTH (FT)
	-3.00	2000.0	1000.0
	0.0	6000.0	2000.0
	10.00	26000.0	2000.0

LENGTH= 14000.0 FT; ETA= 0.250000E-01

CROSS SECTION 2 :	STAGE (FT)	AREA (FT^2)	WIDTH (FT)
	-6.00	1600.0	1600.0
	-2.00	10000.0	2400.0
	0.0	20000.0	4000.0
	10.00	70000.0	6000.0

Table 2.--Model input data for subreach 1,
Albany to West Camp, N.Y. (continued)

BRANCH 7 FROM JUNCTION 7 TO 9 : HUDSON RIVER - STOCKPORT TO CATSKILL

CROSS SECTION 1 :	STAGE (FT)	AREA (FT^2)	WIDTH (FT)
	-10.00	31700.0	1580.0
	-8.00	34900.0	1680.0
	-6.00	38400.0	1790.0
	-4.00	42100.0	1930.0
	-2.00	46000.0	2020.0
	0.0	50300.0	2090.0
	2.00	54400.0	2150.0
	4.00	58800.0	2220.0
	6.00	63300.0	2280.0
	8.00	67400.0	2340.0
	10.00	74200.0	3150.0

LENGTH= 22700.0 FT; ETA= 0.220000E-01

CROSS SECTION 2 :	STAGE (FT)	AREA (FT^2)	WIDTH (FT)
	-10.00	35300.0	2620.0
	-8.00	40600.0	2700.0
	-6.00	46100.0	2780.0
	-4.00	51800.0	2900.0
	-2.00	57700.0	3010.0
	0.0	63700.0	3030.0
	2.00	69800.0	3040.0
	4.00	75900.0	3060.0
	6.00	82000.0	3080.0
	8.00	88200.0	3090.0
	10.00	94400.0	3110.0

LENGTH= 15310.0 FT; ETA= 0.210000E-01

CROSS SECTION 3 :	STAGE (FT)	AREA (FT^2)	WIDTH (FT)
	-10.00	25000.0	970.0
	-8.00	27100.0	1170.0
	-6.00	29700.0	1610.0
	-4.00	33700.0	2300.0
	-2.00	39300.0	3000.0
	0.0	45500.0	3250.0
	2.00	52100.0	3270.0
	4.00	58600.0	3280.0
	6.00	65200.0	3290.0
	8.00	71800.0	3310.0
	10.00	78400.0	3320.0

LENGTH= 7390.0 FT; ETA= 0.210000E-01

Table 2.--Model input data for subreach 1,
Albany to West Camp, N.Y. (continued)

CROSS SECTION 4 :	STAGE (FT)	AREA (FT^2)	WIDTH (FT)
	-10.00	38000.0	1610.0
	-8.00	41200.0	1670.0
	-6.00	44700.0	1740.0
	-4.00	48200.0	1820.0
	-2.00	52000.0	1970.0
	0.0	56000.0	2030.0
	2.00	60100.0	2070.0
	4.00	64300.0	2110.0
	6.00	68600.0	2160.0
	8.00	73900.0	3220.0
	10.00	81400.0	4270.0

BRANCH 8 FROM JUNCTION 8 TO 9 : HUDSON RIVER-STORAGE NEAR CATSKILL

CROSS SECTION 1 :	STAGE (FT)	AREA (FT^2)	WIDTH (FT)
	-10.00	500.0	200.0
	-2.00	1800.0	300.0
	0.0	3000.0	800.0
	2.00	5300.0	1100.0
	10.00	15000.0	1200.0

LENGTH= 13000.0 FT; ETA= 0.250000E-01

CROSS SECTION 2 :	STAGE (FT)	AREA (FT^2)	WIDTH (FT)
	-10.00	1000.0	400.0
	-2.00	3300.0	500.0
	0.0	5100.0	1000.0
	2.00	8000.0	1500.0
	10.00	20200.0	1600.0

Table 2.--Model input data for subreach 1,
Albany to West Camp, N.Y. (continued)

BRANCH 9 FROM JUNCTION 9 TO 10 : HUDSON RIVER - CATSKILL TO W.CAMP

CROSS SECTION 1 :	STAGE (FT)	AREA (FT^2)	WIDTH (FT)
	-10.00	38000.0	1610.0
	-8.00	41200.0	1670.0
	-6.00	44700.0	1740.0
	-4.00	48200.0	1820.0
	-2.00	52000.0	1970.0
	0.0	56000.0	2030.0
	2.00	60100.0	2070.0
	4.00	64300.0	2110.0
	6.00	68600.0	2160.0
	8.00	73900.0	3220.0
	10.00	81400.0	4270.0

LENGTH= 13730.0 FT; ETA= 0.200000E-01

CROSS SECTION 2 :	STAGE (FT)	AREA (FT^2)	WIDTH (FT)
	-10.00	41200.0	2120.0
	-8.00	45500.0	2190.0
	-6.00	50000.0	2340.0
	-4.00	54900.0	2760.0
	-2.00	61300.0	3690.0
	0.0	69000.0	3860.0
	2.00	76800.0	3880.0
	4.00	84600.0	3900.0
	6.00	92400.0	3920.0
	8.00	100000.0	3940.0
	10.00	108000.0	3950.0

LENGTH= 26930.0 FT; ETA= 0.190000E-01

CROSS SECTION 3 :	STAGE (FT)	AREA (FT^2)	WIDTH (FT)
	-10.00	39000.0	2110.0
	-8.00	43300.0	2170.0
	-6.00	47700.0	2240.0
	-4.00	52300.0	2360.0
	-2.00	57400.0	2840.0
	0.0	63900.0	3340.0
	2.00	70600.0	3370.0
	4.00	77400.0	3400.0
	6.00	84200.0	3410.0
	8.00	91000.0	3430.0
	10.00	97900.0	3450.0

Table 3.--Model input data for subreach 2,
West Camp to New Hamburg, N.Y.

UNITS OF INPUT (EN/ME)	=	EN
UNITS OF OUTPUT (EN/ME)	=	EN
BRANCHES (1<=N<=25)	=	5
JUNCTIONS (2<=N<=25)	=	6
BOUNDARY VALUES (1<=N<=10)	=	2
GEOMETRY INPUT UNIT (5/10)	=	5
PRINTOUT OPTION (0<=N<=4)	=	3
PLOT OPTION (0<=N<=4)	=	3
PLOTTER DEVICE (0<=N<=3)	=	0
PRINT MESSAGE OPTION (0/1)	=	0
PLOT MESSAGE OPTION (0/1)	=	0
EXTRAPOLATION OPTION (0/1)	=	0
PUNCH INITIAL COND. (0/1)	=	0
FRICTION TYPE (1<=N<=6)	=	1
MAXIMUM ITERATIONS	=	5
NUMBER OF STEPS	=	96
DERIVATIVE FACTOR (0<=N<=1)	=	0.60
GEOMETRY FACTOR (0<=N<=1)	=	0.60
TIME INCREMENT(MINUTES)	=	15
DISCHARGE CONVERGENCE	=	250.0
STAGE CONVERGENCE	=	0.0200
WIND SPEED(MPH/KPH)	=	0.0
SURFACE DRAG COEFFICIENT	=	0.0026
WATER DENSITY	=	1.9617
STAGE COMPUTATION DATUM	=	0.0
BVD(1) DATUM CORRECTION	=	-9.930
BVD(6) DATUM CORRECTION	=	-10.150

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BRANCH 1 FROM JUNCTION 1 TO 2 : HUDSON RIVER - W.CAMP TO SAUGERTIES

CROSS SECTION 1 : STAGE (FT)	AREA (FT^2)	WIDTH (FT)
-10.00	39000.0	2110.0
-8.00	43300.0	2170.0
-6.00	47700.0	2240.0
-4.00	52300.0	2360.0
-2.00	57400.0	2840.0
0.0	63900.0	3340.0
2.00	70600.0	3370.0
4.00	77400.0	3400.0
6.00	84200.0	3410.0
8.00	91000.0	3430.0
10.00	97900.0	3450.0

LENGTH= 14780.0 FT; ETA= 0.180000E-01

Table 3.--Model input data for subreach 2,
West Camp to New Hamburg, N.Y. (continued)

CROSS SECTION 2 :	STAGE (FT)	AREA (FT^2)	WIDTH (FT)
	-10.00	43300.0	2200.0
	-8.00	47700.0	2250.0
	-6.00	52300.0	2300.0
	-4.00	57100.0	2850.0
	-2.00	63700.0	3520.0
	0.0	71400.0	4320.0
	2.00	80400.0	4340.0
	4.00	89600.0	4360.0
	6.00	98800.0	4380.0
	8.00	108000.0	4400.0
	10.00	118000.0	4420.0

BRANCH 2 FROM JUNCTION 2 TO 3 : HUDSON RIVER - SAUGERTIES TO KINGSTN

CROSS SECTION 1 :	STAGE (FT)	AREA (FT^2)	WIDTH (FT)
	-10.00	43300.0	2200.0
	-8.00	47700.0	2250.0
	-6.00	52300.0	2300.0
	-4.00	57100.0	2850.0
	-2.00	63700.0	3520.0
	0.0	71400.0	4320.0
	2.00	80400.0	4340.0
	4.00	89600.0	4360.0
	6.00	98800.0	4380.0
	8.00	108000.0	4400.0
	10.00	118000.0	4420.0

LENGTH= 26400.0 FT; ETA= 0.170000E-01

CROSS SECTION 2 :	STAGE (FT)	AREA (FT^2)	WIDTH (FT)
	-10.00	57200.0	3140.0
	-8.00	63500.0	3190.0
	-6.00	70000.0	3280.0
	-4.00	76700.0	3380.0
	-2.00	83500.0	3470.0
	0.0	90500.0	3530.0
	2.00	97600.0	3550.0
	4.00	105000.0	3570.0
	6.00	112000.0	3640.0
	8.00	119000.0	3730.0
	10.00	127000.0	3800.0

LENGTH= 13730.0 FT; ETA= 0.170000E-01

Table 3.--Model input data for subreach 2,
West Camp to New Hamburg, N.Y. (continued)

CROSS SECTION 3 :	STAGE (FT)	AREA (FT^2)	WIDTH (FT)
	-10.00	65000.0	2790.0
	-8.00	70700.0	2880.0
	-6.00	76600.0	3030.0
	-4.00	83500.0	3890.0
	-2.00	91400.0	3970.0
	0.0	99300.0	3980.0
	2.00	107000.0	3990.0
	4.00	115000.0	4010.0
	6.00	123000.0	4050.0
	8.00	132000.0	4090.0
	10.00	140000.0	4130.0

LENGTH= 16900.0 FT; ETA= 0.160000E-01

CROSS SECTION 4 :	STAGE (FT)	AREA (FT^2)	WIDTH (FT)
	-10.00	72400.0	2600.0
	-8.00	78000.0	2930.0
	-6.00	84200.0	3270.0
	-4.00	91000.0	3610.0
	-2.00	98600.0	3960.0
	0.0	107000.0	4300.0
	2.00	116000.0	4400.0
	4.00	124000.0	4440.0
	6.00	133000.0	4480.0
	8.00	142000.0	4520.0
	10.00	152000.0	4980.0

BRANCH 3 FROM JUNCTION 3 TO 4 : HUDSON RIVER - KINGSTON TO HYDE PARK

CROSS SECTION 1 :	STAGE (FT)	AREA (FT^2)	WIDTH (FT)
	-10.00	72400.0	2600.0
	-8.00	78000.0	2930.0
	-6.00	84200.0	3270.0
	-4.00	91000.0	3610.0
	-2.00	98600.0	3960.0
	0.0	107000.0	4300.0
	2.00	116000.0	4400.0
	4.00	124000.0	4440.0
	6.00	133000.0	4480.0
	8.00	142000.0	4520.0
	10.00	152000.0	4980.0

LENGTH= 21120.0 FT; ETA= 0.150000E-01

Table 3.--Model input data for subreach 2,
West Camp to New Hamburg, N.Y. (continued)

CROSS SECTION 2 :	STAGE (FT)	AREA (FT^2)	WIDTH (FT)
	-10.00	90000.0	2220.0
	-8.00	94400.0	2240.0
	-6.00	99000.0	2290.0
	-4.00	104000.0	2990.0
	-2.00	111000.0	3840.0
	0.0	120000.0	4910.0
	2.00	131000.0	6150.0
	4.00	144000.0	6180.0
	6.00	156000.0	6220.0
	8.00	169000.0	6260.0
	10.00	181000.0	6300.0

LENGTH= 10560.0 FT; ETA= 0.150000E-01

CROSS SECTION 3 :	STAGE (FT)	AREA (FT^2)	WIDTH (FT)
	-10.00	85300.0	2670.0
	-8.00	90700.0	2680.0
	-6.00	96000.0	2690.0
	-4.00	101000.0	2710.0
	-2.00	107000.0	2720.0
	0.0	112000.0	2730.0
	2.00	118000.0	2760.0
	4.00	123000.0	2780.0
	6.00	129000.0	2810.0
	8.00	135000.0	2840.0
	10.00	140000.0	2860.0

LENGTH= 13730.0 FT; ETA= 0.150000E-01

CROSS SECTION 4 :	STAGE (FT)	AREA (FT^2)	WIDTH (FT)
	-10.00	88500.0	2380.0
	-8.00	93200.0	2400.0
	-6.00	98100.0	2430.0
	-4.00	103000.0	2460.0
	-2.00	108000.0	2490.0
	0.0	113000.0	2500.0
	2.00	118000.0	2510.0
	4.00	123000.0	2520.0
	6.00	128000.0	2540.0
	8.00	133000.0	2560.0
	10.00	138000.0	2570.0

Table 3.--Model input data for subreach 2,
West Camp to New Hamburg, N.Y. (continued)

BRANCH 4 FROM JUNCTION 4 TO 5 : HUDSON RIVER - HYDE PARK TO POUKEPSE

CROSS SECTION 1 :	STAGE (FT)	AREA (FT^2)	WIDTH (FT)
	-10.00	88500.0	2380.0
	-8.00	93200.0	2400.0
	-6.00	98100.0	2430.0
	-4.00	103000.0	2460.0
	-2.00	108000.0	2490.0
	0.0	113000.0	2500.0
	2.00	118000.0	2510.0
	4.00	123000.0	2520.0
	6.00	128000.0	2540.0
	8.00	133000.0	2560.0
	10.00	138000.0	2570.0

LENGTH= 13730.0 FT; ETA= 0.150000E-01

CROSS SECTION 2 :	STAGE (FT)	AREA (FT^2)	WIDTH (FT)
	-10.00	99200.0	1690.0
	-8.00	103000.0	1700.0
	-6.00	106000.0	1730.0
	-4.00	110000.0	1760.0
	-2.00	113000.0	1770.0
	0.0	117000.0	1780.0
	2.00	120000.0	1790.0
	4.00	124000.0	1800.0
	6.00	128000.0	1810.0
	8.00	131000.0	1820.0
	10.00	135000.0	1830.0

LENGTH= 8980.0 FT; ETA= 0.150000E-01

CROSS SECTION 3 :	STAGE (FT)	AREA (FT^2)	WIDTH (FT)
	-10.00	102000.0	2420.0
	-8.00	107000.0	2460.0
	-6.00	111000.0	2510.0
	-4.00	117000.0	2540.0
	-2.00	122000.0	2600.0
	0.0	127000.0	2620.0
	2.00	132000.0	2640.0
	4.00	137000.0	2650.0
	6.00	143000.0	2660.0
	8.00	148000.0	2670.0
	10.00	153000.0	2680.0

LENGTH= 15840.0 FT; ETA= 0.150000E-01

Table 3.--Model input data for subreach 2,
West Camp to New Hamburg, N.Y. (continued)

CROSS SECTION 4 :	STAGE (FT)	AREA (FT^2)	WIDTH (FT)
	-10.00	109000.0	2540.0
	-8.00	115000.0	2550.0
	-6.00	120000.0	2570.0
	-4.00	125000.0	2580.0
	-2.00	130000.0	2590.0
	0.0	135000.0	2630.0
	2.00	140000.0	2650.0
	4.00	146000.0	2660.0
	6.00	151000.0	2670.0
	8.00	156000.0	2690.0
	10.00	162000.0	2700.0

BRANCH 5 FROM JUNCTION 5 TO 6 : HUDSON RIVER - POUKEPSE TO CLINTN PT

CROSS SECTION 1 :	STAGE (FT)	AREA (FT^2)	WIDTH (FT)
	-10.00	109000.0	2540.0
	-8.00	115000.0	2550.0
	-6.00	120000.0	2570.0
	-4.00	125000.0	2580.0
	-2.00	130000.0	2590.0
	0.0	135000.0	2630.0
	2.00	140000.0	2650.0
	4.00	146000.0	2660.0
	6.00	151000.0	2670.0
	8.00	156000.0	2690.0
	10.00	162000.0	2700.0

LENGTH= 13730.0 FT; ETA= 0.150000E-01

CROSS SECTION 2 :	STAGE (FT)	AREA (FT^2)	WIDTH (FT)
	-10.00	102000.0	2390.0
	-8.00	107000.0	2400.0
	-6.00	112000.0	2430.0
	-4.00	116000.0	2460.0
	-2.00	121000.0	2480.0
	0.0	126000.0	2510.0
	2.00	131000.0	2540.0
	4.00	137000.0	2550.0
	6.00	142000.0	2570.0
	8.00	147000.0	2580.0
	10.00	152000.0	2600.0

LENGTH= 15840.0 FT; ETA= 0.150000E-01

Table 3.--Model input data for subreach 2,
West Camp to New Hamburg, N.Y. (continued)

CROSS SECTION 3 :	STAGE (FT)	AREA (FT^2)	WIDTH (FT)
	-10.00	105000.0	2230.0
	-8.00	109000.0	2240.0
	-6.00	114000.0	2260.0
	-4.00	118000.0	2280.0
	-2.00	123000.0	2440.0
	0.0	128000.0	2460.0
	2.00	133000.0	2490.0
	4.00	138000.0	2510.0
	6.00	143000.0	2520.0
	8.00	148000.0	2540.0
	10.00	153000.0	2550.0