MYAKKA RIVER BASIN PROJECT

A Report on Physical and Chemical Processes
Affecting the Management of the Myakka River Basin

(Provisional Results from January 1989 - December 1989)

Susan S. Lowrey
Kimberly J. Babbitt
Jeffrey L. Lincer, Ph.D., Principal Investigator

Sarasota County Natural Resources Department
Ecological Monitoring Division
1301 Cattlemen Road
Sarasota, Florida 34232

Steven J. Schropp, Ph.D.
Fred D. Calder

Florida Department of Environmental Regulation
Coastal Zone Management Section
2600 Blairstone Road
Tallahassee, Florida 32301

Herbert L. Windom, Ph.D.

University of Georgia
Skidaway Institute of Oceanography
Savannah, Georgia 31406

R. Bruce Taylor, Ph.D., P.E.
Terrence Hull

Taylor Engineering
9086 Cypress Green Drive
Jacksonville, Florida 32216

this project are provided by the Florida Department of Environmental Regulation, Office l Management, using funds made available through the National Oceanic and Atmospheric ation under the Coastal Zone Management Act of 1972, as amended.

TABLE OF CONTENTS

APPENDICES

LIST OF TABLES

LIST OF FIGURES

EXECUTIVE SUMMARY

1. The Myakka River Basin Project was initiated in 1988 as the fourth state-wide "Estuarine Initiative" implemented by Florida Department of Environmental Regulation's (FDER's) Coastal Zone Management (CZM) Section, with funds made available through the National Oceanic and Atmospheric Administration (NOAA). The objective of the study is to provide a technical basis for holistic, basin-wide management of the Myakka River Basin.

2. The Myakka River Basin is a relatively undeveloped area in a region where unprecedented growth projections raise concern over the potential for increased environmental impacts. Little information was available on the river basin and no basin-wide studies had been conducted prior to this project.

3. The study area encompasses 1,559 km^2 in portions of five counties (Manatee, Hardee, Sarasota, DeSoto and Charlotte) in southwest Florida. The Myakka River, a meandering 70 mile blackwater river, is the smallest of three main tributaries of Charlotte Harbor, one of the largest and most productive estuaries in Florida.

4. Vegetation near the river goes from hardwood hammock, to oak/cabbage palm hammock, to freshwater marsh, to salt marsh/mangrove plant associations, as one travels downstream. Pine Flatwoods dominate the rest of the basin, with lesser amounts of prairie and improved pasture. Freshwater wetlands are widely distributed throughout the basin.

5. Soils throughout the watershed are sandy and poorly drained. Near the river in the upper reaches of the watershed, soils are typically alluvial and sandy with low organic content. At river mile 15.5, a transition to soils with high organic content occurs, indicating the transition from primarily fresh to primarily saltwater habitats.

6. Results from the first year (January 1989 to December 1989) are presented in this report. The first year of the project focused on collection and compilation of data on the physical and chemical processes affecting the basin. Particular emphasis was given to examining the transport of dissolved and particulate nutrients and suspended solids to the estuary.

7. Sampling was conducted 17 times at 18 stations. Eight stations were located in the basin as follows: Myakka River (4), Howard Creek (1), Deer Prairie Slough (1), and Big Slough (2). The remaining 10 stations were located in the tidal reach of the Myakka River (9) and in Charlotte Harbor (1).

8. Samples were also collected during 2 storm events to determine if these events produced more efficient delivery of materials to the estuary.

9. Drought characterized rainfall conditions in 1989. Rainfall at Myakka River State Park was 253 mm below the mean for the period of record (1943-1989). 1989 was the second consecutive year with rainfall below the long-term mean. Four of the previous six years have also been below the long-term mean.

10. Rainfall/runoff analyses indicate that antecedent soil moisture conditions are important to subbasin retention rates. Low soil moisture results in high retention rates (83% - 99%), while high soil moisture results in lower retention rates (32% -90%). Soil moisture was, generally, low prior to storm 1 and high prior to storm 2. However, Big Slough exhibited a constant level of soil moisture due to flowing wells throughout the subbasin.

11. A summary of physical water quality data for the watershed stations is contained in Appendix C. Maximum temperatures occurred between May and September. pH varied, generally, from 6 to about 9, with lowest pH occurring during high discharge (June - September), associated with high organic acid content in the water.

12. Conductivity values ranged from 128 to 1090 umhos, with lowest levels found during high discharge.

13. Dissolved oxygen values ranged from 0.05 to 15.40 ppm, with roughly one-third falling below 5 ppm, and lowest values generally found during July - September.

14. Dissolved organic carbon (DOC), NH_4 and PO_4 showed seasonal variation. DOC had maximum concentrations during high runoff. The other two parameters also exhibited highest concentrations during high discharge but less consistently. NO_3+NO_2 did not exhibit a similar pattern.

15. Total suspended solids (TSS) varied considerably, with highest levels often occurring during high discharge.

16. Regression analyses indicated that only dissolved organic carbon (DOC) concentrations were significantly related to discharge at all stations. Dissolved phosphate was significantly related to discharge at six of eight stations.

17. Dissolved organic carbon (DOC) was removed from the water column during estuarine transport from July through February. High particulate concentrations of organic carbon in the head waters of the estuary suggest that some of the DOC probably flocculates during this period. In general, dissolved phosphate appears to follow the same pattern.

18. Dissolved NO_3+NO_2 and ammonia have complex estuarine distributions but appear to be removed in the upper reaches of the estuary. Higher levels occurred at higher salinities, suggesting the release of some soluble nitrogen.

19. Estuarine levels of total suspended solids (TSS) were high, probably due to resuspension of estuarine sediment, upstream transport from charlotte Harbor and/or biogenic particle production.

20. Sediment samples were collected form four (4) stations in the Myakka River and one (1) station in Charlotte Harbor. Concentrations of arsenic, cadmium, chromium, copper, lead, nickel, zinc and mercury were compared with that of aluminum to determine if these trace metals have been enriched over time.

21. Myakka River and Upper Charlotte Harbor sediments consisted largely of fine sands, which tend to have low metal concentrations. Concentrations of all metals were low and fell within expected natural ranges.

22. Concentrations of TOC, TKN (total Kjeldahl nitrogen) and TP (total phosphorous) in Myakka River sediments were greatest in those samples which also had the highest aluminum concentrations; high aluminum being an indicator of fine-grained sediments.

23. Sediment nutrient concentrations in the Myakka and Peace Rivers and Charlotte Harbor were compared to concentrations in natural sediments throughout Florida. TP/TKN ratios tended to be higher than typical values found throughout the state and are probably related to regional phosphate rock deposits.

24. Sediments were analyzed for organic compounds (i.e., polynuclear aromatic hydrocarbons, chlorinated pesticides, polychlorinated biphenyls, and aliphatic hydrocarbons). None were found in excess of detection limits.

25. Future technical reports will focus on more detailed trend and other analyses of data from both the basin and the estuary stations.

26. The following management tools were developed, to varying degrees, as part of this study: a one-dimensional hydrodynamic model; biological indicators (i.e., benthic and floodplain vegetative communities); a shoreline assessment and mapping project, and; a spatially-related database.

27. As part of future work on this project, the above management tools will be further developed and a basin-wide management plan established to tie goals and implementation strategies.

ACKNOWLEDGMENTS

When a study like the Myakka River Basin Project is undertaken, many people offer contributions of time and expertise. We would like to recognize all the folks that have helped us through the first phase of the study.

Thanks to the Environmental Chemistry Section of Mote Marine Laboratory, Kellie Dixon, Sue Hufman and Pat Minotti. They only asked a few times when the storm sampling events were going to be over, and they were always there when the samples arrived.

Thanks to Fred Handy at Becky's Bait Bucket for his concern about the river and about the study. He was always there with an interesting story about the Myakka and to tell us what the salinity structure and tides would be like for our sampling runs.

Thanks to Sarasota County's Steve Sauers, Dr. Jose Guira, and Laura Ammeson for helping us through some logistical problems early in the study.

Thanks to the Tampa and Sarasota offices of the USGS for helping us locate, installing, and providing access to the continuous record gaging stations. Additional thanks for providing access to the hydrologic database, and answering questions.

Mr. Chuck Downs and the Turners at the Hi Hat Ranch were most generous in providing access to the gaging stations and proposed sampling locations on their properties.

A special thanks to Dr. Estevez of Mote Marine Laboratory for sharing his knowledge of the Myakka with us. Thanks, too, for that first excursion on the river in January, 1989.

Finally, thanks to the staff of the Ecological Monitoring Division for support and encouragement. Special thanks to Shari Knack for assisting in the production of this report, to Jamie Jones and Mark Franz for assistance with the graphics, and to Dave Aftandilian for help with editing.

I. Introduction

Project Overview/Purpose

In 1987, with funds made available through the National Oceanic and Atmospheric Administration (NOAA), the Florida Department of Environmental Regulation's (FDER's) Coastal Zone Management (CZM) Section implemented an "Estuarine Initiative" aimed at improving research and management of Florida's estuaries. Projects were initiated in: Perdido Bay, on the border of Florida and Alabama; Turkey Creek, in Southeast Florida; and the Little Manatee River, in the southern portion of Tampa Bay. In December 1988, Sarasota County's Ecological Monitoring Division (EMD) and FDER's CZM Section initiated the fourth statewide project; an investigation of the Myakka River Watershed.

The importance of proper management of the Myakka River Basin lies not only in the river's value as an Outstanding Florida Water and a Wild and Scenic River, but also because the Myakka River flows into Charlotte Harbor, one of the largest and most productive estuaries in Florida. Projections for unprecedented growth in the region, and the concern over associated environmental impacts, focused additional attention on the need for a proper management program for the Myakka River Basin. Its size, accessibility and relatively undeveloped nature further made this basin a good candidate for the subject study.

This study represents the first system-wide examination of the Myakka River Basin. Previous research within the basin is limited to disjunct, non-synoptic studies. Although this information may have had localized regulatory value, it did not provide a defendable basis for: (1) projecting the cumulative impacts of changing land uses, nor; (2) developing desirable basin-wide management objectives or implementable strategies.

The major objective of this three-year study was to provide a technical basis for holistic, basin-wide management for the Myakka River Basin. Accomplishing such a comprehensive objective requires effective tools that track land use changes, provide a mechanism for examining cumulative impacts, and link available data to planning and management decisions based on established goals for the system. The best available management tool allowing such a holistic approach to management is the Geographic Information System (GIS).

The first year (1989) focused on data collection and compilation. Information was collected on the physical and chemical processes within the watershed, including rainfall, stream-flow, water chemistry and biological communities. Additional work during the first year accurately characterized the river's shoreline and advanced the development of a predictive flow model for the river. These data were necessary to properly develop management strategies for the basin.

Accomplishments for year two included continued data collection and analyses, enhancement of the historical database, and the initial development of management strategies for the basin. Additionally, spatial coordinates were assigned to environmental data, allowing assimilation of these data into a GIS.

The objective for phase three will be the development of a GIS for the Myakka River Basin. The GIS will provide an important mechanism for timely assessment of impacts related to various development and management strategies. Other work planned for year three includes: development of the management plan; establishment of goals for implementing the plan; and, integration of the GIS into the local government planning process.

Research and Monitoring Programs

Since the initial efforts by County staff to bring additional and proper management to the Myakka River Basin (Lincer, 1979), several research and monitoring efforts have been conducted as funds and political priorities allowed (Table A). Initial efforts included straightforward inventories which helped to identify more specific research needs. These were followed by basin-wide studies, which will result in implementable management strategies.

Description of the Report

This report presents the results from the first year of the Myakka River Basin Project. The emphasis for this report is analysis and documentation of data collected during the first phase of the project. Subsequent reports will present results of continued analyses and and the development of specific implementable management goals.

The next section of the report describes the environmental setting of the Myakka River watershed, including subbasin descriptions, land use and habitat descriptions. Section III describes the methods used for sample collection and analytical and statistical analyses. Results are discussed in Sections IV-VII. The final section provides an assessment of the information and provides the direction for subsequent reports.

TABLE A. Overview of studies conducted within the Myakka River watershed.

PHASE	SPECIFIC EFFORTS	DATE
INITIAL INFORMATION GATHERING/NEEDS ASSESSMENT	♦ Myakka River Workshop (Sarasota County, Myakka River Coalition, Ext. Service)	1978
DATA GATHERING (Physical, Chemical and Biological)	♦ Myakka Lake/VanderRipe Slough Study (Mote Marine Laboratory, Preide-Sedgwick)	1982/83
	♦ Wet & Dry Season Characterization; Downstream Studies, Phases I and II (Mote Marine Laboratory)	1985-86
	♦ Water Quality Work; Carlton Reserve Baseline Studies (Dames & Moore, Mote Marine Laboratory)	1985-86
	♦ Preliminary Salinity Monitoring/Modelling (USGS)	1986-89
	♦ River Wetland Characterization; Downstream Studies, Phase III (Mote Marine Laboratory)	1988-89
	♦ Myakka River Basin Project - Year 1; Water Quality, Flow and Timing; Freshwater Biology (NOAA/DER Grant to County*)	1988-89
	♦ Peer Review of Key Studies and Modelling Needs (NOAA)	1989
	♦ Myakka River Basin Project - Year 2; Fine-Tuned Monitoring, Wetland Functions, Data Analyses and GIS (NOAA/DER Grant to County*)	1990
	♦ Stream Flow, Surficial Aquifer and Water Quality Monitoring (USGS Cooperative Agreement with County, County Monitoring Program)	Ongoing

TABLE A (continued)

PHASE		SPECIFIC EFFORTS	DATE
ENVIRONMENTAL MANAGEMENT	♦	Hydrological One-Dimensial Model; Downstream Studies, Phase IV (Mote Marine Laboratory, Dr. Siler and USGS)	1989-90
	♦	County Involvement in Myakka River Management Plan and Rule-Making (DNR)	1988-90
	♦	Development of County Environmental Database, Using Myakka River Basin as Prototype (Ecological Monitoring Division)	1990
	♦	Shoreline Habitat Computerized Drafting (CADD) Work (CADventure)	Ongoing
	♦	Ecological Interpretation of Hydrological One-Dimensial Model; Downstream Studies, Phase V (Mote Marine Laboratory)	1991
	♦	Myakka River Basin Project - Year 3; Management Options/PC-GIS/Environmental Database (NOAA/DER Grant to County*)	1991

---

* Subject NOAA/FDER study being carried out by Sarasota County's Ecological Monitoring Division.

II. Environmental Setting of the Myakka River Watershed

The Myakka River is a meandering blackwater stream in South West Florida (Figure 1). The river drains approximately 1,559 km^2 and is the smallest of the three main tributaries of Charlotte Harbor (Hammett, 1989). The watershed includes portions of five counties (Manatee, Hardee, Sarasota, Desoto, and Charlotte). From Myakka Head in Manatee County to Cattle Dock Point (considered the river's mouth) in Charlotte County is a straight-line distance of 50 miles. Measured in river miles, the distance increases by 40% to 70 miles.

The Myakka River watershed lies directly in the path of future development in South West Florida. Currently the portion of the basin within Manatee County is used primarily for ranching and agriculture and is not intensively developed. During 1990, phosphate mining was begun again in this part of the watershed. Within Sarasota County, much of the land along the Myakka River is in public ownership, including the Myakka River State Park, the T. Mabry Carlton Jr. Memorial Reserve, and the Walton Tract. Between the Walton Tract and US Highway 41 there are low density residential developments and some commercial water-related establishments. The portion of the basin south of Highway 41 is more intensively developed, with trailer parks and waterfront developments on both sides of the river.

As the populations of Manatee, Sarasota, and Charlotte Counties continue to grow, agricultural interests will be forced to move further east and into the watershed. Population growth will also push urban and suburban development further east as open space becomes more difficult to obtain. These increasing growth pressures make it imperative that the drainage basin be managed as much as possible as an ecological and hydrological unit.

General Physiography of the Watershed

The terrain of the watershed is generally flat. Most of the basin lies within the coastal lowlands topographic region of Florida. A small portion of the headwaters of the basin (28.5 km^2) is in the Central Highlands region (Joyner and Sutcliffe, 1976). Elevations in the basin range from 35 m at the headwaters to sea level at the river's mouth (Figure 2). The slope in the upper reaches of the basin is approximately 1.5 m, decreasing to about 0.3 m near the mouth (Drummond, 1977). Wetlands are a widespread and important component within the basin, particularly at elevations below 60 feet. Research on the T. Mabry Carlton Jr. Memorial Reserve has shown that flatwoods wetlands reach a density of 70 km^2 (Winchester et al., 1985). Four major depressions, or natural water detention areas, occur in the watershed. They are Flatford's Swamp, Tatum Sawgrass, Upper Lake and Lower Lake.

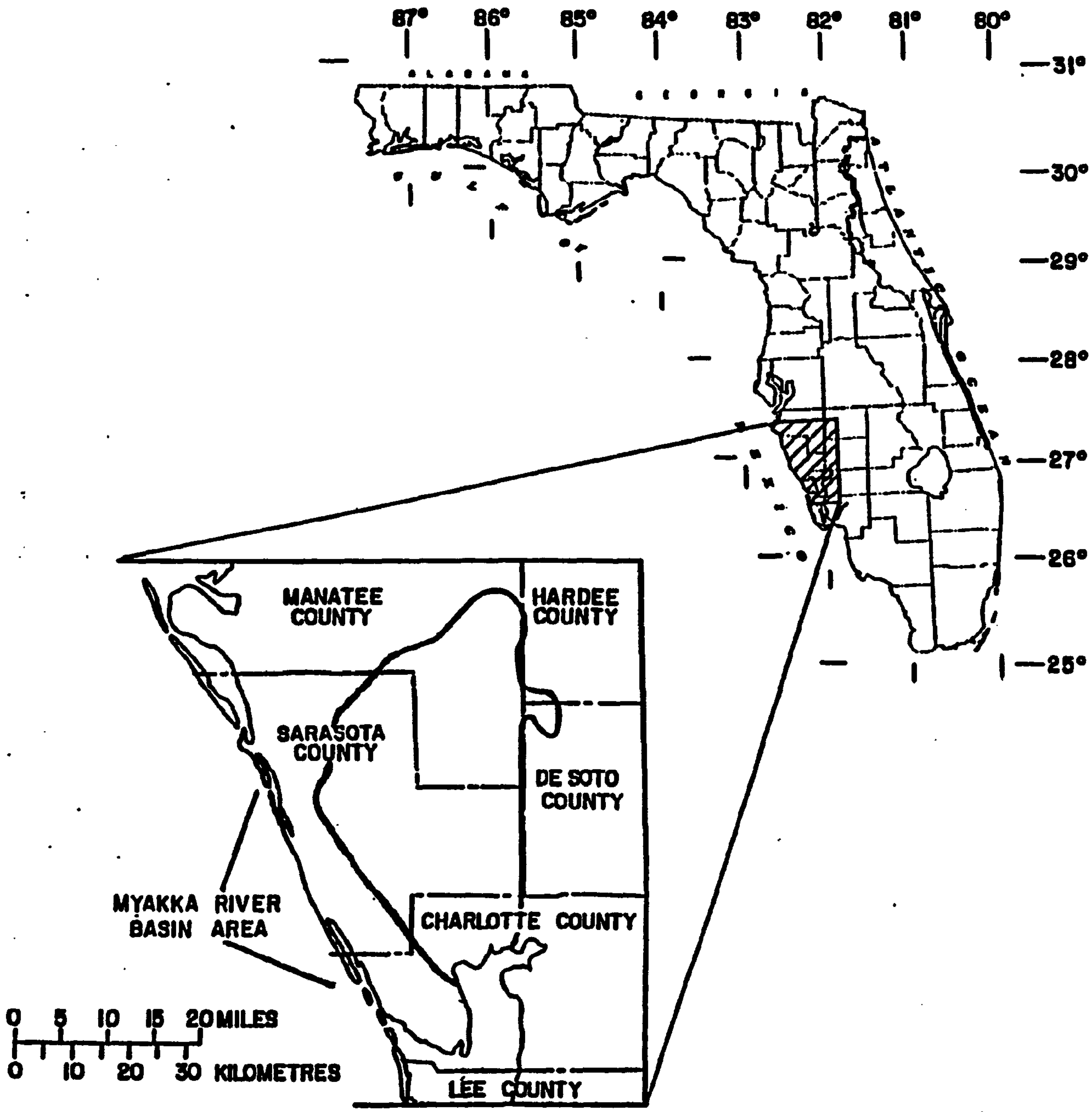


FIGURE 1. Location of the Myakka River Basin (after Joyner and Sutcliffe, 1976).

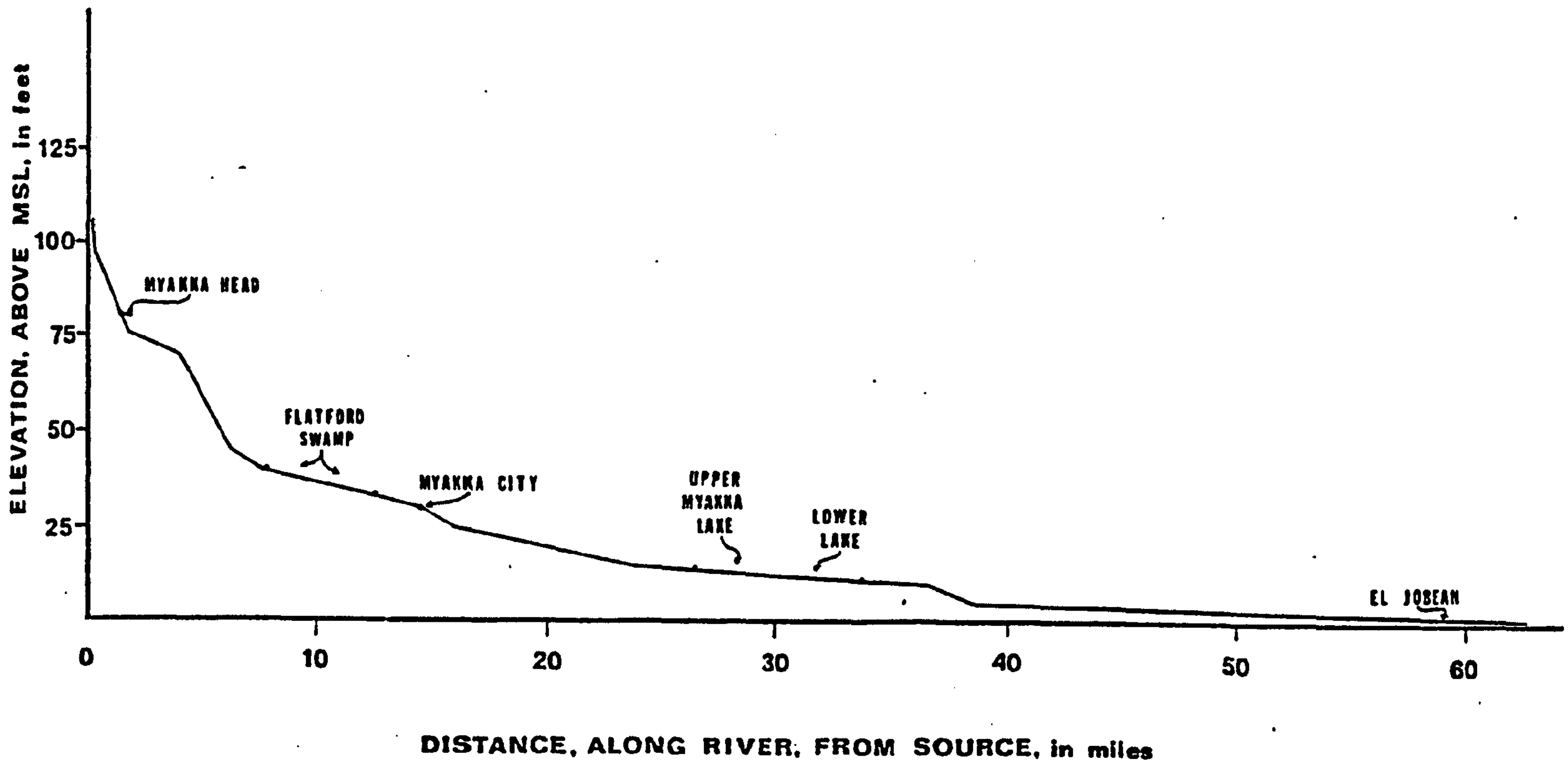


FIGURE 2. Elevational changes within the Myakka River Basin (*from* Drummond, 1977).

The major source of freshwater for the Myakka River is rainfall. The river is characterized by low base flow despite the fact that the water table can be as much as 10 to 15 feet higher than river water levels. Consequently, the Surficial Aquifer has a limited contribution to the river (Hammett, 1989).

The Floridan Aquifer contributes highly mineralized water to the river through Warm Mineral Springs and Little Salt Springs. These inputs occur downstream of river mile 12, in the estuarine portion of the river. The conductivity of the water from these springs is approximately 26.5 millimhos per centimeter, corresponding roughly to salt water of 15 ppt salinity. Although Warm Mineral Springs contributes a constant flow of 0.28 cms to the river, the mineral content of the flow makes this a more brackish than a freshwater source (Rosenau et al., 1977).

The study area has a humid, subtropical climate with long, warm, moist summers and typically dry winters. The average yearly rainfall for the study area is 1423 mm. Most of this rain falls from June to September as a result of convective storms. The rainfall amounts tend to vary widely across the study area because of the localized nature of convective storms. Frontal systems from the north occur in the winter months, and occasionally bring rain in February and March. The area is subject to hurricanes and tropical depressions during the storm season (June through October). In September 1988, such a tropical disturbance dropped 225 mm of rain in a three day period. This rainfall resulted in an 8-fold increase in discharge for the Myakka River and a 50-year flood event.

The hydrology of the Myakka River is strongly related to rainfall in the watershed. Peak discharges occur from July to October. One station, with a period of record dating back to 1936 has a mean discharge of 6.99 cms, with a range for discharge values between 0 and 245 cms. May has the lowest average discharge and September, the highest. Figure 3 illustrates the long-term trends for the USGS gaging station in Myakka River State Park (02298830).

The soils along the Myakka River change from floodplain associated soils to salt marsh/mangrove-associated soils at river mile 15.5 (Soil Conservation Service, 1988). In general, the soils in the watershed are sandy and poorly drained.

Water quality in the Myakka River is considered "good" although mining, rangeland, and agricultural runoff contribute to elevated nutrient levels (Hand et al., 1988). In the upper watershed, Wingate Creek and Clay Gully have "fair" water quality. A section of the Myakka River between Ogleby and Owen Creeks has "poor" water quality due to elevated nutrients and bacteria counts. In the lower watershed, both Deer Prairie and Big Sloughs have "fair" water quality because of elevated bacteria and depressed dissolved oxygen levels.

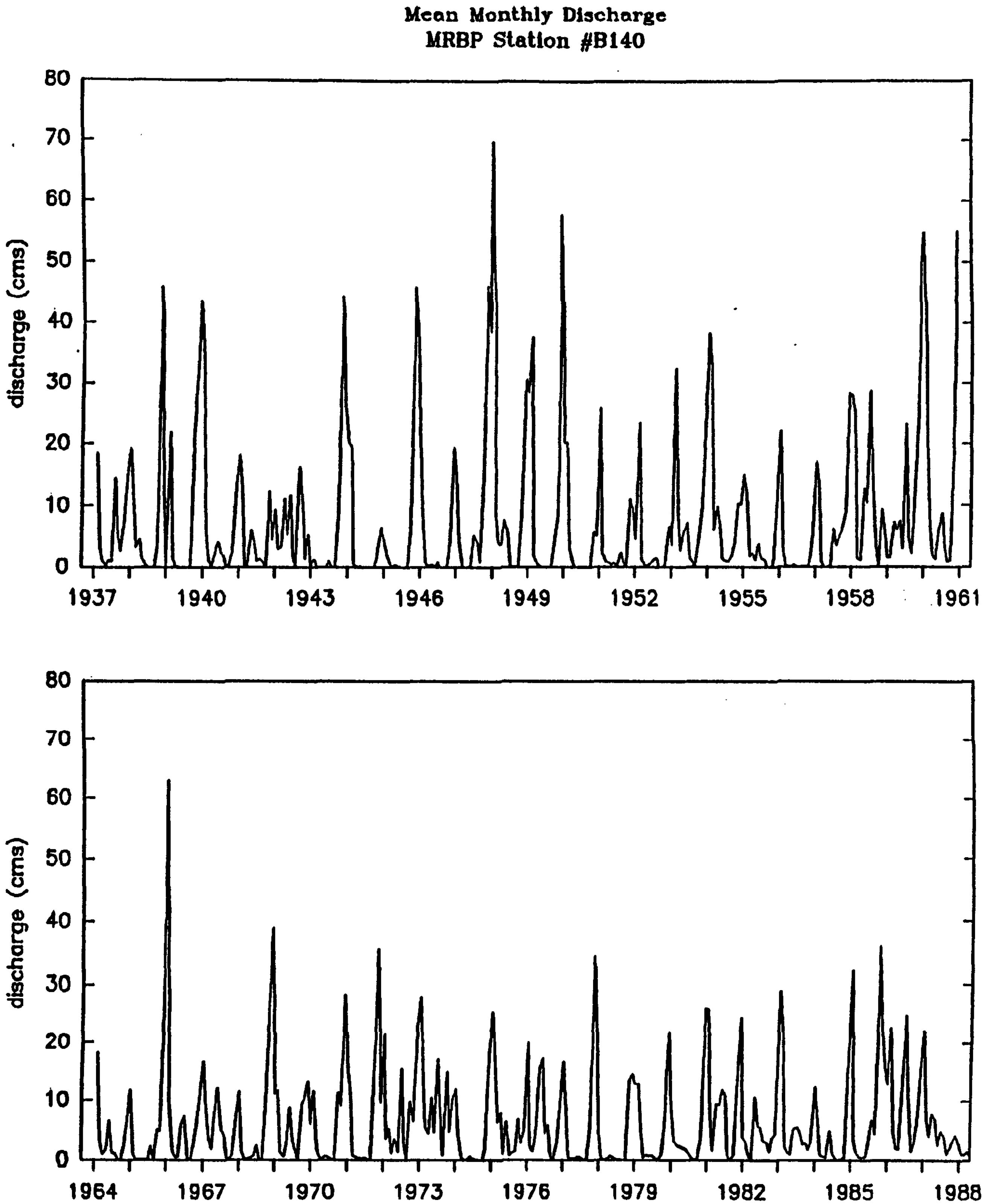


FIGURE 3. Long-term discharge at the USGS gage at Myakka River State Park (B140).

Subbasin Descriptions

The Myakka River basin is composed of over 60 subbasins (Figure 4). However, not all the individual subbasins are associated with a continuous record gaging station. Therefore, for the purposes of this study, the watershed was divided into eight gaged subbasins. Each gaged subbasin contains a number of minor ungaged basins. Table B names the subbasins and lists the associated minor drainage basins.

The Myakka Head subbasin is located in eastern Manatee County and western Hardee County and drains approximately 323.75 km^2. This area contains many small creeks that flow into the first of four major water detention areas associated with the river, Flatford's Swamp. The swamp covers an area of about 15.5 km^2 northwest of Myakka City.

The primary land use in this subbasin is agriculture. A phosphate mine reopened in July 1990 in this subbasin in the northern portion of the basin along Johnson Creek.

The Myakka River is a small meandering creek in this subbasin. During much of the year, it is hardly a meter wide at the State Road 64 bridge. The channel is fairly well defined above and below Flatford's Swamp, but becomes poorly defined as the swamp widens to cover a large area. The river is channelized just north of the gaging station at Myakka City. The average discharge at this station is 3.7 cms, with a range from 0 to 191 cms. Myakka City and State Road 70 delineate the downstream extent of this subbasin.

Downstream of Myakka City, the river flows southwest through southeastern Manatee County and the Tatum Sawgrass subbasin. The 103.6 km^2 drainage area also includes portions of western Sarasota County. This subbasin also contains the second major detention area in the watershed, Tatum Sawgrass.

Agricultural land use is also dominant in this subbasin. Although it is not heavily developed, the subbasin has been altered for agricultural development. Prior to 1974, Tatum Sawgrass was a large (36.26 km^2) freshwater wetland. Private interests installed dikes and ditches in this wetland to allow agricultural development. The alterations also reduced the storage capacity of this area and increased the magnitude and frequency of flood events downstream. The largest change in flood stage was a 19% increase in the 2-year flood (Hammett et al., 1978).

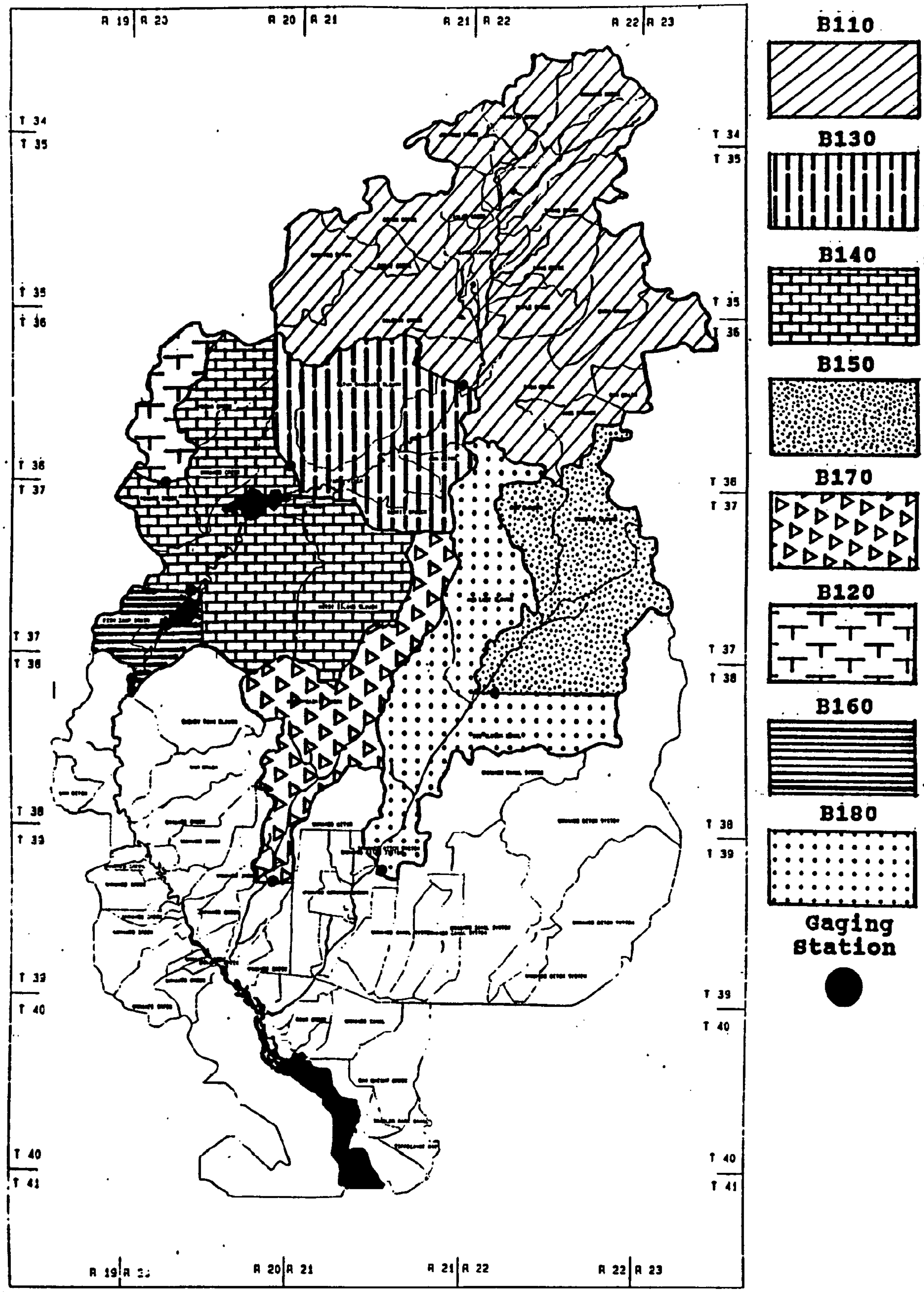


FIGURE 4. Subbasin and gaging station locations within the Myakka River Basin.

TABLE B. Basin names and associated drainage areas.

Sampling Station	Major Basin	Minor Basin(s)
B110	Myakka Head	Johnson Creek Wingate Creek Coker Creek Taylor Creek Sand Slough Young Creek Long Creek Boggy Creek Ogleby Creek Maple Creek Owen Branch Sand Branch Owen Creek Three (3) unnamed drainage areas
B120	Howard Creek	Howard Creek
B130	Tatum Sawgrass	Tatum Sawgrass Slough Sardis Branch One (1) unnamed drainage area
B140	Upper Lake	Indian Creek Clay Gully Mossy Island Slough Howard Creek One (1) unnamed drainage area
B150	Upper Big Slough	Bud Slough Wildcat Slough
B160	Lower Lake	Fish Camp Drain
B170	Deer Prairie Creek	Deer Pairie Slough
B180	Lower Big Slough	Mud Lake Slough Big Slough

Approximately 2 kilometers east of the Manatee/Sarasota County line, the Myakka splits into the main channel, which heads west and skirts the southern edge of Tatum Sawgrass, and Clay Gully, which goes south and enters Upper Myakka Lake at its northeast corner. Due to alterations in Tatum Sawgrass, most of the normal flow of the river flows through Clay Gully, which has been dredged. The main channel of the river flows only during periods of high flow

(Bowman, pers. comm.). The gaging station for this subbasin is located on the State Road 780 bridge, and gages the flow of the main channel. The gage, which was installed for this study, showed a range of discharge from 0 to 103.6 cms during 1989.

Immediately downstream of the 780 bridge, the Myakka River enters Upper Myakka Lake and the Myakka River State Park. The drainage area associated with the Upper Lake subbasin is 114 km^2 and includes parts of northeastern Sarasota County and the northern portion of the State Park. Upper Myakka Lake, the third of the detention areas in the watershed, is located within this subbasin.

Much of the Upper Lake subbasin is publicly owned. To the north and west of Upper Lake are residential areas (zoned for low density, 1 unit per 5 acres). These areas also include agricultural lands used for plant nurseries, range land, and citrus production.

Upper Myakka Lake is a shallow depression. The water is nutrient-enriched and the lake exhibits seasonally low dissolved oxygen levels and aquatic weed problems. Agricultural activities, spray irrigation fields and an effluent treatment system along Howard Creek are possible contributors to the poor water quality of the lake. Historically, Upper Lake had two outfalls, the Myakka River and Vanderipe Slough. The outfall to Vanderipe Slough was blocked with an earthen dam in the 1930's, and water no longer exits the lake there. Also in the 1930's, a dam was constructed at the outfall of the Myakka River in an attempt to better regulate water levels downstream. Culverts were later built to bypass this dam. Between the main channel of the Myakka and Vanderipe Slough is a large area of wetlands which are generally inundated during periods of high flow.

The gaging station for this subbasin is on the main channel of the river, approximately 0.8 kilometers upriver from State Road 72. The mean discharge for the period of record at this site is 6.99 cms, and the range is from 0 to 245.5 cms.

Moving downstream, the Myakka becomes more a river and less a stream. At State Road 72, the channel is 50 meters wide and three meters deep at the center. As the river winds south through the marshes toward Lower Myakka Lake, the oak-cabbage palm hammock opens to a wide fresh water wetland that extends to Lower Myakka Lake. The Lower Lake subbasin drains 62 km^2 of central Sarasota County and the wilderness area of the State Park.

Lower Lake is the fourth major detention area in the Myakka River watershed. Like Upper Lake, it is generally a shallow lake with an abundance of aquatic weeds. It does have one feature that sets it apart from Upper Lake, Deep Hole. Believed to be a collapsed sinkhole, Deep Hole is 91.5 meters in diameter and 45 to

55 meters deep. Joyner and Sutcliffe (1976) reported a groundwater discharge of 0.04 cms. A video camera survey by the Mote Marine Laboratory in 1978 revealed an inverted cone of sediment nearly 24 meters tall, suggesting a sediment sink rather than a ground water source.

The Myakka River continues its meandering course generally south from Lower Lake. A private landowner built a dam just south of the State Park boundary (river mile 28.6). The dam is a concrete structure with a 1.2 m^2 gate which is generally closed. The dam holds back about 1.2 meters of water, though high seasonal flows frequently overtop the dam. The gaging station for this subbasin has an average discharge of 9.6 cms with median discharge of 2.9 cms.

The four subbasins described above are on the main river channel. The remaining four basin gaging stations are located on tributaries of the Myakka: Howard Creek, Deer Prairie Slough, and Big Slough (two stations). Howard Creek discharges into Upper Myakka Lake. Both Deer Prairie Slough and Big Slough enter the estuarine portion of the Myakka River at river miles 12.2 and 9.4, respectively.

Howard Creek drains 51.8 km^2 in northeastern Sarasota County. The creek flows south and enters the northwest portion of Upper Myakka Lake. The subbasin includes diversified agriculture, including cattle, citrus and sod operations. In April 1990, the City of Sarasota rerouted treatment plant effluent from Sarasota Bay to a ridge and furrow disposal system in this subbasin. The ridge and furrow system is designed for zero off-site discharge and to withstand a 5-year storm event. During the 1990 rainy season, the system's capacity was exceeded, and the effluent was again routed into Sarasota Bay. The range of discharge recorded at this gage is from 0 to 62.8 cms.

Deer Prairie Creek drains an area of 86 km^2 in central Sarasota County. The creek is the major water conveyance for the T. Mabry Carlton Jr. Memorial Reserve, a 129.5 km^2 parcel owned by Sarasota County. It also drains the eastern portion of the Myakka River State Park. Agriculture is the major land use in this subbasin. An earthen dam impounds the creek 3.2 kilometers downstream from the gaging station. The dam was constructed to prohibit brackish water from moving any further upstream, allowing year-round agricultural use of the water. The average discharge at this station is 0.72 cms and ranges from 0 to 27.5 cms.

The Big Slough (also known as Myakkahatchee Creek) basin has two gaging stations associated with it. The gaging station at State Road 72 represents a drainage area of 94.5 km^2. The primary land use in this part of the subbasin is agriculture. An additional 130.3 km^2 is gaged at Interstate Highway 75. Big Slough was been dredged to provide more efficient transport of water to the City of North Port in southern Sarasota County. The city uses this creek as its major source of drinking water. The gaging station on upper Big Slough has a period of record of 8 years. The mean discharge for the period was 0.9 cms, ranging from 0 to 70.2 cms. The downstream gage, installed specifically for this study, showed discharges ranging from 0.01 to 6.09 cms.

Soil and Vegetation Types in the Watershed

In the Myakka Head subbasin, the vegetation near the river and throughout Flatford's Swamp is hardwood hammock. This association includes a canopy of ash (Fraxinus caroliniana), swamp maple (Acer rubrum), bay (Gordonia larianthus), hickory (Carya aquatica), water oak (Quercus nigra) and magnolia (Magnolia grandiflora). The understory includes many vines, ferns, and an occasional saw palmetto (Sereno repens) thicket (Morris and Miller, 1976).

The vegetation along the river changes from the hardwood hammocks of the Myakka Head subbasin to oak and cabbage palm hammock in the Tatum Sawgrass, Upper and Lower Lake subbasins. The canopy in this type of hammock is comprised of laurel (Quercus laurifolia) and live oaks (Quercus virginiana) and cabbage palms (Sabal palmetto). The understory includes saw palmetto and various shrubs and grasses (Morris and Miller, 1976). Some freshwater wetlands-associated plants including St. John's wort (Hypericum fasiculatum), pickrelweed (Pontaderia sp.), arrowhead (Sagittaria lancifolia) and beakrush (Rhynchospora sp.) remain in the deeper depressions, around the lakes and along sloughs.

Near river mile 15, in the estuarine reach of the river, the oak and cabbage palm hammocks give way to the salt marsh/mangrove plant associations. Cord grass (Spartina sp.), black rush (Juncus roemerianus), leather fern (Acrostichum aureum), and cattail (Typha sp.) dominate the tidal marshes, along with red (Rhizophora mangle), black (Avicennia germinans), and white mangroves (Languncularia racemosa) (Estevez, 1985).

Pine flatwoods, composed of a canopy of slash pine (Pinus ellioti) and an understory of saw palmetto, dominate the remainder of the basin. Other vegetation types present in the basin include prairies and improved pasture.

In the upper reaches of the watershed, the soils near the river are typically alluvial, sandy, with low organic content. At river mile 15.5, the organic content of the soils increases, marking the transition from fresh to saltwater habitats (Soil Conservation Service, 1988).

The soils in the remainder of the basin are typically soils of the flatwoods. These soils are level and sandy. Most are poorly drained and have a subsoil that is dark colored and sandy in the upper part and loamy in the lower part (Soil Conservation Service, 1988).

Description of the Estuarine Study Area

The study area for the estuarine reach of the Myakka River extends from river mile 21 to river mile -2 in Charlotte Harbor. The tidal reach is normally well mixed, with stratification occurring in the downstream portion of the river only during periods of high flow and high tide. Backwater effects from tides have been recorded as far upstream as river mile 28.6 (the control structure in the Lower Lake subbasin) during periods of low flow. At river mile 26.1, the daily fluctuation in stage averaged 0.13 meters due to tidal effects (Hammett, 1989). There are 4 major tributaries in the estuarine reach of the river (Figure 5). They are: Curry Creek, Deer Prairie Creek, Warm Mineral Springs, and Big Slough.

Downstream of the control structure, the river channel is deeply incised, and the limestone bed of the river is frequently exposed. The river continues to meander through oak-cabbage palm hammock on a south-southwest course through central Sarasota County. Numerous narrow, shallow sloughs, most of which are abandoned meander loops of the river, characterize the river area from the control structure to river mile 23.5 (Milligan, 1990). Pine flatwoods extend to the banks of the river in several areas along this segment of the river. Where the river flows through these relatively higher and drier sections, high sand bluffs have been created. The water in this river segment is generally fresh.

Between river miles 23.5 and 22, the character of the river is very similar to the segment upstream. The sloughs, however, become less numerous, wider and deeper. These sloughs are lined with willow (Salix caroliniana) and popash, and frequently contain floating mats of marsh vegetation (Milligan, 1990). The first residential development on the river occurs at river mile 23 on the west bank of the river. Residences occur on the west bank of the river to river mile 21 (Border Road).

From river miles 22 to 16, the river begins to change. Sloughs become nearly absent from the landscape. The river becomes less meanderous and the channel less incised. The laurel and live oaks in hammocks are replaced by pines. Residential developments occur on both sides of the river from river miles 21 to 19.5 (Interstate 75). The influence of Charlotte Harbor's tides is evidenced by elevated salinity during periods of low flow. In 1985, salinity at Border Road exceeded 10 ppt (Hammett, 1989). A salinity of 2 ppt was recorded at river mile 19.5 by project staff.

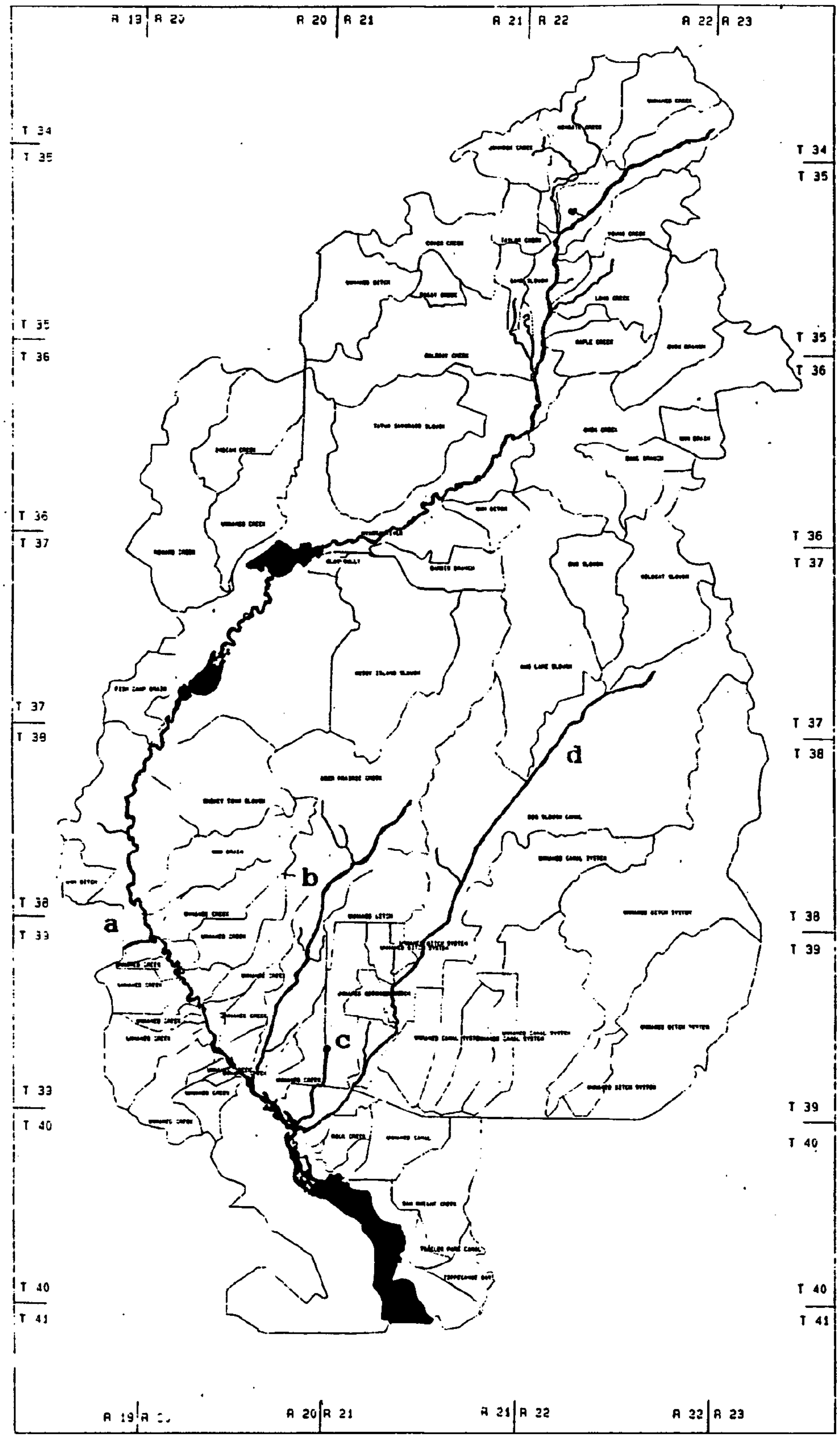


FIGURE 5. Major tributaries of the Myakka River estuary; (a) Curry Creek; (b) Deer Prairie Creek; (c) Warm Mineral Springs; (d) Big Slough.

The most upstream of the four major tributaries, Curry Creek[1], occurs at river mile 20.2. Table C lists the estuary sampling sites and associated salinity data collected during 1989. Snook Haven Fish Camp and a campground are located at river mile 17.8.

TABLE C. Salinity values for estuarine stations.

Site	River Mile	Salinity Mean, ppt	Salinity Range, ppt
E280	16.5	1.50	0.0-11.0
E270	14.2	3.26	0.0-15.1
E260	12.2	5.57	0.1-18.1
E250	10.6	8.23	0.2-20.1
E240	8.5	10.05	1.0-21.5
E230	5.0	15.56	5.2-24.9
E220	3.0	18.84	9.5-26.1
E210	-2.0	23.37	17.4-27.9

Below river mile 15, the river widens and the fringing hammocks give way to salt marshes dominated by black rush and leather fern. The river remains undeveloped between Snook Haven and river mile 11.5, with the exception of a campground at river mile 14.5. The first mangrove along the river occurs near river mile 13. Deer Prairie Creek enters the Myakka at river mile 12.2, just upstream of the Highway 41 bridge.

Residential development increases below river mile 11.5 (Highway 41 bridge). Many of the developments include canals for river access, extensive use of hardened shorelines and numerous piers and docks. Approximately 18% of the shorelines from this point to the mouth of the river have been hardened. The disturbed nature of this river segment is also reflected by the presence of two exotic plant species, Brazilian pepper (Schinus terebinthifolius) and Australian pine (Casuarina equisetifolia), along 27% of the shoreline (Estevez et al., 1990).

The hogchocker (Trinectes maculatus) has been identified as the dominant fish species in the tidal Myakka River (Estevez, 1985; 1986). This fish accounted for 81% of the total number of fish

[1] Curry Creek canal was dredged in the late 1950's to provide an outlet for approximately 10% of the seasonal flood flows of the Myakka River. The canal is approximately 5 miles long, connecting the river with Roberts Bay on the west coast. The original engineering plans for the canal indicated that excess flow would be directed toward the west and Roberts Bay (De Leuw, Cather, and Brill, 1959). Recent empirical evidence, however, indicates that the canal does not function as intended.

collected in trawls during 1985 studies. The hogchocker is primarily a demersal feeder, indicating that the benthic infauna and epifauna are the major energy pathway in this portion of the river (Browder, 1987).

Studies of the benthos by Mote Marine Laboratory (Estevez, 1985; 1986; Milligan, 1990) suggest various zonation schemes for the river based on this important component. The zones differed for molluscs, annelids, and crustaceans. The suggested schemes might be better judged based on the additional studies of the food habits of the hogchocker in-situ (i.e. analysis of stomach contents). The schemes also need to be related to zonations suggested by soil types, vegetation associations, and salinity distributions.

The lower portion of the Myakka River, beginning at river mile 2, is protected as part of the Charlotte Harbor Aquatic Preserve. The Peace River flows into Charlotte Harbor south of Hog Island at river mile -2. The Peace River exerts a strong influence in the salinity structure in the lower part of the Myakka River.

III. STUDY METHODS

Rainfall and Hydrology

Rainfall

Rainfall measurements are taken at several stations within the study area; however, these stations are not distributed evenly across the watershed. Therefore, rainfall data could not be obtained for each "delineated" subbasin. Figure 6 shows the locations of the rainfall stations within and near the watershed. Rainfall data used in this report were collected by NOAA, Sarasota County, Florida Department of Natural Resources (FDNR; Myakka River State Park), and the North Port Water Authority.

NOAA maintains a climatological observation network for the entire United States. Three of these stations were used to assess long-term rainfall patterns for the study area. The station at the Myakka River State Park is the only one of the three located within the watershed. The station at Fort Green lies just north of the northeast corner of the watershed. The Venice station lies west of the basin. Table D gives the coordinates and periods of record for these stations. Several rainfall stations, maintained by the Park Service, Sarasota County, and the North Port Water Authority, occur within the watershed. The period of record for these stations ranges from five to six years (Table E).

Total rainfall and monthly means were calculated for each long-term rainfall station to determine how rain during the study period related to long-term patterns. This information was important for providing perspective on whether rainfall patterns and amounts found during the course of the study were reflective of average or "normal" conditions.

The short and intermediate-term rainfall records provide information on the spatial variation of rainfall that can exist within the study area. Spatial differences in rainfall related to summer convective storms were examined by comparing monthly rainfall totals for June 1989 through September 1989 for six stations within the river basin.

Hydrology

As part of a cooperative agreement with Sarasota County, the United States Geological Survey records stage and discharge at several sites within the Myakka River basin. Four gaging stations are located on the main body of the River, one on Howard Creek, one on Deer Prairie Slough, and two on Big Slough Canal (Figure 4). Table F lists the gaging stations that were coupled with sampling locations for this study and the period of record for each. One record includes values since 1936, although most of the records

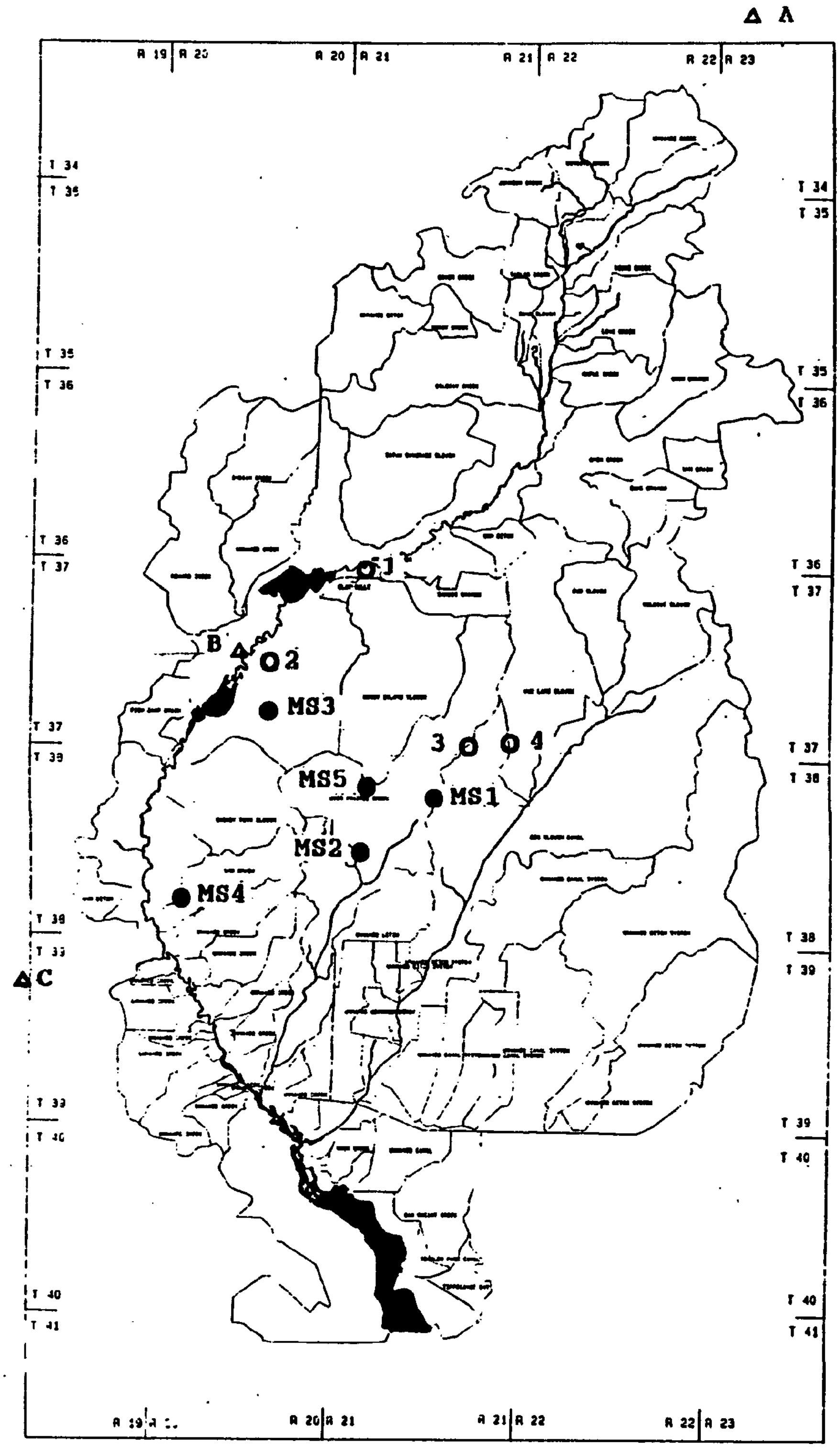


FIGURE 6. Location of rainfall stations within and near the Myakka River watershed. Long-term stations are: (a) Fort Green; (b) Myakka River State Park; and (c) Venice. Short-term stations at Myakka River State Park are: (1) North Entrance; (2) FPL; (3) Rookery; and (4) Preserve. Stations MS1-MS5 are on the Carlton Reserve.

TABLE D. Location, period of record and collection information for long-term rainfall stations.

Station	Location	Period of Record	Data Quality & Completeness	Collection Device	Collection Frequency	Agency
Fort Green	Lat 243417 Long 820817	9/1/55 - present	Missing data Feb, 1976 to Dec, 1984; other records good	All weather gauge	Daily	NOAA
Myakka River State Park	Lat 271431 Long 821028	9/1/43 - present	Missing data Jan, 1967 to Aug, 1967; other records good	All weather gauge	Daily	NOAA
Venice	Lat 270430 Long 822600	8/1/48 - present	Data very incomplete prior to 1955; records good after 4/1/55	All weather gauge	Daily	NOAA

TABLE E. Location, period of record and collection information for intermediate and short-term rainfall stations.

Station	Location	Period of Record	Data Quality & Completeness	Collection Device	Collection Frequency	Agency
North Entrance	Myakka River State Park	Jan, 1985 - present	good	All weather gauge	Daily	Park Service
Rookey	Myakka River State Park	Jan, 1985 - present	good	All weather gauge	Daily	Park Service
Preserve	Myakka River State Park	Jan, 1985 - present	good	All weather gauge	Daily	Park Service
Powerline	Myakka River State Park	Jan, 1985 - present	good	All weather gauge	Daily	Park Service
MS-1	Carlton Reserve	Aug, 1985 - present	good	All weather gauge	Weekly	Dames & Moore; Sarasota Co. Utilities Sarasota Co. EMD
MS-2	Carlton Reserve	Aug, 1985 - present	good	All weather gauge, weighing bucket	Daily	Dames & Moore; Sarasota Co. Utilities Sarasota Co. EMD
MS-3	Carlton Reserve	Aug, 1985 - present	good	All weather gauge, weighing bucket	Daily	Dames & Moore; Sarasota Co. Utilities Sarasota Co. EMD
MS-4	Carlton Reserve	Aug, 1985 - present	good	All weather gauge, weighing bucket	Daily	Dames & Moore; Sarasota Co. Utilities Sarasota Co. EMD
MS-5	Carlton Reserve	Aug, 1985 - present	good	All weather gauge	Daily	Dames & Moore; Sarasota Co. Utilities Sarasota Co. EMD
North Port Water Authority	North Port, FL	Jan, 1984 - present	good	All weather gauge	Daily	North Port Water Authority

TABLE F. Summary of information on USGS gaging stations within the Myakka River watershed.

Station ID	Gaging Station	Location Lat/Long	Name	Period of Record	Average Discharge (cms)	Drainage Area (ha)
B110	02298608	272036	Myakka River at	Feb 1963 - Sept 1966;	3.7	32,376
		820925	Myakka City	Oct 1977 - present		
B120	02298760	271717	Howard Creek	Oct 1983 - present	N/A	5,180
		822025	Near Sarasota			
B130	02298700	271805	Myakka River at	Apr 1989 - present	N/A	42,737
		821515	S.R. 780 bridge			
B140	02298830	271425	Myakka River	Aug 1936 - present	6.99	65,529
		821850	Near Sarasota			
B150	02299410	271135	Big Slough Canal	Oct 1980 - present	32.5	9,583
		820840	Near Myakka City			
B160	02298880	271107	Myakka River at	Mar 1986 - present	9.6	65,529
		822121	Control Near Laurel			
B170	02299160	270651	Deer Prairie Slough	Apr 1981 - present	0.72	8,547
		821550	Near North Port Charlotte			
B180	02299455	270630	Big Slough Canal	Apr 1989 - present	N/A	24,088
		821220	in North Port			

have a much shorter period of record. Two gages (at stations B130 and B180) were installed in 1989, specifically for this project.

As with rainfall, the long-term discharge records allowed comparisons of data collected in 1989 with mean values established over the entire period of record. A composite hydrograph of discharge for the entire period of record was developed for each gaging station. These data were then compared to discharge data for the project year. This comparison was used to determine if the period of intensive study was representative of "normal" hydrologic conditions for the river.

Storm Hydrographs and Rainfall

A detailed analysis of rainfall/runoff relationships within the Myakka River basin was carried out by developing storm hydrographs for the eight gaging stations located along the major tributaries of the watershed. The discharge data used in the development of the hydrographs is summarized in Table G.

Two periods of rainfall activity in the 1989 study year were chosen to represent typical storm conditions within the basin. Rainfall data from eleven regional monitoring stations were used in the development of the hydrographs. These data are summarized in Table H. Rainfall and streamflow data collected during these periods was used to develop the storm hydrographs. The first period, hereafter referred to as storm 1, began on July 15 and continued until August 9. Frequent convective storms occurred during this period producing substantial variations in distribution of rainfall throughout the watershed. The second period, storm 2, began on September 22 and continued until October 16. Rainfall during this period occurred within a four day span which was preceded and followed by periods of inactivity.

The storm hydrographs for both periods were developed by the methods detailed below. However, because of the distinct differences in rainfall patterns between the two periods, the methods used to analyze the hydrographs differed for each storm event. The results of the hydrograph analyses appear in Tables I and J.

Hydrograph Development

Two hydrographs, corresponding to the two storm periods, were developed for each of the eight stream gaging stations and corresponding subbasins. These hydrographs were constructed in a manner that would facilitate the use of United States Soil Conservation Service (SCS) methods of analysis. Discharge data for

TABLE G. Summary of monthly discharge (cms) data at six USGS gaging stations in the Myakka River watershed.

Stream Gauge	J	F	M	A	M	J	J	A	S	O	N	D	Yearly
Myakka City (2298608)													
Total - Monthly	26.32	12.96	60.87	13.65	12.31	48.99	369.99	263.16	232.97	78.39	17.52	76.78	1213.91
Mean - Daily	0.85	0.46	1.96	0.46	0.40	1.63	11.94	8.49	7.75	25.30	0.58	2.48	3.29
Median - Daily	0.40	0.40	0.71	0.37	0.09	0.48	8.66	9.28	6.59	1.47	0.59	1.58	0.85
Maximum - Daily	2.80	1.02	9.71	1.90	3.03	8.60	27.25	12.82	21.65	12.03	0.71	7.78	27.25
Minimum - Daily	0.28	0.31	0.28	0.14	0.02	0.02	4.95	3.11	1.42	0.68	0.45	0.37	0.02
Howard Creek (2298760)													
Total - Monthly	1.86	0.83	1.01	0.00	0.00	0.00	0.22	7.53	31.83	4.12	0.57	4.26	52.23
Mean - Daily	0.06	0.03	0.03	0.00	0.00	0.00	0.01	0.24	1.06	0.13	0.02	0.14	0.14
Median - Daily	0.02	0.02	0.02	0.00	0.00	0.00	0.00	0.45	1.06	0.09	0.02	0.06	0.02
Maximum - Daily	0.24	0.05	0.10	0.00	0.00	0.00	0.06	0.68	2.55	0.76	0.03	0.88	2.55
Minimum - Daily	0.02	0.02	0.00	0.00	0.00	0.00	0.00	0.10	0.14	0.03	0.01	0.01	0.00
Myakka/Sarasota (2298830)													
Total - Monthly	61.07	50.29	71.91	39.90	32.18	15.77	252.21	238.03	271.74	215.42	44.40	67.04	1359.96
Mean - Daily	1.97	1.80	2.32	1.33	1.04	0.53	8.14	7.68	9.06	6.95	1.48	2.16	3.73
Median - Daily	1.56	1.73	3.11	1.95	1.53	0.57	9.86	9.17	10.92	5.55	1.34	1.61	2.32
Maximum - Daily	2.69	2.69	3.40	1.67	1.27	1.67	15.31	11.18	14.91	16.50	2.35	5.09	16.50
Minimum - Daily	1.44	0.99	0.96	1.08	0.57	0.24	1.92	5.38	4.90	2.41	1.19	1.16	0.24
Myakka/Laurel (2298880)													
Total - Monthly	1.73	1.62	2.07	0.00	1.40	1.29	5.22	5.56	5.84	249.78	30.17	0.00	304.67
Mean - Daily	0.06	0.06	0.07	0.00	0.05	0.04	0.17	0.18	0.19	8.06	1.01	0.00	0.83
Median - Daily	0.05	0.06	0.07	0.05	0.04	0.04	0.18	0.18	0.20	8.38	1.32	N/A	0.07
Maximum - Daily	0.07	0.07	0.08	0.00	0.06	0.05	0.23	0.22	0.25	24.59	2.60	0.00	24.59
Minimum - Daily	0.04	0.05	0.05	0.00	0.04	0.04	0.05	0.15	0.14	2.63	0.99	0.00	0.04
Deer Prairie Slough (2299160)													
Total - Monthly	0.99	0.48	0.87	0.00	0.00	0.04	2.12	20.04	17.50	6.74	1.66	1.22	51.66
Mean - Daily	0.03	0.02	0.03	0.00	0.00	0.00	0.07	0.65	0.58	0.22	0.06	0.04	0.14
Median - Daily	0.02	0.02	0.03	0.00	0.00	0.00	N/A	1.08	0.93	0.18	0.05	0.04	0.04
Maximum - Daily	0.13	0.04	0.08	0.00	0.00	0.01	0.71	2.09	2.07	0.62	0.09	0.06	2.09
Minimum - Daily	0.01	0.01	0.00	0.00	0.00	0.00	0.00	0.13	0.10	0.10	0.04	0.03	0.00
Big Slough Canal (2299410)													
Total - Monthly	5.15	3.81	6.11	2.87	2.30	2.40	16.24	20.50	12.27	9.03	2.97	6.34	90.27
Mean - Daily	0.17	0.14	0.20	0.10	0.08	0.08	0.52	0.66	0.41	0.29	0.10	0.20	0.25
Median - Daily	0.12	0.13	0.17	0.10	0.07	0.08	0.45	0.57	0.28	0.19	0.10	0.13	0.14
Maximum - Daily	0.48	0.17	0.62	0.16	0.27	0.17	1.16	2.52	1.50	1.30	0.14	0.62	2.52
Minimum - Daily	0.09	0.10	0.07	0.06	0.05	0.04	0.12	0.15	0.13	0.08	0.07	0.08	0.04

TABLE H. (continued)

Rain Gauge	J	F	M	A	M	J	J	A	S	O	N	D	Yearly
Preserve													
Total Rainfall	59.94	1.78	98.55	22.61	39.88	213.61	246.89	106.17	207.01	106.43	40.39	102.62	1245.87
Mean - Daily	2.03	0.00	3.30	0.76	1.27	7.11	7.87	3.56	6.86	3.56	1.27	3.30	3.30
Median - Daily	0.00	0.00	0.00	0.00	0.00	1.52	1.52	0.00	0.76	0.00	0.00	0.00	0.00
NOAA													
Total Rainfall	71.88	5.84	41.15	18.54	32.00	194.82	244.09	140.46	178.56	75.18	48.01	107.44	1157.99
Mean - Daily	2.29	0.25	1.27	0.51	1.02	6.60	7.87	4.57	5.84	2.54	1.52	3.56	3.05
Medain - Daily	0.00	0.00	0.00	0.00	0.00	5.59	0.00	0.00	1.27	0.00	0.00	0.00	0.00
MS2													
Total Rainfall	79.50	8.89	87.88	5.08	3.56	208.03	112.27	130.56	108.20	61.47	30.48	76.96	912.88
Mean - Daily	2.54	0.25	2.79	0.25	0.00	6.86	3.56	4.32	3.56	2.03	1.02	2.54	2.54
Median - Daily	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
MS3													
Total Rainfall	57.15	2.54	74.17	6.10	38.35	130.56	107.95	60.45	205.23	92.71	33.53	89.15	897.89
Mean - Daily	1.78	0.00	2.29	0.25	1.27	4.32	3.56	2.03	6.80	3.05	1.02	2.79	2.54
Median - Daily	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.00
MS4													
Total Rainfall	51.05	3.56	11.94	6.60	5.59	177.80	274.83	185.17	235.46	63.25	23.62	85.09	1123.95
Mean - Daily	1.52	0.25	0.51	0.25	0.25	5.84	8.89	6.10	7.87	2.03	0.76	2.79	3.05
Median - Daily	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.51	0.00	0.00	0.00	0.00

TABLE H. Summary of monthly rainfall (mm) data within the Myakka River watershed.

Rain Gauge	J	F	M	A	M	J	J	A	S	O	N	D	Yearly
Ft. Green													
Total Rainfall	68.58	0.00	46.99	29.21	3.81	298.45	261.11	176.53	168.91	25.40	26.67	121.92	1227.58
Mean - Daily	2.29	0.00	1.52	9.65	0.25	9.91	8.38	5.59	5.59	8.13	1.02	4.06	3.30
Median - Daily	0.00	0.00	0.00	0.00	0.00	2.54	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Myakka River State Park													
Total Rainfall	71.88	5.84	25.91	18.54	32.00	195.07	244.09	139.70	175.01	100.58	47.50	107.44	1165.61
Mean - Daily	2.29	0.25	0.76	0.51	1.02	6.60	7.87	4.57	5.84	3.30	1.52	3.56	3.30
Median - Daily	0.00	0.00	0.00	0.00	0.00	2.29	0.00	0.00	11.43	0.00	0.00	0.00	0.00
Venice													
Total Rainfall	69.85	3.81	67.31	14.99	1.52	215.90	138.18	140.46	223.01	47.24	24.89	104.65	1065.53
Mean - Daily	2.29	0.25	2.29	0.51	0.00	7.11	4.57	4.57	7.37	1.52	0.76	3.30	2.79
Median - Daily	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.78	0.00	0.00	0.00	0.00
North Entrance													
Total Rainfall	79.25	5.08	83.57	16.26	3.56	213.61	236.98	165.35	188.72	53.85	33.78	99.31	1179.32
Mean - Daily	2.54	0.25	2.79	0.51	0.00	7.11	7.62	5.33	6.35	1.78	1.02	3.30	3.30
Median - Daily	0.00	0.00	0.00	0.00	0.00	2.03	3.81	0.00	1.27	0.00	0.00	0.00	0.00
FPL													
Total Rainfall	64.01	10.41	71.63	34.80	6.86	270.76	119.38	152.40	219.96	69.34	34.04	99.06	1152.65
Mean - Daily	2.03	0.51	2.29	1.27	0.25	9.14	3.81	4.83	7.37	2.29	1.27	3.30	3.05
Median - Daily	0.00	0.00	0.00	0.00	0.00	0.76	2.54	0.00	0.76	0.00	0.00	0.00	0.00
Rookery													
Total Rainfall	71.12	8.89	103.12	28.19	26.42	234.44	257.81	130.81	175.77	72.14	51.05	90.17	1249.93
Mean - Daily	2.29	0.25	3.30	1.02	0.76	7.87	8.38	4.32	5.84	2.29	1.78	2.79	3.30
Median - Daily	0.00	0.00	0.00	0.00	0.00	0.76	3.81	0.00	0.76	0.00	0.00	0.00	0.00

TABLE I. Results of storm 1 hydrograph analysis.

Stream Gage/ Subbasin	Subbasin Area hectares	(mi^2)	Total Rainfall P (mm)	Direct Runoff R (mm)	Total Abstraction F (mm)
Myakka City (2298608)	32376	(125)	188.2	18.8	169.4
Myakka/S.R. 780 (2298700)	42737	(165)	153.2	38.1	125.3
Myakka/Sarasota (2298830)	59313	(229)	141.2	9.2	132.0
Myakka/Laurel (2298880)	65529	(253)	115.3	19.6	95.7
Howard Creek (2298760)	5180	(20)	181.9	2.5	179.4
Deer Prairie Slough (2299160)	8547	(33)	130.6	5.3	125.3
Big Slough Canal (2299410)	9583	(37)	89.4	11.8	77.6
Big Slough Canal North Port (2299455)	24088	(93)	104.9	8.5	96.4

TABLE J. Results of storm 2 hydrograph analysis.

Stream Gage/ Subbasin	Subbasin Area hectares	(mi^2)	Total Rainfall P (mm)	Direct Runoff R (mm)	Total Abstraction F (mm)	Peak Flow Rate* qp (m^3/s)	Time to Peak Tp (hrs)	Return Time Tr (hrs)	Peak Rate Factor K	SCS Curve Number CN
Myakka City (2298608)	32376	(125)	79.3	31.0	48.3	20.4	99	394	0.73	84
Myakka/S.R. 780 (2298700)	42736	(165)	103.1	70.4	33.0	66.0	103	224	0.81	89
Myakka/Sarasota (2298830)	59313	(229)	102.4	14.7	87.6	11.5	155	312	0.73	74
Myakka/Laurel (2298880)	65529	(253)	109.5	21.8	87.7	28.3	—	—	—	—
Howard Creek (2298760)	5180	(20)	103.1	22.6	80.7	2.4	39	268	0.29	76
Deer Prairie Slough (2299160)	8547	(33)	3.12	0.8	78.5	1.4	52	468	3.83	76
Big Slough Canal (2299410)	9583	(37)	83.6	8.4	75.2	1.4	138	432	0.86	77
Big Slough Canal North Port (2299455)	24088	(93)	81.8	7.4	74.4	3.4	30	460	0.21	77

each hydrograph consisted of hourly and daily flow rates recorded at the respective station. Base flow volume was isolated from the plotted discharge curve by extending a horizontal straight line from the beginning point of the rising limb to a point of intersection with the receding limb. The area between the curve and this line was assumed to be the direct runoff volume (R) produced by the storm event.

Rainfall hyetographs were then constructed for each of the hydrographs, based on daily rainfall records. The rainfall amount for each day was taken to be a simple arithmetic mean of measurements from selected monitoring stations associated with each subbasin. This method of rainfall calculation was considered to be adequate since the individual subbasins are of such large area that the effects of rainfall distribution would be of small consequence. The data consisted of daily rainfall totals only and included no information on variations of intensity within the 24 hour period. Since no hourly intensity data were available, rainfall amounts were presented as millimeters per 24 hours.

Storm 1 Hydrograph Analysis

Rainfall activity during the period of July 15 and August 9 was typical for the southwest Florida region. Frequent, localized, convective storms produced wide variations in rainfall amount and intensity throughout the Myakka basin. Daily rainfalls ranging from 9.9 mm to 71.6 mm were recorded at various monitoring stations throughout the basin. The resulting runoff from these storms produced hydrographs that were in many cases multi-peaked, thereby yielding indistinct correlations between rainfall and runoff. The SCS method of analysis provides no means of partitioning combined flows represented by the multiple peaks, therefore, no attempt was made to calculate SCS comparison parameters. However, examination of these hydrographs did provide volumetric comparisons of total period rainfall and total direct runoff which were useful in understanding the retention characteristics of the subbasin.

Storm 2 Hydrograph Analysis

Rainfall activity during the period from September 22 to October 16 was much more stable than during the prior storm period. Rainfall occurred daily during a five day span from September 23 until September 27 at all monitoring stations within the Myakka basin. Daily amounts ranging from 0.5 mm to 58.4 mm were recorded in the basin with fairly consistent distributions within each subbasin. This five day span had been proceeded by four days of zero precipitation, and was followed by ten days of zero precipitation. These periods of inactivity effectively isolated the five day storm thus providing an ideal situation for the creation of single-peaked hydrographs necessary for reliable SCS analysis.

The peak rate factor "K" was calculated for each storm 2 hydrograph in an effort to characterize hydrograph shape and provide a means of comparison to the SCS unit hydrograph. This was accomplished by the use of the following relationship as given in SCS publication TR-55:

$$K = \frac{(q_p \times T_p)}{(A \times R)} \qquad (1)$$

where:

q_p = peak flow rate
T_p = time to peak
A = basin area
R = direct runoff

In an effort to understand the effects of ground cover and land use within the Myakka basin, SCS curve numbers (CN) were treated in the analysis of storm 2 hydrographs. From rainfall data and hydrograph runoff estimations, curve numbers were then back-calculated using two accepted SCS relationships detailed below.

$$R = \frac{(P - .2S)^2}{(P + .8S)} \qquad (2)$$

where:

R = runoff
P = total rainfall
S = potential abstraction

Equation (2) is solved for S, which is an estimate of the maximum retention for the basin. The curve number, which is an indication of the potential runoff of the basin, is inversely related to S by:

$$CN = \frac{1000}{(10 + S)} \qquad (3)$$

A curve number was calculated for each hydrograph in this manner. The resulting values were then compared to accepted SCS values for the soil cover and land uses found in the basin.

Water Chemistry

Sampling Periodicity

Sampling was conducted throughout 1989 during 17 regularly scheduled sampling runs. Sampling periodicity was approximately every three weeks during periods of low rainfall (October - May) and every two weeks during periods of high rainfall (June - September). Sampling was conducted over a two day period; basin sampling on day one and estuary sampling on day two.

In addition to regular sampling events, sampling was conducted during two storm events to characterize loading rates during high flow periods. To accomplish this, several samples were collected at each site over a short time period. Samples were collected during the rising arm of the hydrograph (n=3), at the peak (n=1) and during the declining arm (n=3).

To obtain the desired distribution of samples across the hydrograph, historic rainfall events were compared with their associated hydrographs. In addition to amount and duration of rainfall, factors such as stream stage, channel morphology and depth of the water table can influence hydrograph behavior. Therefore, separate analyses were conducted for several stations. This resulted in sampling regimes that were specific for each site (Table K).

Station Locations

A total of eighteen sampling stations were monitored; eight within the river basin (basin sites) and ten in the estuary and tidal portion of the river (estuary sites) (Figure 7). Appendix A contains a description of the sampling locations. Stations within the basin were chosen so that subbasin water quality could be characterized. Sampling was done in close proximity to USGS continuous record gaging stations so that nutrient loading rates could be determined. Project personnel were not allowed access to one gaging station that is on private property, therefore one station (B170), was located approximately 1.2 kilometers downstream of the corresponding gaging station. On each sampling date, basin sampling began at the northern part of the watershed and proceeded south.

Eight of the ten estuary sites were related to monitoring sites established by Mote Marine Laboratory for wet and dry season characterizations of the Myakka River (Estevez 1985; 1986). These sites ranged from Charlotte Harbor to the "big bend" area (River miles -2.1 to 16.2). The locations of the remaining two stations ("floating" stations) were determined in the field from salinity data obtained from the eight fixed stations. These stations were chosen such that there were no large gaps in salinity between

TABLE K. Determination of days to peak and fall for selected storm events.

	B110			B120			B140		
	Days to Peak	Days to Fall	Total	Days to Peak	Days to Fall	Total	Days to Peak	Days to Fall	Total
	3	5	8	3	7	10	4	9	13
	2	6	8	2	3	5	5	12	17
	3	9	12	1	5	6	7	16	23
	4	10	14	4	4	8	5	6	11
	2	7	9	2	7	9	4	18	22
	5	7	12	3	4	7	7	16	23
	2	9	11	3	2	5	5	13	18
	5	6	11	1	6	7	6	10	16
Mean	3.3	7.4	10.6	2.4	4.8	7.1	5.4	12.5	17.9
Minimum	2	5	3	1	2	5	4	6	11
Maximum	5	10	14	4	7	10	7	18	23
Std. Dev.	1.2	1.7	2.0	1.0	1.7	1.7	1.1	3.8	4.3

	B150			B160		
	Days to Peak	Days to Fall	Total	Days to Peak	Days to Fall	Total
	7	7	14	6	9	15
	2	6	8	7	16	23
	2	2	4	9	6	15
	2	6	8	5	14	19
	4	5	9	5	10	15
	2	5	7	11	14	25
	1	6	7	7	12	19
	5	7	12	6	15	21
Mean	3.1	5.5	8.6	7.0	12.0	19.0
Minimum	1	2	4	5	6	15
Maximum	7	7	14	11	16	25
Std. Dev.	1.9	1.5	2.9	1.9	3.2	3.6

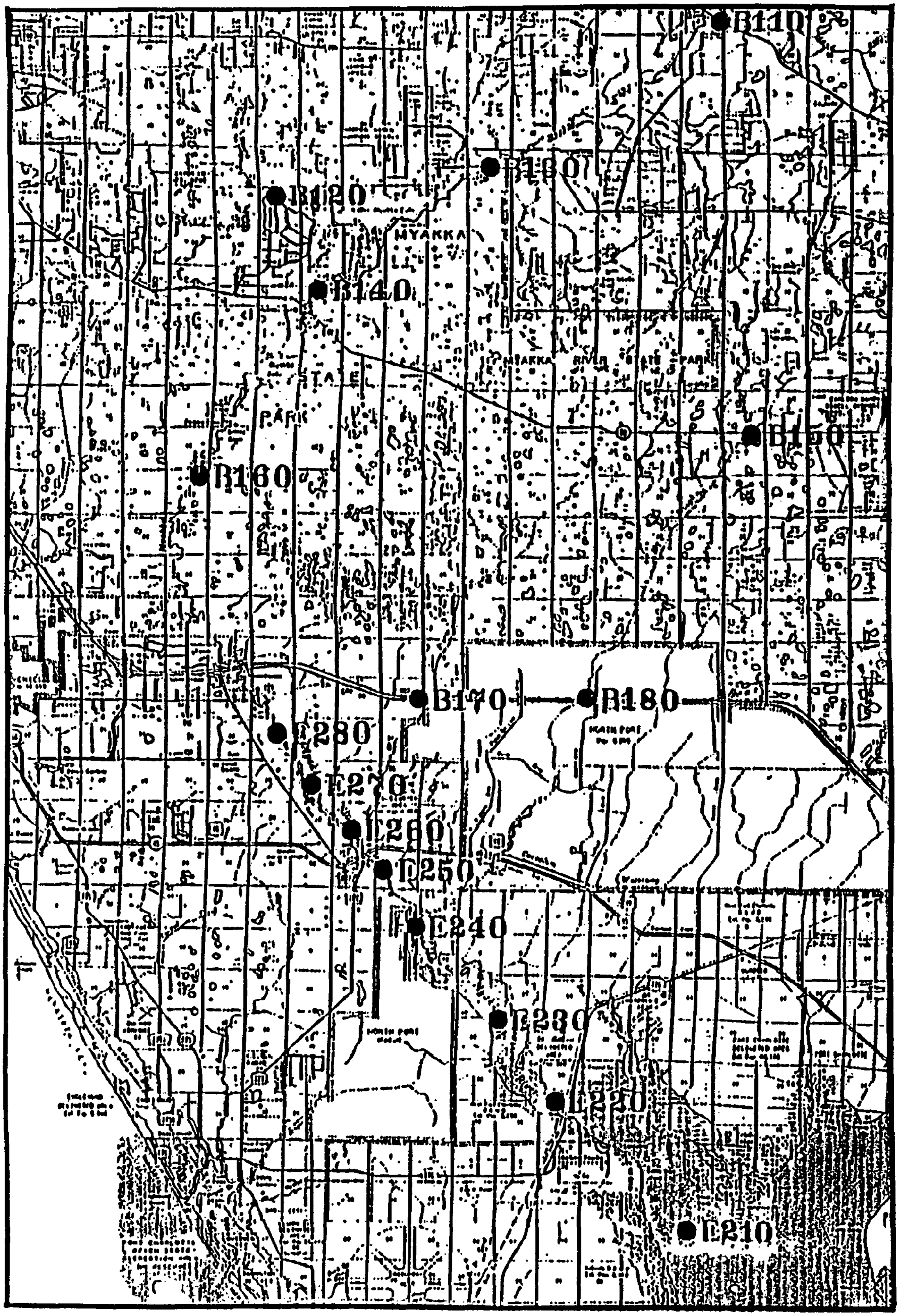


FIGURE 7. Location of basin and estuary sampling sites.

stations. In general, the floating stations were located so that at least four stations were in the 0 to 10 ppt salinity range. Sampling in the estuary began at the southern most station and proceeded upstream. Generally, sampling was done through a rising tide and a slack high tide.

Sampling Methods and In-situ Measurements

Measurements of dissolved oxygen, temperature, and conductivity at basin sites were taken at 0.5 m, or at mid-depth if the water depth was too shallow at allow for readings at 0.5 m without disturbing bottom sediments. At estuary sites, a vertical profile was taken at 0.5 m intervals for dissolved oxygen, temperature, conductivity and salinity. Measurements were taken on the downcast and the upcast.

Measurements were taken with YSI Model 33 S-C-T meter and Model 57 dissolved oxygen meter with a remote stirrer. Meters were calibrated in the laboratory prior to sampling. The D.O. meter was calibrated in chlorine-free, distilled water by Winkler titration (EPA method 360.1). Air calibration was checked at every site, and recalibration was done as necessary. The SCT meter was checked in the lab against a KCl standard.

Water samples at basin sites were collected at mid-depth with an Alpha Bottle (Wildco). When water depth was too shallow for alpha-bottle use without disturbing bottom sediments, samples were collected by hand-dipping sample containers. Hand-dip samples were taken facing the flow of the water. Estuary water samples were collected at mid-depth when the water column was vertically mixed. When the water column was stratified (defined as a 3 o/oo or greater change in salinity or 1.5 mg/l or greater change in dissolved oxygen over a 0.5 meter or less change in depth), samples were collected at the mid-depth of both strata.

Water samples were poured directly into clean 1/2 liter polyethylene bottles. Replicate samples were collected at each station. pH readings were taken from each sample by pouring approximately 15 ml of the sample into a clean 30 ml container. pH was measured with a Beckman Model 10 digital pH meter. The meter was 2-point calibrated in the lab and 1-point calibrated (pH 7.0) at every site. Water samples were immediately put on ice and delivered to the Mote Marine Laboratory after sampling was complete, usually within two hours.

Wind speed and direction were measured at an exposed site near the sampling location. Wind speed was measured with a hand held (Dwyer) wind gage, and wind direction was measured with a hand held compass. Air temperature was measured by placing a thermometer in a non-enclosed area away from direct sunlight.

Cloud cover and other pertinent meteorological information were recorded. Station depth was recorded with a lead line marked in meters.

In addition, Secchi disk depths were taken at all estuary sites. Measurements are made with a 50 cm oceanographic-style disk. Secchi disk depths were measured for both the white and black sides of the disk.

Laboratory Analysis

The parameters analyzed and the methods used are listed in Table L. Mote Marine Laboratory analyzed all parameters except particulate nitrogen and carbon. For particulate nitrogen and carbon analyses, 250 ml of sample water was filtered through precombusted glass fiber filters (Gelman A/E 25 mm). Filters were rinsed three times with 10 ml of deionized water, folded with the residue inward and wrapped in precombusted foil. The filters were frozen, packed on dry ice and shipped overnight to the SWFWMD laboratory for subsequent analysis.

TABLE L. Chemical parameters and methods used for analysis.

Parameters	Methods[1]	Units
DISSOLVED COMPONENTS		
Ammonium-Nitrogen	SM 417F	mg-N L^{-1}
Total Kjeldahl Nitrogen	EPA 351.2	mg-N L^{-1}
Nitrate-Nitrite-Nitrogen	EPA 353.2	mg-N L^{-1}
Orthophosphorus	EPA 365.1	mg-P L^{-1}
Organic Carbon	EPA 415.1	mg-C L^{-1}
PARTICULATE COMPONENTS		
Total Phosphorus	EPA 365.1	mg-P L^{-1}
Total Carbon	P.E.	mg-C L^{-1}
Total Nitrogen	P.E.	mg-N L^{-1}
OTHER		
Total Suspended Solids	SM 209D	mg L^{-1}
Turbidity	EPA 180.1	NTU

[1] SM = Standard Methods, 15th Ed; EPA = EPA 600/4-79-020 Methods for Chemical Analysis of Water and Waste Water; P.E. = Perkin-Elmer Model 2400 Elemental Analyzer Manual.

Nutrient Flux Analysis

The data for water from seven of the eight stations sampled were evaluated to determine fluxes of materials (nutrients and solids) from the various subbasins of the Myakka River Watershed and to elucidate processes influencing the transport of these materials. The reason for using results from only seven of the eight stations is that discharge data for them (all except B130) were available for the entire study period along with water chemistry. Data on water chemistry collected from storm sampling campaigns were used to assess the importance of storm events on the fluxes, (i.e., to see if these events produced more efficient delivery effects). Water chemistry of samples collected from monthly transects of the Myakka River estuary were compared to that of the freshwater sources in the watershed to evaluate processes affecting transport and removal of materials in the estuarine environment.

The following sections describe methods used to reduce and analyze the data for the purposes described above.

Estimates of Annual Material Flux

The flux or load of a chemical substance transported from subbasins of the Myakka River watershed is simply the product of the chemical concentration and water discharge. Instantaneous values of flux are relatively simple to derive for each river station using measured substance concentrations and instantaneous or daily mean discharge at the time of sampling. It is much more difficult to estimate, with a high degree of accuracy, fluxes over longer periods of time such as a year or more since this requires long term records of concentration (C) and discharge (Q), so the flux (F) can be calculated by integration using the equation:

$$F = \int_{0}^{t} CQdt \quad (1)$$

It would be easy to calculate fluxes if concentrations of substances were constant over all variations in discharge. This, however, is not the case since the concentrations of virtually all substances, both particulate and soluble, vary with discharge. Nonetheless, several approaches have been used to calculate fluxes with limited data collected over various flow conditions of a watershed. Generally, the approaches used involve either extrapolation or interpolation of the data. Each of these approaches is discussed below.

Extrapolation Method for Estimating Material Flux

This procedure attempts to extrapolate the available database by developing rating relationships which link chemical concentrations measured at infrequent intervals to stream discharge at the time of sampling. Rating relationships are normally developed for sites with discharge monitoring facilities so that the rating function may be applied to a continuous flow record, thus allowing for extrapolation of chemical concentration (and flux) between periods of sample collection. Simple power functions of the form:

$$\text{Concentration} = aQ^b \quad (2)$$

are used to relate the concentration of a substance and river flow, Q. Such relationships have been routinely documented by many studies. For example, suspended sediments generally show increased concentration with discharge following a relationship described in equation (2) with b being a positive number. In the case of total dissolved solids, a similar relationship is observed, but b is sometimes negative (Figure 8). Rating relationships or rating curves have been demonstrated for many specific substances, for both natural and anthropogenically disturbed (e.g., agricultural areas) watersheds (Nilsson, 1971; Turvey, 1975; Walling and Webb, 1983; Walling and Kane, 1984).

Although rating relationships for total dissolved solids often exhibit decreasing concentrations with increasing discharge typically due to dilution, specific dissolved substances such as nutrients often show increases with discharge (Walling and Webb, 1984; Webb and Walling, 1985).

Rating curves are developed by obtaining concentration data over seasonal variations in discharge for a given watershed. Fitting concentration data to discharge is usually accomplished by least-squares regression techniques. This approach was employed in the present study using the observed concentrations of constituents and mean discharge for the station on the day of sample collection and applying a log transformation of equation (2).

Other authors (e.g., Jansson, 1985) have argued that other methods of curve fitting are more appropriate, and in some cases (e.g., Hall, 1970; Davis and Zorbrist, 1978; Foster, 1980), the relationship between concentration and discharge will not be described by a simple power function. Given the limited data set for each station, the least-squares regression approach used in this study is more appropriate.

Many investigators have stressed the complexity and variability of storm-period sediment and solute responses to discharge (Miller and Drever, 1977; Walling and Foster, 1978; Foster, 1978a,b; Reid et al., 1981, Dupraz et al., 1982; Webb and

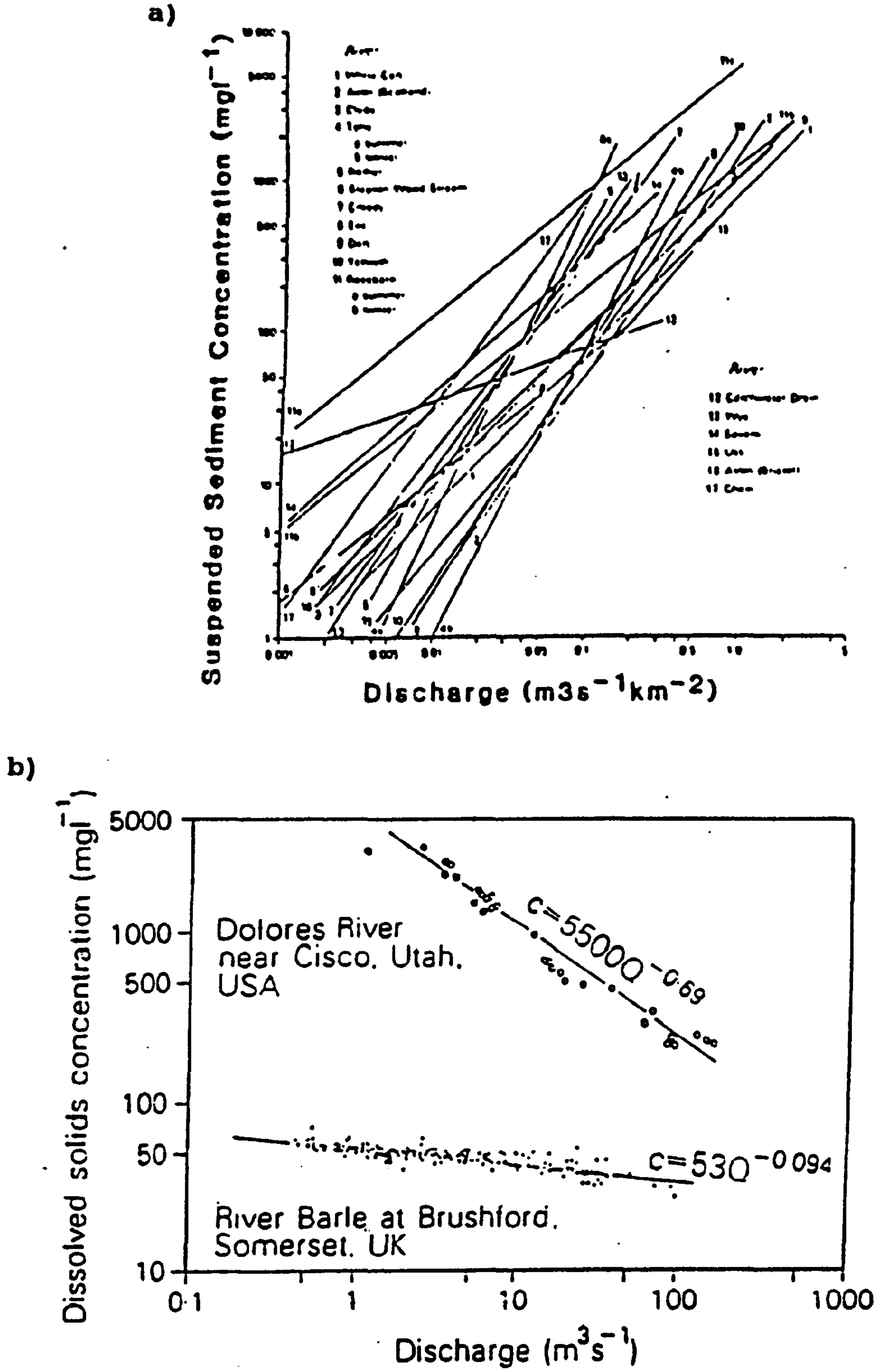


FIGURE 8. Concentration-discharge rating relationship for dissolved, particulate and particulate-associated substances in rivers (after (a) Walling and Webb, 1983 and (b) Walling and Webb, 1981).

Walling, 1983; Walling and Webb, 1986a,b). Thus, it is important to determine concentration relationships to storm-related variations in flow. In practice, for a given watershed, separate rating curves can be developed for seasonal flow and storm-related flow. For this study, however, the data collected during storm events were combined with the data from the periodically collected routine samples.

Once the rating curves are developed (assuming the least square relationship is significant), annual flux of a given material by each river is calculated using the following equation,

$$\text{Flux} = \sum_{i=1}^{n} aQ_i^{b+1}t \quad (3)$$

where Q_i is the mean daily discharge recorded at the specific stream gauge, n = 365, a and b are constants derived from the least square regression analysis of concentration on discharge, and t is the time over which Q_i is averaged.

Interpolation Method for Estimating Material Flux

Several interpolation procedures have been used for estimating total loads or fluxes of materials. Five representative numerical procedures are listed in Table M. These procedures make the assumption that the chemical concentration of a water sample is representative of conditions in the river for the period between sampling. These approaches essentially attempt to weigh the concentration to discharge. For the present study, Method 5 was used. For each parameter, the calculations were carried out using the results from all samples collected January through December 1989. For these calculations, n generally was around 30-35 and the conversion factor K was adjusted for a discharge record of 12 months.

Estuarine Chemistry

Advection-diffusion models have been used by many investigators to interpret estuarine chemical data (e.g., Li and Chan, 1979; Kaul and Froelich, 1984). These models use salinity as a tracer. The distribution of a constituent in estuarine waters can be compared to salinity to determine whether a substance is: 1) conservatively transported throughout the estuary, 2) removed from the water column or 3) added to the water column due to local input (e.g., anthropogenic, release from sediments, etc.). These types of estuarine behaviors are demonstrated in Figure 9.

From the advection-diffusion models using salinity as a conservative tracer, the intercept of the extrapolation (or tangent) of the constituent-salinity curve at the high salinity end of the curve where change in constituent concentration with change in salinity is constant, is defined as the apparent zero salinity

TABLE M. Interpolation methods for flux calculations.

Method	Numerical Procedure
1	TOTAL LOAD $= K\left(\sum_{i=1}^{n} \frac{C_i}{n}\right)\left(\sum_{i=1}^{n} \frac{Q_i}{n}\right)$
2	TOTAL LOAD $= K\bar{Q}_r \left(\sum_{i=1}^{n} \frac{C_i}{n}\right)$
3	TOTAL LOAD $= K\sum_{i=1}^{n} \left(\frac{C_i Q_i}{n}\right)$
4	TOTAL LOAD $= K\sum_{i=1}^{n} (C_i \bar{Q}_p)$
5	TOTAL LOAD $= \frac{K\sum_{i=1}^{n} (C_i Q_i)}{\sum_{i=1}^{n} Q_i} Q_r$

K = CONVERSION FACTOR TO TAKE ACCOUNT OF PERIOD OF RECORD

C_i = INSTANTANEOUS CONCENTRATION ASSOCIATED WITH INDIVIDUAL SAMPLES

Q_i = INSTANTANEOUS DISCHARGE AT TIME OF SAMPLING

Q_r = MEAN DISCHARGE FOR PERIOD OF RECORD

Q_p = MEAN DISCHARGE FOR INTERVAL BETWEEN SAMPLES

n = NUMBER OF SAMPLES

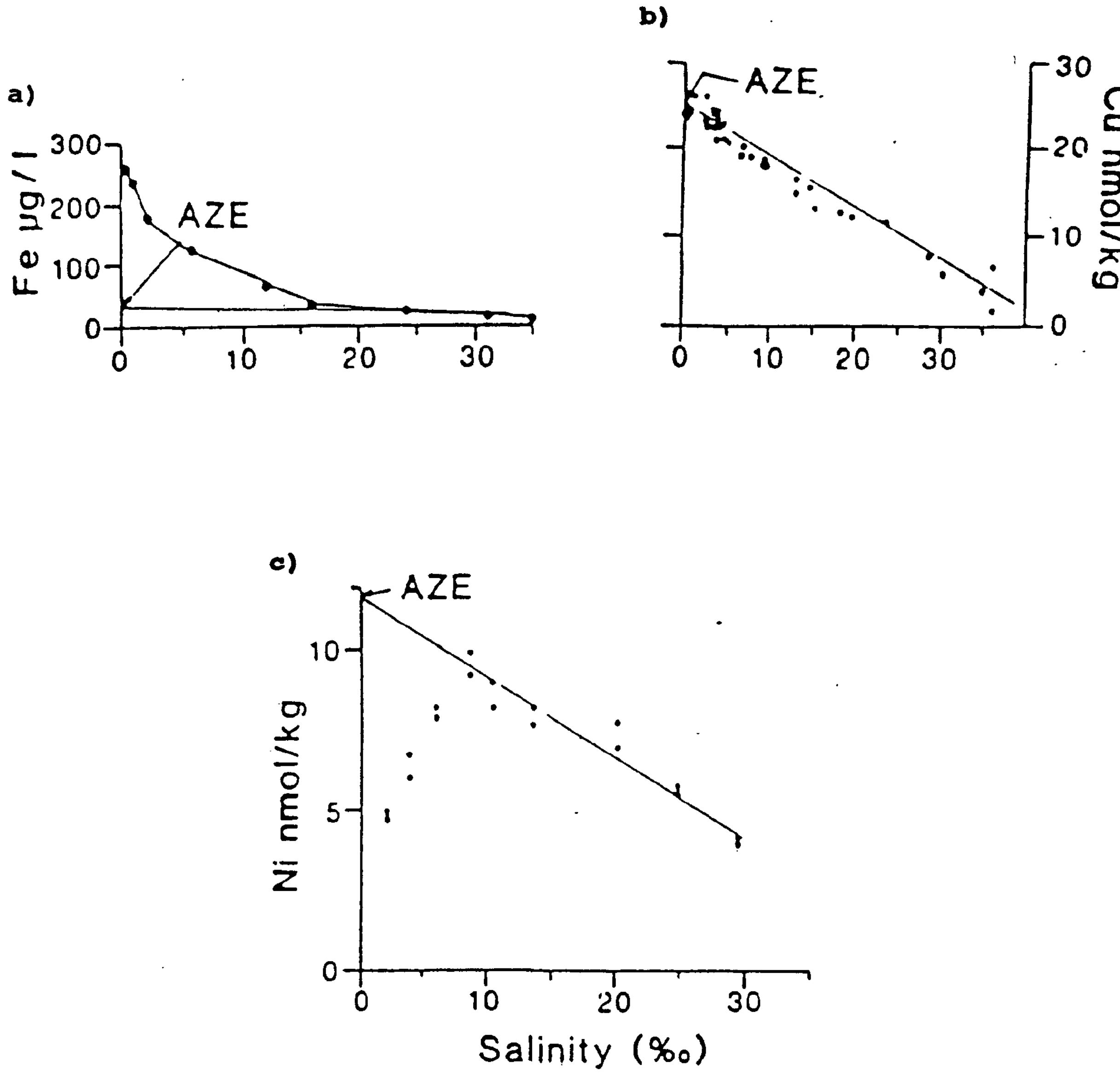


FIGURE 9. Examples of different estuarine behavior of trace metals: (a) removal (after Figueres et al., 1978; (b) conservative; and (c) release (Windom, unpubl. data).

end-member (AZE). It can be demonstrated mathematically that river discharge multiplied by the difference in the observed zero salinity concentration and the AZE value gives the rate of removal, or release, of the constituent, per unit time, necessary to produce the observed concentration distribution. The only assumption required is that the concentration of the constituent in the freshwater input is constant over the residence time of the estuary. For the Myakka River estuary, this assumption is satisfied sufficiently to draw the conclusions that will be made.

Following the approach described above (advection-diffusion model), monthly data for concentrations of dissolved nitrate + nitrite (NO_3+NO_2), orthophosphate (PO_4), organic carbon (DOC), and ammonia; total suspended solids (TSS); and particulate organic carbon (PC), nitrogen (PN) and phosphorus (PP) were plotted against salinity. Concentration of all freshwater samples taken during the same sampling period is also plotted as the freshwater end members.

Sediment Chemistry

Sampling Locations

Sediment samples were collected from four stations in the Myakka River and one station in Charlotte Harbor at the mouth of the Myakka River in November 1989. At the same time, sediments were collected from several other stations in the Peace River and upper Charlotte Harbor. Data from some of these stations are included in this report for comparison with data from the Myakka River. Station locations for all sites are listed in Table N.

TABLE N. Dates and location for Myakka River, Peace River and selected Charlotte Harbor sediment sampling stations.

STATION	DATE	LATITUDE	LONGITUDE	LORAN	
MYK-1	11/07/89	27 01.94	82 15.20	30869.2	44164.1
MYK-2	11/07/89	27 04.25	82 18.81	30871.6	44206.7
MYK-3	11/07/89	27 03.24	82 17.59	30869.6	44191.1
MYK-4	11/07/89	27 00.98	82 16.33	30861.4	44168.7
PER-1	08/29/85	26 57.08	82 03.25	62681.9	44037.8
PER-1	11/07/89	26 57.01	82 03.21	30874.9	44037.5
PER-2	11/07/89	26 59.65	81 59.79	30896.4	44021.0
PER-3	11/07/89	26 58.20	82 00.65	30887.2	44021.3
CHH-2	07/13/85	26 54.65	82 09.67	30846.8	14165.1
CHH-2	11/07/89	26 54.65	82 09.67	30846.8	44081.2
CHH-7	09/24/86	26 51.17	82 08.95	14158.6	44058.9
CHH-7	11/09/89	26 51.17	82 08.95	30831.2	44059.0
CHH-19	11/08/89	26 55.18	82 10.96	30846.2	44094.7
CHH-20	11/08/89	26 54.44	82 10.58	30843.4	44087.9

Sampling Methods

Sediments from all stations were analyzed for nutrients and metals. In addition, several classes of organic compounds were measured in the samples from stations MYK-1 and MYK-3. FDER had previously collected sediment chemistry data from other stations in Charlotte Harbor and the Peace River (locations listed in Table N); these data are also presented in this report.

Sediments were collected with a stainless steel Ponar grab. The grab samples represented surficial sediments to a depth of approximately 5 cm. At each station, triplicate grabs were taken and two were analyzed. The third sample was held in reserve in the event of sample loss.

All samples were placed in pre-cleaned containers, stored on ice, and shipped to the Savannah Laboratories and Environmental Services (SL&ES, Savannah, GA) for processing within 24 hours.

Laboratory Analysis

Metals. Sediment metal concentrations were determined for ten metals: aluminum, arsenic, cadmium, chromium, copper, lead, iron, mercury, nickel, and zinc. For all metals except mercury, sediment was dried at 80° C, thoroughly mixed, and a 0.3 to 0.5 g portion weighed into a 100 ml polytetrafluoroethylene vial. Five ml of Ultrex HF and 10 ml concentrated Ultrex HNO_3 were added, the vials capped, and the sample digested by refluxing at 100° C for 48 hours. After digestion, the sample was taken to dryness and the residue dissolved in 1 ml concentrated Ultrex HNO_3 and 9 ml deionized, double distilled water. Total digestion using HF is essential for releasing all metals from aluminosilicate mineral lattices. Sediment samples for mercury were first digested with H_2SO_4 and HNO_3 in a water bath at 60° C and then further oxidized with potassium permanganate.

Aluminum and zinc were analyzed using flame atomic absorption spectroscopy (AAS). Cadmium, chromium, copper, lead, and nickel were analyzed by flameless AAS using a Zeeman furnace. Flameless AAS methods were used for arsenic (hydride) and mercury (cold vapor). The AAS methods are described in APHA (1985).

Duplicate laboratory analyses and spikes were performed on 10% of all samples. National Bureau of Standards (NBS) Estuarine Sediment Standard Reference Material 1646 was run with each batch of sediment samples. Analyses of all sediment samples in a batch were repeated if analytical results of the Standard Reference Material deviated by more than two standard deviations (lab results) from the mean reported by NBS.

Nutrients. Total organic carbon (TOC), total Kjeldahl nitrogen (TKN) and total phosphorus (TP) were determined according to methods described in APHA (1985).

Organics. Chlorinated pesticides and polychlorinated biphenyls (PCB) were analyzed by Method 608 (40 CFR, Part 136). Semi-volatile organics and polynuclear aromatic hydrocarbons (PAH) were analyzed by Methods 8270 and 8310 (EPA SW 846), respectively. The compounds measured and detection limits are listed in Table O.

TABLE O. Organic compounds measured and detection limits for July 1985 (CHH-2) and November 1989 (MYK-1, MYK-3) sediment samples.

Compound	Detection Limit
<u>Station CHH-2, July 1985</u>	
<u>Polynuclear Aromatic Hydrocarbons (PAH)</u>	
Acenapthene	0.1 mg kg^{-1}
Acenapthylene	0.1
Chrysene + benzo(a)anthracene	0.2
Benzo(a)pyrene	0.2
Benzo(b,k)fluoranthene	0.2
Benzo(g,h,i)perylene	0.4
Fluoranthene	0.1
Fluorene	0.1
Indeno(1,2,3-cd)pyrene + Dibenzo(a,h)anthracene	0.4
Napthalene	0.1
Pyrene	0.1
Phenanthrene + anthracene	0.1
<u>Stations MYK-1, MYK-3, November 1989</u>	
<u>Chlorinated Pesticides</u>	
Aldrin	1 µg kg^{-1}
alpha-BHC	1
beta-BHC	1
delta-BHC	1
gamma-BHC	1
Chlordane	10
4,4'-DDD	2
4,4'-DDE	2
4,4'-DDT	5
Dieldrin	2
Endosulfan I	2
Endosulfan II	5
Endosulfan sulfate	5
Endrin	2
Endrin Aldehyde	5
Heptachlor	1
Heptachlor epoxide	2
Kepone	5
Methoxychlor	10
Toxaphene	20

TABLE O. (continued)

Compound	Detection Limit
Polychlorinated biphenyls (PCB)	
Aroclor 1016	5 µg kg^{-1}
Aroclor 1221	5
Aroclor 1232	5
Aroclor 1242	5
Aroclor 1248	5
Aroclor 1254	5
Aroclor 1260	5
Aliphatic hydrocarbons	
C10 aliphatics	25 ug kg^{-1}
C11 aliphatics	25
C12 aliphatics	25
C13 aliphatics	25
C14 aliphatics	25
C15 aliphatics	25
C16 aliphatics	25
C17 aliphatics	25
C18 aliphatics	25
C19 aliphatics	25
C20 aliphatics	25
C21 aliphatics	25
C22 aliphatics	25
C23 aliphatics	25
C24 aliphatics	25
C25 aliphatics	50
C26 aliphatics	50
C27 aliphatics	50
C28 aliphatics	50
C29 aliphatics	50
C30 aliphatics	50
Polynuclear Aromatic Hydrocarbons (PAH)	
Acenapthene	40 µg kg^{-1}
Acenapthylene	40
Anthracene	40
Benzo(a)anthracene	40
Benzo(a)pyrene	40
Benzo(b)fluoranthene	40
Benzo(g,h,i)perylene	40
Benzo(k)fluoranthene	40
Chrysene	40
Dibenzo(a,h)anthracene	40
Fluoranthene	40

TABLE O. (continued)

Compound	Detection Limit
Fluorene	40
Indeno(1,2,3-cd)pyrene	40
Napthalene	40
Pyrene	40
Phenanthrene	40
1-Methylnaphthalene	40
2-Methylnaphthalene	40
Benzonitrile	85
Quinoline	85
Quinaldine	135
8-Methylquinaline	85
7,8-Benzoquinoline	85
2,4-Dimethylquinoline	135
Acridine	135
Carbazole	85

IV. RESULTS

Rainfall and Hydrological Results

Rainfall

Appendix B contains a detailed listing of monthly rainfall levels for the period of record at the long-term rainfall station. Rainfall for the 1989 study period was below the mean for the period of record at all long-term rainfall stations. Annual rainfall for two long-term rainfall stations within and near the study area is shown in Figure 10. Rainfall in 1989 at the NOAA station in Myakka River State Park was 256 mm below the mean for the period 1944 through 1989. A comparison of mean monthly rainfall for the period of record with monthly rainfall for 1989 indicates that lower than average rainfall in the late winter and spring, particularly during February and May, contributed greatly to the low rainfall in 1989 (Figure 11).

Spatial variability of rainfall inputs within the watershed is high, especially during summer months when rainfall results from highly localized convective storms. Figure 12 shows 1989 monthly rainfall for June through September from six sites within the basin. Most sites are within four miles of each other (Figure 6). Not only do the sites vary in rainfall amount, the relationship among sites is not consistent from month to month (i.e., site 1 does not always receive more rainfall that site 2).

Hydrology

Hydrographs for the seven gauged streams during the period 1 October 1988 to 30 September 1989 are shown in Figure 13. These data indicate that the general seasonal discharge patterns of all subbasins are similar with a well defined low flow period between November and June and a high discharge period during the remainder of the year.

Storm Hydrograph and Rainfall

Myakka City (B110)

Gaging Station #2298608 is located at the State Road 70 bridge near Myakka City. This is the furthermost upstream station on the main body of the River and monitors a watershed of 32,376 ha. The watershed is quite wide for its length and is drained by numerous streams. It contains several large areas of potential surface retention in the form of depressional wetlands.

The storm 1 hydrograph (Figure 14) for this gage was characterized by a series of three distinct peaks. All of these exhibited shapes characteristic of a wide watershed with steep-sloped rising limbs followed by receding limbs of fairly constant

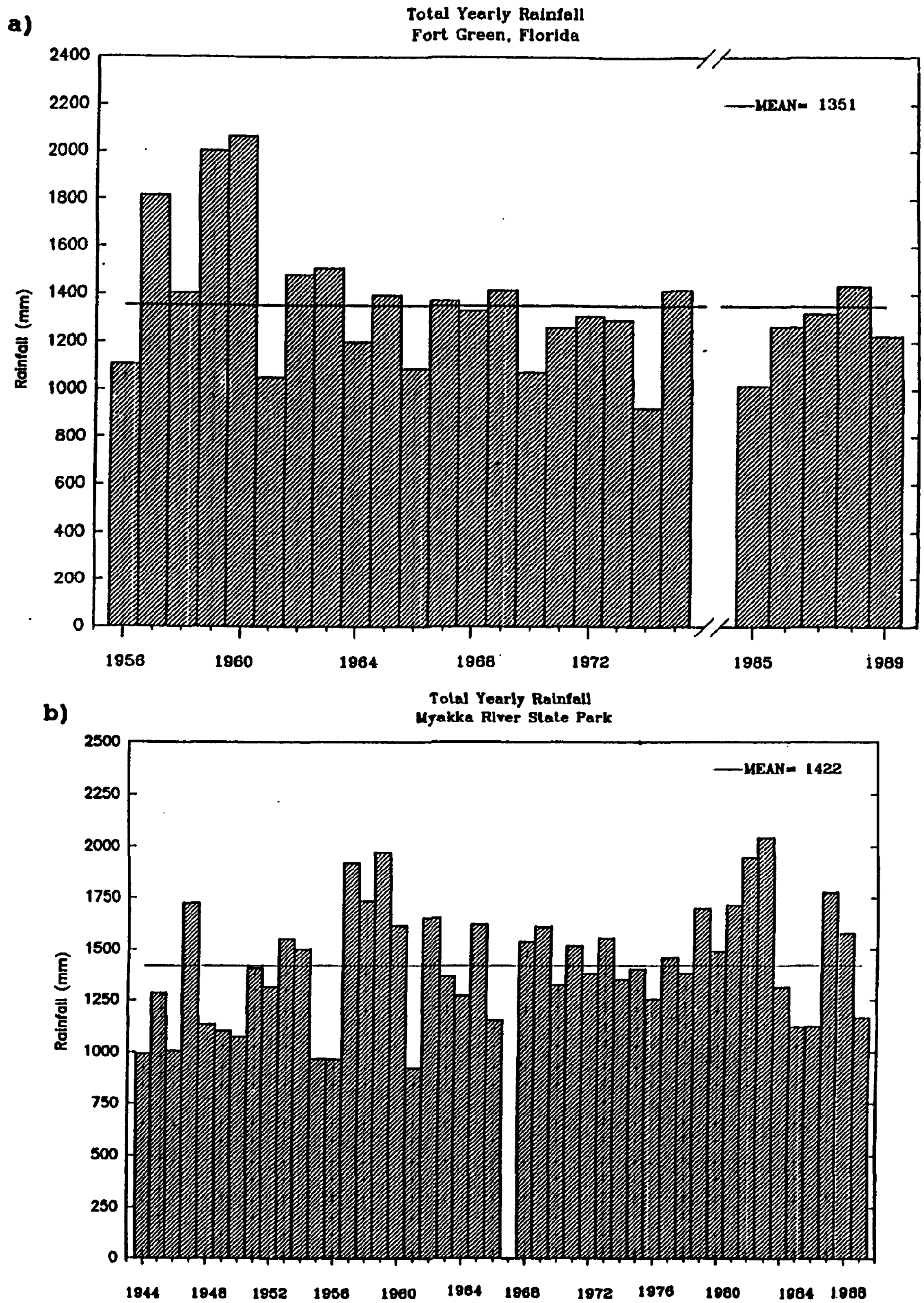


FIGURE 10. Long-term annual rainfall for (a) Fort Green and (b) Myakka River State Park.

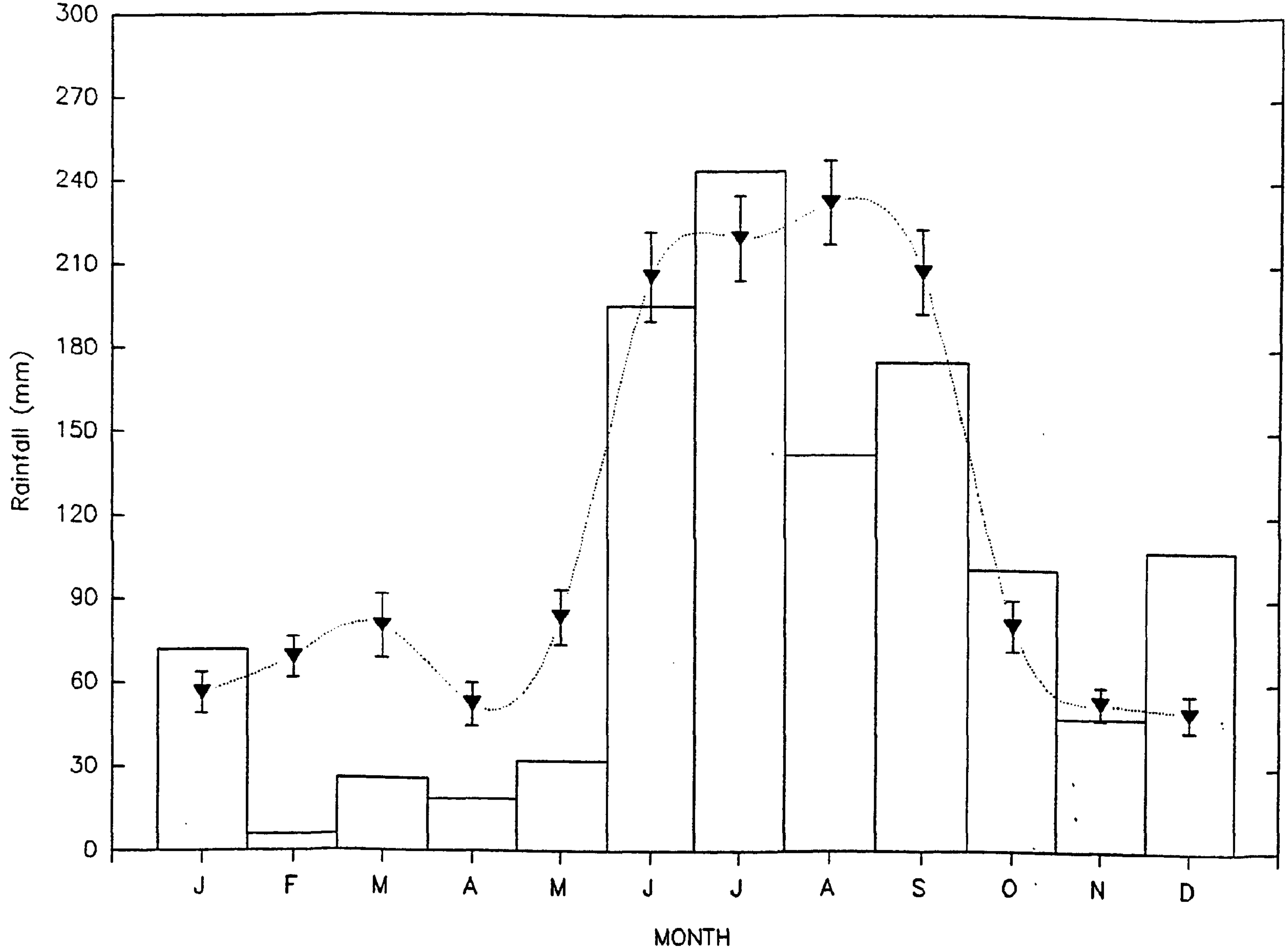


FIGURE 11. Comparison of mean monthly rainfall for 1944-1989 (triangles) with monthly rainfall for 1989 (bars) at Myakka River State Park.

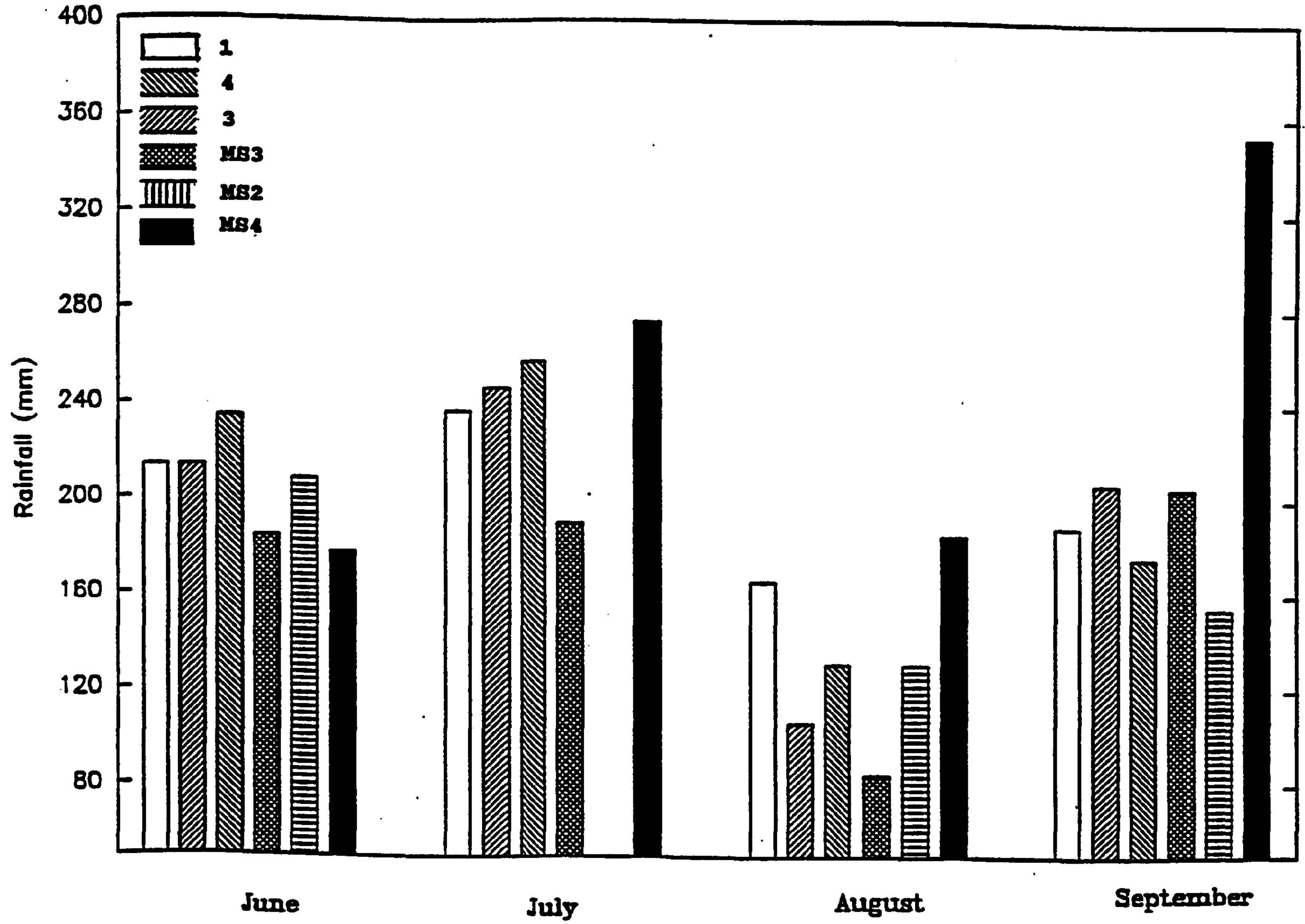


FIGURE 12. Variability of rainfall for June through September, 1989 at six site within the watershed.

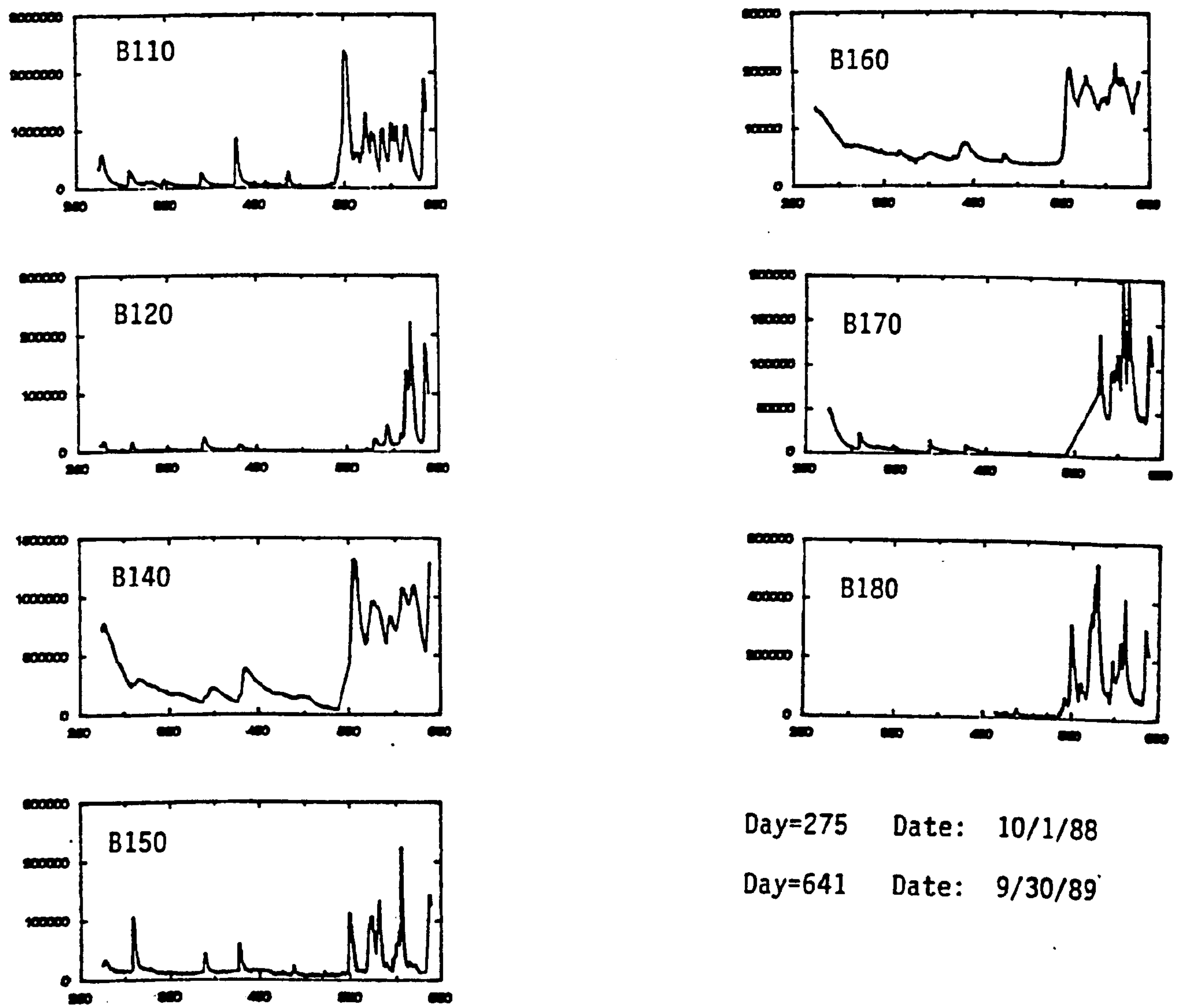


FIGURE 13. Seasonal variation in discharge at subbasin stream gaging stations.

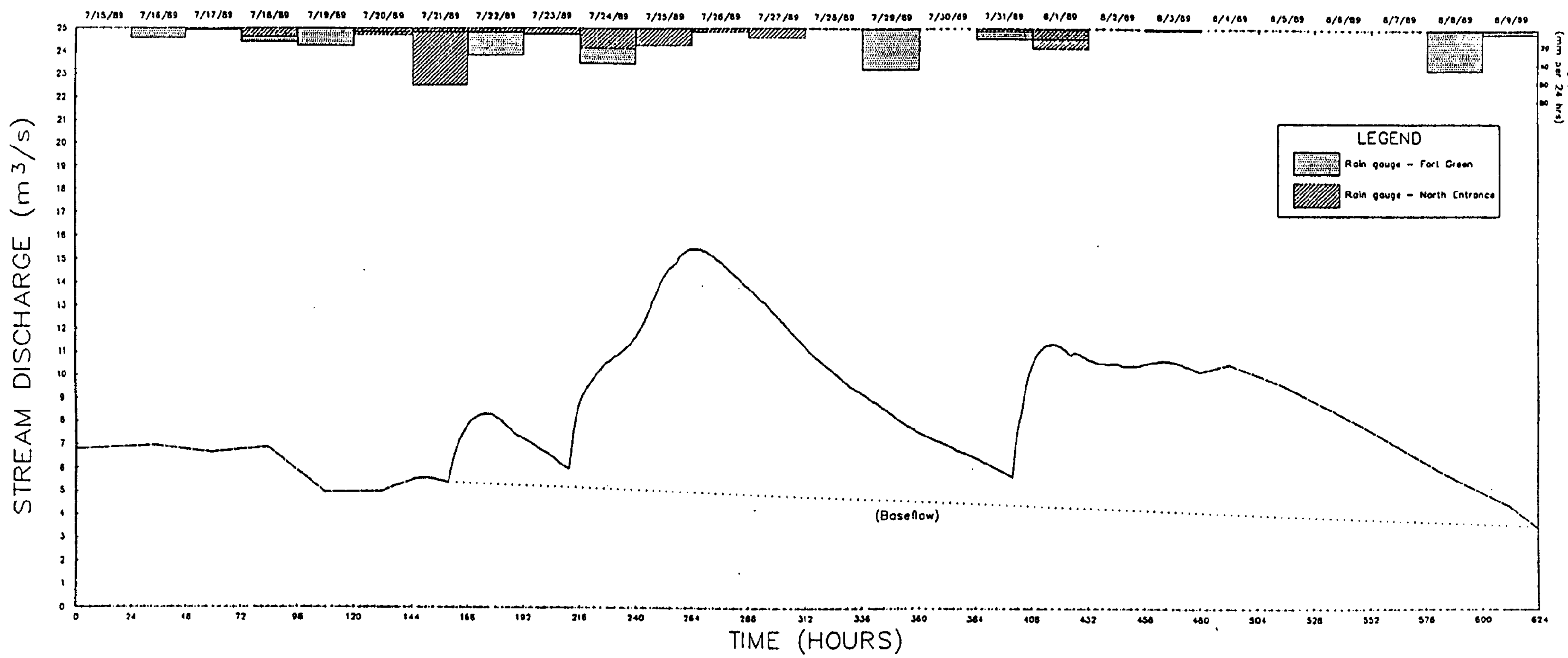


FIGURE 14. Myakka City (B110) - Storm 1.

slope. This indicates that an initial surge was produced by excess runoff from areas near the basin outlet but drainage quickly became uniform after peak flow (q_p) had been reached.

A high base flow remained constant at this station during most of the study period and was estimated to be 5.2 cms. Each succeeding peak rose more sharply from this with the advent of an intense rainfall event. This illustrates the steady increase in soil moisture produced by the frequent low intensity rainfall which occurred throughout the study period.

Total rainfall (P) for this storm period was estimated to be 188.2 mm, based on records of the Fort Green monitoring station and the monitoring station at the North entrance of Myakka River State Park. Direct runoff (R) for the period, as indicated by the storm hydrograph, was 18.8 mm, yielding an abstraction (F) of 169.4 mm. Thus, 90 percent of the estimated excess rainfall was retained in the watershed.

The storm 2 hydrograph (Figure 15) for this station was single-peaked with a peak flow (q_p) of 20.4 cms. This peak was similar in shape to those of the storm 1 hydrograph except that it had a narrower base. Examination of the rainfall records indicated that antecedent soil moisture levels were high prior to the second storm, accounting for the more rapid increase and recession of flow rate (q_p).

Total rainfall (P) for this period was estimated to be 79.3 mm. Examination of the hydrograph indicated that 31.0 mm of direct runoff (R) was produced by the storm yielding a 61 percent retention rate with a total abstraction (F) of 48.3 mm. The difference in abstraction between the two storms illustrates that the level of soil moisture has a significant bearing on the retention capacity of this subbasin.

The peak rate factor (K) for this hydrograph was found to be 0.73. This closely compares to the SCS Unit Hydrograph model peak rate factor (K) of 0.75, which indicates that the SCS model could closely approximate runoff behavior for events similar to this storm.

The curve number (CN) was back-calculated as described previously. Assuming medium antecedent moisture conditions, a value of 84 was obtained. According to SCS guidelines, the poorly-drained sand covering much of the Myakka basin would fall into soil groups B or C. Appropriate curve numbers for open areas with this type of soil cover would range from 61 to 86, depending on land use. Therefore, SCS guidelines would provide adequate determination of curve numbers for this subbasin.

Under low antecedent soil moisture conditions this subbasin has high retention capacity due to a combination of large

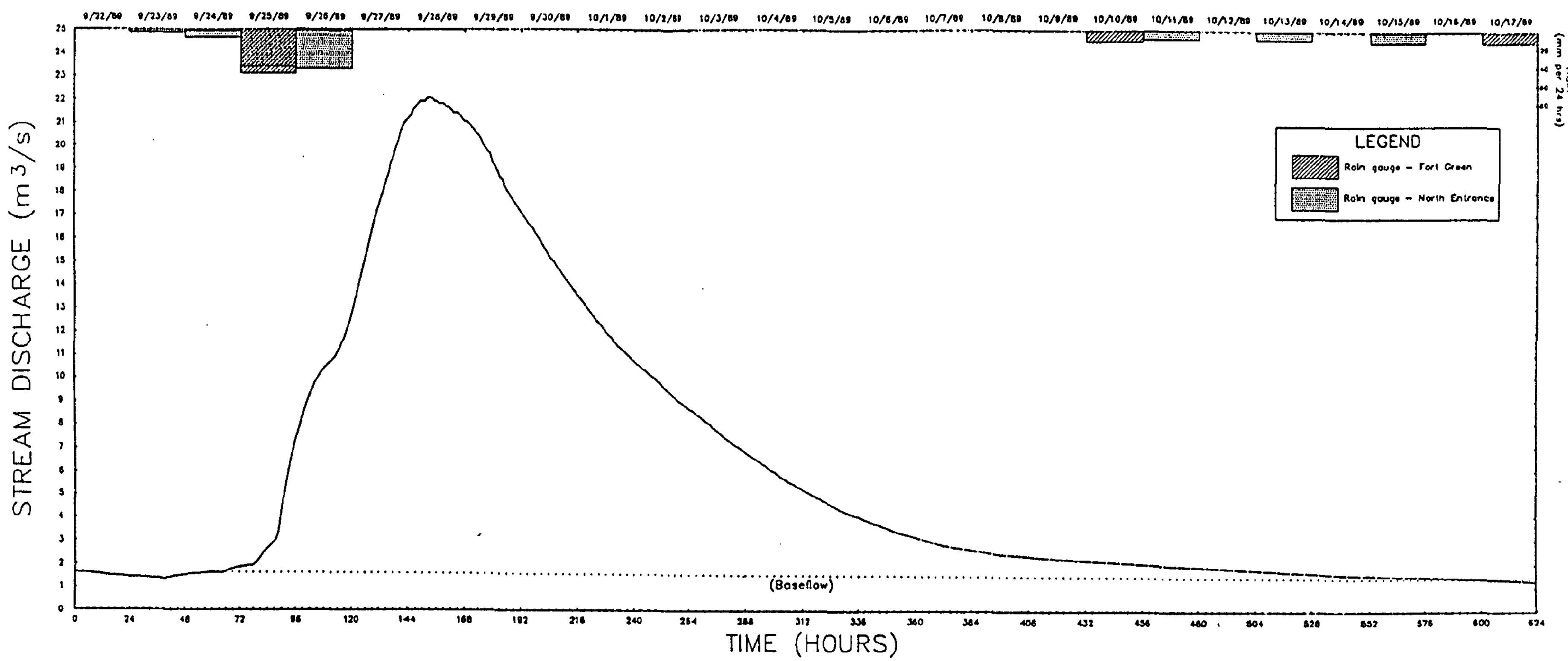


FIGURE 15. Myakka City (B110) - Storm 2.

depressional surface storage areas and the in-situ water storage capacity of the soil cover. However, during extended periods of frequent precipitation this storage is lost and short flow peaking times and high peak flows can occur. This is due mainly to effects of the relatively short, wide watershed which tend to decrease concentration times.

Myakka River at S.R. 780 (B130)

Gaging Station #2298700 is located at the State Road 780 bridge, near the north entrance of the Myakka River State Park. This watershed includes the Myakka City subbasin plus an additional 10,361 ha for a total area of 42,737 ha. Significant portions of this area are cultivated and have been ditched to provide irrigation and drainage. Tatum Sawgrass is partially drained by branches upstream of the gaging station which have a noticeable effect on streamflow activity. The portion of the watershed downstream from Myakka City narrows sharply due to the presence of numerous small streams which meander away from the main channel in both easterly and westerly directions but eventually join the river downstream of the gaging station.

The hydrograph for this storm 1 (Figure 16) was composed of two low, wide based peaks, the largest of which reached a maximum flow rate (q_p) of 34 cms. These peaks corresponded to two separate and distinct periods of rainfall. However, as a result of overlap of the two events, accurate calculation of SCS parameters was impractical. Comparison of this hydrograph to the storm 1 hydrograph of the Myakka City station shows that the short rise time (Tr) observed in the Myakka City subbasin had been moderated substantially by passage through the additional watershed. This results from the narrow shape of the additional drainage area which tends to increase the distance that runoff must travel from the upper reaches of the watershed while adding only a small amount of catchment surface near the gaging station.

Total rainfall (P) for this storm period, based on data taken at the North Entrance monitoring station, was estimated to be 153.2 mm. Direct runoff (R) was estimated to be 38.2 mm with an 82 percent abstraction (F) of 125.3 mm. This high abstraction was a product of low antecedent soil moisture conditions that existed prior to the storm events, and reflects the 90 percent retention rate observed in that portion of the watershed monitored by the Myakka City station.

The storm 2 hydrograph (Figure 17) for this station is a single-peaked curve with rising and receding limbs of nearly equal slope. Peak flow (q_p) for this event reached 66 cms with a time to peak (Tp) of 119 hours. The peak exhibited a shorter base width than the peaks of the storm 1 hydrograph, reflecting an increased ground moisture content and subsequent loss of basin retention capacity. Further illustration in the loss of retention capacity

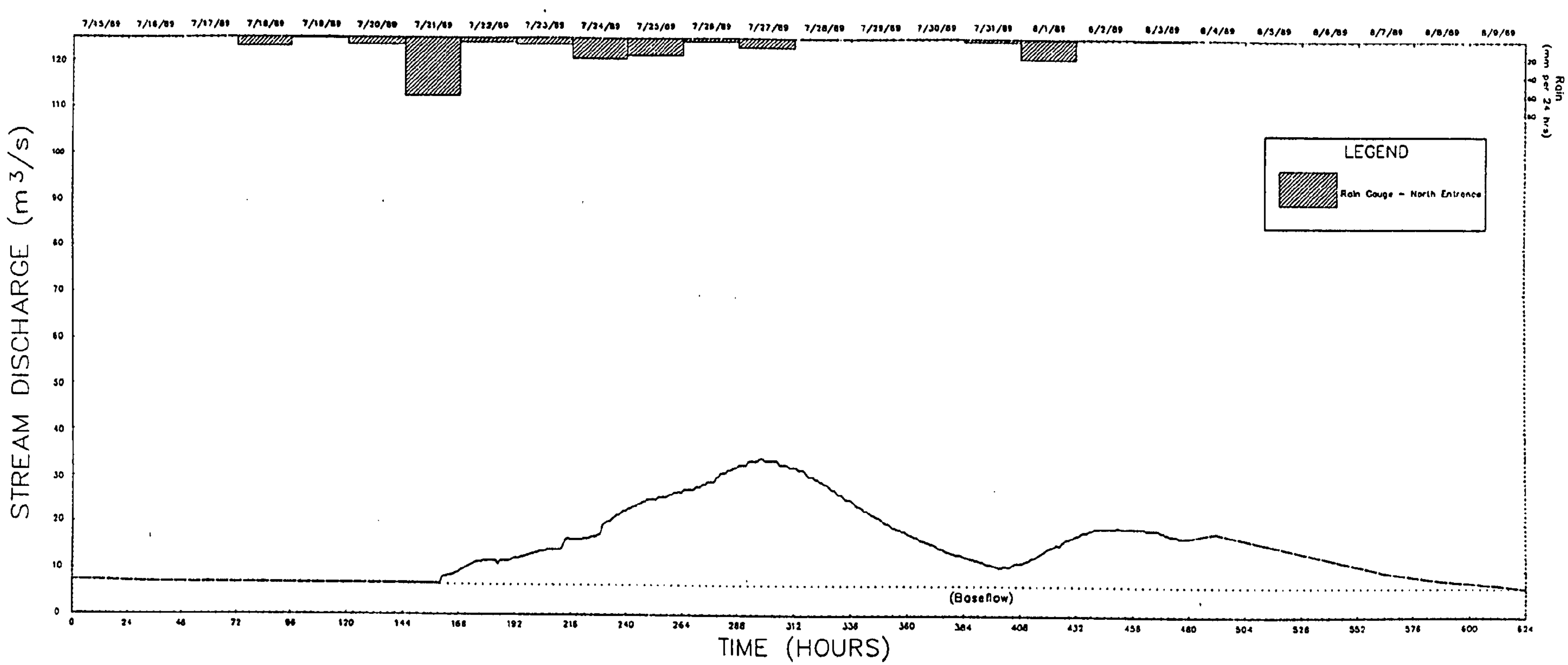


FIGURE 16. Myakka River at S.R. 780 (B130) - Storm 1.

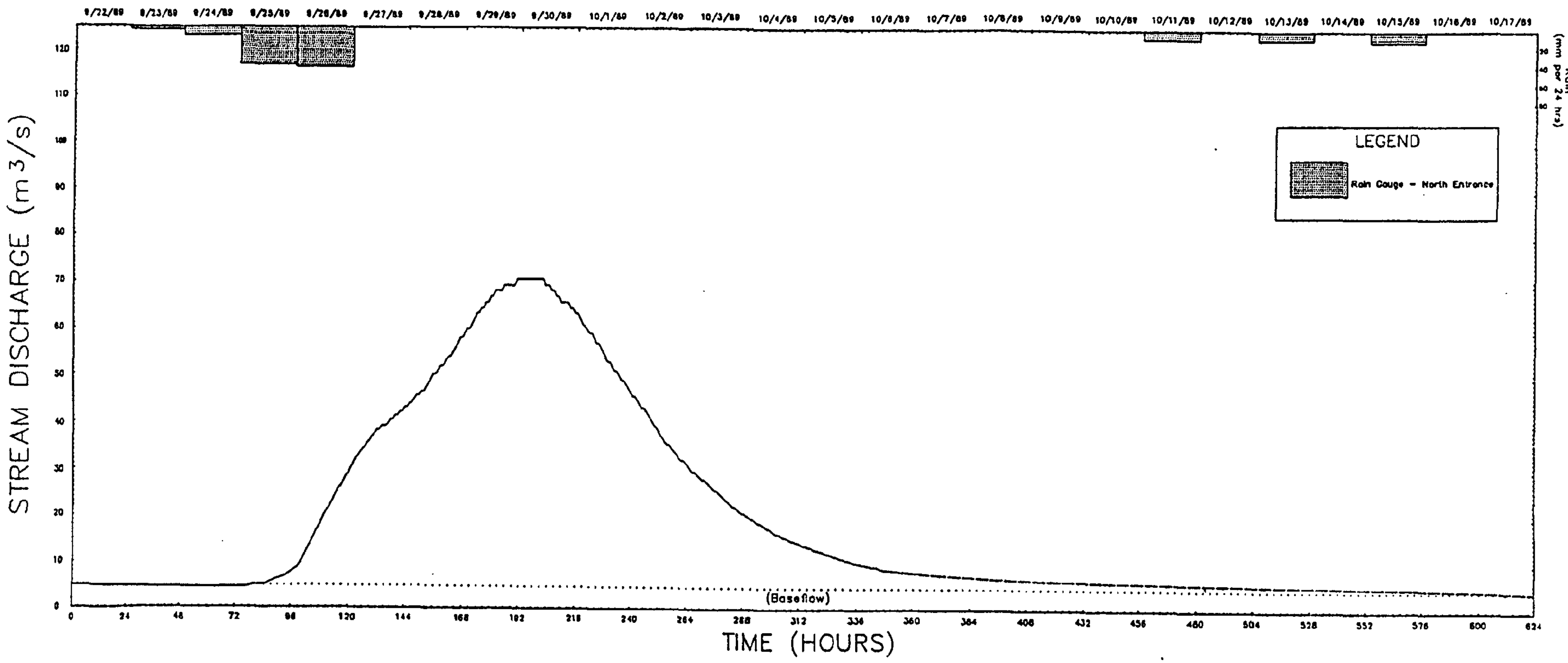


FIGURE 17. Myakka River at S.R. 780 (B130) - Storm 2.

was found by the comparison of rainfall (P) and direct runoff (R). A direct runoff volume (R) of 70.4 mm resulted from 103.1 mm of rainfall (P) yielding a total abstraction (F) of 33.0 mm, with only a 32 percent retention rate. This is considerably lower than the retention observed during storm 1.

The peak rate factor (K), calculated to be 0.81, was slightly higher than the accepted SCS value of 0.75. This seems to be a function of a disproportionately long time to peak (103 hours). Otherwise, the SCS Unit Hydrograph model provides a good approximation of rainfall/runoff relations for this subbasin.

The back-calculated curve number (CN) was found to be 89 which reasonably approximates composite values in the range suggested by SCS guidelines for areas of combined agriculture and idle lands.

The upper portion of the watershed, which is wide, is capable of collecting large amounts of rainfall during dry conditions and is capable of providing storage in both surface depressions and within the sandy topsoil. During wet periods this storage capacity is diminished.

The overall configuration of this watershed tends to dampen the effects of fluctuations in storage capacity. The lower portion of the watershed, which is narrow, presents much less catchment area. Therefore, low initial flow rates are generated near the basin outlet and the time of concentration is increased. The resultant effect is an increase in residence time and a more even rate of flow.

Myakka River between Upper and Lower Lakes (B140)

Gaging Station #2298830 is located on the main channel of the River at a point midway between Upper Lake Myakka and Lower Lake Myakka. The corresponding watershed includes all portions of the Myakka Basin upstream of the station as well as the Howard Creek subbasin, which drains into Upper Lake Myakka. The total surface area of the watershed is 59,313 ha. Potential surface retention areas include Tatum Sawgrass, Upper Lake Myakka, and numerous shallow depressional areas.

The storm 1 hydrograph (Figure 18) was composed of a low, extremely wide feature with no distinguishable peak. There was however a recognizable correlation between rainfall occurrence and variations in runoff rate. The rising limb of the curve was gently sloped as was the receding limb. This illustrates the moderating effect of Upper Lake Myakka on runoff from the watershed.

Total rainfall (P), based on monitoring stations in the Myakka State Park, was estimated to be 141.2 mm. Of this amount, 125.3 mm was retained in the watershed for a total abstraction (F) of 89

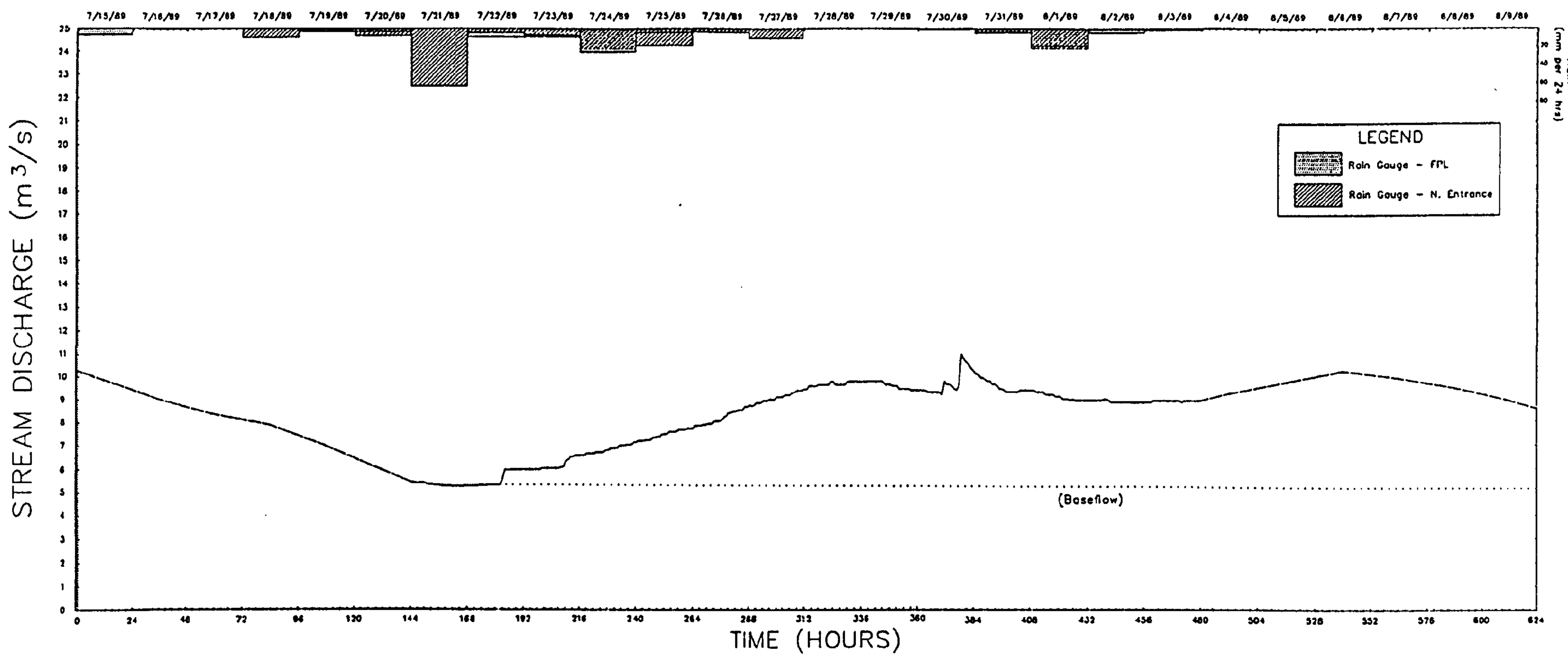


FIGURE 18. **Myakka River between Upper and Lower Lakes (B140) - Storm 1.**

percent. This rate of retention was comparable with rates observed in other subbasins during this storm.

The storm 2 hydrograph (Figure 19) consisted of a single low, wide-based peak climaxed by a peak flow rate (q_p) of 11.5 cms. The most notable feature of this curve was the extremely shallow slope of the receding limb produced by the retention capacity of Upper Lake Myakka. The curve indicated no effects of inflow from the Howard Creek subbasin presumably because the creek drains into Upper Lake Myakka, thus blending smoothly with runoff from other areas of the watershed.

Total rainfall (P) for this storm period was estimated to be 102.4 mm. The total abstraction (F) retained by the watershed was found to be 86 percent, or 87.6 mm. This high rate of abstraction was attributed to the presence of Upper Lake Myakka as well as the numerous depressional areas within the watershed.

The peak rate factor (K) was calculated to be 0.73 which closely approximates the accepted SCS value of 0.75. Based on this observation, the SCS unit hydrograph model should be adequate to describe and predict rainfall/runoff behavior of this subbasin.

The subbasin curve number (CN) was back-calculated to be 74. This falls in the middle of the range of values (61 to 86) given by SCS guidelines for watersheds containing the soil type and land use found in this subbasin.

The combined features of abundant surface storage and a relatively narrow downstream configuration create a dramatic moderating effect on flow rate. Because of this, variations in soil moisture content have minimal effect on residence time. This effect extends to inflow from Howard Creek.

Myakka River at control near Laurel (B160)

Gaging Station #2298880 is located 153 m downstream of the Lower Lake Myakka control structure. The watershed includes all previously described subbasins as well as an additional area of 6,216 ha (including Lower Lake Myakka) for a total surface area of 65,529 ha. The presence of the control structure makes analysis by SCS methods impractical. Therefore, only rainfall-runoff comparisons were performed.

The storm 1 hydrograph (Figure 20) was composed of a major peaking feature that contained several smaller peaks, a pronounced climactic peak, and a receding limb interrupted by a vertical increase in flow rate. The smaller peaks roughly correlated with rainfall events, while the major feature illustrates the moderating effect of the control structure.

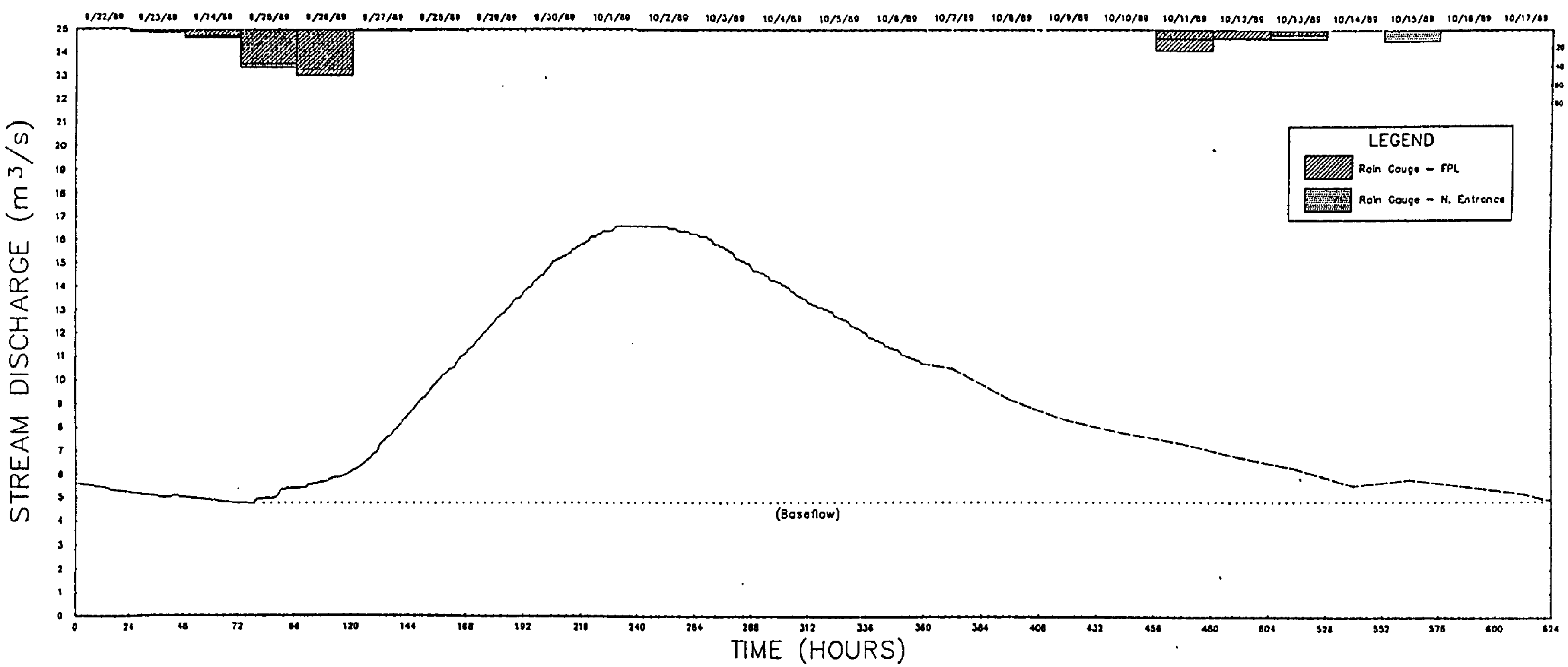


FIGURE 19. Myakka River between Upper and Lower Lakes (B140) - Storm 2.

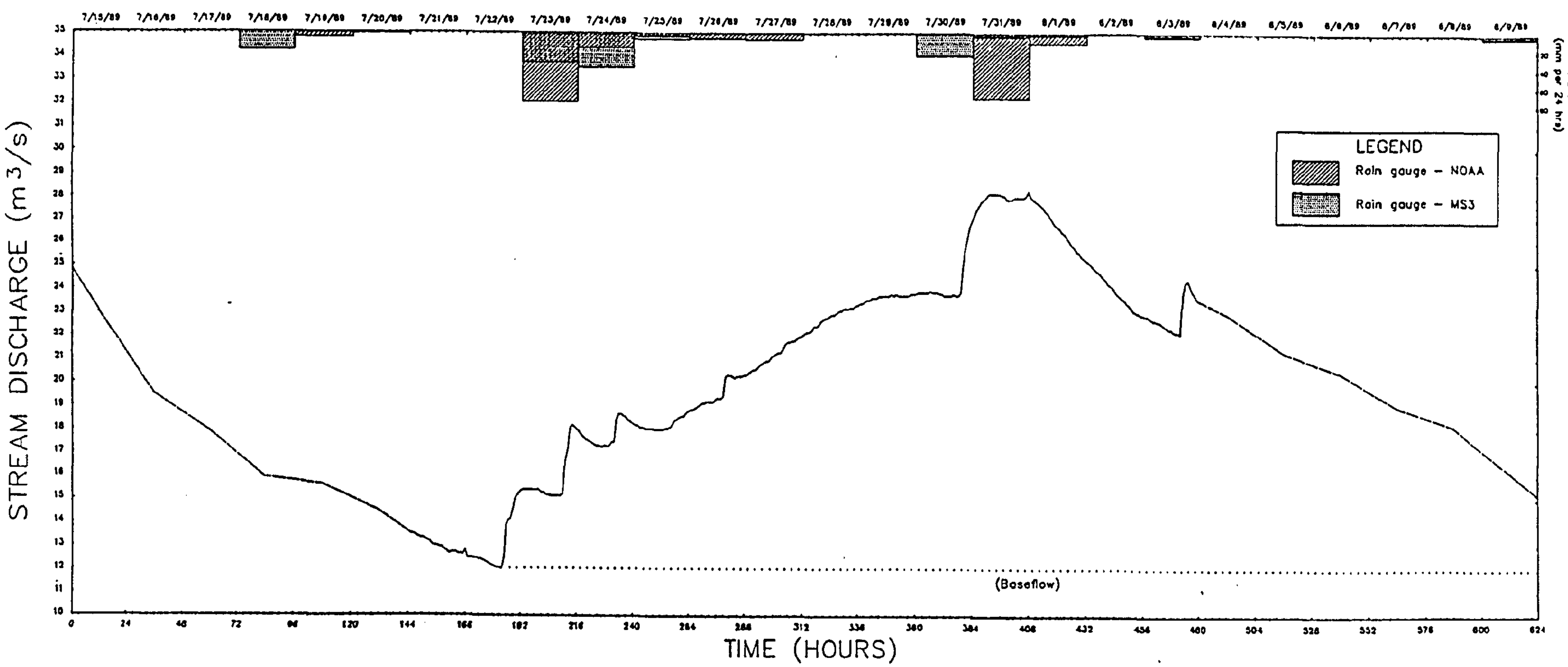


FIGURE 20. Myakka River at control near Laurel (B160) - Storm 1.

Total rainfall (P) was estimated to be 115.3 mm, based on data obtained at monitoring stations located in Myakka River State Park. Direct runoff (R) amounted to 19.6 mm after an abstraction (F) of 95.7 mm had been retained by the watershed. This yields retention rate of 83 percent which is in keeping with those of the other subbasins during this storm.

The storm 2 hydrograph (Figure 21) follows the same major trend as the storm 1 hydrograph, with a multi-peaked rising limb and a climactic peak. Because of a lack of discharge data for October 3 through October 7, only a rough estimation of direct runoff (R) could be made. Using the available data, direct runoff (R) was estimated to be 21.8 mm. When this was compared to the total rainfall (P), an abstraction (F) of 19.6 was obtained. This indicates that 80 percent of the rainfall was retained in the watershed.

Due to the presence of the control structure, more detailed observation and analysis is necessary to fully develop a predictive capability for this subbasin. However, the general characteristics of rainfall/runoff relations seem to indicate that this portion of the Myakka subbasin is an excellent moderator of flow rate for the remainder of the subbasin upstream.

Howard Creek (B120)

Gaging Station #228760 is located on Howard Creek approximately 1.5 km upstream of Upper Lake Myakka. The Howard Creek watershed, with a surface area of 5180 ha, is the smallest subbasin treated in this study. The creek drains a rather narrow area along its length. There are few distinct branches from the main creek channel in the lower portion of the drainage area while the upper portion of the basin has overland connection with the creek. There are areas of sparse development in the upper reaches of the watershed and a small number of depressional wet areas scattered throughout.

For three and a half months prior to storm 1, the Howard Creek gaging station recorded zero flow rates with the exception of the first seven days of July. Therefore, extremely low antecedent soil moisture conditions greatly influenced the shape of the storm 1 hydrograph (Figure 22). A minimal base flow rate of 40.6 mm was created by rainfall which began on July 18 and continued through July 27. During this period a total of 181.9 mm of rain fell, as estimated from records of the monitoring station located at the north entrance of the Myakka River State Park. Of this amount, 179.4 mm was retained by the watershed to yield a 99 percent abstraction rate.

The storm 2 hydrograph (Figure 23) contrasted sharply with the storm 1 hydrograph. Frequent rainfall had occurred prior to the

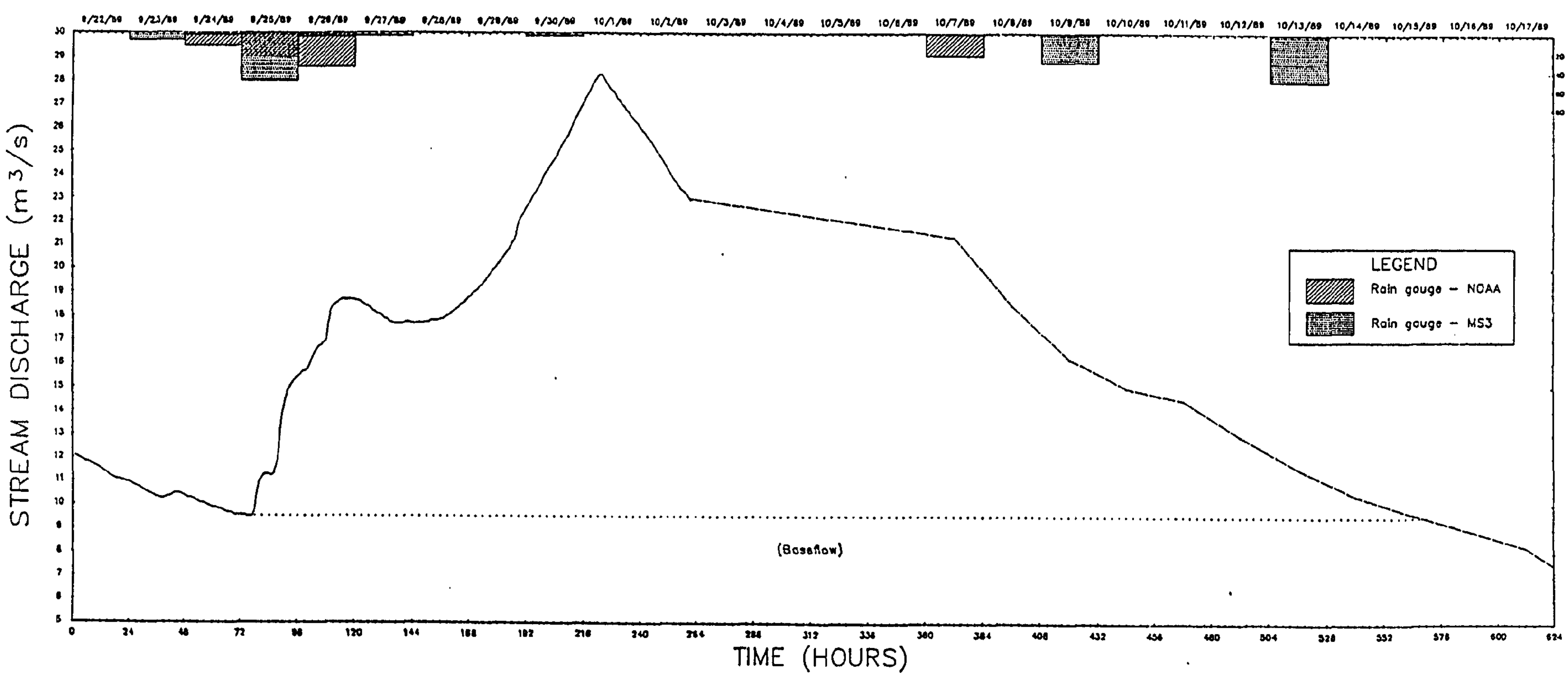


FIGURE 21. Myakka River at control near Laurel (B160) - Storm 2.

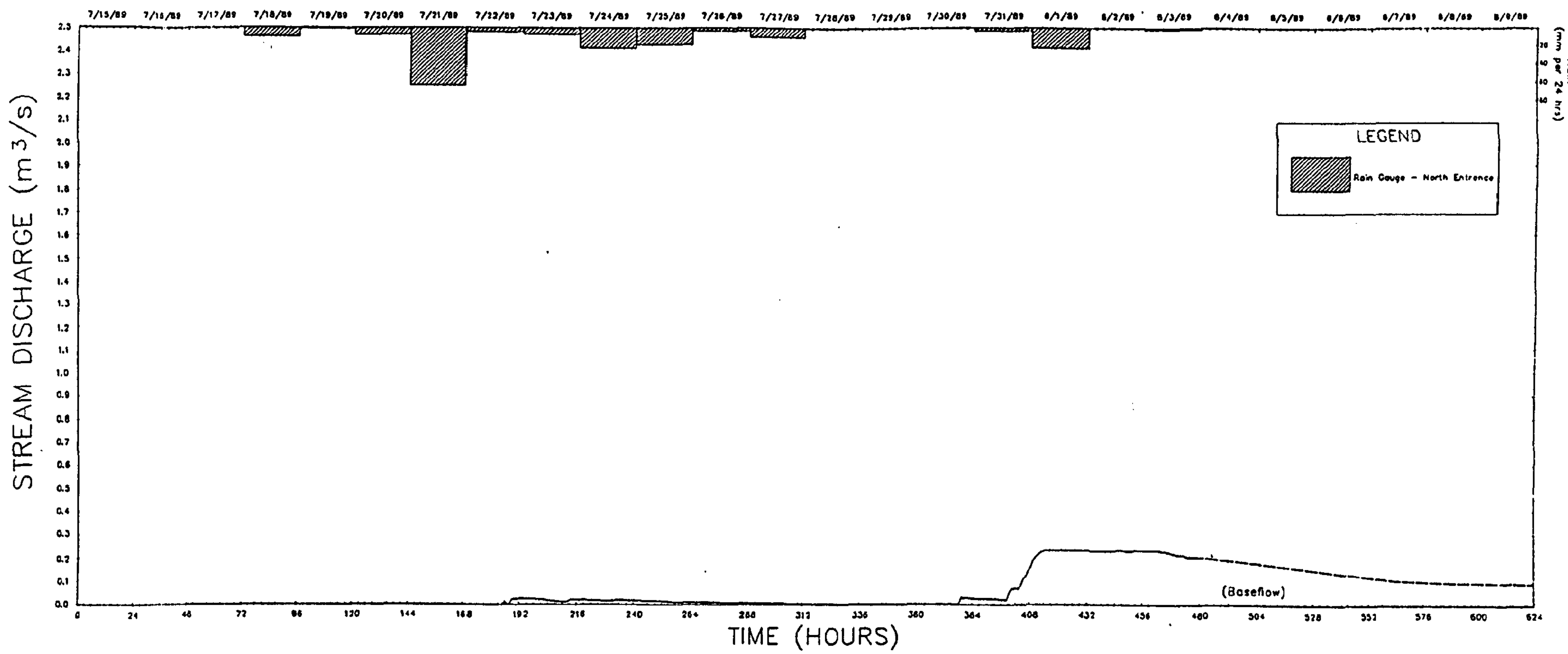


FIGURE 22. **Howard Creek (B120) - Storm 1.**

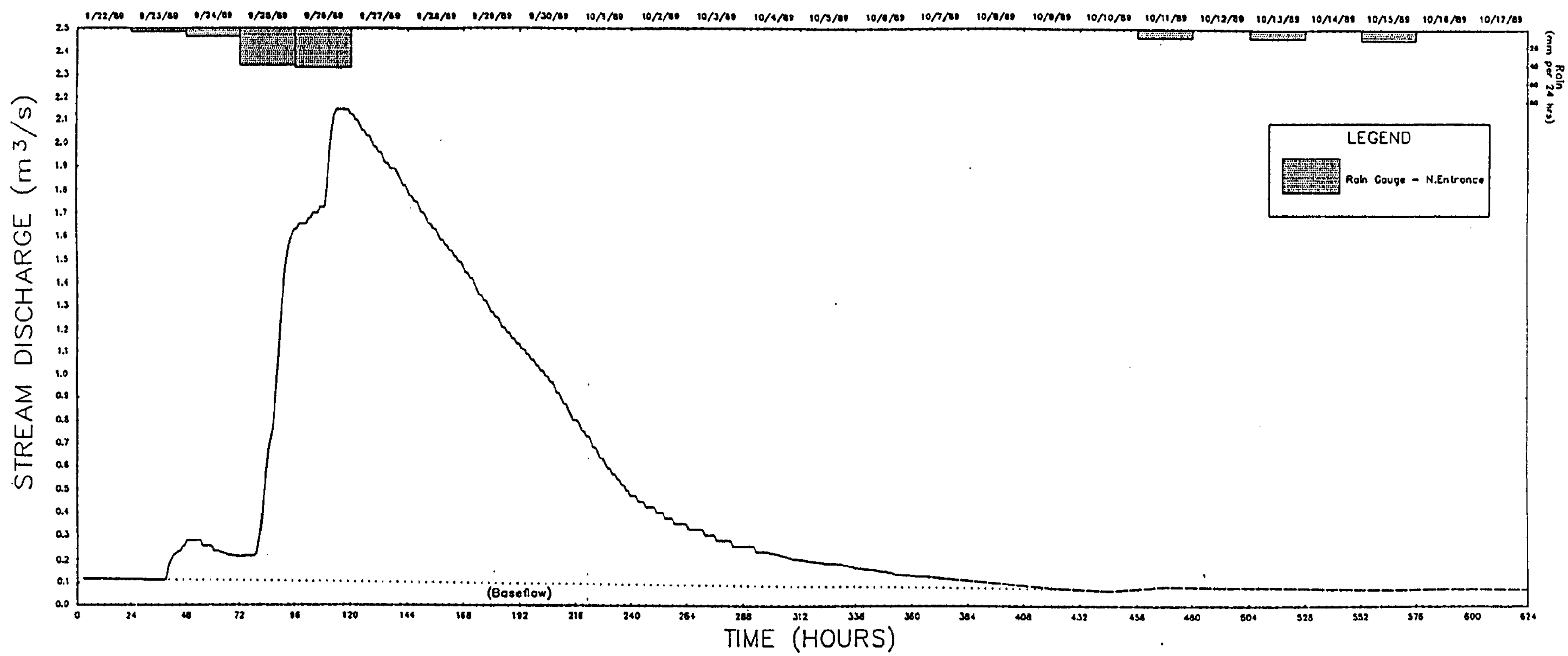


FIGURE 23. Howard Creek (B120) - Storm 2.

second study period, thereby increasing the soil moisture content in the watershed. This was evident by the shape of the single peak of the hydrograph which rose almost vertically reaching a peak flow (q_p) of 2.4 cms within 39 hours. The receding limb of the curve followed a much more gentle slope, returning to the preceding base flow of 0.1 cms after a period of 11 days.

The peak rate factor (K) was calculated to be 0.29 which was well below the standard SCS value of 0.75. This can be directly attributed to the short time to peak (Tp). Based on this finding, extreme care should be exercised in applying SCS methods of rainfall/runoff prediction to this subbasin.

A curve number (CN) of 76 was back-calculated from pertinent event specific data, which agrees with those set forth in SCS guidelines.

The analysis of this subbasin suggests that the most critical factor in the determination of rainfall/runoff relations is the antecedent soil moisture condition. The two hydrographs represent extreme ends of the spectrum of soil moisture content and indicate that substantial fluctuations in flow conditions can occur in short time periods.

Deer Prairie Slough (B170)

Gaging Station #2299160 is located on Deer Prairie Creek, 1.6 km north of Interstate 75. This subbasin contains a surface area of 9,583 ha. The watershed is elongated along the axis of the creek and adjoining slough. The upper reaches of the watershed contain numerous surface-isolated depressional features and areas of swampland.

Storm 1 was preceded by two months of zero flow, or in some cases minimal flow. Rainfall began on July 22 and continued sporadically through August 1. The curve depicted on the storm 1 hydrograph (Figure 24) is based on an incomplete data set. Streamflow data prior to July 28 was not available for this gaging station. Examination of this curve shows that the flow rate rises rapidly in response to rainfall events, and then quickly diminishes. This is attributed to the presence of channelization of the lower one quarter of the watershed which quickly passed runoff from that area through the gaging station. It was also noted that the return to base flow requires an extended period of time due to the lack of channelization in the upper reaches of the watershed.

A total of 130.6 mm of rain fell during the study period of which 5.3 mm was passed out of the watershed as direct runoff (R). Thus, 125.3 mm or 96 percent of the rainfall was retained.

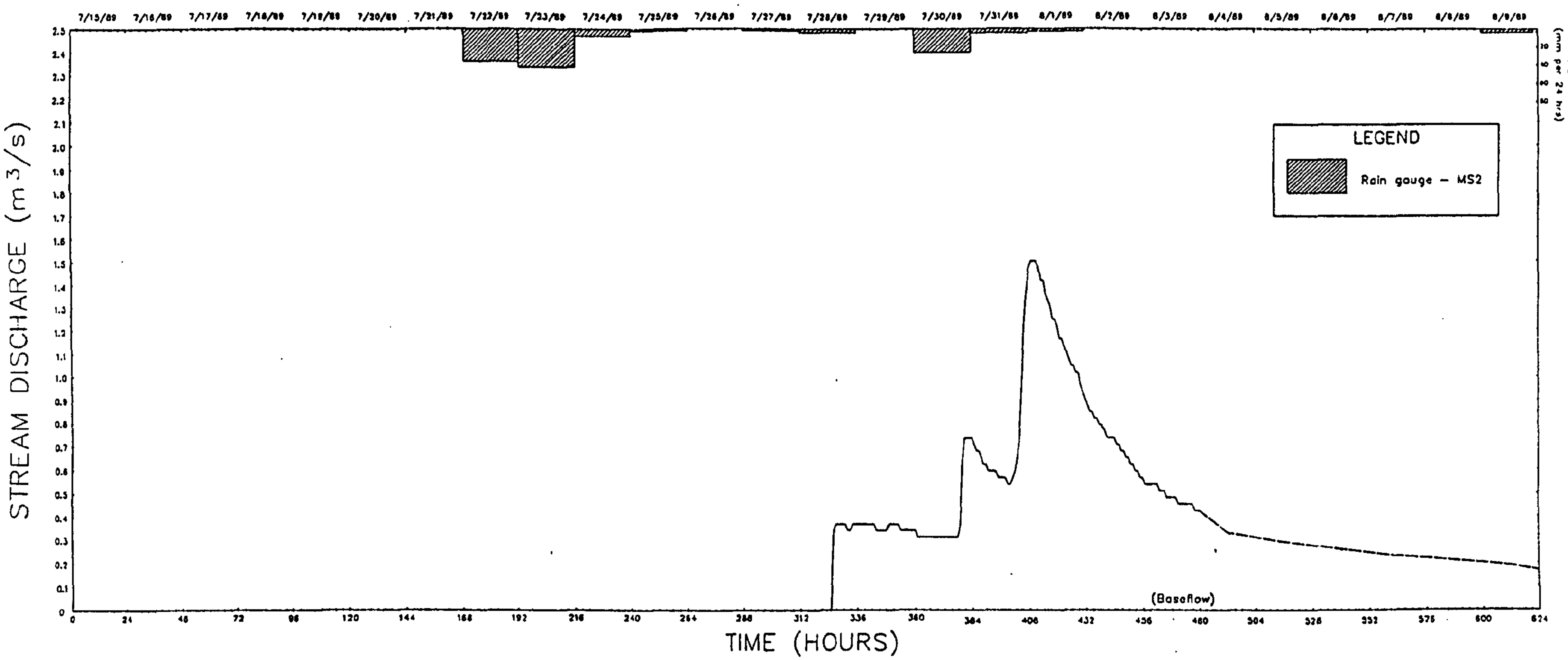


FIGURE 24. Deer Prairie Slough (B170) - Storm 1.

The storm 2 hydrograph (Figure 25) consisted of a single peak on the rising limb, which was nearly vertical. A peak flow (q_p) of 1.4 cms occurred after a time to peak (Tp) of 52 hours. The receding limb of the curve was marked by several fluctuations having no correlation to the rainfall pattern. This may be attributed to variations in the flow pattern of the creek brought about by uneven distributions of rainfall within the subbasin . A peak rate factor (K) of 3.83 was calculated for this hydrograph which rendered comparison to the standard SCS value of 0.75 useless. The extreme quickness with which flow rate increased bears no resemblance to the SCS prediction of runoff behavior.

A subbasin curve number (CN) of 76 was back-calculated which reasonably approximates the accepted SCS value for the type of soil cover and land use found in this area.

The extremely short times required to reach peak flow within this subbasin render the standard SCS hydrograph ineffective in predicting runoff behavior. This subbasin can be divided into two distinct sections based on retention characteristics. The lower one quarter is highly channelized, thus residence time is minimal in this area. The remainder of the area tends to retain runoff in depressional and marshy surface storage releasing runoff in a steady low flow. Therefore, it is believed that a further breakdown of this subbasin for study would permit a more reliable prediction of the characteristic rainfall/runoff response.

Big Slough Canal at S.R. 72 (B150)

Gaging Station #2299410 is located on the upper reach of Big Slough Canal at the State Road 72 bridge. This subbasin encompasses an area of 9,583 ha in which at least six flowing wells are located. The watershed is drained by numerous streams, both ditched and natural, and contains several depressional surface features.

The storm 1 hydrograph (Figure 26) consisted of two major peaking features within which several small peaks appear, roughly corresponding to the pattern of rainfall that occurred during the study period. Because of these smaller features, a reliable analogy to the SCS hydrograph was impractical.

Total rainfall (P) during this storm period was estimated to be 89.4 mm, based on records of monitoring stations in the Myakka River State Park. Direct runoff (R), as indicated by the storm hydrograph, was 11.8 mm, yielding a total abstraction (F) of 77.6 mm. Thus, 87 percent of the excess rainfall (P) was retained in the watershed.

The storm 2 hydrograph (Figure 27) was single-peaked with a peak flow of 1.4 cms. A span of 138 hours elapsed before flow

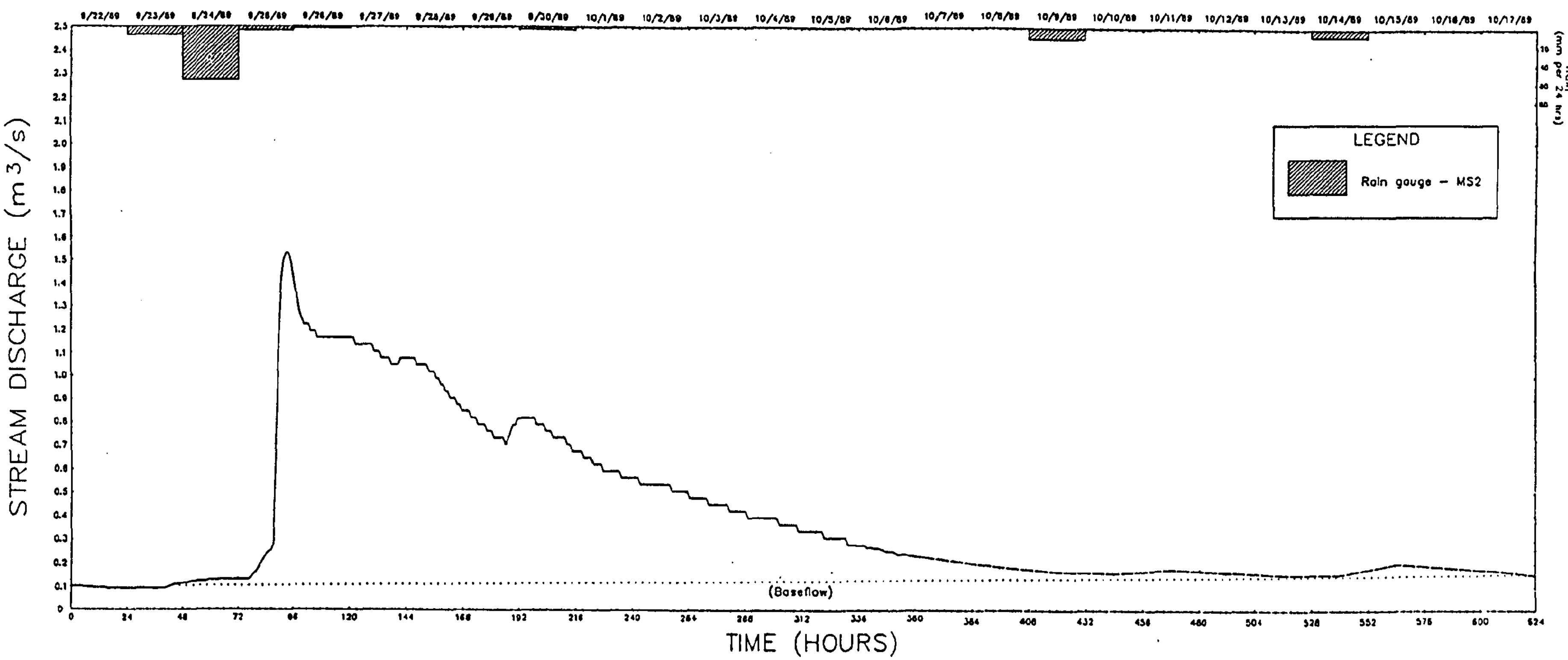


FIGURE 25. Deer Prairie Slough (B170) - Storm 2.

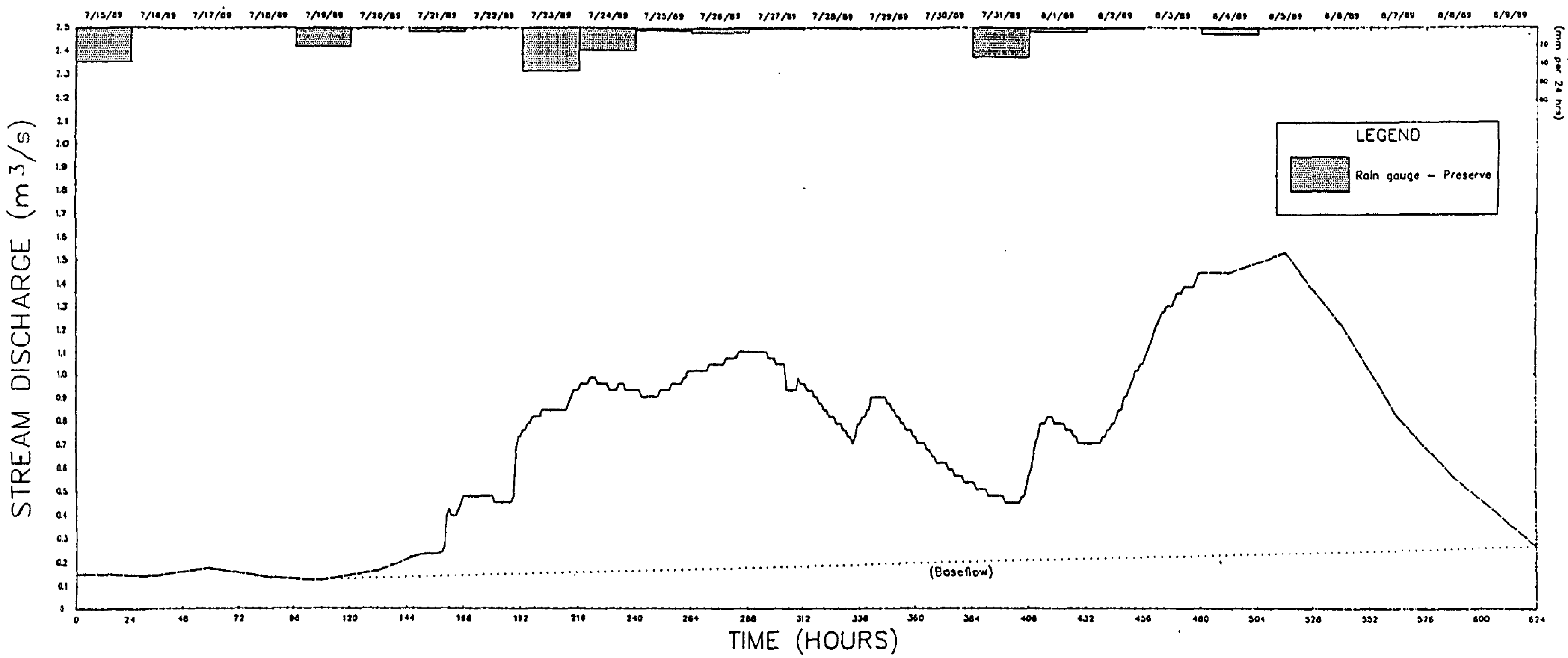


FIGURE 26. **Big Slough at S.R. 72 (B150) - Storm 1.**

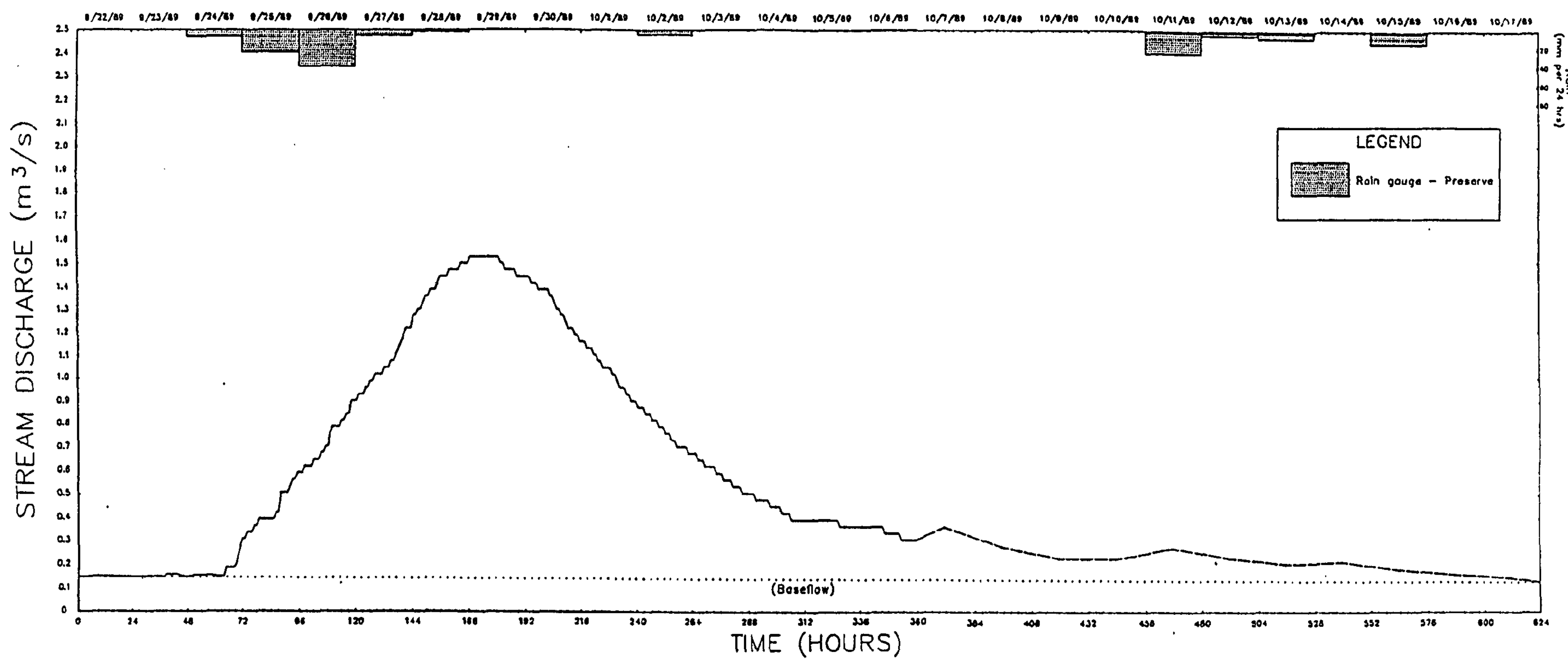


FIGURE 27. **Big Slough at S.R. 72 (B150) - Storm 2.**

peaked. This extended time to peak (Tp) is indicative of the retention capacity of this subbasin.

A total rainfall (P) of 83.6 mm was estimated for this period which produced a direct runoff (R) of 8.4 mm. Thus, a total abstraction (F) of 75.2 mm was retained by the watershed. This abstraction rate of 90 percent is nearly the same as that observed during the first storm. This indicates that antecedent moisture conditions, which varied between the two storms, have a minimal effect on the retention capacity of this subbasin.

The calculated peak rate factor (K) of 0.86 for this hydrograph is somewhat higher than the SCS standard value of 0.75. This is a result of the extended time to peak (Tp) that elapsed during this storm period, and suggests that the effects of intense rainfall events would be moderated.

A curve number (CN) of 77 was back-calculated for this subbasin. This value compares reasonably to the range of values suggested by SCS guidelines for this type of soil cover and land use.

Despite the ditching present in this portion of the Big Slough Canal drainage basin, a high rate of retention was observed during both storm events with little influence by antecedent moisture conditions. This is due in part to the presence of the flowing wells which tend to moderate soil moisture levels.

Big Slough Canal at North Port (B180)

Gaging Station #2299455 is located on Big Slough Canal near North Port. This watershed has a total area of 24,088 ha and encompasses the entire Big Slough Canal drainage basin, including the area of Big Slough Canal described previously. Flowing wells are present throughout this watershed, many of which are drained by ditches.

The storm 1 hydrograph (Figure 28) was composed of a series of three peaks, two of which were similar in shape. The shape of the curve generally correlates with rainfall events of the study period.

Total rainfall (P) for this period was estimated to be 104.9 mm, with a resulting direct runoff (R) of 8.5 mm. This yielded a 92 percent retention with a total abstraction (F) of 96.4 mm.

The storm 2 hydrograph (Figure 29) was single-peaked with a peak flow rate (P) of 3.4 cms. The rising limb of the curve was nearly vertical, with a time to peak (Tp) of 30 hours. The receding limb began with a rapid decline but reached a more gentle slope approximately 24 hours after the peak flow (q_p) occurred.

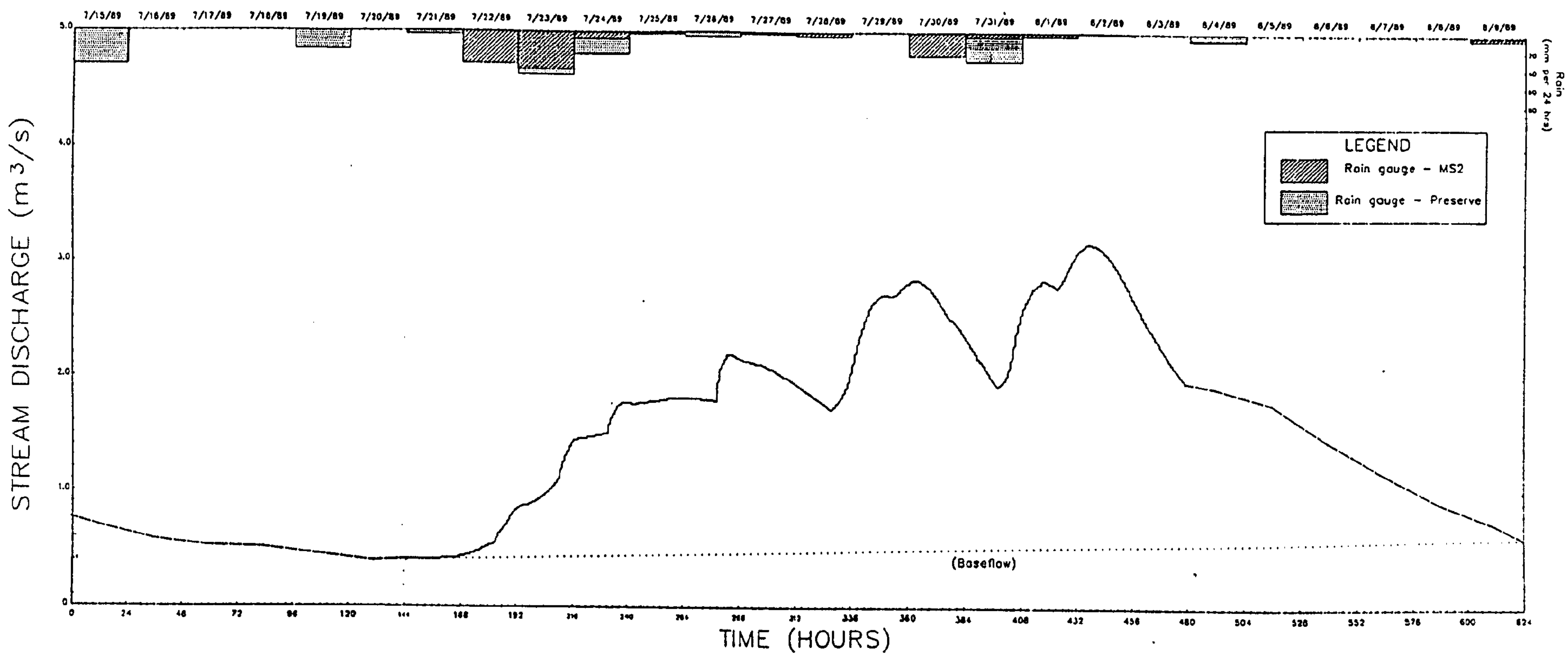


FIGURE 28. Big Slough at North Port (B180) - Storm 1.

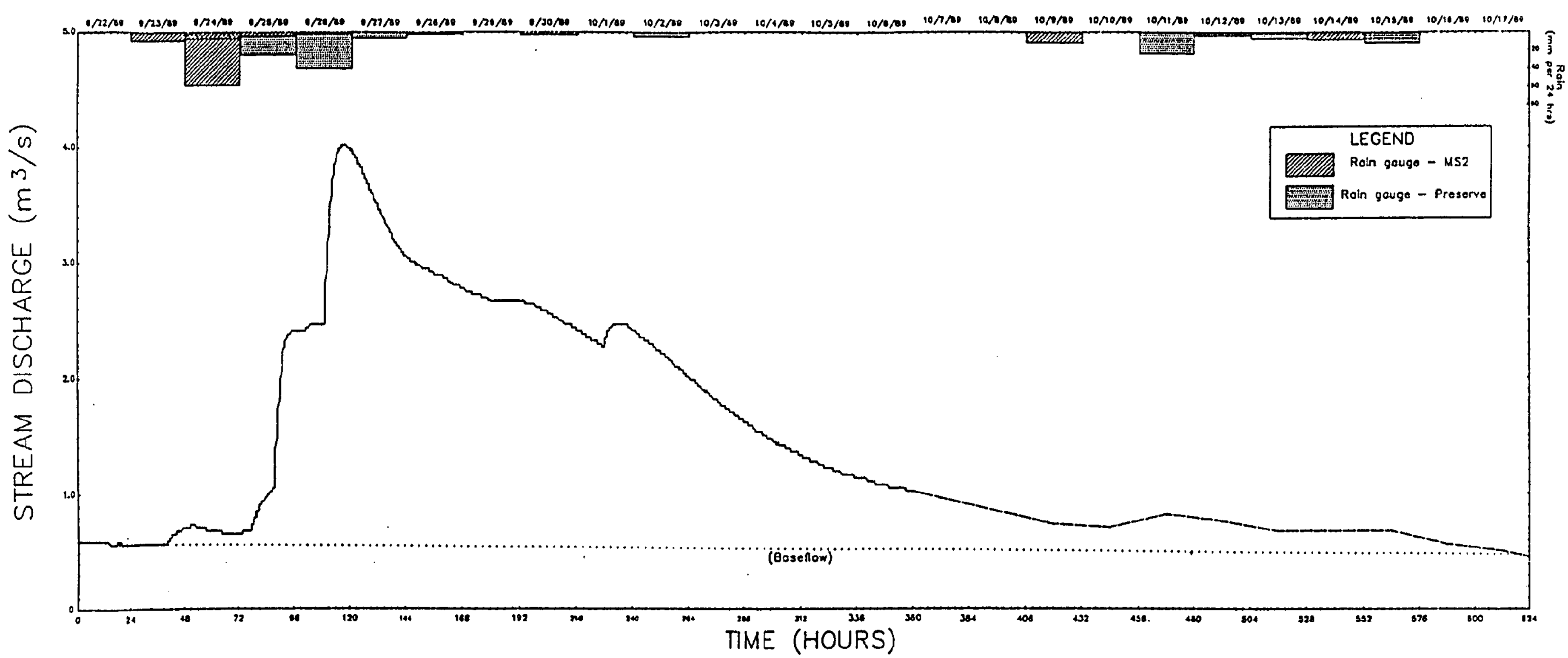


FIGURE 29. Big Slough at North Port (B180) - Storm 2.

Total rainfall for this period was estimated to be 81.8 mm. Direct runoff (R), based on estimations from the hydrograph, was found to be 7.4 mm, with a total abstraction of 74.4 mm, yielding a retention of 91 percent.

The peak flow factor (K) for this hydrograph was calculated to be 0.21. This value is considerably lower than the SCS standard value of 0.75 primarily because of the short time to peak (Tp). Therefore, the SCS unit hydrograph would not provide a reliable model for this subbasin.

The curve number (CN) for this watershed was back-calculated to be 77 which falls within the range of 61 to 86 suggested by SCS guidelines for the soil type and land use found in this subbasin.

The effects of the ditching present in the lower portions of this subbasin are evident in the shape of the storm 2 hydrograph. The ditching allows flow to peak and recede rapidly. These initial rapid fluctuations are followed by a more even passage of runoff from the upper reaches of the watershed which is impeded somewhat by the absence of intense ditching.

River and Tributary Water Chemistry Results

Physical summary

A summary of physical data for basin stations is contained in Appendix C. Seasonal variations in water temperature, with maximum values of around 30-32°C, were similar for stations B140 through B180 (Figure 30). Stations B110-B130 had maximum water temperature of less than 30°C. Maximum temperatures at all stations occurred between May and September. pH varied from about 6 (with one exception of 5.69 at Station B140 during August) to about 9 (Figure 31). The highest pH values were observed at Station B180. Lowest pH was observed at all stations during high discharge (June-September) as a result of increased organic acids flushed from the watershed.

Conductivity values ranged from 128 to 1090 umhos (Figure 32). Conductivity values for sites on the Myakka River (ie. B110, B130, B140 and B160) were below 610 umhos for the entire sampling period. Conductivity was generally the highest at stations B150 and B180 (ie. Big Slough). Lowest conductivity values were found during periods of high discharge.

Dissolved oxygen values ranged from 0.05 to 15.40 mg/l (Table P). Thirty-one percent of all dissolved oxygen values fell below 5.00 mg/l. Lowest values were generally found in July, August and September (Figure 33). Over half of all dissolved oxygen values for sites B130 (80%) and B140 (53%) were below 5.00 mg/l, while no values below 5.00 mg/l were found at site B150. Saturation values

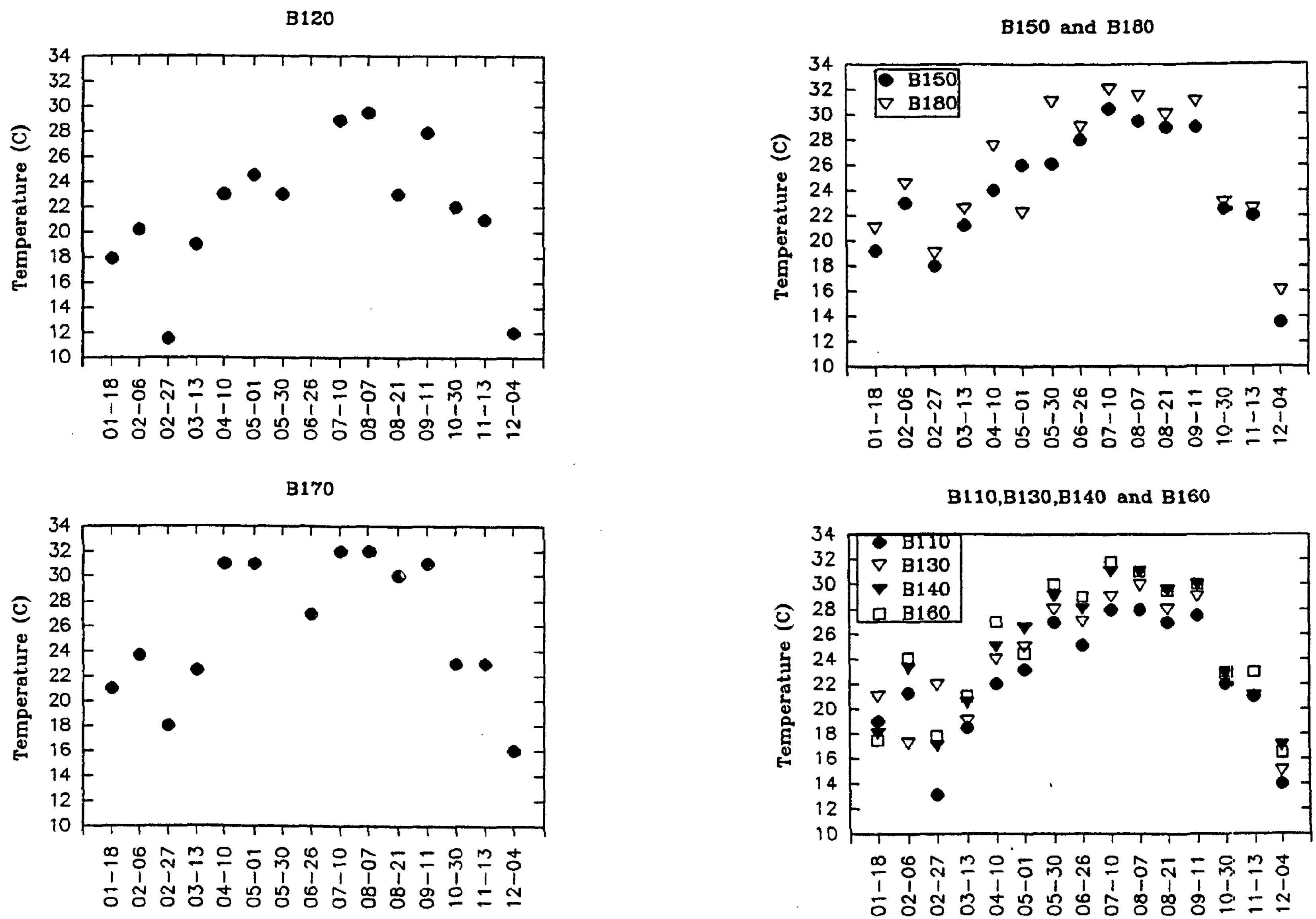


FIGURE 30. Seasonal variation in water temperature at basin sites.

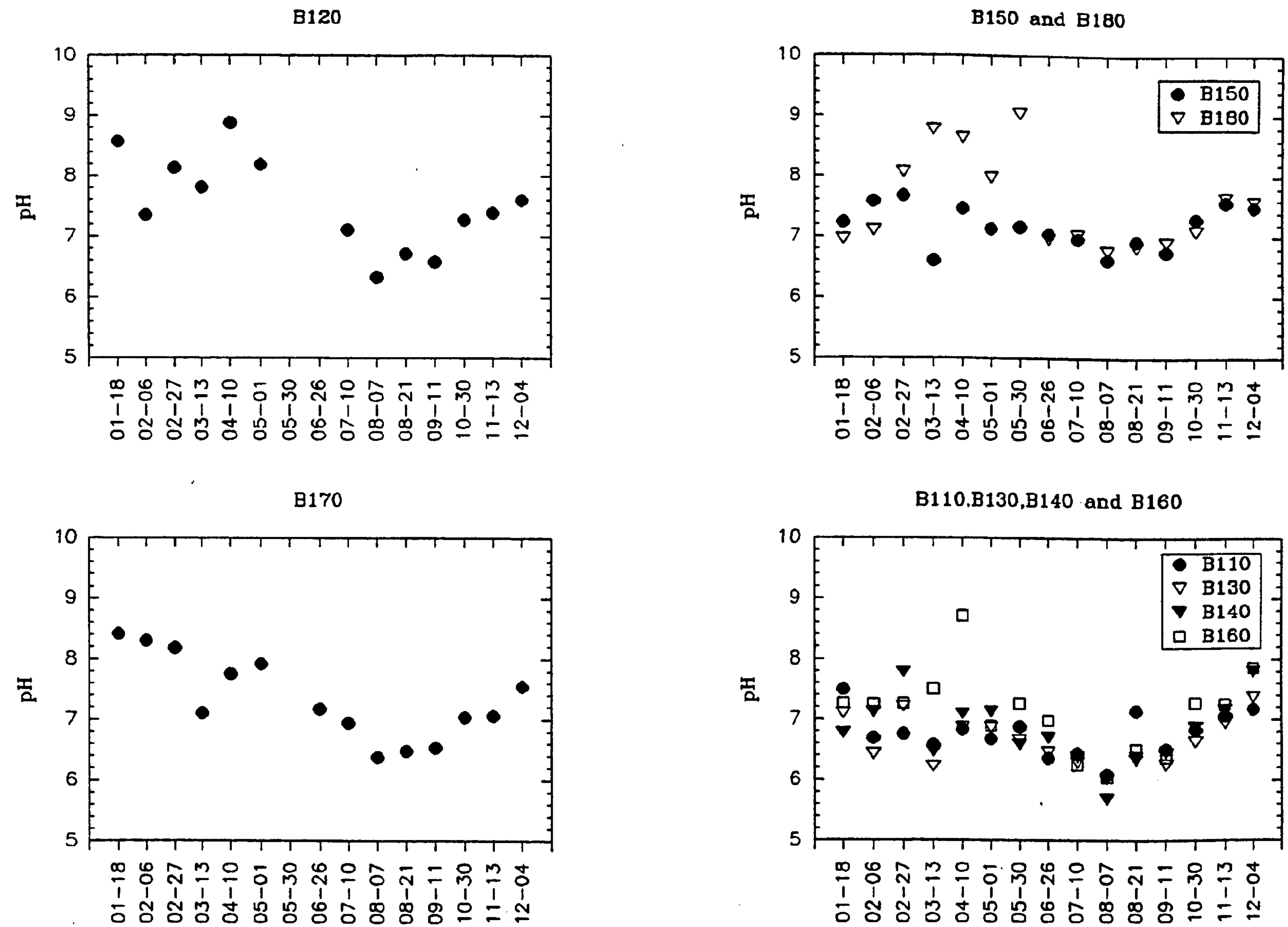


FIGURE 31. Seasonal variation in pH at basin sites.

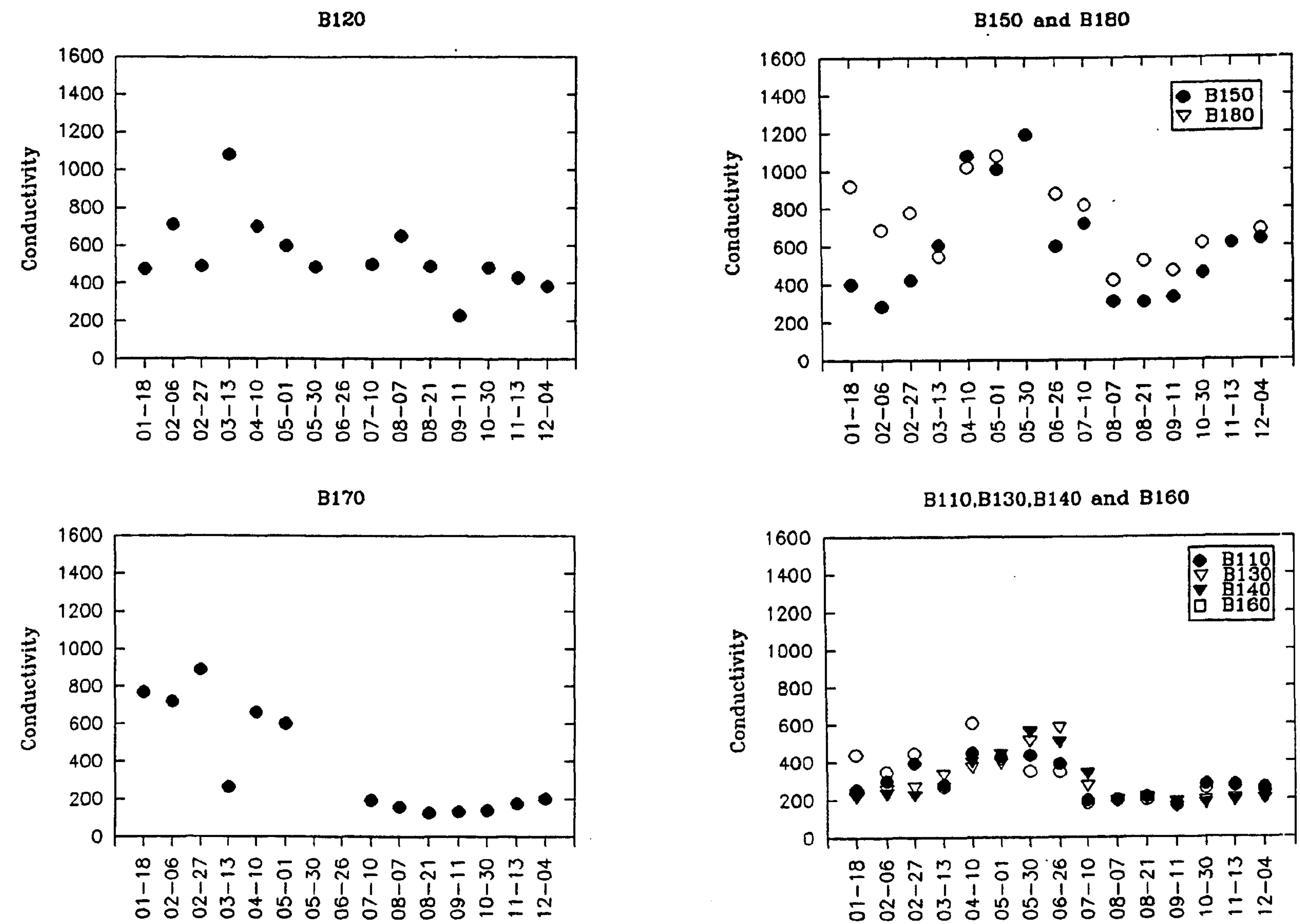


FIGURE 32. **Seasonal variation in conductivity at basin sites.**

TABLE P. Summary of dissolved oxygen values at basin sites.

DATE		B110 TIME	B110 D.O.	B110 SAT %	B130 TIME	B130 D.O.	B130 SAT %	B140 TIME	B140 D.O.	B140 SAT %	B160 TIME	B160 D.O.	B160 SAT %
19890118		1055	7.93	85.6	1142	4.00	44.9	1229	4.70	49.7	1345	4.70	49.2
19890206		1020	6.75	76.6	1058	2.90	30.1	1143	5.20	61.3	1340	6.40	76.2
19890227		1029	9.90	94.1	1112	7.15	82.0	1228	9.40	97.4	1427	9.90	104.8
19890313		1005	9.30	99.4	1040	4.85	52.4	1124	7.20	80.1	1332	9.10	102.2
19890410		1044	7.50	86.0	1125	3.62	43.1	1205	7.50	91.0	1410	9.45	118.9
19890501		1024	9.55	111.6	1106	3.60	43.7	1144	5.00	62.3	1318	8.14	97.8
19890530		930	3.48	43.8	1016	2.45	31.4	1052	4.50	58.7	1224	5.30	70.3
19890626		1005	5.11	62.0	1101	6.65	83.6	1131	4.30	55.1	1322	6.59	85.9
19890710		1041	2.94	37.6	1125	0.71	9.3	1200	0.05	0.7	1358	1.76	24.2
19890807		1048	4.26	54.5	1122	1.60	21.2	1150	0.38	5.1	1316	1.79	24.2
19890821		1035	4.39	55.2	1110	1.63	20.9	1136	2.00	26.3	1307	3.16	41.5
19890911		1052	4.26	54.1	1128	2.62	34.2	1332	1.39	18.4	1457	2.44	32.4
19891030		1008	5.71	65.5	1049	2.42	27.8	1125	4.60	53.7	1323	8.05	94.0
19891113		1020	7.41	83.3	1050	4.48	50.3	1128	6.30	70.8	1254	7.43	86.8
19891204		1119	10.60	103.0	1149	7.70	76.5	1229	9.80	101.6	1358	10.80	110.8
	MIN		2.9	37.6		0.7	9.3		0.1	0.7		1.8	24.2
	MAX		10.6	111.6		7.7	83.6		9.8	101.6		10.8	118.9

DATE		B120 TIME	B120 D.O.	B120 SAT %	B170 TIME	B170 D.O.	B170 SAT %	B150 TIME	B150 D.O.	B150 SAT %	B180 TIME	B180 D.O.	B180 SAT %
19890118		950	9.00	95.2	1640	11.80	132.6	1306	8.05	86.9	1710	8.00	89.9
19890206		908	8.39	92.5	1510	12.10	144.0	1238	8.10	94.6	1535	7.69	92.4
19890227		915	8.80	80.8	1630	11.70	123.8	1311	10.40	110.1	1706	10.20	110.2
19890313		911	10.40	112.3	1522	8.35	96.6	1156	8.35	93.8	1458	15.40	178.2
19890410		955	6.35	74.2	1612	11.00	148.4	1306	8.40	100.0	1550	13.60	172.6
19890501		940	5.10	61.3	1503	9.60	129.6	1217	7.10	87.8	1440	8.75	100.3
19890530								1128	6.31	78.0	1425	14.40	194.3
19890626					1501	6.92	87.0	1203	6.60	84.5	1438	7.60	99.1
19890710		944	8.15	106.3	1550	7.20	98.9	1233	6.83	91.3	1528	7.40	101.6
19890807		956	3.83	50.3	1504	5.98	82.1	1220	5.39	70.8	1446	4.25	57.8
19890821		947	1.64	19.2	2109	4.75	63.0	1209	5.77	75.2	2042	4.83	64.1
19890911		949	0.24	3.1	1719	6.20	83.7	1400	7.01	91.4	1658	6.20	83.7
19891030		910	6.06	69.5	1525	7.99	93.3	1153	8.20	94.9	1504	8.98	104.9
19891113		923	9.25	103.9	1506	7.58	88.6	1154	8.23	94.4	1445	10.90	126.2
19891204		1024	12.80	119.0	1545	10.00	101.5	1258	11.80	113.4	1527	13.60	138.1
	MIN		0.2	3.1		4.8	63.0		5.4	70.8		4.3	57.8
	MAX		12.8	119.0		12.1	148.4		11.8	113.4		15.4	194.3

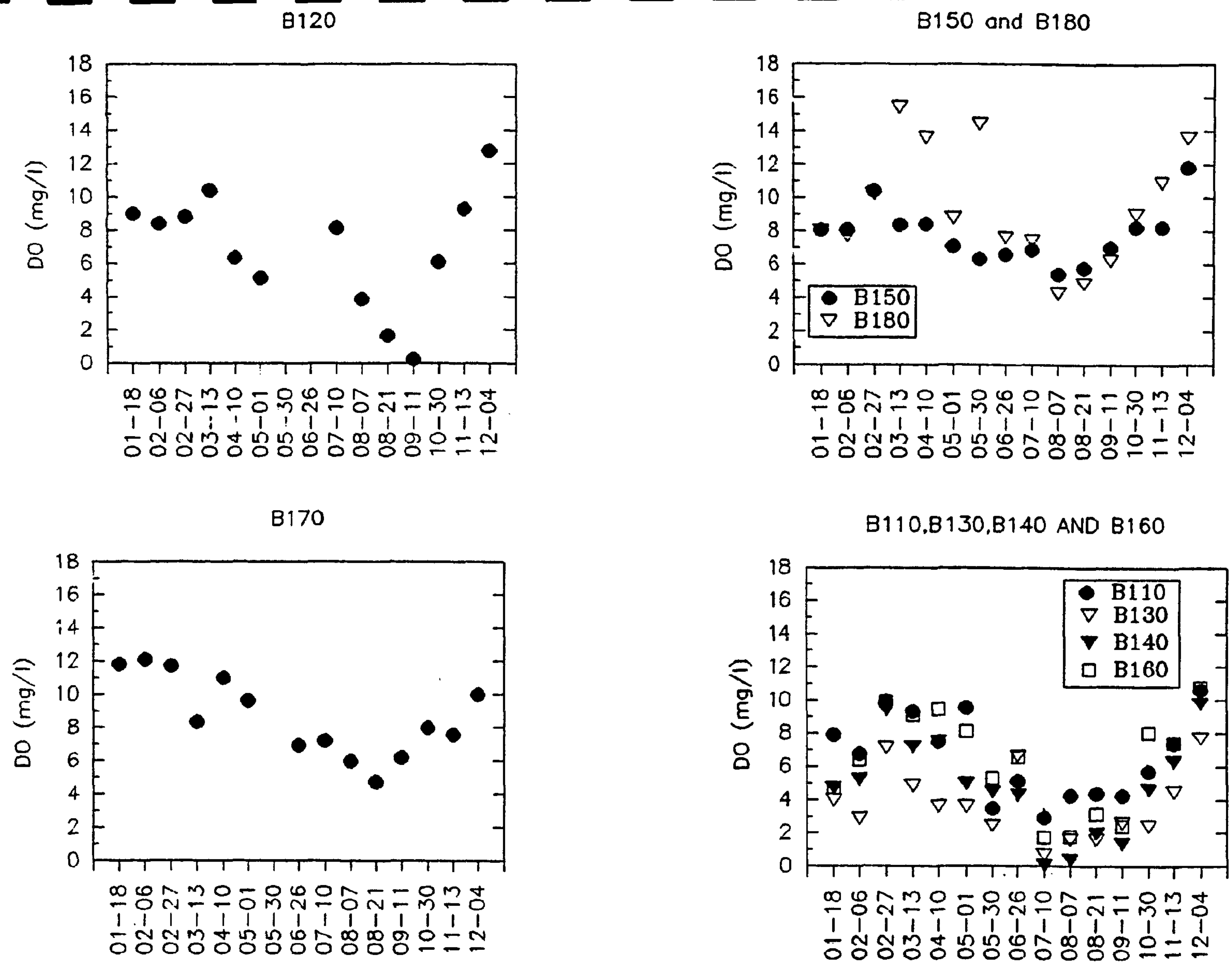


FIGURE 33. **Seasonal variation in dissolved oxygen at basin sites.**

below 10% were found at B120, B130 and B140 (Table P). Supersaturation values were found at all sites except B130. These values suggest that night-time dissolved oxygen values may fall to extremely low values, with the possibility of anoxic conditions. Supersaturated values were most common during periods of low discharge.

Of the dissolved species analyzed (i.e., DOC, NH_4, NO_3+NO_2 and PO_4) all but nitrate + nitrite exhibited a seasonal variation (Appendix C and D). For all sampling stations, DOC had maximum concentrations during high runoff. The other dissolved nutrients with the exception of nitrate and nitrite exhibited highest concentrations generally during high discharge also, but the pattern was not as consistent as that observed with DOC. This is clearly reflected in the rating curve analyses discussed below.

Particulate carbon, nitrogen and phosphorus showed no relation to runoff. The particulate carbon and nitrogen data from the last half of the study, however, have not been evaluated.

Total suspended solid concentrations (TSS) varied erratically during the study period at most stations. Highest suspended solid concentrations often occurred during high discharge, but this was not the rule.

Annual Nutrient Loads

The data on water chemistry collected at each station can be combined with discharge data to calculate annual fluxes or loads from the various subbasins of the Myakka watershed. The approaches to making such calculations were discussed above and the first involves the extrapolation of data using rating curves. Of course, this approach assumes that statistically significant rating curves can be established.

The establishment of rating curves was attempted using the data from seven stations for which water chemistry and discharge data were available. Log-transformed data were used to regress concentration, C, on discharge, Q, assuming the following expected relationship:

$$\mathrm{Log}\ C = a + b\,\mathrm{Log}Q$$

where a and b are regression constants.

The results of regression analyses of the data (Table Q) indicate that only dissolved organic carbon concentrations are significantly related to discharge. Dissolved phosphate is

TABLE Q. Rating curve parameters and statistics.

	Station	a	b	r^2	p
Dissolved Organic Carbon	B110	0.751	0.106	0.733	0.000
	B120	0.673	0.177	0.868	0.000
	B140	0.381	0.170	0.661	0.000
	B150	0.118	0.258	0.717	0.000
	B160	0.134	0.300	0.787	0.000
	B170	0.750	0.136	0.865	0.000
	B180	0.365	0.138	0.841	0.000
Dissolved Nitrate Nitrite	B110	-2.363	0.117	0.096	0.141
	B120	-1.291	-0.114	0.127	0.281
	B140	-1.134	-0.108	0.012	0.690
	B150	1.670	-0.549	0.176	0.041
	B160	-0.505	-0.287	0.079	0.230
	B170	-1.525	-0.012	0.001	0.916
	B180	-2.888	0.342	0.101	0.213
Dissolved Ammonia	B110	-1.374	-0.002	0.000	0.980
	B120	-1.322	0.044	0.010	0.736
	B140	-5.111	0.687	0.615	0.000
	B150	-0.052	-0.317	0.214	0.020
	B160	-0.997	-0.065	0.002	0.838
	B170	-1.952	0.048	0.008	0.772
	B180	-2.119	0.106	0.060	0.285
Dissolved Phosphate	B110	-1.375	0.152	0.345	0.002
	B120	-1.236	0.231	0.741	0.000
	B140	-3.474	0.517	0.719	0.000
	B150	-2.081	0.317	0.527	0.000
	B160	-2.081	0.392	0.405	0.001
	B170	0.407	-0.325	0.601	0.001
	B180	-0.369	-0.062	0.067	0.259
Total Suspended Solids	B110	0.009	0.012	0.002	0.856
	B120	0.690	0.026	0.003	0.854
	B140	-2.248	0.418	0.283	0.009
	B150	-0.662	0.205	0.230	0.015
	B160	1.849	-0.370	0.114	0.125
	B170	-0.116	0.105	0.085	0.293
	B180	0.236	0.051	0.109	0.347
Particulate Organic Carbon	B110	-0.481	-0.080	0.067	0.471
	B120	2.574	-0.979	0.846	0.027
	B140	-2.168	0.330	0.396	0.038
	B150	-3.592	0.754	0.094	0.333
	B160	-1.745	0.430	0.087	0.378
	B170	-2.075	0.446	0.174	0.410
	B180	-1.901	0.301	0.228	0.279
Particulate Organic Nitrogen	B110	-1.322	-0.138	0.065	0.476
	B120	1.820	-1.064	0.868	0.021
	B140	-2.787	0.271	0.172	0.205
	B150	-2.179	0.151	0.002	0.882
	B160	-1.681	0.174	0.005	0.840
	B170	-3.290	0.475	0.071	0.610
	B180	-3.203	0.389	0.275	0.227
Particulate Phosphorous	B110	-1.968	-0.069	0.036	0.372
	B120	-1.620	0.129	0.071	0.338
	B140	-3.835	0.330	0.272	0.011
	B150	-2.482	0.127	0.066	0.216
	B160	-1.396	-0.127	0.011	0.635
	B170	-1.382	-0.093	0.033	0.519
	B180	-3.021	0.255	0.361	0.004

significantly related to discharge for all but two stations. Very few additional significant relationships are observed between nutrient (or TSS) concentrations and discharge.

Because of the general lack of significant relationships between nutrients and discharge, the extrapolation approach to assessing annual fluxes or loads does not appear appropriate. Nonetheless, this exercise is useful for the purpose of comparing subbasins. For example, the rating curves for all stations are similar for DOC (i.e., all slopes of regression curves are positive), but results from most stations have negative slopes for regression curves relating dissolved nitrate + nitrite to discharge (Table Q). Negative slopes are sometimes indicative of constant inputs (e.g., from anthropogenic sources) the effects of which are diluted at high discharge.

Given the availability data for concentrations and discharge, the best approach to estimating annual fluxes of nutrients is by interpolation. For this purpose, we used Method 5 shown in Table M. Results yield the annual dissolved and particulate nutrient fluxes for each station (Table R). These can be compared with subbasin area, discharge and other watershed characteristics to assess the relative efficiency of nutrient transport from each (to be done in later drafts).

Estuarine Water Chemistry Results

A summary of physical and chemical data for estuary stations is contained in Appendix E. The results of the analyses of dissolved and particulate nutrients in estuarine samples are plotted against salinity in Appendix F. Results for the seven freshwater stations are plotted on the left part of each plot (left of zero salinity) in increasing order of station number from left to right. Comparing the freshwater concentrations of a substance to its concentrations at higher salinities provides a basis for judging estuarine behavior of the substance as discussed in the data reduction section. For this purpose, a line is subjectively drawn through the data for concentration versus salinity and interpreted as in Figure 9. The following discussion summarizes the behavior of the nutrients based on their estuarine distributions (some data are missing in this preliminary analysis).

Dissolved organic carbon is removed during estuarine transport from July through February. These are generally times of highest fluxes into the head of the estuary due to freshwater runoff. Following these large inputs, much of the dissolved organic carbon must flocculate, forming particles. This is generally compatible with the observed particulate concentrations in the head waters of the estuary which are considerably enriched over freshwater levels.

TABLE R. Annual fluxes of dissolved and particulate nutrients (metric tons).

Station	Dissolved				Particulate			
	Organic Carbon	Nitrate + Nitrite	Ammonia	Phosphate	Organic Carbon	Organic Nitrite	Phos-phorous	Total Susp. Solids
B110	5,900	5.8	13	98	9.9	1.3	1.3	310
B120	880	0.6	3	22	0.2	0.02	3.0	230
B140	5,000	5.7	22	79	59	7.6	3.5	500
B150	420	3.0	0.6	5	1.6	0.2	0.3	39
B160	97	0.1	0.3	1	2.3	0.4	0.07	11
B170	570	0.5	0.4	1	0.8	0.2	0.4	67
B180	1,800	7.6	2.1	14	3.6	0.5	1.6	230

In general, dissolved phosphate appears to follow DOC in its estuarine distribution. Phosphate removal in the upper estuary appears to be matched by increased particulate phosphorous in the same region.

Both dissolved nitrate-nitrite and ammonia have complex estuarine distributions. In general, all species of dissolved nitrogen appear to be removed in the upper reaches of the estuary. Maxima at higher salinities suggest that some soluble nitrogen is released.

Estuarine concentrations of total suspended solids are generally greater than those in rivers. These concentrations are probably mostly due to resuspension of estuarine sediment and/or sediment transported into the estuary from the seaward end. Certainly some of the increased in suspended solids is also due to biogenic particle production.

Sediment Chemistry Results

Metals

Results of sediment metal analyses are listed in Table S. The concentrations of seven trace metals (arsenic, cadmium, chromium, copper, lead, nickel, zinc, and mercury) were compared to the concentration of aluminum (FDER, 1988) to determine whether sediments were enriched with trace metals. Results of these comparisons are shown in Figures 34 and 35.

The sediments sampled in the Myakka River consisted largely of fine sand. Sands, because of their mineral composition and grain size, tend to have low metal concentrations. This tendency is illustrated by the range of aluminum concentrations in Myakka River (370 to 1850). Concentrations of other metals were also low and fell within expected natural ranges (based on the metal:aluminum relationships).

Other sediments sampled in upper Charlotte Harbor were also predominately fine sand and had correspondingly low metal concentrations. Metal concentrations were within natural ranges. In the Peace River, the sediments had a greater proportion of fine-grained material, thus metal concentrations were higher than in the Myakka River and upper Charlotte Harbor. Metal concentrations were within natural ranges, however, with the exception of cadmium at station PER-2 which was slightly above the naturally expected range.

Mercury cannot be evaluated by its relationship to aluminum. Nevertheless, in its statewide survey of metals in sediments from natural estuarine sites, FDER found that mercury concentrations did not exceed 0.21 (FDER, 1988). Mercury concentrations from all stations in the Myakka River and upper Charlotte Harbor were less

TABLE S. Metal concentrations (ug g^{-1}) in Myakka River, Peace River and Upper Charlotte Harbor sediments.

Station	Date	Aluminum Mean	sd[a]	Arsenic Mean	sd	Cadmium Mean	sd	Chromium Mean	sd	Copper Mean	sd	Iron Mean	sd	Lead Mean	sd	Nickel Mean	sd	Zinc Mean	sd	Mercury Mean	sd
MYK-01	11/07/89	1850	354	0.940	0.085	0.210	0.014	6.30	1.70	0.94	0.08	1750	71	1.600	0.141	2.70	0.14	3.10	0.00	0.040	0.021
MYK-02	11/07/89	370	127	1.000	-1.0[b]	0.125	0.021	1.02	0.11	0.88	0.08	260	85	0.575	0.106	1.60	0.42	0.88	0.08	-2.0[c]	-1.0
MYK-03	11/07/89	630	212	1.100	0.14	0.155	0.007	2.35	1.48	1.05	0.07	765	290	0.775	0.163	2.25	0.78	0.91	0.13	0.015	0.006
MYK-04	11/07/89	1030	382	1.150	0.07	0.130	0.014	1.80	0.99	1.03	0.10	1900	0	1.115	0.262	1.90	0.42	2.70	0.28	0.036	0.014
PER-01	08/29/85	6133	404	2.567	0.75	0.323	0.021	13.67	1.15	4.00	0.35	3767	153	3.600	0.520	-1.0	-1.0	13.67	1.53	0.120	0.030
PER-01	11/07/89	1900	707	0.960	0.33	0.155	0.021	4.40	1.98	0.71	0.11	1950	212	1.750	0.071	2.05	1.20	3.35	0.21	0.026	0.013
PER-02	11/07/89	23000	5657	2.150	0.07	0.755	0.078	49.00	16.97	3.70	0.00	22500	2121	17.500	4.950	11.50	2.12	44.00	7.07	0.235	0.021
PER-03	11/07/89	12500	707	2.650	0.21	0.145	0.035	23.50	3.54	1.80	0.28	9450	5020	10.150	1.202	2.70	0.00	26.50	0.71	0.093	0.053
CHH-02	07/13/85	1333	208	0.507	0.05	0.067	0.006	4.70	0.56	0.75	0.06	797	136	1.833	0.252	-1.0	-1.0	2.83	0.51	0.133	0.040
CHH-02	11/07/89	1400	141	0.930	0.09	0.220	0.085	3.65	0.64	1.05	0.07	1150	71	1.050	0.212	2.35	1.91	1.05	0.07	0.025	0.006
CHH-07	09/24/86	320	99	0.205	0.00	0.010	0.000	1.05	0.07	0.66	0.01	150	42	0.300	0.042	1.85	0.21	1.05	0.07	-2.0	-1.0
CHH-07	11/09/89	375	106	0.640	0.11	0.170	0.057	1.65	0.21	0.72	0.27	270	57	0.440	0.228	1.20	0.14	0.86	0.35	0.034	0.002
CHH-19	11/08/89	2400	283	0.765	0.00	0.210	0.000	6.55	0.35	0.43	0.03	2800	0	1.850	0.071	1.85	1.06	3.40	0.28	0.051	0.016
CHH-20	11/08/89	1025	247	0.695	0.02	0.205	0.134	2.25	1.34	0.59	0.13	1070	325	0.980	0.311	1.90	1.13	1.75	0.21	0.022	0.001

[a]standard deviation.

[b]-1 = no data.

[c]-2 = below detection limit of 0.01 µg g^{-1} for mercury.

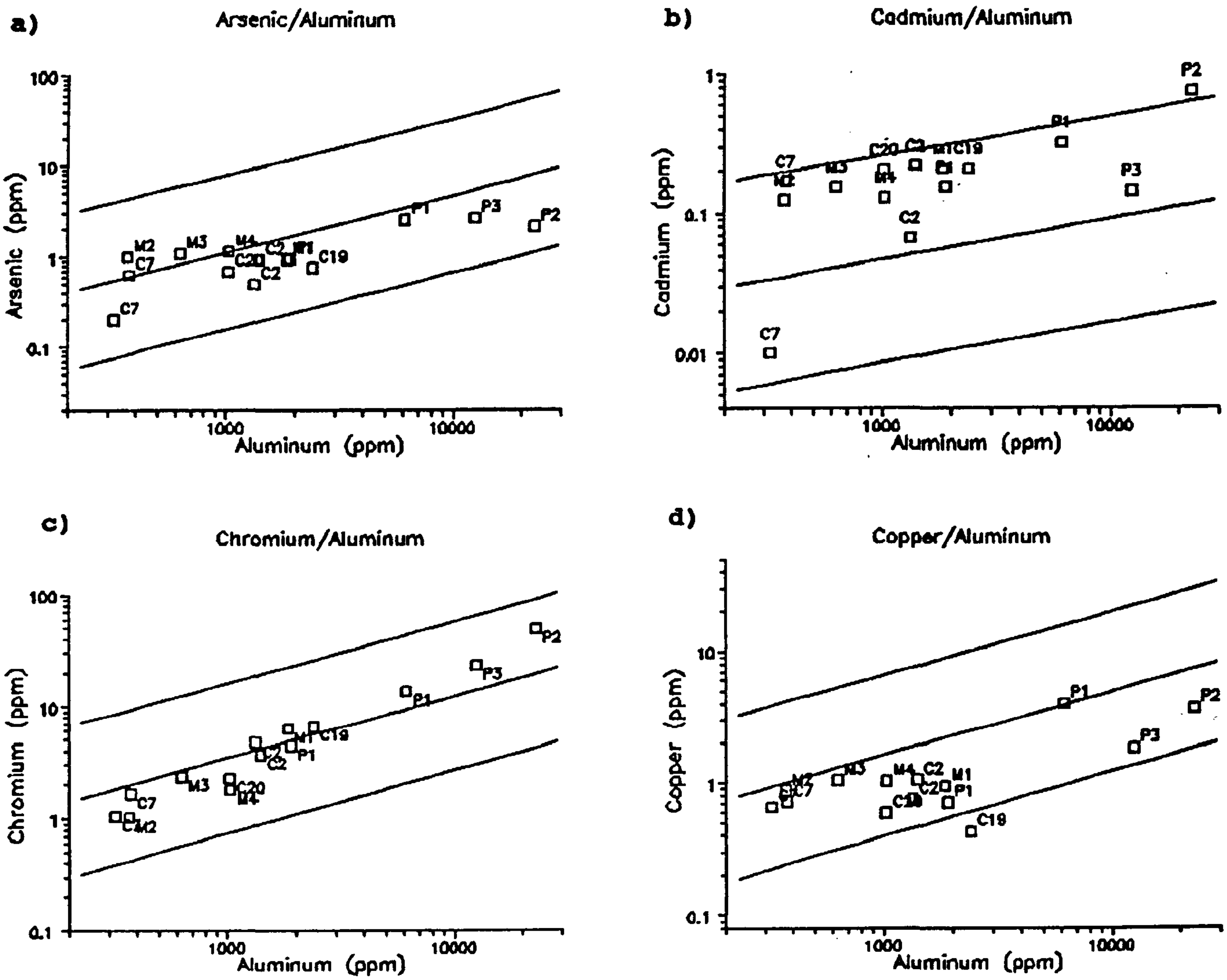


FIGURE 34. Sediment concentrations of (a) arsenic, (b) cadmium, (c) chromium and (d) copper. Points within the two outer lines are considered to be within the range for natural sediments (FDER, 1988).

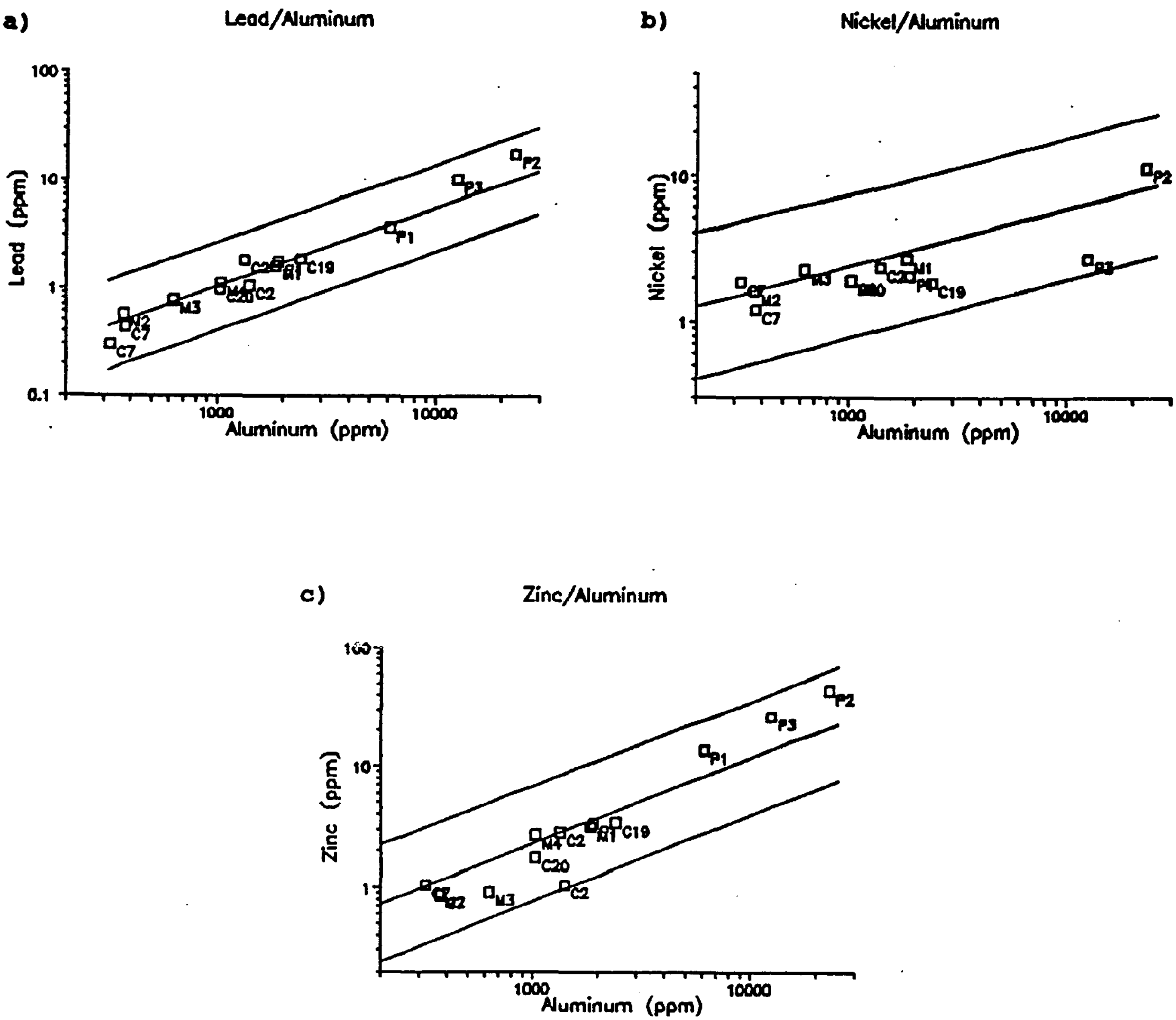


FIGURE 35. Sediment concentrations of (a) lead, (b) nickel and c) zinc. Points within the two outer lines are considered to be within the range for natural sediments (FDER, 1988).

that 0.21 ppm, indicating that mercury was within natural ranges. At one station in the Peace River (PER-2) mercury slightly exceeded the 0.21 ppm guideline for natural sediments.

Nutrients

Concentrations of TOC, TKN, and TP in Myakka River sediments are listed in Table T. Differences among stations in sediment nutrient concentrations appear to be due primarily to sediment grain size. Stations with the greatest nutrient concentrations were those that had the highest aluminum concentrations, high aluminum being an indicator of fine-grained sediments.

TABLE T. Nutrients (ug g^{-1}) in Myakka River, Peace River and Upper Charlotte Harbor sediments.

		TOC		TKN		TP	
STATION	DATE	MEAN	sd	MEAN	sd	MEAN	sd
MYK-01	11/07/89	5550	354	420	57	700.0	84.0
MYK-02	11/07/89	1900	566	66	35	760.0	905.0
MYK-03	11/07/89	2900	707	265	7	120.0	0.0
MYK-04	11/07/89	5350	212	365	21	760.0	42.4
PER-01	08/29/85	9067	1137	550	145	0.6	0.1
PER-01	11/07/89	8350	1061	405	120	825.0	162.6
PER-02	11/07/89	77500	3536	3800	131	5400.0	1131.3
PER-03	11/07/89	60500	2121	1900	283	3500.0	989.9
CHH-02	07/13/85	3600	1735	129	38	-1.0[a]	-1.0
CHH-02	11/07/89	4800	1131	280	57	950.0	70.7
CHH-07	09/24/86	1400	212	130	42	26.5	7.7
CHH-07	02/10/87	1200	141	115	7	52.0	12.0
CHH-07	05/05/87	3750	778	815	134	114.0	23.0
CHH-07	12/10/87	5400	283	250	42	87.0	12.7
CHH-07	11/09/89	1400	141	195	92	106.0	33.9
CHH-19	11/08/89	17500	707	1150	71	565.0	63.6
CHH-20	11/08/89	14500	707	810	141	520.0	282.8

[a] -1 = no data.

Sediment nutrient concentrations in the Myakka River, Peace River, and upper Charlotte Harbor were compared to concentrations in natural sediments throughout Florida. Figure 36 shows TOC/TKN relationships from four statewide (Florida) surveys of sediment nutrients in 1986 - 1987, and, for comparison, TOC/TKN relationships for Myakka River and vicinity surface sediments. Data from the Myakka River area are plotted in the bottom of Figure 36 along with the best fit lines from the September - December 1986, January - March 1978 and November - December 1987 statewide

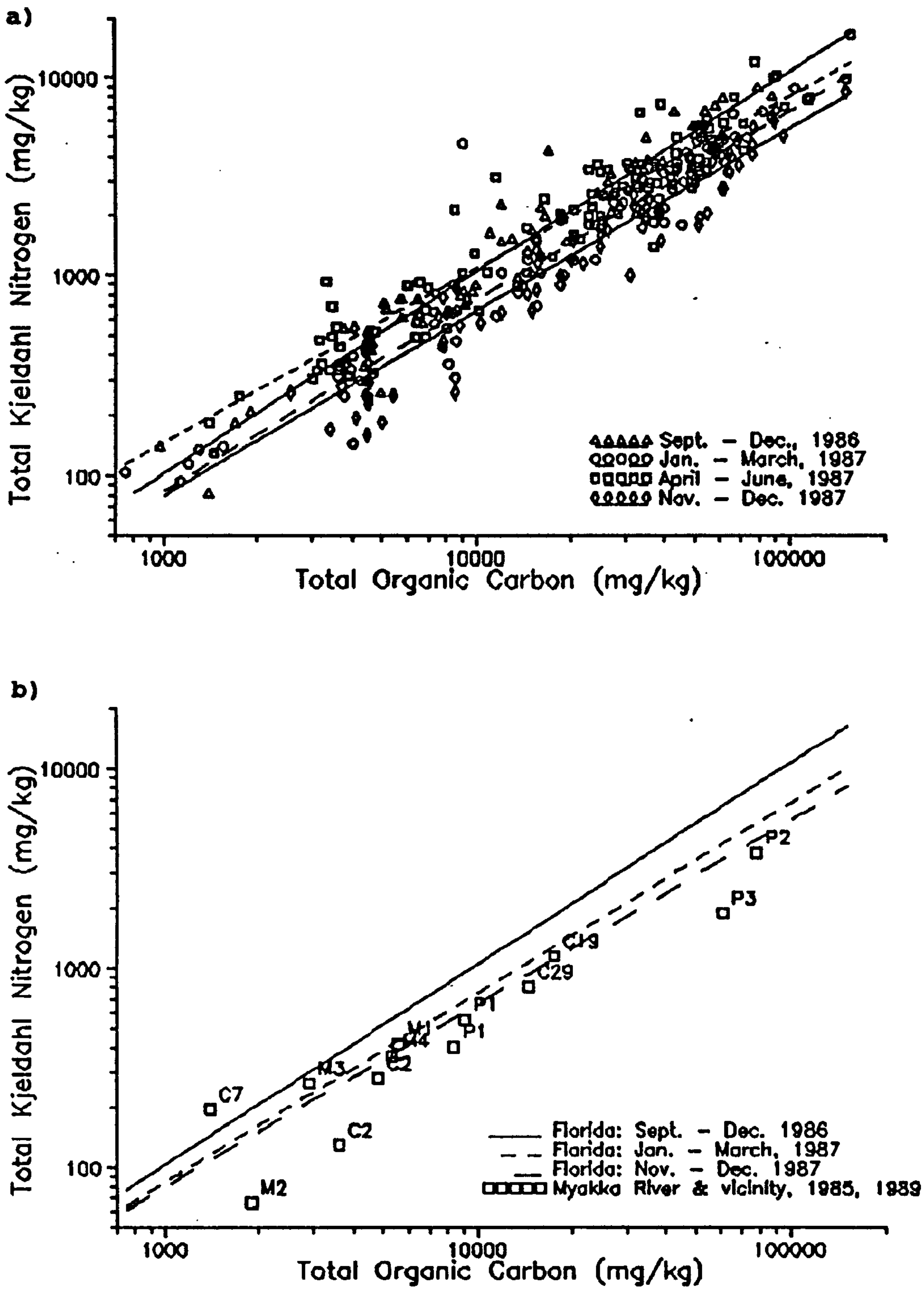


FIGURE 36. TOC and TKN concentrations from (a) natural Florida coastal sediments and (b) Myakka River, Peace River and Upper Charlotte Harbor sediments.

data (from the top of the figure). TKN/TP relationships are shown similarly in Figure 37. Although not statistically rigorous, these comparisons provide a starting point for interpreting sediment nutrient concentrations.

Concentrations of TOC and TKN and the TOC/TKN ratios for the Myakka River area are typical of those found during the statewide surveys. TP concentrations also fall within the range of values found during the statewide surveys but TP/TKN ratios tend to be higher than typical values found throughout the state. Phosphorus-bearing minerals are common in southwest Florida and in the Myakka River watershed, so the higher TP/TKN ratios are probably related to regional geologic features.

Organics

No organic compounds in excess of the detection limits listed in Table O were detected in the sediments of the Myakka River or nearby stations.

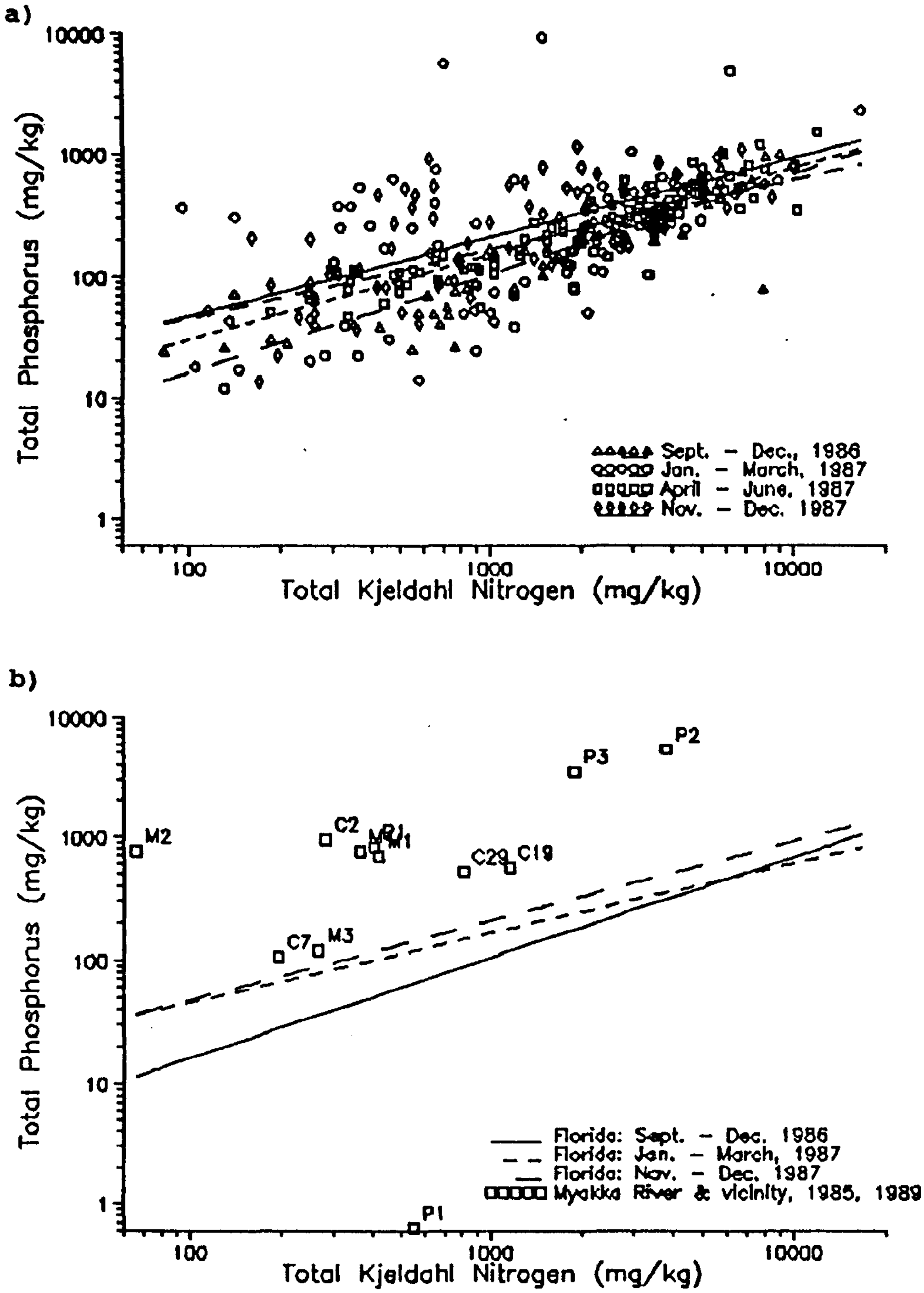


FIGURE 37. TKN and TP concentrations from (a) natural Florida coastal sediments and (b) Myakka River, Peace River and Upper Charlotte Harbor sediments.

VIII. Future Directions

Report Synopsis

The results presented in this report represent the first effort to summarize the information obtained during the first year of the Myakka River Basin Project. The emphasis for this report is on assessing water quality and hydrology of the basin study area. Information is available for the tidal portion of the river (ex. Estevez 1985, 1986); however, there is a paucity of information for the basin study. Therefore, it was most important to characterize the basin study area.

An additional reason for focusing on the basin study area was that activities are occurring (e.g. phosphate mining activity, sludge spreading), or are planned (e.g. Walton Tract landfill, Carlton Reserve wellfield), for the basin that could possibly influence water quality functioning within the basin and estuary. The information obtained during the course of the study is therefore important from a planning perspective. Finally, the information is needed for effective use of the Geographic Information System (GIS) that has been developed for the basin.

Future Technical Reports

Future reports will focus on an expansion of the analysis of data from basin stations, including analysis of data collected in 1990, as well as an examination of long-term water quality and hydrological trends. In addition, a detailed assessment of data from the estuary stations will be made.

Management Tools

Several management tools for the Myakka River basin have been developed as part of this project. They include: a computer model; studies of the benthic and vegetative communities; a shoreline assessment and mapping project; and, a spatially-related database. Each of these provides information on important processes within the basin.

The computer model is capable of duplicating the salinity distributions in the tidal portion of the river. This one-dimensional hydrodynamic model can be used to predict changes in the salinity structure that may result from increases or decreases in freshwater input to the system. Activities in the basin that could result in such an increase include additional hardened surface in the watershed or input of treated wastewater via one or more of the Myakka's tributaries. Water withdrawal for public or private water supply could result in a decrease in input.

Biological studies have established the current composition and condition of riverine communities. The zonation schemes suggested by the data can be used for goal-setting as well as a comparison with future data gathering efforts.

The shoreline mapping and assessment project provides quantified data on the presence of hardened shorelines, wetlands, and exotic species along the river. These figures will provide the basis for measurable management goals.

The database provides a platform for building the GIS, which will allow cumulative impacts on the system to be assessed. The management of natural resources has traditionally been accomplished through the permitting process. This process assesses each impact on a system individually, and tends to be species oriented and segmented in approach. Such a system cannot address cumulative impacts and simply will not work across political boundaries. Five counties, a city, SWFWMD, plus various state and federal agencies have permitting responsibilities within the Myakka River basin. A holistic approach involving goal-setting for the entire watershed and adoption of ordinances basin-wide that recognize and support these goals is needed. A watershed GIS can provide this perspective.

Management Plan

Development of a management plan for the entire watershed will involve, most importantly, establishing basin-wide goals. Many of these goals will result from work done as part of this project. As part of the plan development, we will identify pathways to attain the established goals and propose implementation strategies.

LITERATURE CITED

APHA. 1985. Standard methods for the examination of water and wastewater, 16th edition. American Public Health Association, Washington, D.C.

Browder, J. 1987. An ecosystem view of management research in the Myakka River.

Davis, J.S. and J. Zobrist. 1978. The interrelationships among chemical parameters in rivers - analyzing the effect of natural and anthropogenic sources. Progress Water Technology 10: 65-78.

De Leuw, Cather and Brill. 1959. Engineering report on drainage canal connecting Myakka River and Roberts Bay. Sarasota County, 25 p.

Drummond, R. 1977. The Myakka River Basin, characteristics of a watershed. Senior Thesis, New College.

Dupraz, C., F. LeLong, J.P. Trop and B. Dumazet. 1982. Comparative study of the effects of vegetation on the hydrological and hydrochemical flows in three minor catchments of Mount Lozere (France) - methodological aspects and first results. In: Hydrological Research Basins and Their Use in Water Resources Planning. Landeshydrologie, Berne, pp. 671-682.

Estevez, E.D. 1985. A wet-season characterization of the tidal Myakka River. Draft, 295 p.

Estevez, E.D. 1986. A dry-season characterization of the tidal Myakka River. Draft, 171 p.

Estevez, E.D., C.A. Palmer, R.K. Evans and G.A. Blanchard. 1990. Shorelines of the Myakka River, Sarasota and Charlotte Counties, Florida. Mote Marine Laboratory Technical Report Number 179, 15 p.

FDER. 1988. A guide to the interpretation of metal concentrations in estuarine sediments. Coastal Zone management Section, Florida Department of Environmental Regulation, Tallahassee, Florida.

Figueres, G., J.M. Martin, and M. Meybeck. 1978. Iron behavior in Zaine estuary. Netherlands J. Sea Res. 12: 329-340.

Foster, I.D.L. 1978a. Seasonal solute behaviour of stormflow in a small agricultural catchment. Catena. 5:151-163.

Foster, I.D.L. 1978b. A multivariate model of storm-period solute behaviour. Journal of Hydrology 39:339-353.

Foster, I.D.L. 1980. Chemical yields in runoff and denudation in a small arable catchment, East Devon, England. Journal of Hydrology 47:349-368.

Hall, F.R. 1970. Dissolved solids-discharge relationships. 1: Mixing models. Water Resources Research 6:845-850.

Hammett, K.M. 1989. Physical processes, salinity characteristics and potential salinity changes due to freshwater withdrawals in the tidal Myakka River, Florida. Draft USGS Report.

Hammett, K.M., J.F. Turner, Jr. and W.R. Murphy, Jr. 1978. Magnitude and Frequency of Flooding on the Myakka River, Southwest Florida. U.S. Geological Survey, Water Resources Investigations 78-65, 40 p.

Hand, J., V. Tauxe and J. Watts. 1988. 1988 Florida water quality assessment 305(b) Technical Report, 235 p.

Jansson, M. 1985. A comparison of detransformed logarithmic regressions and power function regressions. Geografiska Annaler 67A:61-70.

Joyner, B.F. and H. Sutcliffe, Jr. 1976. Water Resources of the Myakka River. U.S. Geological Survey, Water Resources Investigations 76-58, 87 p.

Kaul, L.W. and P.N. Froelich. 1984. Modeling estuarine nutrient geochemistry in a simple system. Geochem. Cosmochim. Acta. 48:1417-1433.

Li, Y. and L. Chan. 1979. Desorption of Ba and ^{226}Ra from river-borne sediments in the Hudson estuary. Earth Plant. Sci. Lett. 43:343-350.

Lincer, J.L. (ed.). 1979. Myakka River workshop, Draft, 67 p.

Miller, W.R. and R.H. Drever. 1977. Water chemistry of a stream following a storm, Absaroka Mountains, Wyoming. Geological Society of America Bulletin 88:286-290.

Milligan, M. 1990. Myakka River biological study: Down's Dam to Snook Haven. 200 p.

Morris, J. and J. Miller. 1976. The Myakka River corridor. 115 p.

Nilsson, B. 1971. Sediment transport i svenska vattendrag. Ett IHD-projekt. Del. 1, Methodik, UNGI Rapport 4, Uppsala.

Reid, J.M., D.A. MacLeod and M.S. Cresser. 1981. Factors affecting the chemistry of precipitation and river water in an upland catchment. Journal of Hydrology 50:129-145.

Rosenau, J.C., G.L. Faulkner, C.W. Handry, Jr. and R.W. Hull. 1977. Springs of Florida. Bureau of Geology Bulletin No. 31, Florida Department of Natural Resources, Tallahassee, Florida.

Soil Conservation Service. 1983. Soil Survey of Manatee County, Florida, 159 p.

Soil Conservation Service. 1988. Soil Survey of Sarasota County, Florida. Draft Report.

Turvey, N.D. 1975. Water quality in a tropical rain forested catchment. Journal of Hydrology 27:111-125.

Walling, D.E. and I.D.L. Foster. 1978. The 1976 drought and nitrate levels in the River Exe Basin. Journal of the Institution of Water Engineers and Scientists 32:341-352.

Walling, D.E. and P. Kane. 1984. Suspended sediment properties and their geomorphological significance. In: Catchment Experiments in Fluvial Geomorphology. T.P. Burt and D.E.

Walling, Editors. Geo Books, Norwich, pp. 311-334.

Walling, D.E. and B.W. Webb. 1981. The reliability of suspended sediment load data. IAHS Publication 133: 177-194.

Walling, D.E. and B.W. Webb. 1983. The dissolved loads of rivers: A global overview. IAHS Publication 141:3-20.

Walling, D.E. and B.W. Webb. 1984. Local variation of nitrate levels in the Exe Basin, Devon, UK. Beitrage Zur Hydologie 10:71-100.

Walling, D.E. and B.W. Webb. 1986a. Solutes in river systems. In: Solute Processes. S.T. Trudgill, Editor. Wiley, Chichester, pp. 251-327.

Walling, D.E. and W.B. Webb. 1986b. Suspended load in gravel bed rivers: UK experience. In: Problems of Sediment Transport in Gravel-Bed Rivers. C.R. Thorne, R.D. Hey and J.C. Bathurst, editors. Wiley, Chichester (in press).

Webb, B.W. and D.E. Walling, 1983. Stream solute behaviour in the River Exe basin, Devon, UK. IAHS Publication 414:153-169.

Webb, B.W. and D.E. Walling. 1985. Nitrate behavior in streamflow from a grassland catchment in Devon, U.K. Water Research 19:1005-1016.

Winchester, B.H., J.S. Bays, J.C. Heguian and R.L. Knight. 1985. Physiography and vegetation zonation of shallow emergent marshes in southwestern Florida. Wetlands 5:99-118.

APPENDIX A

Basin and Estuary Station Descriptions

MYAKKA RIVER FRESH H_2O SAMPLING POINTS

Station Designation	Station Description
B110	Myakka City at bridge on State Rd 70 Sample at USGS Continuous Record Gaging Station #02298608 27°20'36" 82°09'25" Manatee Co. Section 13 Township 36S Range 21E
B120	Howard Creek on Hi Hat Ranch approximately 4 mi. south of State Rd. 780 Sample at USGS Continuous Record Gaging Station #02298760 27°17'17" 82°20'25" Sarasota Co. Section 6 Township 37S Range 20E
B130	Myakka River near Clay Gully inflow. Sample from bridge on Clay Gully Road. North of Myakka River State Park. Sample at USGS Continuous Record Gaging Station #02298700 27°18'05" 82°15'15" Sarasota Co. Section 36 Township 36S Range 20E
B140	Myakka River in the Myakka River State Park. 1/2 mile north of the State Road 72 entrance to the State Park on the west bank of the river. Sample at USGS Continuous Record Gaging Station #02298830 27°14'25" 82°18'50" Sarasota Co. Section 21 Township 37S Range 20E
B150	Big Slough Canal at bridge on State Road 72 near Myakka River State Park Sample at USGS Continuous Record Gaging Station #02299410 27°11'35" 82°08'40" Sarasota Co. Section 6 Township 38S Range 22E
B155	Deer Prairie Slough at bridge on State Road 72. Stage recorder to be installed by May 31, 1990. Sarasota Co. Section 4 Township 38S Range 21E
B160	Myakka River on Chuck Down's property, 500ft downstream from concrete dam. Sample at USGS Continuous Record Gaging Station #02298880 27°11'07" 82°21'21" Sarasota Co. Section 12 Township 38S Range 19E

B165 Myakka River at bridge on Border Road.
Sample will be taken in the channel on the north side of the bridge.
Correlate to USGS Continuous Record Gaging Station #02298880 (ie. B160)
Sarasota Co. Section 31 Township 38S Range 19E

B170 Deer Prairie Slough at bridge on I-75. Sample will be taken in the channel on the north side of the bridge.
Correlate to USGS Continous Record Gaging Station #02299160 27°06'51" 82°21'50"
Sarasota Co. Section 21 Township 39S Range 21E

B175 Deer Prairie Slough at the southern boundary of the T. Mabry Carlton Jr. Memorial Reserve.
Stage recorder to be installed by May 31, 1990.
Sarasota Co. Section 36 Township 38S Range 20E

B180 Big Slough in North Port, 25 yards upstream from I-75 bridge.
Sample at USGS Continous Record Gaging Station #02299455 27°06'30" 82°12'20"
Sarasota Co. Section 9 Township 39S Range 21E

MYAKKA RIVER ESTUARINE STATIONS

Station Designation[1]	Station Description
E210	In Charlotte Harbor; 1.5 nautical miles SSE (compass heading 140) of number 9 square green channel marker at the Sarasota-Charlotte county line; sample 25 yards west of the number 8 triangular red channel marker. Longitude W82:09:58; Latitude N26:54:51. Loran Coordinates 14165.4 44080.0
E220	In the Myakka River; 100 yards west of the El Jobean Bridge (Highway 771) on the south side of the channel; between the second and third canals in the development on the south bank of the river; 75 yards south along the bisected railroad bridge. Longitude W82:13:02 Latitude N26:57:22. Loran Coordinates 14165.0 44122.1
E230	In Myakka Bay; 50 yards north of hexagonal channel marker B; line up between the canal on the west bank and the large dead tree on the east bank. Longitude W82:14:45 Latitude N26:59:00. Loran Coordinates 14166.3 44143.2
E240	In the Myakka River; 25 yards east of the dock with a red bench; this dock is the first of three docks south of statue (Myakka River God) on the south end of the Tarpon Point development. Longitude W82:16:39 Latitude N27:00:83. Loran Coordinates 14166.8 44178.7
E250	In the Myakka River; north of Big Slough mouth; on the west side of the island off a trailer park; 200 yards south of the number 3 green square channel marker; line up between the 2 headless palms on the island to the east and just south of an area of low mangroves on the west bank. Longitude W82:16:88 Latitude N27:01:98. Loran Coordinates 14168.5 44178.8

E260	On the Myakka River; north of the highway 41 bridge and Becky's Bait Bucket; 50 yards north of the mouth of Deer Prairie Creek 25 feet from the tip of the island with 3 palm trees; sample in mid-channel. Longitude W82:17:77 Latitude N27:03:03. Loran Coordinates 14169.2 44191.8
E270	On the Myakka River; upstream of the last mangrove; after a bend with a single Australian pine; sample in midstream at the first palm which hangs out over the water; channel markers number 8 red triangular and number 9 green square are 500 yards upstream. Longitude W82:18:86 Latitude N27:03:94. Loran Coordinates 14169.1 44205.7
E280	On the Myakka River; three left bends in the river followed by three right bends upstream of Rambler's Rest Campground; the area is known as Big Bend and is characterized by a high white sand bank on the east bank of the river. Longitude W82:17:63 Latitude N27:02:52. Loran Coordinates 14170.1 44219.4

1. 8 "fixed" stations listed above plus 2 "floating" stations

APPENDIX B

Summary of Longterm Rainfall Data

Rainfall Data Summary

Station: Fort Green	Period of Record:	Sep-55	to	Apr-90			
	Missing data:	Nov-71	Mar-75	and	Feb-76	to	Dec-84

MONTH	YEARS 1955	1956	1957	1958	1959	1960	1961	1962	1963	1964	1965
JANUARY		0.440	2.070	7.700	3.020	1.020	2.650	1.150	2.620	3.760	1.860
FEBRUARY		1.840	7.320	3.310	2.890	5.360	3.570	0.560	8.290	5.570	3.890
MARCH		0.170	4.600	7.810	7.670	5.470	2.230	4.650	1.400	3.170	4.760
APRIL		3.000	5.380	4.060	4.100	2.730	1.840	3.580	0.400	0.440	3.140
MAY		1.470	2.540	3.540	8.950	1.780	2.510	2.460	7.000	4.170	0.130
JUNE		3.150	11.660	9.940	10.070	11.000	7.160	13.550	9.800	4.370	11.650
JULY		11.270	10.890	3.690	8.120	21.560	5.220	5.780	6.410	8.960	16.430
AUGUST		11.780	9.800	2.380	15.070	8.460	13.230	11.740	6.560	5.870	2.980
SEPTEMBER	6.670	7.140	7.100	2.440	8.930	18.450	1.430	10.760	8.530	5.550	5.190
OCTOBER	1.380	2.710	3.610	3.170	6.920	3.080	0.060	1.470	0.400	2.700	1.980
NOVEMBER	1.510	0.200	3.940	2.000	1.050	0.020	0.970	2.290	5.510	1.540	0.530
DECEMBER	0.850	0.500	2.570	5.190	2.080	2.310	0.570	0.270	2.460	1.150	2.350
TOTAL	10.410	43.670	71.480	55.230	78.870	81.240	41.440	58.260	59.380	47.250	54.890

MONTH	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976
JANUARY	6.420	0.840	0.340	3.230	2.000	0.520	0.670	5.400	0.040	0.820	1.440
FEBRUARY	2.570	3.770	2.120	2.280	3.100	4.580	5.370	2.480	1.220	2.270	
MARCH	0.700	0.360	0.870	7.110	8.510	0.960	5.400	3.440	0.440		
APRIL	3.450	0.000	0.620	1.300	0.140	0.570	1.800	3.640	0.540	0.710	
MAY	3.710	0.660	4.430	1.870	8.480	3.300	5.610	2.330	2.010	7.060	
JUNE	7.830	14.200	13.960	8.290	3.780	8.470	6.700	3.620	11.910	10.710	
JULY	4.540	17.100	8.920	4.650	3.720	5.000	4.910	10.710	10.450	9.910	
AUGUST	5.340	10.530	8.580	8.700	4.100	9.850	11.250	7.930	3.640	9.540	
SEPTEMBER	3.300	2.990	3.130	7.630	5.690	6.190	0.480	5.320	3.470	8.580	
OCTOBER	3.680	1.110	3.920	3.970	1.570	8.770	2.900	1.200	0.000	4.910	
NOVEMBER	0.660	0.500	4.040	1.750	0.580		3.460	1.290	0.100	0.500	
DECEMBER	0.670	2.000	1.460	4.990	0.570	1.320	2.940	3.400	2.420	0.730	
TOTAL	42.870	54.060	52.390	55.770	42.240	49.530	51.490	50.760	36.240	55.740	

MONTH	1985	1986	1987	1988	1989	1990	N	MEAN
JANUARY	1.960	2.950	1.250	2.000	2.700	0.200	27	2.188
FEBRUARY	1.150	1.100	0.700	2.500	0.000	4.150	26	3.152
MARCH	1.980	4.220	10.850	6.150	1.850	1.600	25	3.855
APRIL	1.760	1.050	0.180	1.700	1.150	1.900	26	1.892
MAY	1.050	1.750	5.540	1.000	0.150		25	3.340
JUNE	6.670	13.020	6.220	1.840	11.750		25	8.853
JULY	8.130	6.400	9.750	10.400	10.280		25	8.928
AUGUST	8.260	8.760	2.500	15.150	6.950		25	8.358
SEPTEMBER	4.900	3.640	5.400	10.290	6.650		26	6.148
OCTOBER	2.250	2.340	3.000	0.800	1.000		26	2.650
NOVEMBER	0.700	0.850	6.300	3.500	1.050		25	1.794
DECEMBER	1.250	3.750	0.200	1.200	4.800		26	2.000
TOTAL	40.060	49.830	51.890	56.530	48.330			53.157

Rainfall Data Summary
Station: Myakka River State Park
Period of Record: Sep-43 to Jan-90
Missing Data: Apr-49 and Jan-67 to Aug-67

YEAR

MONTH	1943	1944	1945	1946	1947	1948	1949	1950	1951	1952	1953
JANUARY		1.070	1.380	0.910	0.810	4.330	0.640	0.000	0.320	0.740	3.570
FEBRUARY		0.280	0.410	2.700	3.730	0.440	0.340	0.010	1.900	4.250	4.000
MARCH		2.220	0.160	1.540	7.040	0.490	0.420	1.370	1.350	4.560	0.410
APRIL		0.730	0.000	0.040	3.240	7.020		0.430	6.220	0.490	3.610
MAY		4.200	0.420	5.330	1.310	1.350	0.620	2.320	0.610	1.740	0.350
JUNE		7.490	11.800	5.960	12.750	2.870	6.330	10.200	6.450	7.420	12.530
JULY		6.860	14.420	6.950	12.740	9.180	5.950	8.530	12.630	3.840	5.890
AUGUST		5.330	10.740	6.330	8.450	5.480	16.600	7.210	6.360	7.390	6.680
SEPTEMBER	6.000	6.840	5.210	6.550	8.510	9.440	8.430	6.300	7.010	6.910	9.950
OCTOBER	6.400	3.380	3.590	2.160	2.330	1.470	1.680	2.350	10.010	9.320	6.050
NOVEMBER	0.710	0.200	0.370	0.600	5.040	1.690	2.320	0.020	2.080	3.390	5.130
DECEMBER	0.000	0.470	2.110	0.610	2.050	0.790	0.030	3.550	0.540	1.800	2.990
TOTAL	13.110	39.070	50.610	39.680	68.000	44.550	43.360	42.290	55.480	51.850	61.160

MONTH	1954	1955	1956	1957	1958	1959	1960	1961	1962	1963	1964
JANUARY	2.340	2.170	1.100	1.640	6.820	2.650	1.150	2.520	2.060	2.200	3.030
FEBRUARY	1.680	2.810	2.260	5.410	3.740	2.520	4.360	4.970	1.800	6.010	4.260
MARCH	2.150	1.700	0.080	6.160	8.210	8.800	4.470	1.710	2.520	0.910	4.900
APRIL	7.100	1.360	1.940	6.820	2.740	1.700	3.270	3.270	5.010	0.450	0.650
MAY	5.120	0.500	3.530	5.080	2.900	12.810	2.240	2.360	3.220	5.590	2.260
JUNE	8.360	3.530	3.550	11.030	3.740	9.230	5.680	5.150	9.230	6.330	4.500
JULY	6.310	10.600	4.480	4.870	7.650	6.750	14.860	5.950	3.550	3.350	7.360
AUGUST	5.650	7.170	5.350	11.880	10.370	12.670	7.260	6.310	11.810	14.210	8.510
SEPTEMBER	10.690	5.760	9.960	12.820	4.880	8.240	14.040	2.360	22.490	7.420	10.230
OCTOBER	3.350	1.010	5.240	6.290	6.240	7.700	2.500	1.160	0.850	0.300	1.770
NOVEMBER	3.640	0.800	0.410	1.520	4.730	2.300	2.080	0.540	2.360	4.520	1.100
DECEMBER	2.710	0.830	0.250	2.100	6.320	2.220	1.760	0.160	0.220	2.640	1.550
TOTAL	59.100	38.240	38.150	75.620	68.340	77.590	63.670	36.460	65.120	53.930	50.120

MONTH	1965	1966	1967	1968	1969	1970	1971	1972	1973	1974	1975
JANUARY	0.980	5.130		0.090	2.200	3.350	0.660	0.610	8.250	0.000	0.540
FEBRUARY	3.780	3.190		0.850	2.220	1.510	2.390	4.620	1.500	3.390	1.160
MARCH	2.270	0.230		1.760	9.740	6.210	1.510	3.480	2.750	0.470	0.850
APRIL	1.690	3.240		0.720	0.920	0.120	0.330	2.020	2.570	0.960	0.500
MAY	0.830	2.820		6.020	4.930	8.850	2.320	4.800	0.560	3.600	7.950
JUNE	12.800	8.110		16.600	10.380	4.660	4.880	13.380	7.160	20.030	8.230
JULY	14.330	7.850		13.240	5.210	7.170	10.490	1.810	19.340	10.610	17.730
AUGUST	14.540	7.710		8.100	7.490	12.370	18.610	7.870	7.750	5.050	5.830
SEPTEMBER	5.520	4.240	11.820	6.310	9.100	5.510	8.490	2.290	8.090	5.460	5.180
OCTOBER	5.130	1.310	1.280	2.910	5.110	1.150	5.460	4.640	0.440	0.000	6.090
NOVEMBER	0.300	0.540	0.540	2.860	2.480	0.860	1.770	5.010	0.700	0.390	0.580
DECEMBER	1.630	0.960	2.090	1.100	3.600	0.460	2.850	3.850	2.110	3.210	0.660
TOTAL	63.800	45.330	15.730	60.560	63.380	52.220	59.760	54.380	61.220	53.170	55.300

MONTH	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986
JANUARY	1.360	2.280	4.900	7.380	3.550	0.660	2.060	2.710	1.000	0.810	1.790
FEBRUARY	0.490	1.530	5.490	3.070	3.700	5.880	2.670	9.550	2.440	0.970	1.660
MARCH	0.600	0.290	3.260	1.150	1.710	1.530	6.620	7.810	5.410	2.800	4.400
APRIL	1.000	1.040	0.150	0.660	4.210	0.000	5.050	2.720	3.310	2.090	0.970
MAY	7.550	5.330	0.640	4.650	4.010	1.910	2.810	1.990	4.290	0.230	1.940
JUNE	10.930	6.990	13.700	3.070	2.490	15.770	15.610	9.330	2.870	5.580	7.530
JULY	6.600	10.150	7.200	7.320	6.480	8.170	13.240	11.890	15.470	7.460	5.580
AUGUST	5.170	9.100	7.200	13.250	15.990	19.850	11.730	7.410	7.290	9.100	7.090
SEPTEMBER	9.620	11.080	6.350	21.080	10.150	5.960	11.980	11.670	4.190	9.590	2.400
OCTOBER	1.270	0.610	0.610	1.230	1.030	1.780	3.240	2.660	2.760	1.910	5.920
NOVEMBER	3.130	3.000	1.080	1.120	4.040	4.870	0.690	4.420	2.360	3.080	1.310
DECEMBER	1.730	5.970	3.820	2.950	1.150	1.190	1.020	8.200	0.360	0.410	3.530
TOTAL	49.450	57.370	54.400	66.930	58.510	67.570	76.720	80.360	51.750	44.030	44.120

MONTH	1987	1988	1989	1990	N	MEAN
JANUARY	4.960	4.490	2.830	0.170	47	2.217
FEBRUARY	2.540	2.410	0.230		46	2.720
MARCH	12.880	5.170	1.020		46	3.154
APRIL	0.020	1.660	0.730		45	2.062
MAY	5.570	2.630	1.260		46	3.290
JUNE	7.630	3.200	7.680		46	8.103
JULY	9.900	8.670	9.610		46	8.657
AUGUST	9.510	15.620	5.580		46	9.152
SEPTEMBER	8.160	11.470	6.890		48	8.180
OCTOBER	4.410	2.140	3.960		48	3.171
NOVEMBER	4.120	3.430	1.870		48	2.085
DECEMBER	0.190	1.210	4.230		48	1.962
TOTAL	69.890	62.100	45.890	0.170		

RAINFALL DATA: VENICE AIRPORT, VENICE FL
PERIOD OF RECORD 8/48 - 5/90
MISSING DATA: ESSENTIALLY SWISS CHEESE

YEAR MONTH	1948*	1949*	1950*	1951*	1955*	1956	1957	1958	1959	1960	1961
JANUARY		0.30		0.42		2.13	1.56	9.32	2.60	1.20	2.99
FEBRUARY		0.22	0.00	1.93		0.85	6.36	3.26	2.95	4.26	3.64
MARCH		0.15	1.54	1.82		0.10	5.42	6.60	7.74	3.90	1.48
APRIL		2.23	0.78	3.20		1.46	13.85	2.29	1.46	3.73	3.87
MAY		0.68		0.36	1.75	3.43	2.10	3.78	7.70	1.83	3.87
JUNE				3.90	2.45	4.32	7.41	4.30	7.71	1.38	2.01
JULY		8.33			8.28	5.71	6.80	7.00	9.07	10.00	9.13
AUGUST	4.70		6.00	4.63	3.04	3.51	10.19	3.28	12.56	7.18	5.70
SEPTEMBER					6.30	8.99	8.04	3.43	6.71	16.20	1.72
OCTOBER	2.35		1.99		1.77	5.06	5.52	6.21	9.61	4.54	0.74
NOVEMBER	1.81		0.21		0.82	0.30	4.77	2.12	2.91	0.15	0.58
DECEMBER	0.90		3.63		1.14	0.83	2.13	4.16	2.26	0.97	0.77
TOTAL						36.69	74.15	55.75	73.28	55.34	36.50

MONTH	1962	1963	1964*	1965*	1966	1967	1968*	1969	1970	1971	1972*
JANUARY	1.48	2.14	3.68	1.06	6.62	0.84	0.10	2.11	3.00	0.46	1.41
FEBRUARY	0.36	5.51	4.92	3.60	3.71	3.35	1.77	2.35	2.09	2.55	5.47
MARCH	2.91	0.81	3.10	2.99	0.61	0.39	1.10	7.10	8.05	0.64	4.80
APRIL	6.10	0.09	0.62	0.93	4.12	0.00	0.55	0.66	0.17	0.45	0.24
MAY	4.98	1.68	1.49	2.17	4.10	0.40	1.98	8.57	2.68	1.74	
JUNE	12.59	7.66	4.71		6.84	8.10		7.71	3.47	2.46	7.47
JULY	2.02	3.35			4.87	2.33		7.59	3.04	11.23	2.61
AUGUST	8.16	4.06		6.04	5.16	16.47	7.67	6.58	13.11	13.41	5.60
SEPTEMBER	14.77	9.96	4.78	3.69	7.39	8.53	12.31	7.07	6.68	9.59	5.04
OCTOBER	1.52	0.09	0.86	2.77	0.98	7.73	4.19	6.39	0.56	3.24	1.16
NOVEMBER	2.00	5.55	0.54	1.35	0.50	0.56	3.77	3.38	1.48	1.62	5.85
DECEMBER	0.33	2.85	2.05	1.01	0.97	2.73	0.76	3.47	0.75	3.24	3.24
TOTAL	57.22	43.75			45.87	51.43		62.98	45.08	50.63	

MONTH	1973	1974	1975	1976	1977	1978	1979	1980	1981*	1982	1983*
JANUARY	7.00	0.24	0.43	0.65	2.92	3.21	6.28	2.70	3.20	0.54	2.66
FEBRUARY	1.77	0.74	1.91	0.71	1.26	5.62	1.51	0.88	0.19	1.81	
MARCH	3.25	0.40	0.56	1.26	0.33	3.80	1.30	1.80	0.36	5.36	9.46
APRIL	2.62	0.26	0.06	1.16	1.62	0.07	0.63	2.95	1.32	4.51	2.67
MAY	0.56	1.28	5.61	5.86	0.97	2.41	1.43	2.93	8.04	1.06	2.86
JUNE	7.04	11.93	7.33	10.22	2.86	8.59	1.04	1.04	2.12	11.50	7.73
JULY	4.06	11.14	4.04	5.23	10.33	6.40	3.71	5.82	16.77	5.29	5.63
AUGUST	5.68	13.69	4.60	5.94	11.72	6.11	8.81	7.40	1.84	9.45	8.40
SEPTEMBER	7.38	7.62	11.44	5.11	7.39	4.15	9.62	9.14	0.08	9.62	13.23
OCTOBER	0.73	0.20	5.90	2.17	0.77	0.78	1.17	1.71	1.71	8.48	6.65
NOVEMBER	0.74	1.41	0.38	2.28	1.75	0.31	1.39	4.46	0.94	0.76	5.56
DECEMBER	2.27	2.81	0.85	2.48	3.82	2.79	3.85	0.84		0.79	6.50
TOTAL	43.10	51.72	43.11	43.07	45.74	44.24	40.74	41.67		59.17	

Rainfall Summary, Venice...page2

MONTH	1984	1985	1986	1987	1988	1989	1990*	N	MEAN
JANUARY	1.76	1.33	1.73	2.42	3.22	2.75	0.27	27	2.48
FEBRUARY	2.68	0.93	2.20	1.53	1.73	0.15	3.00	28	2.63
MARCH	6.21	3.64	4.17	11.21	5.80	2.65	1.63	28	2.64
APRIL	5.18	3.24	0.69	0.07	2.29	0.59	0.54	28	2.01
MAY	4.66	0.99	3.32	3.51	0.70	0.06	3.56	27	2.83
JUNE	3.95	2.43	6.14	10.15	1.06	8.50		25	5.78
JULY	12.91	6.31	5.27	11.14	5.04	5.44		24	6.34
AUGUST	3.49	5.52	6.47	8.06	8.78	5.53		28	7.54
SEPTEMBER	3.79	4.84	2.61	3.87	10.12	8.78		26	7.81
OCTOBER	1.26	3.06	7.78	2.49	0.75	1.86		28	2.88
NOVEMBER	1.54	2.57	2.68	2.45	3.47	0.98		28	1.89
DECEMBER	0.44	0.66	5.25	0.18	1.53	4.12		28	2.07
TOTAL	47.87	35.52	48.31	57.08	44.49	41.41			46.88

*=missing data

APPENDIX C

Summary of Physical and Chemical Data from Basin Stations

Dissolved Oxygen (mg/l)

DATE	B110	B120	B130	B140	B150	B160	B170	B180
19890206	6.75	8.39	2.90	5.20	8.10	6.40	12.10	7.69
19890227	9.90	8.80	7.15	9.40	10.40	9.90	11.70	10.20
19890313	9.30	10.40	4.85	7:20	8.35	9.10	8.35	15.40
19890410	7.50	6.35	3.62	7.50	8.40	9.45	11.00	13.60
19890501	9.55	5.10	3.60	5.00	7.10	8.14	9.60	8.75
19890530	3.48		2.45	4.50	6.31	5.30		14.40
19890626	5.11		6.65	4.30	6.60	6.59	6.92	7.60
19890710	2.94	8.15	0.71	0.05	6.83	1.76	7.20	7.40
19890807	4.26	3.83	1.60	0.38	5.39	1.79	5.98	4.25
19890821	4.39	1.64	1.63	2.00	5.77	3.16	4.75	4.83
19890911	4.26	0.24	2.62	1.39	7.01	2.44	6.20	6.20
19891030	5.71	6.06	2.42	4.60	8.20	8.05	7.99	8.98
19891113	7.41	9.25	4.48	6.30	8.23	7.43	7.58	10.90
19891204	10.60	12.80	7.70	9.80	11.80	10.80	10.00	13.60
min	2.94	0.24	0.71	0.05	5.39	1.76	4.75	4.25
max	10.6	12.8	7.7	9.8	11.8	10.8	12.1	15.4

pH

DATE	B110	B120	B130	B140	B150	B160	B170	B180
19890118	7.49	8.57	7.10	6.77	7.23	7.26	8.41	6.96
19890206	6.69	7.35	6.42	7.12	7.58	7.25	8.30	7.10
19890227	6.75	8.13	7.21	7.78	7.67	7.26	8.18	8.07
19890313	6.58	7.81	6.22	6.47	6.60	7.50	7.11	8.77
19890410	6.83	8.88	6.87	7.09	7.46	8.71	7.76	8.64
19890501	6.68	8.19	6.86	7.13	7.13	6.89	7.92	7.98
19890530	6.88		6.65	6.59	7.17	7.26		9.05
19890626	6.36		6.46	6.70	7.04	6.98	7.17	6.97
19890710	6.43	7.11	6.29	6.38	6.97	6.25	6.94	7.03
19890807	6.08	6.33	6.03	5.69	6.63	6.05	6.38	6.77
19890821	7.14	6.71	6.33	6.38	6.93	6.50	6.48	6.83
19890911	6.50	6.58	6.25	6.44	6.76	6.37	6.53	6.91
19891030	6.83	7.28	6.63	6.88	7.30	7.27	7.04	7.10
19891113	7.06	7.40	6.94	7.16	7.57	7.25	7.06	7.65
19891204	7.17	7.61	7.37	7.80	7.50	7.85	7.54	7.58
MIN	6.08	6.33	6.03	5.69	6.60	6.05	6.38	6.77
MAX	7.49	8.88	7.37	7.80	7.67	8.71	8.41	9.05
AVG	6.76	7.53	6.64	6.83	7.17	7.11	7.34	7.56

Conductivity (umhos/cm)

DATE	B110	B120	B130	B140	B150	B160	B170	B180
19890118	440	475	252	210	920	220	770	400
19890206	350	710	300	250	690	228	720	283
19890227	445	490	395	265	780	220	890	421
19890313	269	1080	280	332	550	265	265	610
19890410	610	700	449	370	1020	397	660	1080
19890501	417	600	430	390	1080	439	600	1010
19890530	351	485	435	510	1190	560		1190
19890626	348		392	580	880	502		600
19890710	182	500	197	271	820	334	195	720
19890807	198	650	200	190	421	191	159	310
19890821	198	488	214	196	525	209	128	305
19890911	168	230	179	185	470	157	133	329
19891030	260	484	280	189	620	176	141	460
19891113	279	430	271	201	620	190	176	620
19891204	265	385	260	220	690	199	201	640
min	168	230	179	185	421	157	128	283
max	610	1080	449	580	1190	560	890	1190

Temperature (^oC)

DATE	B110	B120	B130	B140	B150	B160	B170	B180
19890118	19.0	17.9	21.0	18.0	19.2	17.5	21.0	21.0
19890206	21.3	20.2	17.2	23.3	23.0	24.1	23.7	24.5
19890227	13.1	11.5	21.9	17.0	18.0	17.8	18.0	19.0
19890313	18.5	19.0	19.0	20.5	21.2	21.0	22.5	22.5
19890410	22.0	23.0	24.0	25.0	24.0	27.0	31.0	27.5
19890501	23.2	24.5	25.0	26.5	26.0	24.5	31.0	22.2
19890530	27.0		28.0	29.1	26.1	30.0		31.0
19890626	25.1		27.0	28.0	28.0	29.0	27.0	29.0
19890710	28.0	28.9	29.0	31.0	30.5	31.8	32.0	32.0
19890807	28.0	29.5	29.9	31.0	29.5	31.0	32.0	31.5
19890821	27.0	23.0	28.0	29.5	29.0	29.5	30.0	30.0
19890911	27.5	27.9	29.0	29.9	29.0	30.0	31.0	31.0
19891030	22.0	22.0	22.2	22.8	22.5	23.0	23.0	23.0
19891113	21.0	21.0	21.0	21.0	22.0	23.0	23.0	22.5
19891204	14.0	12.0	15.0	17.0	13.5	16.5	16.0	16.0
min	13.1	11.5	15.0	17.0	13.5	16.5	16.0	16.0
max	28.0	29.5	29.9	31.0	30.5	31.8	32.0	32.0

STATION	DEPTH	TIME	DATE	TSS	DNH4N	DNO23N	PART C	PART N	PART P	TURB	DPO4P	DOC
B110	0.20	1100	19890118	0.3	0.037	0.028	0.0962	0.0062	0.002	1.4	0.245	14.9
B110	0.50	1026	19890206	0.8	0.062	0.030	0.1214	0.0126	0.003	1.0	0.168	15.6
B110	0.20	1031	19890227	0.2	0.029	0.015	0.0592	0.0048	0.017	0.7	0.092	15.4
B110	0.20	1009	19890313	1.3	0.012	0.011	0.1016	0.0080	0.004	1.3	0.124	15.1
B110	0.25	1048	19890410	0.6	0.021	0.019	0.1426	0.0112	0.006	0.9	0.123	14.8
B110	0.70	1030	19890501	2.8	0.020	0.010			0.092	1.8	0.120	16.1
B110	0.05	0921	19890530	0.8	0.062	0.005	0.0988	0.0054	0.508	1.3	0.254	13.9
B110	0.80	1016	19890626	4.0	0.059	0.005	0.3388	0.0566	0.167	3.8	0.152	20.4
B110	1.10	1046	19890710	0.9	0.098	0.007	0.0886	0.0072	0.070	0.9	0.431	31.5
B110	0.85	1053	19890807	0.8	0.018	0.019	0.1902	0.0124	0.064	1.6	0.260	26.1
B110	0.90	1042	19890821	1.3	0.028	0.009	0.1866	0.0168	0.030	1.4	0.244	27.1
B110	1.00	1047	19890911	0.7	0.005	0.014	0.1582	0.0068	0.039	1.4	0.296	23.0
B110	0.30	1011	19891030	1.1	0.005	0.021	0.1846	0.0072	0.052	1.4	0.165	17.5
B110	0.25	1023	19891113	0.6	0.023	0.012	0.1098	0.0020	0.067	2.2	0.176	18.4
B110	0.30	1122	19891204	0.6	0.016	0.005	0.1190	0.0052	0.049	1.1	0.100	16.6
MIN	0.05			0.2	0.005	0.005	0.0592	0.0020	0.002	0.7	0.092	13.9
MAX	1.10			4.0	0.098	0.030	0.3388	0.0566	0.508	3.8	0.431	31.5
MEAN	0.51			1.1	0.033	0.014	0.1425	0.0116	0.078	1.5	0.197	19.1

STATION	DEPTH	TIME	DATE	TSS	DNH4N	DNO23N	PART C	PART N	PART P	TURB	DPO4P	DOC
B120	0.10	0955	19890118	0.8	0.019	0.005	0.1464	0.0132	0.009	2.7	0.293	15.8
B120	0.50	0910	19890206	1.6	0.028	0.008	0.2652	0.0306	0.014	3.2	0.217	16.4
B120	0.10	0920	19890227	2.5	0.032	0.007	0.7162	0.0646	0.444	2.4	0.261	17.2
B120	0.10	0913	19890313	0.9	0.005	0.005	0.1512	0.0172	0.012	2.0	0.167	14.2
B120	0.35	1004	19890410	12.1	0.025	0.009	1.9869	0.2460	1.650	9.2	0.353	14.6
B120	0.30	0946	19890501	19.9	0.022	0.005	3.2273	0.5781	2.787	17.4	0.603	18.4
B120	0.10	0948	19890710	15.3	0.043	0.005	5.3606	1.2113	5.773	18.5	0.371	26.4
B120	0.25	0958	19890807	7.0	0.016	0.018	1.4010	0.1304	6.064	15.3	0.440	31.1
B120	0.25	0939	19890821	5.0	0.154	0.009	0.7882	0.0626	3.432	9.6	0.742	34.9
B120	0.75	1004	19890911	8.7	0.034	0.014	1.4985	0.1491	3.760	11.6	1.346	37.9
B120	0.10	0915	19891030	3.9	0.005	0.005	0.6060	0.0674	1.144	7.5	0.195	20.1
B120	0.10	0925	19891113	6.0	0.028	0.005	0.5714	0.0600	0.904	12.7	0.240	19.7
B120	0.10	1027	19891204	5.4	0.010	0.005	0.6150	0.0574	0.894	7.7	0.077	18.2
MIN	0.10			0.8	0.005	0.005	0.1464	0.0132	0.009	2.0	0.077	14.2
MAX	0.75			19.9	0.154	0.018	5.3606	1.2113	6.064	18.5	1.346	37.9
MEAN	0.24			6.9	0.032	0.008	1.3334	0.2068	2.068	9.2	0.408	21.9

STATION	DEPTH	TIME	DATE	TSS	DNH4N	DNO23N	PART C	PART N	PART P	TURB	DPO4P	DOC
B130	0.50	1147	19890118	2.6	0.046	0.014	0.7654	0.0850	0.011	3.5	0.244	18.7
B130	0.50	1102	19890206	1.9	0.070	0.026	0.4144	0.0424	0.009	2.2	0.244	18.3
B130	0.50	1116	19890227	1.7	0.029	0.014	0.3690	0.0342	0.110	1.9	0.142	16.4
B130	0.80	1048	19890313	1.2	0.012	0.013	0.2112	0.0228	0.004	1.1	0.221	14.4
B130	0.80	1130	19890410	1.4	0.029	0.011	0.3528	0.0388	0.144	1.3	0.215	14.2
B130	0.85	1110	19890501	1.8	0.007	0.005	0.4232	0.0620	0.168	1.3	0.227	14.9
B130	0.50	1019	19890530	1.6	0.032	0.005	0.4032	0.0882	0.486	1.4	0.243	15.4
B130	1.00	1107	19890626	1.2	0.082	0.149	0.1830	0.0366	0.189	1.8	0.170	18.4
B130	1.50	1131	19890710	1.8	0.096	0.007	0.3906	0.0426	0.209	3.4	0.472	29.0
B130	0.90	1127	19890807	1.1	0.044	0.024	0.2968		0.149	2.5	0.326	26.6
B130	1.45	1115	19890821	3.8	0.059	0.015	0.4398	0.3524	0.888	3.0	0.253	26.7
B130	1.15	1132	19890911	1.1	0.005	0.012	0.1612	0.0148	0.094	1.9	0.303	26.3
B130	1.00	1052	19891030	1.5	0.005	0.023	0.2212	0.0156	0.087	1.8	0.169	25.8
B130	0.80	1053	19891113	1.8	0.042	0.014	1.2744	0.1046	0.282	1.7	0.184	24.6
B130	1.10	1153	19891204	1.0	0.020	0.005	0.1794	0.0132	0.085	1.2	0.110	23.4
MIN	0.50			1.0	0.005	0.005	0.1612	0.0132	0.004	1.1	0.110	14.2
MAX	1.50			3.8	0.096	0.149	1.2744	0.3524	0.888	3.5	0.472	29.0
MEAN	0.89			1.7	0.039	0.022	0.4057	0.0681	0.194	2.0	0.235	20.9

STATION	DEPTH	TIME	DATE	TSS	DNH4N	DNO23N	PART C	PART N	PART P	TURB	DPO4P	DOC
B140	0.50	1241	19890118	0.3	0.029	0.068	0.4600	0.0502	0.007	1.1	0.365	20.1
B140	0.50	1151	19890206	0.9	0.029	0.025	0.6710	0.0718	0.012	2.1	0.290	18.4
B140	0.50	1230	19890227	0.3	0.016	0.011	0.1384	0.0134	0.043	0.9	0.154	18.4
B140	0.90	1129	19890313	0.5	0.009	0.005	0.3568	0.0474	0.007	0.9	0.163	13.9
B140	0.80	1208	19890410	0.3	0.015	0.007	0.2206	0.0252	0.058	0.6	0.099	14.3
B140	0.85	1150	19890501	0.7	0.017	0.005	0.2358	0.0216	0.096	0.5	0.071	14.9
B140	0.80	1101	19890530	0.6	0.029	0.005	0.2608	0.0490	0.139	0.5	0.071	13.8
B140	0.70	1137	19890626	0.6	0.041	0.005	0.2802	0.0524	0.131	0.9	0.118	15.3
B140	1.25	1207	19890710	2.8	0.111	0.005	1.0376	0.1370	0.808	3.0	0.475	28.4
B140	1.05	1155	19890807	3.4	0.116	0.011	0.2974		0.222	1.4	0.475	28.4
B140	1.50	1148	19890821	1.9	0.099	0.018	0.4662	0.0450	0.208	0.9	0.268	25.2
B140	1.75	1338	19890911	0.9	0.024	0.023	0.2312	0.0218	0.084	1.1	0.275	23.4
B140	1.50	1131	19891030	8.9	0.005	0.014	1.5534	0.2270	0.810	4.4	0.241	22.2
B140	1.40	1131	19891113	2.2	0.032	0.027	0.6172	0.0868	0.243	2.1	0.215	23.4
B140	1.30	1235	19891204	3.2	0.017	0.024	0.8032	0.1072	0.362	2.7	0.108	23.5
MIN	0.50			0.3	0.005	0.005	0.1384	0.0134	0.007	0.5	0.071	13.8
MAX	1.75			8.9	0.116	0.068	1.5534	0.2270	0.810	4.4	0.475	28.4
MEAN	1.02			1.8	0.039	0.017	0.5087	0.0683	0.215	1.5	0.226	20.2

STATION	DEPTH	TIME	DATE	TSS	DNH4N	DNO23N	PART C	PART N	PART P	TURB	DPO4P	DOC
B150	0.50	1309	19890118	0.9	0.088	0.252	0.1490	0.0116	0.010	3.6	0.161	11.8
B150	0.50	1249	19890206	0.9	0.042	0.117	0.1252	0.0106	0.007	3.5	0.137	11.7
B150	0.50	1315	19890227	1.1	0.028	0.805	0.2088	0.0198	0.152	2.8	0.069	12.9
B150	0.85	1207	19890313	2.0	0.038	0.593	1.6162	0.1286	0.013	3.3	0.146	13.6
B150	0.20	1311	19890410	0.9	0.026	0.010	0.3544	0.0304	0.340	1.1	0.105	12.2
B150	0.50	1220	19890501	2.5	0.045	0.013	0.2666	0.0178	0.234	1.2	0.120	10.1
B150	0.20	1137	19890530	2.1	0.043	0.005	0.5100	0.1094	0.515	1.6	0.158	14.8
B150	0.35	1206	19890626	1.5	0.083	0.314	0.1846	0.0398	0.238	2.7	0.335	16.9
B150	0.35	1237	19890710	2.9	0.061	1.419	0.6484	0.0738	0.309	2.5	0.197	20.1
B150	0.40	1225	19890807	1.4	0.036	0.217	0.1724		0.225	2.3	0.385	30.2
B150	0.40	1214	19890821	1.2	0.052	0.740	0.1892	0.0136	0.114	1.5	0.227	19.5
B150	0.30	1405	19890911	5.7	0.010	0.487	0.1236	0.0126	0.096	3.0	0.246	21.4
B150	0.30	1157	19891030	0.8	0.005	0.024	0.2134	0.0058	0.097	1.4	0.153	17.4
B150	0.30	1158	19891113	0.4	0.015	0.005	0.0542	0.0020	0.079	1.2	0.111	13.6
B150	0.45	1302	19891204	1.0	0.013	0.036	0.1880	0.0140	0.147	0.9	0.066	11.9
MIN	0.20			0.4	0.005	0.005	0.0542	0.0020	0.007	0.9	0.066	10.1
MAX	0.85			5.7	0.088	1.419	1.6162	0.1286	0.515	3.6	0.385	30.2
MEAN	0.41			1.7	0.039	0.336	0.3336	0.0350	0.172	2.2	0.174	15.9

STATION	DEPTH	TIME	DATE	TSS	DNH4N	DNO23N	PART C	PART N	PART P	TURB	DPO4P	DOC
B160	0.10	-	19890118	3.3	0.058	0.082	0.6344	0.0520	0.008	3.0	0.349	20.5
B160	0.50	1348	19890206	1.1	0.054	0.057	0.2962	0.0310	0.006	0.9	0.316	18.4
B160	0.50	1431	19890227	0.6	0.044	0.037	0.1884	0.0176	0.060	0.9	0.183	18.3
B160	0.25	1337	19890313	4.3	0.014	0.008	0.5562	0.0448	0.005	1.1	0.146	14.6
B160	0.05	1416	19890410	2.5	0.032	0.015	0.4614	0.0384	0.151	1.1	0.173	12.9
B160	0.10	1326	19890501	5.2	0.009	0.005	1.1482	0.1484	1.784	1.9	0.217	16.4
B160	0.05	1231	19890530	8.7	0.287	0.013	1.5660	1.0218	0.744	3.9	0.372	17.4
B160	0.05	1325	19890626	8.6	0.127	0.027	1.3016	0.2434	0.699	2.2	0.101	15.2
B160	1.00	1409	19890710	4.6	0.055	0.005	2.0051	0.2888	1.136	2.1	0.533	26.1
B160	0.80	1324	19890807	3.5	0.095	0.011	0.2414		0.160	0.9	0.432	25.1
B160	0.70	1317	19890821	2.0	0.083	0.030	0.5016	0.0508	0.152	1.1	0.279	23.4
B160	0.85	1506	19890911	1.3	0.009	0.036	0.2842	0.0222	0.244	1.4	0.249	25.7
B160	0.30	1331	19891030	3.5	0.011	0.017	0.7108	0.0892	0.370	1.7	0.192	21.2
B160	0.20	1258	19891113	3.3	0.042	0.024	0.7312	0.0784	0.325	2.0	0.164	23.8
B160	0.10	1402	19891204	1.6	0.034	0.037	0.6588	0.0858	0.254	1.6	0.110	22.6
MIN	0.05			0.6	0.009	0.005	0.1884	0.0176	0.005	0.9	0.101	12.9
MAX	1.00			8.7	0.287	0.082	2.0051	1.0218	1.784	3.9	0.533	26.1
MEAN	0.37			3.6	0.064	0.027	0.7524	0.1580	0.407	1.7	0.254	20.1

STATION	DEPTH	TIME	DATE	TSS	DNH4N	DNO23N	PART C	PART N	PART P	TURB	DPO4P	DOC
B170	0.05	1648	19890118	0.3	0.005	0.054	0.0412	0.0044	0.002	1.4	0.164	13.1
B170	0.20	1513	19890206	1.4	0.019	0.053	0.0980	0.0072	0.007	2.0	0.169	15.1
B170	0.05	1709	19890227	3.8	0.011	0.009	0.3266	0.0238	1.148	4.3	0.232	14.9
B170	0.05	1525	19890313	1.6	0.019	0.021	0.2648	0.0228	0.026	3.5	0.235	18.6
B170	0.05	1416	19890410	2.0	0.023	0.009	0.2542	0.0232	1.150	3.0	0.232	11.9
B170	0.01	1505	19890501	5.0	0.010	0.005	0.5022	0.0436	2.938	3.6	0.202	12.1
B170	0.10	1504	19890626	5.1	0.101	0.276	1.6392	0.4768	1.826	7.0	0.676	22.1
B170	0.10	1553	19890710	5.8	0.176	0.024	0.8994	0.0788	1.266	5.9	0.622	35.4
B170	0.10	1510	19890807	1.1	0.032	0.032	0.2768		0.328	3.6	0.126	30.1
B170	0.25	2113	19890821	2.2	0.042	0.017	0.3662	0.0296	0.153	3.0	0.042	27.1
B170	0.15	1726	19890911	2.0	0.053	0.021	0.4012	0.0304	0.183	2.9	0.063	25.8
B170	0.05	1530	19891030	1.7	0.055	0.028	0.2874	0.0130	0.268	2.8	0.090	21.0
B170	0.05	1509	19891113	1.1	0.037	0.021	0.2152	0.0124	0.308	3.5	0.182	25.0
B170	0.05	1548	19891204	1.0	0.036	0.017	0.1960	0.0088	0.304	3.7	0.154	23.0
MIN	0.01			0.3	0.005	0.005	0.0412	0.0044	0.002	1.4	0.042	11.9
MAX	0.25			5.8	0.176	0.276	1.6392	0.4768	2.938	7.0	0.676	35.4
MEAN	0.09			2.4	0.044	0.042	0.4120	0.0596	0.708	3.6	0.228	21.1

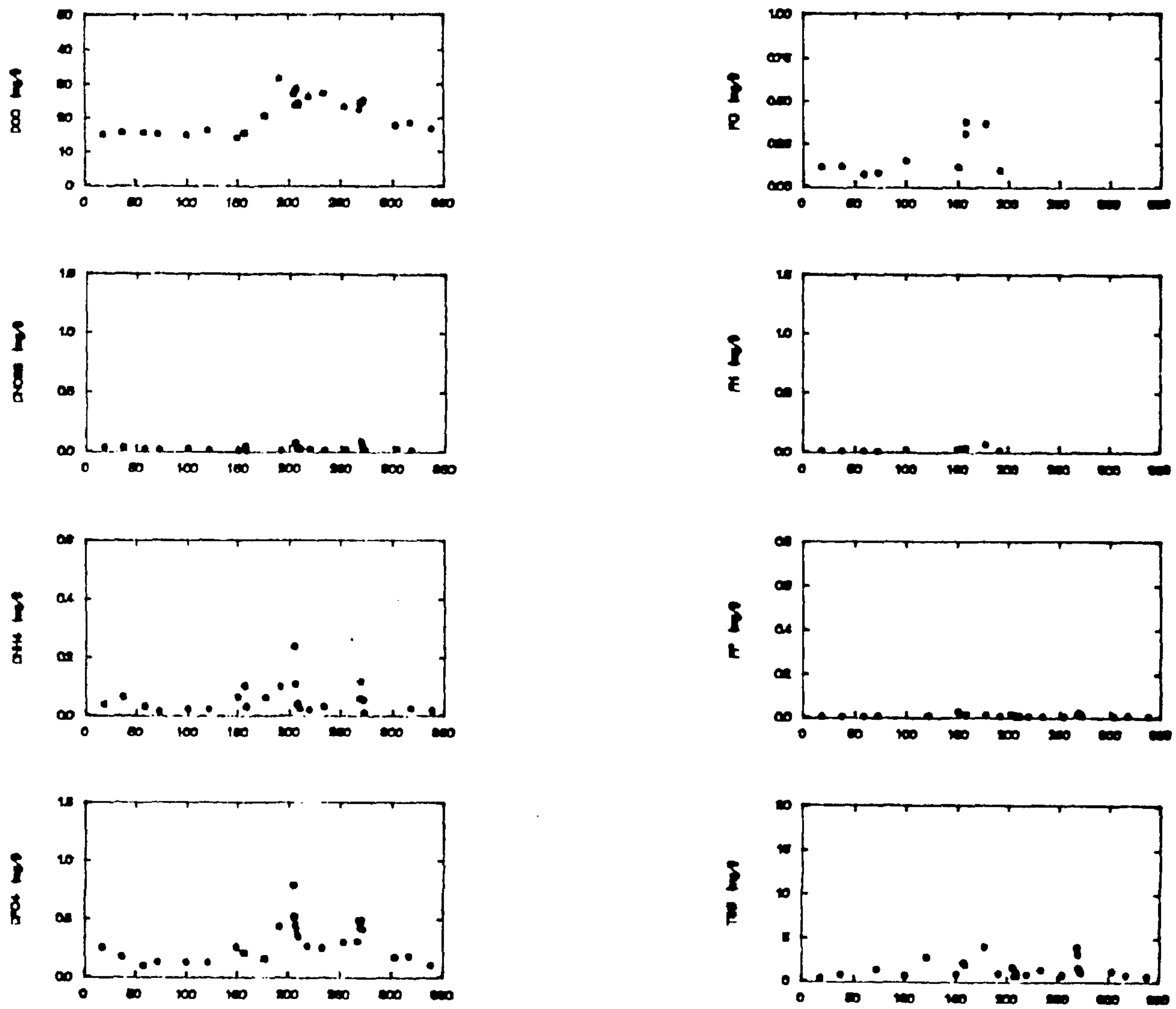
STATION	DEPTH	TIME	DATE	TSS	DNH4N	DNO23N	PART C	PART N	PART P	TURB	DPO4P	DOC
B180	0.05	-	19890118	0.8	0.012	0.048	0.1946	0.0134	0.026	7.7	0.339	15.9
B180	0.10	1540	19890206	1.4	0.060	0.136	0.2564	0.0210	0.021	6.0	0.247	22.8
B180	0.10	1636	19890227	4.8	0.011	0.011	0.0840	0.0048	0.074	1.1	0.063	13.1
B180	0.20	1501	19890313	0.7	0.005	0.282	0.1312	0.0108	0.004	2.0	0.176	14.6
B180	0.20	1553	19890410	1.5	0.015	0.007	0.1138	0.0078	0.102	0.6	0.124	12.4
B180	0.20	1441	19890501	5.0	0.019	0.005	0.1862	0.0140	0.211	0.5	0.201	14.2
B180	0.10	1427	19890530	1.4	0.029	0.005	0.1542	0.0216	0.124	0.5	0.344	14.1
B180	0.35	1441	19890626	1.6	0.073	0.128	0.2252	0.0478	0.204	1.9	0.282	20.9
B180	0.30	1530	19890710	2.2	0.044	0.596	0.4518	0.0520	0.411	2.5	0.262	23.6
B180	0.45	1449	19890807	3.1	0.062	0.115	0.5378		0.630	4.0	0.343	33.5
B180	0.45	2046	19890821	2.8	0.053	0.139	0.5454	0.0320	0.345	3.5	0.158	23.1
B180	0.30	1700	19890911	3.3	0.019	0.255	0.4474	0.0322	0.423	3.0	0.192	25.7
B180	0.15	1506	19891030	1.0	0.019	0.070	0.1022	0.0001	0.116	1.9	0.142	18.5
B180	0.20	1447	2.0e+07	0.3	0.049	0.006	0.0900	0.0048	0.098	0.9	0.131	17.2
B180	0.05	1530	19891204	0.2	0.005	0.005	0.0624	0.0022	0.093	1.1	0.087	16.2
MIN	0.05			0.2	0.005	0.005	0.0624	0.0001	0.004	0.5	0.063	12.4
MAX	0.45			5.0	0.073	0.596	0.5454	0.0520	0.630	7.7	0.344	33.5
MEAN	0.21			2.0	0.032	0.121	0.2388	0.0189	0.192	2.5	0.206	19.1

APPENDIX D

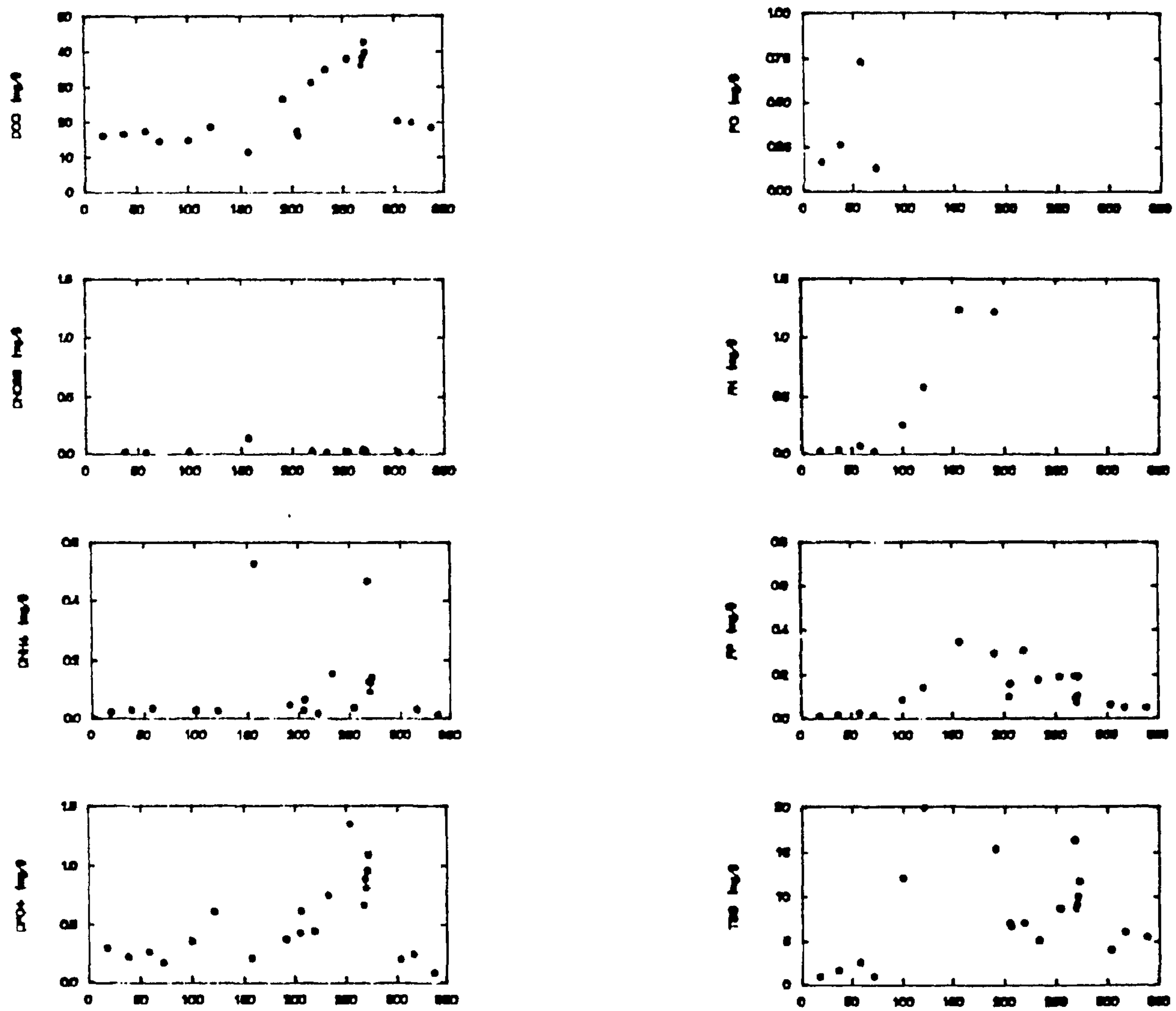
Seasonal Changes in Water Chemistry at Basin Stations

(Day 0-350 given along the abscissa represents 31 December 1988 to 16 December 1989.)

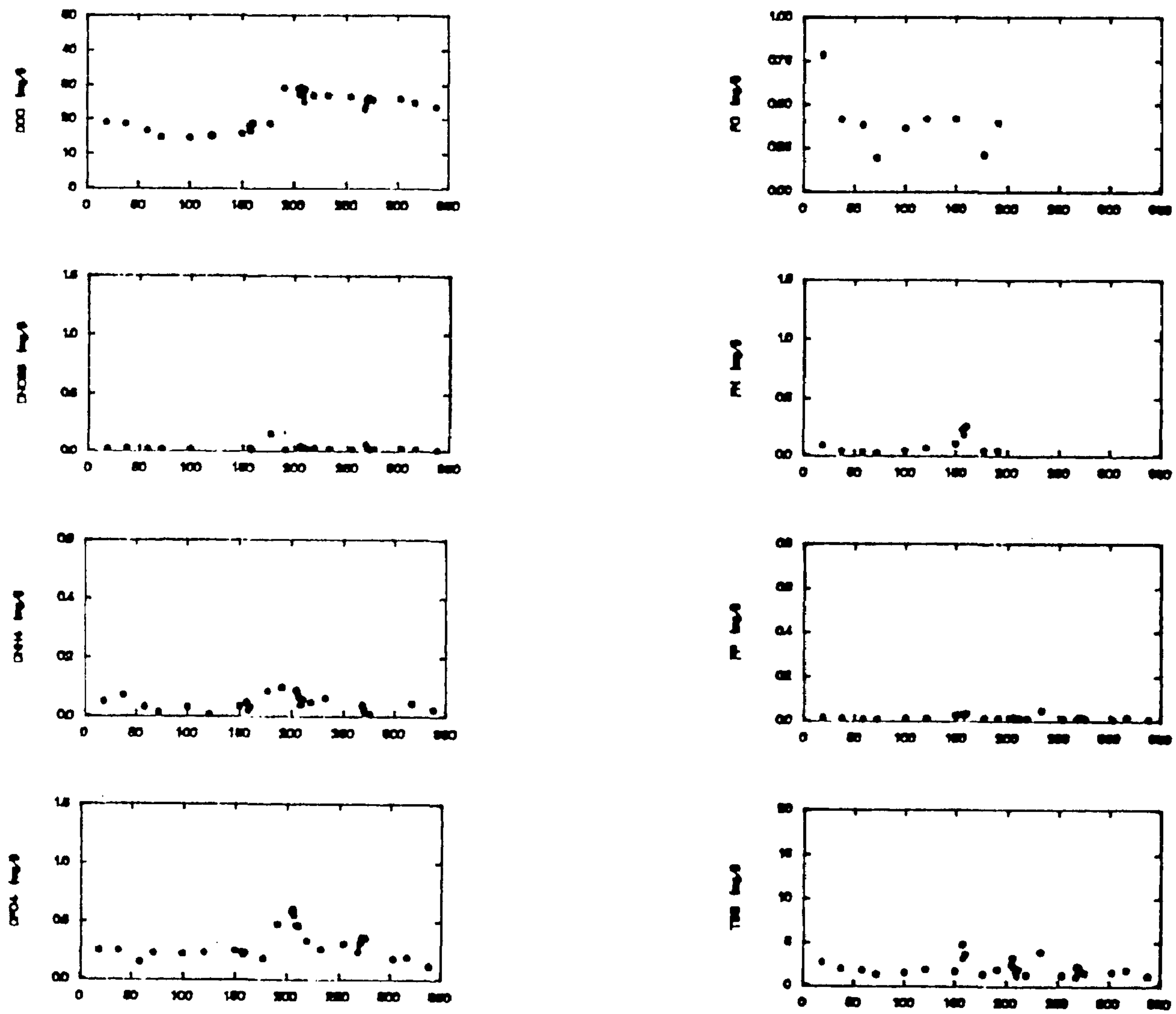
MYAKKA RIVER Station# B110



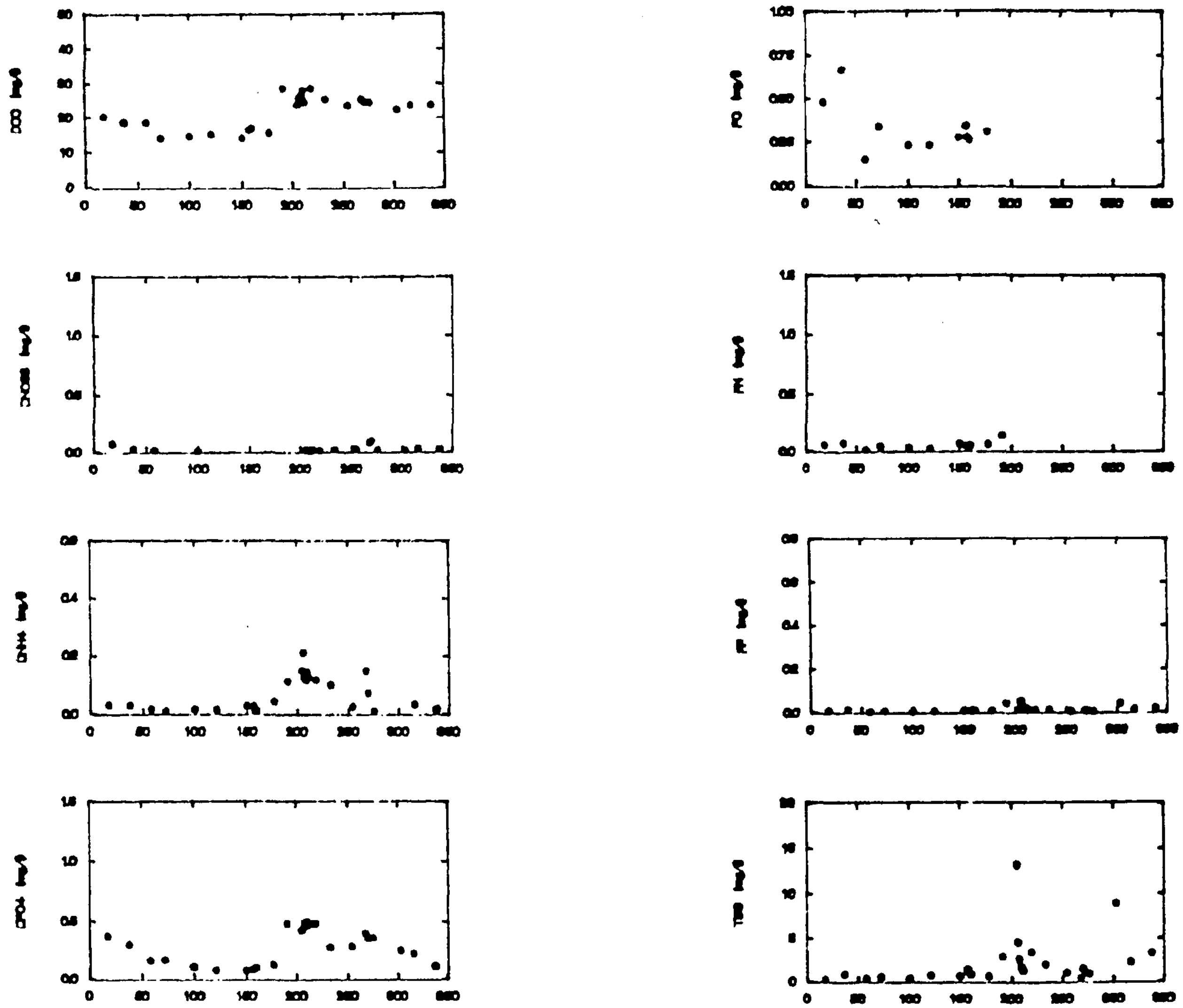
MYAKKA RIVER   Station# B120



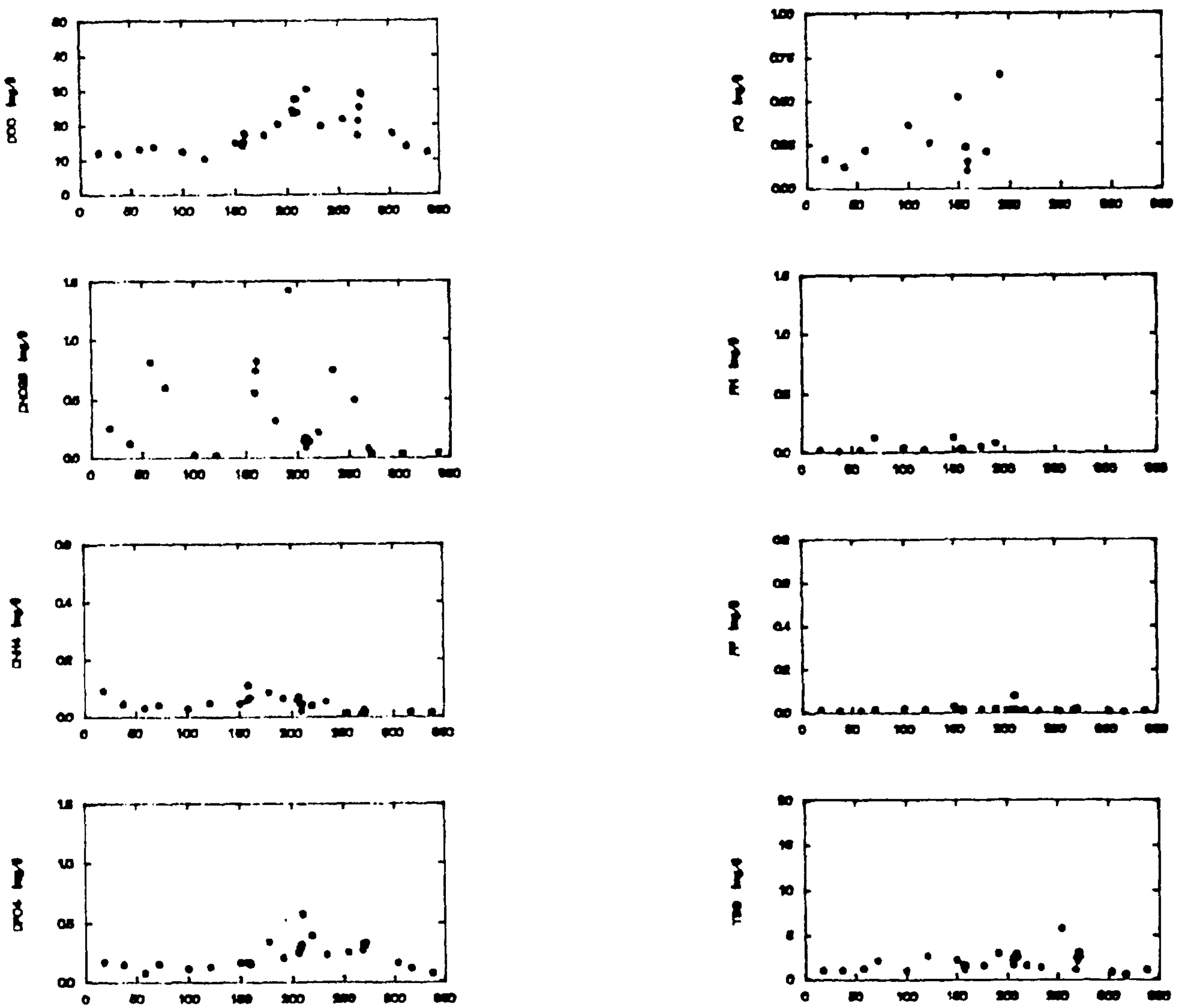
MYAKKA RIVER Station# B130



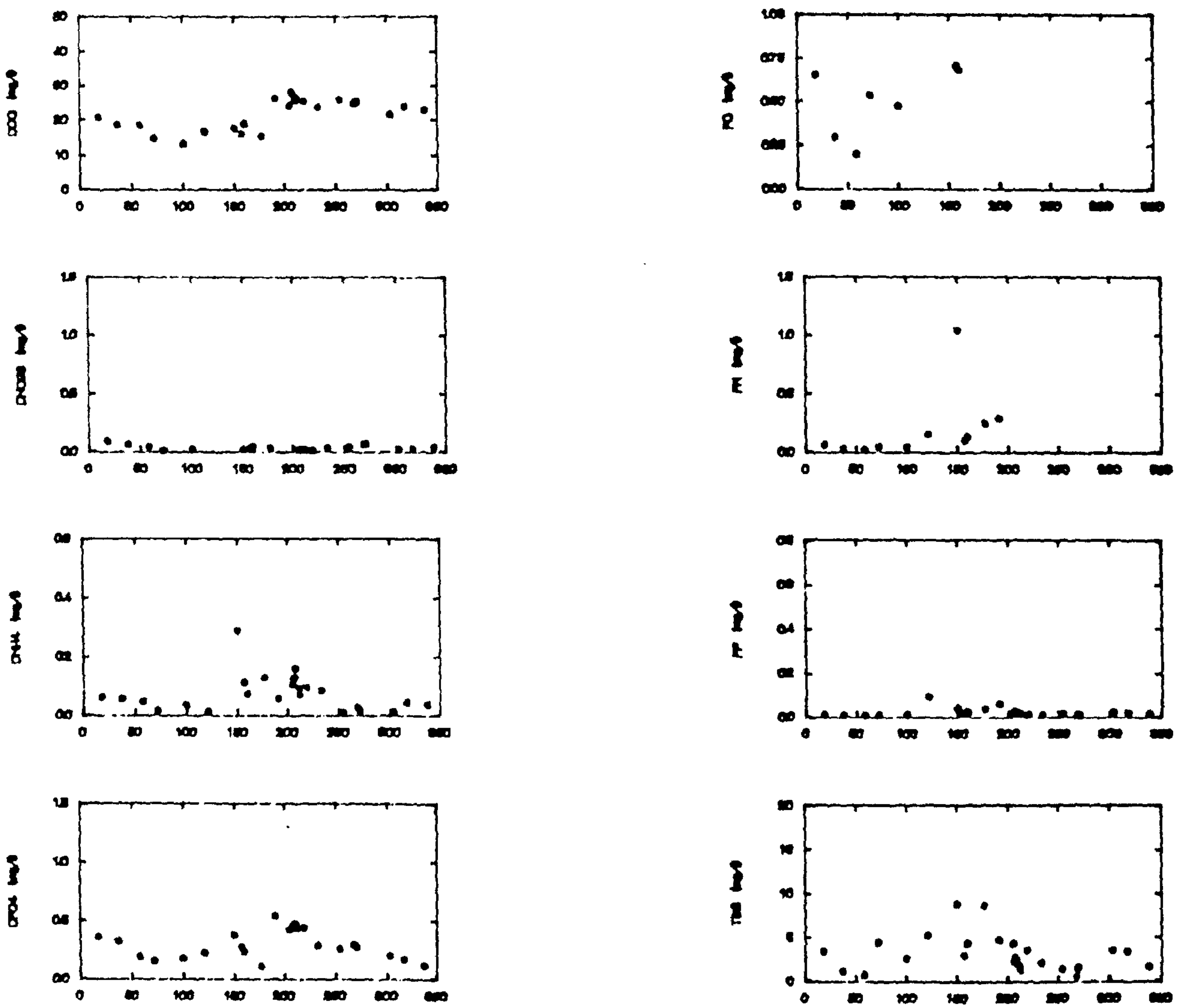
MYAKKA RIVER Station# B140



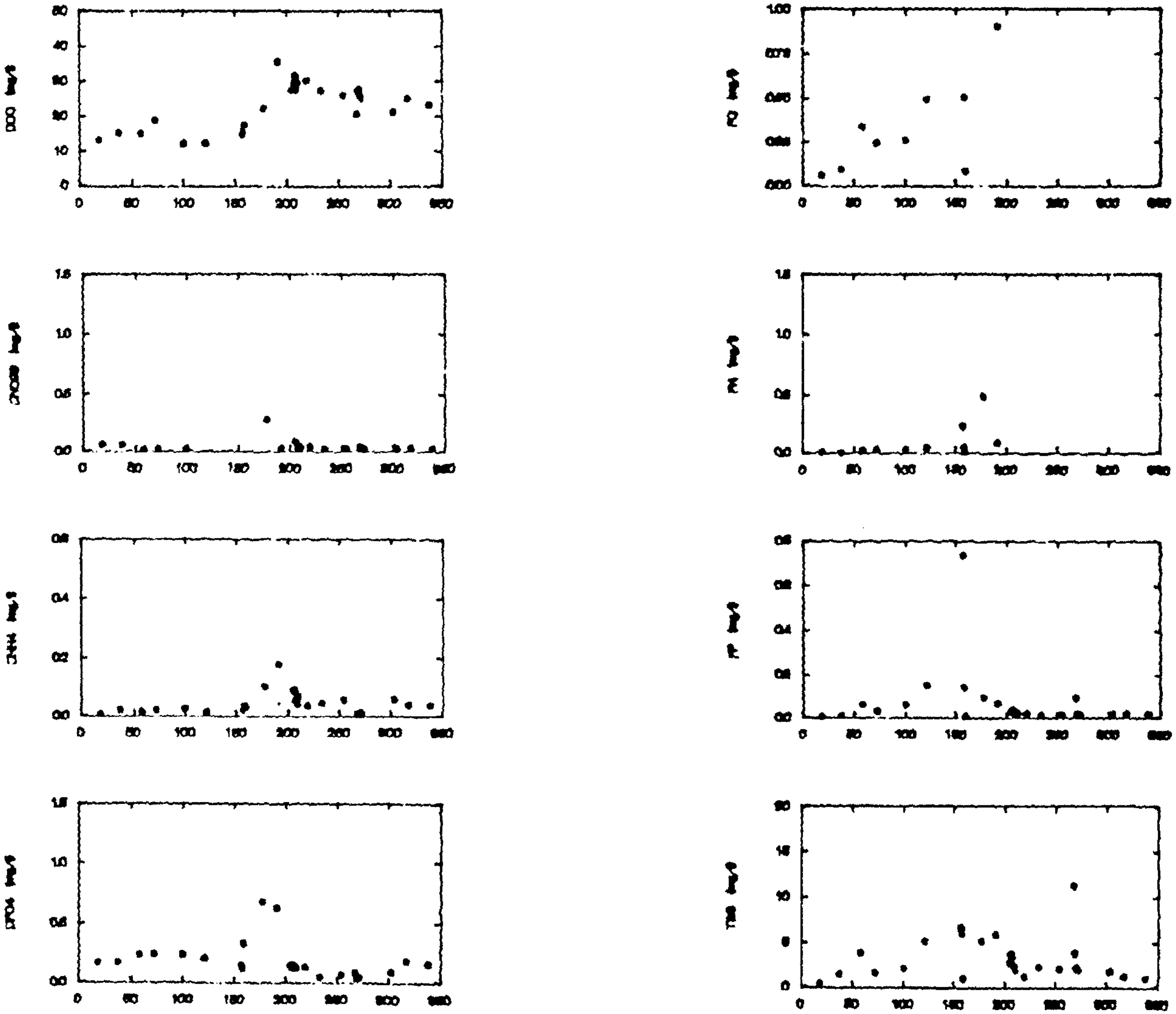
MYAKKA RIVER Station# B150



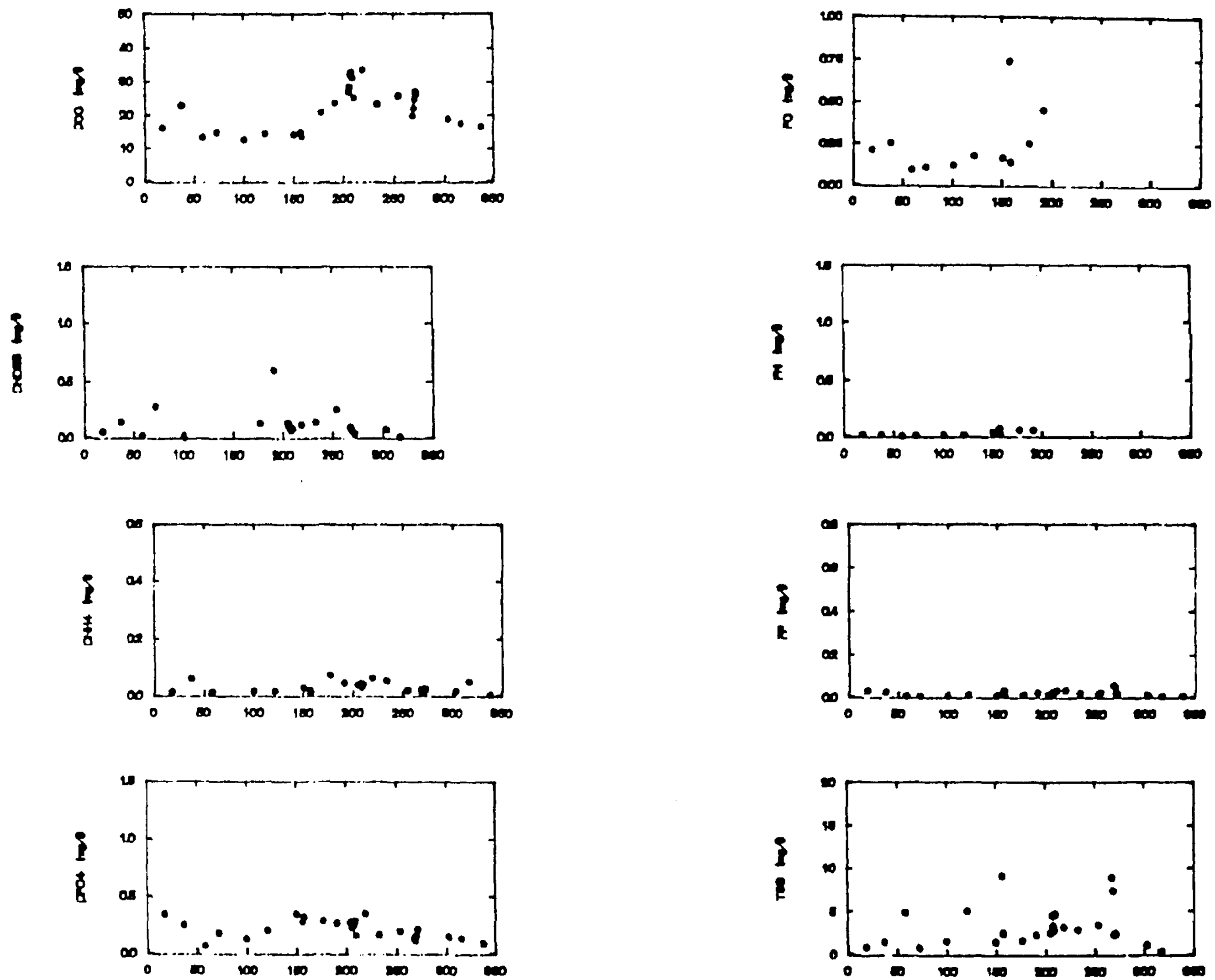
MYAKKA RIVER Station# B160



MYAKKA RIVER Station# B170



MYAKKA RIVER Station# B180



APPENDIX E

Summary of Physical and Chemical Data from Estuary Stations

pH

DATE	E210	E220	E230	E240	E250	E260	E270	E280
19890117	7.90	7.63	7.74	7.70	7.74	7.23	7.44	7.35
19890207	8.03	7.92	7.77	7.74	7.73	7.73	7.80	7.76
19890228	8.03	8.32	8.34	8.23	7.88	7.99	7.90	8.00
19890314	8.08	7.88	7.81	7.73	7.62	7.57	7.33	7.71
19890411	8.01	7.55	7.60	7.50	7.35	7.42	7.45	7.23
19890502	7.86	7.56	7.64	7.55	7.42	7.35	7.47	7.66
19890531	8.04	7.68	7.67	7.63	7.54	7.55	7.48	7.55
19890627	7.88	7.57	7.44	7.30	7.10	6.96	6.90	6.91
19890711	8.63	8.23	8.43	8.22	7.87	7.61	7.44	7.51
19890808	7.82	7.17	7.14	6.89	6.92	7.05	6.96	6.91
19890824	7.56	7.33	7.13	6.82	6.82	6.75	6.63	6.93
19890912	7.71	7.36	7.12	7.00	6.95	6.80	6.70	6.65
19891031	7.43	7.46	7.19	6.99	7.04	7.22	7.23	6.94
19891120	7.50	7.84	7.67	7.73	7.68	7.66	7.75	7.52
19891205	7.81	7.62	7.46	7.72	7.58	7.51	7.70	7.36
MIN	7.43	7.17	7.12	6.82	6.82	6.75	6.63	6.65
MAX	8.63	8.32	8.43	8.23	7.88	7.99	7.90	8.00
AVG	7.89	7.67	7.61	7.52	7.42	7.36	7.35	7.33

STATION	DEPTH	TIME	DATE	TSS	DNH4N	DNO23N	PART C	PART N	PART P	TURB	DPO4P	DOC
E210	1.25	1053	19890117	3.2	0.005	0.007	0.2058	0.0152	0.003	0.7	0.122	5.8
E210	1.20	1114	19890207	6.9	0.021	0.007	0.9230	0.0982	0.035	3.5	0.072	6.5
E210	1.30	1118	19890228	9.8	0.008	0.009	0.6148	0.0546	0.332	2.5	0.066	5.3
E210	1.40	1129	19890314	5.0	0.009	0.005	0.4334	0.0492	0.010	1.4	0.065	4.2
E210	1.30	1133	19890411	7.0	0.009	0.010	0.6386	0.0700	0.485	2.8	0.081	4.4
E210	1.30	0931	19890502	13.6	0.005	0.005	1.3374	0.1758	1.153	6.0	0.077	4.9
E210	1.35	1013	19890531	12.5	0.012	0.005	0.9050	0.2838	0.162	4.8	0.081	4.8
E210	1.50	0926	19890627	7.6	0.005	0.005	0.3144	0.0784	0.292	1.4	0.085	5.1
E210	1.35	1152	19890711	6.2	0.005	0.005	0.5376	0.0702	0.281	1.8	0.170	7.3
E210	1.00	1340	19890808	7.1	0.007	0.005	1.2042		0.542	4.0	0.194	11.1
E210	1.50	0743	19890824	5.0	0.032	0.005	0.4456	0.0516	0.487	1.9	0.178	9.6
E210	1.50	1047	19890912	5.3	0.021	0.005	1.0446	0.0946	0.335	2.3	0.170	9.7
E210	1.15	1032	19891031	3.8	0.025	0.005	0.2884	0.0198	0.181	1.0	0.052	7.5
E210	1.20	1128	19891120	4.2	0.024	0.008	0.3592	0.0392	0.205	1.2	0.043	7.4
E210	1.20	1052	19891205	4.9	0.014	0.005	0.3114	0.0320	0.219	0.7	0.029	5.3
MIN	1.00			3.2	0.005	0.005	0.2058	0.0152	0.003	0.7	0.029	4.2
MAX	1.50			13.6	0.032	0.010	1.3374	0.2838	1.153	6.0	0.194	11.1
MEAN	1.30			6.8	0.013	0.006	0.6376	0.0809	0.315	2.4	0.099	6.6

STATION	DEPTH	TIME	DATE	TSS	DNH4N	DNO23N	PART C	PART N	PART P	TURB	DPO4P	DOC
E220	1.30	1120	19890117	4.3	0.005	0.005	0.5180	0.0502	0.009	1.5	0.136	8.6
E220	1.50	1159	19890207	4.0	0.024	0.007	0.3964	0.0524	0.013	1.4	0.089	8.1
E220	1.55	1155	19890228	7.7	0.005	0.007	0.8862	0.0734	0.267	2.5	0.083	6.0
E220	1.50	1214	19890314	16.1	0.005	0.005	1.5642	0.1672	0.069	7.5	0.073	4.4
E220	1.25	1218	19890411	32.2	0.023	0.010	2.4846	0.2762	2.474	13.2	0.104	6.0
E220	1.20	1012	19890502	6.3	0.032	0.005	0.5358	0.0692	0.458	2.2	0.098	7.1
E220	1.25	1059	19890531	25.8	0.013	0.005	2.5553	0.2949	0.160	10.1	0.080	6.8
E220	1.40	0856	19890627	10.4	0.005	0.005	0.6936	0.1750	0.868	3.6	0.110	6.9
E220	0.70	1228	19890711	9.8	0.005	0.005	1.1854	0.1544	0.846	4.6	0.160	9.1
E220	1.10	1425	19890808	6.4	0.006	0.017	0.8740		0.676	3.5	0.276	14.3
E220	1.20	0816	19890824	8.6	0.016	0.005	0.7868	0.0894	0.626	3.6	0.190	13.2
E220	1.40	1150	19890912	8.2	0.005	0.005	1.8976	0.1724	0.627	4.2	0.191	10.6
E220	1.00	1102	19891031	4.8	0.021	0.005	1.1902	0.0870	0.312	2.5	0.116	12.4
E220	1.15	1208	19891120	2.5	0.058	0.053	0.2362	0.0262	0.165	1.3	0.087	10.2
E220	0.90	1135	19891205	3.3	0.072	0.033	0.2818	0.0352	0.205	1.1	0.053	8.1
MIN	0.70			2.5	0.005	0.005	0.2362	0.0262	0.009	1.1	0.053	4.4
MAX	1.55			32.2	0.072	0.053	2.5553	0.2949	2.474	13.2	0.276	14.3
MEAN	1.23			10.0	0.020	0.011	1.0724	0.1231	0.518	4.2	0.123	8.8

STATION	DEPTH	TIME	DATE	TSS	DNH4N	DNO23N	PART C	PART N	PART P	TURB	DPO4P	DOC
E230	0.80	1200	19890117	4.1	0.005	0.005	0.6706	0.0670	0.010	2.0	0.142	9.6
E230	0.70	1231	19890207	3.5	0.028	0.009	0.3580	0.0476	0.010	1.4	0.102	10.1
E230	1.45	1229	19890228	5.7	0.014	0.009	0.5832	0.0578	0.203	1.6	0.097	8.2
E230	1.00	1240	19890314	5.9	0.007	0.005	0.4738	0.0512	0.013	1.9	0.088	5.4
E230	0.90	1249	19890411	11.5	0.021	0.009	1.0584	0.1142	0.856	4.2	0.117	6.7
E230	0.80	1047	19890502	12.8	0.005	0.005	1.0856	0.1404	0.784	4.1	0.109	8.9
E230	0.90	1124	19890531	18.0	0.009	0.005	1.0894	0.3888	0.236	7.6	0.118	7.3
E230	1.00	1009	19890627	11.7	0.005	0.005	0.9884	0.2644	1.338	5.8	0.117	7.0
E230	0.90	1255	19890711	5.6	0.008	0.005	1.0826	0.1292	0.571	3.5	0.194	11.5
E230	0.50	1458	19890808	3.8	0.087	0.065	0.5300		0.461	3.1	0.336	21.5
E230	1.00	0840	19890824	7.7	0.013	0.005	1.4650	0.1776	0.562	4.2	0.235	13.9
E230	1.00	1213	19890912	10.1	0.007	0.052	1.7728	0.1850	0.930	5.5	0.189	13.6
E230	0.65	1128	19891031	3.7	0.026	0.010	0.6734	0.0670	0.420	2.5	0.133	14.5
E230	0.75	1233	19891120	4.5	0.024	0.065	0.4992	0.0542	0.273	2.3	0.095	12.9
E230	0.60	1159	19891205	4.2	0.017	0.048	0.3742	0.0390	0.259	1.6	0.063	9.9
MIN	0.50			3.5	0.005	0.005	0.3580	0.0390	0.010	1.4	0.063	5.4
MAX	1.45			18.0	0.087	0.065	1.7728	0.3888	1.338	7.6	0.336	21.5
MEAN	0.86			7.5	0.018	0.020	0.8470	0.1274	0.462	3.4	0.142	10.7

STATION	DEPTH	TIME	DATE	TSS	DNH4N	DNO23N	PART C	PART N	PART P	TURB	DPO4P	DOC
E240	0.80	1222	19890117	2.8	0.024	0.013	0.3412	0.0334	0.009	1.3	0.152	11.8
E240	0.80	1303	19890207	4.6	0.034	0.014	0.8264	0.0934	0.020	3.0	0.113	12.8
E240	1.00	1259	19890228	3.9	0.008	0.007	0.4560	0.0562	0.181	1.2	0.114	10.1
E240	1.00	1300	19890314	4.2	0.005	0.005	0.4630	0.0478	0.009	1.5	0.102	8.0
E240	0.90	1325	19890411	6.7	0.014	0.007	0.7524	0.0866	0.558	3.1	0.134	8.2
E240	0.95	1151	19890502	10.9	0.005	0.005	1.2666	0.1408	0.730	3.8	0.126	10.5
E240	1.10	1152	19890531	20.1	0.019	0.005	1.6395	0.6197	0.353	8.9	0.176	8.7
E240	1.10	1034	19890627	10.8	0.005	0.005	1.0744	0.2764	1.149	5.3	0.172	8.8
E240	1.00	1315	19890711	8.8	0.033	0.006	1.6187	0.2208	1.172	5.2	0.349	17.9
E240	0.85	1531	19890808	3.3	0.088	0.077	1.1670	0.0768	0.435	2.8	0.398	22.7
E240	1.00	0935	19890824	4.0	0.066	0.074	0.5516	0.0588	0.443	3.2	0.274	21.1
E240	1.05	1331	19890912	4.0	0.036	0.083	0.5030	0.0606	0.360	3.2	0.202	21.1
E240	0.80	1248	19891031	3.3	0.005	0.037	0.6434	0.0882	0.415	2.5	0.175	19.2
E240	0.80	1253	19891120	5.6	0.014	0.019	0.7010	0.0734	0.392	3.0	0.107	16.5
E240	0.75	1222	19891205	3.5	0.017	0.010	0.5328	0.0556	0.245	2.2	0.071	11.3
MIN	0.75			2.8	0.005	0.005	0.3412	0.0334	0.009	1.2	0.071	8.0
MAX	1.10			20.1	0.088	0.083	1.6395	0.6197	1.172	8.9	0.398	22.7
MEAN	0.93			6.4	0.025	0.024	0.8358	0.1326	0.431	3.3	0.178	13.9

STATION	DEPTH	TIME	DATE	TSS	DNH4N	DNO23N	PART C	PART N	PART P	TURB	DPO4P	DOC
E250	0.80	1308	19890117	5.8	0.005	0.009	1.0014	0.1106	0.026	3.5	0.157	12.6
E250	0.70	1329	19890207	4.8	0.018	0.009	0.9438	0.5358	0.018	3.5	0.130	14.7
E250	0.95	1324	19890228	2.8	0.014	0.010	0.2912	0.0430	0.138	1.2	0.123	10.9
E250	1.00	1338	19890314	3.4	0.007	0.005	0.5692	0.0560	0.010	2.0	0.107	10.9
E250	0.95	1357	19890411	5.8	0.015	0.009	0.5592	0.0592	0.421	2.9	0.141	8.8
E250	0.95	1216	19890502	8.8	0.005	0.005	1.3108	0.1534	0.720	4.0	0.124	10.4
E250	1.05	1220	19890531	15.9	0.022	0.005	1.3279	0.5075	0.370	7.4	0.185	9.9
E250	1.15	1057	19890627	13.9	0.005	0.005	0.9792	0.2584	0.885	4.0	0.190	9.9
E250	0.80	1415	19890711	7.0	0.112	0.025	1.2926	0.1512	0.832	3.8	0.556	22.7
E250	0.85	1550	19890808	3.2	0.074	0.071	0.5048	0.0516	0.297	2.1	0.415	26.0
E250	1.05	0953	19890824	3.2	0.064	0.081	0.4430	0.0438	0.321	2.8	0.258	22.5
E250	1.15	1350	19890912	2.3	0.036	0.076	0.4078	0.0410	0.277	2.3	0.202	23.2
E250	0.75	1308	19891031	2.0	0.007	0.067	0.5212	0.0556	0.314	1.9	0.198	21.1
E250	0.80	1317	19891120	5.5	0.008	0.005	0.9680	0.1074	0.460	3.2	0.111	17.0
E250	0.75	1240	19891205	3.2	0.015	0.007	0.5446	0.6672	0.294	2.8	0.086	14.1
MIN	0.70			2.0	0.005	0.005	0.2912	0.0410	0.010	1.2	0.086	8.8
MAX	1.15			15.9	0.112	0.081	1.3279	0.6672	0.885	7.4	0.556	26.0
MEAN	0.91			5.8	0.027	0.026	0.7776	0.1894	0.359	3.2	0.199	15.6

STATION	DEPTH	TIME	DATE	TSS	DNH4N	DNO23N	PART C	PART N	PART P	TURB	DPO4P	DOC
E260	1.00	1400	19890117	6.5	0.005	0.005	1.7278	0.1914	0.036	4.9	0.221	16.5
E260	0.80	1614	19890207	5.8	0.027	0.006	1.2336	0.1266	0.030	4.4	0.156	16.4
E260	1.05	1423	19890228	2.0	0.017	0.007	0.5278	0.0510	0.168	1.9	0.149	12.1
E260	1.20	1356	19890314	4.2	0.005	0.005	0.6184	0.0584	0.013	2.5	0.128	10.9
E260	1.10	1508	19890411	5.2	0.010	0.008	0.8154	0.0836	0.416	3.0	0.146	10.8
E260	1.20	1258	19890502	7.8	0.005	0.005	1.4710	0.1706	0.728	4.2	0.139	10.4
E260	1.25	1259	19890531	11.1	0.020	0.005	1.4560	0.5424	0.344	5.8	0.172	8.9
E260	1.30	1212	19890627	6.2	0.005	0.005	0.7510	0.2140	0.689	3.1	0.192	9.1
E260	1.00	1523	19890711	4.8	0.074	0.021	1.5034	0.1850	0.801	3.4	0.550	26.0
E260	0.95	1749	19890808	2.8	0.077	0.063	0.4840	0.0510	0.290	2.0	0.418	24.7
E260	1.25	1026	19890824	2.6	0.062	0.072	0.4012	0.0408	0.246	2.0	0.256	23.6
E260	1.25	1426	19890912	1.3	0.026	0.050	0.2900	0.0304	0.198	1.5	0.211	24.6
E260	0.95	1337	19891031	1.8	0.029	0.091	0.4238	0.0420	0.257	1.7	0.216	21.1
E260	0.90	1412	19891120	3.8	0.011	0.010	0.8878	0.1002	0.380	2.7	0.153	21.7
E260	0.95	1919	19891205	3.0	0.009	0.048	0.6096	0.0348	0.284	2.5	0.113	16.4
MIN	0.80			1.3	0.005	0.005	0.2900	0.0304	0.013	1.5	0.113	8.9
MAX	1.30			11.1	0.077	0.091	1.7278	0.5424	0.801	5.8	0.550	26.0
MEAN	1.08			4.6	0.025	0.027	0.8801	0.1281	0.325	3.0	0.215	16.9

STATION	DEPTH	TIME	DATE	TSS	DNH4N	DNO23N	PART C	PART N	PART P	TURB	DPO4P	DOC
E270	1.00	1418	19890117	6.7	0.005	0.005	1.8278	0.1722	0.034	4.8	0.290	19.5
E270	1.10	1550	19890207	6.0	0.019	0.007	1.4898	0.1362	0.033	4.2	0.245	21.9
E270	1.30	1510	19890228	3.2	0.012	0.007	0.7132	0.0634	0.290	2.7	0.195	16.4
E270	0.90	1414	19890314	4.7	0.005	0.005	0.8632	0.0820	0.022	3.2	0.169	14.2
E270	1.10	1537	19890411	5.3	0.012	0.007	0.9374	0.0866	0.435	3.5	0.174	12.1
E270	1.20	1321	19890502	8.0	0.005	0.005	1.3678	0.1472	0.626	3.3	0.152	11.6
E270	1.25	1321	19890531	8.1	0.010	0.005	1.5080	0.5514	0.721	4.3	0.168	9.4
E270	1.40	1233	19890627	6.7	0.005	0.005	0.6424	0.1750	0.563	2.7	0.179	10.3
E270	1.10	1552	19890711	5.7	0.089	0.021	1.2478	0.1532	0.745	2.9	0.554	24.4
E270	1.10	1805	19890808	1.9	0.071	0.061	0.5712	0.0544	0.306	1.9	0.425	23.6
E270	1.25	1050	19890824	1.1	0.078	0.076	0.2924	0.0264	0.470	1.3	0.254	24.4
E270	1.50	1444	19890912	0.8	0.013	0.050	0.1684	0.0206	0.144	1.1	0.221	25.5
E270	1.00	1356	19891031	1.9	0.009	0.091	0.5584	0.0542	0.336	1.7	0.241	23.9
E270	1.05	1430	19891120	2.7	0.025	0.062	0.6314	0.0592	0.270	2.1	0.176	22.4
E270	1.10	1400	19891205	2.5	0.025	0.108	0.4436	0.0284	0.216	1.8	0.149	19.3
MIN	0.90			0.8	0.005	0.005	0.1684	0.0206	0.022	1.1	0.149	9.4
MAX	1.50			8.1	0.089	0.108	1.8278	0.5514	0.745	4.8	0.554	25.5
MEAN	1.16			4.4	0.026	0.034	0.8842	0.1207	0.347	2.8	0.239	18.6

STATION	DEPTH	TIME	DATE	TSS	DNH4N	DNO23N	PART C	PART N	PART P	TURB	DPO4P	DOC
E280	1.75	1455	19890117	5.1	0.005	0.009	1.1110	0.1228	0.026	3.0	0.322	20.6
E280	1.70	1521	19890207	8.0	0.026	0.009	1.6230	0.1472	0.036	3.8	0.276	21.4
E280	1.55	1549	19890228	3.4	0.017	0.007	0.8986	0.0892	0.399	2.5	0.269	19.1
E280	1.75	1434	19890314	5.6	0.005	0.005	1.3356	0.1166	0.036	3.0	0.180	17.9
E280	1.80	1616	19890411	5.2	0.019	0.007	1.0186	0.0958	0.551	3.7	0.228	15.9
E280	1.55	1347	19890502	8.7	0.005	0.005	1.8830	0.2100	0.784	4.3	0.164	14.9
E280	2.20	1359	19890531	7.8	0.030	0.005	1.5120	0.5636	0.359	4.0	0.179	10.2
E280	2.00	1256	19890627	7.2	0.005	0.005	1.1868	0.3156	0.856	3.9	0.178	11.6
E280	1.50	1611	19890711	7.3	0.093	0.015	1.6382	0.1870	1.038	3.4	0.560	25.4
E280	1.40	1823	19890808	3.5	0.072	0.058	0.6734	0.0616	0.415	2.3	0.420	21.8
E280	2.00	1111	19890824	1.1	0.064	0.069	0.3208	0.0280	0.113	1.2	0.268	24.6
E280	1.75	1506	19890912	0.9	0.015	0.048	0.1366	0.0208	0.115	1.1	0.225	23.0
E280	1.25	1418	19891031	2.0	0.033	0.085	0.3784	0.0266	0.249	1.6	0.215	22.3
E280	1.75	1452	19891120	2.0	0.037	0.116	0.5076	0.0472	0.236	1.9	0.174	22.4
E280	1.80	1425	19891205	2.0	0.051	0.107	0.3052	0.0186	0.161	1.5	0.151	20.8
MIN	1.25			0.9	0.005	0.005	0.1366	0.0186	0.026	1.1	0.151	10.2
MAX	2.20			8.7	0.093	0.116	1.8830	0.5636	1.038	4.3	0.560	25.4
MEAN	1.72			4.7	0.032	0.037	0.9686	0.1367	0.358	2.7	0.254	19.5

STATION	DEPTH	TIME	DATE	TSS	DNH4N	DNO23N	PART C	PART N	PART P	TURB	DPO4P	DOC
E215	0.50	1116	19890912	8.4	0.009	0.005	1.4096	0.1302	0.447	5.0	0.173	10.1
E215	1.50	1127	19890912	9.1	0.005	0.005	1.7424	0.1490	0.598	4.7	0.171	8.8
E232	0.50	1349	19890711	6.7	0.011	0.005	1.5570	0.1812	0.781	4.0	0.221	13.4
E232	0.40	1645	19890808	2.9	0.102	0.076	0.5396	0.0694	0.405	3.0	0.353	23.7
E232	1.00	1230	19890912	4.9	0.046	0.083	0.6558	0.0830	0.522	3.5	0.189	15.7
E232	0.65	1153	19891031	5.5	0.042	0.026	0.7916	0.0812	0.514	3.4	0.161	16.1
E234	0.80	1707	19890808	2.5	0.083	0.081	0.4600	0.0542	0.387	2.9	0.363	22.2
E234	1.10	1254	19890912	4.0	0.043	0.085	0.5554	0.1016	0.450	3.2	0.200	18.9
E235	0.70	1235	19890117	3.4	0.005	0.005	0.3918	0.0376	0.009	1.5	0.143	9.6
E235	0.85	0901	19890824	6.0	0.043	0.036	0.7202	0.0780	0.583	3.5	0.255	16.9
E238	1.00	0921	19890824	4.5	0.053	0.061	0.5032	0.0530	0.397	3.1	0.266	17.8
E238	0.70	1208	19891031	4.5	0.009	0.033	0.7920	0.0968	0.555	3.3	0.179	18.5
E255	1.10	1635	19890711	5.7	0.083	0.021	1.4630	0.1782	0.823	3.5	0.564	25.0
E255	1.10	1337	19891120	4.8	0.014	0.005	0.9134	0.1086	0.401	2.7	0.129	18.9
E255	1.05	1300	19891205	3.5	0.013	0.019	0.7014	0.0696	0.302	2.6	0.097	15.9

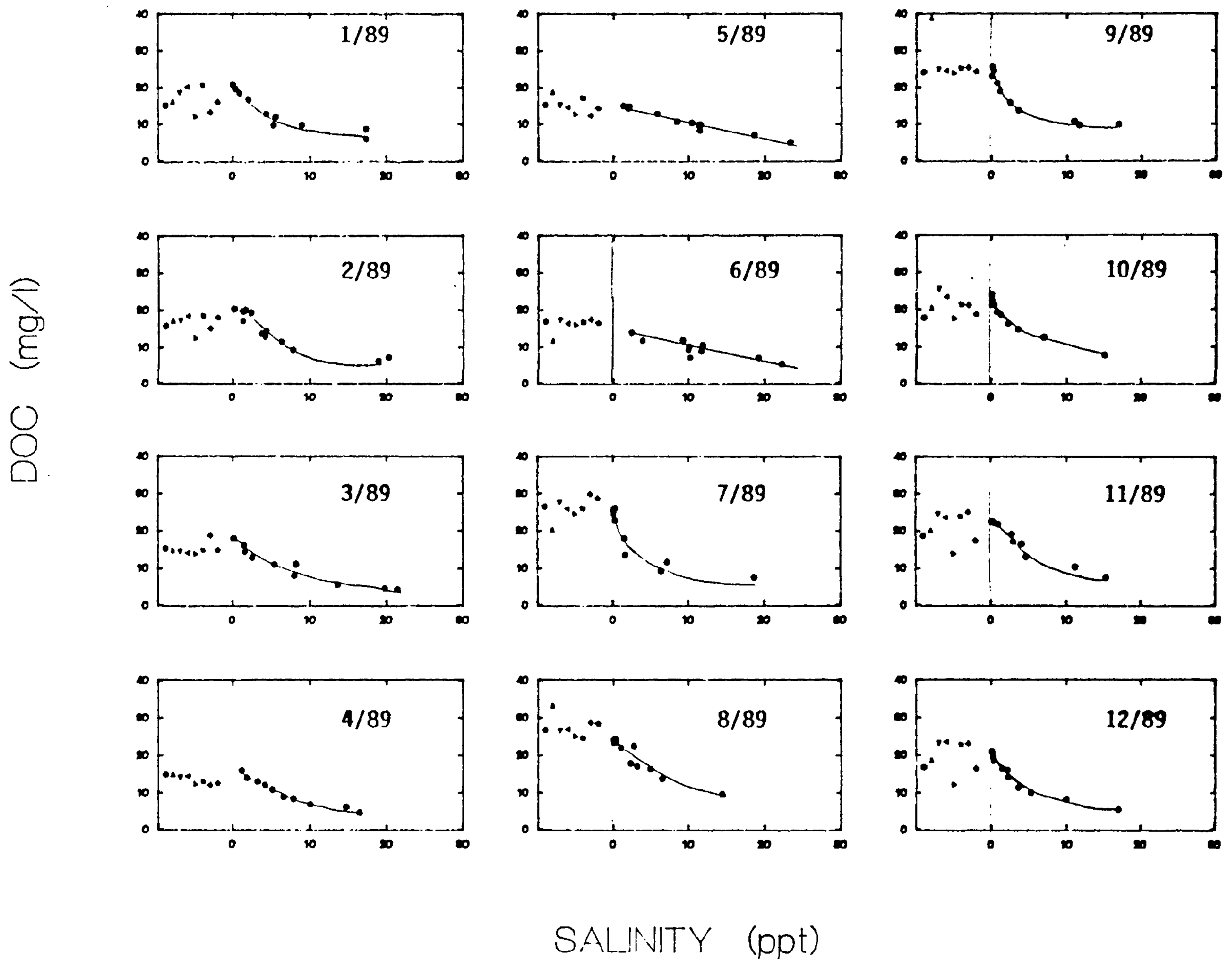
STATION	DEPTH	TIME	DATE	TSS	DNH4N	DNO23N	PART C	PART N	PART P	TURB	DPO4P	DOC
E264	0.80	1641	19890207	7.0	0.038	0.009	1.5242	0.1440	0.030	4.6	0.190	19.6
E265	0.60	1526	19890117	8.9	0.005	0.005	2.1282	0.2180	0.042	5.5	0.248	18.3
E265	0.70	1640	19890228	4.2	0.011	0.006	0.8906	0.0840	0.263	2.7	0.164	13.6
E265	0.90	1525	19890314	4.2	0.025	0.005	0.6998	0.0738	0.016	2.9	0.154	12.7
E265	0.80	1523	19891120	3.4	0.015	0.050	0.4148	0.0422	0.311	2.3	0.173	22.1
E265	0.75	1504	19891205	3.2	0.019	0.087	0.3742	0.0610	0.339	2.2	0.134	18.4
E268	1.80	1656	19890207	6.5	0.057	0.007	1.3228	0.1258	0.030	4.2	0.213	20.0
E274	1.35	1726	19890411	5.8	0.012	0.008	1.1964	0.1104	0.517	3.6	0.176	12.9
E275	0.80	1616	19890228	3.5	0.014	0.007	0.9264	0.0850	0.372	2.8	0.221	16.9
E275	1.55	1501	19890314	5.0	0.015	0.005	0.9918	0.0864	0.028	3.4	0.177	16.0
E275	1.20	1537	19890502	8.2	0.009	0.005	1.5724	0.1500	0.640	3.5	0.161	14.7
E276	1.60	1649	19890411	5.0	0.024	0.007	1.1604	0.1042	0.521	3.3	0.203	13.9
E290	1.10	1511	19890502	7.9	0.009	0.005	1.8658	0.2068	0.718	4.3	0.163	14.9
E290	1.20	1425	19890531	5.9	0.013	0.005	0.8444	0.3026	0.402	3.7	0.201	13.4
E290	1.25	1403	19890627	7.7	0.005	0.005	1.2972	0.3586	0.936	5.2	0.181	11.6
E300	1.10	1448	19890531	4.2	0.012	0.005	0.6516	0.2286	0.453	3.0	0.227	14.8
E300	1.20	1226	19890627	7.8	0.005	0.005	1.2770	0.3578	1.090	5.2	0.194	13.8

APPENDIX F

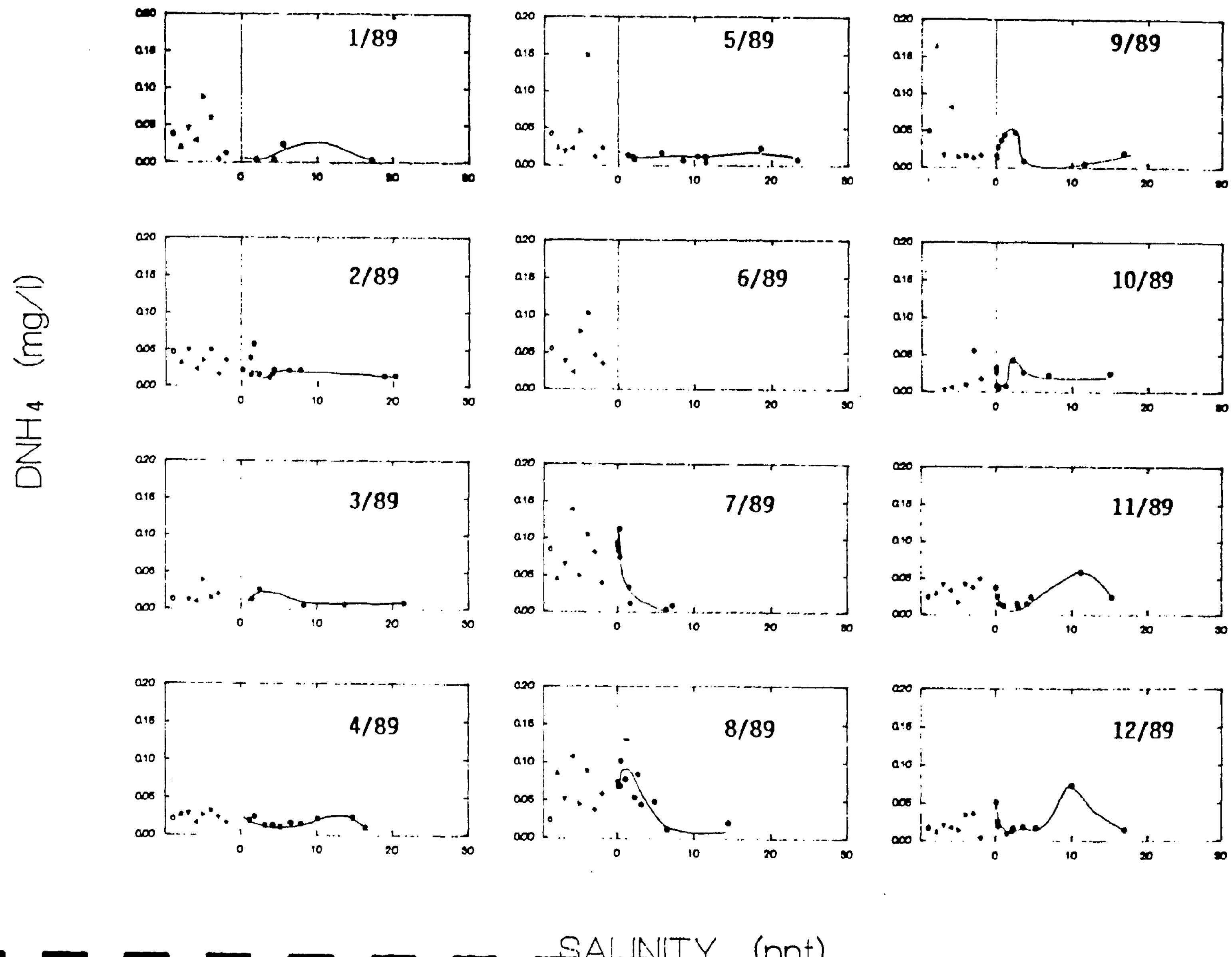
Monthly Distributions of Nutrient Concentrations at Estuary Stations

(Concentrations of nutrients in samples collected from the eight freshwater stations are indicated on the graphs left of zero salinity.)

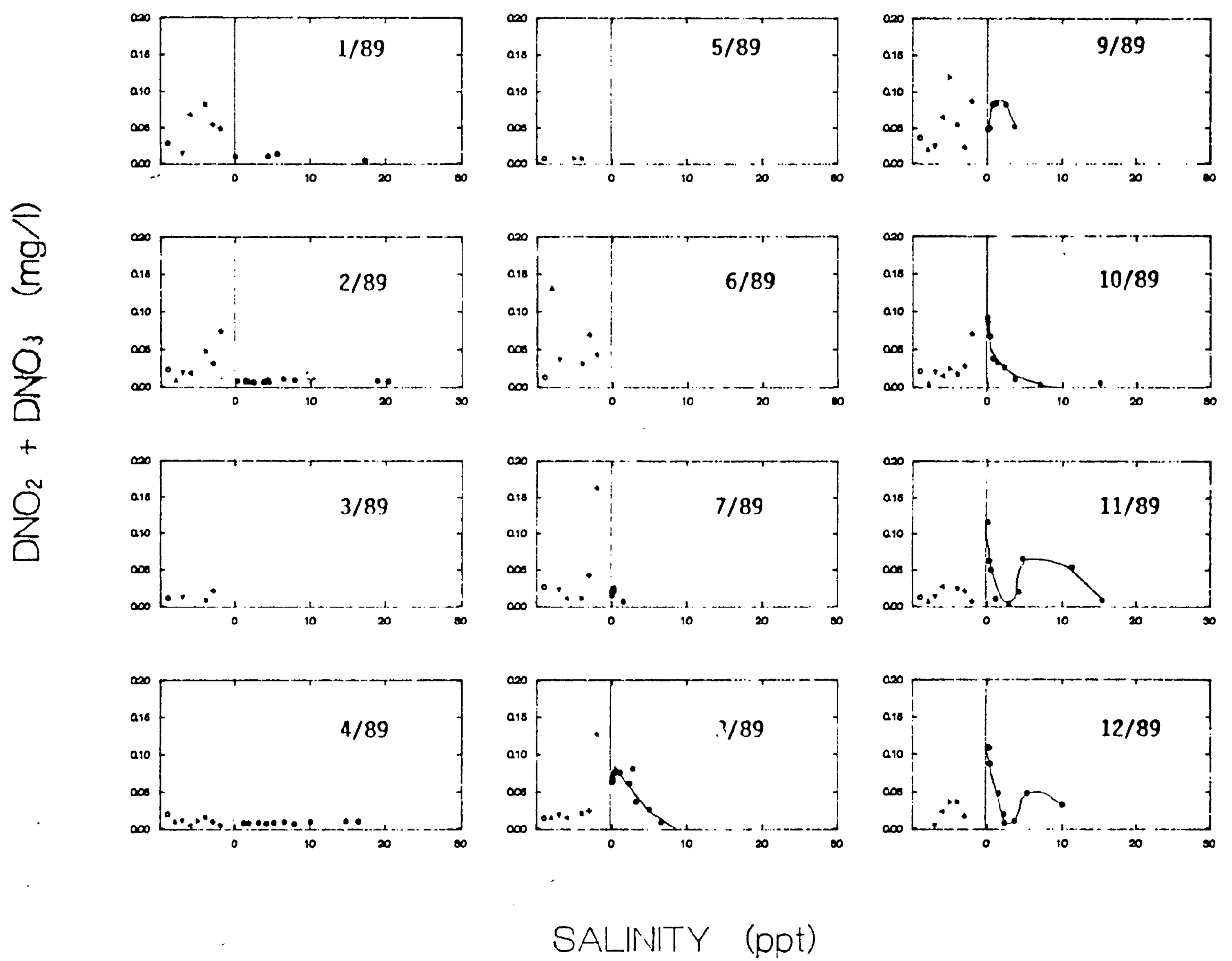
MYAKKA RIVER - ESTUARY TRANSECT



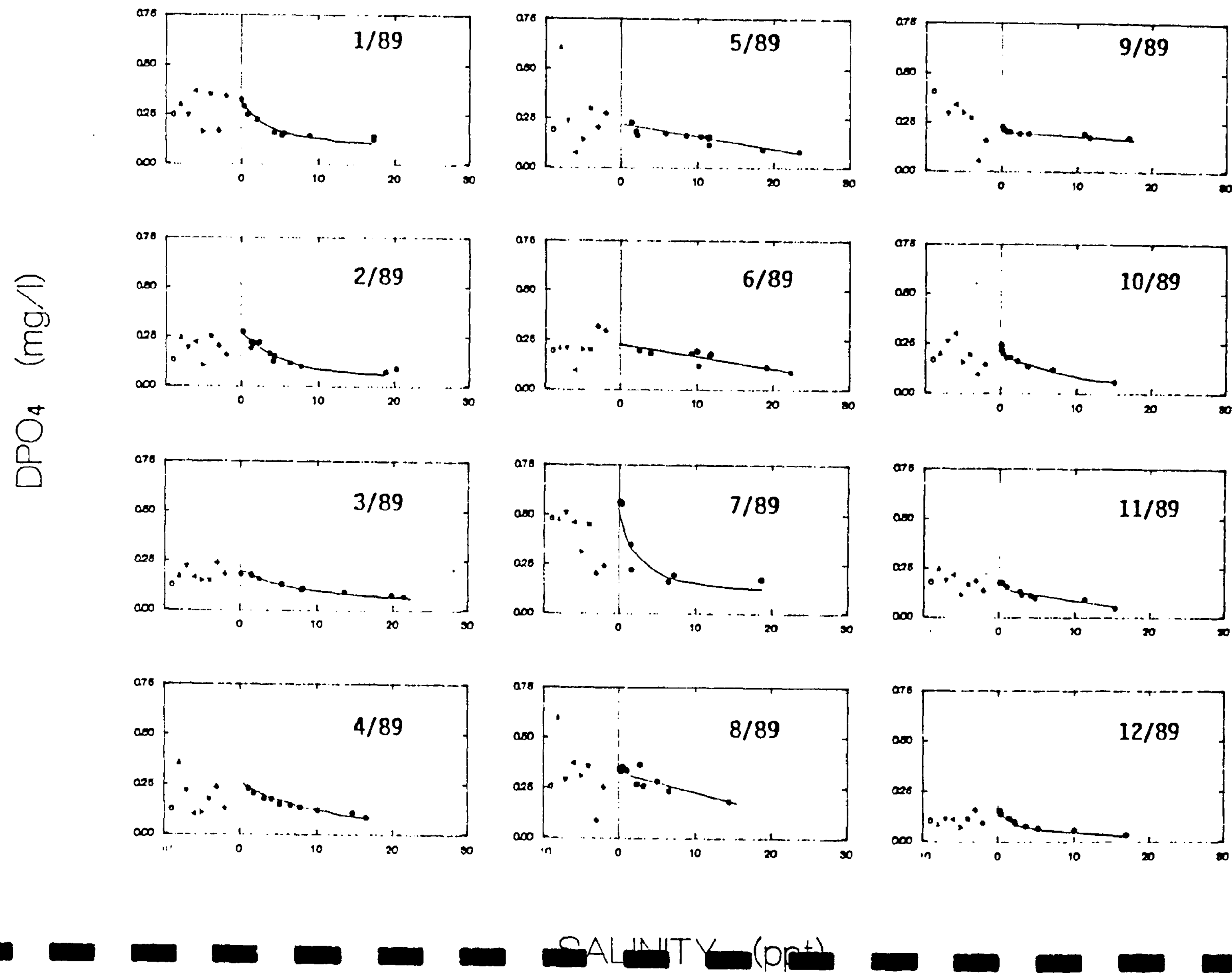
MYAKKA RIVER - ESTUARY TRANSECT



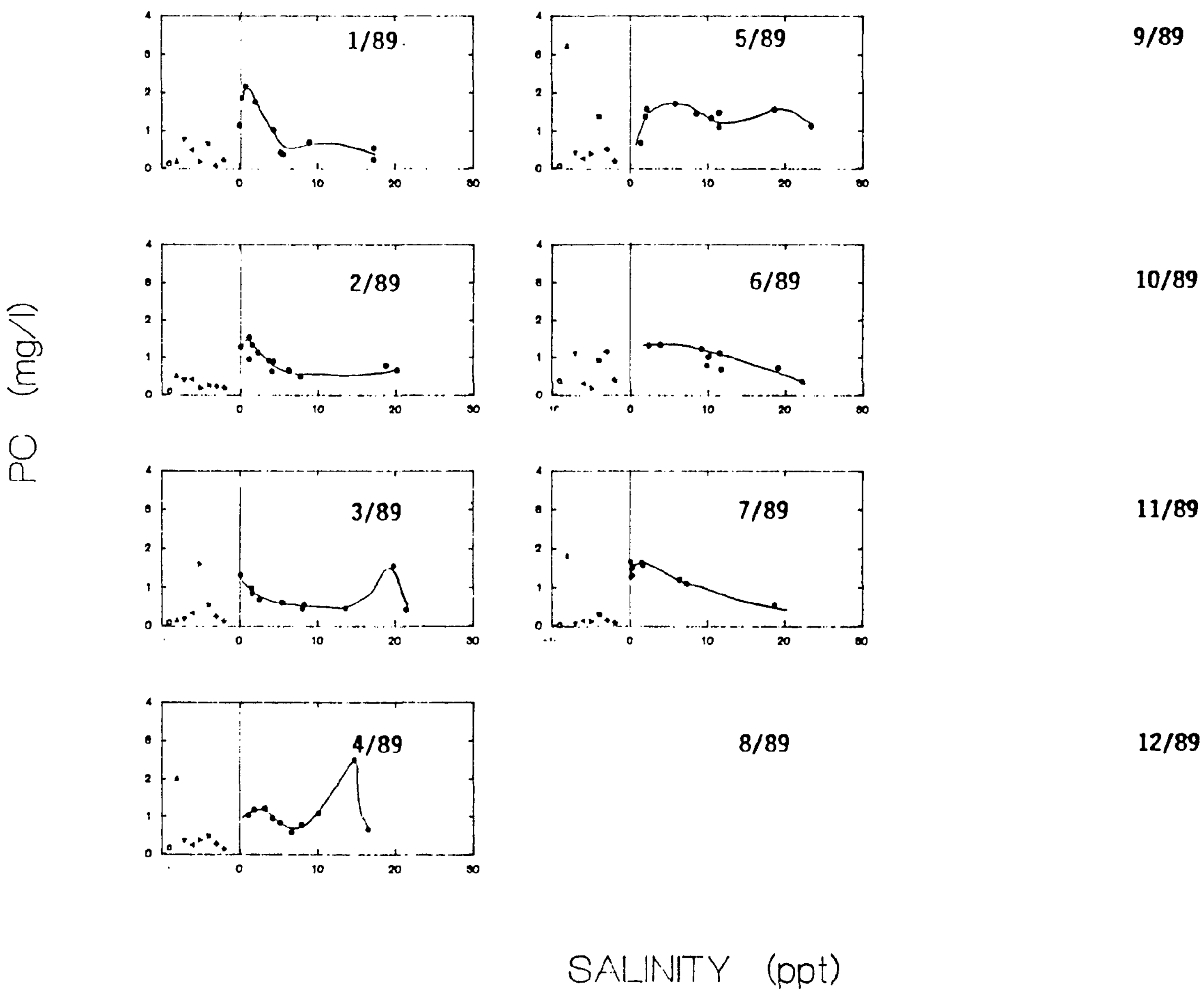
MYAKKA RIVER - ESTUARY TRANSECT



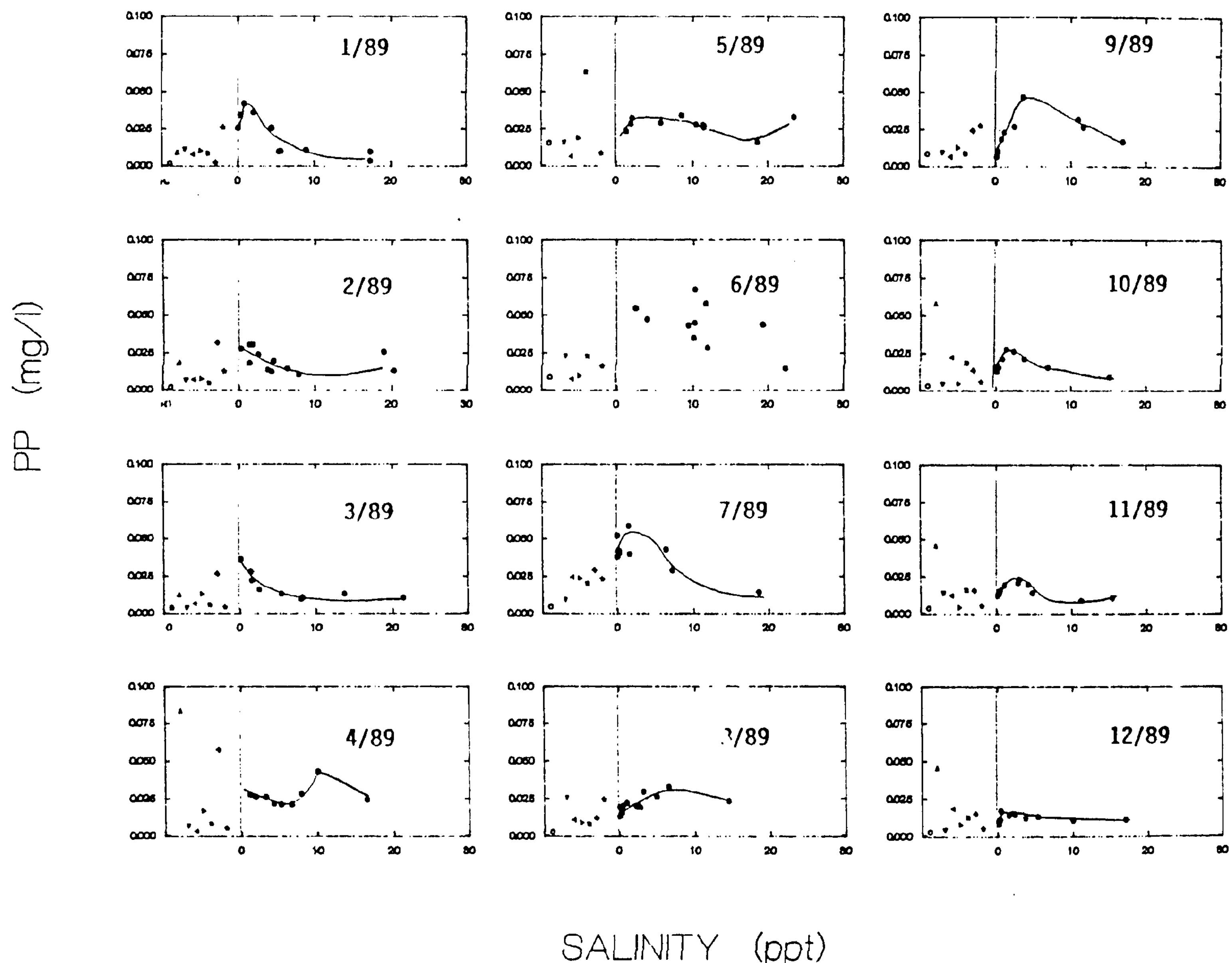
MYAKKA RIVER - ESTUARY TRANSECT



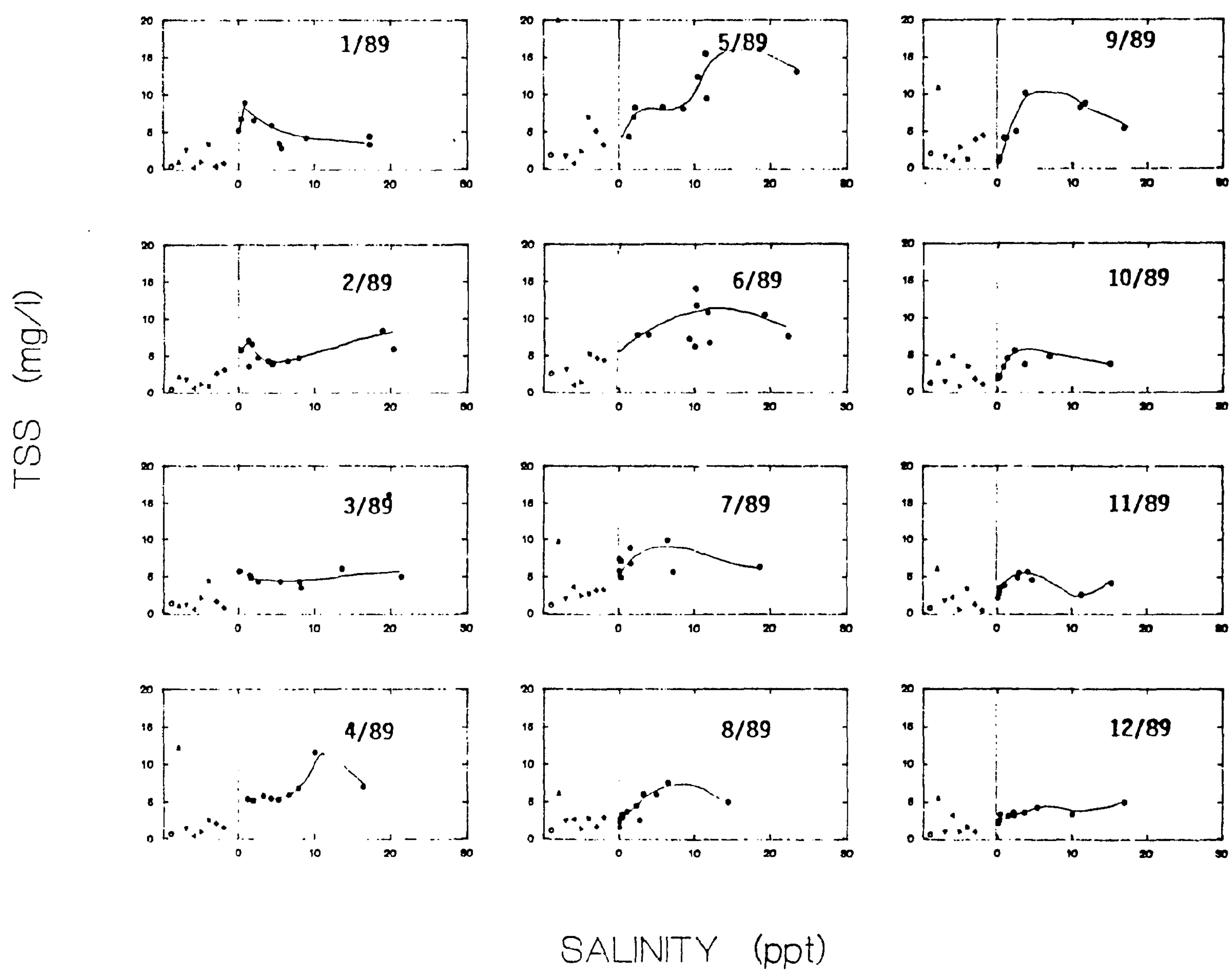
MYAKKA RIVER - ESTUARY TRANSECT



MYAKKA RIVER - ESTUARY TRANSECT



MYAKKA RIVER - ESTUARY TRANSECT



MYAKKA RIVER - ESTUARY TRANSECT