HYDROLOGIC AND WATER-QUALITY DATA FOR STREAMS AND IMPOUNDMENTS IN THE COTEAU DES PRAIRIES--UPPER MINNESOTA RIVER BASIN, 1979-84

By C. J. Smith, G. A. Payne, and L. H. Tornes

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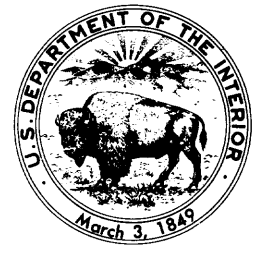

St. Paul, Minnesota

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CONVERSION FACTORS AND ABBREVIATIONS

Readers who prefer to use metric (International System) units rather than inch-pound units can make conversions by using the following factors:

Multiply inch-pound unit	By	To obtain metric unit
inch (in.)	25.4	millimeter (mm)
foot (ft)	0.3084	meter (m)
mile (mi)	1.609	kilometer (km)
acre	4,047	square meter (m^2)
square mile (mi^2)	2.59	square kilometer (km^2)
acre-feet (acre-ft)	1,233	cubic meter (m^3)
cubic feet per second ft^3/s	0.02832	cubic meters per second m^3/s
tons (short)	0.9072	Megagrams (Mg) or metric tons (tonne)

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ABSTRACT

Water-quality and streamflow data were collected in the Coteau des Prairies region of southwestern Minnesota and eastern South Dakota from 1979-84. Data were collected to (1) document the water-quality characteristics of streams and impoundments in the Coteau area, (2) predict the impact of proposed impoundments, (3) define the amount of dissolved and suspended material transported, and (4) determine the differences in water quality between the impoundment inflows and outflows.

Streamflow and water-quality data were collected at 12 stream and four impoundment sites. Continuous-record gages, set to collect data at 15-minute intervals, and readings taken by local observers were used to complete discharge records at 10 stream sites and stage records at three impoundment sites. Automatic samplers and local observers collected storm runoff, sediment, and nutrient samples at 10 stream sites. Water-quality samples were collected at various time and stage intervals during high flow and periodically during low flow. Primary emphasis in the stream-sampling program was on analysis of samples for nutrients in 1980-82, and on analysis of suspended sediment and nutrients in 1983-84. Field measurements were made of pH, water temperature, dissolved oxygen, specific conductance, alkalinity, and bacteria. Secondary emphasis was on analysis of major dissolved substances. Primary emphasis in the impoundments was on analysis of samples for phosphorus and chlorophyll and on the measurement of transparency. Temperature and dissolved-oxygen concentrations were measured to determine the degree of stratification.

All data collected during the study are given in tables 4-13 of this report. The tables list mean-daily stream discharge, mean-daily suspended-sediment concentration, daily suspended-sediment discharge, results of water-quality analyses, and bed-material particle-size analyses at stream sites. The tables also list information on pool stage, water temperature, and transparency, on dissolved-oxygen, chlorophyll *a*, phytoplankton, and nutrient concentrations, and on chemical and partical-size analyses of bed material at impoundment sites.

INTRODUCTION

In recent years, losses of soil to streams have increased as a result of flooding, bank sloughing, and soil movement from farm fields in the predominantly agricultural watersheds of the Coteau des Prairies (Coteau). The Coteau, a linear upland plateau extending from southwestern Minnesota into eastern South Dakota, lies along and above the steep slopes of the Minnesota River valley and is the headwaters of five principal tributaries of the Minnesota River. Soil losses to these streams may have been accelerated by drainage of wetlands and by bringing marginal lands into production. These actions resulted in increased peak flows and sediment transport.

To determine the extent that streams are being affected by land-use practices, the upper Minnesota subbasin study (Public Law 87-639) was begun by the U.S. Army Corps of Engineers and the U.S. Soil Conservation Service. Control or reduction of the increasing peak flows and sediment discharge is expensive, and various alternatives for improving the quality of water of streams draining the Coteau are being considered by local, State and Federal agencies.

A commonly used method for improving water quality is to construct a series of small in-stream impoundments. Impoundments have been constructed at several locations along the Coteau since the 1930's by the U.S. Soil Conservation Service in cooperation with local landowners and Watershed Conservation Districts. The use of impoundments in the Coteau area is increasing, but their effectiveness in reducing sediment loading of streams has not been evaluated.

Purpose and Scope

This report presents hydrologic data collected by the U.S. Geological Survey during 1979-84 and describes the approach and methods used. The analysis of these data is presented in a separate report titled "Water quality assessment of existing and planned impoundments in the Coteau des Prairies - Upper Minnesota River basin."

Acknowledgments

Assistance by the following people is gratefully acknowledged: Marilyn Johnson (rainfall observer and landowner for LaBolt inlet stream-gaging station) and Adolf Peterson (landowner for recording-rainfall station), of LaBolt, South Dakota; Robert Weber (rainfall observer and landowner for recording-rainfall station) of Strandburg, South Dakota; Loye January (rainfall observer and landowner for recording-rainfall station) and William Webber (rainfall observer and landowner for Webber impoundment sites) of Gary, South Dakota; Henry Fairchild and family (rainfall and sediment observers, and landowner for Florida Creek stream-gaging and recording-rainfall stations) of Burr, Minnesota; Richard Olson (rainfall observer), and Duane Nordseth and family (rainfall and sediment observers and landowner for Lac Qui Parle stream-gaging and recording-rainfall stations) of Canby, Minnesota; Mark Syltie (rainfall observer and landowner at Dillon-Syltie inlet stream-gaging and recording-rainfall station), Raymond Lozinskii, (rainfall observer and landowner for recording-rainfall station), Yellow Medicine River Watershed District (landowner of Dillon-Syltie Impoundment) of Porter, Minnesota; Ruth Morud (rainfall observer) of Brandt, South Dakota; Charles Dahl (rainfall observer) of Astoria, South Dakota; Marlow and Conrad Freeburg (rainfall and sediment observer and landowner for Lake Laura south inlet recording-rainfall and stream-gaging station) of Walnut Grove, Minnesota; Donald Swenson (sediment observer) of Walnut Grove, Minnesota and Redwood County Board of Commissioners (landowner for Lake Laura Impoundment stream-gaging station and pool site) of Redwood Falls, Minnesota; Palmer Bush (sediment and rainfall observer and landowner for Dry Creek stream-gaging station) of Jeffers, Minnesota.

STUDY AREA

Climate

Minnesota has a continental-type climate with cold, dry winters and warm, wet summers (Kuehnast and Baker, 1978). Two-thirds of the annual precipitation occurs in the five months of May to September. Precipitation during winter is as snow and during summer is as showers or thunderstorms. Monthly precipitation at Canby, Minnesota, is shown in figure 1 for 1979-84. Figure 1 shows that the 1980-82 open-water periods were preceded and followed by dry winters; dry conditions continued throughout the spring and summer seasons; zero flows occurred at most of the study sites during the summer-winter period. The 1983-84 open-water periods were wetter with increased spring and summer flows.

Geology and Soils

The topography of the Coteau is gently undulating, resulting from deposition and erosion of glacial till that underlies most of the study area. The till is underlain by rocks of Cretaceous age. Headwaters of the western streams are in the Altamont recessional ground moraine left after the Wisconsin glaciation (Thiel, 1944). Data-collection sites are on the Coteau slope, which forms the northeast flank of the Coteau des Prairies.

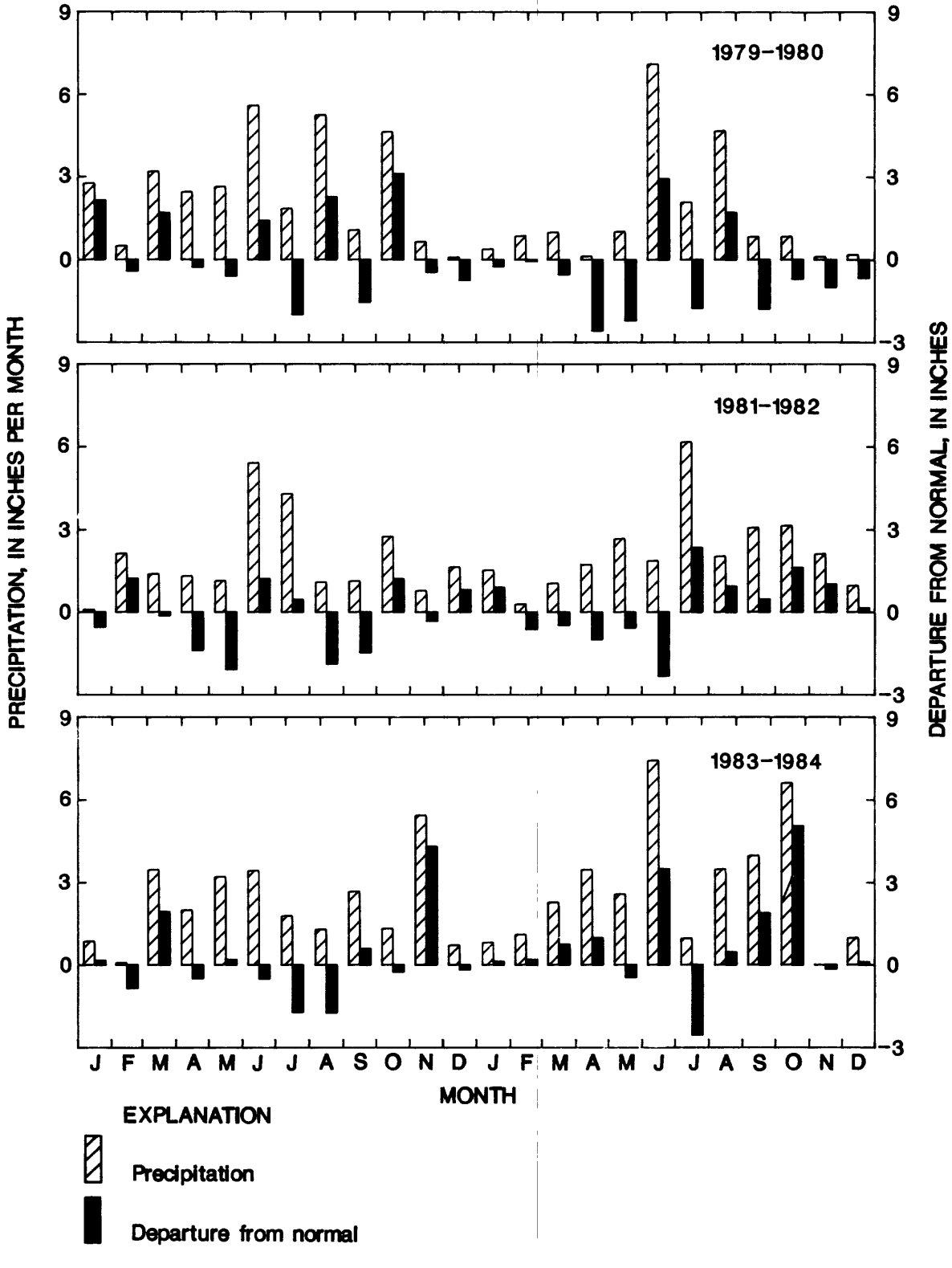

FIGURE 1.--Monthly precipitation and departure from normal precipitation at Canby, Minnesota. (Data from National Oceanic and Atmospheric Administration, 1979–1984)

A soil-association map (Arneman, 1963) shows that soils in the Yellow Bank, Lac Qui Parle, and Yellow Medicine River basins and in the headwaters of the Redwood River basin are medium-fine- to fine-textured prairie and prairie-border soils characteristic of western Minnesota. In the lower parts of the Redwood River and Cottonwood River basins, the soils are medium- to fine-textured prairie soils characteristic of south-central Minnesota. In these areas, the topography varies from nearly flat to hilly, and the dark-colored soils developed from calcareous glacial till. Some prominent soil groups developed from calcareous gravel of Wisconsin age. The dark color of the soil is closely related to organic matter derived from the decay of shallow rooted plants with extensive root systems. Erosion control and water conservation are major problems.

Sample Sites

Four impoundments, inlets and outlets to the impoundments, and four streams were chosen for investigation based on information gathered during a reconnaissance in June 1979. During the reconnaissance, 66 proposed impoundment sites on streams, 24 impoundments, and 21 inlets and outlets were sampled. Sites for intensive sampling were selected from the reconnaissance sites on the basis of drainage area, accessibility, location in study area, and feasibility studies prepared by the U.S. Army Corps of Engineers (1980) and U.S. Soil Conservation Service. These sites were selected to represent areas where impoundment of streams is most likely.

The location and drainage area of the reconnaissance-sampling sites are given in table 1. Sites that were selected for intensive sampling are noted in table 1 also. The location of sites studied is shown in figure 2.

Three of the four impoundments, LaBolt, Dillon-Syltie, and Lake Laura, are used frequently by the public for recreational purposes. Drainage areas above the impoundments ranged from 1.4 to 17.1 mi^2 (square miles). Drainage areas above the stream sites ranged from 3.1 to 186 mi^2. The primary land use in the watersheds is agricultural. Row crops are grown on the flatter slopes; pasture is common on steeper slopes adjacent to the streams.

Table 2 summarizes watershed characteristics at each intensively studied site. Land-use characteristics are based on information provided by the U.S. Soil Conservation Service (SCS) (written Comm., 1984). Drainage areas, stream length, slope, and wetland areas were measured from U.S. Geological Survey topographic maps and from aerial photographs provided by SCS. Normal impoundment volume was determined from field surveys in spring 1983. Estimates of peak discharge for the listed frequencies at each impoundment inlet and at each proposed impoundment site were based on regional flood-frequency equations determined by Jacques and Lorenz (1987). Estimates of 7-day 2-year and 7-day 10-year low-flow discharge were based on observations of zero flow or correlation of base-flow measurements with an index station (Stedinger and Thomas, 1985).

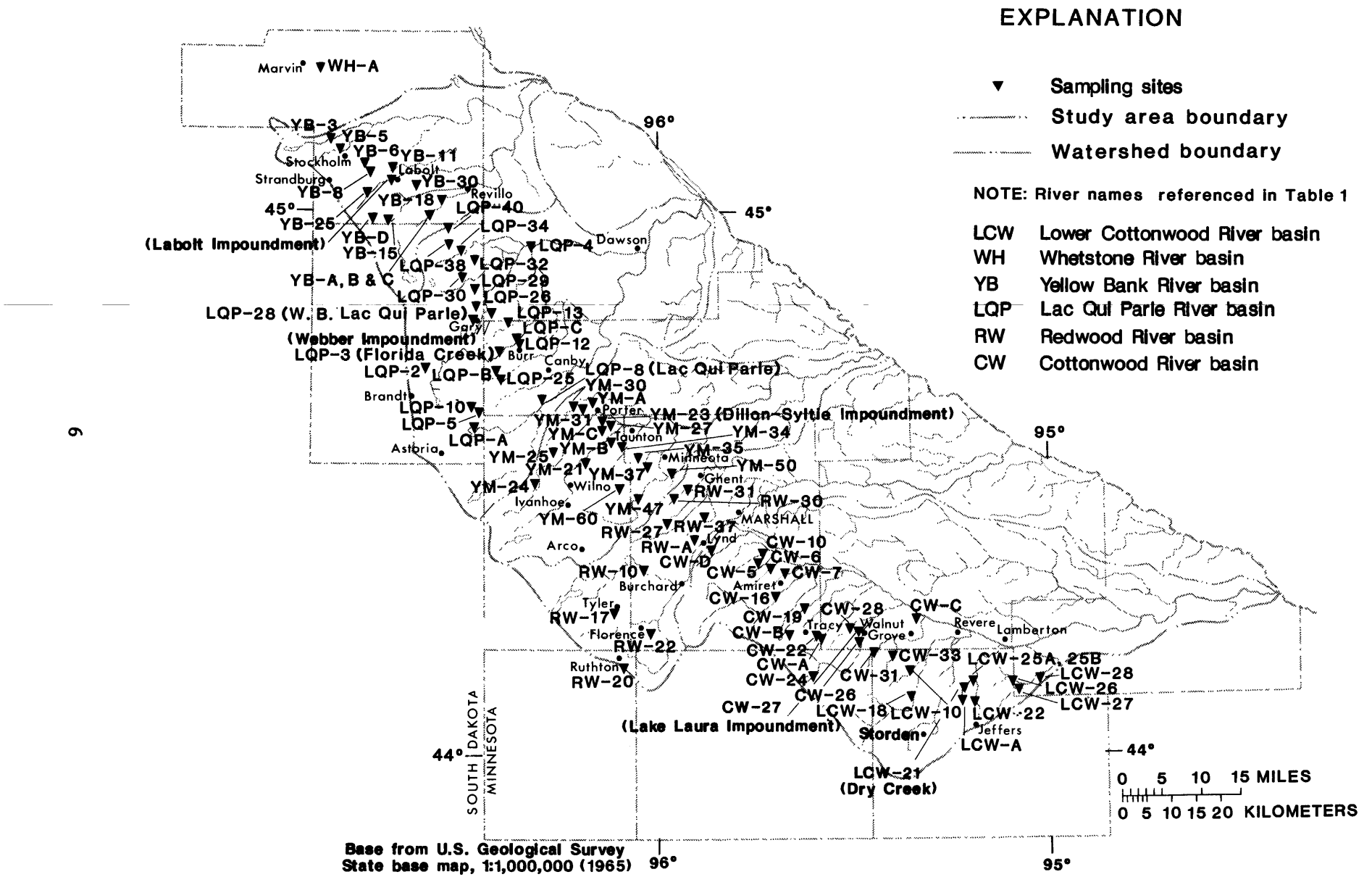

FIGURE 2.--Location of sampling sites.

METHODS OF DATA COLLECTION

Collection of repetitive physical, chemical, and biological data began in March 1980. During 1980, three impoundment sites, Dillon-Syltie, LaBolt, and Webber, and their respective inlets and outlets were sampled monthly. Tables 3 and 4 list the type of data collected in 1980-84.

In February 1981, the three impoundments and their inlets and outlets were sampled during a period of ice cover. Sampling of all sites at LaBolt and Webber impoundments then was discontinued for the remainder of 1981. Termination of sampling did not result in significant lost record because the 1981 spring breakup was gradual. Only one significant runoff event occurred during the latter part of the year; inlets were dry much of the time and the pool stages were low. A reduced number of samples also was collected from the Dillon-Syltie inlet and outlet sites due to zero flows.

In 1982, sampling was resumed at the LaBolt and Webber impoundment sites and three new stream sites (Florida Creek, West Branch Lac qui Parle River, and Lac qui Parle River) were added. The sites were sampled monthly from early spring through October. The impoundments were sampled every two weeks from May to September.

In May 1983, the Lake Laura impoundment, its two inlets, and its outlet were added to the study. As in 1982, the impoundments were sampled at 2-week intervals. In September 1983, sampling at the Webber impoundment sites and in the LaBolt impoundment was discontinued; the LaBolt impoundment inlet was continued with a reduced sampling schedule.

In 1984, a new site on Dry Creek was added to the study and sampling in the impoundments was reduced to monthly from May through September.

At various times during the study, schedules were modified to adjust to special conditions. These conditions included lack of flow, equipment malfunctions, or the need to reallocate resources to streams having more significant runoff.

Stream Sites

During the study, 11 sites were instrumented with continuous-record-stage recorders (15-minute recorder interval), and three sites were instrumented with simple pipe gages to determine peaks. Of the 11 sites with continuous recorders, 9 were established to obtain streamflow records, one was established to obtain both impoundment stage and a streamflow record, and another was used for impoundment stage. At Lake Laura, the impoundment stage was recorded by a local observer.

Periodic streamflow measurements were made at stream sites according to techniques described by Buchanan and Somers (1969). These measurements were used to define the stage-discharge relationship for each station. The stage-discharge relationship and stage record were used to define the daily mean discharge at each station.

During scheduled visits, water temperature, pH, dissolved oxygen, specific conductance and alkalinity were measured in situ according to the methods of Skougstad and others (1979). These measurements were made most often using a Hydrolab[1] four-parameter meter. Single-constituent meters were used as backups and periodically for quality-assurance checks.

Fecal coliform and fecal Streptococci bacteria were determined in the field by the membrane-filter method described by Greeson and others (1979a). During runoff, water temperature, pH, dissolved oxygen, and specific conductance were measured periodically and sediment samples were collected using the methods described in Guy and Norman (1970).

From 1982-84, local observers were hired and automatic samplers were installed to assist in the collection of samples. Stage-activated automatic samplers were installed at inlets and outlets of the LaBolt and Dillon-Syltie impoundments, the two inlets of Lake Laura impoundment, and on Florida Creek, Lac qui Parle River, and Dry Creek. In 1982-83, the automatic samplers were set to collect samples at specified time intervals. The time intervals were manually set and varied from 15-minutes to 24 hours, depending on how rapidly stage rose or fell. In 1984, the samplers were set to initially activate above a predetermined stage, and above this stage were set to be activated by either a half-foot rise or fall in stage, or at the end of a 24-hour time interval.

At the time observers collected sediment samples, water temperature and stage were measured. Samples were collected weekly by observers during periods of base flow. During periods of rising stage, observers collected samples once or twice daily; during periods of falling stage, samples were collected daily until the stage fell below a predetermined level. Observers collected samples at Dillon-Syltie inlet, LaBolt inlet, Florida Creek, Lac qui Parle River, Lake Laura (north inlet, south inlet, and outlet,) and Dry Creek.

Two suspended-sediment samples and one bed-material sample were collected at each site and analyzed for particle-size distribution (Guy and Norman, 1970, and Guy, 1969). During most runoff events, flow-weighted-composite samples (Pickering, 1980) were collected and analyzed. Daily sediment concentration and load were determined by the methods of Porterfield (1972).

The annual discharge hydrographs for the impoundment inlets and outlets and the points on the hydrographs when either an instantaneous or composite water-quality sample was collected are shown in figures 3-12.

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[1] Use of trade names in this report is for identification purposes only and does not constitute endorsement by the U.S. Geological Survey.

Impoundment Sites

Impoundment sites were sampled for chemical and biological analyses once in February or March each year. In 1980-81 and in 1984, the impoundments were sampled monthly from May through September. Only Dillon-Syltie impoundment was sampled during 1981. During 1982 and 1983, a two-week sampling interval was used. During scheduled visits, vertical profiles of water temperature, pH, dissolved oxygen, and specific conductance were obtained. Transparency and depth were measured at the sampling sites during each visit. Composite samples were collected from the euphotic zone[1] using a horizontal Van Dorn sampler during 1980-81, and a 2-inch plastic pipe during 1982-84. Phytoplankton and chlorophyll concentrations were determined using the methods described in Greeson and others (1979a and 1979b). Phytoplankton samples collected during 1981-83 were analyzed by the U.S. Geological Survey Laboratory, Doraville, Georgia. Phytoplankton samples collected during 1984 were analyzed by Aquatic Analysts, Portland, Oregon.

One bed-material sample was collected from the center of each impoundment and analyzed for nutrients, trace metals, organic carbon, volatile solids, and particle size. Supplemental bed-material samples for determination of particle size and volatile solids also were collected in the pools near the mouth of each inlet. At Lake Laura, the supplemental samples also were analyzed for nutrient and trace-metal concentrations.

The types of analyses of the water samples are summarized in table 3.

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[1] The euphotic zone was assumed to be 1.5 times the Secchi-disk transparency.

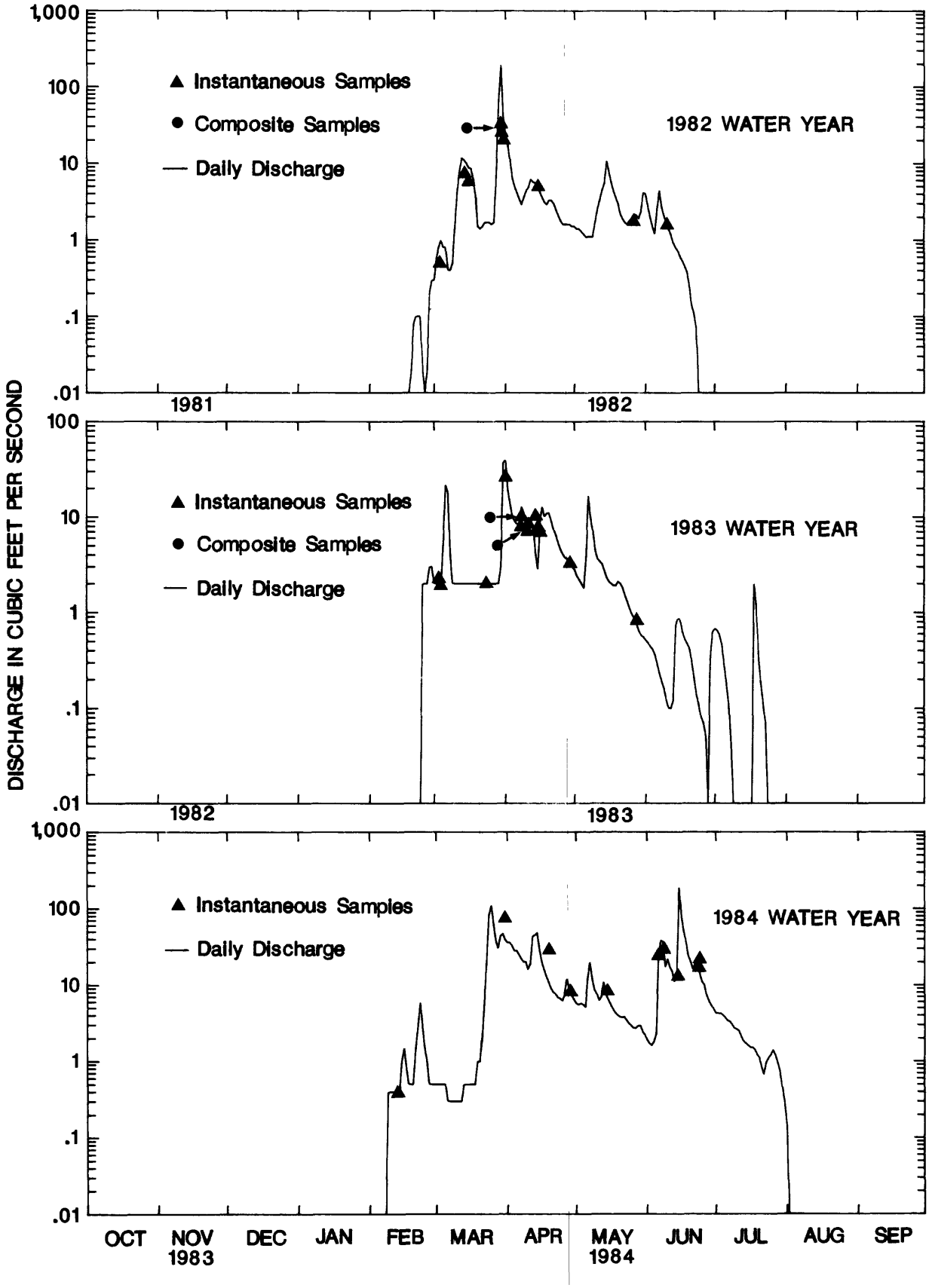


FIGURE 3.--Discharge hydrograph and sample collection at LaBolt Impoundment Inlet near Labolt, South Dakota

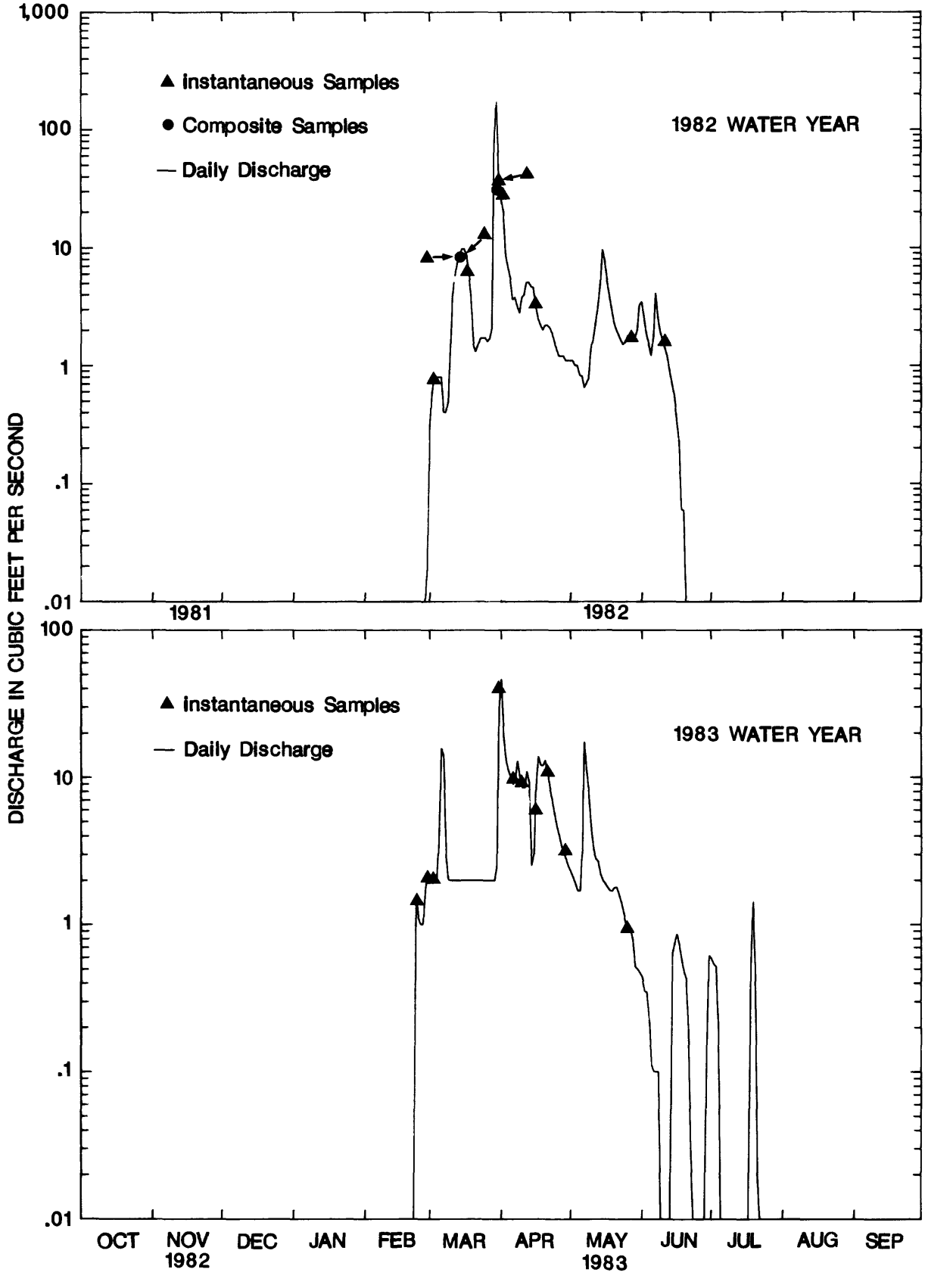


FIGURE 4.--Discharge hydrograph and sample collection at LaBolt impoundment outlet near Labolt, South Dakota.

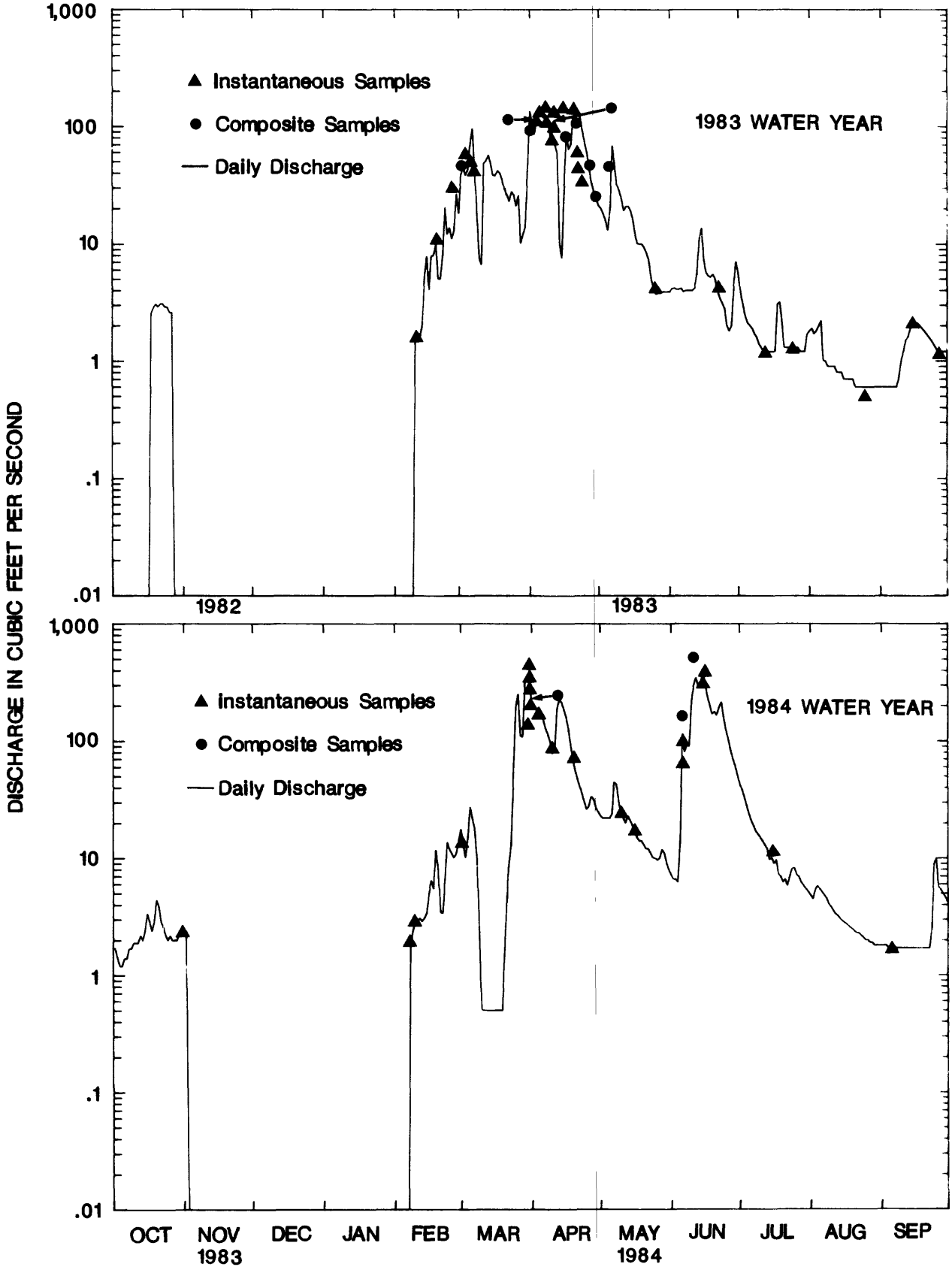


FIGURE 5.--Discharge hydrograph and sample collection at Florida Creek near Burr, Minnesota.

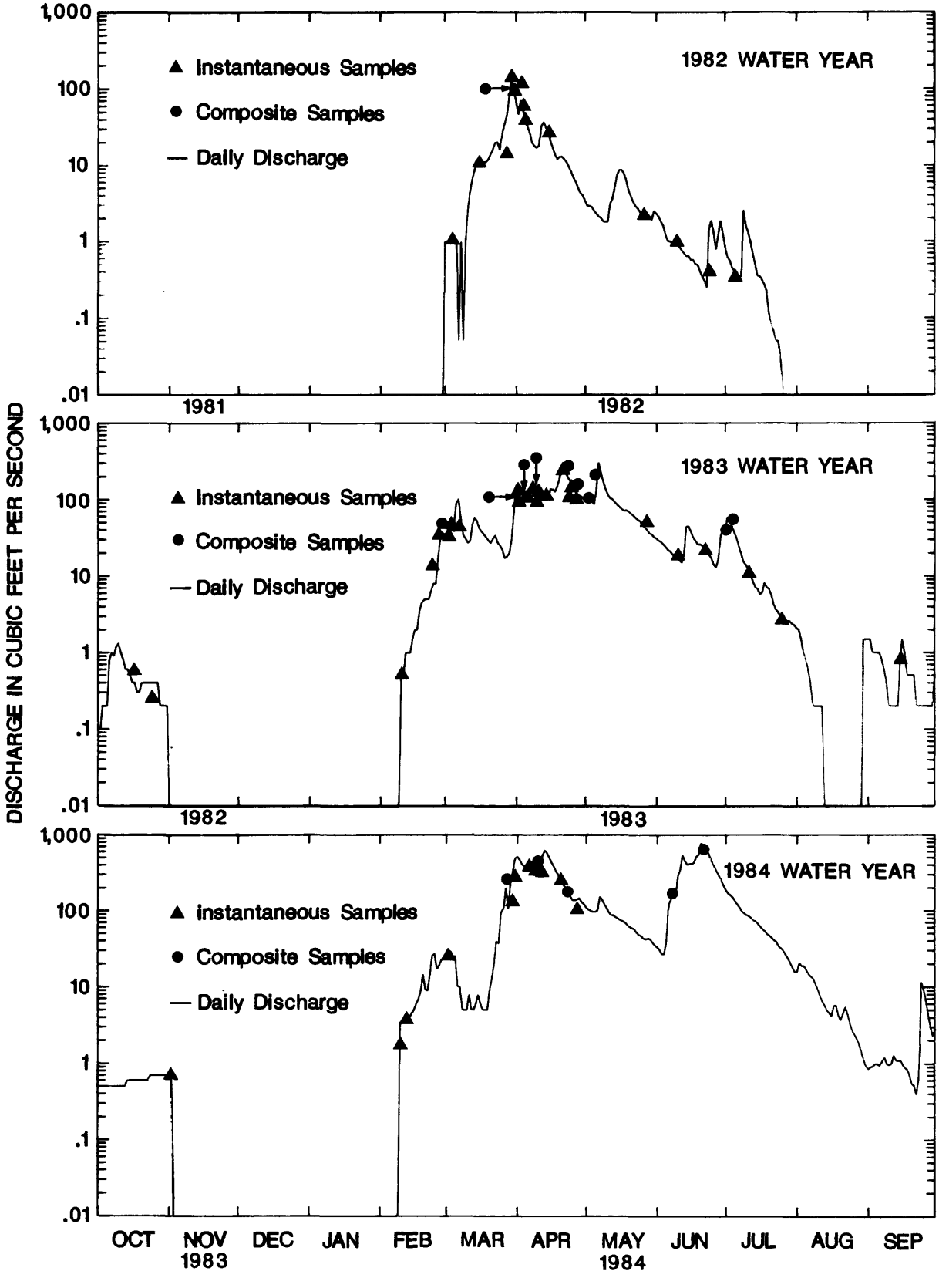


FIGURE 6.--Discharge hydrograph and sample collection at Lac Qui Parle River near Canby, Minnesota.

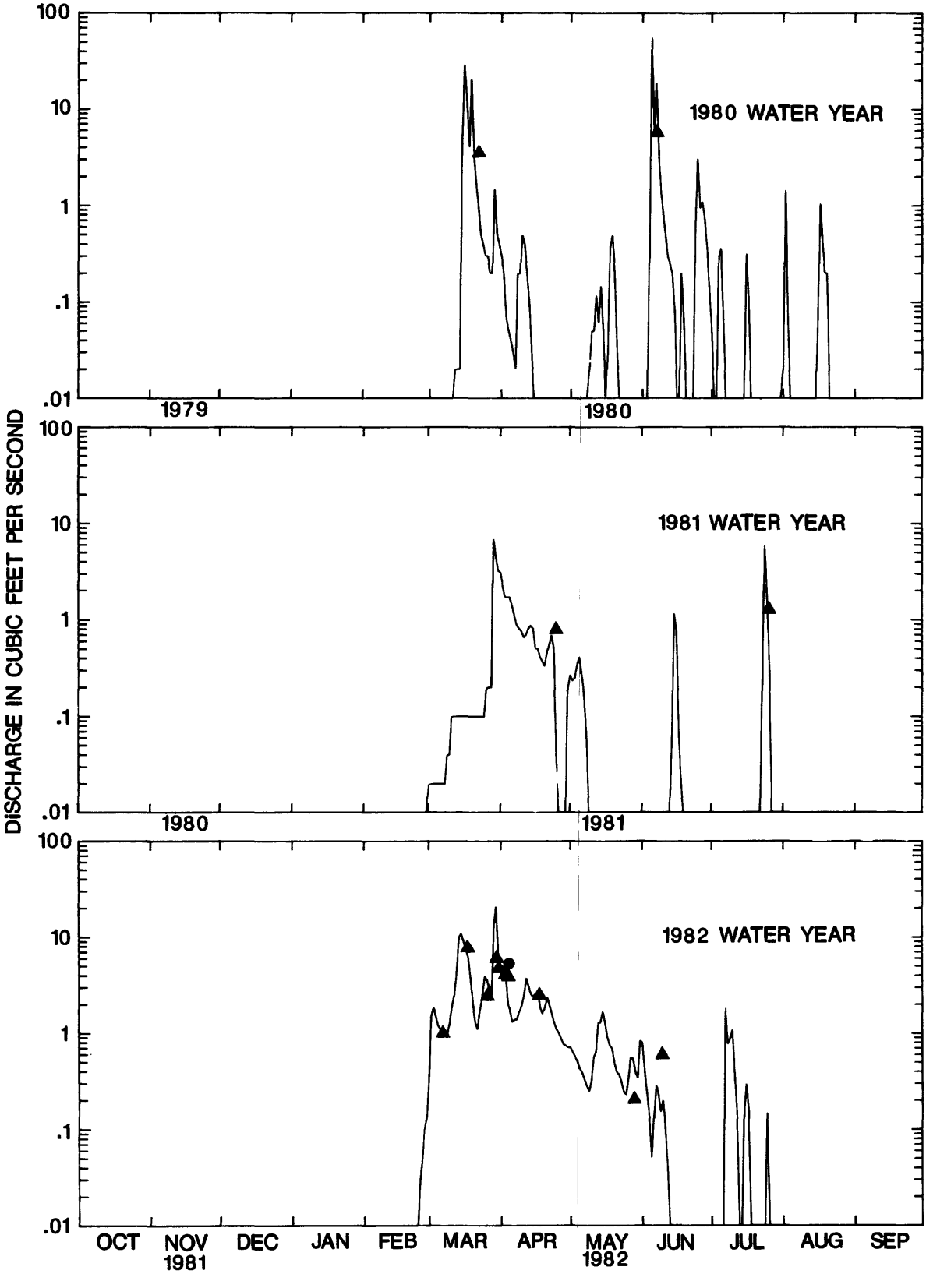
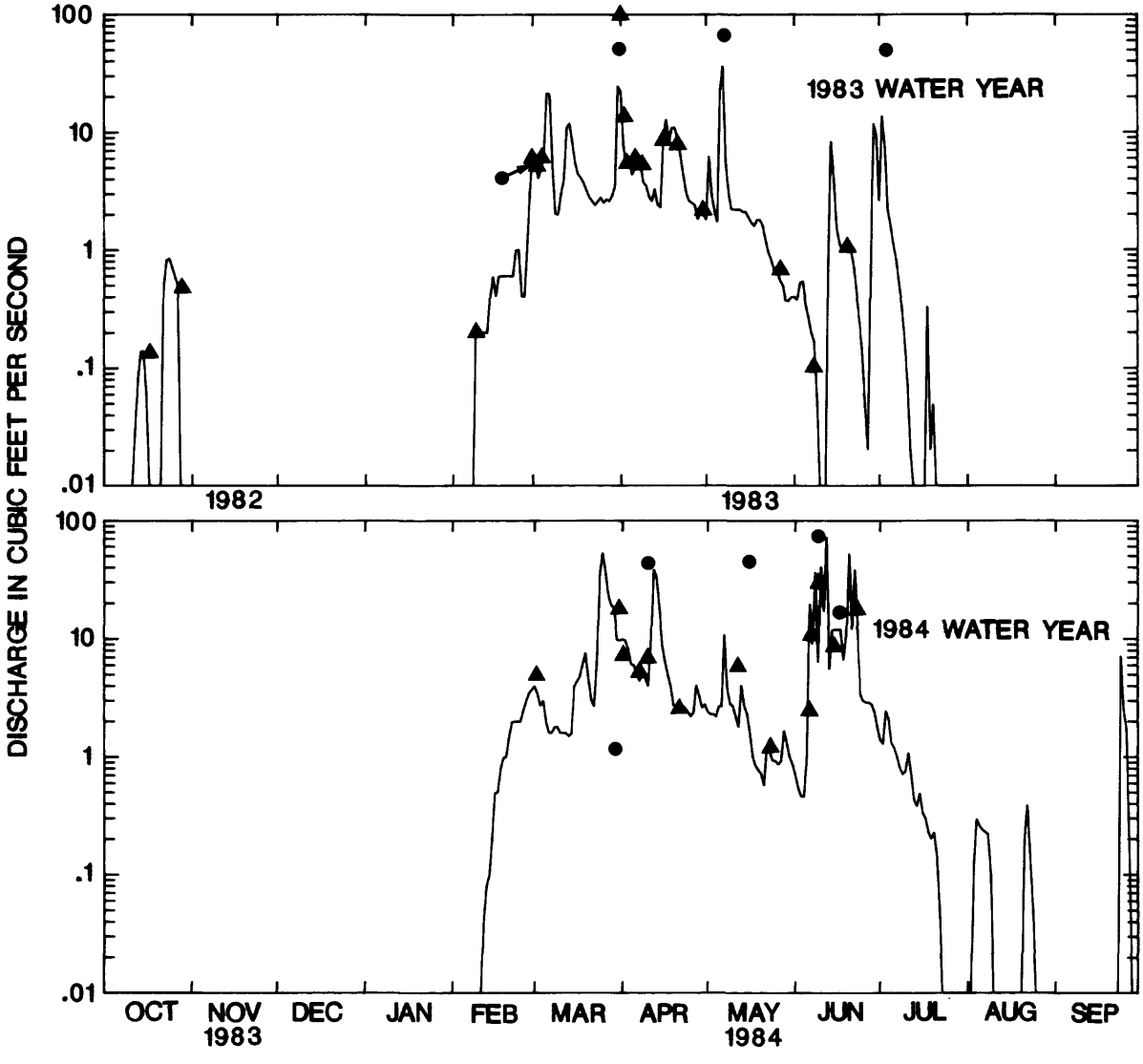


FIGURE 7.--Discharge hydrograph and sample collection



EXPLANATION

▲ Instantaneous Samples

● Composite Samples

—— Daily Discharge

at Dillon-Syltie Impoundment inlet near Porter Minnesota.

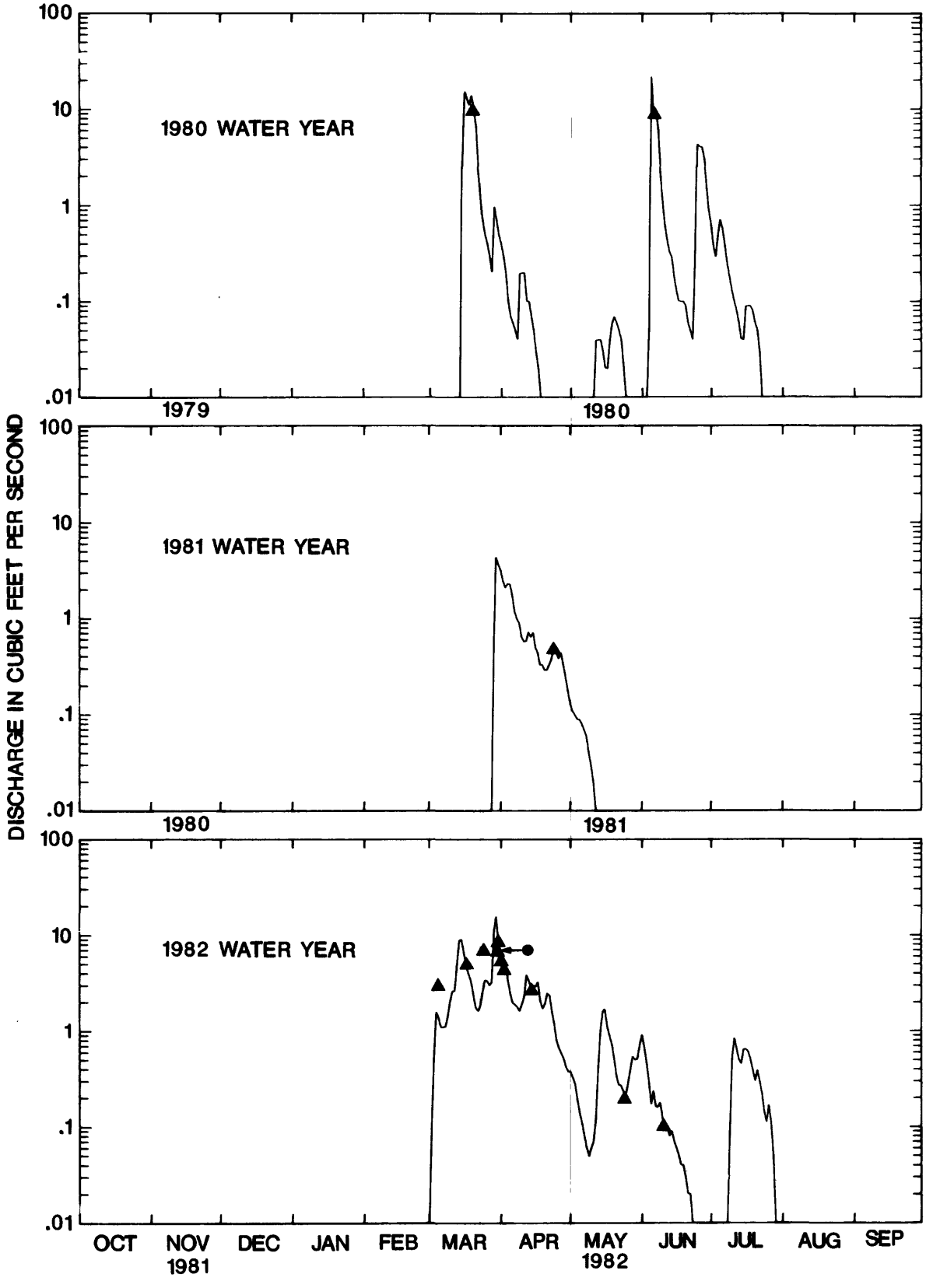
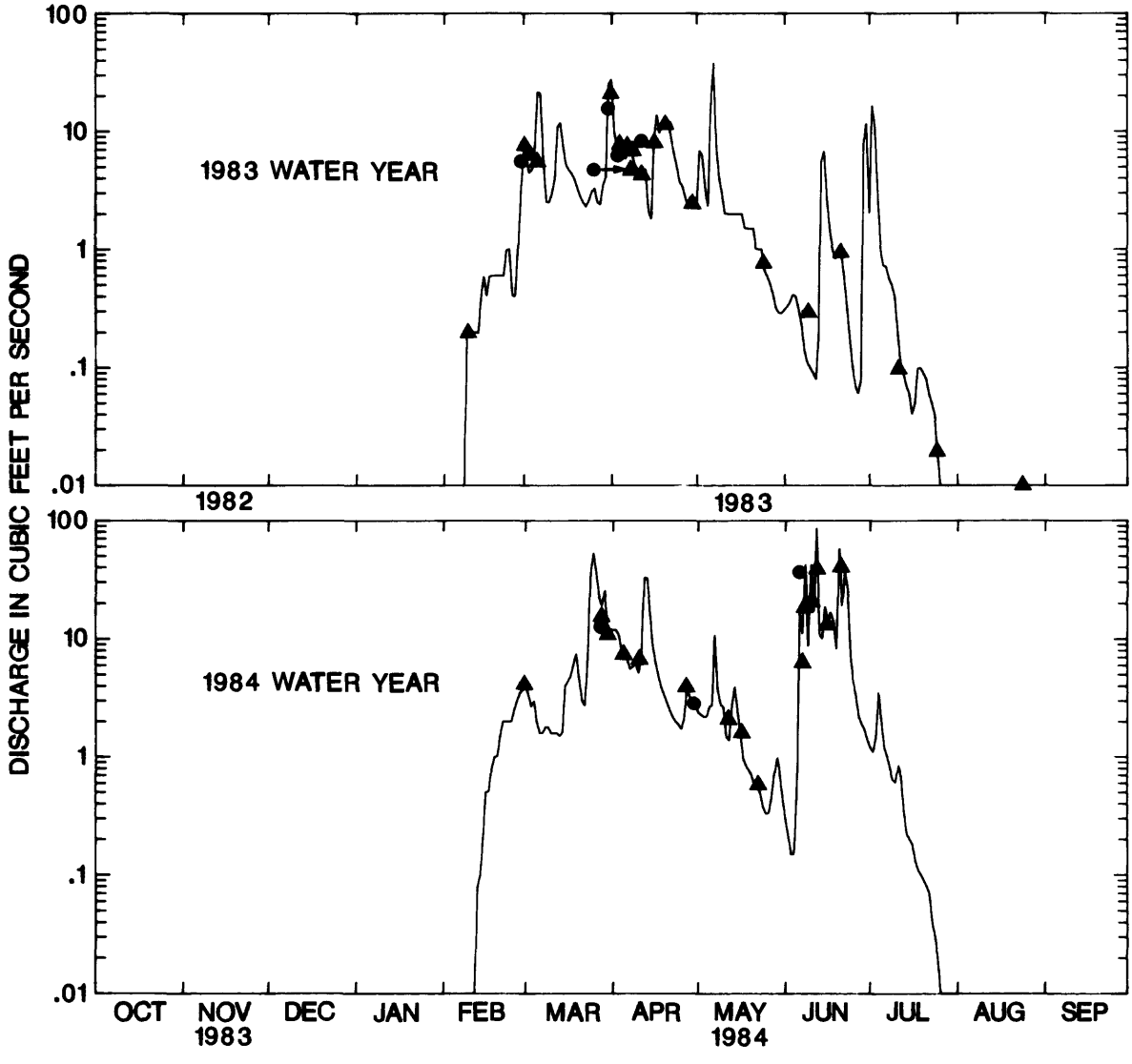


FIGURE 8.--Discharge hydrograph and samples collected



EXPLANATION

▲ Instantaneous Samples

● Composite Samples

— Daily Discharge

at Dillon-Sylvie Impoundment outlet near Porter, Minnesota.

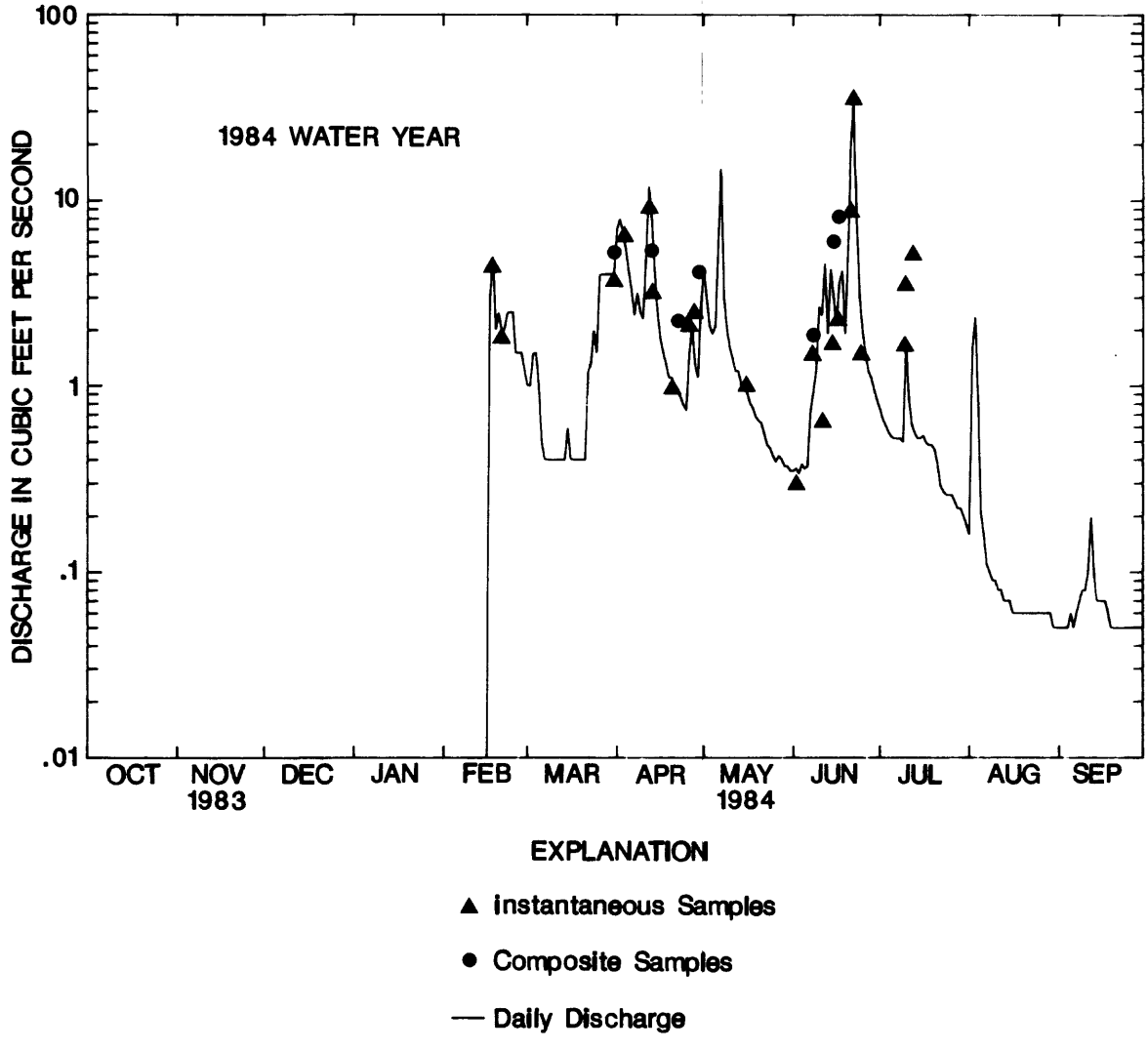


FIGURE 9.--Discharge hydrograph and sample collection at Lake Laura impoundment north inlet near Wainut Grove, Minnesota.

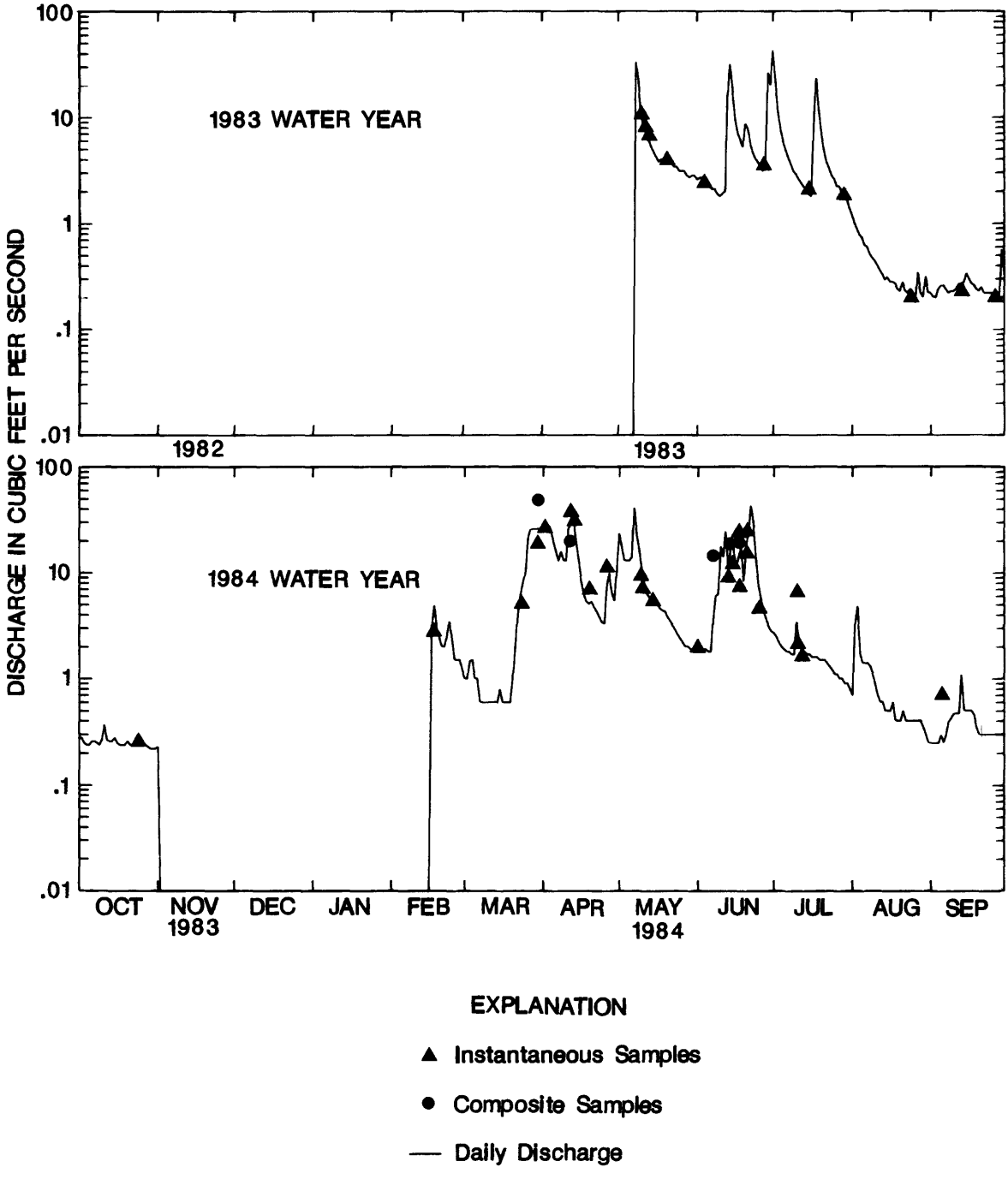


FIGURE 10.--Discharge hydrograph and sample collection at Lake Laura Impoundment south inlet near Walnut Grove, Minnesota.

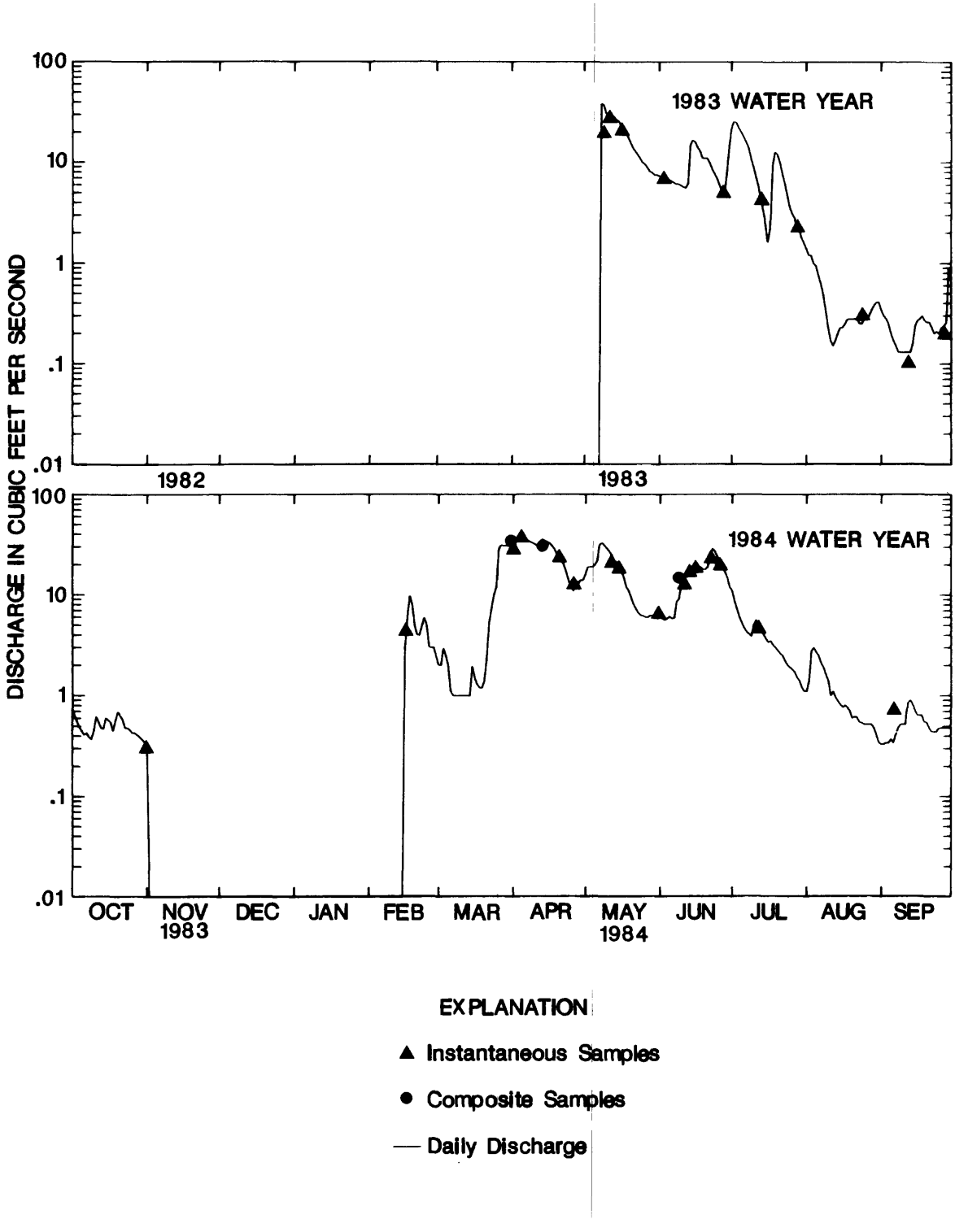


FIGURE 11.--Discharge hydrograph and sample collection at Lake Laura Impoundment outlet near Walnut Grove, Minnesota.

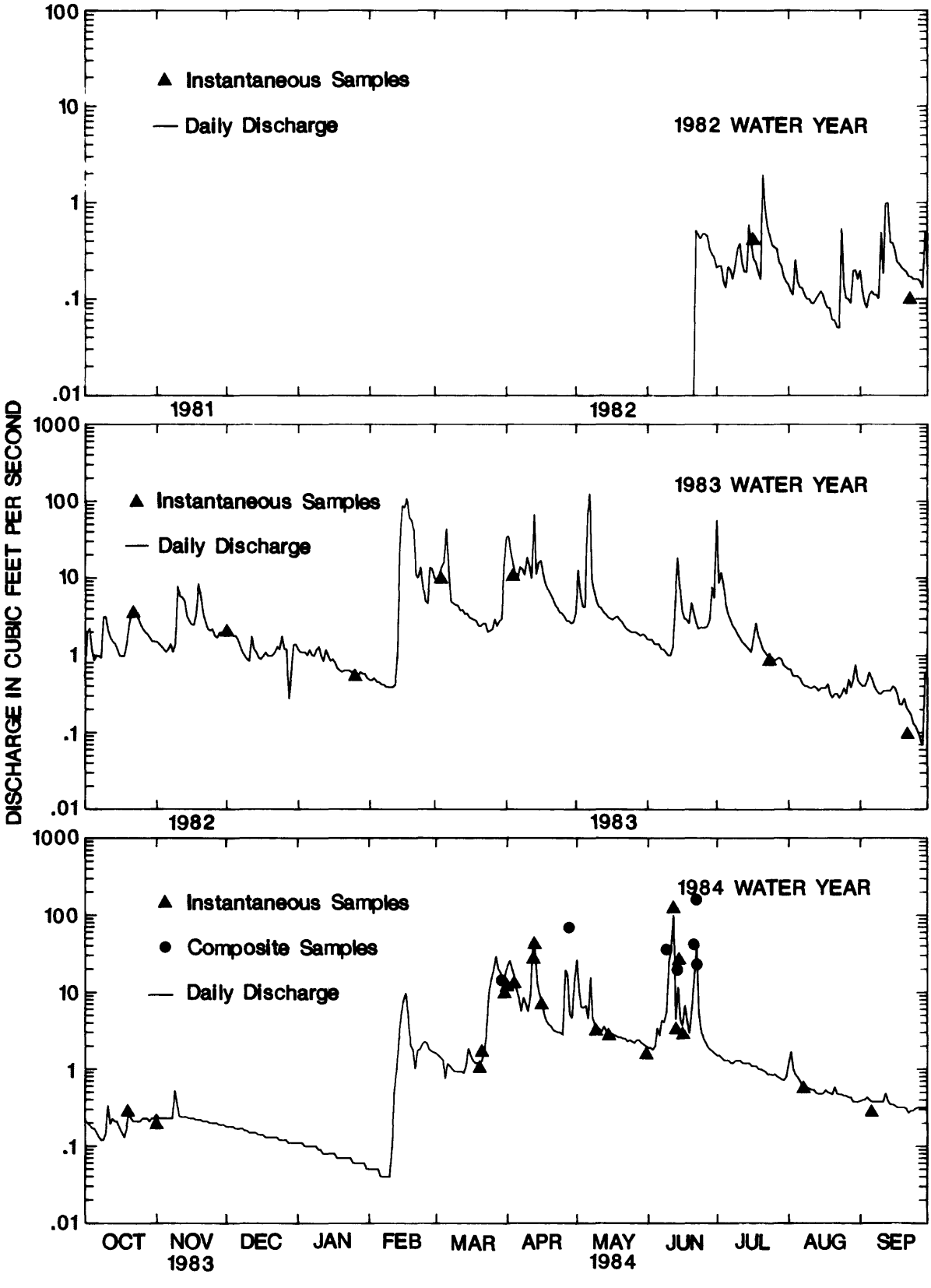


FIGURE 12.--Discharge hydrograph and sample collection at Dry Creek near Jeffers, Minnesota.

Table 1.--*Name and drainage area of reconnaissance-sampling sites*

[USGS, U.S. Geological Survey; USACE, U.S. Army Corps of Engineers; *, site selected for intensive sampling;--, drainage area not defined; Wh, Whetstone River; YB, Yellow Bank River; LQP, Lac Qui Parle River; YM, Yellow Medicine River; CW, Cottonwood River; RW, Redwood River; LCW, Lower Cottonwood River]

USGS station identification number	USACE 639 site number	County	Site name	Drainage area (mi^2)
			WHETSONE RIVER WATERSHED	
451503096533000	WH-A	Grant	Blue Cloud Abbey impoundment site 1 near Marvin, So. Dak.	---
451503096533001		Grant	Blue Cloud Abbey impoundment site 2 near Marvin, So. Dak.	---
451503096533002		Grant	Blue Cloud Abbey inlet pond near Marvin, So. Dak.	---
			YELLOW BANK RIVER WATERSHED	
450809096484201	YB-3	Grant	North Fork Yellow Bank River near Stockholm, So. Dak.	29.6
450704096471201	YB-5	Grant	North Fork Yellow Bank River tributary near Stockholm, So. Dak.	13.6
450609096454001	YB-6	Grant	North Fork Yellow Bank River tributary near Stockholm, So. Dak.	8.0
450459096442801	YB-8	Grant	North Fork Yellow Bank River tributary near LaBolt, So. Dak.	3.6
450343096421001	YB-11	Grant	North Fork Yellow Bank River tributary near LaBolt, So. Dak.	5.8
450014096392301	YB-15	Grant	South Fork Yellow Bank River near LaBolt, So. Dak.	67.2
445940096355401	YB-18	Grant	South Fork Yellow Bank River tributary near Revillo, So. Dak.	4.9
450256096431001	YB-25	Grant	South Fork Yellow Bank River tributary near LaBolt, So. Dak.	13

Table 1.--*Name and drainage area of reconnaissance-sampling sites*--Continued

USGS station identification number	USACE 639 site number	County	Site name	Drainage area (mi^2)
			YELLOW BANK RIVER WATERSHED--Continued	
450210096381601	YB-30	Grant	South Fork Yellow Bank River near LaBolt, So. Dak.	2.6
450317096412100		Grant	*LaBolt impoundment near LaBolt, So. Dak.	17.4
450317096412102		Grant	*LaBolt inlet near LaBolt, So. Dak.	17.1
450317096412104		Grant	*LaBolt outlet near LaBolt, So. Dak.	17.4
445808096355900	YB-A	Deuel	Gene Brondenbuiger impoundment near Revillo, So. Dak.	---
445846096345600	YB-B	Grant	Mud Creek impoundment near Revillo, So. Dak.	---
445846096345604		Grant	Mud Creek outlet near Revillo, So. Dak.	---
445912096363900	YB-C	Grant	Daniel Schafer impoundment near Revillo, So. Dak.	---
445912096363904		Grant	Daniel Schafer impoundment outlet near Revillo, So. Dak.	---
450006096461500	YB-D	Grant	Edwin Swenson impoundment near Strandburg, So. Dak.	---
450006096461502		Grant	Edwin Swenson inlet near Strandburg, So. Dak.	---

Table 1.--*Name and drainage area of reconnaissance-sampling sites*--Continued

USGS station identification number	USACE 639 site number	County	Site name	Drainage area (mi^2)
			LAC QUI PARLE RIVER WATERSHED	
444417096322701	LQP-2	Deuel	North Branch Cobb Creek (So. Dak.) headwaters to Florida Creek near Brandt, So. Dak.	17
444410096251001	LQP-3	Yellow Medicine	*Florida Creek near Burr, Minn.	28
445609096192101	LQP-4	Lac qui Parle	Florida Creek near Dawson, Minn.	150
443638096275401	LQP-5	Deuel	Fish Lake outlet near Astoria, So. Dak.	72
443916096174801	LQP-8	Yellow Medicine	*Lac qui Parle River near Canby, Minn.	186
443751096315101	LQP-10	Deuel	Cobb Creek (So. Dak.) headwaters at Florida Creek near Astoria, So. Dak.	
444754096224501	LQP-12	Yellow Medicine	Cobb Creek (Minn.) tributary near Gary, So. Dak.	4.9
444812096235901	LQP-13	Yellow Medicine	Cobb Creek (Minn.) near Gary, Minn.	3.0
444125096243501	LQP-25	Yellow Medicine	Lazarus Creek near Canby, Minn.	25
444911096270601	LQP-26	Deuel	Monighan Creek near Gary, Minn.	30
444726096274201	LQP-28	Deuel	*West Branch Lac qui Parle River near Gary, So. Dak.	50

Table 1.--*Name and drainage area of reconnaissance-sampling sites*--Continued

USGS station identification number	USACE 639 site number	County	Site name	Drainage area (mi^2)
			LAC QUI PARLE RIVER WATERSHED--Continued	
445108096284501	LQP-29	Deuel	West Branch Lac qui Parle River near Gary, Minn.	2.2
445146096305401	LQP-30	Deuel	Crow Creek near Gary, So. Dak.	10.8
445329096294601	LQP-32	Deuel	Crow Creek tributary near Gary, So. Dak.	10.8
445509096312201	LQP-34	Deuel	Crow Timber Creek near Revillo, So. Dak.	6.5
445600096344301	LQP-38	Deuel	Lost Creek tributary near Revillo, So. Dak.	5.3
445754096332601	LQP-40	Deuel	West Branch Lac qui Parle River near Revillo, So. Dak.	2.8
444900096240000		Lac qui Parle	*Webber impoundment near Gary, So. Dak.	1.4
444900096240002		Lac qui Parle	*Webber inlet near Gary, So. Dak.	1.4
444900096240004		Lac qui Parle	*Webber outlet near Gary, So. Dak.	1.4
443634096281700	LQP-A	Deuel	Fish Lake near Astoria, So. Dak.	approx. 72
444249096234600	LQP-B	Yellow Medicine	Knutson impoundment near Burr, Minn.	---

Table 1.--*Name and drainage area of reconnaissance-sampling sites*--Continued

USGS station identification number	USACE 639 site number	County	Site name	Drainage area (mi^2)
			LAC QUI PARLE RIVER WATERSHED--Continued	
444249096234602		Yellow Medicine	Knutson inlet near Burr, Minn.	---
444506096222400	LQP-C	Yellow Medicine	Full impoundment near Burr, Minn.	---
			YELLOW MEDICINE RIVER WATERSHED	
443330096105301	YM-21	Lincoln	Yellow Medicine River above Wilno, Minn.	61
443203096164001	YM-24	Lincoln	North Branch Yellow Medicine River near Ivanhoe, Minn.	34
443538096140701	YM-25	Lincoln	North Branch Yellow Medicine River near Porter, Minn.	6.4
443617096080101	YM-27	Lincoln	North Branch Yellow Medicine River near Porter, Minn.	2.8

Table 1.--*Name and drainage area of reconnaissance-sampling sites*--Continued

USGS station identification number	USACE 639 site number	County	Site name	Drainage area (mi^2)
			YELLOW MEDICINE RIVER WATERSHED--Continued	
443845096124401	YM-30	Yellow Medicine	Mud Creek tributary near Porter, Minn.	6.4
443752096115601	YM-31	Lincoln	Mud Creek tributary near Porter, Minn.	3.7
443328096053801	YM-34	Lincoln	Yellow Medicine River tributary near Taunton, Minn.	74
443329096040201	YM-35	Lyon	Yellow Medicine River tributary near Taunton, Minn.	4.8
443211096033601	YM-37	Lyon	Yellow Medicine River tributary near Minneota, Minn.	3.5
442826096043001	YM-47	Lyon	South Branch Yellow Medicine River near Arco, Minn.	3.5
442914096004501	YM-50	Lincoln	Yellow Medicine River tributary near Ghent, Minn.	6.9
442909096055901	YM-60	Lincoln	South Branch Yellow Medicine River near Taunton, Minn.	60
443636096095400	YM-23	Lincoln,	*Dillon-Syltie impoundment near Porter, Minn.	4.8
443636096095402		Lincoln,	*Dillon-Syltie inlet near Porter, Minn.	4.78
443636096095404		Lincoln,	*Dillon-Syltie outlet near Porter, Minn.	4.8

Table 1.--*Name and drainage area of reconnaissance-sampling sites*--Continued

USGS station identification number	USACE 639 site number	County	Site name	Drainage area (mi^2)
			YELLOW MEDICINE RIVER WATERSHED--Continued	
443839096120400	YM-A	Yellow Medicine	Tibbetts impoundment near Porter, Minn.	---
443839096120402		Yellow Medicine	Tibbetts inlet near Porter, Minn.	---
443351096073300	YM-B	Lincoln	Van Over Beke impoundment near Minneota, Minn.	---
443606091700001	YM-C	Lincoln	Miller Estate impoundment near Taunton, Minn.	---
			REDWOOD RIVER WATERSHED	
442008096020800	RW-10	Lyon	Coon Creek DNR impoundment near Russell, Minn.	44
442008096020802		Lyon	Coon Creek DNR impoundment inlet near Russell, Minn.	---
441512096074501	RW-17	Lincoln	County ditch 7 near Tyler, Minn.	---
440841096054401	RW-20	Pipestone	Redwood River tributary near Ruthton, Minn.	2.9
441325095595101	RW-22	Lyon	Redwood River near Florence, Minn.	50
442708095573101	RW-30	Lyon	Three Mile Creek tributary near Ghent, Minn.	3.2
442914095563301	RW-31	Lyon	Three Mile Creek tributary near Ghent, Minn.	4.0
442600095523601	RW-37	Lyon	Redwood River tributary near Marshall, Minn.	9.1

Table 1.--*Name and drainage area of reconnaissance-sampling sites*--Continued

USGS station identification number	USACE 639 site number	County	Site name	Drainage area (mi^2)
			REDWOOD RIVER WATERSHED--Continued	
442324095565800	RW-A	Lyon	Banks impoundment near Marshall, Minn.	---
442324095565802		Lyon	Banks inlet near Marshall, Minn.	---
442324095565804		Lyon	Banks outlet near Marshall, Minn.	---
			COTTONWOOD RIVER WATERSHED	
442116095440601	CW-5	Lyon	Meadow Creek tributary near Amiret, Minn.	53
442029095425301	CW-6	Lyon	Meadow Creek tributary near Amiret, Minn.	3.1
442028095414001	CW-7	Lyon	Meadow Creek tributary near Amiret, Minn.	4.1
442158095455001	CW-10	Lyon	Meadow Creek tributary above Lake Marshall near Marshall, Minn.	6.0
441751095415901	CW-16	Lyon	Cottonwood River near Amiret, Minn.	48
441657095354801	CW-19	Lyon	Cottonwood River tributary near Tracy, Minn.	7.2
441421095343101	CW-22	Redwood	Cottonwood River tributary near Tracy, Minn.	3.8
440909095362101	CW-24	Murray	Plum Creek tributary below Robbins slough near Kelly, Minn.	6.1
441228095292101	CW-26	Redwood	Plum Creek near Walnut Grove, Minn.	61

Table 1.--*Name and drainage area of reconnaissance-sampling sites*--Continued

USGS station identification number	USACE 639 site number	County	Site name	Drainage area (mi^2)
			COTTONWOOD RIVER WATERSHED--Continued	
441357095315801	CW-28	Redwood	Plum Creek tributary near Tracy, Minn.	4.5
441146095265801	CW-31	Cotton-wood	Pell Creek near Walnut Grove, Minn.	4.7
441049095242401	CW-33	Cotton-wood	Pell Creek tributary near Revere, Minn.	5.5
441246096274200	CW-27	Redwood	*Lake Laura impoundment near Walnut Grove, Minn.	7.0
441246096274201		Redwood	*Lake Laura south inlet near Walnut Grove, Minn.	5.0
441246096274202		Redwood	*Lake Laura north inlet near Walnut Grove, Minn.	2.0
441246096274204		Redwood	*Lake Laura outlet near Walnut Grove Minn.	17.0
441252095340100	CW-A	Redwood	Drayum impoundment near Tracy, Minn.	---
441252095340102		Redwood	Drayum inlet near Tracy, Minn.	---
441252095340104		Redwood	Drayum outlet near Tracy, Minn.	---
441417095405500	CW-B	Lyon	Kass impoundment near Tracy, Minn.	---
441417095405502		Lyon	Kass Tile inlet near Tracy, Minn.	---
441749095251700	CW-C	Redwood	Knott impoundment near Lamberton, Minn.	---

Table 1.--*Name and drainage area of reconnaissance-sampling sites*--Continued

USGS station identification number	USACE 639 site number	County	Site name	Drainage area (mi^2)
			COTTONWOOD RIVER WATERSHED--Continued	
441749095251702		Redwood	Knott inlet near Lamberton, Minn.	---
444222409551400	CW-D	Lyon	Pagel impoundment near Marshall, Minn.	---
			LOWER COTTONWOOD RIVER WATERSHED	
440907095212901	LCW-10	Cotton-wood	Dutch Charley Creek tributary near Lamberton, Minn.	10.6
440630095212201	LCW-18	Cotton-wood	Dutch Charley Creek near Storden, Minn.	42
05316900	LCW-21	Cotton-wood	*Dry Creek near Jeffers, Minn.	3.13
440538095114101	LCW-22	Cotton-wood	Dry Creek tributary near Jeffers, Minn.	3.2
440814095114501	LCW-25A	Cotton-wood	Dry Creek near Sanborn, Minn.	---
440831095120501	LCW-25B	Cotton-wood	Dry Creek near Sanborn, Minn.	---
440750095052001	LCW-26	Brown	Mound Creek tributary near Sanborn, Minn.	14.0
440720095051501	LCW-27	Brown	Mound Creek near Sanborn, Minn.	13.5

Table 1.--*Name and drainage area of reconnaissance-sampling sites*--Continued

USGS station identification number	USACE 639 site number	County	Site name	Drainage area (mi^2)
			LOWER COTTONWOOD RIVER WATERSHED--Continued	
440839095012601	LCW-28	Brown	Mound Creek tributary near Sanborn, Minn.	3.8
440524095164000	LCW-A	Cotton-wood	Swenson impoundment near Jeffers, Minn.	---
440524095164002		Cotton-wood	Swenson Tile inlet to impoundment near Jeffers, Minn.	---

Table 2.--*General description of intensively sampled sites*

[ft, feet; mi, mile; mi^2, square miles; in., inch; ft^3/s, cubic feet per second; ft/mi, feet per mile]

Site name	General watershed characteristics		
	YELLOW BANK RIVER WATERSHED		
LaBolt impoundment near LaBolt, So. Dak.	Outlet structure - ogee wier width	26.8	ft
	Residual storage volume	36.7	acres
	Surface area at normal pool elev	6.8	acres
	Depth at sampling point (approx)	10	ft
	Length	1,030	ft
	Width	350	ft
LaBolt inlet near LaBolt, So. Dak.	Drainage Area	17.1	mi^2
	Length of main channel	9.8	mi
	Slope	49	ft/mi
	Percent of lakes and swamps	5.4	percent
	Mean annual runoff	2.0	in.
	Peak-flow		
	Estimate of 2-year peak discharge	90	ft^3/s
	Estimate of 5-year peak discharge	206	ft^3/s
	Estimate of 10-year peak discharge	310	ft^3/s
	Estimate of 25-year peak discharge	478	ft^3/s
	Estimate of 100-year peak discharge	784	ft^3/s
	Low-flow		
	Estimate of 7-day 2-year low discharge	0	ft^3/s
	Estimate of 7-day 10-year low discharge	0	ft^3/s
	Land Use		
	Cropland	42	percent
	Pasture	54	percent
	Woods	1	percent
	Other	3	percent
LaBolt outlet near LaBolt, So. Dak.	Drainage area	17.4	mi^2

Table 2.--*General description of intensively sampled sites*--Continued

Site name	General watershed characteristics		
	LAC QUI PARLE RIVER WATERSHED		
Webber impoundment near Gary, So. Dak.	Drainage area	1.4	mi^2
Webber inlet near Gary, So. Dak.	Drainage area	1.4	mi^2
West Branch Lac qui Parle River near Gary, So. Dak.	Drainage area	14.4	mi^2
	Length of main channel	11.7	mi
	Slope	17.6	ft/mi
	Percent of lakes and swamps	7.8	percent
	Mean annual runoff	2	in.
	Peak-flow		
	Estimate of 2-year peak discharge	51	ft^3/s
	Estimate of 5-year peak discharge	115	ft^3/s
	Estimate of 10-year peak discharge	171	ft^3/s
	Estimate of 25-year peak discharge	260	ft^3/s
	Estimate of 100-year peak discharge	419	ft^3/s
	Low-flow		
	Estimate of 7-day 2-year low discharge	0.9	ft^3/s
	Estimate of 7-day 10-year low discharge	0.6	ft^3/s
	Land use		
	Cropland	51	percent
	Pasture	45	percent
	Woodland	1	percent
	Other	3	percent

Table 2.--*General description of intensively sampled sites*--Continued

Site name	General watershed characteristics		
	LAC QUI PARLE RIVER WATERSHED		
Florida Creek near Burr, Minn.	Drainage area	50	mi^2
	Length of main channel	41	mi
	Slope	5.5	ft/mi
	Percent of lakes and swamps	4.8	percent
	Mean annual Runoff	2	in.
	Peak-flow		
	Estimate of 2-year peak discharge	106	ft^3/s
	Estimate of 10-year peak discharge	339	ft^3/s
	Estimate of 25-year peak discharge	506	ft^3/s
	Estimate of 100-year peak discharge	799	ft^3/s
	Low-flow		
	Estimate of 7-day 2-year low discharge	0.6	ft^3/s
	Estimate of 7-day 10-year low discharge	0.2	ft^3/s
	Land use		
	Cropland	67	percent
	Pasture	29	percent
	Woodland	1	percent
	Other	3	percent

Table 2.--*General description of intensively sampled sites*--Continued

Site name	General watershed characteristics		
	LAC QUI PARLE RIVER WATERSHED		
Lac qui Parle River near Canby, Minn.	Drainage area	186	mi^2
	Length of main channel	47	mi
	Slope	10.7	ft/mi
	Percent of Lakes and Swamps	5.6	percent
	Mean annual Runoff	2	in.
	Peak-flow		
	Estimate of 2-year peak discharge	325	ft^3/s
	Estimate of 5-year peak discharge	715	ft^3/s
	Estimate of 10-year peak discharge	1,050	ft^3/s
	Estimate of 25-year peak discharge	1,560	ft^3/s
	Estimate of 100-year peak discharge	2,470	ft^3/s
	Low-flow		
	Estimate of 7-day 2-year low discharge	0	ft^3/s
	Estimate of 10-day 10-year low discharge	0	ft^3/s
	Land use		
	Cropland	75	percent
	Pasture	20	percent
	Woodland	1	percent
	Other	4	percent

Table 2.--*General description of intensively sampled sites*--Continued

Site name	General watershed characteristics		
	YELLOW MEDICINE RIVER WATERSHED		
Dillon-Syltie impoundment near Porter, Minn.	Outlet structure - drop inlet at edge of pool		
	Residual storage volume	117	acre-feet
	Surface area at normal pool elev.	15.5	acres
	Length of shore line	5,300	ft
	Length	1,730	ft
	Width	570	ft
Dillon-Syltie inlet near Porter, Minn.	Drainage area	4.78	mi^2
	Length of main channel	5.55	mi
	Slope	43	ft/mi
	Percent of lakes and swamps	0.5	percent
	Mean annual Runoff	2	in.
	Peak-flow		
	Estimate of 2-year peak discharge	58	ft^3/s
	Estimate of 5-year peak discharge	138	ft^3/s
	Estimate of 10-year peak discharge	210	ft^3/s
	Estimate of 25-year peak discharge	329	ft^3/s
	Estimate of 100-year peak discharge	552	ft^3/s
	Low-flow		
	Estimate of 7-day 2-year low discharge	0	ft^3s
	Estimate of 7-day 10-year low discharge	0	ft^3/s
	Land use		
	Cropland	85	percent
	Pasture	7	percent
	Woodland	3	percent
	Other	5	percent
Dillon-Syltie outlet near Porter, Minn.	Drainage area	4.8	mi^2

Table 2.--*General description of intensively sampled sites*--Continued

Site name	General watershed characteristics	
	COTTONWOOD RIVER WATERSHED	
Lake Laura impoundment near Walnut Grove, Minn.	Outlet structure - tower with drop inlet in pool	
	Residual storage volume.....221	acre-feet
	Length of shore line.....10,800	ft
	Surface area at normal pool elev.....21.3	acres
	Length.....2,480	ft
	Width.....550	ft
	Land use	
	Cropland.....79	percent
	Pasture.....2	percent
	Woodland.....6	percent
	Other.....13	percent
Lake Laura south inlet near Walnut Grove, Minn.	Drainage area.....5.0	mi^2
	Length of main channel.....2.46	mi
	Slope.....32	ft/mi
	Percent of lakes and swamps.....0.2	percent
	Mean annual runoff.....3.5	in.
	Peak-flow	
	Estimate of 2-year peak discharge...109	ft^3/s
	Estimate of 5-year peak discharge...238	ft^3/s
	Estimate of 10-year peak discharge.....350	ft^3/s
	Estimate of 25-year peak discharge.....526	ft^3/s
	Estimate of 100-year peak discharge.....843	ft^3/s
	Low-flow	
	Estimate of 7-day 2-year low discharge.....0	ft^3/s
	Estimate of 7-day 10-year low discharge.....0	ft^3/s

Table 2.--*General description of intensively sampled sites*--Continued

Site name	General watershed characteristics	
	COTTONWOOD RIVER WATERSHED	
Lake Laura north inlet near Walnut Grove, Minn.	Drainage area.....1.12	mi^2
	Length of main channel.....2.5	mi
	Slope.....54	ft/mi
	Percent of lakes and swamps.....0.5	percent
	Mean annual runoff.....3.5	in.
	Peak-flow	
	Estimate of 2-year peak discharge...39	ft^3/s
	Estimate of 5-year peak discharge...86	ft^3/s
	Estimate of 10-year peak discharge.....128	ft^3/s
	Estimate of 25-year peak discharge.....195	ft^3/s
	Estimate of 100-year peak discharge.....317	ft^3/s
	Low-flow	
	Estimate of 7-day 2-year low discharge.....0	ft^3/s
	Estimate of 7-day 10-year low discharge.....0	ft^3/s
Lake Laura outlet near Walnut Grove, Minn.	Drainage area.....6.83	mi^2

Table 2.--*General description of intensively sampled sites*--Continued

Site name	General watershed characteristics		
	LOWER COTTONWOOD RIVER		
Dry Creek near Jeffers, Minn.	Drainage area	3.13	mi^2
	Length of main channel	4.62	mi
	Slope	61.4	ft/mi
	Percent of lakes and swamps	0	percent
	Mean annual runoff	4.0	in.
	Peak-flow		
	Estimate of 2-year peak discharge	127	ft^3/s
	Estimate of 5-year peak discharge	280	ft^3/s
	Estimate of 10-year peak discharge	416	ft^3/s
	Estimate of 25-year peak discharge	802	ft^3/s
	Estimate of 100-year peak discharge	1,000	ft^3/s
	Low-flow		
	Estimate of 7-day 2-year low discharge	0	ft^3/s
	Estimate of 7-day 10-year low discharge	0	ft^3/s
	Land use		
	Cropland	90	percent
	Pasture	5	percent
	Woodland	1	percent
	Other	4	percent

Table 3.--*Type of data collected, 1980-84 water years*

[X indicates stream sites; P indicates impoundment site;--, data not collected]

	Water Years				
	1980	1981	1982	1983	1984
Streamflow	X	X	X	X	X
Suspended sediment					
Daily	---	---	X	X	X
Instantaneous	X	X	X	X	X
Suspended particle size	---	---	X	X	X
Bed-material size	---	---	X	X	X
Vertical profile	P	P	P	P	P
Water temperature	PX	PX	PX	PX	PX
pH	PX	PX	PX	PX	PX
Specific conductance	PX	PX	PX	PX	PX
Dissolved oxygen	PX	PX	PX	PX	PX
Secchi-disk transparency	P	P	P	P	P
Stage	PX	PX	PX	PX	PX
Depth at sampling point	P	P	P	P	P
Air temperature	PX	PX	PX	PX	PX
Barometric pressure	---	---	PX	PX	PX
Phosphorus, total	PX	PX	PX	PX	PX
Dissolved phosphorus	---	---	P	P	P
Dissolved ortho phosphorus	---	---	P	P	P
Nitrite plus nitrate, total	P	P	---	---	---
Ammonia nitrogen, total	P	P	---	---	---
Organic nitrogen, total	P	P	---	---	---
Ammonia plus organic nitrogen, total	P	P	X	X	X
Nitrogen, total	P	P	---	---	---
Dissolved nitrite plus nitrate nitrogen	---	---	PX	PX	PX
Dissolved ammonia nitrogen	---	---	P	P	P
Dissolved ammonia plus organic nitrogen	---	---	P	P	P
Dissolved calcium	---	---	PX	PX	PX
Dissolved magnesium	---	---	PX	PX	PX
Dissolved potassium	---	---	X	X	X

Table 3.--*Type of data collected, 1980-84 water years*--Continued

	Water Years				
	1980	1981	1982	1983	1984
Dissolved silica	---	---	PX	PX	PX
Dissolved sodium	---	---	X	X	X
Dissolved chloride	---	---	PX	PX	PX
Dissolved fluoride	---	---	X	X	X
Dissolved sulfate	---	---	X	X	X
Dissolved suspended solids at 180°C	---	---	PX	PX	PX
Bicarbonate	---	---	PX	PX	PX
Carbonate	---	---	PX	PX	PX
Total alkalinity	---	---	PX	PX	PX
Fecal coliform	---	---	PX	PX	PX
Fecal Streptococci	---	---	PX	PX	PX
Chlorophyll a and b	P	P	P	P	P
Phytoplankton	---	P	P	P	P

Table 4.--*One-time chemical analyses of bed material at impoundments, 1982-83 water years*

[Analyses made for LaBolt, Webber, and Dillon-Syltie impoundments 1982 water year; Analyses made for Lake Laura impoundment 1983 water year]

Phosphorus, total
Nitrite plus nitrate, total
Ammonia, total
Ammonia plus organic nitrogen, total
Arsenic, total
Barium, total recoverable
Beryllium, total recoverable
Cadmium, total recoverable
Chromium, total recoverable
Copper, total recoverable
Iron, total recoverable
Lead, total recoverable
Manganese, total recoverable
Mercury, total recoverable
Nickel, total recoverable
Zinc, total recoverable
Carbon, total organic
Carbon, total inorganic
Cyanide, total
Volatile solids, total

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TABLES OF DATA

Tables given in this section of the report are a compilation of streamflow and water-quality data collected for this study. Mean daily discharge data (5a, 5j, 8a, 9a, 10a, 10j, 11a, 11e, 11n, and 12a), water-quality data (tables 5b, 5f, 5k, 6a, 6c, 7b, 8b, 9b, 10b, 10g, 10k, 11b, 11f, 11k, 11o, and 12b), water-quality-profile data (5f, 6b, 10f, and 11j), and suspended-sediment data 5c, 5m, 7c, 8c, 9c, 10c, 10l, 11c, 11g, 11p, and 12d) are stored in the U.S. Geological Survey WATSTORE system in Reston, Virginia, and on the Minnesota District's Prime Computer. The water-quality data also are stored in the U.S. Environmental Protection Agency STORET system; figures 3-13 present the annual discharge hydrographs and points on the hydrograph when either a composite or instantaneous water-quality sample was collected.

Tables 5a to 13g are on the microfiche.

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