HYDROLOGIC AND SEDIMENTOLOGIC DATA COLLECTED DURING THREE CRUISES ON THE MISSISSIPPI RIVER AND SOME OF ITS TRIBUTARIES FROM MINNEAPOLIS, MINNESOTA, TO NEW ORLEANS, LOUISIANA, JULY 1991–MAY 1992

By JOHN A. MOODY and ROBERT H. MEADE

U.S. GEOLOGICAL SURVEY

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CONVERSION FACTORS

Multiply	*By*	*To obtain*
	Length	
micrometer (µm)	0.00003937	inch
millimeter (mm)	0.03937	inch
centimeter (cm)	0.3937	inch
meter (m)	3.281	foot
kilometer (km)	0.6214	mile
	Area	
square meter (m^2)	10.76	square foot
square kilometer (km^2)	0.3861	square mile
	Volume	
milliliter (mL)	0.03382	ounces, fluid
liter (L)	0.2642	gallon
cubic meter (m^3)	35.31	cubic foot
	Velocity	
centimeter per second (cm/s)	0.03281	foot per second
meter per second (m/s)	3.281	foot per second
kilometer per hour (km/h)	0.6214	mile per hour
	Discharge	
liter per minute (L/min)	0.2642	gallon per minute
cubic meter per second (m^3/s)	35.31	cubic foot per second
cubic meter per year (m^3/yr)	35.31	cubic foot per year
cubic kilometer per year (km^3/yr)	35.31×10^9	cubic foot per year
metric ton per day (metric ton/d)	1.102	short ton per a day
	Mass	
milligram (mg)	0.00003527	ounce, avoirdupois
gram (g)	0.002205	pound, avoirdupois
metric ton	2,205	pound, avoirdupois
	Temperature	
degree Celsius (°C)	F=1.8x°C+32	degree Fahrenheit

HYDROLOGIC AND SEDIMENTOLOGIC DATA COLLECTED DURING THREE CRUISES ON THE MISSISSIPPI RIVER AND SOME OF ITS TRIBUTARIES FROM MINNEAPOLIS, MINNESOTA, TO NEW ORLEANS, LOUISIANA, JULY 1991–MAY 1992

By John A. Moody and Robert H. Meade

ABSTRACT

Bed sediments, water, and suspended-sediment samples were collected and water discharge was measured at 12 sites on the Mississippi River. These sites and 14 sites on tributaries to the Mississippi River were sampled on three cruises during an 11-month period from July 5, 1991, to May 10, 1992. Discharge-weighted pumping and depth-integration methods were used at several equally spaced locations across the river to collect composite samples of river water containing suspended sediment. Water discharge was measured by the depth-integration method and ranged from about 220 cubic meters per second for Mississippi River above St. Anthony Falls, Minnesota, in October 1991 to 21,700 cubic meters per second below Vicksburg, Mississippi, in May 1992. Concentration of suspended sediment in the Mississippi River varied from 9 milligrams per liter downstream from Lake Pepin to 701 milligrams per liter at Thebes, Illinois.

This report contains the following hydrologic data associated with the samples: cross-sectional area of the river, water depths, depth-averaged velocities, water discharge, and temperature, pH, and specific conductance of the surface water. It contains the following sedimentologic data: concentrations of the suspended sand fraction, silt and clay fraction, and colloid fraction, and particle sizes of bed sediment and suspended sediment. These data provide the framework for interpreting subsequent chemical analyses of the water and suspended-sediment samples collected during the three cruises and for calculating bed-load transport in the Mississippi River and some of its tributaries.

INTRODUCTION

The Mississippi River drains about 40 percent of the conterminous United States and commonly is divided into two parts—the Lower Mississippi River and the Upper Mississippi River. Distances on the Lower Mississippi River begin at mile 0.0 where the mouth of the river divides into three separate channels at Head of Passes in Louisiana and increase upstream to the mouth of the Ohio River at Cairo, Illinois (Lower Mississippi River Mile 953.8). Distances on the Upper Mississippi River begin at mile 0.0 at the mouth of the Ohio River and increase upstream to the source of the Mississippi River in Minnesota (fig. 1). The Lower and Upper Mississippi Rivers are very different in their hydrologic character. The Lower Mississippi River is a free-flowing river, whereas about 80 percent of the navigable length of the Upper Mississippi River is controlled by a series of 29 navigation locks and dams creating a stair-step series of navigation pools. The mean annual water discharge of the Mississippi River increases from about 7 km^3/yr near Minneapolis, Minnesota (period of record: 1931–88; U.S. Geological Survey, Minnesota, 1988), to about 500 km^3/yr at Vicksburg, Mississippi (period of record: 1931–91), while the corre-

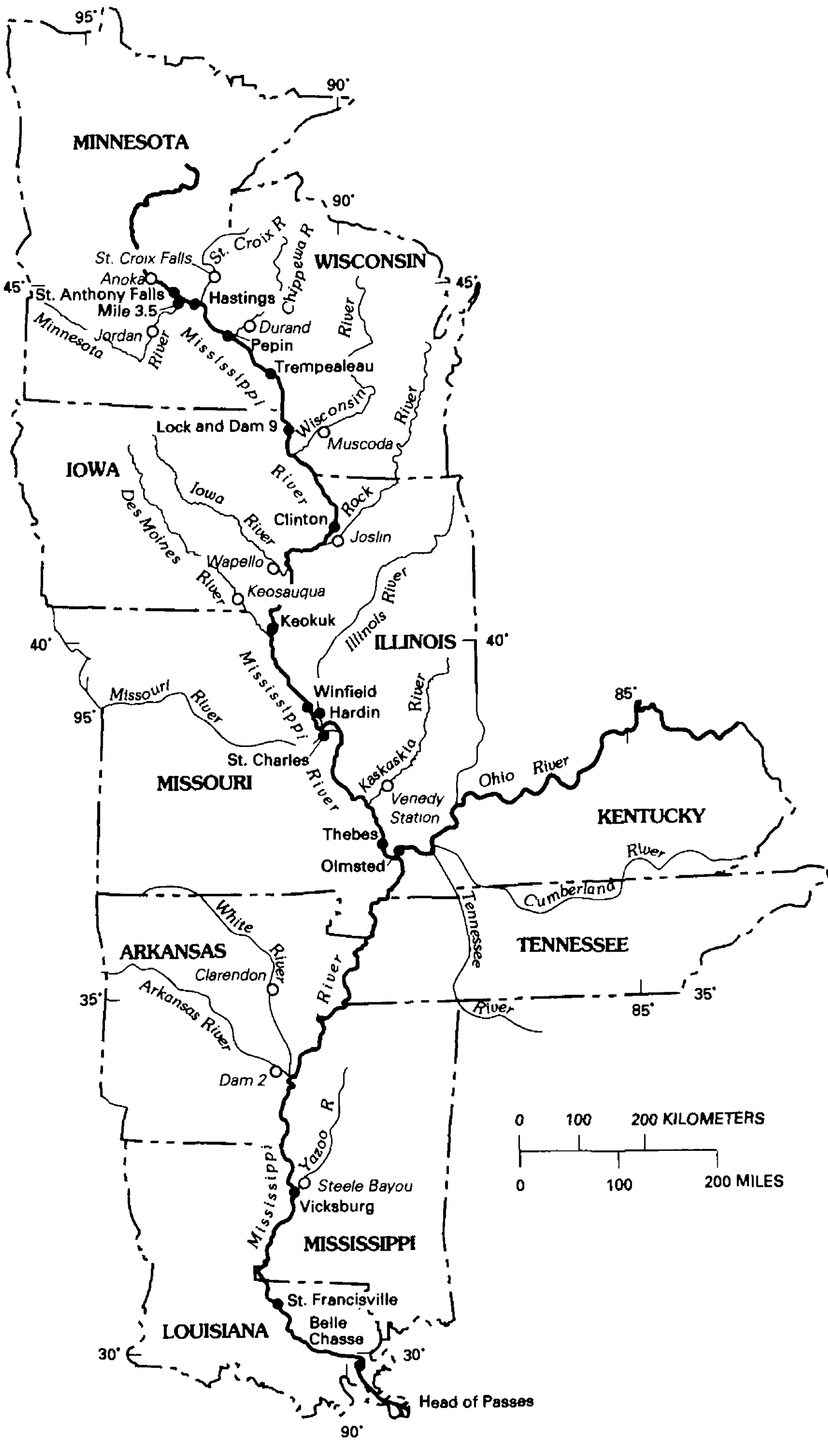

Figure 1.--Mississippi River and some of its tributaries. Sampling sites are shown as solid circles. Other geographical sites are shown as open circles.

sponding sediment discharge increases from about 0.2 x 10^6 metric tons/yr (Keown and others, 1981) to about 200 x 10^6 metric tons/yr (Moody and Meade, 1992). The mean annual water discharge of the Mississippi River more than doubles with the addition of water from the Minnesota and St. Croix Rivers just downstream from Minneapolis, Minnesota (see table 1). The mean annual discharge of the river increases slowly with each tributary input (table 1) until the combined water discharges of the Illinois and Missouri Rivers more than double the discharge of the Upper Mississippi River to about 160 km^3/yr (fig. 2). The addition of water from the Ohio River again doubles the discharge of the Mississippi River, but the contributions of water by the White and Arkansas Rivers (each having discharges two to five times greater than the combined flow of the Minnesota and St. Croix Rivers) only account for about 5 to 8 percent of the discharge of the Lower Mississippi River at Vicksburg, Mississippi. At 191 kilometers downstream from Vicksburg, approximately 25 percent of the water and sediment discharges are diverted from the Mississippi River by the Old River Control Structures into the Atchafalaya River and then into the Gulf of Mexico. The remaining water (375 km^3/yr) and sediment (150 x 10^6 metric tons/yr) are discharged by the Mississippi River directly into the Gulf of Mexico (Moody and Meade, 1992).

The U.S. Geological Survey began a study of the sediment-transported pollutants in the Mississippi River and some of its tributaries in 1987 and made three research cruises at low water in July–August 1987, in November–December 1987, and during the record low water in May–June 1988 (Moody and Meade, 1992). Four cruises were made during high waters in March–April 1989, in June 1989, in February–March 1990, and in May–June 1990 (Moody and Meade, 1993). These cruises started about 50 km upstream from the confluences of the Upper Mississippi-Missouri-Illinois Rivers near St. Louis, Missouri, and ended about 40 km downstream from New Orleans, Louisiana.

The broad objectives of this multidisciplinary study were to investigate the movement, mixing, and storage processes of sediment-associated and dissolved pollutants in the Mississippi River system. Some specific objectives were to:

1. Examine the geochemistry of the suspended silt, clay, and colloidal material, and dissolved phases of river water;
2. Assess the contamination of bed sediments stored in the navigation pools;
3. Understand the compartmentalization of organic and inorganic chemicals among the water, sediment, and biotic phases;
4. Investigate the mixing, partitioning, and redistribution processes of the various pollutants downstream from major river confluences;
5. Understand the movement, storage, and remobilization of suspended sediment and associated pollutants at seasonal or longer time periods; and
6. Predict the location and travel time of water masses and the associated sediment and pollutants.

Table 1.--Drainage area and mean annual discharge for some of the tributaries to the Mississippi River

[Mean annual discharge is given for the gaging station closest to the mouth of the tributary; km^2, square kilometers; km^3/yr; cubic kilometer per year; %, percent]

Tributary	Length of record (years)	Drainege area (km^2)	Mean annual discharge (km^3/yr)	Percent of discharge of Mississippi River downstream from the mouth of the tributary (%)
Minnesota R. near Jordan, Minn.[1]	54	42,000	3.4	34
St. Croix R. at St. Croix Falls, Wis.[1]	86	16,200	3.9	25
Chippewa R. at Durand, Wis.[2]	61	23,300	6.8	27
Wisconsin R. at Muscoda, Wis.[2]	76	26,900	7.8	20
Rock R. near Joslin, Ill.[3]	51	24,700	5.5	11
Iowa R. at Wapello, Iowa[4]	75	32,400	6.2	11
Des Moines R. at Keosauqua, Iowa[4]	80	36,400	5.2	8
Illinois R. at Meredosia, Ill.[5]	51	67,400	19.6	23
Missouri R. at Hermann, Mo.[6]	88	1,358,000	72.0	44
Kaskaskia R. near Venedy Station, Ill.[3]	21	11,400	3.3	2
Ohio R. at Metropolis, Ill.[6]	58	528,300	243.1	57
White R. at Devalls Bluff, Ark.[7]	22	60,700	23.3	5
Arkansas R. at Murray Dam, Ark.[7]	62	409,300	37.4	8
Yazoo R. at Redwood, Miss.[6]	20	35,800	12.3	3
TOTAL			449.8	

[1] U.S. Geological Survey, Water Resources Data for Minnesota, Water Year 1988, volume 2.
[2] U.S. Geological Survey, Water Resources Data for Wisconsin, Water Year 1989.
[3] U.S. Geological Survey, Water Resources Data for Illinois, Water Year 1989, volume 1.
[4] U.S. Geological Survey, Water Resources Data for Iowa, Water Year 1989.
[5] U.S. Geological Survey, Water Resources Data for Illinois, Water Year 1989, volume 2.
[6] Moody and Meade, 1992.
[7] U.S. Geological Survey, Water Resources Data for Arkansas, Water Year 1989.

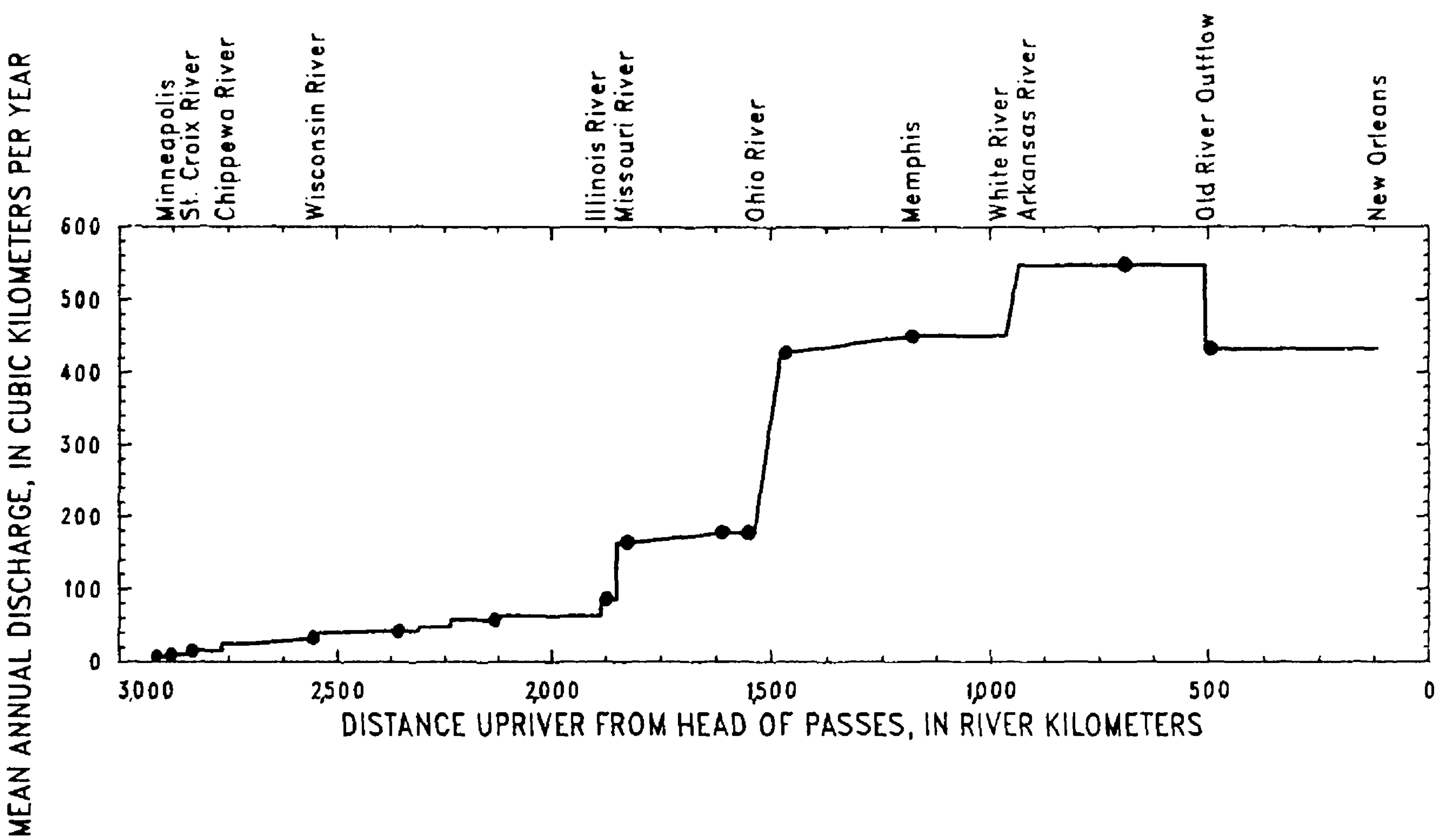

Figure 2. Mean annual discharge of the Mississippi River for period of record prior to 1989. Solid circles are discharge at gaging stations. (Data from U.S. Geological Survey publications: Water-Resources Data for Minnesota, for Iowa, and for Missouri; and from Don Flowers, U.S. Army Corps of Engineers, oral commun., 1992).

Purpose and Scope

The purpose of this report is (1) to describe the sampling procedures used to collect and process bed-sediment samples and a representative water and suspended-sediment sample for physical and chemical analysis, and (2) to publish the hydrologic and sedimentologic data collected during three cruises. The hydrologic data are river width, cross-sectional area of the river, water depths, depth-averaged velocities, and water discharge. The sedimentologic data are concentrations of suspended sand (greater than 63 µm) and silt and clay (finer than 63 µm) and particle-size distributions of the bed sediment and suspended sediment. Temperature, pH, and specific conductance of the surface water are listed in this report, but inorganic and organic chemical data are published elsewhere. The hydrologic data that are published in this report provide some of the necessary framework for interpreting the chemical data.

This report includes data from three cruises that collected samples from sites on the Mississippi River starting at Minneapolis, Minnesota, and ending about 40 km downstream from New Orleans, Louisiana (fig. 1). Samples also were collected from sites within 40 km of the mouths of the following tributaries: Minnesota, St. Croix, Chippewa, Wisconsin, Rock, Iowa, Des Moines, Illinois, Missouri, Kaskaskia, Ohio, White, Arkansas, and Yazoo Rivers. The sampling-site locations for each cruise are listed in table 2. The July–August 1991 cruise (July 5 through August 7, 1991) and the October–November 1991 cruise (October 7 through November 13, 1991) were during periods of relatively low-water discharge, but the April–May 1992 cruise (April 6 through May 10, 1992) was during a period of relatively high discharge on the Mississippi River (figs. 3 and 4).

Table 2.--Sampling sites for July–August 1991 cruise, October–November 1991 cruise, and April–May 1992 cruise

[River miles taken from navigation charts, U.S. Army Corps of Engineers, 1983?, 1986?, 1987a, 1987b, 1989a?, 1989b?, the x designates that the site was sampled]

Sampling site	River mile[1]	July–August 1991	October–November 1991	April–May 1992
Mississippi R. above St. Anthony Falls, Minn.	UM 857.7	x[2]	x	x
Minnesota R. at Mile 3.5, Minn.	MN 3.5	x	x	x
Mississippi R. at Hastings, Minn.	UM 812.2	x	x	x
St. Croix R. at Mile 0.5, Wis.	SC 0.5	x	x	x
Mississippi R. near Pepin, Wis.	UM 764.5	x	x	x
Chippewa R. at Mile 1.7, Wis.	CH 1.7	x	x	x
Mississippi R. at Trempealeau, Wis.	UM 713.8	x	x	x
Mississippi R. below Lock and Dam 9, Wis.	UM 639.7	x	x	x
Wisconsin R. at Mile ~1.0, Wis.	WI 1.0	x	x	x
Mississippi R. at Clinton, Iowa	UM 520.3	x	x	x
Rock R. at Mile ~1.0, Ill.	RK 1.0	x	x	x
Iowa R. at Mile ~1.0, Iowa	IA 1.0	x	x	x
Mississippi R. at Keokuk, Iowa	UM 363.1	x	x	x
Des Moines R. at Mile ~1.0, Iowa	DM 1.0	x	x	x
Mississippi R. near Winfield, Mo.	UM 239.2	x	x	x
Illinois R. at Hardin, Ill.	IL 21.8	x	x	x
Missouri R. at St. Charles, Mo.	MO 24.8	x	x	x[3]
Kaskaskia R. at Mile 1.5, Ill.	KA 1.5	x	x	x
Mississippi R. at Thebes, Ill.	UM 44.0	x	x	x
Ohio R. at Olmsted, Ill.	OH 965.0	x[4]	x	x
White R. at Mile 1.2, Ark.	WH 1.2	x	x	x
Arkansas R. at Mile 0.0, Ark.	AR 0.0	x	x	x
Yazoo R. at Mile ~3.0, Miss.	YZ ~3.0	x	x	x[5]
Mississippi R. below Vicksburg, Miss.	LM 433.4	x	x	x
Mississippi R. near St. Francisville, La.	LM 266.4	x	x	x
Mississippi R. below Belle Chasse, La.	LM 73.1	x[6]	x	x

[1] UM, Upper Mississippi River miles measured upriver from confluence with Ohio River.
LM, Lower Mississippi River miles measured upriver from Head of Passes, Louisiana.
MN, Minnesota River miles measured upriver from confluence with the Upper Mississippi River (UM 844.0).
SC, St. Croix River miles measured upriver from confluence with the Upper Mississippi River (UM 811.3).
CH, Chippewa River miles measured upriver from confluence with the Upper Mississippi River (UM 763.5).
WI, Wisconsin River miles measured upriver from confluence with the Upper Mississippi River (UM 630.6).
RK, Rock River miles measured upriver from confluence with the Upper Mississippi River (UM 479.0).
IA, Iowa River measured upriver from confluence with the Upper Mississippi River (UM 434.0).
DM, Des Moines River measured upriver from confluence with the Upper Mississippi River (UM 361.5).
IL, Illinois River miles measured upriver from confluence with Upper Mississippi River (UM 218.0).
MO, Missouri River miles measured upriver from confluence with Upper Mississippi River (UM 195.3).
KA, Kaskaskia River measured upriver from confluence with the Upper Mississippi River (UM 117.3).
OH, Ohio River miles measured downriver from Pittsburgh, Pennsylvania. Ohio-Mississippi confluence is at Ohio River mile 981.5 and Lower Mississippi River mile 953.8.
WH, White River miles measured upriver from confluence with Lower Mississippi River (LM 598.8).
AR, Arkansas River miles measured upriver from confluence with Lower Mississippi River (LM 581.5).
YZ, Yazoo River miles measured upriver from confluence with Lower Mississippi River (LM 437.2).

[2] Sample was collected at Upper Mississippi River mile 858.3.

[3] Sample was collected at Missouri River mile 29.4.

[4] Sample was collected at Ohio River mile 965.5.

[5] Sample was collected at Yazoo River mile 9.0

[6] Sample was collected at Lower Mississippi River mile 72.8.

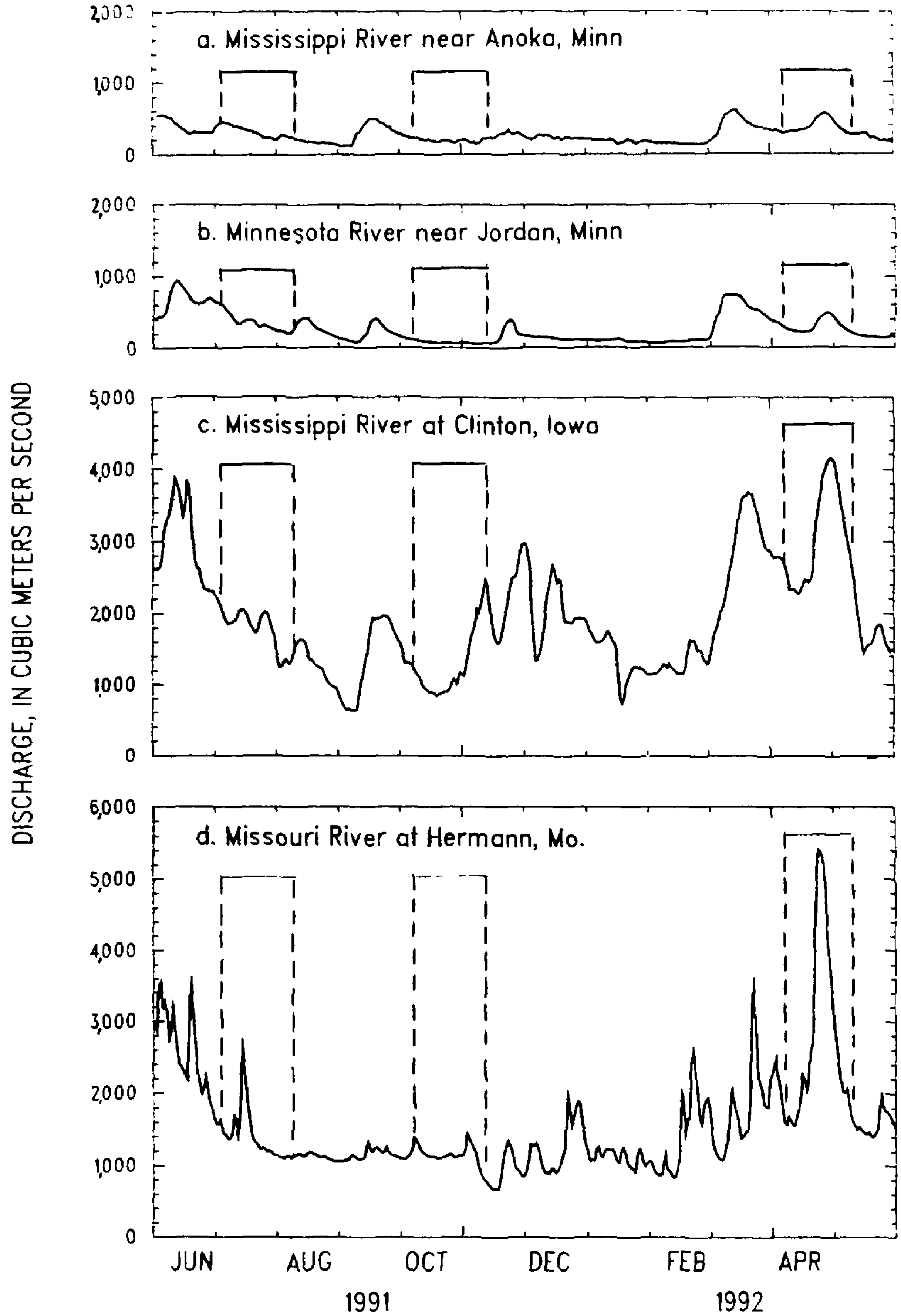

Figure 3.--Water discharge at selected locations upstream from St. Louis, Missouri on the Upper Mississippi River and some of its tributaries from June 1991 through May 1992. The period of time for each cruise is shown by two vertical dashed lines. Discharge data are from the U.S. Geological Survey.
(a) The discharge gaging station at Anoka is about 11 kilometers upstream from the sampling site above St. Anthony Falls, Minnesota. The mean discharge prior to 1989 is about 230 cubic meters per second (U.S. Geological Survey, 1990d);
(b) The discharge gaging station near Jordan is about 63 kilometers upstream from the Mississippi River. The mean discharge prior to 1989 is about 110 cubic meters per second (U.S. Geological Survey, 1990d);
(c) The mean discharge at Clinton prior to 1990 is about 1,400 cubic meters per second (U.S. Geological Survey, 1989); and
(d) The discharge gaging station at Hermann is about 158 kilometers upstream from the Mississippi River. The mean discharge prior to 1990 is about 2,300 cubic meters per second (U.S. Geological Survey, 1990c).

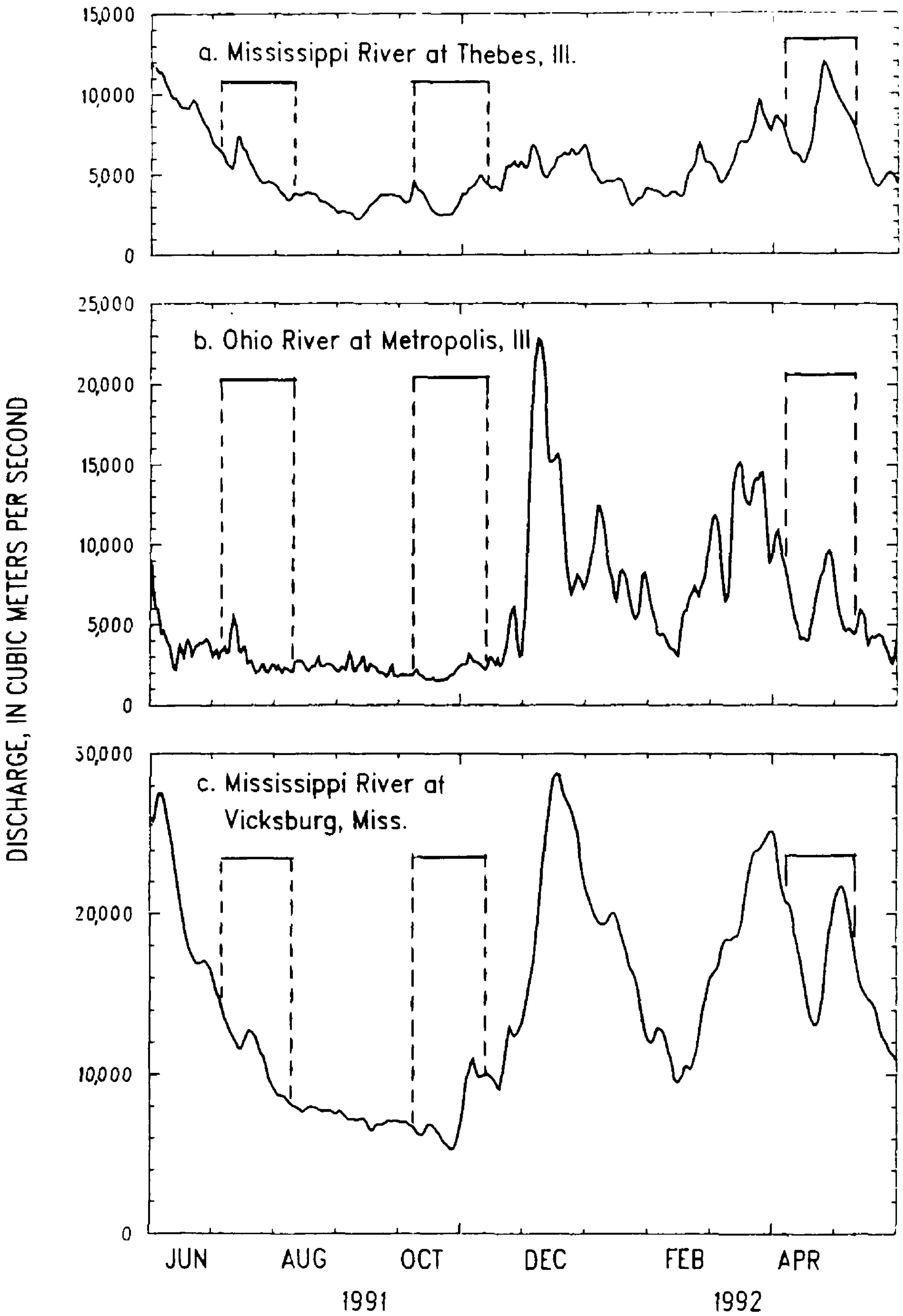

Figure 4.--Water discharge at selected locations downstream from St. Louis, Missouri, on the Upper Mississippi River and some of its tributaries from June 1991 through May 1992. The period of time for each cruise is shown by two vertical dashed lines. Discharge data are from the U.S. Geological Survey, except for the Mississippi River at Vicksburg, Mississippi (Henry Noble, U.S. Army Corps of Engineers, Vicksburg District, written commun., 1992).

(a) The mean discharge at Thebes prior to 1990 is about 5,600 cubic meters per second (U.S. Geological Survey, 1990c);

(b) The discharge gaging station at Metropolis is about 29 kilometers upstream from the sampling site at Olmsted, Illinois. The mean discharge prior to 1990 is about 7,700 cubic meters per second (U.S. Geological Survey, 1990b); and

(c) The mean discharge at Vicksburg prior to 1990 is about 17,400 cubic meters per second.

Acknowledgments

The U.S. Army Corps of Engineers representatives were very accommodating in providing logistic support, overnight docking facilities, and hydrological data. Paul Kornberger, Bill Gretten, and Dennis Erickson ensured that the research vessel was given priority lockage through the 29 locks on the Upper Mississippi River, which allowed the research work to stay on schedule. We wish to especially thank Joe Dvorak, Lockmaster at Lock and Dam No. 1 in Minneapolis, Minnesota, for his help in facilitating crew changes, news conferences, and loading scientific equipment. We also thank James Morgan and the crew at Lock and Dam 15 in Rock Island, Illinois, and Harvey Vance and the crew at Lock and Dam 16 in Muscatine, Iowa, where crew changes, resupply, and repairs were made. Ray Kopsky, St. Louis District; Whit Barton, Memphis District; Henry Noble, Vicksburg District; and Don Flowers with Army Corps Lower Mississippi River Commission, all answered many requests for hydrologic data on short notice.

The U.S. Coast Guard personnel at Keokuk, Iowa, and Hickman, Kentucky, permitted the research vessel to dock for the night and provided supplies.

Dan Helwig and Harold Wiegner, Minnesota Pollution Control Agency, provided assistance in planning the initial cruise, and John Sullivan, Wisconsin Department of Natural Resources, also provided assistance in planning the research as well as logistical support in LaCrosse, Wisconsin. Rick Bensinger, Waterways Journal, helped in finding fuel for the vessel.

The crew of the research vessel ACADIANA--Wayne Simoneaux, Craig LeBoeuf, Bob Cutting, Cheryl Blanchard, George Collier, Wilton Delaune, Mike Detraz, Derral Dupre, Chuck Guidry, and Jonathan Landry--were especially accommodating and showed an unusual interest and concern in maintaining proper scientific operations.

Measuring river discharge or collecting suspended-sediment samples from large rivers is not a two-man operation, and the following people's collaboration was necessary to get the job done: Ron Antweiler, Larry Barber, LaDonna Bishop, Terry Brinton, Greg Brown, Wes Campbell, Gail Chmura, Lesly Conaway, Dolly Dieter, Geoff Ellis, Kathy Fitzgerald, John Garbarino, Don Goolsby, Heidi Hayes, Bob Hirsch, Jim Krest, Jerry Leenheer, Gail Mallard, Dick Martin, Stephanie Monsterleet, Ted Noyes, Dale Peart, Ron Rathbun, Dave Roth, Colleen Rostad, Alan Shiller, Mike Simpson, Charles Tabor, Howard Taylor, Lisa Torick, Woodrow Wang, Wayne Webb, and Jeff Writer.

SAMPLING PROCEDURES AND RESULTS

The onsite sampling procedures were carried out from the 17-m research vessel ACADIANA, owned and operated by the Louisiana Universities Marine Consortium. This vessel was used because it has a shallow draft (about 1.2 m) which permitted samples to be collected close to the river banks. The samples were collected in downstream order from Minneapolis, Minnesota, to New Orleans, Louisiana, during three cruises, but they probably were not collected as close to a Lagrangian sequence as were the samples from the previous seven cruises (Moody and Meade, 1992, 1993; Moody 1993). The procedures consisted of collecting representative samples of bed sediment, water and suspended sediment, and of measuring physical and basic chemical properties of the water. Bed sediments were sampled at three locations across the navigation channel to provide information for velocity, suspended-sediment, and bed-load calculations. Bed sediments also were collected from 15–21 locations in approximately the lower one-third of each navigation pool off the main navigation channel. The sampling strategy, particle-size analysis, and chemical analyses of these bed samples are all reported in a separate U.S. Geological Survey Open-File Report entitled "Hydrologic, sedimentologic, and chemical data describing water and bed sediments in the navigation pools of the Upper Mississippi River, July 1991–April 1992." Suspended sediments were collected at a number of locations or verticals spaced across the river channel by two different methods: (1) discharge-weighted pumping from fixed depths, and (2) depth integration when the water velocity was large enough to flow isokinetically into the sample bottle. For each of the two suspended-sediment sampling methods, the individual samples from each vertical across the river were combined to form two representative samples, which were processed differently—a pumped composite sample and a depth-integrated composite sample. While the depth-integrated sample was being collected, the physical (water depth, depth-integrated or depth-averaged velocity, and surface temperature) and simple chemical (surface pH and surface specific conductance) properties of the water were measured at each location across the river.

This report is basically organized in the order in which the data are needed to investigate the movement, mixing, and storage processes of sediment-associated and dissolved pollutants. The detailed bed-sediment procedures and results are presented first because bed sediments affect velocities, suspended-sediment, and bed-load transport. The water-discharge procedures and results are presented next because this information is needed to compute the flux of suspended sediment and dissolved constituents. Suspended-sediment collecting methods, processing procedures, and results follow the "Water-Discharge" section. Also briefly described are the procedures used for concentrating the suspended sediment finer than 63 µm. These procedures were carried out aboard the ACADIANA to reduce the sample volumes to a manageable size that could be shipped to the laboratory for chemical analyses. This report does not include a description of how each of the numerous chemical subsamples from the pumped and depth-integrated composites were prepared, treated, and processed in the laboratory (see Pereira and others, 1995). The last section describes the procedures for determining the suspended-sediment concentration and particle sizes of both the suspended sand and the suspended silt and clay fractions.

Bed Sediments

A BM–54 sampler (Guy and Norman, 1970, p. 15) was used to collect bed-sediment samples for particle-size analyses. At the beginning of the measurements at each sampling site, while equipment was being set up for the water-discharge measurement and suspended-sediment sampling, the ship drifted downstream and, as it crossed the line of section, a bed-sediment sample was collected. A fathometer (Lowrance, Model X16) was used to obtain a continuous record of depth; at the time each bed sample was taken, a mark was made on this continuous trace of the river bottom. Samples generally were collected at 0.2, 0.5, and 0.8 of the distance between the left and right banks. All particle-size analyses were done at the U.S. Geological Survey sediment laboratory in Iowa, City Iowa. The percent finer than one-half phi sizes (expressed in millimeters) are listed in tables 3, 4, and 5 along with the median diameter determined by straight-line interpolation between appropriate particle sizes listed in tables 3, 4, and 5.

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Table 3.--Particle size of bed sediment collected from the Mississippi River and some of its tributaries for July–August 1991 cruise

[SediGraph method was used for particle sizes finer than 0.032 mm and sieving method was used for particles coarser than 0.032 mm; Analysis was done by U.S. Geological Survey sediment laboratory in Iowa City, Iowa; m, meters; mm, millimeters; –, no measurement]

Date 1991	Location in cross section (fraction of distance between left and right banks)	Depth of water (m)	Percent finer than indicated size in millimeters (mm)																					Median diameter[1] (mm)
			0.001	0.002	0.004	0.008	0.016	0.032	0.063	0.090	0.125	0.180	0.250	0.355	0.50	0.71	1.00	1.41	2.00	4.00	8.00	16.00	32.00	
7-05			Mississippi River above St. Anthony Falls, Minn.																					
	0.2	3.0							0.1	0.2	0.3	0.8	4.5	26.4	58.6	87.0	96.1	98.4	99.5	100.0				0.46
	0.5	4.0							0.1	0.1	0.2	0.3	1.3	12.7	52.3	85.8	95.4	97.7	99.0	99.6	100.0			0.49
	0.8	3.0							0.1	0.1	0.1	0.5	2.9	23.2	64.5	86.9	93.0	95.3	97.2	98.6	99.6	100.0		0.45
7-06			Minnesota River at Mile 3.5, Minn.																					
	0.2	6.0	Bed material was mud—no sample was saved.																					
	0.5	7.0							1.3	1.6	3.5	9.9	63.8	91.4	98.0	99.2	99.5	99.6	99.8	99.8	100.0			0.23
	0.8	5.5	Bed material was mud— no sample was saved.																					
7-08			Mississippi River at Hastings, Minn.																					
	0.2	8.7							0.8	1.4	2.5	4.9	8.3	13.7	23.4	35.3	43.7	48.9	57.6	80.0	97.4	100.0		1.48
	0.5	6.5							0.0	0.1	0.2	0.5	5.3	47.6	88.0	98.6	99.5	99.7	99.8	99.8	100.0			0.36
	0.8	3.5	1.4	2.0	2.8	3.9	5.7	9.5	13.6	20.4	32.3	50.5	66.6	78.7	84.8	90.0	93.5	95.5	96.9	98.9	100.0			0.18
7-10			Mississippi River near Pepin, Wis.																					
	0.2	3.8	A minuscule amount of sand with a few shell fragments.																					
	0.4	4.0	Sand, poorly sorted, with gravel 10–20 mm, and small snail and mussel-shell fragments.																					
	0.8	8.0	Sand, poorly sorted, with gravel 10–20 mm, and small snail and mussel-shell fragments.																					
7-12			Mississippi River at Trempealeau, Wis.																					
	0.2	4.9							0.1	0.2	0.4	1.1	6.0	19.0	43.2	73.5	89.1	94.8	98.6	99.8	100.0			0.55
	0.5	4.3							0.0	0.1	0.1	0.4	3.7	13.7	31.6	59.4	79.3	87.6	94.6	99.4	100.0			0.64
	0.8	7.0							0.1	0.1	0.2	0.8	11.5	54.1	83.9	96.4	98.5	99.0	99.2	99.6	100.0			0.34
7-15			Mississippi River below Lock and Dam 9, Wis.																					
	0.5	6.5							0.2	0.3	0.3	1.1	7.4	48.8	82.1	95.7	98.6	99.3	99.8	100.0	100.0			0.36
7-18			Mississippi River at Clinton, Iowa																					
	0.2	3.5	8.1	9.2	10.5	12.6	16.8	24.6	27.7	–	31.5	–	52.4	–	88.0	–	97.6	99.6	100.0					0.24
	0.5	8.0							2.0	2.3	4.0	11.8	34.3	60.8	82.2	91.3	93.6	94.7	95.7	97.5	100.0			0.31
	0.8	9.4							0.2	0.2	0.3	0.5	2.1	16.8	38.3	59.4	74.3	82.0	90.1	96.1	98.3	100.0		0.62
7-21			Mississippi River at Keokuk, Iowa																					
	0.2	3.2							0.0	0.1	0.2	4.0	29.3	84.0	97.0	99.1	99.5	99.6	99.6	99.7	100.0			0.29
	0.5	4.2							0.3	0.4	0.6	1.0	2.9	11.7	24.6	34.1	37.4	39.1	41.8	48.5	67.4	100.0		4.32

Table 3.--Particle size of bed sediment collected from the Mississippi River and some of its tributaries for July–August 1991 cruise

Date 1991	Location in cross section (fraction of distance between left and right banks)	Depth of water (m)	Percent finer than indicated size in millimeters (mm)																					Median diameter[1] (mm)
			0.001	0.002	0.004	0.008	0.016	0.032	0.063	0.090	0.125	0.180	0.250	0.355	0.50	0.71	1.00	1.41	2.00	4.00	8.00	16.00	32.00	
7-24			Mississippi River near Winfield, Mo.																					
	0.2	8.9								0.0	0.1	0.1	0.2	7.8	34.2	67.0	87.4	94.1	97.7	99.7	100.0			0.60
	0.5	6.0								0.0	0.1	0.5	5.2	20.7	40.5	64.3	79.1	86.4	93.2	97.9	100.0			0.58
	0.8	4.3							0.1	0.2	0.3	1.0	7.9	45.4	73.7	88.9	95.5	97.6	98.8	99.7	100.0			0.38
			Illinois River at Hardin, Ill.																					
			No samples were collected.																					
7-27			Missouri River at St. Charles, Mo.																					
	0.2	4.3								0.0	0.2	3.9	23.8	53.8	67.9	81.1	90.2	94.2	97.4	99.2	100.0			0.34
	0.5	3.7								0.0	0.3	4.4	24.0	48.5	56.8	65.5	75.4	81.6	91.8	97.2	99.6	100.0		0.38
	0.8	3.9								0.0	0.2	2.3	12.5	47.0	75.2	85.0	91.3	94.3	97.0	99.0	99.5	100.0		0.37
7-29			Mississippi River at Thebes, Ill.																					
	0.3	8.3							0.0	0.1	0.1	0.9	2.0	3.3	6.8	18.4	36.8	48.0	60.9	76.3	85.4	100.0		1.50
	0.5	9.0							0.9	1.5	3.1	5.6	11.9	26.5	37.9	46.2	50.4	53.1	57.4	66.2	88.2	92.3	100.0	0.97
	0.8	6.6							0.0	0.1	0.3	2.8	14.5	35.0	67.3	90.6	97.6	98.8	99.5	99.8	100.0			0.42
7-30			Ohio River at Olmsted, Ill.																					
			No samples were collected.																					
8-03			Mississippi River below Vicksburg, Miss.																					
	0.2	12.8							0.1	0.1	0.6	4.6	7.9	13.1	22.0	37.8	54.8	64.7	76.0	88.8	95.4	100.0		0.92
	0.5	10.6							0.1	0.1	0.2	0.5	3.7	28.4	81.4	99.0	99.9	99.9	99.9	100.0				0.41
	0.8	4.0							0.3	0.6	1.0	3.4	18.2	85.2	99.7	99.9	100.0							0.30
8-05			Mississippi River near St. Francisville, La.																					
	0.2	5.5							0.4	0.9	3.9	37.1	97.8	99.8	99.9	100.0								0.19
	0.5	8.6							0.1	0.6	3.0	18.2	84.6	98.9	99.8	99.9	99.9	99.9	100.0					0.21
	0.8	12.5							0.1	0.2	0.2	0.7	2.0	16.8	72.3	98.7	99.7	99.8	99.9	100.0				0.44
8-07			Mississippi River below Belle Chasse, La.																					
	0.2	13.1	3.1	4.0	4.6	5.8	8.1	15.0	20.9	24.7	36.6	78.7	99.3	99.9	99.9	99.9	100.0							0.14
	0.4	16.9							1.4	1.8	6.4	35.7	66.3	91.4	99.2	99.9	100.0							0.21
	0.6	28.6							0.7	1.2	3.1	13.9	39.8	80.0	97.4	99.4	99.6	99.7	99.9	100.0				0.28
	0.7	33.0							0.7	1.2	4.5	17.6	51.6	95.9	99.7	100.0								0.25
	0.8	35.6							Small amount of very fine sand and mud—no sample was saved.															

[1]Median diameter was determined by straight-line interpolation.

Table 4.--Particle size of bed sediment collected from the Mississippi River and some of its tributaries for October–November 1991 cruise

[SediGraph method was used for particle sizes fined than 0.032 mm and sieving method was used for particles coarser than 0.032 mm; Analysis was done by U.S. Geological Survey sediment laboratory in Iowa City, Iowa; m, meters; mm, millimeters; –, no measurement]

Date 1991	Location in cross section (fraction of distance between left and right banks)	Depth of water (m)	Percent finer than indicated size in millimeters (mm) 0.001	0.002	0.004	0.008	0.016	0.032	0.063	0.090	0.125	0.180	0.250	0.355	0.50	0.71	1.00	1.41	2.00	4.00	8.00	16.00	32.00	Median diameter[1] (mm)
									Mississippi River above St. Anthony Falls, Minn.															
									No samples were collected.															
10-08									Minnesota River at Mile 3.5, Minn.															
	0.5	4.8							1.2	2.5	5.5	13.9	83.8	96.7	98.1	98.6	98.9	99.1	99.3	99.8	100.0			0.22
10-10									Mississippi River at Hastings, Minn.															
	0.2	7.5							1.0	1.4	2.6	4.7	9.0	16.0	23.6	34.0	41.9	47.8	56.6	70.3	93.4	10.0		1.56
	0.5	5.2							0.2	0.2	0.3	0.4	2.0	21.7	59.8	84.6	93.3	100.0						0.47
	0.8	3.6							0.8	1.0	1.2	1.7	4.3	17.0	39.5	70.4	87.5	94.7	98.8	99.8	100.0			0.57
10-13									Mississippi River near Pepin, Wis.															
									No bed sediment was collected because on 7-10-91 only shells and gravel were collected.															
10-15									Mississippi River at Trempealeau, Wis.															
	0.2	4.2							0.2	0.2	0.4	1.3	8.4	28.0	53.7	80.5	90.0	92.9	95.5	99.5	100.0			0.48
	0.6	4.0								0.0	0.1	0.2	2.2	12.3	25.6	56.3	82.0	92.8	98.9	100.0				0.67
	0.9	7.6							0.2	0.3	0.8	2.8	14.5	35.4	46.5	59.5	67.4	72.0	78.1	85.2	92.5	95.7	100.0	0.56
10-18									Mississippi River below Lock and Dam 9, Wis.															
	0.2	3.6							0.1	0.3	1.1	7.3	35.4	78.3	97.7	99.8	99.9	100.0						0.29
	0.5	5.9							0.5	0.6	0.8	1.1	2.5	16.9	38.9	70.2	88.1	94.1	98.4	100.0				0.57
	0.8	5.2							Fine gravel and mussel-shell fragments.															
10-22									Mississippi River at Clinton, Iowa															
	0.2	3.9	5.6	7.2	9.2	12.5	17.0	24.2	26.6	–	31.3	–	57.0	–	80.4	–	85.1	–	99.6	100.0				0.22
	0.5	7.1							2.2	2.9	4.7	11.0	29.9	54.1	69.8	79.0	82.2	83.7	85.7	89.3	96.1	100.0		0.34
	0.8	9.0							0.9	1.0	1.1	1.3	4.1	27.9	60.5	86.3	90.9	92.1	93.4	95.3	99.1	100.0		0.45
10-27									Mississippi River at Keokuk, Iowa															
	0.3	3.4							0.5	0.9	1.8	3.1	6.1	17.3	29.1	42.1	47.9	50.6	54.0	59.6	79.0	100.0		1.32
	0.5	3.2							Fine gravel, sand, and shell fragments—sample was too small to save.															
	0.8	4.1							Fine gravel, sand, and shell fragments—sample was too small to save.															
10-30									Mississippi River near Winfield, Mo.															
	0.2	7.5							0.0	0.1	0.1	0.3	1.8	15.0	41.4	76.1	89.5	93.8	97.8	99.8	100.0			0.61
	0.5	5.2							0.0	0.0	0.1	0.3	3.9	19.8	40.8	74.9	90.8	95.1	97.8	99.2	100.0			0.56
	0.7	4.1							1.0	1.3	2.0	3.1	9.0	36.8	67.5	89.0	94.3	95.7	96.7	97.4	99.2	100.0		0.42

Table 4.--Particle size of bed sediment collected from the Mississippi River and some of its tributaries for October–November 1991 cruise--Continued

Date 1991	Location in cross section (fraction of distance between left and right banks)	Depth of water (m)	Percent finer than indicated size in millimeters (mm)																					Median diameter[1] (mm)
			0.001	0.002	0.004	0.008	0.016	0.032	0.063	0.090	0.125	0.180	0.250	0.355	0.50	0.71	1.00	1.41	2.00	4.00	8.00	16.00	32.00	
			Illinois River at Hardin, Ill.																					
			No samples were collected.																					
11-03			Missouri River at St. Charles, Mo.																					
	0.2	4.9								0.0	0.1	1.1	8.9	24.1	38.5	65.9	84.5	91.0	96.8	99.3	100.0			0.59
	0.5	5.0							0.0	0.1	0.8	7.2	42.2	86.1	96.1	98.8	99.5	99.8	100.0					0.27
	0.8	4.5									0.0	0.9	8.6	33.0	58.1	81.2	88.8	91.2	93.4	95.2	96.6	100.0		0.45
11-05			Mississippi River at Thebes, Ill.																					
	0.2	7.6							0.0	0.1	0.1	0.3	0.8	1.6	16.9	60.7	75.2	79.8	85.5	93.3	99.6	100.0		0.66
	0.5	6.6								0.0	0.2	2.2	18.1	67.2	93.9	99.0	99.3	99.3	99.3	99.5	99.7	100.0		0.32
	0.8	4.4								0.0	0.1	0.7	6.6	20.1	47.1	85.1	96.4	98.5	99.6	99.9	100.0			0.52
11-06			Ohio River at Olmsted, Ill.																					
	0.2	3.5	22.2	28.4	36.7	45.6	53.6	57.7	59.2	--	59.6	--	62.0	--	92.6	--	99.5	--	100.0					0.01
	0.2	3.5	Sand layer beneath surface mud.						1.7	2.2	2.8	3.4	6.9	34.4	71.5	92.2	95.8	97.1	98.3	99.5	100.0			0.42
	0.4	6.1							2.6	4.7	7.1	7.9	11.4	33.1	64.6	89.7	94.8	96.4	97.8	99.4	100.0			0.43
	0.5	7.5							0.6	1.8	4.3	4.9	6.0	15.3	36.2	56.4	62.8	65.7	69.7	75.7	81.4	93.6	100.0	0.64
	0.7	7.0							0.0	0.1	0.3	0.4	0.7	3.1	13.4	38.7	54.7	63.0	73.2	85.6	93.9	97.8	100.0	0.91
	0.8	10.0							0.4	0.9	1.7	1.9	3.4	8.1	19.0	44.3	57.8	64.5	72.2	81.1	90.9	94.6	100.0	0.83
11-09			Mississippi River below Vicksburg, Miss.																					
	0.2	13.6							0.1	0.1	0.5	3.2	6.8	9.6	18.4	38.2	53.4	60.0	65.0	69.3	75.2	90.1	100.0	0.94
	0.5	12.2								0.0	0.2	0.8	5.4	43.6	86.8	99.3	99.8	99.9	100.0					0.38
	0.8	3.6							0.2	0.3	0.8	2.8	17.0	83.8	99.6	100.0								0.31
11-11			Mississippi River near St. Francisville, La.																					
	0.2	7.3							0.3	0.9	5.2	39.0	98.1	99.9	100.0									0.19
	0.5	10.2							0.2	0.9	6.4	25.1	86.2	99.2	99.7	99.9	100.0							0.21
	0.8	15.1							0.0	0.1	0.3	1.2	2.4	15.7	63.6	99.2	99.9	100.0						0.46
11-13			Mississippi River below Belle Chasse, La.																					
	0.2	21.0							6.6	8.7	20.3	57.7	76.9	91.9	95.8	97.1	98.2	98.9	100.0					0.17
	0.6	25.0							2.5	3.4	7.7	18.1	34.4	79.4	98.0	99.2	99.5	99.7	99.7	99.8	100.0			0.29
	0.8	23.0	19.6	25.1	31.1	37.9	52.5	79.0	91.4	--	95.8	--	98.1	--	100.0									0.01

[1]Median diameter was determined by straight-line interpolation.

Table 5.--Particle size of bed sediment collected from the Mississippi River and some of its tributaries for April–May 1992 cruise

[Sedigraph method was used for particle sizes finer than 0.032 mm and sieving method was used for particles coarser than 0.032 mm; Analysis was done by U.S. Geological Survey sediment laboratory in Iowa City, Iowa; m, meters; mm, millimeters; –, no measurement]

Date 1992	Location in cross section (fraction of distance between left and right banks)	Depth of water (m)	Percent finer than indicated size in millimeters (mm)																					Median diameter[1] (mm)
			0.001	0.002	0.004	0.008	0.016	0.032	0.063	0.090	0.125	0.180	0.250	0.355	0.50	0.71	1.00	1.41	2.00	4.00	8.00	16.00	32.00	
4-06			Mississippi River above St. Anthony Falls, Minn.																					
	0.2	3.6								0.0	0.1	0.7	3.2	10.3	21.7	44.2	58.2	63.1	65.8	69.1	81.8	96.2	100.0	0.83
	0.5	2.9									0.0	0.2	1.2	7.2	23.5	47.2	65.8	78.4	91.5	98.6	100.0			[2]0.75
	0.8	3.0							0.0	0.2	1.0	4.1	14.2	40.1	62.2	84.0	93.2	96.7	99.4	99.8	100.0			0.42
4-08			Minnesota River at Mile 3.5, Minn.																					
	0.4	5.9							0.5	0.8	2.6	11.3	38.9	55.9	62.3	70.6	76.8	81.2	88.2	95.7	98.3	100.0		0.32
	0.6	6.0							2.5	6.3	25.2	77.8	96.7	98.0	98.5	98.9	99.1	99.6	99.9	100.0				0.15
4-10			Mississippi River at Hastings, Minn.																					
	0.2	7.5							0.3	0.4	1.0	2.5	5.9	12.8	17.9	24.4	29.9	34.2	45.6	75.1	99.1	100.0		2.30
	0.4	6.4							0.2	0.2	0.3	0.4	1.5	12.8	32.0	58.7	75.2	83.9	94.3	99.3	100.0			0.64
	0.8	4.6	2.7	3.9	4.9	6.3	7.8	10.0	11.8	–	15.0	–	39.2	--	74.0	–	90.3	–	97.5	100.0				0.33
4-12			Mississippi River near Pepin, Wis.																					
			No bed sediment was collected because on 7-10-91 only shells and gravel were collected.																					
4-14			Mississippi River at Trempealeau, Wis.																					
	0.2	4.7								0.0	0.1	0.8	10.6	39.8	59.1	79.8	89.1	92.6	96.5	99.1	100.0			0.43
	0.5	4.6									0.0	0.2	3.8	26.1	52.9	81.0	92.5	95.8	98.3	99.9	100.0			0.48
	0.8	6.1								0.0	0.1	0.3	6.2	38.1	67.1	90.2	96.8	98.5	99.4	100.0				0.41
4-17			Mississippi River below Lock and Dam 9, Wis.																					
	0.2	4.5							0.1	0.2	0.8	12.4	51.9	91.8	99.6	100.0								0.25
	0.5	7.0								0.0	0.1	0.1	0.3	3.2	28.3	75.4	99.9	100.0						0.60
	0.8	6.5	Mussel-shell fragments up to 20-30 mm across; sample was not saved.																					
4-19			Mississippi River at Clinton, Iowa																					
	0.3	7.8							0.1	0.1	0.3	1.5	11.4	46.3	73.6	93.6	98.3	99.3	99.9	100.0				0.37
	0.8	10.0							0.1	0.1	0.1	0.2	1.4	14.6	41.9	69.8	83.0	89.0	95.3	99.0	100.0			0.56
4-23			Mississippi River at Keokuk, Iowa																					
	0.2	5.0							0.0	0.2	0.3	0.3	1.2	5.7	26.4	74.8	83.8	86.9	89.6	93.0	99.0	100.0		0.60
	0.5	6.0							0.5	0.5	0.6	0.8	1.6	5.2	10.8	17.9	21.6	23.3	25.7	33.1	56.0	94.2	100.0	7.0

Table 5.--Particle size of bed sediment collected from the Mississippi River and some of its tributaries for April–May 1992 cruise--Continued

Date 1992	Location in cross section (fraction of distance between left and right banks)	Depth of water (m)	Percent finer than indicated size in millimeters (mm)																					Median diameter[1] (mm)
			0.001	0.002	0.004	0.008	0.016	0.032	0.063	0.090	0.125	0.180	0.250	0.355	0.50	0.71	1.00	1.41	2.00	4.00	8.00	16.00	32.00	
4-26			Mississippi River near Winfield, Mo.																					
	0.2	11								0.0	0.1	0.5	4.0	34.3	77.1	96.7	98.6	98.8	98.9	99.0	99.3	100.0		0.41
	0.5	9.2							0.0	0.1	0.2	1.1	7.4	28.9	53.8	73.6	82.0	85.5	89.2	94.2	100.0			0.48
	0.8	6.0							0.0	0.1	0.1	0.5	5.3	40.1	67.0	84.9	93.5	96.3	98.3	99.3	100.0			0.41
4-27			Illinois River at Hardin, Ill.																					
	0.2	3.2	17.4	22.7	29.5	37.7	53.6	83.6	96.6	--	98.8	--	99.8	--	99.8	--	99.8	--	100.0					[3]0.01
4-29			Missouri River at St. Charles, Mo.																					
	0.2	4.5							0.2	0.4	1.2	4.7	18.7	42.0	70.2	91.8	97.6	98.6	99.4	99.8	100.0			[4]0.40
	0.5	8.0							0.0	0.1	0.3	2.0	18.7	31.3	56.4	90.3	98.8	99.6	100.0					0.46
	0.8	7.0								0.0	0.2	0.6	6.5	32.4	61.9	80.2	88.1	90.9	93.8	96.3	98.3	100.0		0.44
5-01			Mississippi River at Thebes, Ill.																					
	0.3	12.5								0.0	0.1	0.4	2.0	6.2	22.3	61.5	82.0	87.9	92.3	96.3	98.8	100.0		0.65
	0.7	11.0								0.0	0.1	0.4	2.6	8.3	35.1	77.5	91.7	94.2	95.6	96.4	98.0	100.0		0.57
			Ohio River at Olmsted, Ill.																					
			No samples were collected.																					
5-06			Mississippi River below Vicksburg, Miss.																					
	0.2	18.0	Pebble jammed BM54; no sample was collected.																					
	0.4	16.5								0.0	0.1	0.6	7.6	30.9	68.6	98.4	99.8	99.9	99.9	99.9	100.0			0.43
	0.6	14.5							0.1	0.1	0.8	6.0	42.8	79.5	98.7	100.0								0.27
	0.8	9.0							0.1	0.1	1.2	8.8	35.8	92.6	100.0									0.28
5-08			Mississippi River near St. Francisville, La.																					
	0.2	12.0							0.2	0.6	3.3	24.9	92.7	99.9	100.0									0.21
	0.5	12.5							0.0	0.1	0.6	7.0	70.1	98.9	99.9	100.0								0.23
	0.8	17.2								0.0	0.2	0.9	12.4	43.9	90.6	99.8	99.9	99.9	100.0					0.37
5-10			Mississippi River below Belle Chasse, La.																					
	0.2	20.5							0.1	0.2	3.1	30.8	98.2	99.9	99.9	100.0								0.20
	0.6	25.5							0.2	0.4	5.4	46.1	80.5	96.5	100.0									0.18
	0.8	23.0							1.0	2.7	17.1	64.9	81.3	94.9	99.3	100.0								0.16

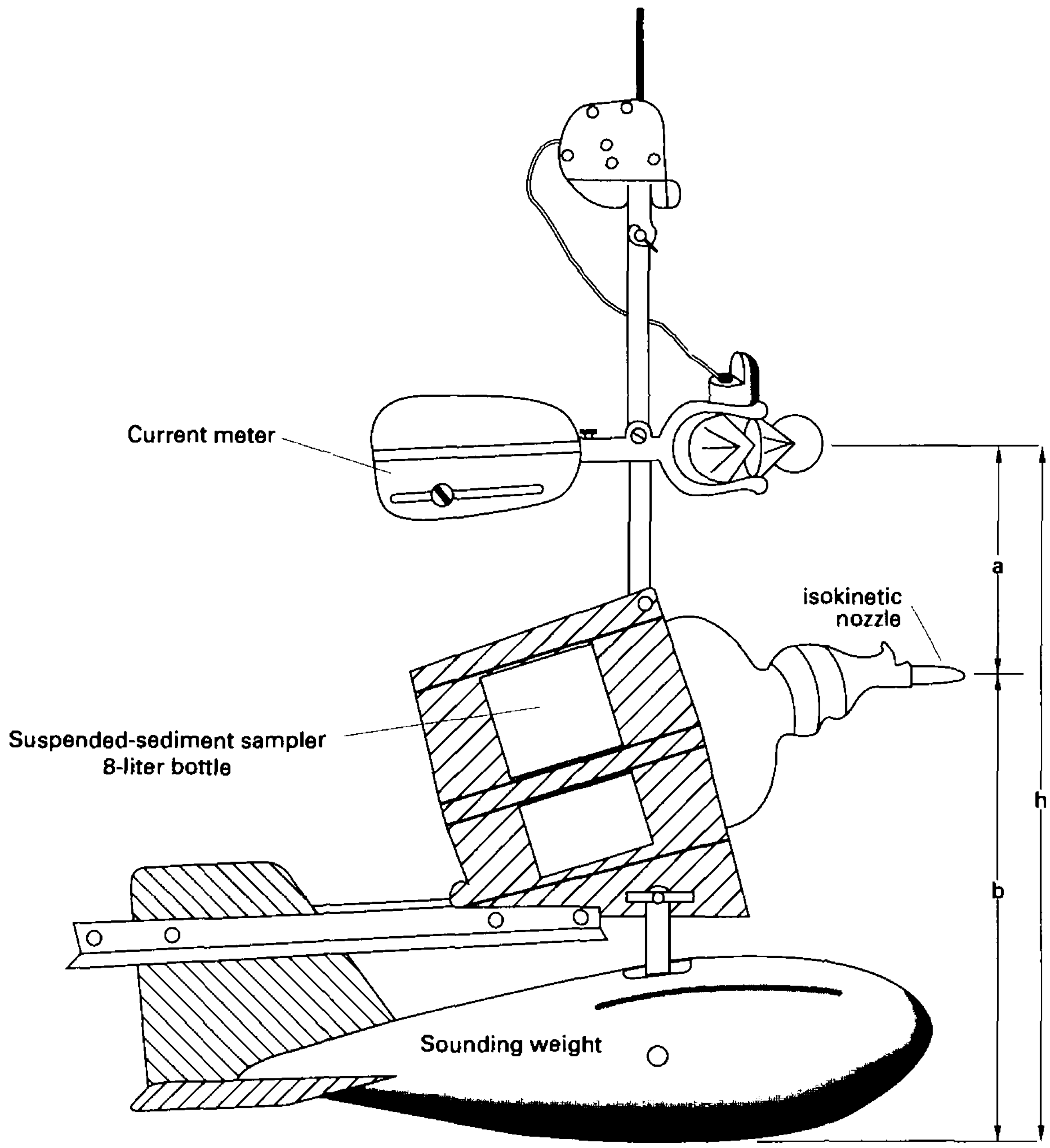
[1]Median diameter was determined by straight-line interpolation.
[2]Sample was split and analyzed twice; differences were less than 1.5 percent for all size categories except for the less than 0.50 mm which was 4.5 percent.
[3]Sample was split and analyzed twice; differences were less than 0.5 percent for all size categories less than 0.063 mm.
[4]Sample was split and analyzed twice; differences were less than 2.4 percent for all size categories.

Water Discharge

The depth-averaged velocity was measured by depth integration from the river bottom to the river surface at several locations (referred to as verticals) across the river. The current meter (Price AA; fig. 5) and suspended-sediment sampler were first lowered to the bottom at a constant transit rate. The depth-averaged velocity was determined only during the upcast when the current meter was not in the turbulent wake of the suspended-sediment sampler bottle. Ideally, for discharge measurements, the transit rate should be as slow as possible and the number of verticals as large as possible so that the integration time is as long as possible. However. at very slow transit rates, the suspended-sediment sampler would overfill. Therefore, the transit rate and number of verticals was determined by the total volume of the composite sample of water and suspended sediment desired (see Nordin and others, 1983), and the transit rate was kept at less than 20 percent of the mean velocity (based on unpublished data from the Amazon River) to obtain a reliable measurement of velocity and, hence, discharge.

Because the ship usually was not anchored during the vertical sampling procedure, the measured velocities were corrected for ship drift according to procedures described by Moody and Troutman (1992). Two microwave transmitter/receiver stations on shore and a master station (Del Norte Technology Trisponder system) aboard the ship were used to measure the change in upriver-downriver and cross-river position. The mean depth was obtained from the fathometer, which produced a continuous strip-chart record of depth during the upcast. The depth-averaged velocity was measured at 4 to 18 equally spaced vertical locations across the river depending upon the width of the river in addition to about 5 measurements made to initially estimate the water discharge (see section titled "Pumped Composite Sample"). These measurements took about 4 hours to complete because extra time was required to repeat some of the depth-integrated water samples and to finish pumping the large water volumes at each vertical.

This method of measuring discharge has associated bias and standard errors, as discussed by Moody and Troutman (1992). Most of the error in the discharge measurement results from errors in measuring the depth-averaged velocity. The major bias is the incomplete depth-integration error (2–5 percent) incurred because the measurement of velocity is started slightly above the bottom (see h in fig. 5). This error can be estimated by assuming a theoretical velocity profile dependent upon the roughness length scale, the water depth, and the height, h, of the unmeasured zone. The major source of standard error comes from the natural variability (which is assumed to be random) of river velocities. The standard error of the natural variability is about 5–12 percent of the mean velocity. Typical standard errors in discharge are between 1 and 2 percent. Because the total discharge is essentially a statistically weighted mean of the random velocities, the total discharge error is reduced by the averaging process. The bias and standard errors have been estimated for each discharge measurement according to the methods discussed by Moody and Troutman (1992) (see tables 6–8). The estimated bias error generally is positive (overestimated) because the velocities in the unmeasured zone near the bottom (where velocities are lowest) have not been included in determining the mean velocity. However, at some sections where only a few verticals can be measured, this positive bias error may be smaller than the negative bias error that results from neglecting the flow between the banks and halfway out to the first or last vertical; thus, the total bias error is negative (for example, see Minnesota River, tables 7 and 8, and Mississippi River at Hastings, Minnesota, in table 7). The standard errors in discharge were 6 percent or less and averaged 3 percent.



WEIGHT, IN POUNDS	DISTANCE, IN CENTIMETERS a	b	h
150	22	42	64
200	22	45	67
300	22	48	70

Figure 5.--Suspended-sediment sampler with current meter. No water velocity is measured in a zone of height, h, above the bottom.

Table 6.--Summary of hydrologic data for the Mississippi River and some of its tributaries for July–August 1991 cruise

[m, meters; m^2, square meters; m/s, meters per second; m^3/s, cubic meters per second; %, percent; NC, not calculated because a different method of measuring discharge was used]

Date	Site name	Width	Cross section area	Mean depth	Mean velocity	Discharge		
						Magnitude	Errors	
							Bias[1]	Standard[2]
1991		(m)	(m^2)	(m)	(m/s)	(m^3/s)	(%)	(%)
7-05	Mississippi R. above St. Anthony Falls, Minn.	200	505	2.5	0.93	470	6	4
7-06	Minnesota R. at Mile 3.5, Minn.	109	565	5.2	1.06	600	4	3
7-08	Mississippi R. at Hastings, Minn.	240	1,290	5.4	0.76	980	7	2
7-10	Mississippi R. near Pepin, Wis.	466	2,140	4.6	0.63	1,350	9	2
7-12	Mississippi R. at Trempealeau, Wis.	435	1,950	4.5	0.74	1,440	6	3
7-15	Mississippi R. below Lock and Dam 9, Wis.	450	2,150	4.8	0.74	1,590	5	2
7-18	Mississippi R. at Clinton, Iowa	480	2,930	6.1	0.63	1,850	5	2
7-21	Mississippi R. at Keokuk, Iowa	773	2,890	3.7	0.71	2,050	6	2
7-24	Mississippi R. near Winfield, Mo.	570	3,410	6.0	0.80	2,730	5	2
7-25	Illinois R. at Hardin, Ill.	286	1,080	3.8	0.24	260	NC	NC
7-27	Missouri R. at St. Charles, Mo.	279	1,040	3.7	1.06	1,100	7	2
7-29	Mississippi R. at Thebes, Ill.	584	3,960	6.8	1.11	4,390	5	2
7-30	Ohio R. at Olmsted, Ill.	780	6,400	8.2	0.38	2,410	6	2
8-03	Mississippi R. below Vicksburg, Miss.	1,176	9,380	8.0	0.93	8,750	5	2
8-05	Mississippi R. near St. Francisville, La.	960	7,800	8.1	0.79	6,190	4	2
8-07	Mississippi R. below Belle Chasse, La.	720	14,450	20.1	0.30	4,340	-2	5

[1]The bias error is the sum of errors resulting from not making velocity measurements within a distance above the bottom equal to the distance from the current meter to the bottom of the sounding weight (positive bias) and from neglecting the flow along the bank (negative bias) for a distance out from the bank equal to one-half of the distance between the first or last vertical and the edge of water.

[2]The standard error is primarily the sum of errors resulting from the velocity variability inherent in the fluid flow of all rivers and the error resulting from using a finite number of verticals to approximate a continuous variation in discharge across a river.

Table 7.—Summary of hydrologic data for the Mississippi River and some of its tributaries for October–November 1991 cruise

[m, meters; m^2, square meters; m/s, meters per second; m^3/s, cubic meters per second; %, percent]

Date 1991	Site name	Width (m)	Cross section area (m^2)	Mean depth (m)	Mean velocity (m/s)	Discharge		
						Magnitude (m^3/s)	Errors	
							Bias[1] (%)	Standard[2] (%)
10-07	Mississippi R. above St. Anthony Falls, Minn.	163	423	2.6	0.52	220	13	5
10-08	Minnesota R. at Mile 3.5, Minn.	103	384	3.7	0.33	130	-2	5
10-10	Mississippi R. at Hastings, Minn.	215	938	4.4	0.37	350	-4	5
10-13	Mississippi R. near Pepin, Wis.	440	1,610	3.7	0.32	510	4	5
10-15	Mississippi R. at Trempealeau, Wis.	430	1,740	4.0	0.38	660	0	4
10-18	Mississippi R. below Lock and Dam 9, Wis.	444	1,720	3.9	0.40	690	-2	5
10-22	Mississippi R. at Clinton, Iowa	450	2,540	5.6	0.37	940	-2	4
10-27	Mississippi R. at Keokuk, Iowa	745	2,200	3.0	0.64	1,410	-2	4
10-30	Mississippi R. near Winfield, Mo.	563	2,630	4.7	0.47	1,230	-1	4
10-31	Illinois R. at Hardin, Ill.	270	1,120	4.1	0.47	520	2	3
11-03	Missouri R. at St. Charles, Mo.	280	1,170	4.2	1.15	1,350	5	3
11-05	Mississippi R. at Thebes, Ill.	590	3,360	5.7	1.15	3,870	5	2
11-06	Ohio R. at Olmsted, Ill.	962	5,810	6.0	0.43	2,480	1	3
11-09	Mississippi R. below Vicksburg, Miss.	1,180	10,630	9.0	1.01	10,700	5	2
11-11	Mississippi R. near St. Francisville, La.	974	9,170	9.4	0.98	8,950	3	2
11-13	Mississippi R. below Belle Chasse, La.	781	15,810	20.2	0.56	8,840	0	4

[1] The bias error is the sum of errors resulting from not making velocity measurements within a distance above the bottom equal to the distance from the current meter to the bottom of the sounding weight (positive bias) and from neglecting the flow along the bank (negative bias) for a distance out from the bank equal to one-half of the distance between the first or last vertical and the edge of water.

[2] The standard error is primarily the sum of errors resulting from the velocity variability inherent in the fluid flow of all rivers and the error resulting from using a finite number of verticals to approximate a continuous variation in discharge across a river.

Table 8.--Summary of hydrologic data for the Mississippi River and some of its tributaries for April–May 1992 cruise

[m, meters; m^2, square meters; m/s, meters per second; m^3/s, cubic meters per second; %, percent; NC, not calculated because a different method of measuring discharge was used]

Date	Site name	Width	Cross section area	Mean depth	Mean velocity	Discharge: Magnitude	Discharge: Errors: Bias[1]	Discharge: Errors: Standard[2]
1992		(m)	(m^2)	(m)	(m/s)	(m^3/s)	(%)	(%)
4-06	Mississippi R. above St. Anthony Falls, Minn.	168	515	3.1	0.60	310	12	3
4-07	Mississippi R. at Mile 844.0, Minn.	145	706	[3]4.9	0.51	360	-3	5
4-08	Minnesota R. at Mile 3.5, Minn.	93	419	4.5	0.62	260	-7	6
4-07	Minnesota R. at Mile 0.0, Minn.	141	411	[3]2.9	0.75	310	-10	6
4-10	Mississippi R. at Hastings, Minn.	225	1,140	5.0	0.50	570	7	3
4-11	St. Croix R. at Mile 0.0, Minn/Wis.	152	994	6.5	0.32	320	NC	NC
4-12	Mississippi R. near Pepin, Wis.	460	1,970	4.3	0.48	950	5	4
4-12	Chippewa R. at Mile 2.0, Wis.	212	317	1.5	0.95	300	NC	NC
4-14	Mississippi R. at Trempealeau, Wis.	428	2,010	4.7	0.66	1,330	6	2
4-17	Mississippi R. below Lock and Dam 9, Wis.	450	2,260	5.0	0.70	1,590	5	2
4-19	Mississippi R. at Clinton, Iowa	475	3,250	6.8	0.71	2,320	5	2
4-23	Mississippi R. at Keokuk, Iowa	790	4,030	5.1	1.05	4,220	5	2
4-26	Mississippi R. near Winfield, Mo.	580	4,560	7.9	1.11	5,070	5	2
4-27	Illinois R.at Hardin, Ill.	277	1,290	4.7	0.66	860	8	3
4-29	Missouri R. at St. Charles, Mo.	415	2,310	5.6	1.54	3,560	5	2
5-01	Mississippi R. at Thebes, Ill.	617	6,320	10.2	1.66	10,500	3	2
5-03	Ohio R. at Olmsted, Ill.	1,012	9,980	9.9	0.62	6,150	2	2
5-06	Mississippi R. below Vicksburg, Miss.	1,213	15,820	13.0	1.37	21,700	3	1
5-08	Mississippi R. near St. Francisville, La.	1,015	12,750	12.6	1.18	15,100	3	2
5-10	Mississippi R. below Belle Chasse, La.	795	16,350	20.6	0.89	14,500	3	2

[1] The bias error is the sum of errors resulting from not making velocity measurements within a distance above the bottom equal to the distance from the current meter to the bottom of the sounding weight (positive bias) and from neglecting the flow along the bank (negative bias) for a distance out from the bank equal to one-half of the distance between the first or last vertical and the edge of water.

[2] The standard error is primarily the sum of errors resulting from the velocity variability inherent in the fluid flow of all rivers and the error resulting from using a finite number of verticals to approximate a continuous variation in discharge across a river.

[3] Mean depth is biased toward shallow depth because only 4–5 equally spaced verticals were used to measure the discharge.

The nearly instantaneous (about 4 hours measurement time) discharge values measured by depth integration on each cruise were compared with the published daily mean discharge values for gaging stations near or at five of the sampling sites (Mississippi River above St. Anthony Falls, Minnesota; at Clinton, Iowa; at Thebes, Illinois; below Vicksburg, Mississippi; and Ohio River at Olmsted, Illinois). The discharges ranged from 220 to 21,700 m^3/s, the 15 differences between the published discharge values and those we measured ranged from -10 to 9 percent. The average depth-integrated discharge was 0.3 percent greater than the published daily mean discharge.

The water discharge of the tributaries (where only surface samples were collected within 2–3 km of the mouth of the St. Croix, Chippewa, Wisconsin, Rock, Iowa, Des Moines, Kaskaskia, White, Arkansas, and Yazoo Rivers) was assumed to be equal to the daily mean discharge for the gaging station closest to the mouth of the tributary for the day the tributary was sampled. The discharges for these tributary sites and the discharges measured by the depth-integration method for the other sampling sites have been summarized for all three cruises in table 9.

Table 9.--Summary of water discharges for the Mississippi River and some of its tributaries for three cruises

[Discharges are for the day the site was sampled which is listed in tables 6-8; River miles are given for the mouth of the tributary; m^3/s, cubic meters per second; --, does not apply]

Mississippi and tributary sites	River miles		Water discharge (m^3/s)		
	Upriver from mouth of Ohio R.	Upriver from Head of Passes	July–August 1991 cruise	October–November 1991 cruise	April–May 1992 cruise
Mississippi R. above St. Anthony Falls, Minn.	857.7	1,811.5	470	220	310
Minnesota R. at Mile 3.5, Minn.	844.0	1,797.8	600	130	[5]260
Mississippi R. at Hastings, Minn.	812.2	1,766.0	980	350	570
St. Croix R. at St. Croix Falls, Wis.[1]	811.3	1,765.1	260	95	[5]320
Mississippi R. near Pepin, Wis.	764.5	1,718.3	1,350	510	950
Chippewa R. at Durand, Wis.[1]	763.5	1,717.3	160	161	[5]300
Mississippi R. at Trempealeau, Wis.	713.8	1,667.6	1,440	660	1,330
Mississippi R. below Lock and Dam 9, Wis.	639.7	1,593.5	1,590	690	1,590
Wisconsin R. at Muscoda, Wis.[1]	630.6	1,584.4	145	161	368
Mississippi R. at Clinton, Iowa	520.3	1,474.1	1,850	940	2,320
Rock R. near Joslin, Ill.[1]	479.0	1,432.8	68	82	337
Iowa R. at Wapello, Iowa[1]	434.0	1,387.8	200	74	685
Mississippi R. at Keokuk, Iowa	363.1	1,316.9	2,050	1,410	4,220
Des Moines R. at Keosauqua, Iowa[1]	361.5	1,315.3	623	39	719
Mississippi R. near Winfield, Mo.	239.2	1,193.0	2,730	1,230	5,070
Illinois R. at Hardin, Ill.	218.0	1,171.8	260	520	860
Missouri R. at St. Charles, Mo.	195.3	1,149.1	1,100	1,350	3,560
Kaskaskia R. near Venedy Station, Ill.[1]	117.3	1,071.1	7	10	31
Mississippi R. at Thebes, Ill.	44.0	997.8	4,390	3,870	10,500
Ohio R. at Olmsted, Ill.	0	953.8	2,410	2,480	6,150
White R. at Clarendon, Ark.[2]	--	598.8	374	1,220	920
Arkansas R. at Dam 2, Ark.[3]	--	581.5	480	1,620	710
Yazoo R. below Steele Bayou, Miss.[4]	--	437.2	640	540	~70
Mississippi R. below Vicksburg, Miss.	--	433.4	8,750	10,700	21,700
Mississippi R. near St. Francisville, La.	--	266.4	6,190	8,950	15,100
Mississippi R. below Belle Chasse, La.	--	73.1	4,340	8,840	14,500

[1]Daily mean discharge based on U.S. Geological Survey discharge for the gaging station closest to the mouth of the tributary.

[2]Discharge provided by U.S. Army Corps of Engineers, Memphis District for White River at Clarendon, Arkansas—about 142 kilometers upstream from the mouth.

[3]Discharge at 0800 hours over Dam 2 on the Arkansas River—approximately 56 kilometers upriver from the mouth.

[4]Discharge is only an estimate based on the measurement of discharge at Redwood, Mississippi, that is closest in time to the sampling date plus discharge at Steele Bayou.

[5]Discharge was measured at the mouth.

Water and Suspended Sediment

Two methods were used for collecting composite water and suspended-sediment samples. One method was the pumping method from fixed depths, which yielded large volumes (about 500–1000L) of water and a representative sample of particles finer than 63 μm (Moody and Meade, 1994). The pumping method also could be used to collect smaller volumes when the water velocity was too slow for using the depth-integration method. The depth-integration method yielded relatively smaller volumes of water but representative samples of both the sand fraction (greater than 63 μm) and the silt and clay fraction (finer than 63 μm) of suspended sediment. This method could not be used to collect a representative sample when the water velocity was less than about 50 cm/s, because the sampling efficiency became unpredictable. Different procedures were used to process the pumped and depth-integrated composite samples after collection.

Pumped Composite Sample

The pumped composite sample was collected by using a 12-mm-diameter, perflourinated-alkoxy (PFA) Teflon tube inside a 12.7-mm-diameter, double-braided stainless-steel hose, which was attached to a 300-pound sounding weight to keep the nozzle directed into the current. A hydraulic winch was used to lower the nozzle and sounding weight at each vertical to a depth of 5 m below the surface or one-half the water depth (whichever was less). Water was pumped from the fixed depth by a double-diaphragm pump (Wilden MI/UP/TF/TF/TF), driven by compressed air and constructed entirely of PFA Teflon, through a 63-μm sieve and into a calibrated funnel (45-L upside-down carboy with no bottom).

The sand that collected in the 63-μm sieve was called the pumped, composite sand sample, and the water and remaining suspended sediment was called the pumped, composite silt, clay, and colloid sample. The volume of river water that was pumped at each vertical was proportional to the estimated fractional water discharge at each vertical. The following steps (described in greater detail by Moody and Meade, 1994) were used to estimate the volume of water to be pumped at each vertical:

1. Determine the depth of each vertical (where water will be pumped) from the continuous strip-chart record of the bottom provided by the fathometer;

2. Measure a few depth-averaged velocities at three to five locations with different depths;

3. Calculate the proportionality constant relating depth-averaged velocity to the depth to the 2/3 power (Manning's formula, Chow, 1959; Sium, 1975; and Sayre and Caro-Cordero, 1977);

4. Interpolate the value of the proportionality constant at verticals (where water will be pumped) between the three to five locations where depth-averaged velocities were measured;

5. Compute the discharge, centered about each vertical, and its fraction of the total discharge; and

6. Calculate the volume to be pumped at each vertical as the fraction of the total discharge at each vertical times the total volume to be pumped.

The total volume of river water collected by the pumping method is listed in table 10 for the July–August 1991 cruise, in table 11 for the October–November 1991 cruise, and in table 12 for the April–May 1992 cruise.

Table 10.--Volumes of river water collected and processed, associated sampling parameters, and percent recovery of suspended sediment for the July–August 1991 cruise

[V_c, total volume collected; V_d, volume centrifuged; V_u, volume ultrafiltered; L, liters; cm/s, centimeters per second; µm, micrometer; %, percent; Integration, depth-integration; Pumped, discharge-weighted pumping from fixed depths; Dipped, surface dip sample at one location; --, dashes mean does not apply]

Date 1991	Site name	Collecting method	Sample volumes: V_c (L)	Sample volumes: V_d (L)	Sample volumes: V_u (L)	Sampling parameters: Number of verticals	Sampling parameters: Nozzle size (inches)	Sampling parameters: Transit rate (cm/s)	Recovery of suspended sediment less than 63 µm[1] (%)
7-05	Mississippi R. above St. Anthony Falls, Minn.	Integration	121.1	101.7	101.7	[2,3]5	5/16	5.0-8.0	62
		Pumped	507	507	240	[2,3]5	--	--	96
7-06	Minnesota R. at Mile 3.5, Minn.	Integration	122.8	101.9	101.9	[2,3]5	1/4-5/16	7.0-17.0	50
		Pumped	526	526	526	[2,3]5	--	--	84
7-08	Mississippi R. at Hastings, Minn.	Integration	109.4	102.1	102.1	8	5/16	11	57
		Pumped	511	511	511	8	--	--	87
7-08	St. Croix R. at Mile 0.5, Wis.	Dipped	42.9	0	41.6	1	--	--	--
7-10	Mississippi R. near Pepin, Wis.	Integration	121.7	112.8	112.8	[3]12	5/16	2.0-8.5	69
		Pumped	509	509	509	[3]12	--	--	98
7-10	Chippewa R. at Mile 1.7, Wis.	Dipped	38.9	0	37.6	1	--	--	--
7-12	Mississippi R. at Trempealeau, Wis.	Integration	126.3	117.8	117.8	8	5/16	7.0	61
		Pumped	717	717	489	8	--	--	80
7-15	Mississippi R. below Lock and Dam 9, Wis.	Integration	133.5	114.1	114.1	9	5/16	7.0	69
		Pumped	603	603	603	9	--	--	88
7-15	Wisconsin R. at Mile ~1.0, Wis.	Dipped	38.6	0	37.3	1	--	--	--
7-18	Mississippi R. at Clinton, Iowa	Integration	126.5	103.8	103.8	9	5/16	8.0	48
		Pumped	974	974	743	9	--	--	87
7-20	Rock R. at Mile ~1.0, Ill.	Dipped	38.9	0	37.6	1	--	--	--
7-20	Iowa R. at Mile ~1.0, Iowa	Dipped	39.6	0	38.3	1	--	--	--
7-21	Mississippi R. at Keokuk, Iowa	Integration	147.5	115.8	115.8	9	5/16	5.0	59
		Pumped	1004	1004	763	9	--	--	86
7-22	Des Moines R. at Mile ~1.0, Iowa	Dipped	39.3	0	38.0	1	--	--	--
7-24	Mississippi R. near Winfield, Mo.	Integration	119.2	100.0	100.0	10	1/4	7.5	47
		Pumped	507	507	507	10	--	--	85
7-25	Illinois R. at Hardin, Ill.	Integration	30.7	0	0	[2]1	None[4]	2.0	--
		Pumped	104	104	104	[2]1	--	--	81
		Pumped	854	854	649	[2]1	--	--	101
7-27	Missouri R. at St. Charles, Mo.	Integration	118.5	94.8	94.8	15	1/4	5.0	49
		Pumped	508	508	508	15	--	--	93

Table 10.--Volumes of river water collected and processed, associated sampling parameters, and percent recovery of suspended sediment for the July–August 1991 cruise--Continued

Date 1991	Site name	Collecting method	Sample volumes V_c (L)	V_d (L)	V_u (L)	Sampling parameters Number of verticals	Nozzle size (inches)	Transit rate (cm/s)	Recovery of suspended sediment less than 63 μm[1] (%)
7-28	Kaskaskia R. at Mile 1.5, Ill.	Dipped	39.9	0	38.7	1	--	--	--
7-29	Mississippi R. at Thebes, Ill.	Integration	115.6	96.5	96.5	15	1/4	10.0	48
		Pumped	611	611	608	15	--	--	88
7-30	Ohio R. at Olmsted, Ill.	Pumped	121.0	103.9	103.9	15	--	--	61
		Pumped	1006	1006	1001	15	--	--	77
8-01	White R. at Mile 1.2, Ark.	Dipped	42.6	0	38.6	1	--	--	--
8-01	Arkansas R. at Mile 0.0, Ark.	Dipped	42.6	0	38.6	1	--	--	--
8-02	Yazoo R. at Mile ~3.0, Miss.	Dipped	42.0	0	38.0	1	--	--	--
8-03	Mississippi R. below Vicksburg, Miss.	Integration	133.7	109.0	109.0	17	3/16	7.0	57
		Pumped	621	621	621	17	--	--	90
8-05	Mississippi R. near St. Francisville, La.	Integration	95.7	82.2	82.2	15	3/16	6.5	64
		Pumped	603	603	603	15	--	--	89
8-07	Mississippi R. below Belle Chasse, La.	Pumped	119.9	113.5	113.5	5	--	--	67
		Pumped	1021	1021	1021	5	--	--	83

[1] See table 13 for total suspended-sediment concentration of silt and clay (<63μm) which was dried at 105–110°C. Data for the integration and small volume pumped samples were provided by John Garbarino. They do not include the sediment trapped in the centrifuge bowl bottom sealing unit; the silt and clay and colloid material were freeze dried. Data for the large volume pumped samples were provided by Colleen Rostad and do include the trapped sediment. The silt and clay were air dried at room temperature (about 23°C) and the colloid material was freeze dried.

[2] Ship anchored at all verticals.

[3] Equal-discharge increments.

[4] The sampling bottle had a cap without the isokinetic nozzle; the intake diameter of the threaded hole in the cap was 1/2 inch.

Table 11.--Volumes of river water collected and processed, associated sampling parameters, and percent recovery of suspended sediment for the October–November 1991 cruise

[V_c, total volume collected; V_d, volume centrifuged; V_u, volume ultrafiltered; L, liters; cm/s, centimeters per second; µm, micrometer; %, percent; Integration, depth-integration; Pumped, discharge-weighted pumping from fixed depths; Dipped, surface dip sample at one location; --, dashes mean does not apply]

Date 1991	Site name	Collecting method	Sample volumes: V_c (L)	Sample volumes: V_d (L)	Sample volumes: V_u (L)	Sampling parameters: Number of verticals	Sampling parameters: Nozzle size (inches)	Sampling parameters: Transit rate (cm/s)	Recovery of suspended sediment less than 63 µm[1] (%)
10-07	Mississippi R. above	Integration	25.6	0	0	[2]5	5/16	2.0	--
	St. Anthony Falls, Minn.	Pumped	120.0	117	117	[2]5	--	--	54
		Pumped	620	620	620	[2]5	--	--	90
10-08	Minnesota R. at	Integration	12.6	0	0	[2]5	5/16	2.0	--
	Mile 3.5, Minn.	Pumped	120.1	117	117	[2]5	--	--	72
		Pumped	759	759	511	[2]5	--	--	94
10-10	Mississippi R. at	Pumped	120.0	114	114	[3]5	--	--	23
	Hastings, Minn.	Pumped	769	769	514	[3]5	--	--	102
10-10	St. Croix R. at Mile 0.5, Wis.	Dipped	42.8	0	40.7	1	--	--	--
10-13	Mississippi R. near	Pumped	120.0	114	114	6	--	--	[4]161
	Pepin, Wis.	Pumped	1201	1201	594	6	--	--	82
10-12	Chippewa R. at Mile 1.7, Wis.	Dipped	42.2	0	38.0	1	--	--	--
10-15	Mississippi R. at	Pumped	120.1	114	114	7	--	--	12
	Trempealeau, Wis.	Pumped	1009	1009	499	7	--	--	87
10-18	Mississippi R. below	Pumped	120.0	114	114	6	--	--	65
	Lock and Dam 9, Wis.	Pumped	1017	1017	757	6	--	--	89
10-19	Wisconsin R. at Mile ~1.0, Wis.	Dipped	42	0	~38	1	--	--	--
10-22	Mississippi R. at	Pumped	120.1	114	114	6	--	--	65
	Clinton, Iowa	Pumped	770	770	531	6	--	--	90
10-24	Rock R. at Mile ~1.0, Ill.	Dipped	42.2	0	38.4	1	--	--	--
10-25	Iowa R. at Mile ~1.0, Iowa	Dipped	42.0	0	38.2	1	--	--	--
10-27	Mississippi R. at	Pumped	120.0	114	114	7	--	--	81
	Keokuk, Iowa	Pumped	1011	1011	505	7	--	--	92
10-28	Des Moines, R. at Mile ~1.0, Iowa	Dipped	42.0	0	38.2	1	--	--	--
10-30	Mississippi R. near	Pumped	120.0	114	114	7	--	--	72
	Winfield, Mo.	Pumped	505	505	505	7	--	--	98
10-31	Illinois R. at	Pumped	120.0	114	114	[2]1	--	--	83
	Hardin, Ill.	Pumped	1000	1000	500	[2]1	--	--	111
11-03	Missouri R. at	Integration	94.3	76.8	76.8	10	1/4	5.0	50
	St. Charles, Mo.	Pumped	498	498	498	10	--	--	89

Table 11.--Volumes of river water collected and processed, associated sampling parameters, and percent recovery of suspended sediment for the October–November 1991 cruise--Continued

Date 1991	Site name	Collecting method	Sample volumes V_c (L)	Sample volumes V_d (L)	Sample volumes V_u (L)	Sampling parameters: Number of verticals	Sampling parameters: Nozzle size (inches)	Sampling parameters: Transit rate (cm/s)	Recovery of suspended sediment less than 63 µm[1] (%)
11-04	Kaskaskia R. at Mile 1.5, Ill.	Dipped	~42	0	40.5	1	--	--	--
11-05	Mississippi R. at Thebes, Ill.	Integration	83.7	66.2	66.2	12	1/4	10.0	35
		Pumped	501	501	501	12	--	--	91
11-06	Ohio R. at Olmsted, Ill.	Pumped	120.0	114	114	11	--	--	39
		Pumped	996	996	500	11	--	--	84
11-08	White R. at Mile 1.2, Ark.	Dipped	41.1	0	37.6	1	--	--	--
11-08	Arkansas R. at Mile 0.0, Ark.	Dipped	41.0	0	37.5	1	--	--	--
11-10	Yazoo R. at Mile ~3.0, Miss.	Dipped	39.8	0	36.3	1	--	--	--
11-09	Mississippi R. below Vicksburg, Miss.	Integration	82.0	64.5	64.5	13	3/16	9.5	39
		Pumped	503	503	503	13	--	--	90
11-11	Mississippi R. near St. Francisville, La.	Integration	83.4	66.9	66.9	12	3/16	7.5	50
		Pumped	501	501	501	12	--	--	85
11-13	Mississippi R. below Belle Chasse, La.	Integration	32.1	0	0	5	1/4	6.0	--
		Pumped	120.0	114	114	5	--	--	67
		Pumped	1000	1000	500	5	--	--	85

[1] See table 14 for total suspended-sediment concentration of silt and clay (<63µm) which was dried at 105–110°C. Data for the integration and small volume pumped samples were provided by John Garbarino. They do not include the sediment trapped in the centrifuge bowl bottom sealing unit; the silt and clay and colloid material were freeze dried. Data for the large volume pumped samples were provided by Colleen Rostad and do include the trapped sediment. The silt and clay were air dried at room temperature (about 23°C) and the colloid material was freeze dried.

[2] Ship anchored at all verticals.

[3] Ship anchored at two verticals.

[4] Data associated with this sample are questionable.

Table 12.--Volumes of river water collected and processed, associated sampling parameters, and percent recovery of suspended sediment for the April–May 1992 cruise

[V_c, total volume collected; V_d, volume centrifuged; V_u, volume ultrafiltered; L, liters; cm/s, centimeters per second; μm, micrometer; %, percent; Integration, depth-integration; Pumped, discharge-weighted pumping from fixed depths; Dipped, surface dip sample at one location; --, does not apply]

Date 1992	Site name	Collecting method	Sample volumes			Sampling parameters			Recovery of suspended sediment less than 63 μm[1] (%)
			V_c (L)	V_d (L)	V_u (L)	Number of verticals	Nozzle size (inches)	Transit rate (cm/s)	
4-06	Mississippi R. above St. Anthony Falls, Minn.	Integration	98.6	92.4	92.4	[2,3]5	5/16	1.0-4.0	50
		Pumped	758	758	758	[2,3]5	--	--	72
4-08	Minnesota R. at Mile 3.5, Minn.	Integration	75.1	56.5	56.5	[2,3]4	5/16	2.5-6.5	69
		Pumped	11.9	0	0	[2,3]4	--	--	--
		Pumped	773	773	773	[2,3]4	--	--	97
4-10	Mississippi R. at Hastings, Minn.	Integration	19.7	0	0	7	5/16	3.0-8.0	--
		Pumped	100.1	98.9	98.9	7	--	--	72
		Pumped	11.9	0	0	7	--	--	--
		Pumped	804	804	420	7	--	--	95
4-11	St. Croix R. at Mile 0.5, Wis.	Dipped	43.2	0	Unmeasured	1	--	--	--
4-12	Mississippi R. near Pepin, Wis.	Pumped	155.2	149.3	149.3	7	--	--	75
		Pumped	1002	1002	413	7	--	--	94
4-12	Chippewa R. at Mile 1.7, Wis.	Dipped	40.3	0	35.9	1	--	--	--
4-14	Mississippi R. at Trempealeau, Wis.	Integration	112.4	105.2	105.2	7	5/16	5.5	56
		Pumped	1001	1001	506	7	--	--	96
4-17	Mississippi R. below Lock and Dam 9, Wis.	Integration	118.4	88.4	88.4	7	5/16	6.0	55
		Pumped	752	752	503	7	--	--	94
4-17	Wisconsin R. at Mile ~1.0, Wis.	Dipped	41.6	0	Unmeasured	1	--	--	--
4-18	Mississippi R. at Clinton, Iowa	Integration	116.4	98.7	98.7	7	1/4	6.0	74
		Pumped	12.6	0	0	7	--	--	--
		Pumped	605	605	500	7	--	--	87
4-20	Rock R. at Mile ~1.0, Ill.	Dipped	41.7	0	Unmeasured	1	--	--	--
4-22	Iowa R. at Mile ~1.0, Iowa	Dipped	40.3	0	Unmeasured	1	--	--	--
4-23	Mississippi R. at Keokuk, Iowa	Integration	67.4	50.1	50.1	7	5/16	8.5	82
		Pumped	12.1	0	0	7	--	--	--
		Pumped	1011	1011	505	7	--	--	50
4-24	Des Moines R. at Mile ~1.0, Iowa	Dipped	40.3	0	Unmeasured	1	--	--	--

Table 12.--Volumes of river water collected and processed, associated sampling parameters, and percent recovery of suspended sediment for the April–May 1992 cruise--Continued

Date 1992	Site name	Collecting method	Sample volumes V_c (L)	V_d (L)	V_u (L)	Sampling parameters Number of verticals	Nozzle size (inches)	Transit rate (cm/s)	Recovery of suspended sediment less than 63 µm[1] (%)
4-26	Mississippi R. near Winfield, Mo.	Integration	83.4	66.3	66.3	10	1/4	11.0	59
		Pumped	12.0	0	0	10	--	--	--
		Pumped	503	503	503	10	--	--	73
4-27	Illinois R. at Hardin, Ill.	Integration	92.4	75.0	75.0	5	5/16	5.0	82
		Pumped	12.1	0	0	5	--	--	--
		Pumped	500	500	500	5	--	--	115
4-29	Missouri R. at St. Charles, Mo.	Integration	48.1	38.7	38.7	8	1/4, 3/16	8.0, 14.0	61
		Pumped	12.1	0	0	8	--	--	--
		Pumped	259	259	259	8	--	--	100
4-30	Kaskaskia R. at Mile 1.5, Ill.	Dipped	41.0	0	37.7	1	--	--	--
5-01	Mississippi R. at Thebes, Ill.	Integration	69.3	56.5	56.5	9	3/16	15.0	53
		Pumped	12.2	0	0	9	--	--	--
		Pumped	501	501	501	9	--	--	99
5-02	Ohio R. at Olmsted, Ill.	Pumped	20.0	0	0	11	--	--	--
		Pumped	120.1	114.2	114.2	11	--	--	64
		Pumped	1001	1001	991	11	--	--	94
5-05	White R. at Mile 1.2, Ark.	Dipped	38.5	0	35.2	1	--	--	--
5-05	Arkansas R. at Mile 0.0, Ark.	Dipped	41.0	0	Unmeasured	1	--	--	--
5-07	Yazoo R. at Mile ~3.0, Miss.	Dipped	42.2	0	Unmeasured	1	--	--	--
5-06	Mississippi R. below Vicksburg, Miss.	Integration	58.9	41.8	41.8	18	1/8	9.0	60
		Pumped	12.0	0	0	9	--	--	--
		Pumped	509	509	509	18	--	--	98
5-08	Mississippi R. near St. Francisville, La.	Integration	60.9	45.2	45.2	16	3/16	13.0	60
		Pumped	12.0	0	0	8	--	--	--
		Pumped	504	504	501	16	--	--	87
5-10	Mississippi R. below Belle Chasse, La.	Integration	65.5	48.0	48.0	7	3/16	13.0	52
		Pumped	12.0	0	0	7	--	--	--
		Pumped	508	508	508	7	--	--	88

[1] See table 15 for total suspended-sediment concentration of silt and clay (<63µm) which was dried at 105–110°C. Data for the integration and small volume pumped samples were provided by John Garbarino. They do not include the sediment trapped in the centrifuge bowl bottom sealing unit; the silt and clay and colloid material were freeze dried. Data for the large volume pumped samples were provided by Colleen Rostad and do include the trapped sediment. The silt and clay were air dried at room temperature (about 23°C) and the colloid material was freeze dried.

[2] Ship anchored at all verticals.

[3] Equal-discharge increments.

The water and suspended-sediment mixture in the funnel was processed by allowing it to drain at 2 L/min into a continuous-flow centrifuge (Sharples, model AS–12; see Leenheer and others, 1989, for more details) spinning at about 16,000 r.p.m. Some sediment was retained on the Teflon centrifuge liner, some sediment was trapped in the centrifuge bowl bottom sealing unit, and some was elutriated from the centrifuge (see Moody and Meade, 1994, for more details). The elutriated water and remaining sediment was processed further by passing it through an ultrafiltration unit with pore sizes of 0.005 μm (Rees and others, 1991). The sediment retained on the Teflon centrifuge liner and the sediment trapped in the sealing unit were combined and called the pumped, composite silt and clay samples. This sample usually was extracted from a water volume of 500 to 1000L and was used for organic contaminant analyses. At some sampling sites, a smaller volume of elutriated water and sediment was processed through the ultrafiltration unit than was processed through the centrifuge in order to reduce the processing time. The volume was based on the nature of the colloidal material and previous experience. The sediment retained on the membranes of the ultrafilter was called the pumped, composite colloid sample. The total mass of silt and clay and colloid material that was recovered is listed in table 10 for the July–August 1991 cruise, in table 11 for the October–November 1991 cruise, and in table 12 for the April–May 1992 cruise as a percent of the suspended silt and clay concentration (<63μm) listed in tables 13–15.

Table 13.--Concentrations of suspended sediment in composite samples collected from the Mississippi River and some of its tributaries and the corresponding sediment discharges for July–August 1991 cruise

[A and B are depth-integrated composites; P, pump composite collected when the water velocities were too slow for collecting a depth-integrated composite; Total sediment concentration of composites A and B were averaged in order to calculate a single value of sediment discharge; m ³/s, cubic meters per second; mg/L, milligrams per liter; µm, micrometers; Analyses by R.H. Meade. Water discharge calculated by J.A. Moody]

Date 1991	Site name	Composite	Number of verticals[1]	Water discharge (m^3/s)	Sediment concentration (mg/L)			Sediment discharge (metric tons/day)		
					Silt and clay <63µm	Sand >63µm	Total	Silt and clay <63µm	Sand >63µm	Total
7-05	Mississippi R. above	A	[2]5	470	30	2	32	1,200	80	1,300
	St. Anthony Falls, Minn.	B	[2]5		31	2	33			
7-06	Minnesota R. at	A	[2]5	600	103	71	174	5,340	3,680	9,020
	Mile 3.5, Minn.	B	[2]5		103	71	174			
7-08	Mississippi R. at	A	[3]8	980	82	0.3	82	6,940	30	6,970
	Hastings, Minn.	B	[3]8		83	0.3	83			
7-10	Mississippi R. near	A	12	1,350	9	[4]0	9	1,000	0	1,000
	Pepin, Wis.	B	12		9	[4]0	9			
7-12	Mississippi R. at	A	[3]8	1,440	28	[4]0	28	3,500	0	3,500
	Trempealeau, Wis.	B	[3]8		28	[4]0	28			
7-15	Mississippi R. below	A	[3]9	1,590	72	0.2	72	10,000	30	10,000
	Lock and Dam 9, Wis.	B	[3]9		74	0.2	74			
7-18	Mississippi R. at	A	[3]9	1,850	68	[5]<0.1	68	10,500	<16	10,500
	Clinton, Iowa	B	[3]9		65		65			
7-21	Mississippi R. at	A	[3]9	2,050	46	[4]0	46	8,000	0	8,000
	Keokuk, Iowa	B	[3]9		44	[4]0	44			
7-24	Mississippi R. near	A	[3]10	2,730	74	0.2	74	17,500	50	17,500
	Winfield, Mo.	B	[3]10		74	0.2	74			
7-25	Illinois R. at	P	1	260	47	[4]0	47	1,100	0	1,100
	Hardin, Ill.									
7-27	Missouri R. at	A	15	1,100	109	31	140	10,300	2,900	13,200
	St. Charles, Mo.	B	15		108	31	139			
7-29	Mississippi R. at	A	15	4,390	82	24	106	31,100	8,700	39,800
	Thebes, Ill.	B	15		83	22	105			
7-30	Ohio R. at	P	15	2,410	22	[4]0	22	4,600	0	4,600
	Olmsted, Ill.									
8-03	Mississippi R. below	A	17	8,750	105	2.7	108	81,600	2,300	83,900
	Vicksburg, Miss.	B	17		111	3.3	114			
8-05	Mississippi R. near	A	15	6,190	111	4.2	115	59,900	2,300	62,200
	St. Francisville, La.	B	15		113	4.4	117			
8-07	Mississippi R. below	P	5	4,340	42	0	42	16,000	0	16,000
	Belle Chasse, La.									

[1]The A and B samples were collected at the same locations.
[2]A and B sample bottles were both lowered three times at each vertical.
[3]A and B sample bottles were both lowered twice at each vertical.
[4]Visual estimates.
[5]Sand in A and B composite were combined to give one value listed opposite composite A.

Table 14.--Concentrations of suspended sediment in composite samples collected from the Mississippi River and some of its tributaries and the corresponding sediment discharges for October–November 1991 cruise

[A and B are depth-integrated composites; P, pump composite collected when the water velocities were too slow for collecting a depth-integrated composite; Total sediment concentration of composites A and B were averaged in order to calculate a single value of sediment discharge; m^3/s, cubic meters per second; mg/L, milligrams per liter; µm, micrometers; Analyses by R.H. Meade. Water discharge measured by J.A. Moody]

Date 1991	Site name	Composite	Number of verticals[1]	Water discharge (m^3/s)	Sediment concentration (mg/L)			Sediment discharge (metric tons/day)		
					Silt and clay <63µm	Sand >63µm	Total	Silt and clay <63µm	Sand >63µm	Total
10-07	Mississippi R. above St. Anthony Falls, Minn.	A	5	220	12	0.1	12	230	2	230
10-08	Minnesota R. at Mile 3.5, Minn.	A	5	130	61	0.1	61	690	1	690
		P	5		62	no sample	62			
10-10	Mississippi R. at Hastings, Minn.	P	5	350	45	<0.1	45	1,400	<3	1,400
10-13	Mississippi R. near Pepin, Wis.	P	6	510	9	~0	9	400	~0	400
10-15	Mississippi R. at Trempealeau, Wis.	P	7	660	12	<0.1	12	680	<6	680
10-18	Mississippi R. below Lock and Dam 9, Wis.	P	6	690	28	<0.1	28	1,700	<6	1,700
10-22	Mississippi R. at Clinton, Iowa	P	6	940	31	<0.1	31	2,500	<8	2,500
10-27	Mississippi R. at Keokuk, Iowa	P	7	1,410	32	<0.1	32	3,900	<10	3,900
10-30	Mississippi R. near Winfield, Mo.	P	7	1,230	36	<0.1	36	3,800	<10	3,800
10-31	Illinois R. at Hardin, Ill.	P	1	520	143	0.1	143	6,420	4	6,420
11-03	Missouri R. at St. Charles, Mo.	A	10	1,350	164	145	309	19,000	16,800	35,800
		B	10		162	142	304			
11-05	Mississippi R. at Thebes, Ill.	A	12	3,870	81	68	149	26,700	20,100	46,800
		B	12		79	52	131			
11-06	Ohio R. at Olmsted, Ill.	P	11	2,480	19	0.6	20	4,100	130	4,200
11-09	Mississippi R. below Vicksburg, Miss.	A	13	10,700	155	27	182	142,000	26,000	168,000
		B	13		152	30	182			
11-11	Mississippi R. near St. Francisville, La.	A	12	8,950	173	36	209	133,000	28,000	161,000
		B	12		172	37	209			
11-13	Mississippi R. below Belle Chasse, La.	A	5	8,840	142	0.1	142	108,000	80	108,000
		P	5	8,840	112	0.1	112	85,500	80	85,600

[1] The A and B samples were collected at the same locations.

Table 15.–Concentrations of suspended sediment in composite samples collected from the Mississippi River and some of its tributaries and the corresponding sediment discharges for April–May 1992 cruise

[A and B are depth-integrated composites; P, pump composite collected when the water velocities were too slow for collecting a depth-integrated composite; Total sediment concentration of composites A and B were averaged in order to calculate a single value of sediment discharge; m^3/s, cubic meters per second; mg/L, milligrams per liter; µm, micrometer; Analyses by R.H. Meade. Water discharge calculated by J.A. Moody]

Date 1992	Site name	Composite	Number of verticals[1]	Water discharge (m^3/s)	Sediment concentration (mg/L)			Sediment discharge (metric tons/day)		
					Silt and clay <63µm	Sand >63µm	Total	Silt and clay <63µm	Sand >63µm	Total
4-06	Mississippi R. above	A	[2]5	310	12	1.3	13	320	32	350
	St. Anthony Falls, Minn.	B	[2]5		12	1.2	13			
4-08	Minnesota R. at	A	[3]4	260	95	10.5	105	2,160	230	2,390
	Mile 3.5, Minn.	B	[3]4		97	10.3	107			
4-10	Mississippi R. at Hastings, Minn.	A	7	570	36	<0.1	36	1,800	<5	1,800
4-12	Mississippi R. near Pepin, Wis.	P	7	950	12	[4]0	12	980	0	980
4-14	Mississippi R. at	A	[3]7	1,330	15	0.1	15	1,600	10	1,600
	Trempealeau, Wis.	B	[3]7		14		14			
4-17	Mississippi R. below	A	[3]7	1,590	24	0.2	24	3,300	30	3,300
	Lock and Dam 9, Wis.	B	[3]7		24	0.3	24			
4-19	Mississippi R. at	A	[3]8	2,320	40	0.1	40	8,000	20	8,000
	Clinton, Iowa	B	[3]8		40	0.1	40			
4-23	Mississippi R. at	A	7	4,220	298	0.2	298	109,000	90	109,000
	Keokuk, Iowa	B	7		300	0.3	300			
4-26	Mississippi R. near	A	10	5,070	295	15	310	128,000	7,000	135,000
	Winfield, Mo.	B	10		291	16	307			
4-27	Illinois R. at	A	[3]5	860	235	0.3	235	17,100	30	17,100
	Hardin, Ill.	B	[3]5		225	0.4	225			
4-29	Missouri R. at	A	8	3,560	1,180	169	1,349	363,000	55,400	418,000
	St. Charles, Mo.	B	8		1,180	192	1,372			
5-01	Mississippi R. at	A	9	10,500	591	113	704	544,000	90,700	635,000
	Thebes, Ill.	B	9		610	88	698			
5-03	Ohio R. at Olmsted, Ill.	P	11	6,150	67	0.3	67	35,600	200	35,800
5-06	Mississippi R. below	A	[5]9	21,700	296	55	351	562,000	109,000	671,000
	Vicksburg, Miss.	B	[5]9		304	61	365			
5-08	Mississippi R. near	A	[5]8	15,100	297	38	335	387,000	50,000	437,000
	St. Francisville, La.	B	[5]8		297	38	335			
5-10	Mississippi R. below	A	7	14,500	300	9	309	378,000	10,000	388,000
	Belle Chasse, La.	B	7		305	8	313			

[1] The A and B samples were collected at the same locations.

[2] A and B sample bottles were lowered different numbers of times at different verticals to obtain equal-discharge-increment sample.

[3] A and B sample bottles were both lowered twice at each vertical.

[4] Visual estimate.

[5] The A and B samples were collected at different locations.

Depth-Integrated Composite Sample

The equal-width-increment (equal-transit-rate), depth-integration method (Nordin and others, 1983; Richey and others, 1986; Meade and Stevens, 1990) was used to collect a depth-integrated composite sample of water and suspended sediment from 1 to 18 vertical locations across the river. A collapsible-bag sampler (Stevens and others, 1980) fitted with an isokinetic nozzle (Guy and Norman, 1970, p. 8–10) collected suspended sediment in sand, silt, and clay sizes (see tables 10, 11, and 12 for nozzle sizes). The sampler was held in a frame so that the nozzle was horizontal, faced into the current, and was about 45 cm above the bottom of a sounding weight (fig. 5). A Price AA current meter was mounted 22 cm above the nozzle of the sampler. The current meter was used to measure the depth-averaged velocity and to determine the nozzle efficiency (volume of water collected divided by the mean velocity, the cross-sectional area of the nozzle, and the integration time). The vertical transit rate was controlled by a hydraulic winch, which produced a constant transit rate for the downcast and for the upcast. The multiple gears on the hydraulic system allowed transit rates as slow as 2 cm/s and as fast as 17 cm/s. The same transit rate was reproduced within 1 cm/s for each vertical across the river and was verified with a hand-held tachometer at the beginning of each downcast and at the beginning of each upcast.

Two 8-L plastic bottles, identified as A and B, with collapsible, perflourinated-alkoxy (PFA) Teflon bags and fluorinated-ethylene-propylene (FEP) Teflon nozzles were used in the isokinetic sampler to collect individual samples at alternate verticals, which were combined into two separate, depth-integrated, composite samples. During previous cruises summarized earlier (Moody and Meade, 1992, 1993), bottle A was used to collect samples at the odd-numbered verticals and bottle B at the even-numbered verticals. However, during the cruises of 1991–92 reported here, both bottles usually were used to collect samples at the same vertical, and at some sites they were used repeatedly at the same vertical in order to obtain the necessary volume. The A and B samples were poured into separate glass, graduated cylinders through separate, nickel-mesh, 63-µm sieves to remove the sand. This sand was saved and called the depth-integrated, composite sand sample. The water volume collected at each individual vertical was measured and then composited in one of two separate Teflon-coated, stainless-steel, churn splitters labeled A and B (see tables 10, 11, and 12 for total volume of water collected). The only significant difference between these procedures and those described for the low-water cruises by Leenheer and others (1989) and Moody and Meade (1992) is the substitution of the stronger, but less flexible, PFA Teflon bags for the previously used FEP Teflon bags. Leenheer and others (1989) describe the Teflon bags, nickel sieves, and churn splitters in more detail and discuss the evaluation of materials considered for the fabrication of each item so they would meet the diverse requirements for suspended-sediment, trace-organic, and trace-element analysis.

The remaining water and suspended sediment was processed further by keeping the suspended sediment in suspension by churning, and different-sized subsamples were taken from the A and B churn splitters for determining suspended-sediment concentration (150–250 mL) and particle-size distribution (4–24 L) and for analysis of major ions, trace elements, organic compounds, and nutrients. The remaining water and suspended sediment in the A and B churn splitters was combined and processed through the continuous-flow centrifuge described earlier. The sediment retained on the Teflon centrifuge liner was saved for trace-element analyses and called the depth-integrated, composite silt and clay sample. The sediment trapped on the centrifuge bowl bottom sealing unit may have been contaminated by coming in contact with metal parts which were not coated with Teflon. Therefore, this trapped sediment was not combined with the sediment from the Teflon centrifuge liner as was done for the pumped, composite silt and clay samples but was saved as a separate sample called the reject sample. The water and sediment elutriated from the centrifuge was processed further by ultrafiltration to obtain a depth-integrated colloid sample. The total mass of silt and clay (which does not include the trapped sediment) and colloid material recovered is listed in tables 10–12 as a percent of the suspended silt and clay concentration (<63μm) listed in tables 13–15. A generalized flow diagram for processing the depth-integrated composite sample is shown in figure 6.

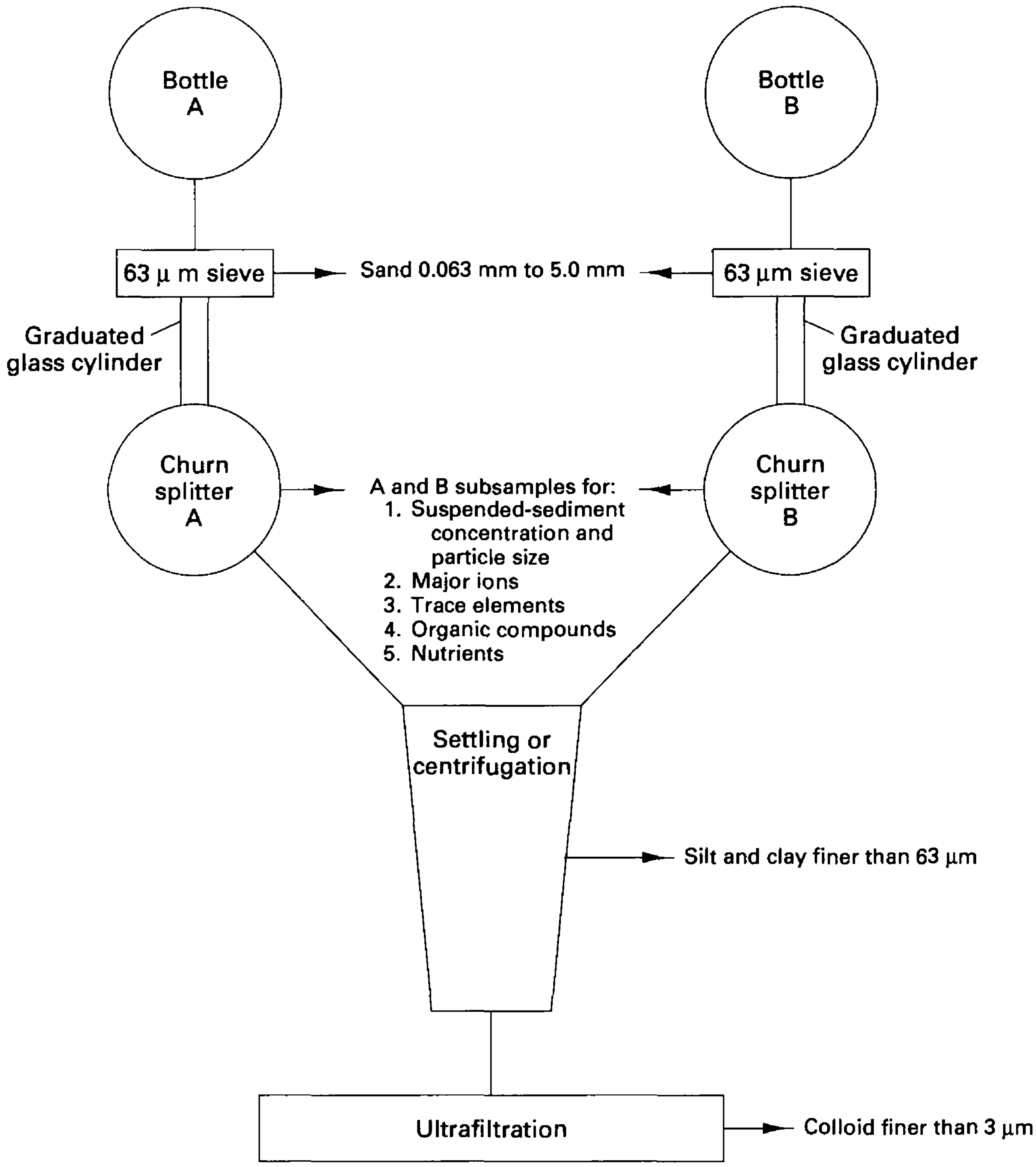


Figure 6.--Flow diagram for processing the suspended-sediment sample collected by the depth-integration method.

Suspended-Sediment Analysis

The suspended sediment collected by using the depth-integration method was split into a sand fraction consisting of particle diameters greater than 63 µm and a fine fraction consisting of silt and clay-size particles with diameters finer than 63 µm. The particle concentrations of the sand and the silt and clay fractions were measured separately and then added together to determine the total particle concentration.

The particle-size analysis of the sand and the silt and clay fraction used different methods. However, the results were combined to give particle-size distribution for the entire composite suspended-sediment sample collected at each sampling site.

Concentration

There were two replicate suspended-sand samples (composites A and B) for most sampling sites. If there was not enough sand in either the A or B composite samples, the two samples were combined to form a single suspended-sand sample. The sands were transferred to glass jars and transported to a USGS laboratory in Denver, Colorado, where they were dried at 80°C, weighed to within 0.1 mg, and stored in polypropylene bottles for particle-size analysis. The masses ranged from 1 mg to about 5,000 mg. The collected volume of water was about 50 L (measured to 0.1 L) so that the sand concentrations in tables 13–15 have analytical errors ranging from about 2 percent for concentrations of 0.1 mg/L to less than 0.1 percent for concentrations of 100 mg/L. The mean percent difference between the two replicate sand concentrations for all three cruises ranged from 0 to 20 percent with an average of 7 percent based on the sampling sites that had more than 1 mg/L of sand.

Two subsamples (about 150–250 mL) were taken from composite A and composite B for determining the suspended-sediment concentration of material finer than 63 µm. Each of the four subsamples was filtered through paired, preweighed Millipore HA filters (0.45-µm pore size) and dried at about 40°C on board the research vessel. Later, in a laboratory ashore, the filter with sediment was dried at 105–110°C and reweighed to within 0.05 mg, and the preweight of the filter was subtracted to obtain the mass of silt and clay, which typically was 20 to 40 mg. The volume of each subsample was measured to within ±1 mL, so that the concentrations in tables 13–15 have an analytical error of ± 1 percent, or typically 1 mg/L.

The mean range in silt and clay concentration (calculated from two to four replicate samples at each sampling site) was 3±3 percent of the mean silt and clay concentration for the July–August 1991 cruise, 2±3 percent for the October–November 1991 cruise, and 3±2 percent for the April–May 1992 cruise. The mean percent difference between the silt and clay concentrations of the two replicates (composites A and B) for all sampling sites was about 2±4 percent of the mean silt and clay concentration for all three cruises with a relative standard deviation of ±4 percent.

The suspended-sediment concentrations were multiplied by the water discharges (listed in the fifth column of tables 13–15) and by a unit-conversion constant (0.0864) to obtain the sediment discharges in metric tons per day listed in the last three columns of tables 13–15.

Particle Size

Particle-size distributions of the suspended sediment (from 1 to 1,000 μm) for the three cruises are listed in tables 16–18. The particle-size distributions of the suspended sand (greater than 63 μm) were analyzed by the visual-accumulation tube method, and the particle-size distribution of the suspended silt and clay (finer than 63 μm) were analyzed by the SediGraph method. Both methods are based on settling properties of the particles. Both methods involve preliminary chemical treatment that disaggregates the particles as they exist in the river. Therefore, the size analyses reported here are more representative of the assemblages of individual particles available to interact with the dissolved matter in the river and less representative of the hydraulic properties of the grains as they are transported by the river. Stallard and Martin (1989) noted that settling velocities of suspended sediments that were chemically dispersed for analysis, such as those reported here, were markedly slower than settling velocities of suspended sediments that were allowed to settle in native river water immediately after sampling.

The sand samples that were saved in separate polypropylene bottles were sent to the USGS sediment laboratory in Iowa City, Iowa, for size analysis by the visual-accumulation-tube method (Guy, 1969). Replicate samples were run, and if the results did not agree within 5 percent for all size classes, the analysis was repeated (Matthes and others, 1992). A complication arose during the particle-size analysis when the sand samples were treated with hydrogen peroxide, the standard technique for removing organic matter (Guy, 1969, p. 52). This treatment apparently disaggregated silt particles from sand-size aggregates. In most of the suspended-sand samples, the hydrogen peroxide treatment released silt grains from sand-size aggregates. Although the quantities of released silt grains were almost always 2 percent or less of the total concentration of suspended sediment, they were subtracted, where appropriate, from the sand concentrations and added to the concentration of the coarsest silt fraction (32 to 63 μm) in the data reported in tables 16–18.

The reproducibility of the sampling and size-analysis procedures was previously addressed by Moody and Meade (1992, table 18) for the sand fractions of the A and B composites of 12 suspended-sediment samples collected during 1987–88. When results were expressed as percentages of the sand fraction, differences between percents finer than certain sizes were as great as 7 percent. When results were expressed as percentages of the total sample, these differences were never more than 2 percent.

Only the samples collected by the depth-integration method were used in the particle-size analysis of suspended sediment finer than 63 μm (except as indicated by footnote 3 in tables 16, 17, and 18). The essential problem in preparing a silt and clay fraction sample for particle-size analysis is one of converting the dilute suspensions collected in the field into the concentrated suspensions required for SediGraph analysis. In the procedure used, the suspended-sediment sample remained wet from the time it was collected to the time it was analyzed. The two subsamples of about 2–12 L of water and sediment (finer than 63 μm) that were taken from the A and B churn splitters on the research vessel were combined in polyethylene carboys to which 10–15 mL of chloroform was added to retard organic growth. The carboys from all sampling sites were transported to the USGS laboratory in Denver, Colorado, where the suspended sediment was allowed to settle undisturbed for at least 35 days. At the maximum vertical settling distance of 36 cm in the carboys, this time was sufficient for all particles coarser than about 0.5 μm to settle (assuming Stokesian settling of quartz spherical particles of density 2.65 gm/cm^3). After 35 days or longer, the supernatant water was siphoned from the carboys, and the settled sediment was transferred to 1-L glass jars (maximum settling distance, 15 cm) where it was allowed to settle for another 35 days or more. The supernatant was siphoned off once more, and the settled sediment was transferred to 250-mL polyethylene bottles.

All analyses of the size distribution of particles finer than 63 µm were made in the USGS sediment laboratory in Iowa City, Iowa, by the SediGraph method as described by Lara and Matthes (1986). Duplicate measurements were made on 10 percent of the SediGraph samples, and if the results did not agree within 5 percent for all size classes, the analysis was repeated (Matthes and others, 1992). After the particle-size distribution was determined, the sample was dried and weighed. The dry mass was compared with the mass of sediment calculated from the concentration of suspended sediment finer than 63 µm determined by the filtering-and-weighing procedure (silt and clay column in tables 13–15) and the known volume (4–24 L) of river water from which the analyzed sample was allowed to settle. The differences between the calculated dry masses and the measured dry masses were assumed to represent the material finer than 0.5 µm that remained in suspension and was siphoned from the carboys along with the supernatant water. These differences have been added to the mass of material finer than 1 µm for purposes of calculating the percentages listed in tables 16–18. The amount of siphoned material finer than 0.5 µm averaged 14 percent for the July–August 1991 cruise, 17 percent for the October–November 1991 cruise, and 9 percent for the April–May 1992 cruise. The largest proportions (greater than 20 percent) of siphoned material finer than 0.5 µm were in general measured in samples collected from the reach of the Upper Mississippi River that is controlled by the navigation dams. The proportion of siphoned material finer than 0.5 µm averaged about 8 percent for the free-flowing river below St. Louis, Missouri, in which there are no navigation dams.

Table 16.--Particle-size distribution of suspended-sediment samples collected from the Mississippi River and some of its tributaries for July–August 1991 cruise

[Finer than 63 µm was determined by SediGraph and coarser than 63 µm was determined by visual-accumulation tube; mg/L, milligrams per liter; µm, micrometers; Analysis was done by U.S. Geological Survey sediment laboratory in Iowa City, Iowa; --, not enough material to determine median diameter]

Date 1991	Site name	Total suspended-sediment concentration (mg/L)[1]	Percent finer than indicated size (µm)										Median diameter[2] (µm)
			1	2	4	8	16	32	63	125	250	500	
7-05	Mississippi R. above St. Anthony Falls, Minn.	32	54	61	70	79	85	91	95	97	99	100	<1
7-06	Minnesota R. at Mile 3.5, Minn.	174	26	31	38	46	52	57	62	82	99	100	13
7-08	Mississippi R. at Hastings, Minn.	82	Not enough material was collected for size analysis.										--
7-10	Mississippi R. near Pepin, Wis.	9	Not enough material was collected for size analysis.										--
7-12	Mississippi R. at Trempealeau, Wis.	28	Not enough material was collected for size analysis.										--
7-15	Mississippi R. below Lock and Dam 9, Wis.	73	47	54	64	75	86	98	100				1
7-18	Mississippi R. at Clinton, Iowa	66	48	56	65	76	87	98	100				1
7-21	Mississippi R. at Keokuk, Iowa	45	57	65	73	81	87	98	100				<1
7-24	Mississippi R. near Winfield, Mo.	74	48	54	61	70	84	96	100				1
7-25	Illinois R. at Hardin, Ill.	47	Not enough material was collected for size analysis.										--
7-27	Missouri R. at St. Charles, Mo.	140	35	41	46	53	62	74	78	83	98	100	6
7-29	Mississippi R. at Thebes, Ill.	106	40	46	51	59	68	77	79	82	98	100	4
7-30	Ohio R. at Olmsted, Ill.	22	Not enough material was collected for size analysis.										--
8-03	Mississippi R. below Vicksburg, Miss.	111	45	53	60	70	82	95	98	99	100		2
8-05	Mississippi R. near St. Francisville, La.	116	47	54	63	72	82	92	98	99	100		1
8-07	Mississippi R. below Belle Chasse, La.[3]	42	68	79	89	95	99	99	100				<1

[1] Total suspended-sediment concentration (sand and fine material) is the average of composite A and B values in table 13.

[2] Median diameters greater than 1.0 µm computed by linear interpolation; those less than 1.0 µm by linear extrapolation.

[3] Water velocities were too slow for collecting a representative depth-integrated sample, so that a subsample (for size analysis) was taken from the discharge-weighted pumped sample. Under such low-velocity conditions, concentrations of suspended sediment coarser than 63 µm are presumed to be virtually zero.

Table 17.-- Particle-size distribution of suspended-sediment samples collected from the Mississippi River and some of its tributaries for October–November 1991 cruise

[Finer than 63 μm was determined by SediGraph and coarser than 63 μm was determined by visual-accumulation tube; mg/L, milligrams per liter; μm, micrometers; Analysis was done by U.S. Geological Survey sediment laboratory in Iowa City, Iowa; --, not enough material to determine median diameter]

Date 1991	Site name	Total suspended-sediment concentration (mg/L)[1]	Percent finer than indicated size (μm)										Median diameter[2] (μm)
			1	2	4	8	16	32	63	125	250	500	
10-07	Mississippi R. above St. Anthony Falls, Minn.	12	70	74	80	91	99	100					0.6
10-08	Minnesota R. at Mile 3.5, Minn.	62	42	49	65	76	81	99	100				2
10-10	Mississippi R. at Hastings, Minn.[3]	45	60	71	82	92	98	98	100				<1
10-13	Mississippi R. near Pepin, Wis.[3]	9	Not enough material was collected for size analysis.										--
10-15	Mississippi R. at Trempealeau, Wis.[3]	12	65	76	84	90	94	97	100				<1
10-18	Mississippi R. below Lock and Dam 9, Wis.[3]	28	58	71	84	94	99	99	100				<1
10-22	Mississippi R. at Clinton, Iowa[3]	31	70	81	91	98	99	99	100				<1
10-27	Mississippi R. at Keokuk, Iowa[3]	32	62	76	87	94	98	98	100				<1
10-30	Mississippi R. near Winfield, Mo.[3]	36	63	74	85	94	98	99	100				<1
10-31	Illinois R. at Hardin, Ill.[3]	143	40	53	68	83	94	99	99	100			2
11-03	Missouri R. at St. Charles, Mo.	306	21	26	33	39	47	52	54	58	94	100	26
11-05	Mississippi R. at Thebes, Ill.	140	28	34	40	46	51	56	58	64	90	100	14
11-06	Ohio R. at Olmsted, Ill.[3]	20	51	60	71	81	89	95	97	98	99	100	1
11-09	Mississippi R. below Vicksburg, Miss.	182	40	48	55	64	73	82	90	96	99	100	3
11-11	Mississippi R. near St. Francisville, La.	209	38	46	53	62	71	80	85	93	100		3
11-13	Mississippi R. below Belle Chasse, La.[4]	142	51	63	77	90	96	99	100				1
11-13	Mississippi R. below Belle Chasse, La.[5]	112	58	68	81	92	98	100					<1

[1] Total suspended-sediment concentration (sand and fine material) is the average of composite A and B values in table 14

[2] Median diameters greater than 1.0 mm were computed by linear interpolation; those less than 1.0 mm by linear extrapolation.

[3] Water velocities were too slow for collecting a representative depth-integrated sample, so that a subsample (for size analysis) was taken from the discharge-weighted pumped sample. Under such low-velocity conditions, concentrations of suspended sediment coarser than 63 mm are presumed to be virtually zero.

[4] Depth-integrated sample.

[5] Discharge-weighted pumped sample.

Table 18.--Particle-size distribution of suspended-sediment samples collected from the Mississippi River and some of its tributaries for April–May 1992 cruise

[Finer than 63 µm was determined by SediGraph and coarser than 63 µm was determined by visual-accumulation tube; mg/L, milligrams per liter; µm, micrometers; Analysis was done by U.S. Geological Survey sediment laboratory in Iowa City, Iowa; --, not enough material to determine median diameter]

Date 1992	Site name	Total suspended-sediment concentration (mg/L)[1]	Percent finer than indicated size (µm)										Median diameter[2] (µm)
			1	2	4	8	16	32	63	125	250	500	
4-06	Mississippi R. above St. Anthony Falls, Minn.	13	Not enough material was collected for size analysis.					91	92	97	100		--
4-08	Minnesota R. at Mile 3.5, Minn.	106	24	32	42	54	66	84	94	99	100		7
4-10	Mississippi R. at Hastings, Minn.	36	50	61	74	87	96	100					1
4-12	Mississippi R. near Pepin, Wis.[3]	12	Not enough material was collected for size analysis.										--
4-14	Mississippi R. at Trempealeau, Wis.	14	Not enough material was collected for size analysis.										--
4-17	Mississippi R. below Lock and Dam 9, Wis.	24	57	65	71	82	91	97	99	100			<1
4-19	Mississippi R. at Clinton, Iowa	40	55	63	71	81	90	97	100				<1
4-23	Mississippi R. at Keokuk, Iowa	299	33	46	60	74	84	98	100				3
4-26	Mississippi R. near Winfield, Mo.	308	36	48	59	71	84	94	96	98	99	100	2
4-27	Illinois R. at Hardin, Ill.	230	42	55	70	85	95	99	100				2
4-29	Missouri R. at St. Charles, Mo.	1,360	24	34	43	54	67	83	88	92	98	100	7
5-01	Mississippi R. at Thebes, Ill.	701	27	38	49	59	72	83	86	88	99	100	4
5-03	Ohio R. at Olmsted, Ill.[3]	67	41	54	69	84	95	98	100				2
5-06	Mississippi R. below Vicksburg, Miss.	358	20	34	48	60	72	82	84	87	97	100	5
5-08	Mississippi R. near St. Francisville, La.	335	25	38	52	64	74	84	90	94	100		4
5-10	Mississippi R. below Belle Chasse, La.	311	36	49	64	76	88	96	98	99	100		2

[1] Total suspended-sediment concentration (sand and fine material) is the average of composite A and B values in table 15.

[2] Median diameters greater than 1.0 µm were computed by linear interpolation; those less than 1.0 µm by linear extrapolation.

[3] Water velocities were too slow for collecting a representative depth-integrated sample, so that a subsample (for size analysis) was taken from the discharge-weighted pumped sample. Under such low-velocity conditions, concentrations of suspended sediment coarser than 63 µm are presumed to be virtually zero.

SUMMARY

The average (all sites and all cruises) median diameter of the bed sediments in the navigation lock and dam reach of the Mississippi River was 0.70 mm and the average median diameter was 0.40 mm in the free-flowing reach of the Mississippi River downstream from St. Louis, Missouri. Suspended-sediment samples from the Mississippi River were collected from water discharges ranging from 220 m^3/s above St. Anthony Falls, Minnesota, in October 1991 to 21,700 m^3/s below Vicksburg, Mississippi, in May 1992; in mean water depths ranging from 2.5 m above St. Anthony Falls, Minnesota, in July 1991 to 20.6 m below Belle Chasse, Louisiana, in May 1992; and in cross-sectional mean velocities ranging from 0.30 m/s below Belle Chasse, in August 1991 and 0.30 m/s near Pepin, Wisconsin in October 1991, to 1.66 m/s at Thebes, Illinois, in April 1992. The average (all sites and all cruises) total suspended-sediment concentration in the navigation lock and dam reach of the Mississippi River was 34 mg/L, and 55 percent of this suspended sediment was less than 1 µm in size. However, in April 1992 at Keokuk, Iowa, and near Winfield, Missouri, heavy runoff from the Iowa and Des Moines Rivers increased the total suspended-sediment concentrations to about 300 mg/L, of which about 34 percent was less than 1 µm in size. In the free-flowing reach of the Mississippi River downstream from St. Louis, Missouri, the average (all sites and all cruises) total suspended-sediment concentration was 229 mg/L, of which 40 percent was less than 1 µm in size.

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___1990c, Water-resources data for Missouri, water year 1989: U.S. Geological Survey Water-Data Reports MO–89–1, 354 p.

___1990d, Water-resources data for Minnesota, water year 1988: U.S. Geological Survey Water-Data Reports MN–88–1, 331 p.

___1990e, Water-resources data for Wisconsin, water year 1989: U.S. Geological Survey Water-Data Reports WI–89–1, 436 p.

TABULATED CRUISE DATA

The data in this section are organized by individual cruises. In the listings of measurements made at each vertical: The A and B after the vertical number identifies the sample bottle used at that vertical, the X preceding the vertical number indicates that an extra velocity measurement was made but no sample was collected, and an R indicates that the vertical was repeated because the velocity measurement was incorrect, the suspended-sediment collection bag leaked, or debris on the nozzle prevented the collection of a suitable sample. Verticals usually were occupied in numerical order. Exceptions owing to weather conditions or towboat traffic are noted in the REMARKS section of each sampling site listing. Inch-pound units are used in these listings for: (1) part of the name of a sampling site; (2) gage height, which is the elevation of the gage in feet above sea level (National Geodetic Vertical Datum of 1929) and which will serve as a reference for future cruises; (3) the name of a sampling weight; and (4) the designation of the nozzle size used to sample suspended sediment. In the current meter equation the * represents multiplication.

The following abbreviations are used in the tabulated cruise data and are listed below.

SUSP	=	type of suspension
pH	=	surface pH of the river water
LEW	=	left edge of water
REW	=	right edge of water
Rev/s	=	revolutions per second
SAFU	=	St. Anthony Falls Upper Pool
TW	=	tailwater
--	=	no sample was collected or no measurement was made
ft	=	feet
lb	=	pound
cm	=	centimeter
cm/s	=	centimeter per second
°C	=	degree Celsius
L	=	liter
µS/cm	=	microsiemens per centimeter at 25 degrees Celsius
<63 µm	=	finer than 63 micrometers
>63 µm	=	greater than 63 micrometers
m/s	=	meters per second
s	=	second

DATA LIST

FOR

JULY–AUGUST 1991 CRUISE

SITE: Mississippi River above St. Anthony Falls, Minn.—Mile 858.3 07-05-91
PARTY: Moody, Garbarino, Antweiler, and Simoneaux
GAGE HEIGHT @ Anoka: 810.63 ft GAGE HEIGHT @ SAFU Pool: 800.48 ft
RIVER SLOPE: 178×10^{-6}
SUSP. Bag sampler and 150-lb weight
PRICE AA CURRENT METER No: W-223906 DATE RATED: 06-91
CURRENT METER EQUATION: V(m/s)=Rev/s* 0.670 + 0.010
REMARKS:

Anchored at five verticals, used 5/16-inch nozzle and transit rates that ranged from 5.0 to 8.0 cm/s. Section was about 100 m downriver from the Minneapolis Water Works intake.

Vertical	Distance from LEW (m)	Depth (m)	Mean velocity (m/s)	Discharge m^3/s	Temperature (°C)	pH	Specific conductance (µS/cm)
LEW	0	0.0					
01A,B	44	3.1	0.97	86	--	--	--
02A,B	57	3.7	0.91	59	--	--	--
03A,B	79	4.0	0.92	79	--	--	--
X03	100	3.3	0.96	46	--	--	--
04A,B	108	3.1	0.98	40	--	--	--
05A,B	126	3.6	0.90	39	--	--	--
X04	132	3.6	0.90	120			
REW	200	0.0	0.00				
MEANS		2.5	0.93				
TOTAL	200			467			

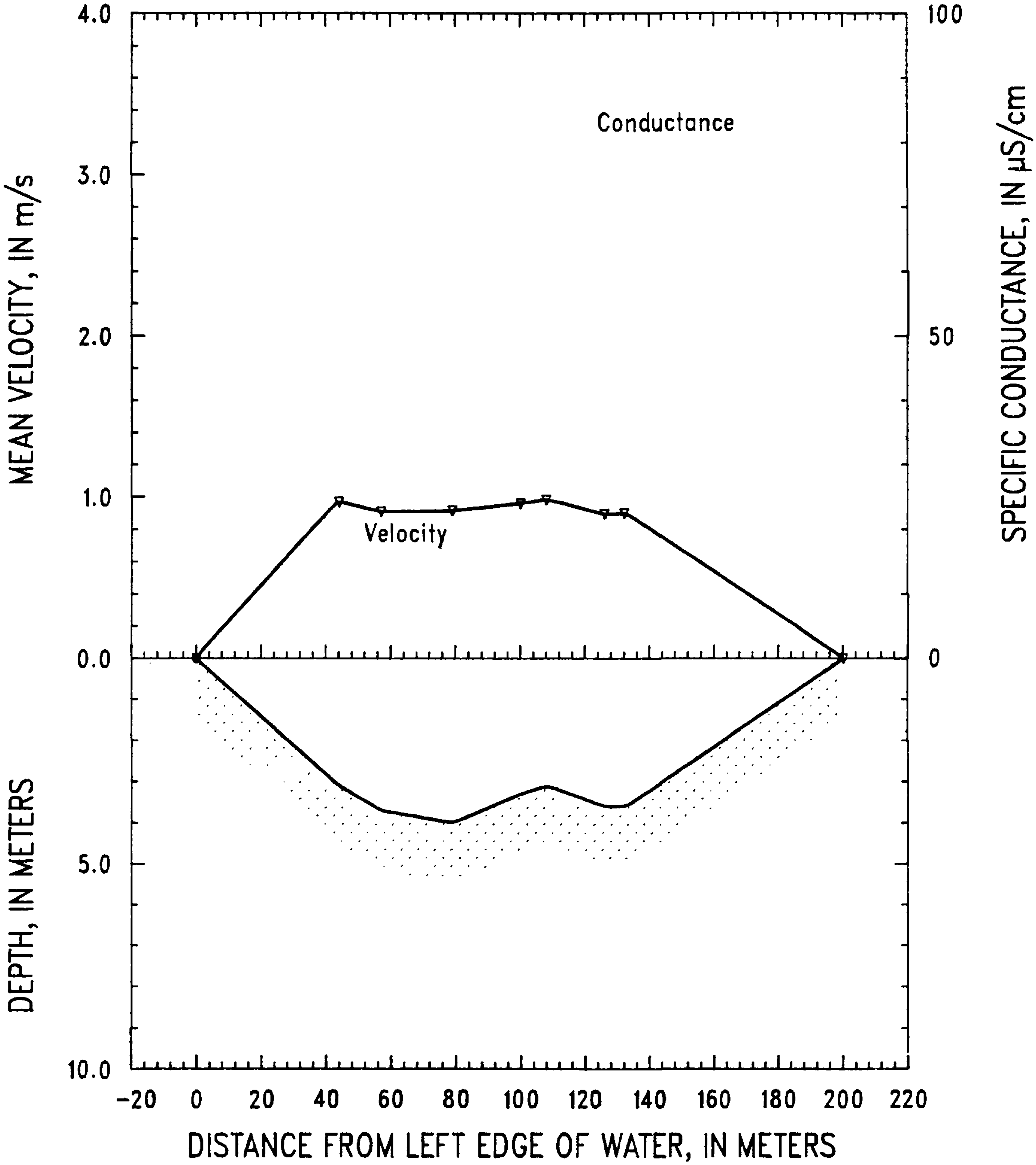

Figure 7. Mississippi River above St. Anthony Falls, Minnesota, on July 5, 1991.

SITE: Minnesota River at Mile 3.5, Minn. 07-06-91
PARTY: Moody, Garbarino, Antweiler, and Simoneaux
GAGE HEIGHT @ Savage: 699.46 ft GAGE HEIGHT @ Pool 2: 686.68 ft
RIVER SLOPE: 55×10^{-6}
SUSP. Bag sampler and 150-lb weight
PRICE AA CURRENT METER No: W-223906 DATE RATED: 06-91
CURRENT METER EQUATION: V(m/s)=Rev/s* 0.670 + 0.010
REMARKS:

Anchored at five verticals, used 5/16- and 1/4-inch nozzles and transit rates that ranged from 7.0 to 17.0 cm/s. Section was about 50 m upstream from the Metropolitan Waste Control Commission dock.

Vertical	Distance from LEW (m)	Depth (m)	Mean velocity (m/s)	Discharge (m^3/s)	Temperature (°C)	pH	Specific conductance (μS/cm)
LEW	0	0.0	0.00				
X05	21	6.0	1.04	72	--	--	--
01A,B	23	6.6	1.19	35	25.8	8.1	760
X06	30	6.9	1.15	55	--	--	--
02A,B	37	7.0	1.07	38	25.9	8.1	762
X04	40	7.0	1.06	56	--	--	--
03A,B	52	7.0	1.07	60	25.4	8.1	776
X01	56	7.1	1.20	68	--	--	--
04A,B	68	6.8	1.11	91	26.3	8.2	761
05A,B	80	6.1	1.01	49	25.2	8.2	775
X02	84	5.8	0.89	75	--	--	--
REW	109	0.0	0.00				
MEANS		5.2	1.06				
TOTAL	109			598			

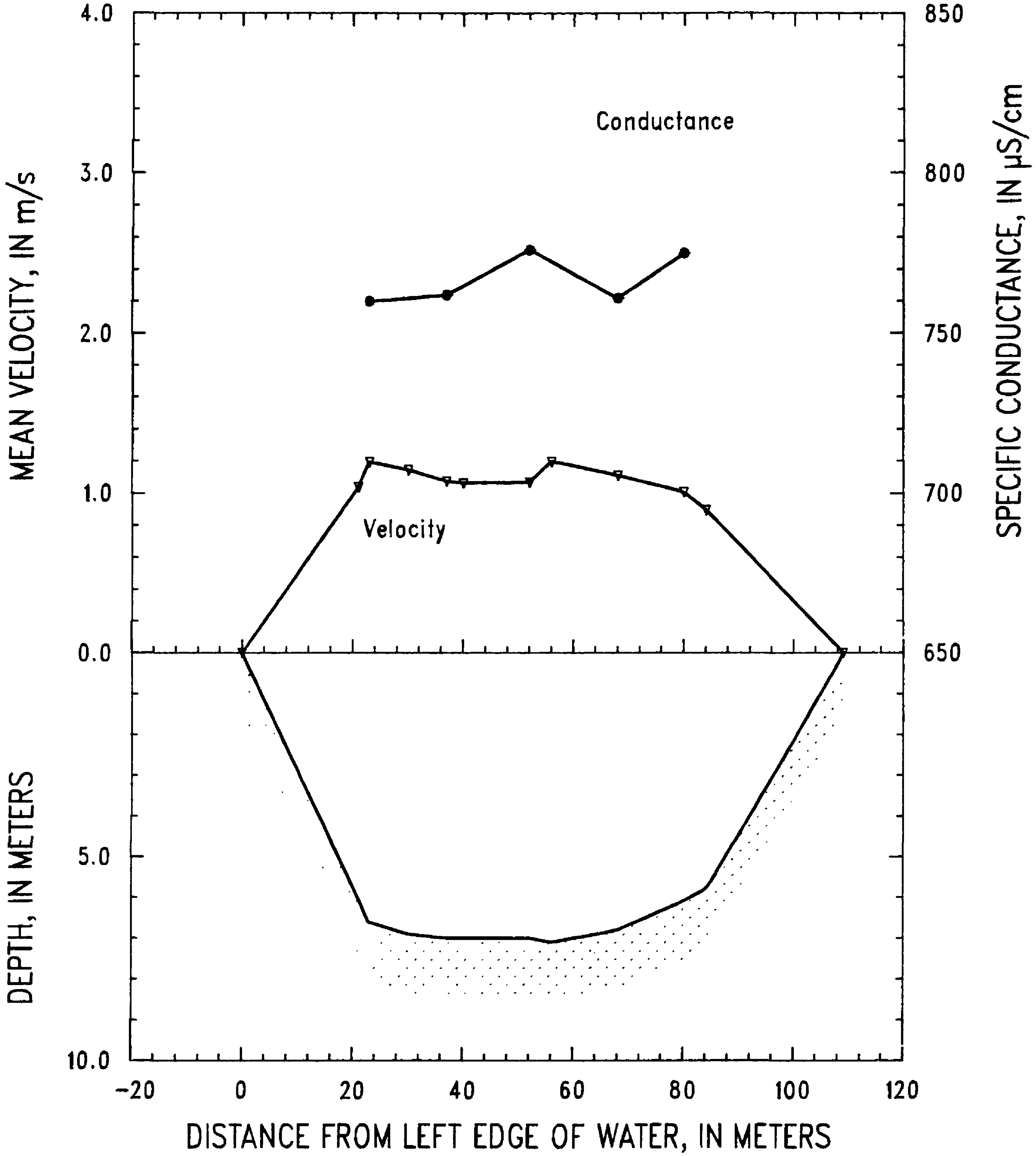

Figure 8. Minnesota River at Mile 3.5, Minnesota, on July 6, 1991.

SITE: Mississippi River at Hastings, Minn.—Mile 812.2 07-08-91
PARTY: Moody, Garbarino, and Simoneaux
GAGE HEIGHT @ TW Pool 2: 681.28 ft GAGE HEIGHT @ Pool 3: 674.99 ft
RIVER SLOPE: 66×10^{-6}
SUSP. Bag sampler and 150-lb weight
PRICE AA CURRENT METER No: W-223906 DATE RATED: 06-91
CURRENT METER EQUATION: V(m/s)=Rev/s* 0.670 + 0.010
REMARKS:
Sampled eight verticals (equal-width increment) using a 5/16-inch nozzle and a transit rate of 11 cm/s.

Vertical	Distance from LEW (m)	Depth (m)	Mean velocity (m/s)	Discharge (m^3/s)	Temperature (°C)	pH	Specific conductance (μS/cm)
LEW	0	0.0	0.00				
01A,B	31	9.0	0.79	157	24.3	7.8	647
X12	44	8.3	0.90	86	--	--	--
02A,B	54	8.0	0.86	124	24.5	7.7	644
03A,B	80	7.1	0.85	108	24.6	7.8	646
X03	90	7.1	0.84	83	--	--	--
04A,B	108	6.7	0.69	78	24.6	7.9	646
X04	124	6.2	0.82	61	--	--	--
05A,B	132	6.0	0.81	83	24.6	8.0	647
06A,B	158	5.2	0.69	50	24.7	8.0	647
X05	160	5.2	0.72	41	--	--	--
07A,B	180	4.9	0.58	35	24.5	8.0	648
X06	185	4.9	0.57	28	--	--	--
X07	200	4.0	0.43	15	--	--	--
08A,B	203	3.3	0.51	34	24.5	8.0	647
REW	240	0.0	0.00				
MEANS		5.4	0.76				
TOTAL	240			983			

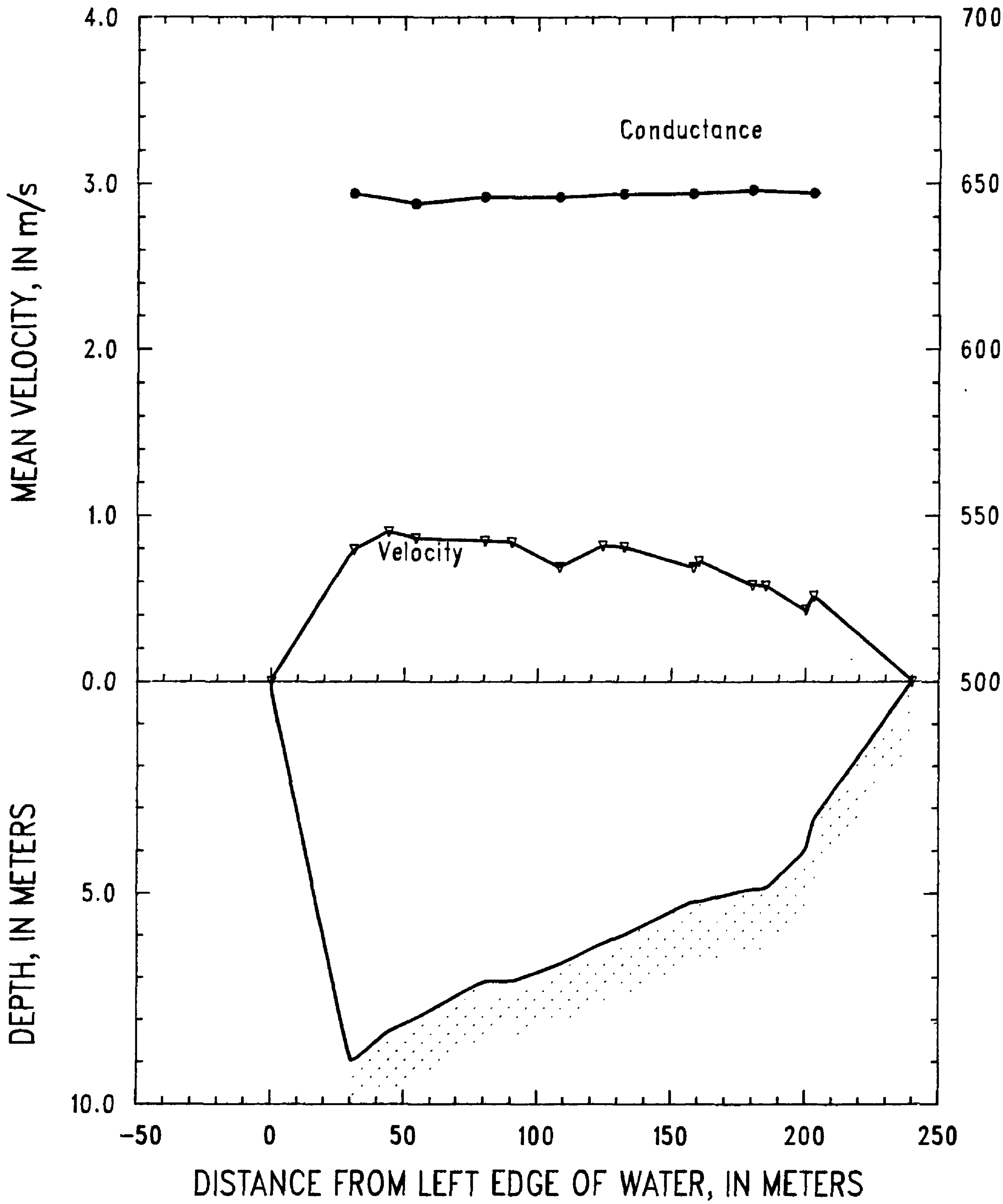

Figure 9. Mississippi River at Hastings, Minnesota, on July 8, 1991.

SITE: Mississippi River near Pepin, Wis.—Mile 764.5 07-10-91
PARTY: Moody, Garbarino, and Simoneaux
GAGE HEIGHT @ Lake City: 671.81 ft GAGE HEIGHT @ Wabasha: 669.60 ft
RIVER SLOPE: 34×10^{-6}
SUSP. Bag sampler and 150-lb weight
PRICE AA CURRENT METER No: W-223906 DATE RATED: 06-91
CURRENT METER EQUATION: V(m/s)=Rev/s* 0.670 + 0.010
REMARKS:

Sampled 12 verticals (equal-discharge increment) using a 5/16-inch nozzle and variable transit rates ranging from 2 to 8.5 cm/s. Verticals sampled from 12 to 1.

Vertical	Distance from LEW (m)	Depth (m)	Mean velocity (m/s)	Discharge (m^3/s)	Temperature (°C)	pH	Specific conductance[1] (μS/cm)
LEW	0	0.0	0.00				
X05	65	3.6	0.55	71	--	--	--
01A,B	72	3.7	0.61	67	26.8	8.2	549
02B	124	3.9	0.59	66	--	--	--
02A	129	3.9	0.59	21	26.1	8.1	550
X04	142	4.0	0.63	50	--	--	--
03A,B	169	4.0	0.58	71	26.1	8.0	549
04A	203	3.9	0.64	50	25.3	7.8	551
04B	209	4.1	0.59	35	--	--	--
X03	232	3.4	0.68	36	--	--	--
05A	240	4.3	0.61	18	26.1	7.9	549
X07	246	4.2	0.71	16	--	--	--
05B	251	4.3	0.63	46	--	--	--
06A,B	280	4.8	0.62	83	26.4	7.9	550
07A,B	307	5.2	0.65	89	26.6	8.0	549
X02	333	6.0	0.66	63	--	--	--
08A,B	339	6.2	0.68	61	24.9	7.8	551
09A,B	362	6.9	0.66	100	24.8	7.8	551
10A,B	383	8.2	0.67	101	25.5	7.9	549
11A,B	399	9.1	0.65	119	25.1	7.8	549
12B	423	7.6	0.66	75	--	--	--
12A	429	7.9	0.68	116	25.2	7.8	548
REW	466	0.0	0.00				
MEANS		4.6	0.63				
TOTAL	466			1,352			

[1]Specific conductance is questionable since readings of the standard (718 microsiemens/cm) drifted from 722 (at the start of the section) to 701 (at the end of the section).

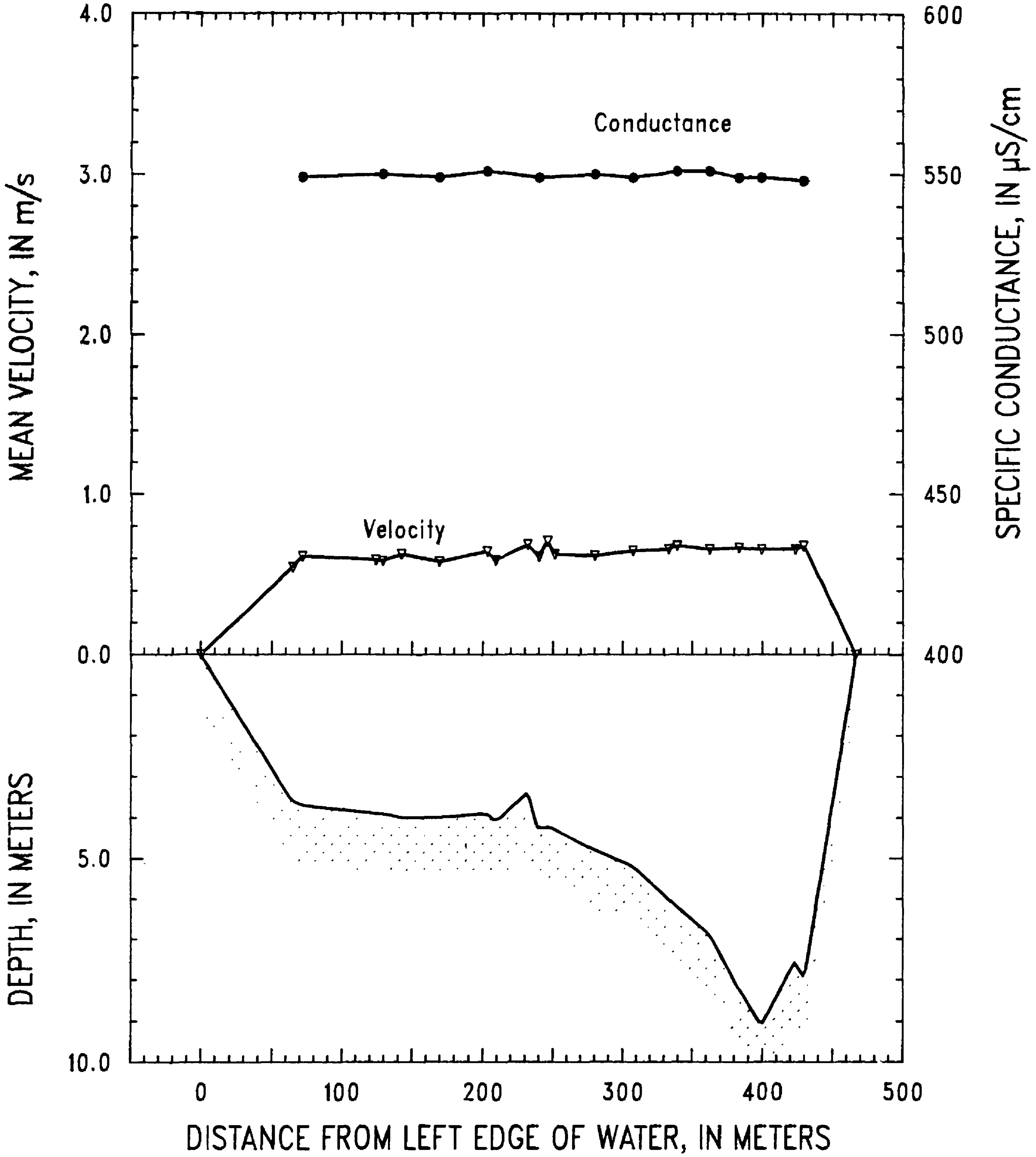

Figure 10. Mississippi River near Pepin, Wisconsin, on July 10, 1991.

SITE: Mississippi River at Trempealeau, Wis.—Mile 713.8 07-12-91
PARTY: Moody, Roth, and Simoneaux
GAGE HEIGHT @ Pool 6 TW: 642.33 ft GAGE HEIGHT @ Pool 7: 639.03 ft
RIVER SLOPE: 57×10^{-6}
SUSP. Bag sampler and 150-lb weight
PRICE AA CURRENT METER No: W-223906 DATE RATED: 06-91
CURRENT METER EQUATION: V(m/s)=Rev/s* 0.670 + 0.010
REMARKS:

Unmeasured flow through a shallow side channel was estimated at 50 m^3/s. Sampled eight verticals (equal-width increment) using a 5/16-inch nozzle and transit rate of 7 cm/s. Discharge at Dam 6 was reported to be 1,625 m^3/s. Verticals sampled from 8 to 1.

Vertical	Distance from LEW (m)	Depth (m)	Mean velocity (m/s)	Discharge (m^3/s)	Temperature (°C)	pH	Specific conductance[1] (µS/cm)
LEW	0	0.0	0.00				
01A,B	61	2.5	0.69	87	25.8	7.8	492
02A,B	101	4.8	0.65	129	25.5	7.7	491
03A,B	144	5.1	0.68	159	25.8	7.8	497
04A,B	193	4.1	0.75	113	25.0	7.8	501
X03	218	4.1	0.87	105	--	--	--
05A,B	252	4.2	0.82	125	25.0	7.6	503
06A,B	291	4.8	0.77	145	25.0	7.6	506
X02	331	6.3	0.79	112	--	--	--
07B	336	6.4	0.77	34	--	--	--
07A	345	6.6	0.77	140	25.0	7.8	512
08A,B	391	7.5	0.73	167	25.0	7.9	512
X01	406	7.8	0.70	119	--	--	--
REW	435	0.0	0.00				
MEANS		4.5	0.74				
TOTAL	435			1,436			

[1]Specific conductance is questionable since readings of the standard (718 microsiemens/cm) drifted from 729 (at the start of the section) to 691 (at the end of the section).

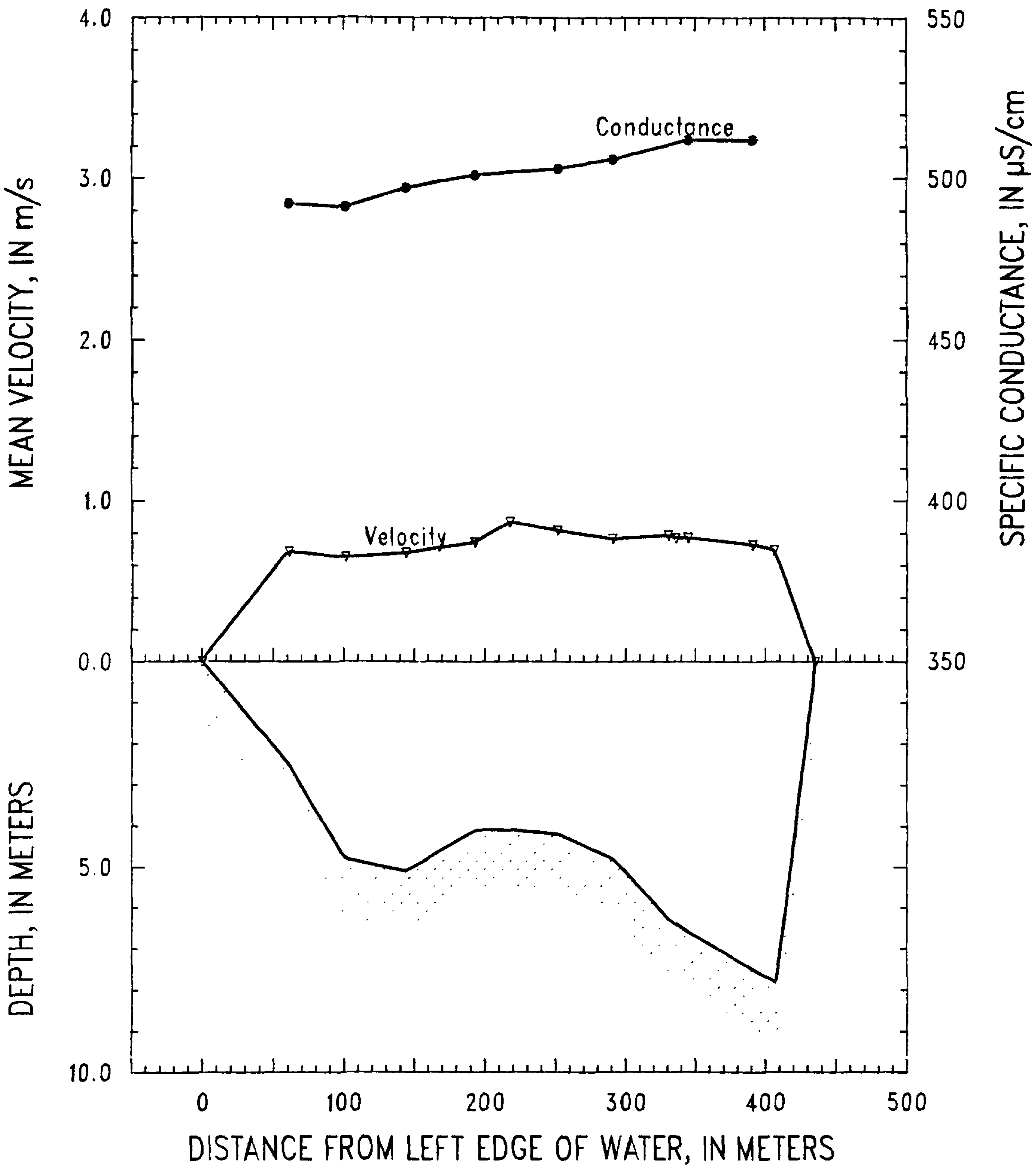

Figure 11. Mississippi River at Trempealeau, Wisconsin, on July 12, 1991.

SITE: Mississippi River below Lock and Dam 9, Wis.—Mile 639.7 07-15-91
PARTY: Moody, Roth, and Simoneaux
GAGE HEIGHT @ Pool 9 TW: 617.59 ft GAGE HEIGHT @ Pool 10: 610.42 ft
RIVER SLOPE: 41 x 10^{-6}
SUSP. Bag sampler and 150-lb weight
PRICE AA CURRENT METER No: W-223906 DATE RATED: 06-91
CURRENT METER EQUATION: V(m/s)=Rev/s* 0.670 + 0.010
REMARKS:

Unmeasured flow through a shallow side channel was estimated at 30 m^3/s. Sampled nine verticals (equal-width increment) using a 5/16-inch nozzle and transit rate of 7 cm/s. Discharge at Dam 9 was reported to be 1,595 m^3/s. Verticals sampled from 9 to 1.

Vertical	Distance from LEW (m)	Depth (m)	Mean velocity (m/s)	Discharge (m^3/s)	Temperature (°C)	pH	Specific conductance (μS/cm)
LEW	0	0.0	0.00				
01B	49	2.8	0.44	34	--	--	--
01A	55	3.0	0.44	16	26.3	8.2	487
02A,B	73	3.4	0.47	58	26.2	8.2	487
03A,B	127	4.8	0.66	108	26.4	8.2	488
X05	141	4.9	0.76	91	--	--	--
04A,B	176	6.0	0.72	176	25.9	8.1	504
05A,B	222	6.2	0.83	240	25.7	8.0	493
06A,B	270	6.7	0.83	211	25.6	7.9	496
X03	298	6.4	0.88	150	--	--	--
07A,B	323	6.3	0.86	181	25.1	7.9	498
X01	365	5.9	0.79	121	--	--	--
08A,B	375	5.7	0.72	88	25.2	7.9	500
X02	408	4.2	0.70	72	--	--	--
09A,B	424	3.8	0.55	44	24.9	7.9	504
REW	450	0.0	0.00				
MEANS		4.8	0.74				
TOTAL	450			1,589			

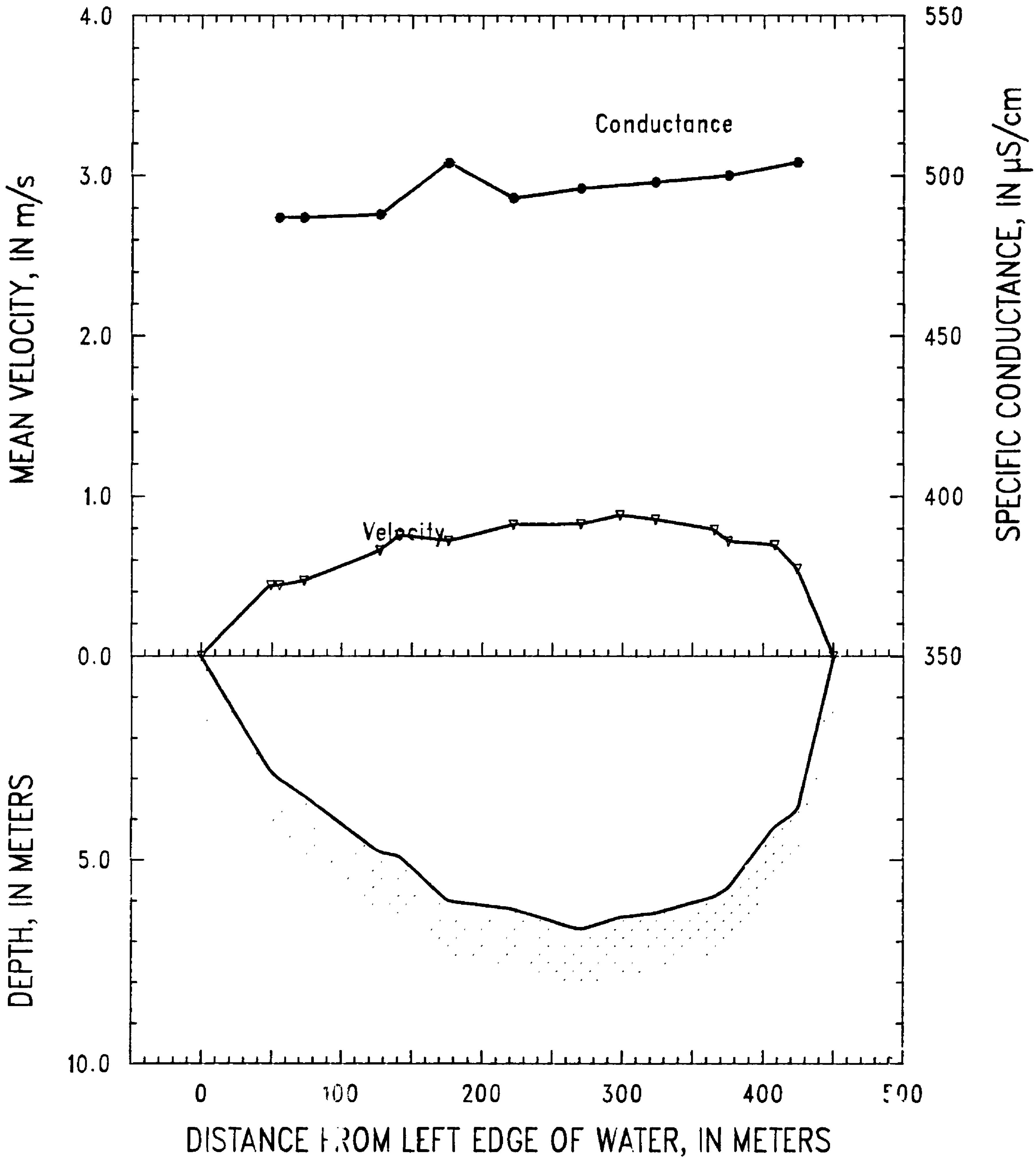

Figure 12. Mississippi River below Lock and Dam 9, Wisconsin, on July 15, 1991.

SITE: Mississippi River at Clinton, Iowa—Mile 520.3 07-18-91
PARTY: Moody, Roth, and Simoneaux
GAGE HEIGHT @ Dam 13 TW: 576.66 ft GAGE HEIGHT @ Pool 14: 571.93 ft
RIVER SLOPE: 30×10^{-6}
SUSP. Bag sampler and 150-lb weight
PRICE AA CURRENT METER No: W-223906 DATE RATED: 06-91
CURRENT METER EQUATION: V(m/s)=Rev/s* 0.670 + 0.010
REMARKS:

An additional discharge of 12 m^3/s adjacent to the left bank (between an island and the bank) which could not be measured from the R/V ACADIANA because of shallow water, was measured from a small boat. Discharge from Dam 13 was about 1,810 m^3/s. Transit rate was 8.0 cm/s and a 5/16-inch nozzle was used. Order of verticals: 7–10 then, 6–2. Vertical 1 was not sampled because it was in shallow water.

Vertical	Distance from LEW (m)	Depth (m)	Mean velocity (m/s)	Discharge (m^3/s)	Temperature (°C)	pH	Specific conductance (μS/cm)
LEW	0	0.0	0.00				
02A,B	87	3.0	0.33	49	26.9	8.1	481
X06	101	3.4	0.36	22	--	--	--
03A,B	124	4.3	0.35	53	26.9	8.2	483
04A,B	171	7.0	0.59	188	26.6	8.0	484
05A,B	216	7.6	0.61	169	26.7	8.0	484
X04	244	7.9	0.66	118	--	--	--
06A,B	261	8.3	0.70	199	26.7	7.9	485
07A,B	313	9.2	0.74	351	26.1	7.8	483
08A,B	364	8.8	0.79	248	26.1	8.1	481
X02	384	9.4	0.71	148	--	--	--
09A,B	408	8.9	0.68	168	26.2	8.1	486
X01	440	7.0	0.66	115	--	--	--
10A,B	458	4.7	0.22	21	27.0	8.2	485
REW	480	0.0	0.00				
MEANS		6.1	0.63				
TOTAL	480	6.1	0.63	1,850			

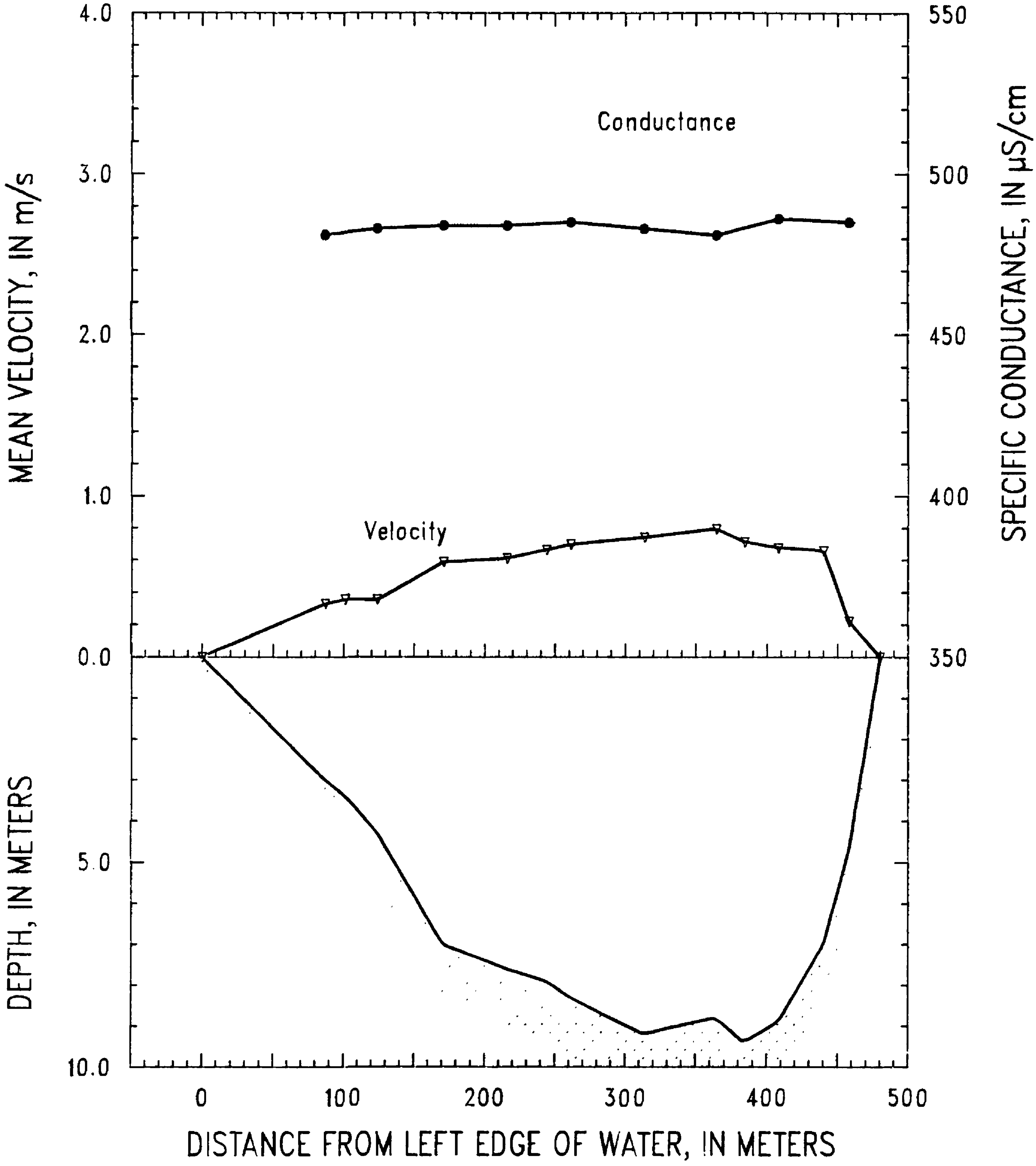

Figure 13. Mississippi River at Clinton, Iowa, on July 18, 1991.

SITE: Mississippi River at Keokuk, Iowa—Mile 363.1 07-21-91
PARTY: Moody, Roth, and Simoneaux
GAGE HEIGHT @ Dam 19 TW: 484.06 ft GAGE HEIGHT @ Pool 20: 478.54
RIVER SLOPE: 50 x 10^{-6}
SUSP. Bag sampler and 150-lb weight
PRICE AA CURRENT METER No: W-223906 DATE RATED: 06-91
CURRENT METER EQUATION: V(m/s)=Rev/s* 0.670 + 0.010
REMARKS:

Dam 19 discharge was about 1,915 m^3/s. Discharge increased during the sampling. Nine verticals were sampled from vertical number 10 to 2. Vertical 1 was not sampled because it was in shallow water. The transit rate was 5.0 cm/s and the nozzle was 5/16 inch. Temperature, pH, and specific conductance are the average of 3–6 individual samples.

Vertical	Distance from LEW (m)	Depth (m)	Mean velocity (m/s)	Discharge (m^3/s)	Temperature (°C)	pH	Specific conductance (μS/cm)
LEW	0	0.0	0.00				
X05	69	3.2	0.38	70	--	--	--
02A,B	114	3.5	0.51	115	28.5	8.1	480
03A,B	198	4.1	0.53	113	29.6	8.0	480
X04	219	3.9	0.53	81	--	--	--
04A,B	277	3.9	0.72	187	29.6	8.1	480
05A,B	352	4.3	0.84	181	29.3	8.0	481
X03	378	4.2	0.76	120	--	--	--
06A,B	427	4.3	0.80	221	28.8	8.0	481
07A,B	507	5.1	0.91	247	29.1	7.9	481
X02	534	4.5	0.84	138	--	--	--
08A,B	580	4.7	0.95	273	29.3	8.2	484
09A,B	656	3.9	0.79	178	28.4	8.4	485
X01	696	3.9	0.63	84	--	--	--
10A,B	724	2.7	0.37	39	28.4	8.4	483
REW	773	0.0	0.00				
MEANS		3.7	0.71				
TOTAL	773	3.7	0.71	2,047			

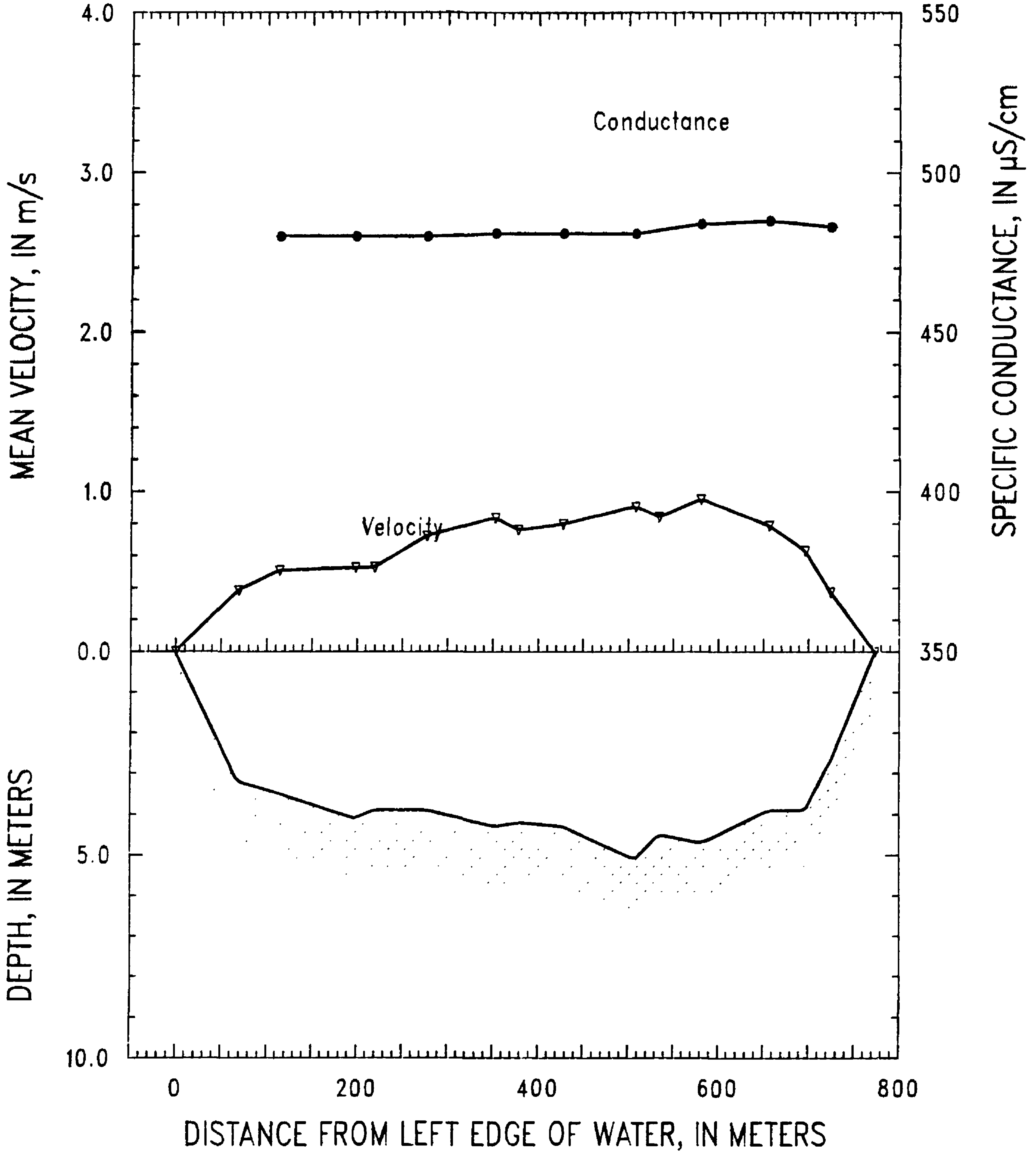

Figure 14. Mississippi River at Keokuk, Iowa, on July 21, 1991.

SITE: Mississippi River near Winfield, Mo.—Mile 239.2 07-24-91
PARTY: Moody, Roth, and Simoneaux
GAGE HEIGHT @ Dam 25 TW: 425.78 ft GAGE HEIGHT @ Pool 26: 418.40 ft
RIVER SLOPE: 35×10^{-6}
SUSP. Bag sampler and 150-lb weight
PRICE AA CURRENT METER No: W-223906 DATE RATED: 06-91
CURRENT METER EQUATION: V(m/s)=Rev/s* 0.670 + 0.010
REMARKS:

Transit rate was 7.5 cm/s and nozzle was 1/4 inch. Temperature, pH, and specific conductance are the average of three separate samples.

Vertical	Distance from LEW (m)	Depth (m)	Mean velocity (m/s)	Discharge (m^3/s)	Temperature (°C)	pH	Specific conductance (µS/cm)
LEW	0	0.0	0.00				
01A,B	29	5.9	0.51	105	27.7	7.9	478
X01	70	8.5	0.95	234	--	--	--
02A,B	87	8.2	1.00	243	27.4	8.0	474
X02	129	7.7	1.03	247	--	--	--
03A,B	149	8.1	0.96	244	27.7	8.0	473
X03	192	8.1	0.89	187	--	--	--
04A,B	201	8.0	0.85	228	27.5	8.1	473
05A,B	259	6.8	0.79	251	27.5	8.1	468
X04	295	6.0	0.81	147	--	--	--
06A,B	319	7.4	0.75	209	27.7	8.0	467
07A,B	370	5.7	0.68	133	27.6	8.1	462
X05	388	5.4	0.85	133	--	--	--
08A,B	428	5.1	0.63	134	27.2	8.1	462
X06	471	4.0	0.56	64	--	--	--
09A,B	486	4.2	0.64	86	27.5	8.1	468
10A,B	535	3.9	0.51	83	27.4	8.1	469
REW	570	0.0	0.00				
MEANS		6.0	0.80				
TOTAL	570			2,729			

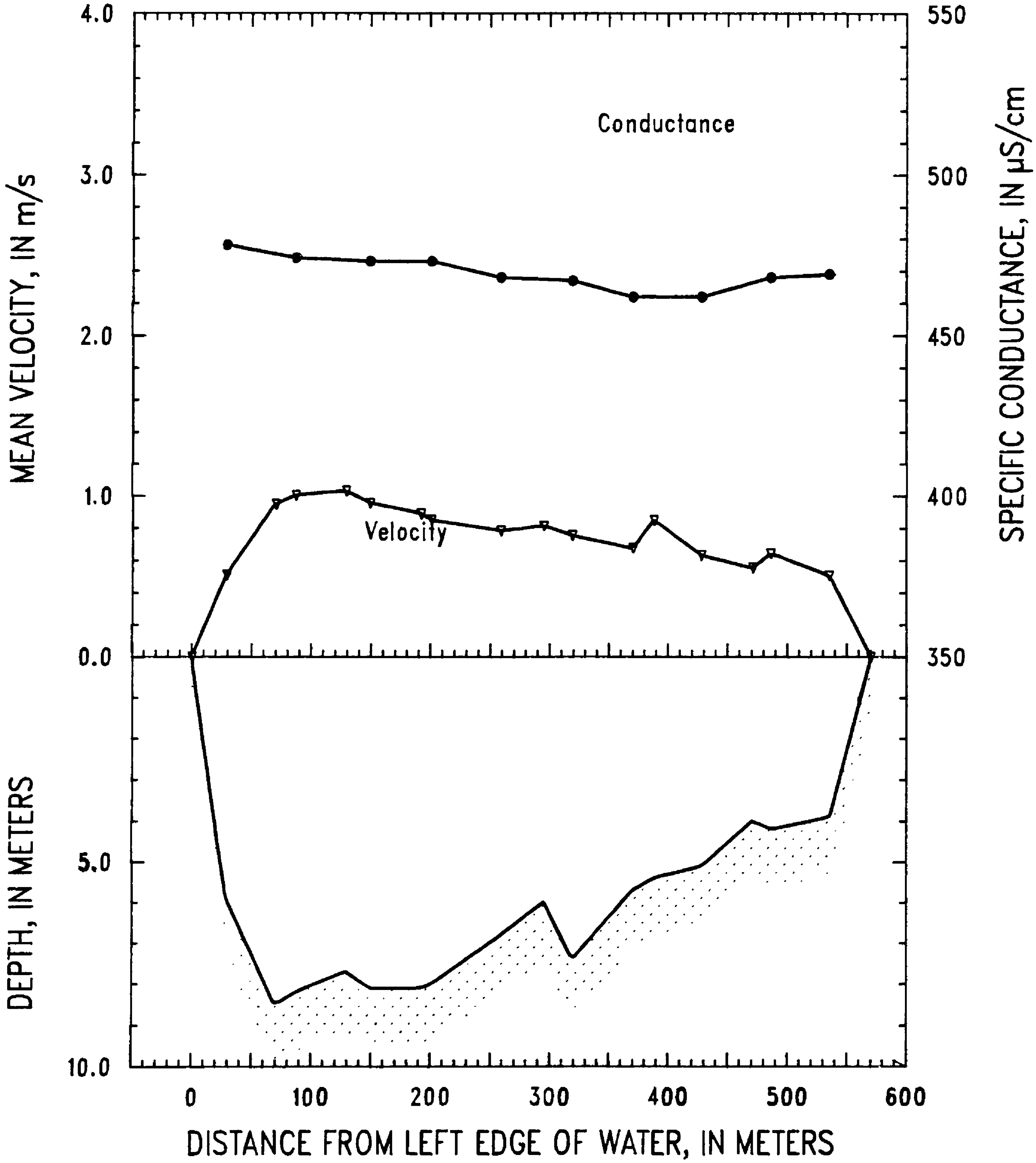

Figure 15. Mississippi River near Winfield, Missouri, on July 24, 1991.

SITE: Illinois River at Hardin, Ill.—Mile 21.8 07-25-91
PARTY: Moody and Simoneaux
GAGE HEIGHT @ Meredosia: ~439.4 ft GAGE HEIGHT @ Grafton: 419.7 ft
RIVER SLOPE: 52×10^{-6}
SUSP. 30-lb weight
PRICE AA CURRENT METER No: 90JM1 DATE RATED: 06-91
CURRENT METER EQUATION: V(m/s)=Rev/s* 0.667 + 0.006
REMARKS:

Velocities were measured from the small boat at 0.6 depth. ACADIANA was anchored near midriver. A depth-integrated sample was collected without a nozzle. The sample for trace metal analysis was collected by pumping 104 L after the pump sample (854 L) was collected. Temperature and specific conductance were measured with LabComp instrument, instead of the Beckman and Amber Science meters.

Vertical	Distance from LEW (m)	Depth (m)	Mean velocity (m/s)	Discharge (m^3/s)	Temperature (°C)	pH	Specific conductance (μS/cm)
LEW	0	0.0	0.00				
01	23	1.0	0.12	3	28.4	--	712
02	49	3.3	0.14	11	28.5	--	714
03	71	4.2	0.13	14	28.7	--	716
04	100	4.1	0.21	23	28.9	--	716
05	123	4.0	0.27	22	29.0	--	713
06	141	4.5	0.29	27	28.7	--	716
07	164	5.7	0.29	40	28.8	--	717
08	189	6.0	0.22	29	28.7	--	716
09	207	6.0	0.27	35	28.9	--	718
10	232	5.0	0.22	20	29.0	--	718
11	243	3.9	0.30	17	29.0	--	716
12	261	2.3	0.44	22	29.0	--	718
REW	286	0.0	0.00				
MEANS		3.8	0.24				
TOTAL	286			262			

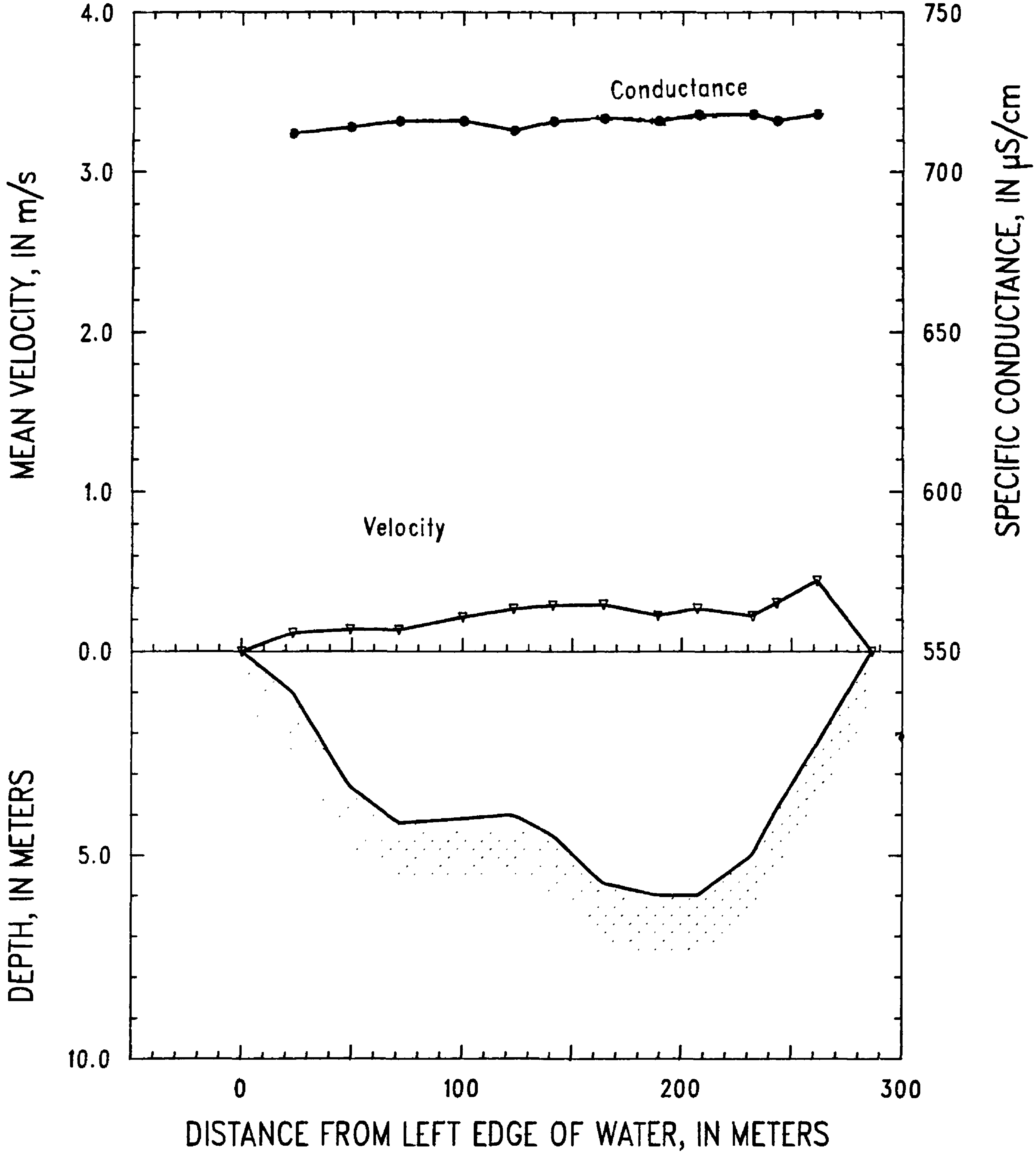

Figure 16. Illinois River at Hardin, Illinois, on July 25, 1991.

SITE: Missouri River at St. Charles, Mo.—Mile 24.8 07-27-91
PARTY: Moody, Antweiler, and Simoneaux
GAGE HEIGHT @ Hermann: 487.46 ft GAGE HEIGHT @ St. Charles: 431.7 ft
RIVER SLOPE: 151 x 10^{-6}
SUSP. Bag sampler and 150-lb weight
PRICE AA CURRENT METER No: 90JM1 DATE RATED: 06-91
CURRENT METER EQUATION: V(m/s)=Rev/s* 0.667 + 0.006
REMARKS:

Transit rate was 5 cm/s and the nozzle was 1/4 inch. Towboat reported sunk at about river mile 90 on July 26, 1991. Temperature, pH, and specific conductance are the average of three separate samples.

Vertical	Distance from LEW (m)	Depth (m)	Mean velocity (m/s)	Discharge (m^3/s)	Temperature (°C)	pH	Specific conductance (μS/cm)
LEW	0	0.0	0.00				
01A,B	33	5.4	1.01	111	26.9	7.4	671
02A,B	41	5.4	0.99	37	26.5	7.6	668
X01	47	4.7	1.03	34	--	--	--
03A,B	55	4.4	1.06	56	27.1	7.5	665
04A,B	71	4.1	1.09	72	27.2	7.6	681
05A,B	87	3.8	1.06	70	27.1	7.6	681
06A,B	106	4.1	0.96	63	27.5	7.8	683
07A,B	119	3.6	1.13	69	27.2	7.6	684
08A,B	140	3.7	1.03	66	26.8	7.9	681
09A,B	154	3.7	1.12	67	27.1	7.7	681
10A,B	172	3.7	1.01	67	27.3	7.7	680
11A,B	190	3.8	1.10	78	27.4	7.8	681
12A,B	209	3.9	1.04	71	27.5	7.7	682
13A,B	225	3.9	1.16	57	27.4	7.8	680
X05	234	4.0	0.99	30	--	--	--
14A,B	240	4.4	1.05	58	27.3	8.0	681
15A,B	259	4.1	1.15	92	27.5	7.8	684
REW	279	0.0	0.00				
MEANS		3.7	1.06				
TOTAL	279			1,096			

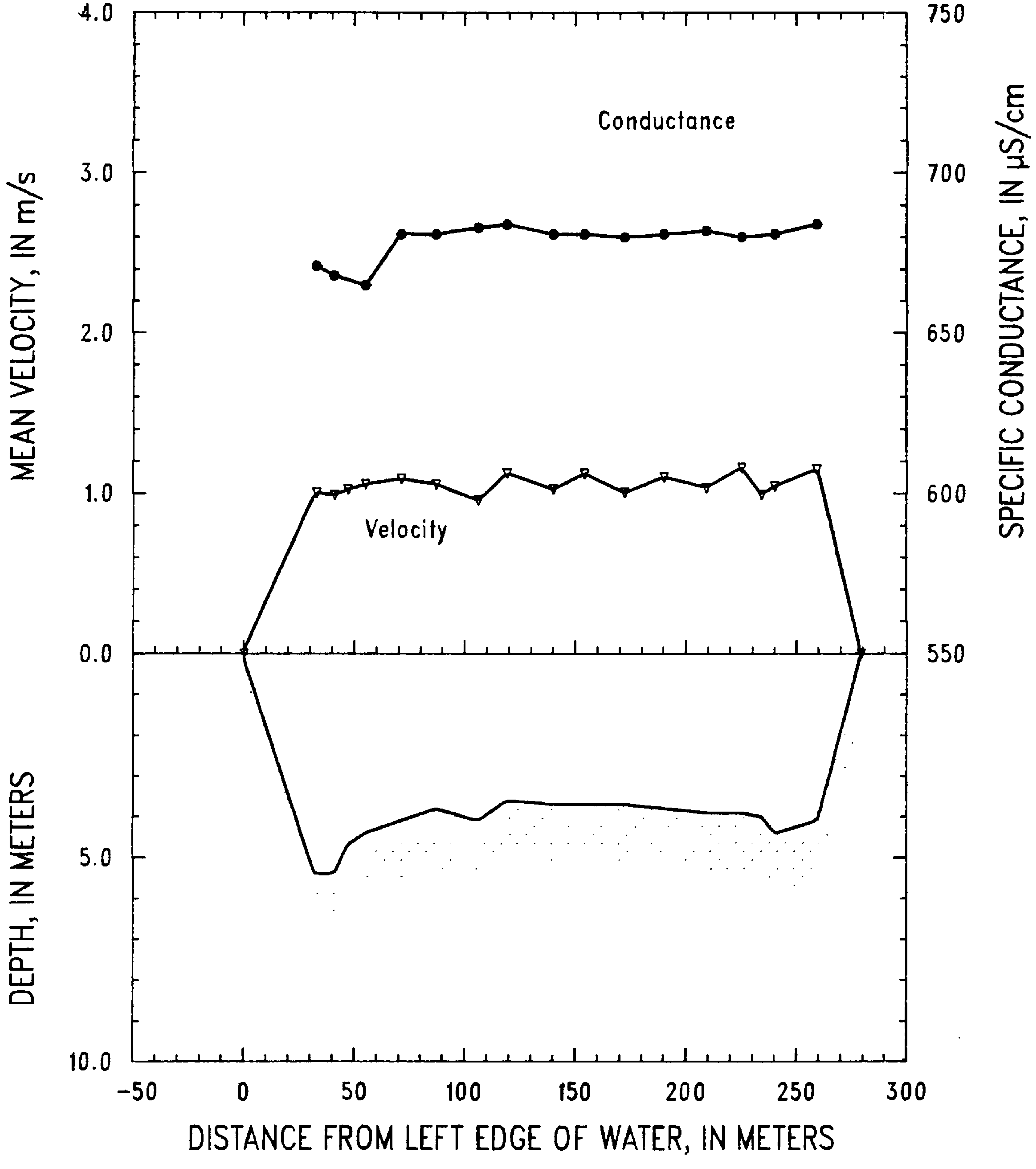

Figure 17. Missouri River at St. Charles, Missouri, on July 27, 1991.

SITE: Mississippi River at Thebes, Ill.—Mile 44.0 07-29-91
PARTY: Moody, Ellis, and Simoneaux
GAGE HEIGHT @ Chester: 351.7 ft GAGE HEIGHT @ Cape Girardeau: 320.4 ft
RIVER SLOPE: 102×10^{-6}
SUSP. Bag sampler and 150-lb weight
PRICE AA CURRENT METER No: W-223906 DATE RATED: 06-91
CURRENT METER EQUATION: V(m/s)=Rev/s* 0.670 + 0.010
REMARKS:

Transit rate was 10 cm/s and the nozzle was 1/4 inch. Order of verticals was 1–7, then 15–8. Temperature, pH, and specific conductance are the average of three separate samples.

Vertical	Distance from LEW (m)	Depth (m)	Mean velocity (m/s)	Discharge (m^3/s)	Temperature (°C)	pH	Specific conductance (μS/cm)
LEW	0	0.0	0.00				
01A,B	39	6.6	0.40	95	27.5	8.0	538
02A,B	72	8.2	0.73	158	27.3	8.1	539
X05	92	7.8	1.02	139	--	--	--
03A,B	107	8.1	1.12	291	27.0	8.0	539
04A,B	156	8.4	1.45	495	27.4	8.2	539
05A,B	188	8.4	1.49	262	27.3	8.4	544
X06	198	8.5	1.47	188	--	--	--
06A,B	218	8.6	1.43	339	27.2	8.2	544
07A,B	253	9.1	1.28	443	27.6	8.1	544
08A,B	294	8.6	1.28	419	27.6	8.2	544
09A,B	329	8.3	1.20	337	27.6	8.2	543
10A,B	362	7.3	1.12	278	27.5	8.2	544
11A,B	397	6.7	1.16	291	27.7	8.2	545
12A,B	437	6.8	1.08	294	27.7	8.2	546
13A,B	477	5.3	0.97	196	28.3	8.2	546
14A,B	513	4.8	0.72	76	28.3	8.2	546
X01	521	4.7	0.71	52	--	--	--
15A,B	544	3.9	0.34	42	28.7	8.1	545
REW	584	0.0	0.00				
MEANS		6.8	1.11				
TOTAL	584			4,394			

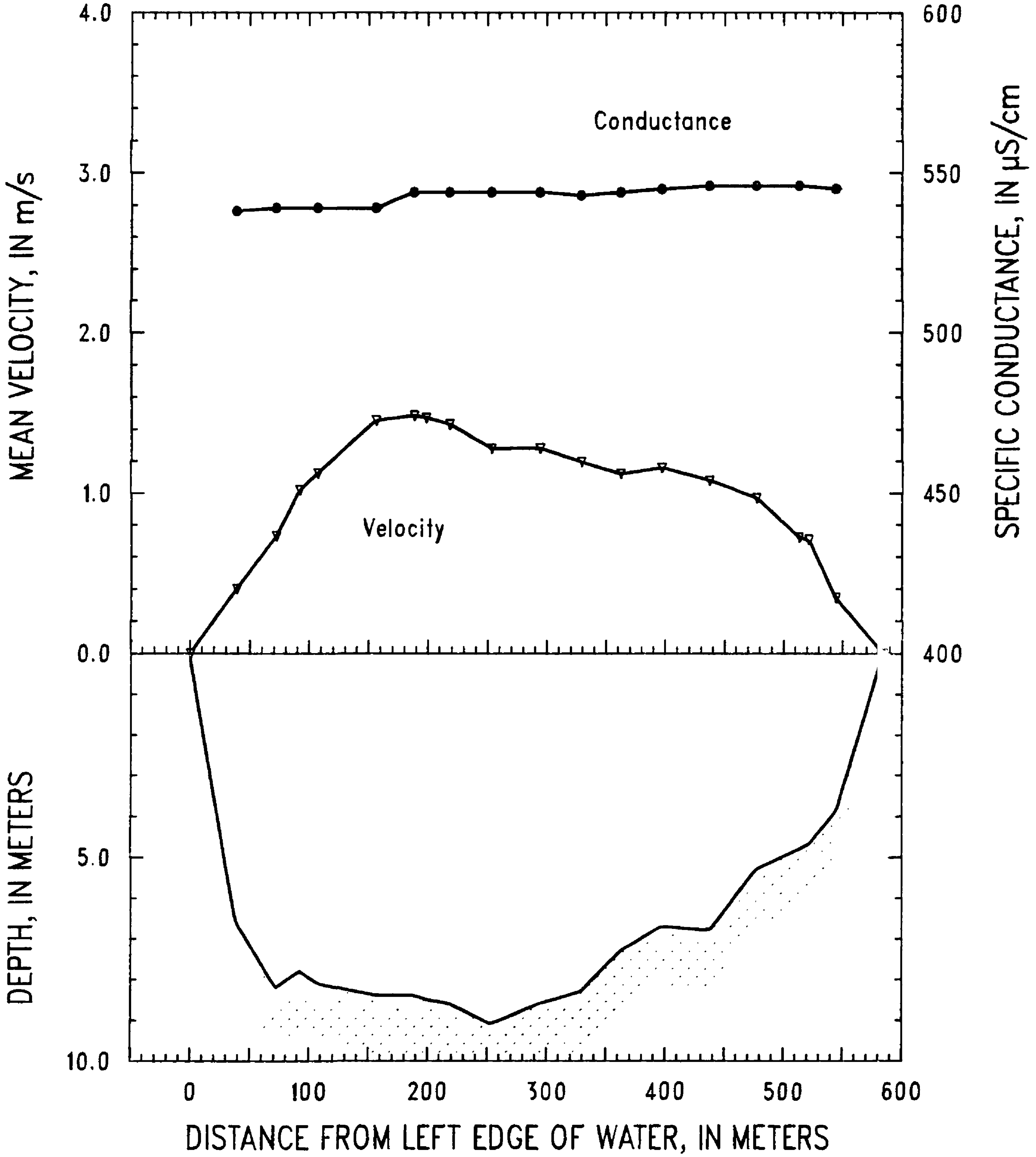

Figure 18. Mississippi River at Thebes, Illinois, on July 29, 1991.

SITE: Ohio River at Olmsted, Ill.—Mile 965.5 07-30-91
PARTY: Moody, Ellis, and LeBoeuf
GAGE HEIGHT @ Dam 53: 287.7 ft GAGE HEIGHT @ Cairo: 286.3 ft
RIVER SLOPE: 14×10^{-6}
SUSP. Bag sampler and 150-lb weight
PRICE AA CURRENT METER No: W-223906 DATE RATED: 06-91
CURRENT METER EQUATION: V(m/s)=Rev/s* 0.670 + 0.010
REMARKS:

Water velocities were too slow (~30 cm/sec) to collect depth-integrated samples. Order of verticals was 11, then 1–15. Anchored at each vertical to measure velocity and collect discharge-weighted pump sample.

Vertical	Distance from LEW (m)	Depth (m)	Mean velocity (m/s)	Discharge (m^3/s)	Temperature (°C)	pH	Specific conductance (µS/cm)
LEW	0	0.0					
01	49	5.7	0.21	42	28.6	8.0	210
X06	69	6.3	0.24	45	--	--	--
02	107	7.4	0.28	87	28.8	8.2	212
03	152	8.5	0.39	100	28.7	8.1	221
X05	167	8.7	0.34	72	--	--	--
04	200	8.5	0.39	134	28.9	8.2	222
05	249	8.0	0.45	171	29.0	8.1	228
06	295	8.7	0.40	126	28.9	8.1	225
X04	321	7.9	0.46	85	--	--	--
07	342	7.6	0.44	115	29.1	8.1	226
08	389	8.9	0.42	178	29.0	8.1	219
09	438	8.2	0.42	97	29.0	8.1	224
X01	445	7.7	0.45	59	--	--	--
10	472	8.0	0.44	180	29.1	8.1	229
11	547	10.7	0.39	204	28.8	8.1	267
12	571	10.3	0.42	129	29.1	8.1	260
X03	606	9.6	0.36	84	--	--	--
13	620	9.7	0.42	160	29.1	8.1	264
14	684	10.4	0.38	216	29.1	8.1	277
X02	730	9.9	0.28	80	--	--	--
15	742	10.4	0.19	49	29.1	8.1	284
REW	780	0.0	0.00				
MEANS		8.2	0.38				
TOTAL	780			2,410			

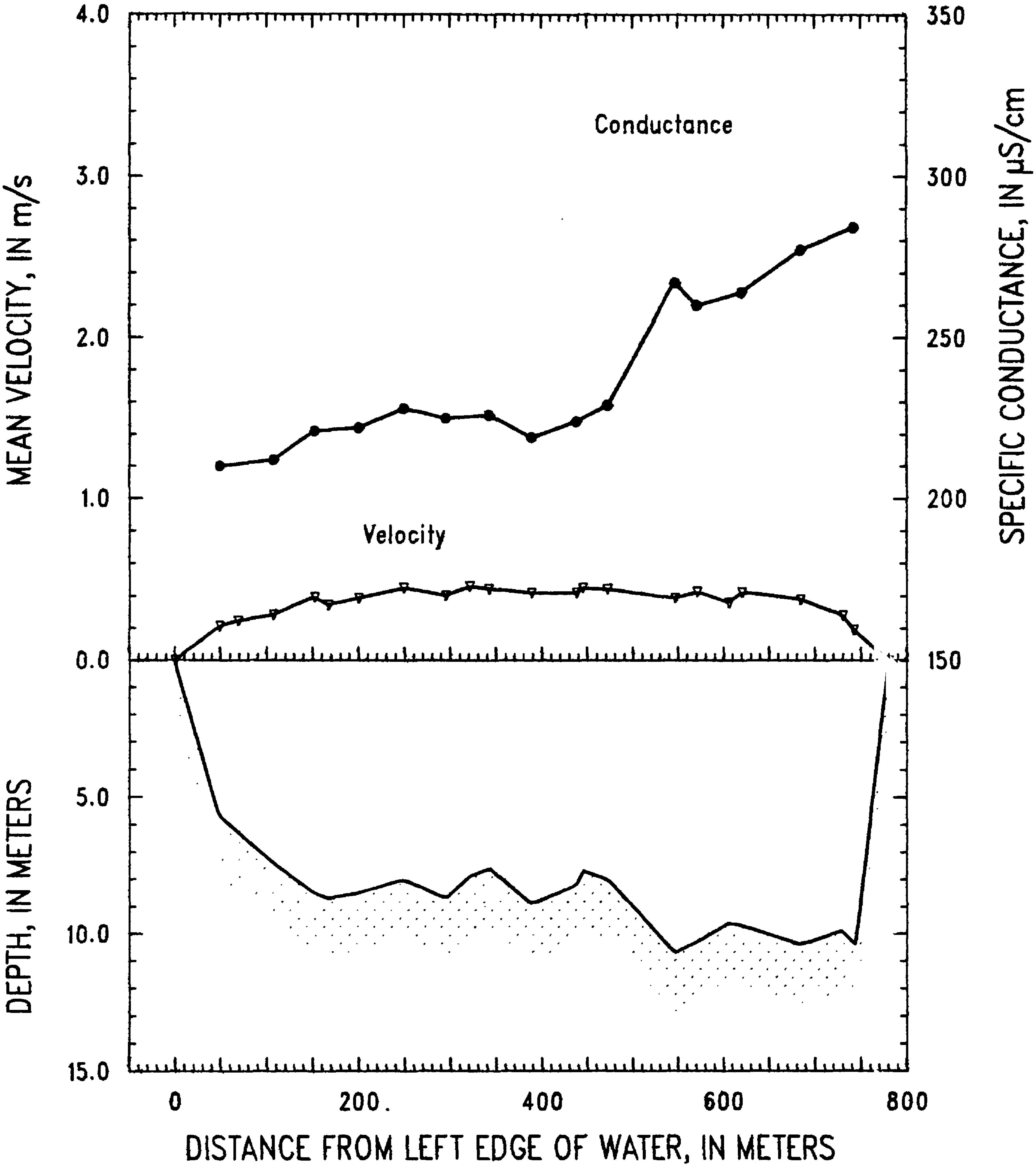

Figure 19. Ohio River at Olmsted, Illinois, on July 30, 1991.

SITE: Mississippi River below Vicksburg, Miss.—Mile 433.4 08-03-91
PARTY: Moody, Ellis, and LeBoeuf
GAGE HEIGHT @ Greenville: 91.6 ft GAGE HEIGHT @ Natchez: 32.9 ft
RIVER SLOPE: 66 x 10^{-6}
SUSP. Bag sampler and 150-lb weight
PRICE AA CURRENT METER No: W-223906 DATE RATED: 06-91
CURRENT METER EQUATION: V(m/s)=Rev/s* 0.670 + 0.010
REMARKS:

Twenty equally spaced verticals were planned, but only 17 were sampled owing to shallow water along the right edge of water. Transit rate was 7.0 cm/s and the nozzle was 3/16 inch. Temperature, pH, and specific conductance are the average of three separate samples.

Vertical	Distance from LEW (m)	Depth (m)	Mean velocity (m/s)	Discharge (m^3/s)	Temperature (°C)	pH	Specific conductance (μS/cm)
LEW	0	0.0	0.00				
01A,B	54	6.0	0.47	102	28.9	8.0	392
X01	72	7.0	0.69	156	--	--	--
02A,B	118	14.6	1.01	621	28.9	8.0	394
X02	156	13.9	1.12	335	--	--	--
X03	161	13.8	1.14	87	--	--	--
03A,B	167	13.7	1.12	415	29.0	8.0	404
04A,B	215	12.8	1.14	776	29.0	8.0	406
05A,B	273	12.4	1.15	832	29.2	8.1	413
06A,B	332	11.8	1.07	745	29.2	8.1	420
07A,B	391	11.1	1.06	589	29.2	8.1	423
X04	432	11.4	0.97	342	--	--	--
08A,B	453	10.8	1.03	406	29.2	8.1	426
09A,B	505	10.3	1.01	570	29.4	8.1	430
10A,B	563	9.8	1.04	618	29.2	8.1	435
11A,B	626	10.3	0.89	518	29.4	8.1	437
12A,B	676	9.7	0.87	361	29.3	8.1	438
X05	712	8.9	0.84	216	--	--	--
13A,B	734	8.6	0.78	243	29.3	8.1	440
14A,B	784	7.2	0.71	291	29.5	8.1	440
15A,B	848	6.0	0.57	196	29.0	8.2	440
16A,B	899	5.3	0.53	144	29.1	8.2	439
17A,B	950	3.4	0.63	92	29.5	8.2	441
X06	985	2.5	0.33	92			
REW	1,176	0.0	0.00				
MEANS		8.0	0.93				
TOTAL	1,176			8,746			

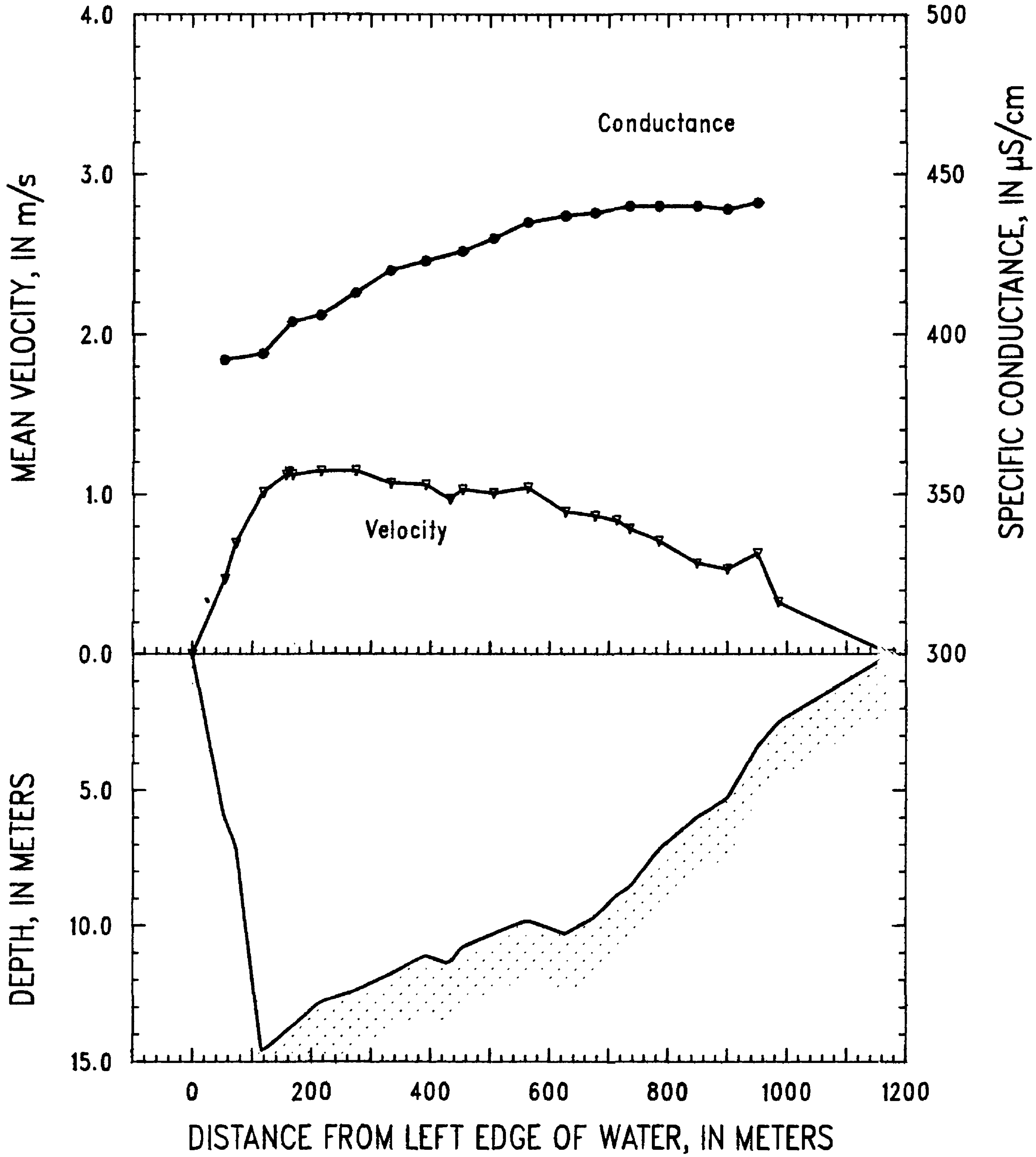

Figure 20. Mississippi River below Vicksburg, Mississippi, on August 3, 1991.

SITE: Mississippi River near St. Francisville, La.—Mile 266.4 08-05-91
PARTY: Moody, Ellis, and LeBoeuf
GAGE HEIGHT @ Red River Landing: 19.6 ft GAGE HEIGHT @ Baton Rouge: 7.8 ft
RIVER SLOPE: 30 x 10^{-6}
SUSP. Bag sampler and 150-lb weight
PRICE AA CURRENT METER No: W-223906 DATE RATED: 06-91
CURRENT METER EQUATION: V(m/s)=Rev/s* 0.670 + 0.010
REMARKS:

Transit rate was 6.5 cm/s and the nozzle was 3/16 inch. Temperature, pH, and specific conductance are the average of three separate samples.

Vertical	Distance from LEW (m)	Depth (m)	Mean velocity (m/s)	Discharge (m^3/s)	Temperature (°C)	pH	Specific conductance (μS/cm)
LEW	0	0.0					
01A,B	59	3.0	0.39	69	30.4	8.0	417
02A,B	118	5.5	0.56	159	30.5	8.0	417
X05	162	5.7	0.55	116	--	--	--
03A,B	192	5.6	0.59	125	30.2	8.0	417
04A,B	238	5.0	0.61	167	30.2	8.0	418
05A,B	301	5.9	0.74	272	30.2	8.0	418
06A,B	362	6.9	0.77	201	30.3	8.0	418
X04	377	7.0	0.76	161	--	--	--
07A,B	423	8.6	0.78	357	30.1	8.0	417
08A,B	484	8.5	0.80	421	30.1	8.0	417
09A,B	547	9.0	0.86	365	30.0	8.0	417
X03	578	9.9	0.92	199	--	--	--
10A,B	591	9.7	0.89	318	29.7	8.0	416
11A,B	652	12.1	0.81	623	29.8	8.0	416
12A,B	718	11.7	0.82	594	29.9	8.0	416
13A,B	776	12.2	0.87	652	29.6	8.0	416
14A,B	841	13.1	0.89	731	29.8	8.0	416
15A,B	901	10.5	0.93	412	29.8	8.0	416
X01	925	10.0	0.83	244	--	--	--
REW	960	0.0					
MEANS		8.1	0.79				
TOTAL	960			6,186			

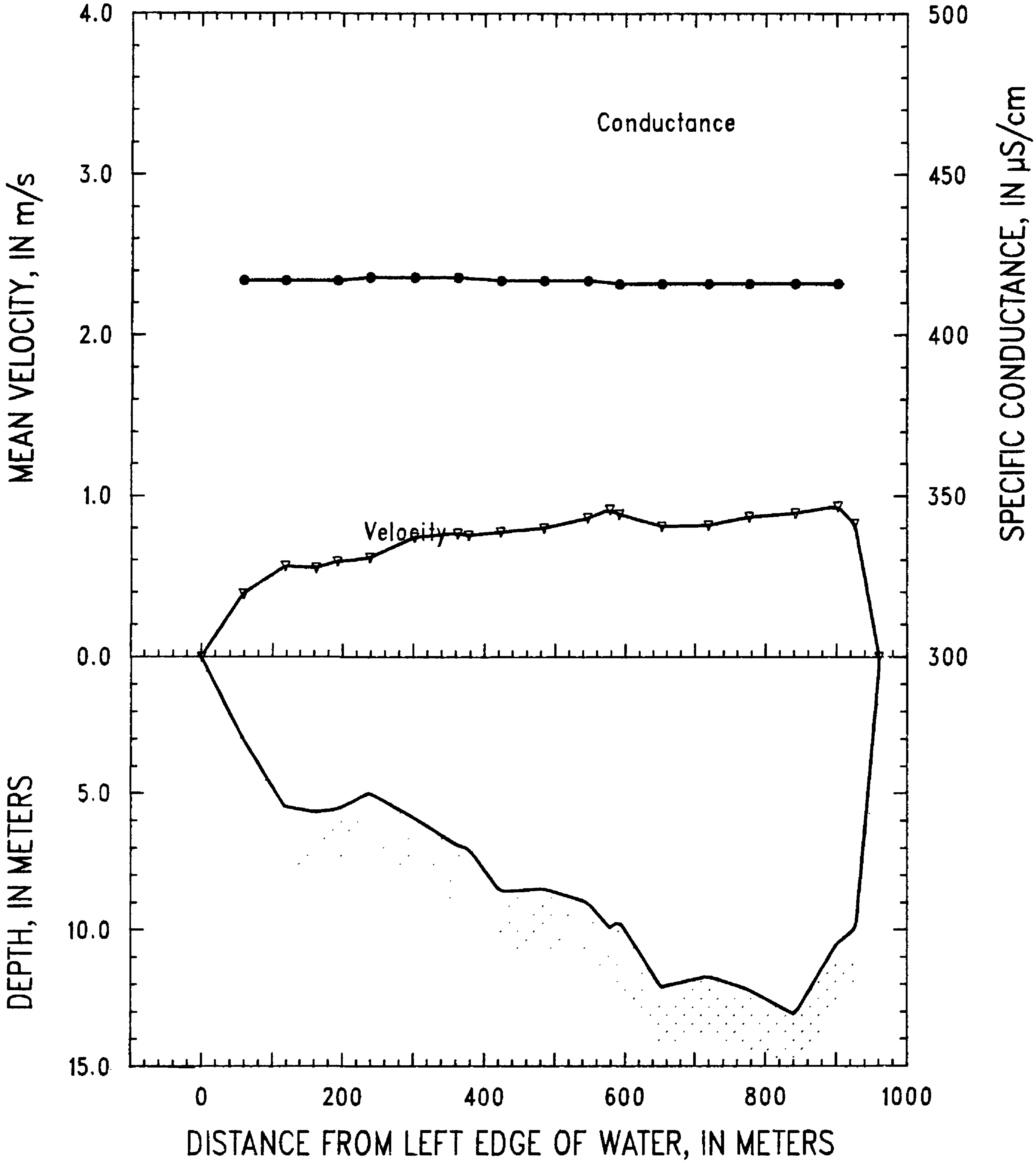

Figure 21. Mississippi River near St. Francisville, Louisiana, on August 5, 1991.

SITE: Mississippi River below Belle Chasse, La.—Mile 72.8 08-07-91
PARTY: Moody, Ellis, and Simoneaux
GAGE HEIGHT @ Baton Rouge: ~7.8 ft GAGE HEIGHT @ New Orleans: ~2.9 ft
RIVER SLOPE: 7×10^{-6}
SUSP. Bag sampler and 150-lb weight
PRICE AA CURRENT METER No: W-223906 DATE RATED: 06-91
CURRENT METER EQUATION: V(m/s)=Rev/s* 0.670 + 0.010
REMARKS:

Transit rate for velocity measurements was 3.0 cm/s. No depth-integrated sample was collected because of the slow water velocity. Since the water was well mixed, water was pumped from five equally spaced verticals (2–6) for both the pump and depth-integrated sample. Temperature, pH, and specific conductance are the average of three separate samples. Vertical 5 was measured after verticals 1–6.

Vertical	Distance from LEW (m)	Depth (m)	Mean velocity (m/s)	Discharge (m^3/s)	Temperature (°C)	pH	Specific conductance (µS/cm)
LEW	0	0.0	0.00				
06	84	10.2	0.21	233	30.2	7.9	465
05	223	15.8	0.26	505	31.1	7.9	476
04	326	20.2	0.31	748	30.3	7.9	468
03	465	32.0	0.33	1,330	30.0	7.9	467
02	581	35.1	0.33	1,110	30.2	7.9	465
01	655	22.1	0.27	415	30.0	7.8	465
REW	720	0.0	0.00				
MEANS		20.1	0.30				
TOTAL	720			4,341			

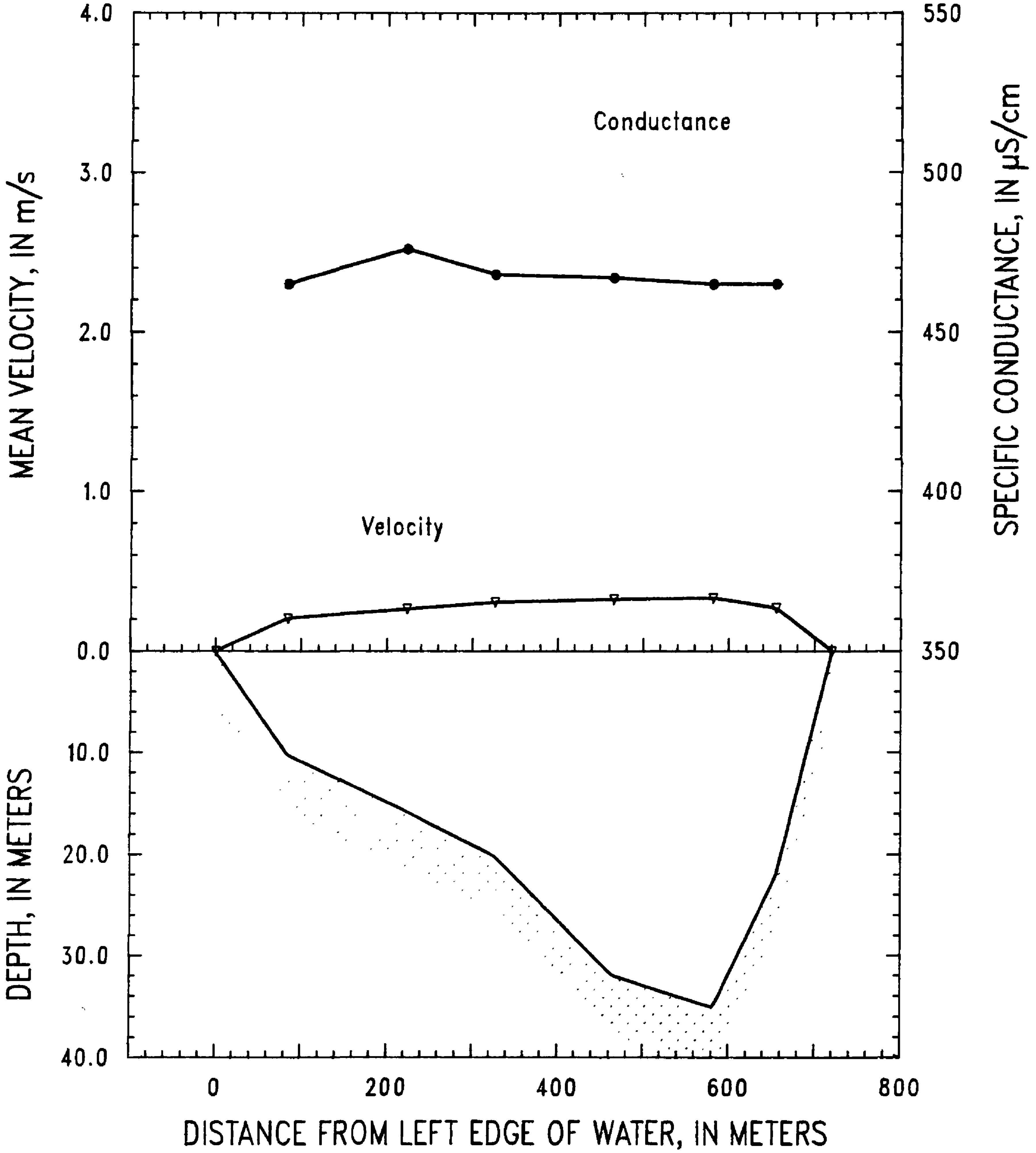

Figure 22. Mississippi River below Belle Chasse, Louisiana, on August 7, 1991.

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DATA LISTINGS

FOR

OCTOBER–NOVEMBER 1991 CRUISE

SITE: Mississippi River above St. Anthony Falls, Minn.—Mile 857.7 10-07-91
PARTY: Moody, Noyes, Antweiler, and Simoneaux
GAGE HEIGHT @ Anoka: 808.57 ft GAGE HEIGHT @ SAFU Pool: 799.70 ft
RIVER SLOPE: 156 x 10^{-6}
SUSP. Bag sampler and 150-lb weight
PRICE AA CURRENT METER No: W-223906 DATE RATED: 06-91
CURRENT METER EQUATION: V(m/s)=Rev/s* 0.670 + 0.010
REMARKS:

Anchored at five verticals, used 5/16-inch nozzle and 2.0 cm/s transit rate. Temperature, pH, and specific conductance were measured in order from left to right bank and are the average of three separate samples.

Vertical	Distance from LEW (m)	Depth (m)	Mean velocity (m/s)	Discharge (m^3/s)	Temperature (°C)	pH	Specific conductance (μS/cm)
LEW	0	0.0	0.00				
01A,B	27	2.4	0.59	30	10.0	8.4	443
X01	42	3.3	0.46	14	10.3	8.4	446
02A,B	46	3.2	0.51	24	10.2	8.5	451
X02	72	2.9	0.66	34	10.2	8.6	457
03A,B	81	3.5	0.55	20	10.2	8.6	461
X03	93	3.7	0.43	23	10.5	8.5	467
04A,B	110	3.9	0.48	22	10.4	8.6	472
05A	116	4.1	0.51	12	--	--	--
05B	121	3.6	0.50	43	10.3	8.6	476
REW	163	0.0	0.00				
MEANS		2.6	0.52				
TOTAL	163			221			

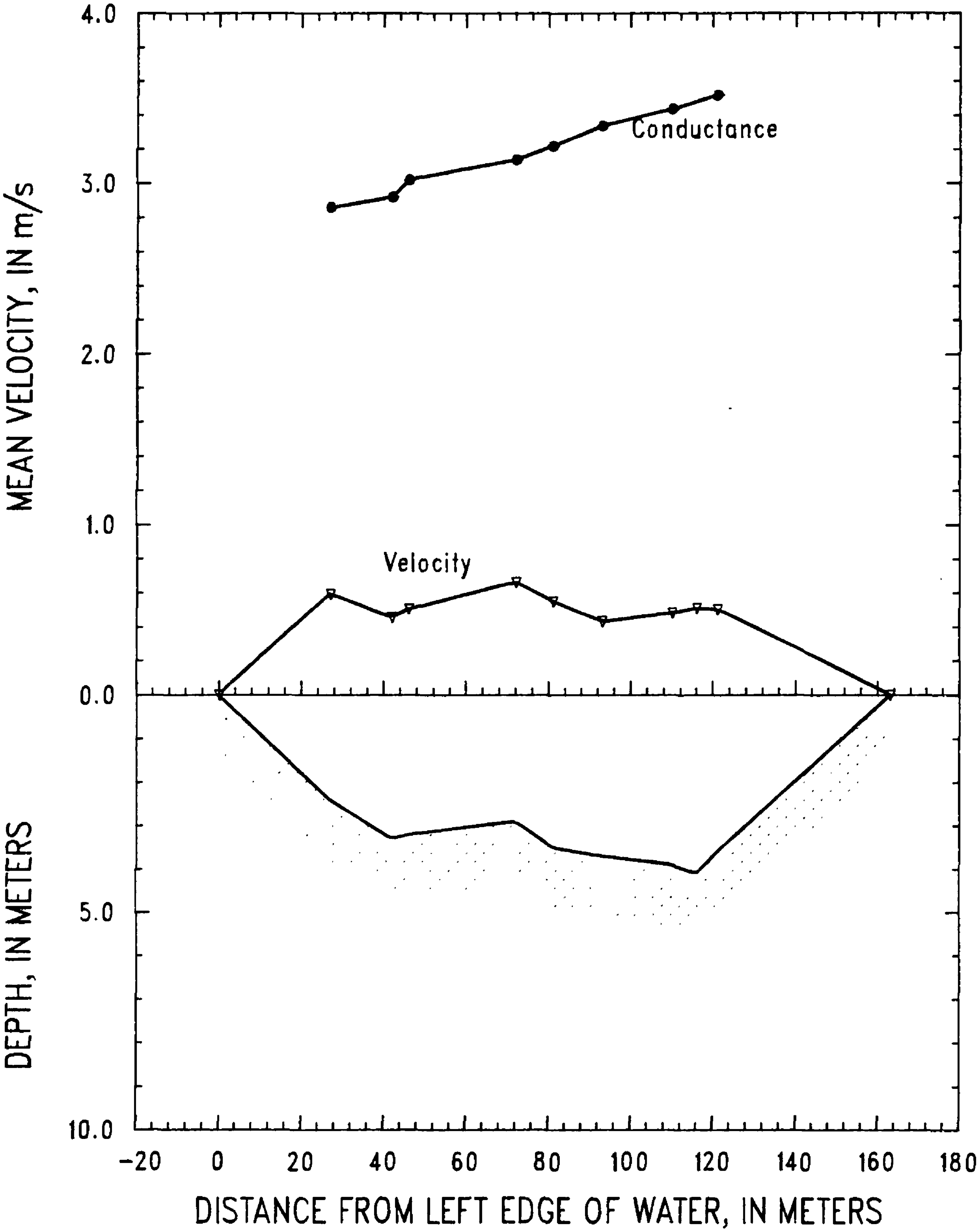

Figure 23. Mississippi River above St. Anthony Falls, Minnesota, on October 7, 1991.

SITE: Minnesota River at Mile 3.5, Minn. 10-08-91
PARTY: Moody, Antweiler, and Simoneaux
GAGE HEIGHT @ Savage: 688.7 ft GAGE HEIGHT @ Pool 2: 686.84 ft
RIVER SLOPE: 8×10^{-6}
SUSP. Bag sampler and 150-lb weight
PRICE AA CURRENT METER No: W-223906 DATE RATED: 06-91
CURRENT METER EQUATION: V(m/s)=Rev/s* 0.670 + 0.010
REMARKS:

Anchored at five verticals, used 5/16-inch nozzle and 2.0 cm/s transit rate. Temperature, pH, and specific conductance were collected from right to left bank.

Vertical	Distance from LEW (m)	Depth (m)	Mean velocity (m/s)	Discharge (m^3/s)	Temperature (°C)	pH	Specific conductance (μS/cm)
LEW	0	0.0	0.00				
01A	17	3.7	0.28	16	11.3	8.5	927
02A	31	4.7	0.34	31	11.5	8.5	928
03A	57	4.8	0.35	37	11.4	8.4	930
04A	74	4.8	0.35	26	11.3	8.3	930
05A	88	3.8	0.31	17	11.4	8.1	930
REW	103	0.0	0.00				
MEANS		3.7	0.33				
TOTAL	103			127			

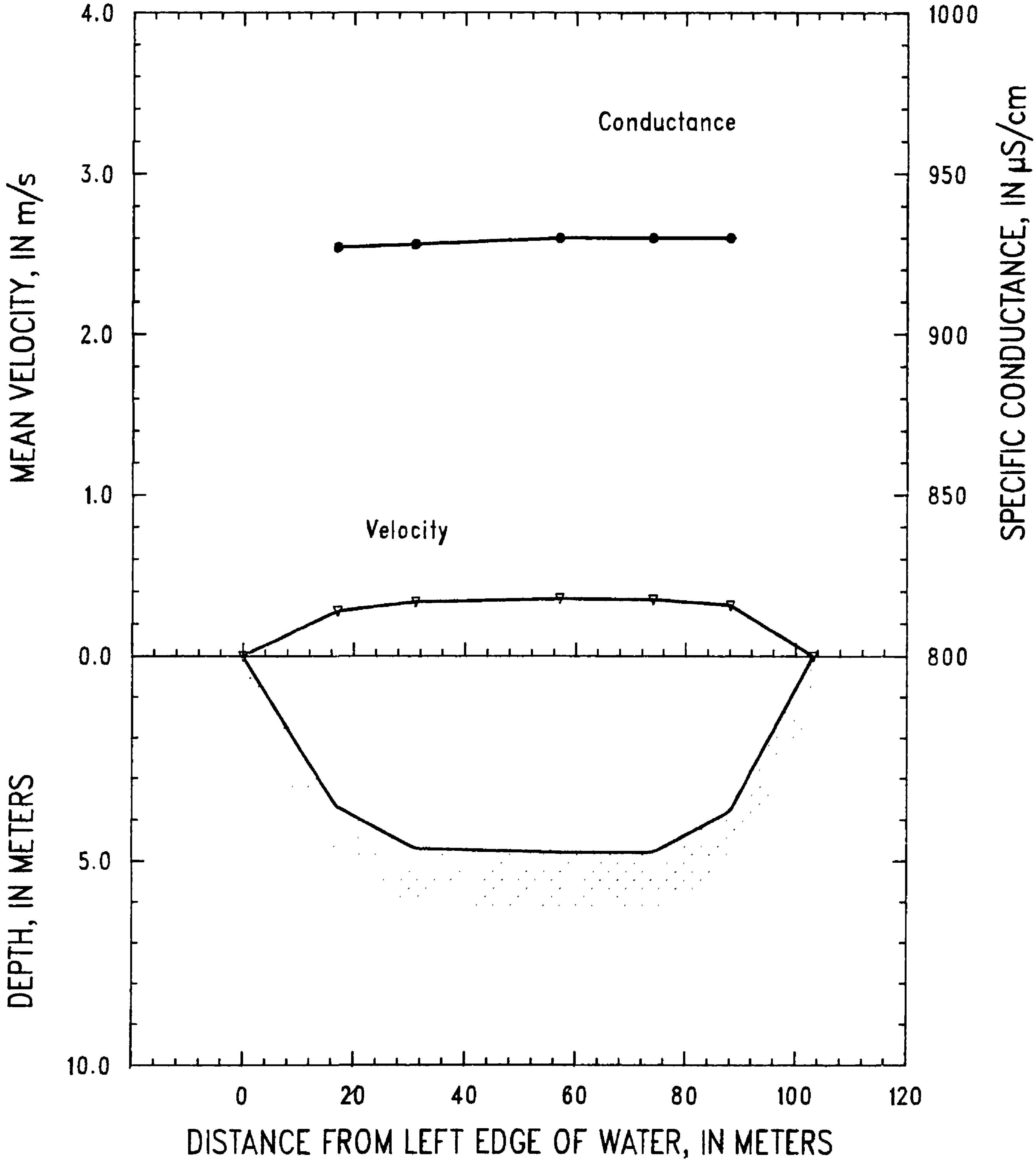

Figure 24. Minnesota River at Mile 3.5, Minnesota, on October 8, 1991.

SITE: Mississippi River at Hastings, Minn.—Mile 812.2 10-10-91
PARTY: Moody and Simoneaux
GAGE HEIGHT @ TW Pool 2: 675.89 ft GAGE HEIGHT @ Pool 3: 674.10 ft
RIVER SLOPE: 19×10^{-6}
SUSP. Bag sampler and 150-lb weight
PRICE AA CURRENT METER No: W-223906 DATE RATED: 06-91
CURRENT METER EQUATION: V(m/s)=Rev/s* 0.670 + 0.010
REMARKS:
Anchored at verticals 4 and 5. Did not collect a depth-integrated sample.

Vertical	Distance from LEW (m)	Depth (m)	Mean velocity (m/s)	Discharge (m^3/s)	Temperature (°C)	pH	Specific conductance (μS/cm)
LEW	0	0.0	0.00				
01	36	7.5	0.50	145	11.0	8.5	653
02	77	6.0	0.46	98	11.0	8.4	653
03	107	5.1	0.38	69	11.1	8.4	653
04	149	4.4	0.19	23	11.1	8.4	653
05	162	4.0	0.11	15	11.1	8.3	654
REW	215	0.0	0.00				
MEANS		4.4	0.37				
TOTAL	215			350			

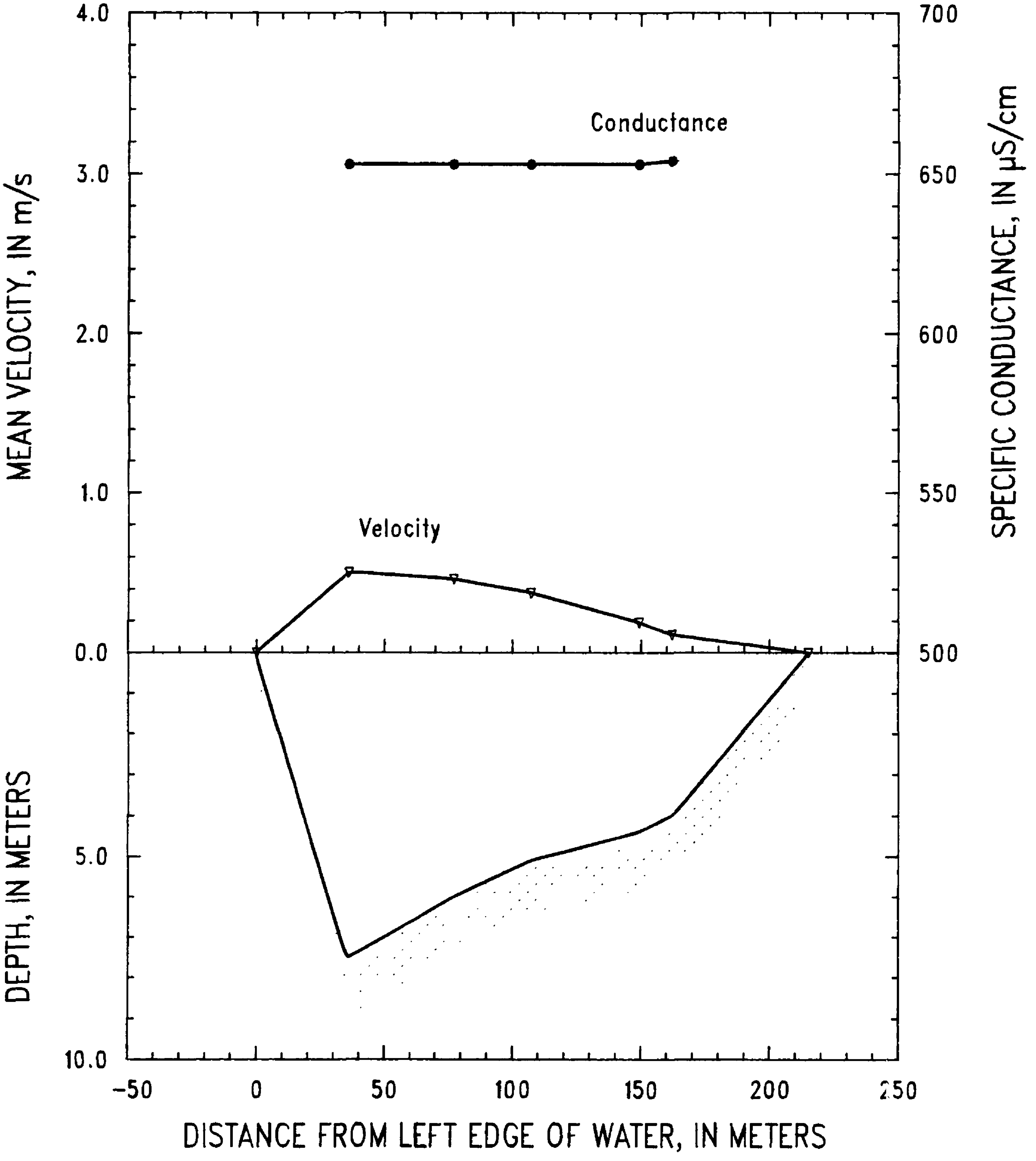

Figure 25. Mississippi River at Hastings, Minnesota, on October 10, 1991.

SITE: Mississippi River near Pepin, Wis.—Mile 764.5 10-13-91
PARTY: Moody, Noyes, and Simoneaux
GAGE HEIGHT @ Lake City: 667.66 ft GAGE HEIGHT @ Wabasha: 667.11 ft
RIVER SLOPE: 8×10^{-6}
SUSP. Bag sampler and 150-lb weight
PRICE AA CURRENT METER No: W-223906 DATE RATED: 06-91
CURRENT METER EQUATION: V(m/s)=Rev/s* 0.670 + 0.010
REMARKS:
Very strong wind (20–30 mph) upriver. No depth-integrated sample was collected. Vertical 1 at 55 m from LEW was not sampled because of the shallow water depths.

Vertical	Distance from LEW (m)	Depth (m)	Mean velocity (m/s)	Discharge (m^3/s)	Temperature (°C)	pH	Specific conductance (μS/cm)
LEW	0	0.0	0.00				
02	111	2.8	0.22	48	11.7	8.3	517
03	157	2.9	0.23	36	11.9	8.3	515
04	218	4.0	0.32	77	11.9	8.3	514
05	278	4.0	0.35	65	11.9	8.3	514
X01	311	4.7	0.37	54	--	--	--
06	340	5.6	0.38	54	12.0	8.3	514
X02	362	6.7	0.33	50	--	--	--
07	385	7.9	0.35	73	12.0	8.3	516
X03	414	5.9	0.32	51	--	--	--
REW	440	0.0	0.00				
MEANS		3.7	0.32				
TOTAL	440			508			

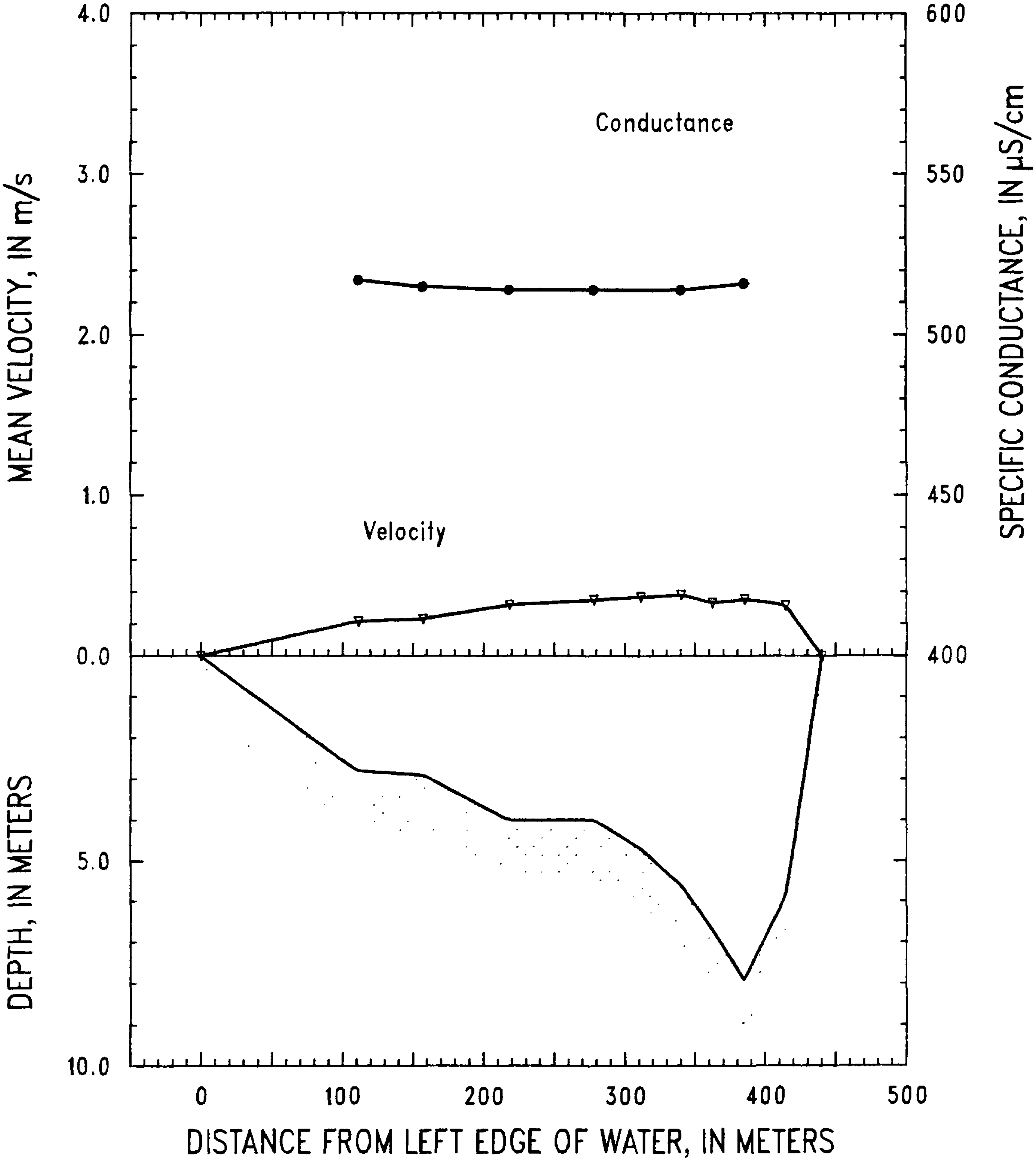

Figure 26. Mississippi River near Pepin, Wisconsin, on October 13, 1991.

SITE: Mississippi River at Trempealeau, Wis.—713.8 10-15-91
PARTY: Moody, Bishop, and Simoneaux
GAGE HEIGHT @ Pool 6 TW: 639.98 ft GAGE HEIGHT @ Pool 7: 639.15 ft
RIVER SLOPE: 14×10^{-6}
SUSP. Bag sampler and 150-lb weight
PRICE AA CURRENT METER No: W-223906 DATE RATED: 06-91
CURRENT METER EQUATION: V(m/s)=Rev/s* 0.670 + 0.010
REMARKS:

No depth-integrated sample was collected. Vertical 1 at 48 m from LEW was not sampled because of the shallow water depths. Discharge at Dam 6 was reported to be 671 m^3/s.

Vertical	Distance from LEW (m)	Depth (m)	Mean velocity (m/s)	Discharge (m^3/s)	Temperature (°C)	pH	Specific conductance (µS/cm)
LEW	0	0.0	0.00				
02	103	4.2	0.29	86	9.7	8.6	426
03	143	4.8	0.24	49	9.8	8.5	427
04	187	3.9	0.36	61	9.8	8.5	431
05	229	4.0	0.42	80	9.7	8.5	431
06	282	4.2	0.45	88	9.8	8.5	431
07	322	5.5	0.45	119	9.8	8.4	435
08	378	7.7	0.43	180	9.7	8.3	436
REW	430	0.0	0.00				
MEANS		4.0	0.38				
TOTAL	430			662			

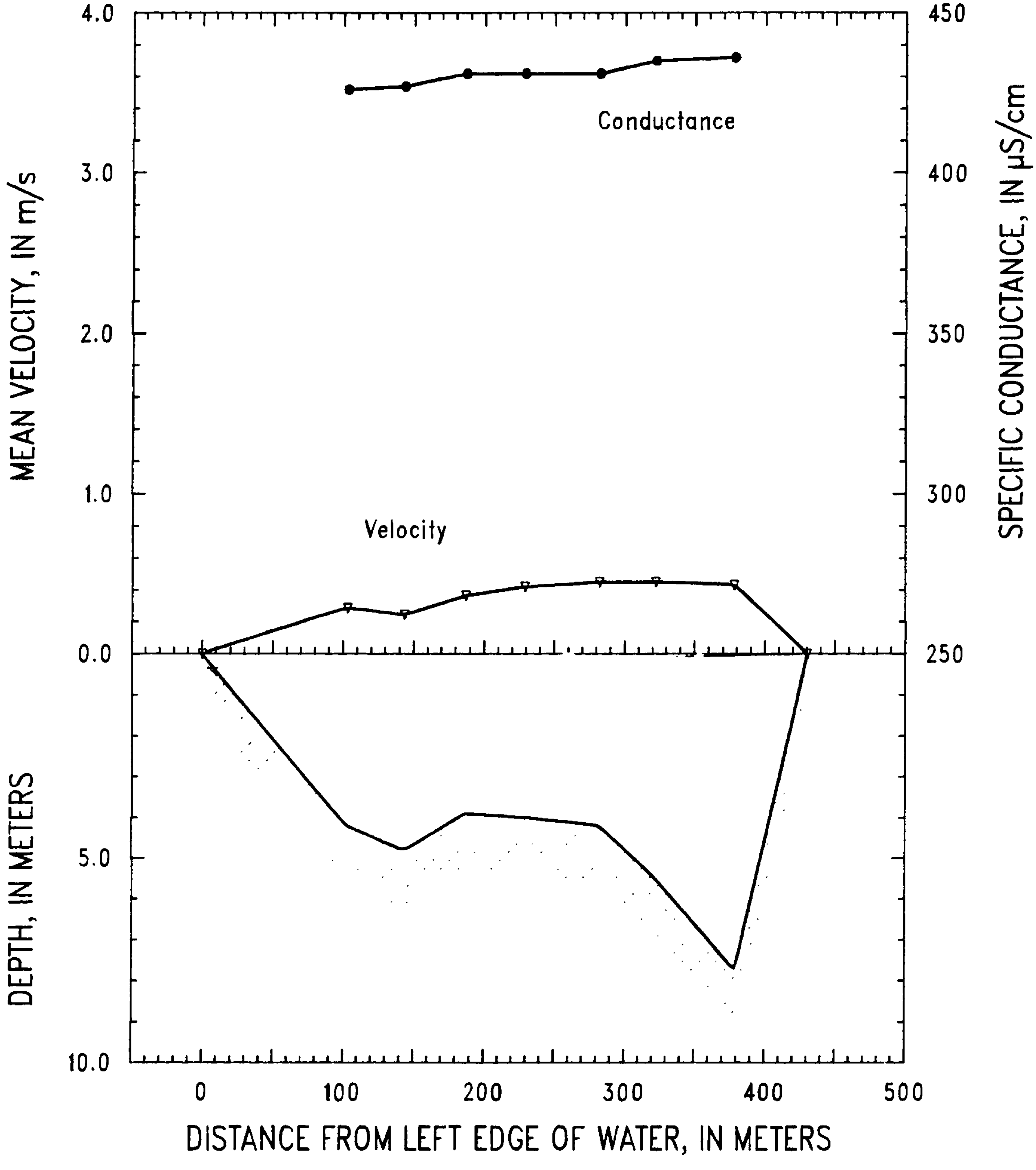

Figure 27. Mississippi River at Trempealeau, Wisconsin, on October 15, 1991.

SITE: Mississippi River below Lock and Dam 9, Wis.—Mile 639.7 10-18-91
PARTY: Moody, Brinton, and Simoneaux
GAGE HEIGHT @ Pool 9 TW: 613.39 ft GAGE HEIGHT @ Pool 10: 611.18 ft
RIVER SLOPE: 12.7×10^{-6}
SUSP. Bag sampler and 150-lb weight
PRICE AA CURRENT METER No: W-223906 DATE RATED: 06-91
CURRENT METER EQUATION: V(m/s)=Rev/s* 0.670 + 0.010
REMARKS:

No depth-integrated sample was collected. Discharge from Dam 9 was reported to be 663 m^3/s. No sample was collected at vertical 1 because of the shallow water.

Vertical	Distance from LEW (m)	Depth (m)	Mean velocity (m/s)	Discharge (m^3/s)	Temperature (°C)	pH	Specific conductance (μS/cm)
LEW	0	0.0	0.00				
02	107	3.6	0.32	97	10.7	8.5	436
03	168	5.0	0.42	125	10.7	8.5	438
04	226	5.9	0.42	126	11.0	8.5	439
05	270	5.6	0.45	133	10.8	8.5	437
06	332	5.2	0.43	119	10.6	8.5	439
07	376	4.3	0.39	94	10.7	8.5	442
REW	444	0.0	0.00				
MEANS		3.9	0.40				
TOTAL	444			694			

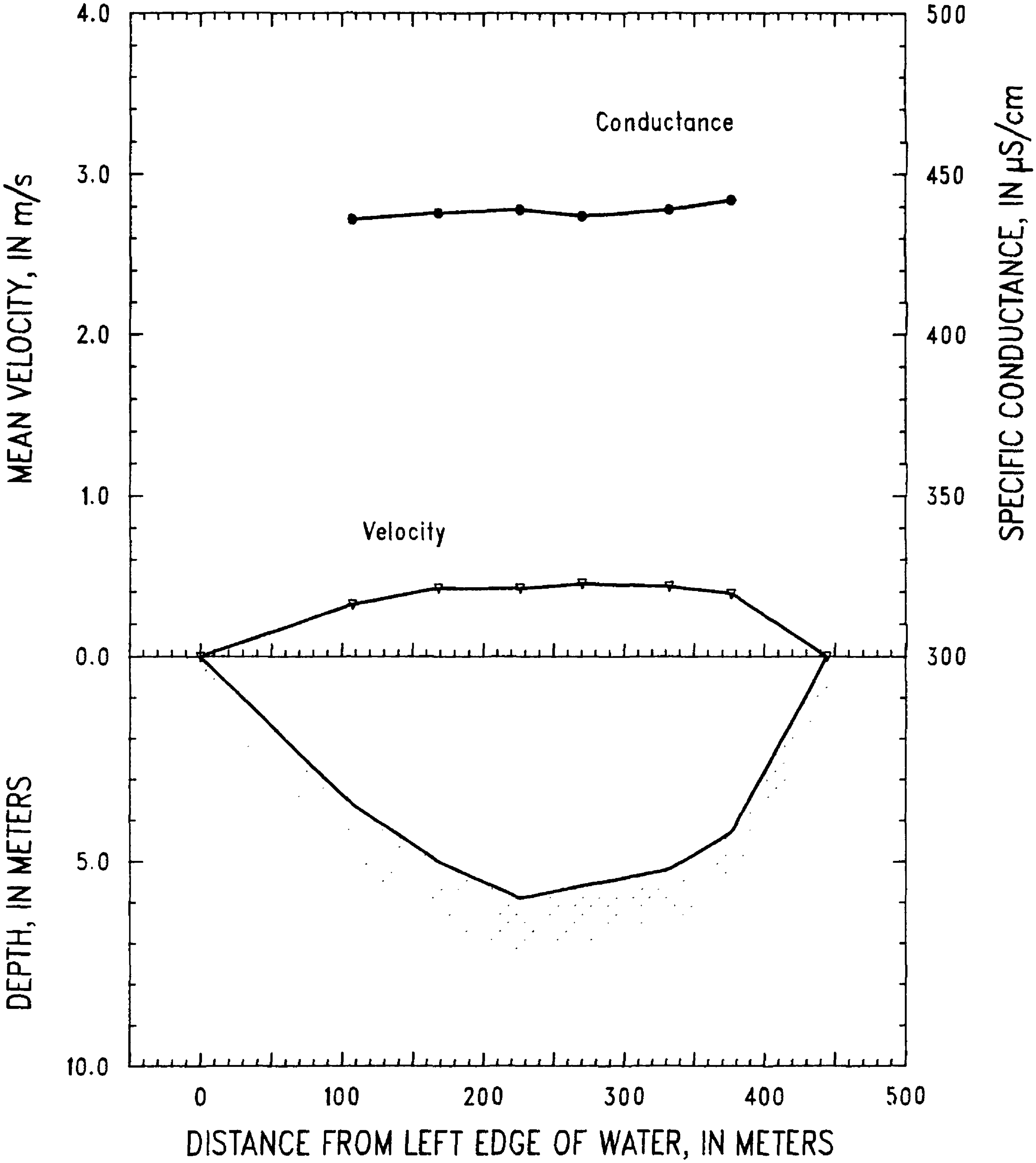

Figure 28. Mississippi River below Lock and Dam 9, Wisconsin, on October 18, 1991.

SITE: Mississippi River at Clinton, Iowa—Mile 520.3 10-22-91
PARTY: Moody, Brinton, and Simoneaux
GAGE HEIGHT @ Dam 13 TW: 573.75 ft GAGE HEIGHT @ Pool 14: 572.02 ft
RIVER SLOPE: 10.9×10^{-6}
SUSP. Bag sampler and 150-lb weight
PRICE AA CURRENT METER No: W-223906 DATE RATED: 06-91
CURRENT METER EQUATION: V(m/s)=Rev/s* 0.670 + 0.010
REMARKS:

No depth-integrated sample was collected. Vertical 1 at 56 m from LEW was not sampled because of the shallow water depths. Doug Goodrich (USGS, Iowa City) measured a discharge of 880 m^3/s from the Highway 30 bridge.

Vertical	Distance from LEW (m)	Depth (m)	Mean velocity (m/s)	Discharge (m^3/s)	Temperature (°C)	pH	Specific conductance (μS/cm)
LEW	0	0.0	0.00				
02	115	4.0	0.18	58	11.9	8.5	425
03	165	6.6	0.31	107	12.0	8.5	423
04	221	7.1	0.39	150	11.7	8.5	425
05	274	8.2	0.43	211	12.2	8.5	427
06	340	8.9	0.44	231	12.1	8.4	428
07	392	8.3	0.40	182	12.2	8.4	426
REW	450	0.0	0.00				
MEANS		5.6	0.37				
TOTAL	450			939			

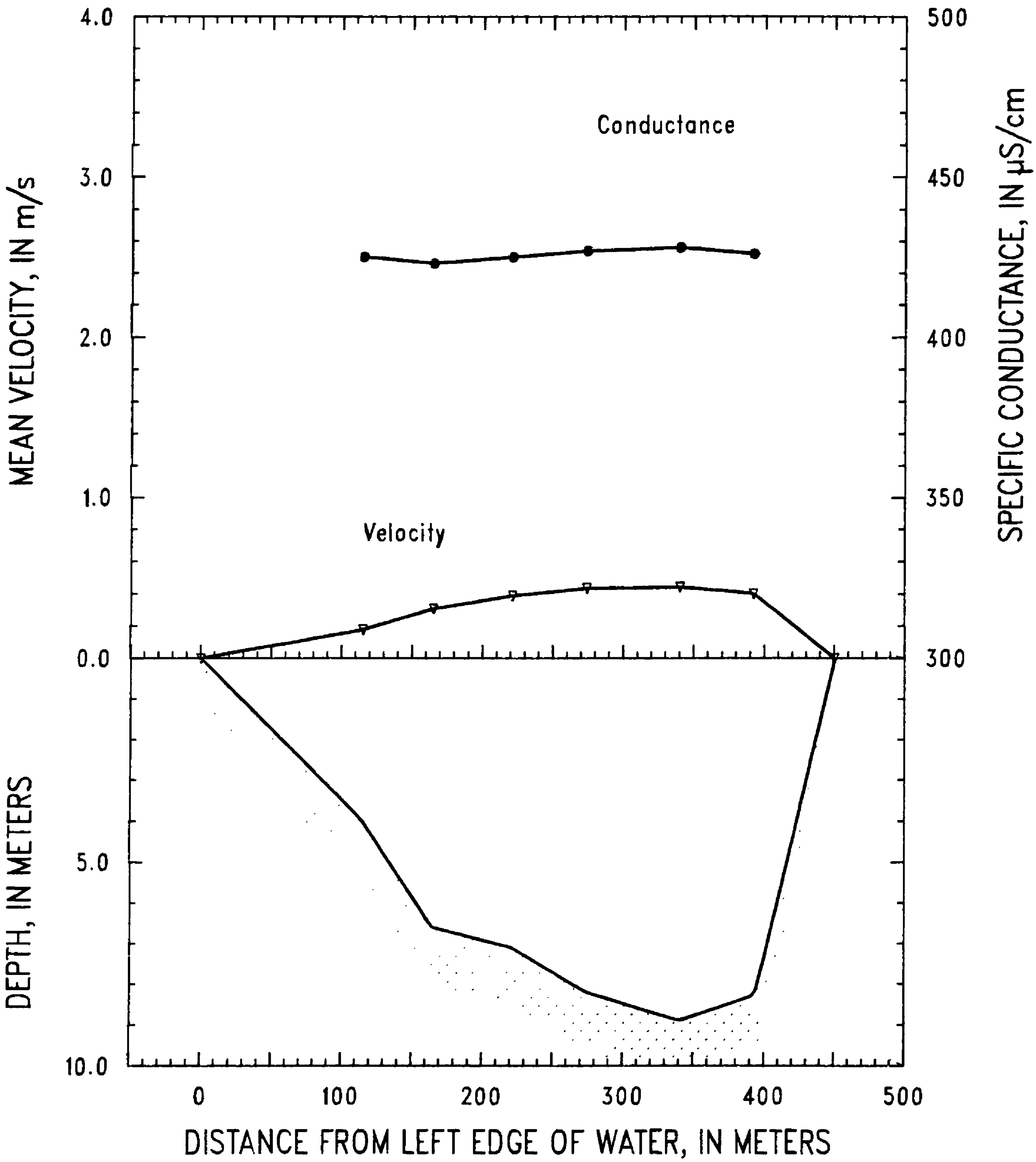

Figure 29. Mississippi River at Clinton, Iowa, on October 22, 1991.

SITE: Missippi River at Keokuk, Iowa—Mile 363.1 10-27-91
PARTY: Moody, Garbarino, and LeBoeuf
GAGE HEIGHT @ Dam 19 TW: 481.65 ft GAGE HEIGHT @ Pool 20: 479.38 ft
RIVER SLOPE: 20.5×10^{-6}
SUSP. Bag sampler and 150-lb weight
PRICE AA CURRENT METER No: W-223906 DATE RATED: 06-91
CURRENT METER EQUATION: V(m/s)=Rev/s* 0.670 + 0.010
REMARKS:

No depth-integrated sample was collected. Water level rose about 0.3 m after starting section. Mean discharge from Dam 19 was about 1,300 m^3/s.

Vertical	Distance from LEW (m)	Depth (m)	Mean velocity (m/s)	Discharge (m^3/s)	Temperature (°C)	pH	Specific conductance (μS/cm)
LEW	0	0.0	0.00				
01	96	2.6	0.38	95	14.5	8.3	458
02	193	3.4	0.39	126	14.0	8.3	459
03	287	3.0	0.64	173	14.0	8.4	460
04	374	3.2	0.70	204	13.9	8.4	462
05	470	4.3	0.83	345	13.9	8.4	462
06	567	4.1	0.79	287	14.0	8.4	464
07	647	3.2	0.63	178	13.9	8.4	463
REW	745	0.0	0.00				
MEANS		3.0	0.64				
TOTAL	745			1,408			

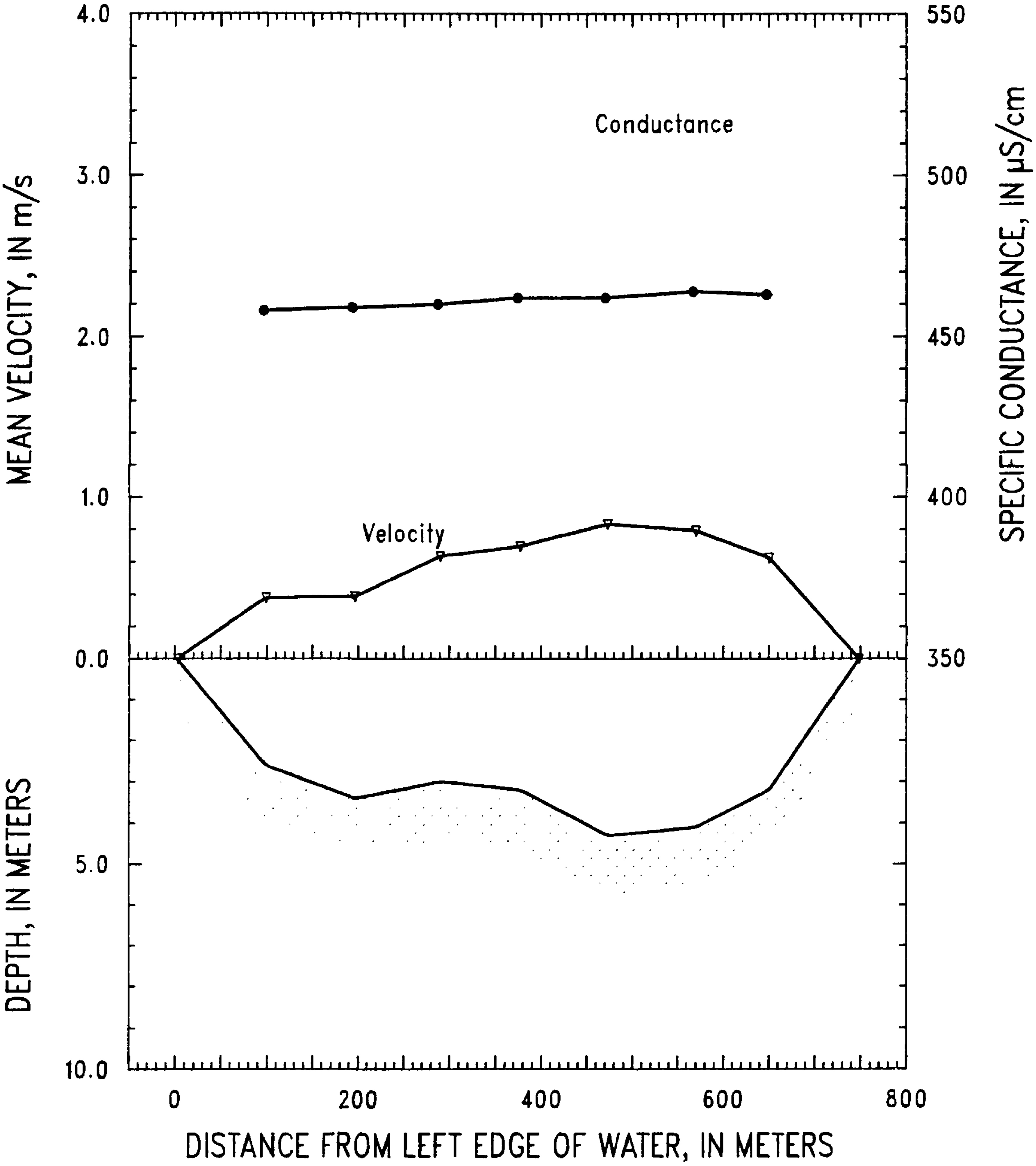

Figure 30. Mississippi River at Keokuk, Iowa, on October 27, 1991.

SITE: Mississippi River near Winfield, Mo.—Mile 239.2 10-30-91
PARTY: Moody, Garbarino, and Simoneaux
GAGE HEIGHT @ Dam 25 TW: 421.28 ft GAGE HEIGHT @ Pool 26: 419.10 ft
RIVER SLOPE: 10.3×10^{-6}
SUSP. Bag sampler and 150-lb weight
PRICE AA CURRENT METER No: W-223906 DATE RATED: 06-91
CURRENT METER EQUATION: V(m/s)=Rev/s* 0.670 + 0.010
REMARKS:
No depth-integrated sample was collected.

Vertical	Distance from LEW (m)	Depth (m)	Mean velocity (m/s)	Discharge (m^3/s)	Temperature (°C)	pH	Specific conductance (µS/cm)
LEW	0	0.0	0.00				
01	93	7.7	0.55	283	13.3	8.4	453
02	135	7.6	0.55	261	13.4	8.4	454
03	218	6.9	0.52	269	13.5	8.4	454
04	284	5.2	0.48	167	13.6	8.4	454
05	352	4.7	0.35	111	13.6	8.4	454
06	419	4.1	0.35	78	13.5	8.4	453
07	461	3.2	0.28	64	13.5	8.4	453
REW	563	0.0	0.00				
MEANS		4.7	0.47				
TOTAL	563			1,233			

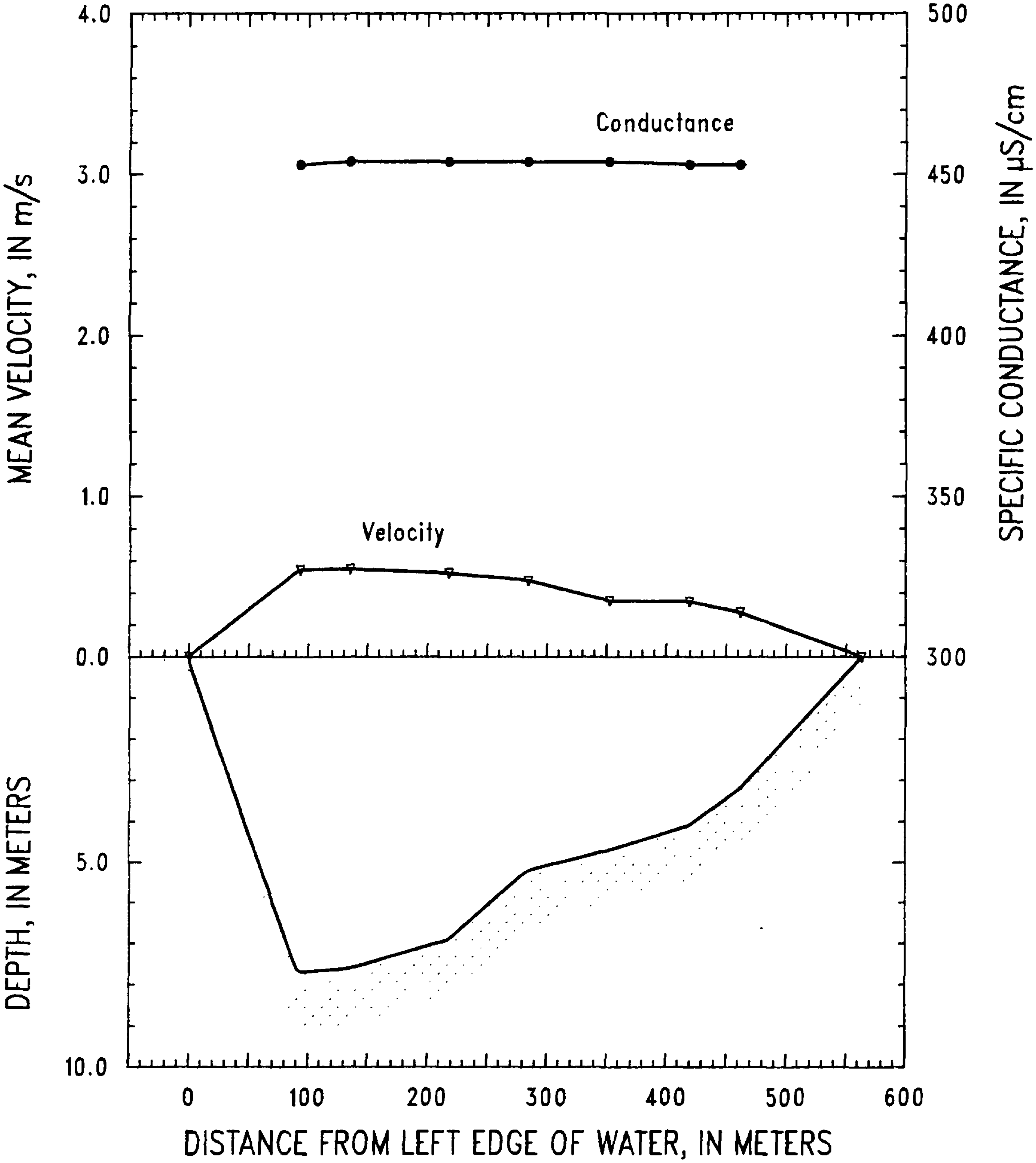

Figure 31. Mississippi River near Winfield, Missouri, on October 30, 1991.

SITE: Illinois River at Hardin, Ill.—Mile 21.8 10-31-91
PARTY: Moody, Garbarino, Krest, and Simoneaux
GAGE HEIGHT @ Meredosia: 442.1 ft GAGE HEIGHT @ Grafton: 419.3 ft
RIVER SLOPE: 60.3×10^{-6}
SUSP. 15-lb weight
PRICE AA CURRENT METER No: W-223906 DATE RATED: 06-91
CURRENT METER EQUATION: V(m/s)=Rev/s* 0.670 + 0.010
REMARKS:

Velocities were measured from the small boat at 0.6 depth and by depth integration from the small boat. One trisponder was at LEW and one was in the small boat. A discharge of 525 m^3/s was calculated using the 0.6 depth velocity measurements.

Vertical	Distance from LEW (m)	Depth (m)	Mean velocity (m/s)	Discharge (m^3/s)	Temperature (°C)	pH	Specific conductance (μS/cm)
LEW	0	0.0	0.00				
01	23	1.3	0.19	7	13.8	8.0	671
02	53	3.4	0.33	42	13.9	8.0	673
03	97	4.1	0.47	81	13.7	8.0	673
09	138	4.8	0.56	68	13.6	8.0	676
04	148	5.2	0.59	52	13.8	8.0	676
05	172	6.1	0.53	87	14.0	8.0	676
06	202	6.1	0.49	99	13.9	8.0	678
07	238	5.8	0.44	63	13.8	8.0	678
08	251	4.0	0.33	21	13.7	8.0	675
REW	270	0.0	0.00				
MEANS		4.1	0.47				
TOTAL	270			520			

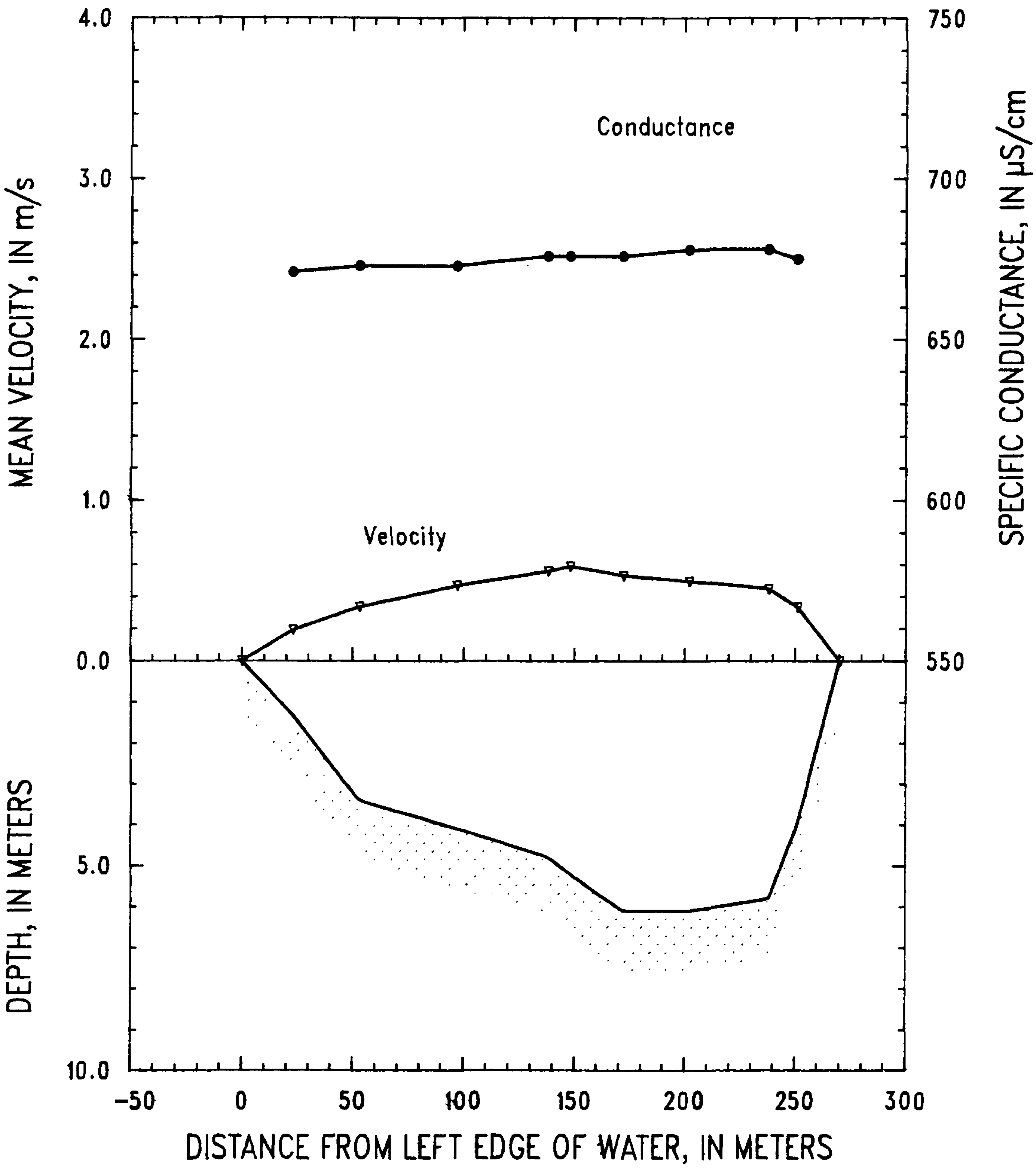

Figure 32. Illinois River at Hardin, Illinois, on October 31, 1991.

SITE: Missouri River at St. Charles, Mo.—Mile 24.8 11-03-91
PARTY: Moody, Roth, and Simoneaux
GAGE HEIGHT @ Hermann: 488.56 ft GAGE HEIGHT @ St. Charles: 432.0 ft
RIVER SLOPE: 151×10^{-6}
SUSP. Bag sampler and 150-lb weight
PRICE AA CURRENT METER No: W-223906 DATE RATED: 06-91
CURRENT METER EQUATION: V(m/s)=Rev/s* 0.670 + 0.010
REMARKS:

Several problems were encountered because of the very cold weather (-1 to 2°C). Transit rate was 5 cm/s and nozzle size was 1/4 inch. Unmeasured zone was 0.67 m. Gage heights above are for November 2, 1991.

Vertical	Distance from LEW (m)	Depth (m)	Mean velocity (m/s)	Discharge (m^3/s)	Temperature (°C)	pH	Specific conductance (μS/cm)
LEW	0	0.0	0.00				
01A,B	39	6.0	1.07	187	7.8	8.0	655
02A,B	58	4.9	1.15	105	7.9	8.0	654
03A,B	76	4.7	1.21	123	7.9	8.0	654
04A,B	101	4.6	1.22	146	8.0	8.0	652
05A,B	128	4.5	1.10	137	8.1	8.0	652
06A,B	156	4.2	1.20	123	8.1	8.0	654
07A,B	177	4.3	1.16	113	8.1	8.0	656
08A,B	201	4.7	1.12	131	8.3	8.0	658
09A,B	227	4.6	1.16	141	8.2	7.9	658
10A,B	254	4.7	1.19	148	8.2	7.8	659
REW	280	0.0	0.00				
MEANS		4.2	1.15				
TOTAL	280			1,352			

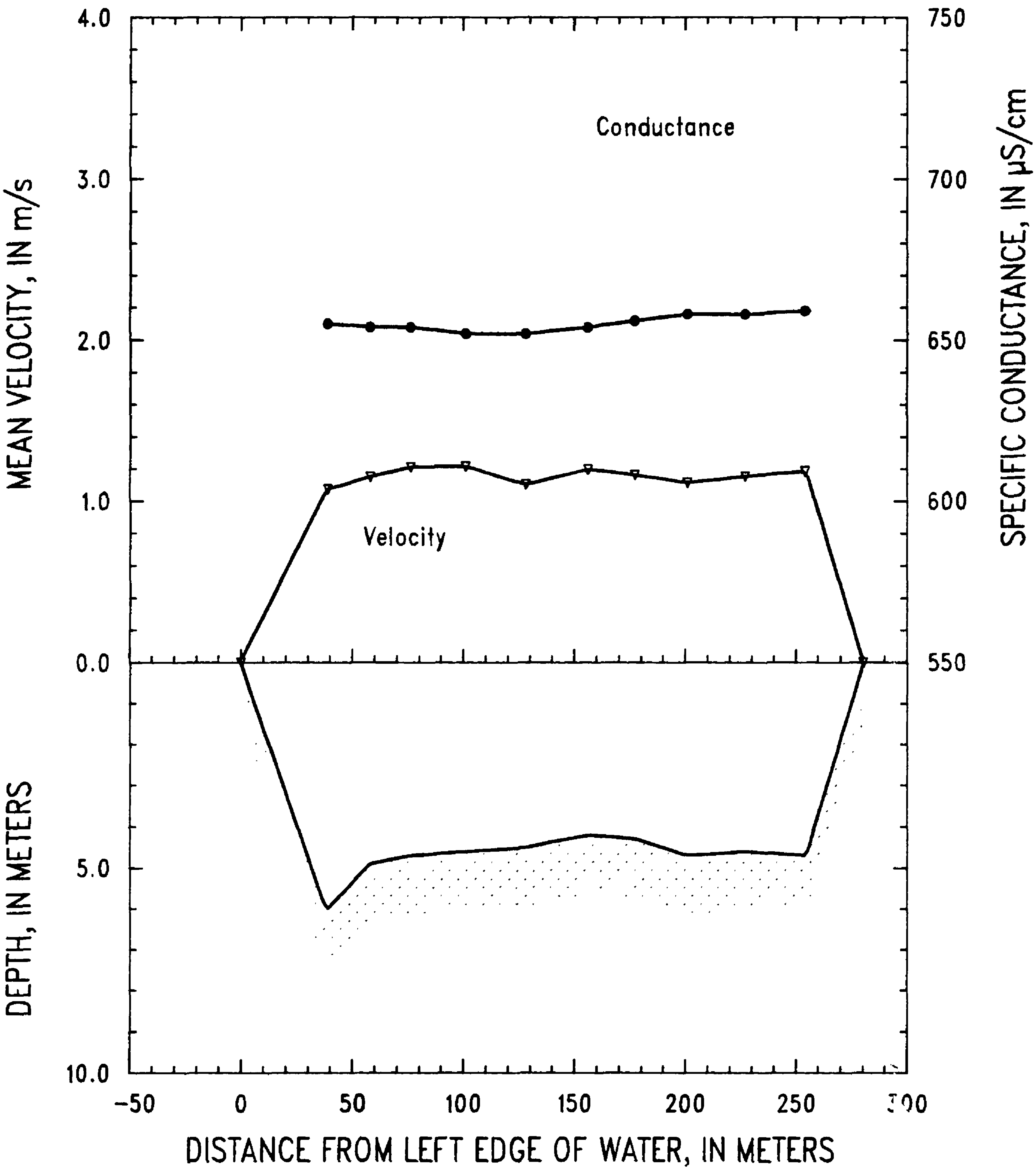

Figure 33. Missouri River at St. Charles, Missouri, on November 3, 1991.

SITE: Mississippi River at Thebes, Ill.—Mile 44.0 11-05-91
PARTY: Moody, Roth, and Simoneaux
GAGE HEIGHT @ St. Louis: 387.3 ft GAGE HEIGHT @ Cape Girardeau: 319.2 ft
RIVER SLOPE: 101 x 10^{-6}
SUSP. Bag sampler and 150-lb weight
PRICE AA CURRENT METER No: W-223906 DATE RATED: 06-91
CURRENT METER EQUATION: V(m/s)=Rev/s* 0.670 + 0.010
REMARKS:

Transit rate was 10 cm/s and nozzle size was 1/4 inch. Unmeasured zone was 0.67 m. Order of verticals was 1–4, 9–12, and 8–5.

Vertical	Distance from LEW (m)	Depth (m)	Mean velocity (m/s)	Discharge (m^3/s)	Temperature (°C)	pH	Specific conductance (µS/cm)
LEW	0	0.0	0.00				
01A,B	51	6.5	0.62	177	8.7	uncertain	568
02A,B	88	7.3	1.09	365	8.7	uncertain	569
03A,B	143	8.1	1.38	492	8.6	8.2	569
04A,B	176	7.8	1.49	481	8.6	8.3	570
05A,B	226	8.1	1.37	538	8.7	8.4	571
06A,B	273	7.1	1.20	380	8.6	8.4	572
07A,B	315	5.8	1.20	307	8.7	8.4	572
08A,B	361	5.1	1.16	259	8.6	8.3	571
09A,B	403	5.3	1.14	260	8.6	8.3	570
10A,B	447	5.3	1.07	258	8.6	8.4	568
11A,B	494	4.5	1.02	219	8.6	8.3	567
12A,B	542	3.8	0.75	137	8.6	8.4	567
REW	590	0.0	0.00				
MEANS		5.7	1.15				
TOTAL	590			3,872			

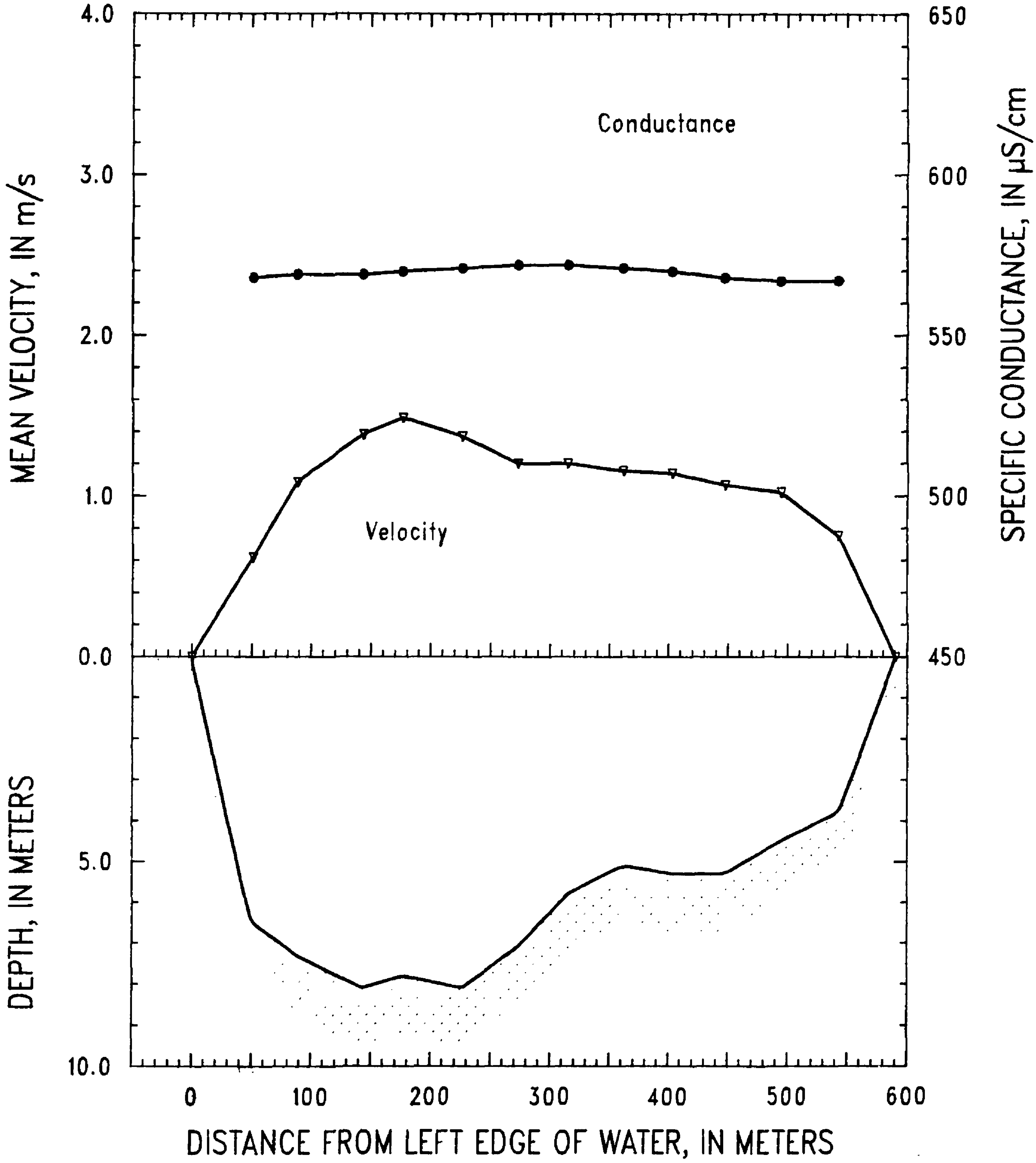

Figure 34. Mississippi River at Thebes, Illinois, on November 5, 1991.

SITE: Ohio River at Olmsted, Ill.—Mile 965.5 11-06-91
PARTY: Moody, Ellis, and Simoneaux
GAGE HEIGHT @ Dam 53: 287.9 ft GAGE HEIGHT @ Cairo: 286.3 ft
RIVER SLOPE: 16.5×10^{-6}
SUSP. Bag sampler and 150-lb weight
PRICE AA CURRENT METER No: W-223906 DATE RATED: 06-91
CURRENT METER EQUATION: V(m/s)=Rev/s* 0.670 + 0.010
REMARKS:

Did not collect a depth-integrated composite sample. Maximum transit rate was 1.2 cm/s and the unmeasured zone was 0.20 m. Specific conductance was measured twice: verticals 11–1 in the morning and verticals 1–11 in the afternoon, shown in parenthesis.

Vertical	Distance from LEW (m)	Depth (m)	Mean velocity (m/s)	Discharge (m^3/s)	Temperature (°C)	pH	Specific conductance (µS/cm)
LEW	0	0.0	0.00				
01	127	2.8	0.26	70	13.4	7.8	287 (286)
02	194	3.6	0.27	71	13.4	7.8	286 (285)
03	274	4.8	0.33	125	13.4	7.7	300 (286)
04	353	6.1	0.40	193	13.2	7.6	289 (306)
05	430	7.4	0.43	236	13.3	7.6	309 (302)
06	502	7.6	0.54	345	13.2	7.6	310 (310)
07	598	7.5	0.52	320	13.2	7.6	297 (324)
08	665	7.0	0.57	295	13.2	7.6	341 (333)
09	746	7.9	0.52	331	13.2	7.6	330 (373)
10	825	10.0	0.38	335	13.2	7.5	333 (376)
11	921	8.6	0.27	159	13.1	7.5	353 (377)
REW	962	0.0	0.00				
MEANS		6.0	0.43				
TOTAL	962			2,479			

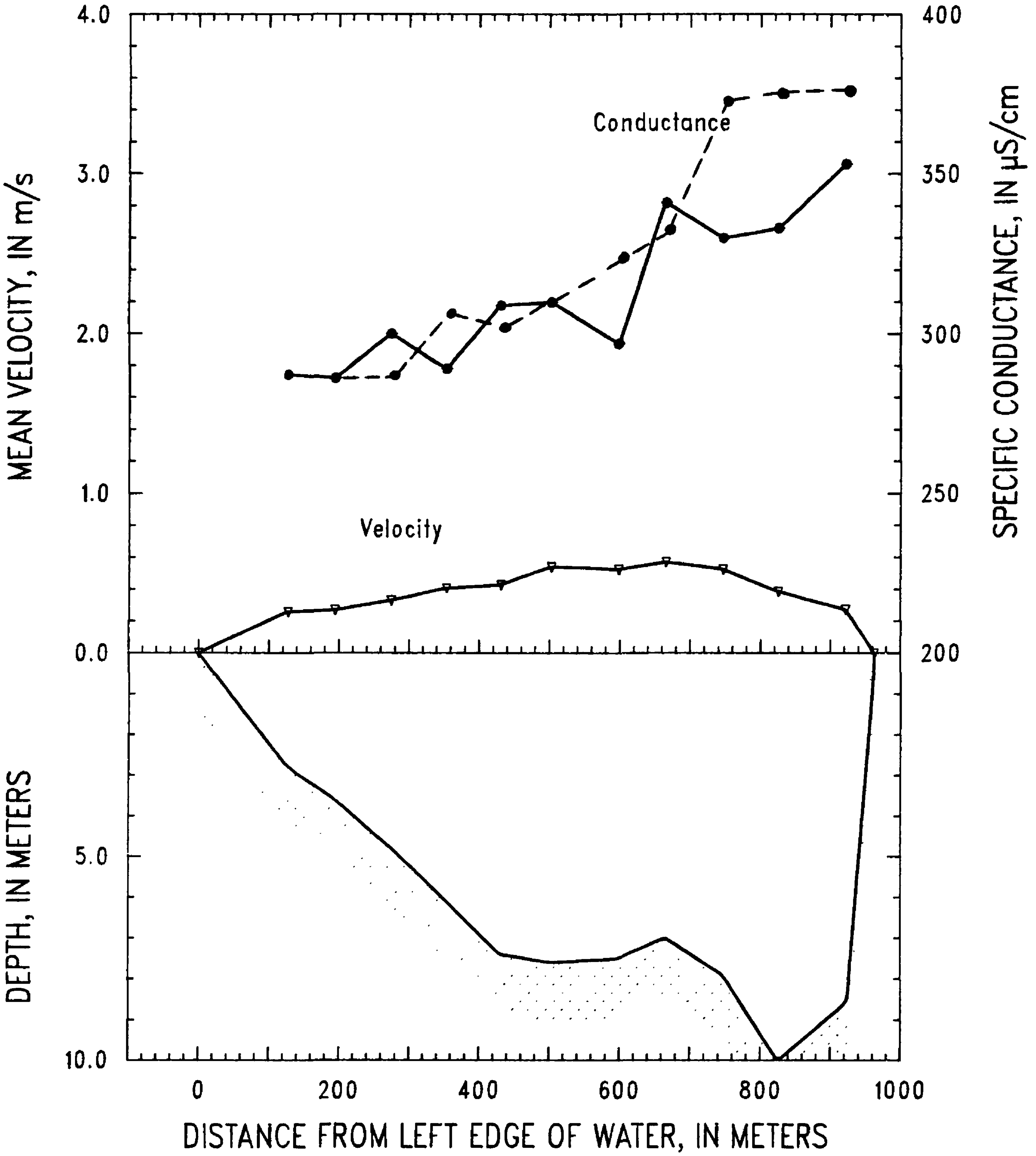

Figure 35. Ohio River at Olmsted, Illinois, on November 6, 1991.

SITE: Mississippi River below Vicksburg, Miss.—Mile 433.4 11-09-91
PARTY: Moody, Roth, and Simoneaux
GAGE HEIGHT @ Greenville: 94.3 ft GAGE HEIGHT @ Natchez: 36.2 ft
RIVER SLOPE: 65.4 x 10^{-6}
SUSP. Bag sampler and 150-lb weight
PRICE AA CURRENT METER No: W-223906 DATE RATED: 06-91
CURRENT METER EQUATION: V(m/s)=Rev/s* 0.670 + 0.010
REMARKS:

Fifteen equally spaced verticals were planned, but only 13 were sampled because of shallow water near the right bank. Transit rate was 9.5 cm/s and the nozzle was 3/16 inch. The section was about 12 degrees off orthogonality. Arkansas River water was about 40 percent of the total discharge. Order of verticals was: X01–X04, 1–3, 9–4, and 10–13.

Vertical	Distance from LEW (m)	Depth (m)	Mean velocity (m/s)	Discharge (m^3/s)	Temperature (°C)	pH	Specific conductance (μS/cm)
LEW	0	0.0					
01B	78	9.0	0.85	317	11.4	7.3	381
01A	83	13.1	0.96	214	11.4	7.1	381
X04	112	15.3	1.07	644	--	--	--
02A,B	162	14.5	1.24	878	11.4	7.6	399
X03	210	13.7	1.25	523	--	--	--
03A,B	223	13.8	1.21	777	11.4	7.7	403
04A,B	303	13.4	1.25	1,279	11.5	7.9	424
05A,B	376	13.7	1.10	1,149	11.4	7.9	431
06A,B	456	12.4	1.06	881	11.5	7.9	432
X02	510	12.0	1.04	398	--	--	--
07A,B	520	12.3	1.05	562	11.5	7.9	435
08A,B	597	12.5	0.97	907	11.5	7.8	433
09A,B	670	11.5	0.88	739	11.5	7.8	433
10A,B	743	9.3	0.84	536	11.5	7.9	433
11A,B	807	7.2	0.79	400	12.3	7.9	438
12A,B	883	5.1	0.58	183	11.8	7.9	435
X01	931	4.0	0.49	69	--	--	--
13A,B	954	3.7	0.51	235	11.5	8.0	435
REW	1,180	0.0					
MEANS		9.0	1.01				
TOTAL	1,180			10,689			

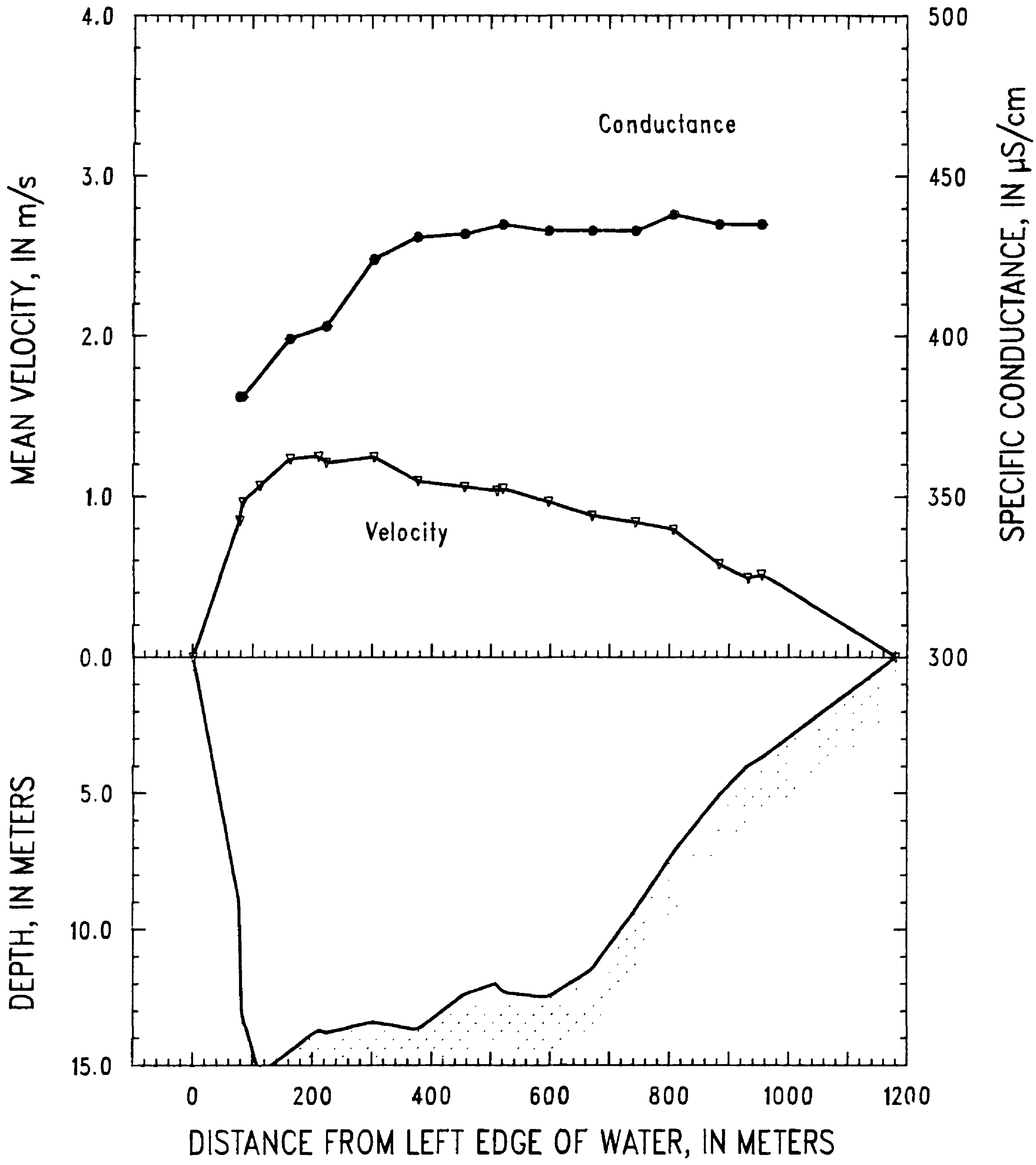

Figure 36. Mississippi River below Vicksburg, Mississippi, on November 9, 1991.

SITE: Mississippi River near St. Francisville, La.—Mile 266.4 11-11-91
PARTY: Moody, Roth, Simoneaux, and LeBoeuf
GAGE HEIGHT @ Red River Landing: 25.5 ft GAGE HEIGHT @ Baton Rouge: 12.4 ft
RIVER SLOPE: 33.5×10^{-6}
SUSP. Bag sampler and 150-lb weight
PRICE AA CURRENT METER No: W-223906 DATE RATED: 06-91
CURRENT METER EQUATION: V(m/s)=Rev/s* 0.670 + 0.010
REMARKS:

Transit rate was 7.5 cm/s and the nozzle was 3/16 inch. Gage heights and river slope are for November 9, 1991. Order of verticals was 12–9, 5, 4, 8, 3, 2, 1, 6, and 7.

Vertical	Distance from LEW (m)	Depth (m)	Mean velocity (m/s)	Discharge (m^3/s)	Temperature (°C)	pH	Specific conductance (µS/cm)
LEW	0	0.0	0.00				
01A,B	80	5.5	0.73	311	11.7	7.8	430
02A,B	154	7.5	0.77	439	11.8	7.8	430
03A,B	232	7.1	0.74	391	11.6	7.8	431
04A,B	303	7.2	0.78	229	11.6	7.8	432
X03	314	7.9	0.83	248	--	--	--
05A,B	379	8.1	0.79	430	11.7	7.8	430
06A,B	448	9.7	0.83	607	11.7	7.8	430
07A,B	529	10.6	1.05	906	11.9	7.8	430
X02	611	12.5	1.08	610	--	--	--
08A,B	619	12.1	1.08	420	11.6	7.8	430
09A,B	675	11.9	1.03	847	11.5	7.8	430
10A,B	757	14.2	1.07	936	11.6	7.7	430
X01	798	16.3	1.04	605	--	--	--
11A,B	828	14.2	1.13	828	11.4	7.6	430
12A,B	901	13.3	1.18	1,145	11.5	7.3	431
REW	974	0.0	0.00				
MEANS		9.4	0.98				
TOTAL	974			8,950			

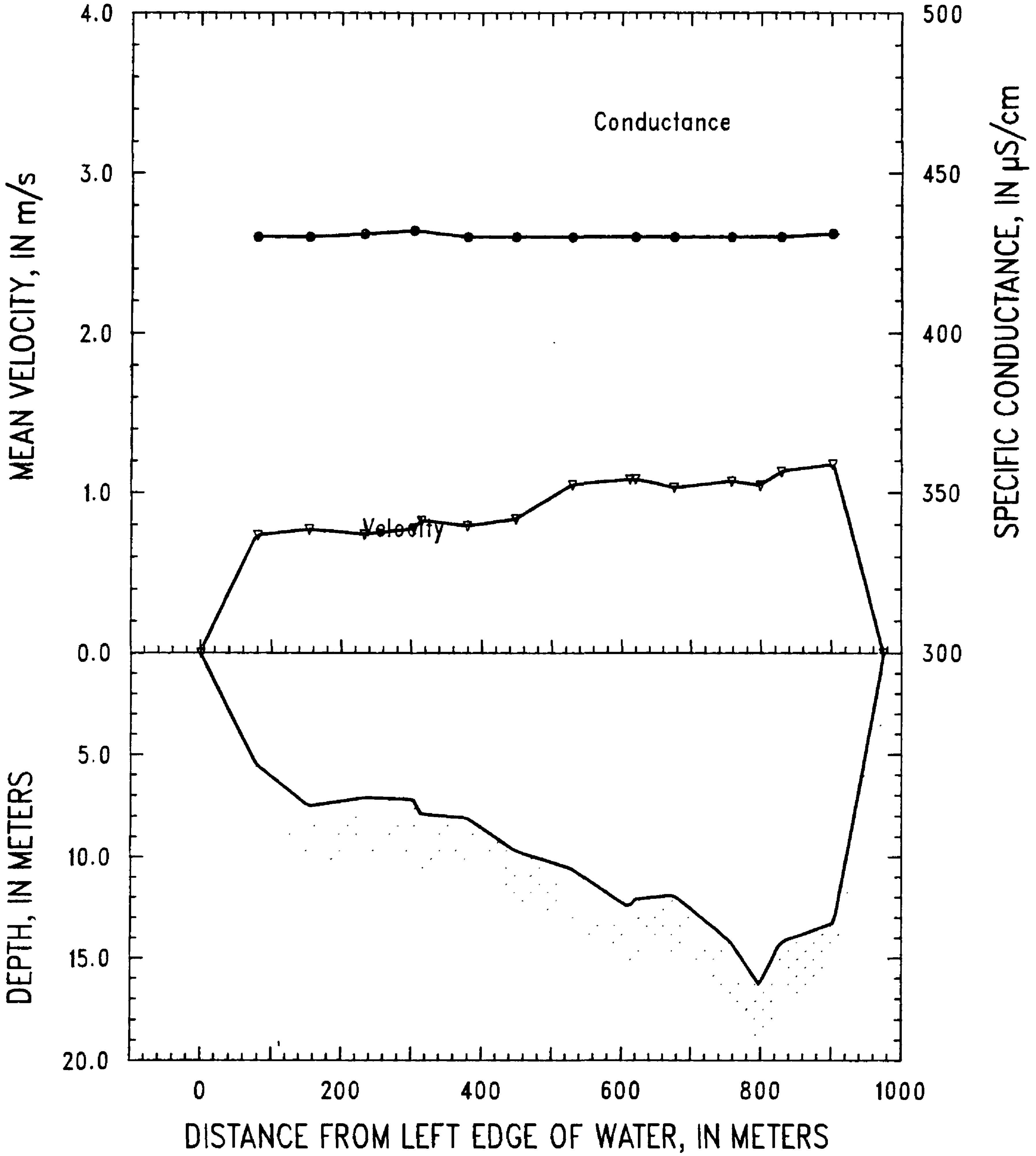

Figure 37. Mississippi River near St. Francisville, Louisiana, on November 11, 1991.

SITE: Mississippi River below Belle Chasse, La.—Mile 73.1 11-13-91
PARTY: Moody, Roth, Ellis, and Simoneaux
GAGE HEIGHT @ Baton Rouge: 12.7 ft GAGE HEIGHT @ New Orleans: 3.3 ft
RIVER SLOPE: 14.2×10^{-6}
SUSP. Bag sampler and 150-lb weight
PRICE AA CURRENT METER No: W-223906 DATE RATED: 06-91
CURRENT METER EQUATION: V(m/s)=Rev/s* 0.670 + 0.010
REMARKS:

Transit rate was 6.0 cm/s and the nozzle was 1/4 inch. Gage heights and slope are for November 11, 1991. Order of verticals was 5–1, 6, and 7.

Vertical	Distance from LEW (m)	Depth (m)	Mean velocity (m/s)	Discharge (m^3/s)	Temperature (°C)	pH	Specific conductance (μS/cm)
LEW	0	0.0	0.00				
06A	66	14.0	0.41	400	14.5	7.4	489
01A	140	21.0	0.57	1,396	12.8	7.8	490
02A	299	23.0	0.69	2,334	13.9	7.8	488
03A	433	24.6	0.63	2,011	14.1	7.8	488
04A	560	24.2	0.49	1.319	14.0	7.8	488
05A	655	22.8	0.46	794	14.1	7.6	492
07A	712	21.9	0.42	585	14.2	7.4	488
REW	781	0.0	0.00				
MEANS		20.2	0.56				
TOTAL	781			8,838			

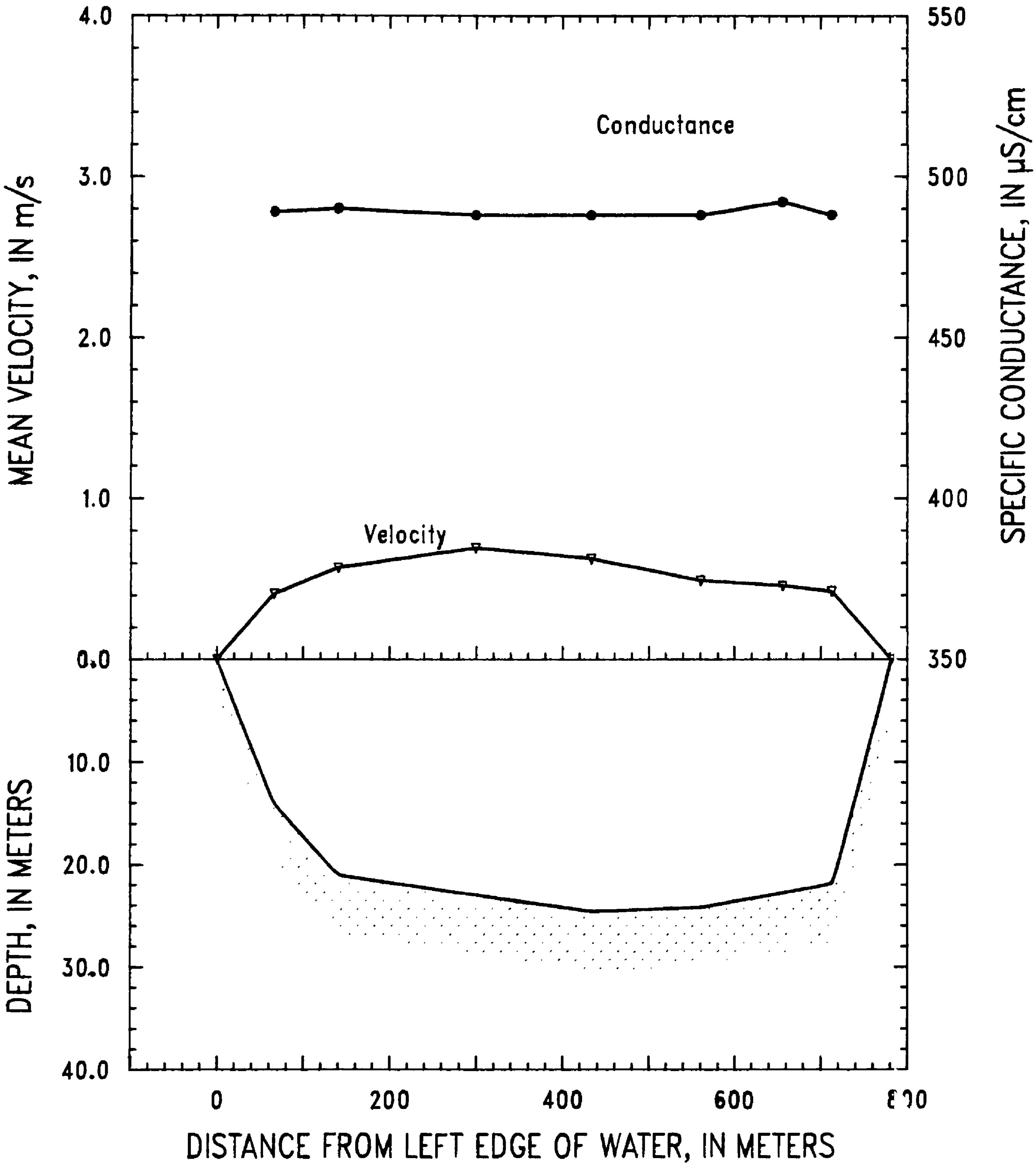

Figure 38. Mississippi River below Belle Chasse, Louisiana, on November 13, 1991.

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DATA LISTINGS

FOR

APRIL–MAY 1992 CRUISE

SITE: Mississippi River above St. Anthony Falls, Minn.—Mile 857.7 04-06-92
PARTY: Moody, Roth, and LeBoeuf
GAGE HEIGHT @ Anoka: 809.13 ft GAGE HEIGHT @ SAFU Pool: 799.56 ft
RIVER SLOPE: 168 x 10^{-6}
SUSP. Bag sampler and 150-lb weight
PRICE AA CURRENT METER No: W-297222 DATE RATED: 06-91
CURRENT METER EQUATION: V(m/s)=Rev/s* 0.670 + 0.010
REMARKS:

Anchored at four verticals and free-boated at vertical 5. Variable transit rate (1–4 cm/s) and 5/16-inch nozzle. Unmeasured zone was 0.7 and 0.3 m (at X-labeled verticals). River was unmixed at mile 859.6. Order of verticals was 3, 1, 2, 4, and 5. Temperature, pH, and specific conductance are the mean of three measurements.

Vertical	Distance from LEW (m)	Depth (m)	Mean velocity (m/s)	Discharge (m^3/s)	Temperature (°C)	pH	Specific conductance (μS/cm)
LEW	0	0.0	0.00				
X01	26	2.7	0.75	40	--	--	--
01A,B	39	3.7	0.72	44	10.6	8.7	365
X02	59	3.8	0.64	29	--	--	--
02A,B	63	3.7	0.61	25	10.6	8.7	381
03A,B	81	2.9	0.63	24	10.3	8.7	392
X03	89	3.6	0.76	56	--	--	--
X04	122	4.8	0.57	52	--	--	--
04A,B	127	4.7	0.53	28	10.6	8.7	446
05A,B	144	3.0	0.28	8	11.1	8.7	482
X05	146	2.7	0.19	6			
REW	168	0.0	0.00				
MEANS		3.1	0.60				
TOTAL	168			310			

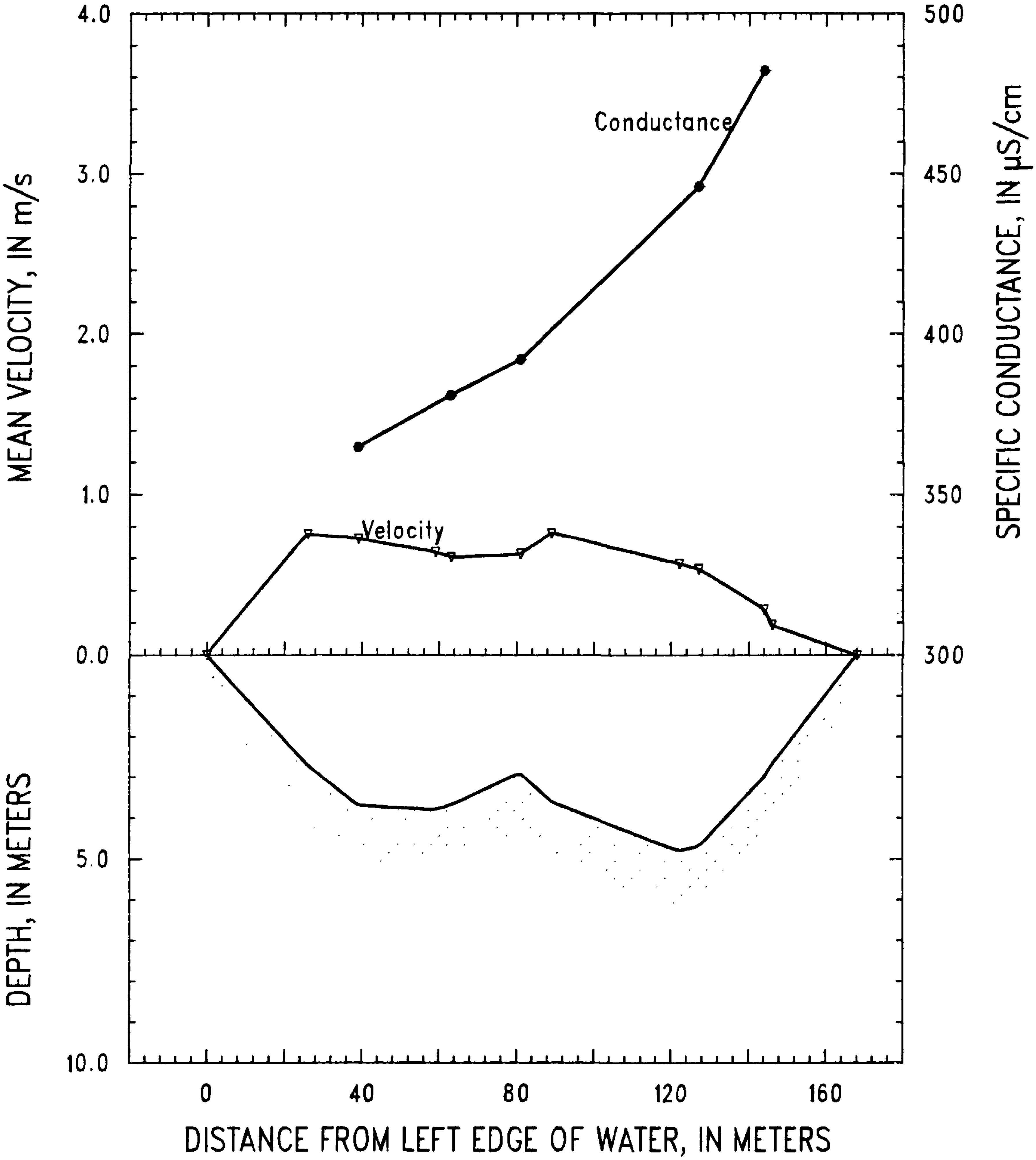

Figure 39. Mississippi River above St. Anthony Falls, Minnesota, on April 6, 1992.

SITE: Mississippi River at Mile 844.0, Minn. 04-07-92
PARTY: Moody and Garbarino
GAGE HEIGHT @ Savage: 692.77 ft GAGE HEIGHT @ Pool 2: 686.50 ft
RIVER SLOPE: 27 x 10^{-6}
SUSP. 15-lb weight
PRICE AA CURRENT METER No: 90JM-1 DATE RATED: 06-91
CURRENT METER EQUATION: V(m/s)=Rev/s* 0.667 + 0.006
REMARKS:

Anchored at five verticals using the small boat. Depth integrated measurement by hand. Specific conductance and temperature were measured by a Sea Bird, SeaCat profiler.

Vertical	Distance from LEW (m)	Depth (m)	Mean velocity (m/s)	Discharge (m^3/s)	Temperature (°C)	pH	Specific conductance (μS/cm)
LEW	0	0.0	0.00				
01	22	5.8	0.55	71	9.6	--	421
02	44	6.4	0.61	74	9.6	--	424
03	60	6.7	0.62	73	9.6	--	431
04	79	6.3	0.56	84	9.6	--	440
05	108	5.7	0.29	55	9.6	--	466
REW	145	0.0	0.00				
MEANS		4.9	0.51				
TOTAL	145			357			

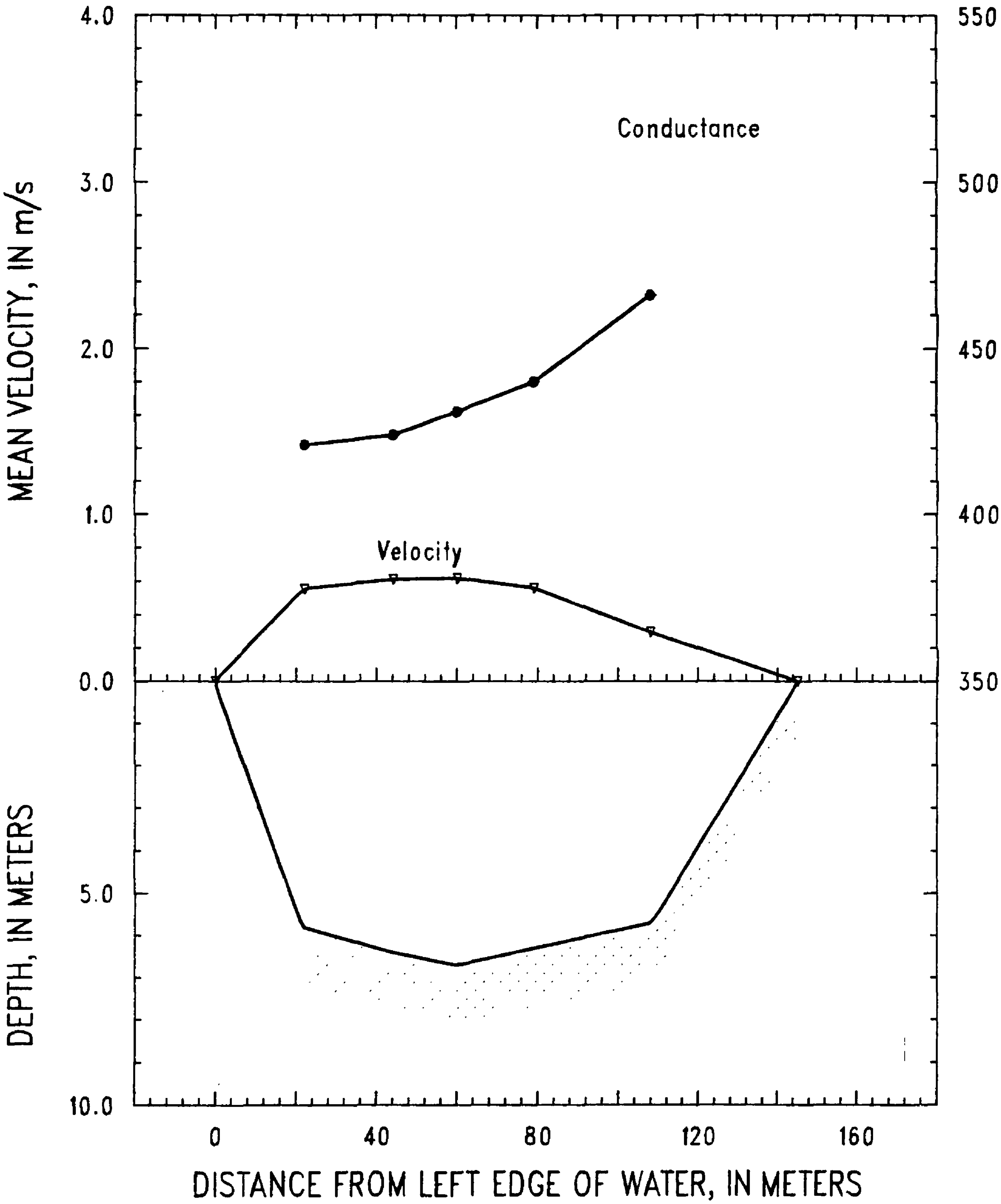

Figure 40. Mississippi River at Mile 844.0, Minnesota, on April 7, 1992.

SITE: Minnesota River at Mile 3.5, Minn. 04-08-92

PARTY: Moody, Roth, and LeBoeuf

GAGE HEIGHT @ Savage: 692.50 ft GAGE HEIGHT @ Pool 2: 686.58 ft

RIVER SLOPE: 25×10^{-6}

SUSP. Bag sampler and 150-lb weight

PRICE AA CURRENT METER No: W-223906 DATE RATED: 06-91

CURRENT METER EQUATION: V(m/s)=Rev/s* 0.670 + 0.010

REMARKS:

Discharge based on velocity and depth measurements from an anchored boat at four verticals. Used 5/16-inch nozzle and a variable transit rate. Microwave remote units were 9 m from the LEW and the REW. Unmeasured zone was 0.66 m. Order of verticals was 2, 1, 3, and 4. Temperature, pH, and specific conductance are the mean of three measurements.

Vertical	Distance from LEW (m)	Depth (m)	Mean velocity (m/s)	Discharge (m^3/s)	Temperature (°C)	pH	Specific conductance (µS/cm)
LEW	0	0.0	0.00				
01	24	4.9	0.60	70	10.1	8.4	863
02	48	6.1	0.64	76	9.7	8.4	862
03	63	6.0	0.67	78	10.5	8.4	866
04	87	4.5	0.51	35	11.0	8.4	868
REW	93	0.0	0.00				
MEANS		4.5	0.62				
TOTAL	93			259			

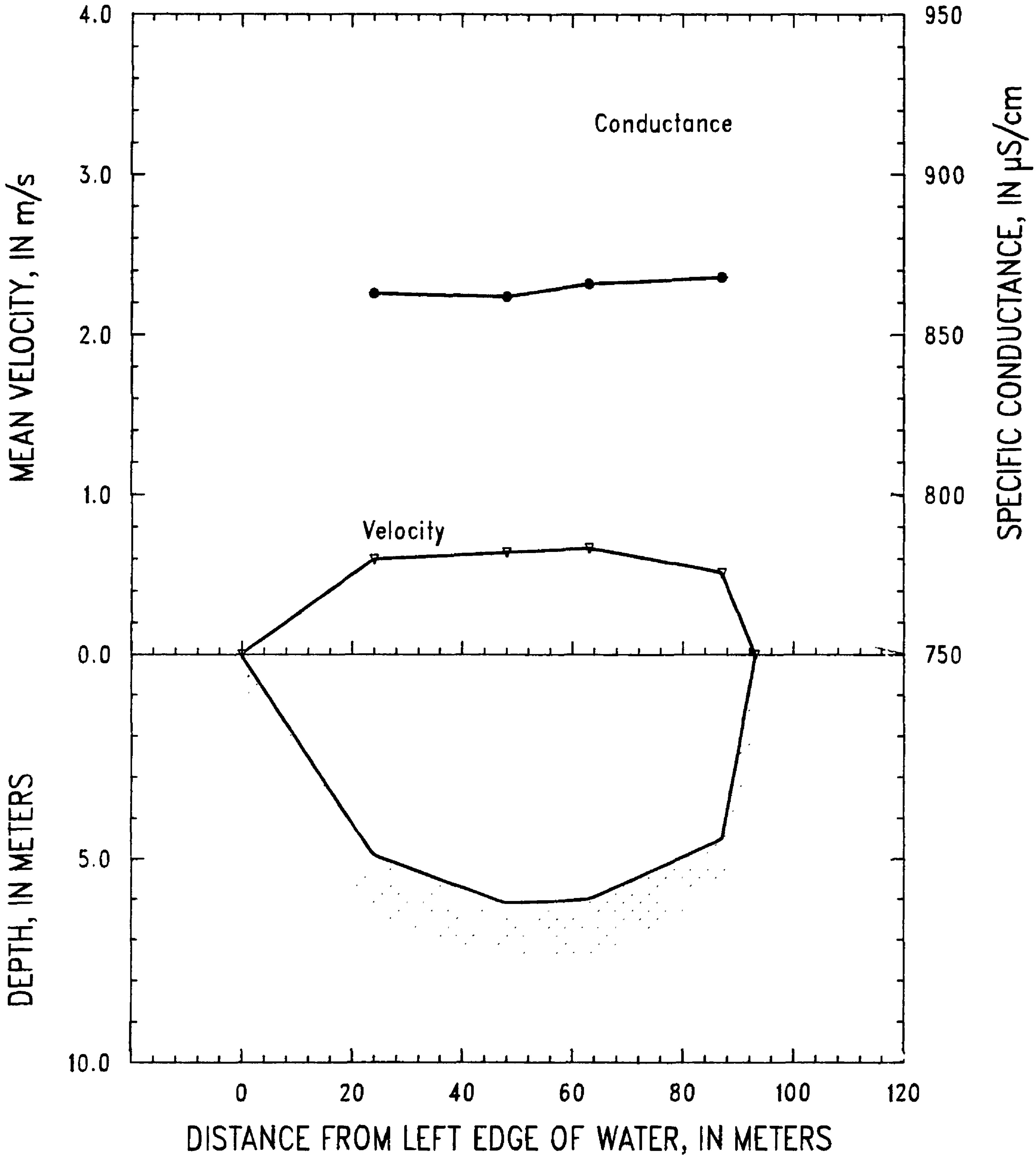

Figure 41. Minnesota River at Mile 3.5, Minnesota, on April 8, 1992.

SITE: Minnesota River at Mile 0.0, Minn. 04-07-92

PARTY: Moody and Garbarino

GAGE HEIGHT @ Savage: 692.77 ft GAGE HEIGHT @ Pool 2: 686.50 ft

RIVER SLOPE: 27×10^{-6}

SUSP. 15-lb weight

PRICE AA CURRENT METER No: 90JM-1 DATE RATED: 06-91

CURRENT METER EQUATION: V(m/s)=Rev/s* 0.667 + 0.006

REMARKS:

Anchored at four verticals using the small boat. Depth integrated measurement by hand. Verticals 1–5 were in the Mississippi River. Unmeasured zone was 0.17 m. Temperature and specific conductance were measured by a Sea Bird, SeaCat profiler.

Vertical	Distance from LEW (m)	Depth (m)	Mean velocity (m/s)	Discharge (m^3/s)	Temperature (°C)	pH	Specific conductance (μS/cm)
LEW	0	0.0					
09	41	4.0	0.71	83	9.0	--	896
08	59	4.8	0.88	78	8.9	--	896
07	78	5.0	0.80	88	8.9	--	897
06	103	4.7	0.67	63	8.8	--	898
REW	141	0.0					
MEANS		2.9	0.75				
TOTAL	141			312			

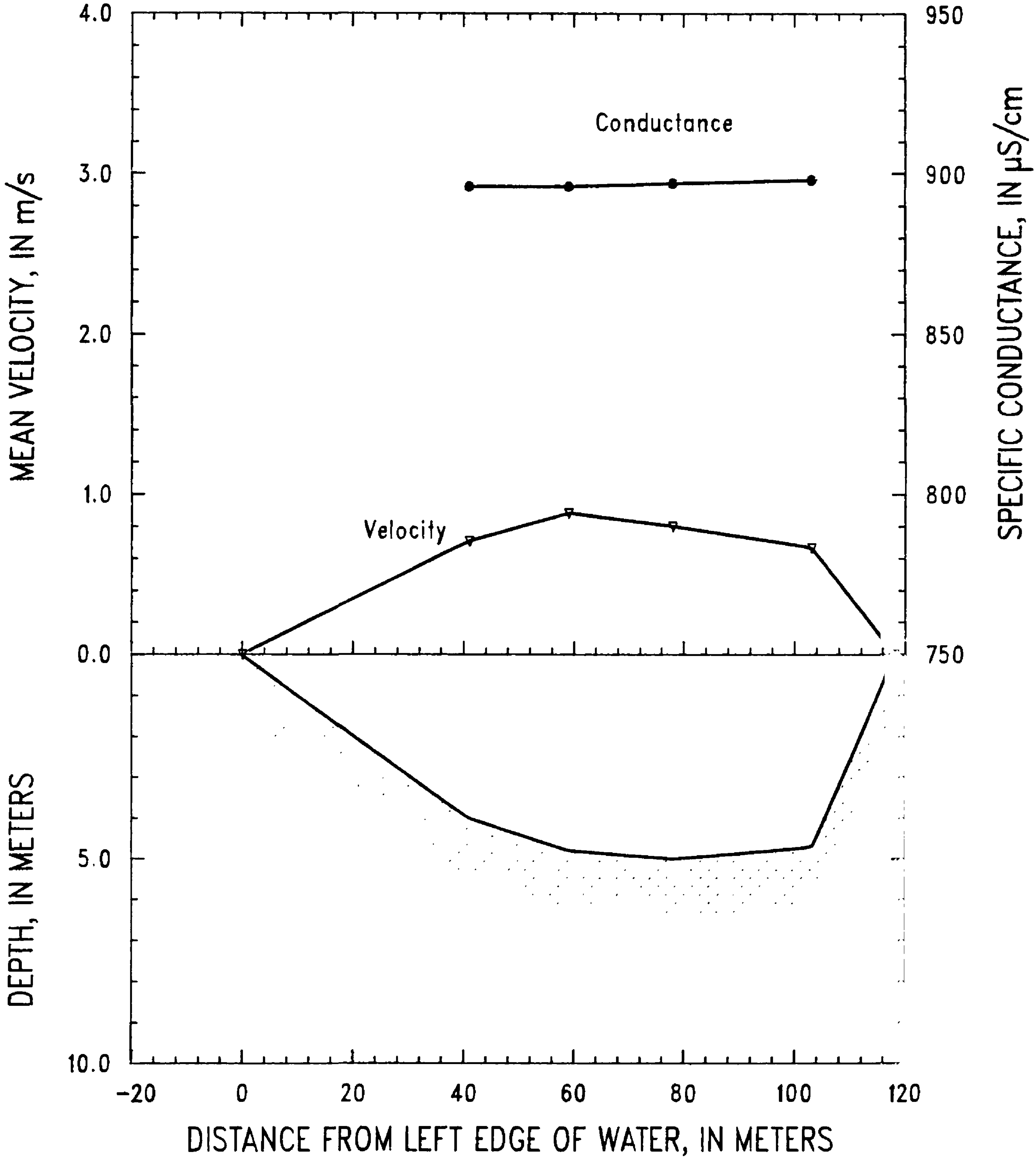

Figure 42. Minnesota River at Mile 0.0, Minnesota, on April 7, 19?2.

SITE: Mississippi River at Hastings, Minn.—Mile 812.2 04-10-92
PARTY: Moody, Roth, and LeBoeuf
GAGE HEIGHT @ TW Pool 2: 678.05 ft GAGE HEIGHT @ Pool 3: 674.24 ft
RIVER SLOPE: 40×10^{-6}
SUSP. Bag sampler and 150-lb weight
PRICE AA CURRENT METER No: W-223906 DATE RATED: 06-91
CURRENT METER EQUATION: V(m/s)=Rev/s* 0.670 + 0.010
REMARKS:

Gusty, cold wind with rain, sleet, and snow that blew upriver. Lost the 300-pound pump weight. Used the 5/16-inch nozzle and various transit rates. Temperature, pH, and specific conductance are the mean of three measurements.

Vertical	Distance from LEW (m)	Depth (m)	Mean velocity (m/s)	Discharge (m^3/s)	Temperature (°C)	pH	Specific conductance (µS/cm)
LEW	0	0.0	0.00				
01A	26	8.3	0.53	102	9.8	8.6	634
02A	46	7.5	0.59	114	9.5	8.6	633
03A	77	6.7	0.52	67	9.2	8.6	633
X03	85	6.5	0.47	45	--	--	--
04A	107	5.7	0.57	73	9.0	8.6	633
05A	130	5.4	0.51	69	8.8	8.6	632
06A	157	4.7	0.42	51	8.7	8.6	631
07A	182	3.8	0.32	19	8.8	8.6	632
X07	189	3.7	0.33	26	--	--	--
REW	225	0.0	0.00				
MEANS		5.0	0.50				
TOTAL	225			567			

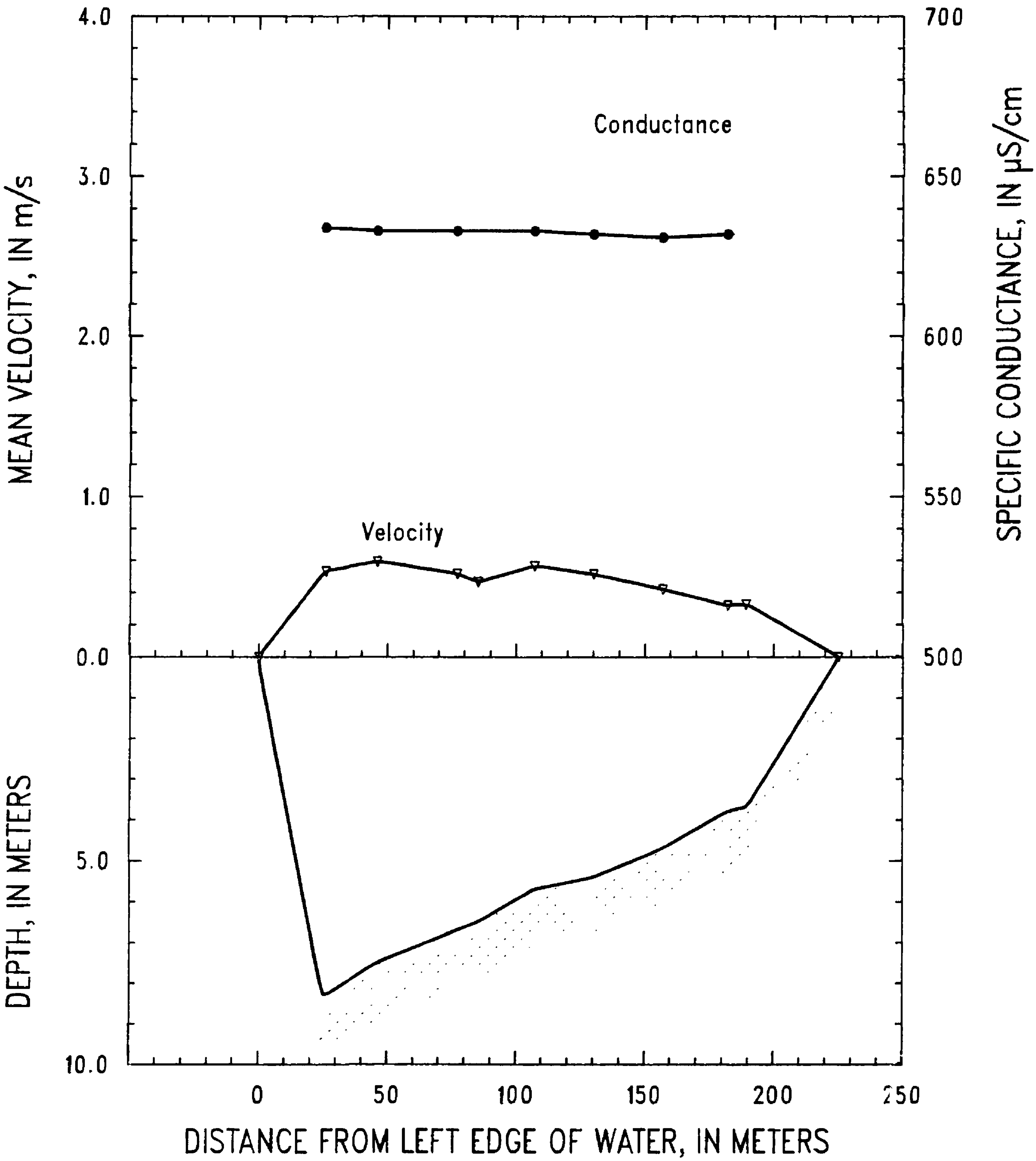

Figure 43. Mississippi River at Hastings, Minnesota, on April 10, 1992.

SITE: St. Croix River at Mile 0.0, Minn.-Wis. 04-11-92

PARTY: Moody and Garbarino

GAGE HEIGHT @ Dam 2 TW: 678.09 ft GAGE HEIGHT @ Pool 3: 674.26 ft

SUSP. 15-lb weight

PRICE AA CURRENT METER No: 90JM-1 DATE RATED: 06-91

CURRENT METER EQUATION: V(m/s)=Rev/s* 0.667 + 0.006

REMARKS:

Anchored at five verticals using the small boat. Depth integrated measurement by hand. Temperature and specific conductance measured by the Sea Bird, SeaCat profiler. Maximum transit rate was 8 cm/s and the unmeasured zone was 0.17 m.

Vertical	Distance from LEW (m)	Depth (m)	Mean velocity (m/s)	Discharge (m^3/s)	Temperature (°C)	pH	Specific conductance (µS/cm)
LEW	0	0.0	0.00				
01	16	5.1	0.29	28	4.5	--	150
02	38	9.5	0.35	116	4.5	--	148
03	85	9.1	0.40	128	4.5	--	149
04	108	7.6	0.23	44	4.5	--	149
05	136	2.6	0.13	7	4.4	--	148
REW	152	0.0	0.00				
MEANS		6.5	0.32				
TOTAL	152			324			

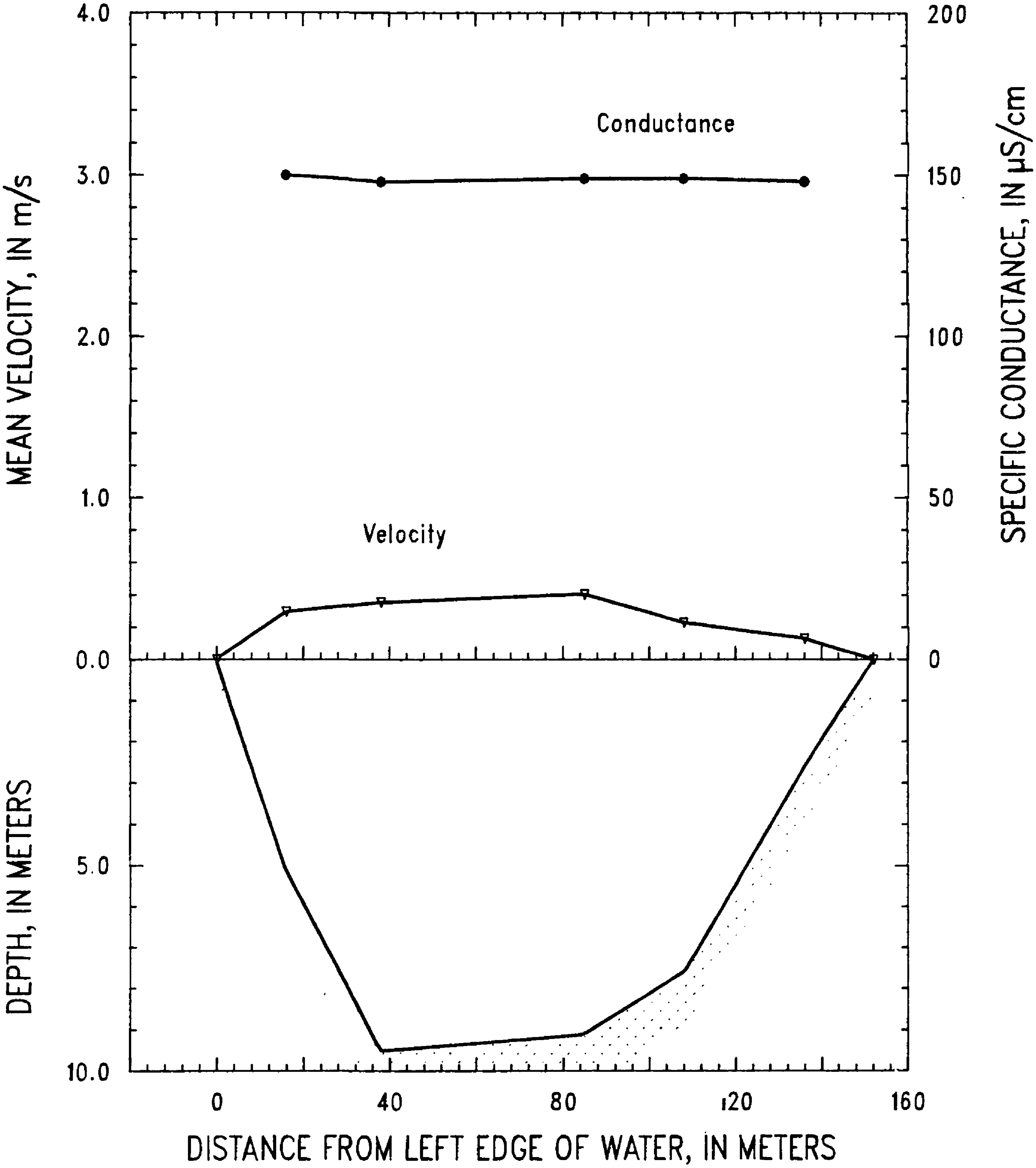

Figure 44. St. Croix River at Mile 0.0, Minnesota–Wisconsin, on April 11, 1992.

SITE: Mississippi River near Pepin, Wis.—Mile 764.5 04-12-92
PARTY: Moody, Roth, and LeBoeuf
GAGE HEIGHT @ Lake City: 670.27 ft GAGE HEIGHT @ Wabasha: 668.76 ft
RIVER SLOPE: 23 x 10^{-6}
SUSP. Bag sampler and 150-lb weight
PRICE AA CURRENT METER No: W-223906 DATE RATED: 06-91
CURRENT METER EQUATION: V(m/s)=Rev/s* 0.670 + 0.010
REMARKS:

No depth-integrated sample was collected. The unmeasured zone was 0.66 m. The discharge through Dam 4 was 1,370 m^3/s (Chippewa River joins Mississippi River between gaging site and Dam 4). Velocities were measured during 1 hour in the morning and the temperature, pH, and specific conductance were measured during 7 hours of collecting water samples by pumping at the same verticals—in the following order: 7,5,6,4,3,2, and 1.

Vertical	Distance from LEW (m)	Depth (m)	Mean velocity (m/s)	Discharge (m^3/s)	Temperature (°C)	pH	Specific conductance (µS/cm)
LEW	0	0.0	0.00				
01	61	2.6	0.37	57	7.3	8.6	513
02	117	3.6	0.43	94	7.6	8.6	511
03	183	3.9	0.43	95	8.2	8.5	513
04	231	4.3	0.46	97	8.5	8.5	513
05	281	4.5	0.52	136	8.0	8.6	513
06	348	6.4	0.52	205	8.5	8.6	517
07	403	8.9	0.53	222	7.3	8.6	513
X01	443	3.2	0.45	41	--	--	--
REW	460	0.0	0.00				
MEANS		4.3	0.48				
TOTAL	460			946			

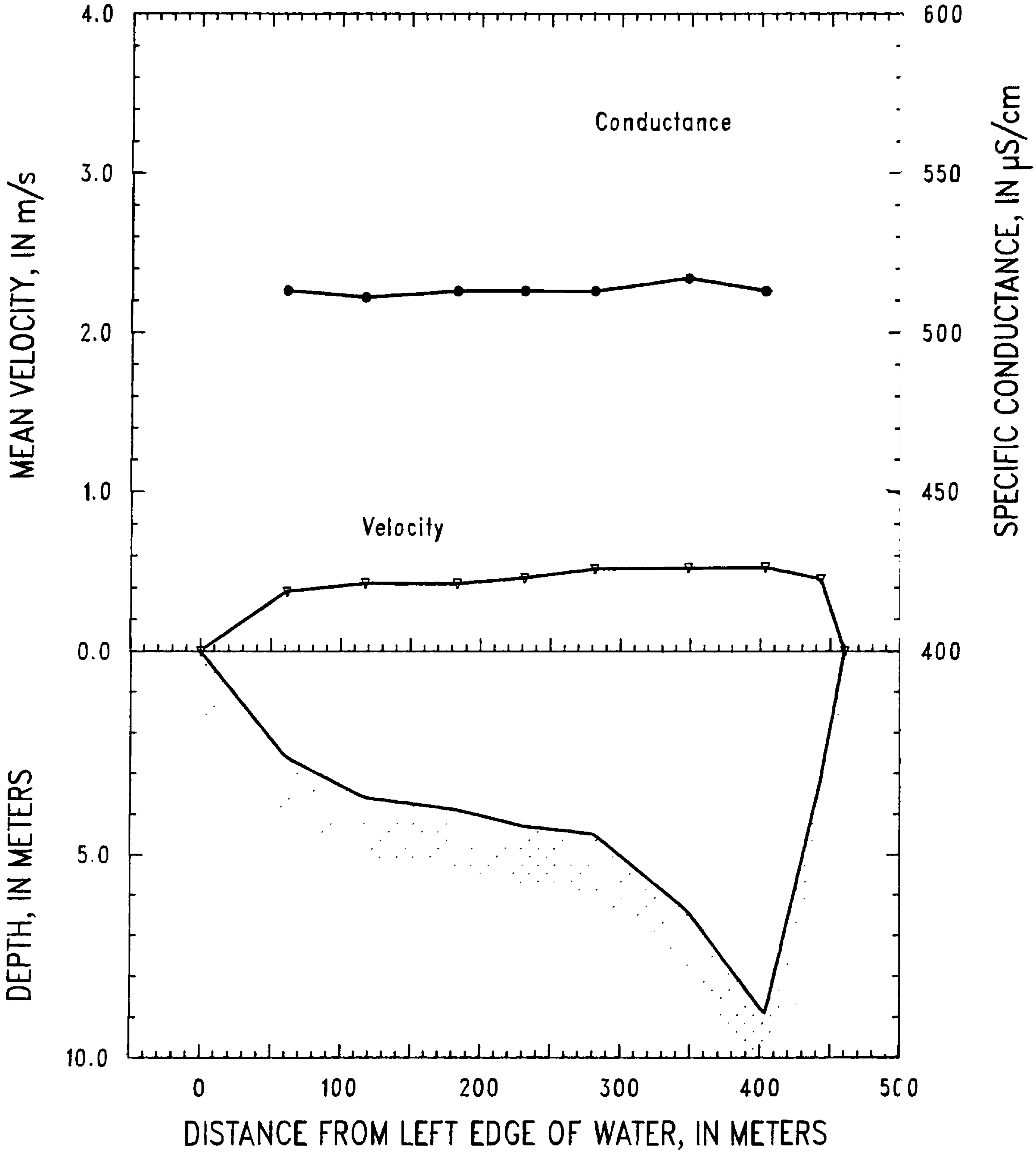

Figure 45. Mississippi River near Pepin, Wisconsin, on April 12, 1992.

SITE: Chippewa River at Mile 2.0, Wis. 04-12-92
PARTY: Moody
GAGE HEIGHT @ Pool 4: 666.65 ft
SUSP. 15-lb weight
PRICE AA CURRENT METER No: 90-JM-1 DATE RATED: 06-91
CURRENT METER EQUATION: V(m/s)=Rev/s* 0.667 + 0.006
REMARKS:

Discharge was measured from the small boat using the microwave system to measure distances from LEW to the anchored boat. Temperature and specific conductance were measured with LabComp instrument.

Vertical	Distance from LEW (m)	Depth (m)	Mean velocity (m/s)	Discharge (m^3/s)	Temperature (°C)	pH	Specific conductance (µS/cm)
LEW	0	0.0	0.00		4.6	--	115
09	18	2.2	0.99	34	4.9	--	114
01	31	2.5	1.29	43	4.4	--	117
08	45	2.1	1.11	34	5.0	--	117
02	60	1.9	0.92	28	4.3	--	117
03	77	1.9	0.88	31	4.4	--	120
04	97	1.4	0.79	21	4.6	--	120
05	115	1.2	0.82	21	4.9	--	122
06	140	1.2	0.89	39	5.0	--	127
07	187	1.6	0.78	45	5.4	--	131
REW	212	0.0	0.00		4.8	--	135
MEANS		1.5	0.95				
TOTAL	212			295			

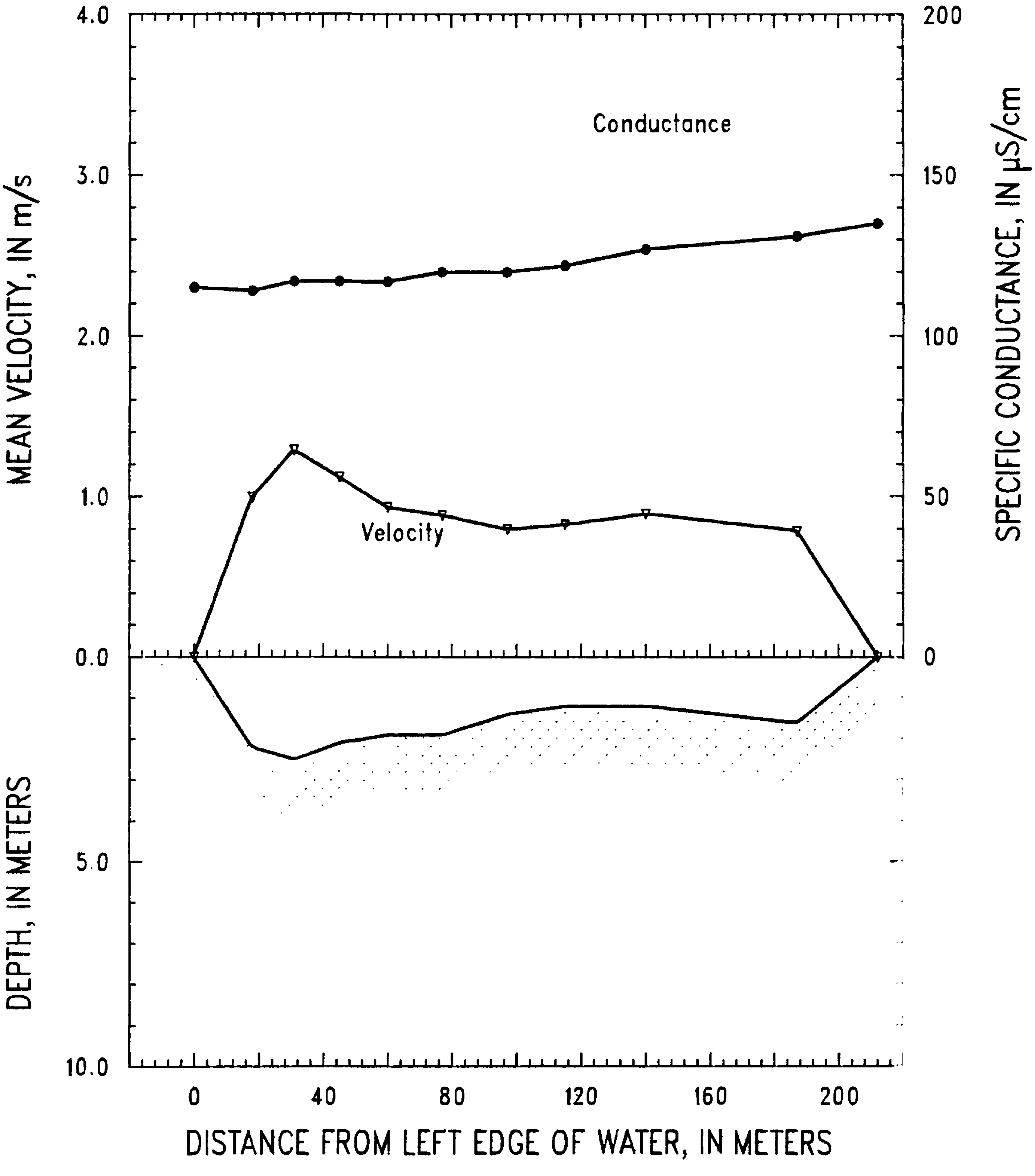

Figure 46. Chippewa River at Mile 2.0, Wisconsin, on April 12, 1992.

SITE: Mississippi River at Trempealeau, Wis.—Mile 713.8 04-14-92
PARTY: Moody, Roth, and LeBoeuf
GAGE HEIGHT @ Dam 6 TW: 641.64 ft GAGE HEIGHT @ Pool 7: 638.85 ft
RIVER SLOPE: 48.0×10^{-6}
SUSP. Bag sampler and 150-lb weight
PRICE AA CURRENT METER No: W-223906 DATE RATED: 06-91
CURRENT METER EQUATION: V(m/s)=Rev/s* 0.670 + 0.010
REMARKS:
Transit rate was 5.5 cm/s and the nozzle was 5/16 inch. Unmeasured zone was 0.66 m.

Vertical	Distance from LEW (m)	Depth (m)	Mean velocity (m/s)	Discharge (m^3/s)	Temperature (°C)	pH	Specific conductance (μS/cm)
LEW	0	0.0	0.00				
X06	45	2.5	0.31	20	--	--	--
01A,B	50	2.7	0.41	28	6.0	8.4	392
02A,B	96	4.8	0.57	124	6.1	8.4	395
X05	141	4.7	0.57	72	--	--	--
X11	150	4.6	0.65	36	--	--	--
03A,B	165	4.7	0.65	93	5.8	8.5	401
04A,B	211	4.6	0.67	105	5.8	8.5	411
X09	233	4.8	0.76	127	--	--	--
05A,B	281	5.2	0.69	131	5.7	8.5	419
X08	306	5.7	0.72	116	--	--	--
06A,B	338	6.1	0.72	136	5.8	8.5	430
X07	368	8.1	0.81	151	--	--	--
X10	384	8.0	0.66	73	--	--	--
07A,B	396	7.8	0.67	115	5.7	8.5	440
REW	428	0.0	0.00				
MEANS		4.7	0.66				
TOTAL	428			1,328			

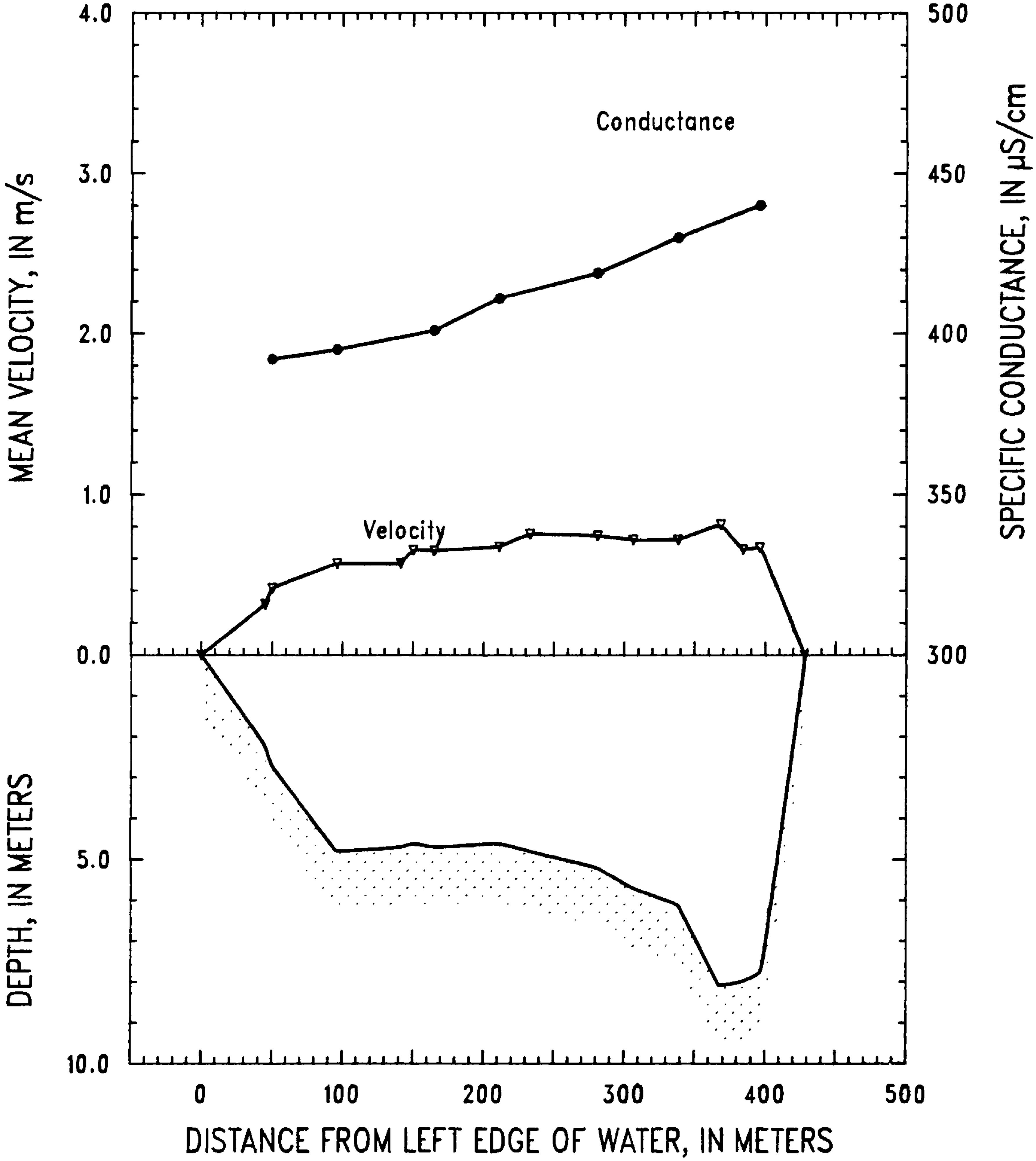

Figure 47. Mississippi River at Trempealeau, Wisconsin, on April 14, 1992.

SITE: Mississippi River below Lock and Dam 9, Wis.—Mile 639.7 04-17-92
PARTY: Moody, Antweiler, and LeBoeuf
GAGE HEIGHT @ Dam 9 TW: 617.75 ft GAGE HEIGHT @ Pool 10: 610.15 ft
RIVER SLOPE: 43.6 x 10^{-6}
SUSP. Bag sampler and 150-lb weight
PRICE AA CURRENT METER No: W-223906 DATE RATED: 06-91
CURRENT METER EQUATION: V(m/s)=Rev/s* 0.670 + 0.010
REMARKS:
Transit rate was 6.0 cm/s and the nozzle was 5/16 inch. Discharge from Dam 9 was 1,490 m^3/s.

Vertical	Distance from LEW (m)	Depth (m)	Mean velocity (m/s)	Discharge (m^3/s)	Temperature (°C)	pH	Specific conductance (μS/cm)
LEW	0	0.0	0.00				
X01	40	2.7	0.41	29	--	--	--
01A,B	52	3.1	0.41	45	6.6	8.9	389
02A,B	111	4.6	0.58	122	6.6	8.9	391
X02	144	5.4	0.62	85	--	--	--
03A,B	162	5.9	0.77	174	6.6	8.9	392
04A,B	221	6.8	0.78	193	6.6	8.9	397
X03	235	7.0	0.79	161	--	--	--
05A,B	279	6.9	0.81	286	6.7	8.7	401
06A,B	337	6.6	0.79	162	6.5	8.3	412
X04	341	6.5	0.72	134	--	--	--
07A,B	394	4.9	0.67	129	6.8	8.2	417
X05	419	4.1	0.61	71			
REW	450	0.0	0.00				
MEANS		5.0	0.70				
TOTAL	450			1,589			

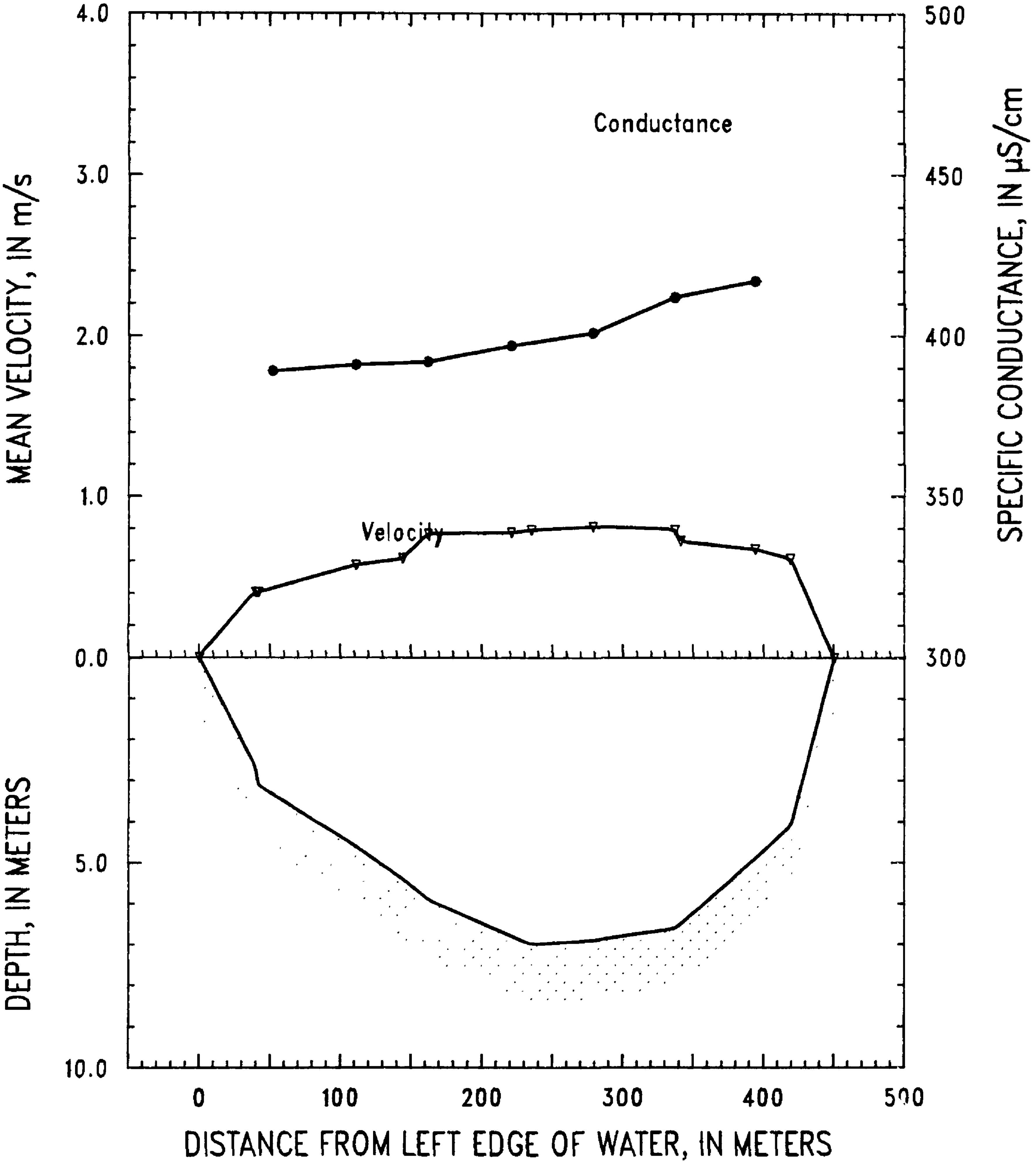

Figure 48. Mississippi River below Lock and Dam 9, Wisconsin, on April 17, 1992.

SITE: Mississippi River at Clinton, Iowa—Mile 520.3 04-19-92
PARTY: Moody, Antweiler, and LeBoeuf
GAGE HEIGHT @ Dam 13 TW: 578.42 ft GAGE HEIGHT @ Pool 14: 571.83 ft
RIVER SLOPE: 41.6×10^{-6}
SUSP. Bag sampler and 150-lb weight
PRICE AA CURRENT METER No: W-223906 DATE RATED: 06-91
CURRENT METER EQUATION: V(m/s)=Rev/s* 0.670 + 0.010
REMARKS:

Transit rate was 6.0 cm/sec and the nozzle was 1/4 inch. The unmeasured zone was 0.66 m. Verticals 1 and 2 were combined and collected at a location about halfway between the two verticals. The order of the verticals was 8, 7, 3, 1+2, 4, 5, and 6.

Vertical	Distance from LEW (m)	Depth (m)	Mean velocity (m/s)	Discharge (m^3/s)	Temperature (°C)	pH	Specific conductance (μS/cm)
LEW	0	0.0	0.00				
1+2A	66	2.7	0.26	25	11.1	8.7	395
1+2B	72	3.2	0.39	15	--	--	--
X01	90	3.9	0.47	68	--	--	--
X02	146	6.9	0.59	149	--	--	--
03A,B	163	7.8	0.62	128	11.4	8.8	378
X03	199	8.2	0.66	128	--	--	--
04A,B	210	8.3	0.69	167	11.4	8.8	376
05A,B	257	9.0	0.82	329	11.0	8.8	377
X04	299	9.8	0.90	261	--	--	--
06A,B	316	10.0	0.89	267	10.7	8.9	376
X05	359	10.1	0.92	278	--	--	--
07A,B	376	10.1	0.87	249	10.5	8.9	386
X07	416	8.8	0.66	152	--	--	--
08A,B	428	8.2	0.53	71	10.1	9.0	403
X06	449	5.6	0.26	34			
REW	475	0.0	0.00				
MEANS		6.8	0.71				
TOTAL	475			2,320			

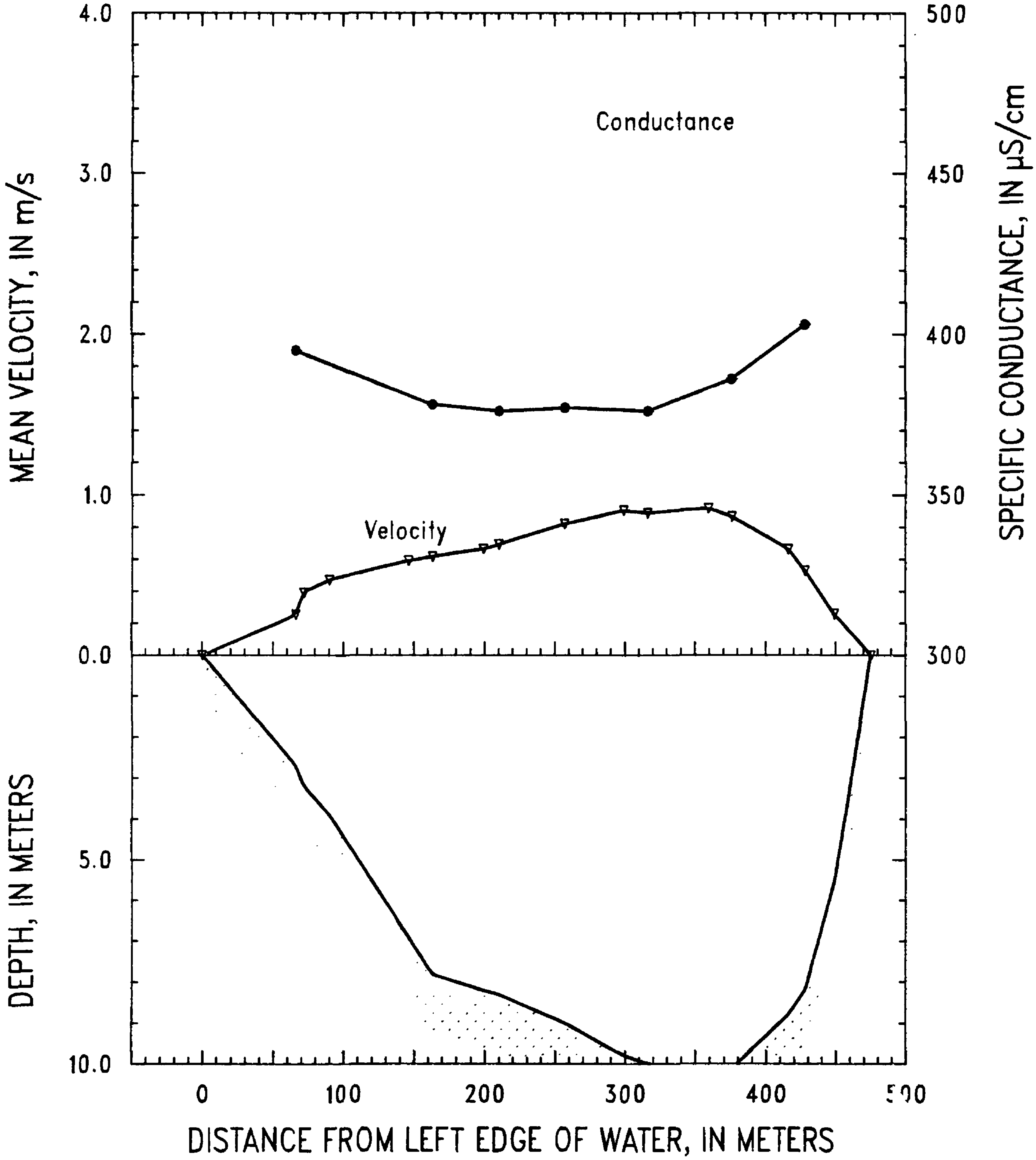

Figure 49. Mississippi River at Clinton, Iowa, on April 19, 1992.

SITE: Mississippi River at Keokuk, Iowa—Mile 363.1 04-23-92
PARTY: Moody, Brown, Krest, and LeBoeuf
GAGE HEIGHT @ Dam 19 TW: 489.06 ft GAGE HEIGHT @ Pool 20: 481.12 ft
RIVER SLOPE: 71.6 x 10^{-6}
SUSP. Bag sampler and 150-lb weight
PRICE AA CURRENT METER No: W-223906 DATE RATED: 06-91
CURRENT METER EQUATION: V(m/s)=Rev/s* 0.670 + 0.010
REMARKS:

Transit rate was 8.5 cm/s and the nozzle was 5/16 inch. Unmeasured zone was 0.66 m. The pH meter was calibrated at the start of the day but the readings at the last vertical (vertical 1) were much more variable (7.68, 7.04, and 7.12) so that the meter was recalibrated and the readings increased to 8.51 at vertical 1. Anchored at vertical 1 to prevent prop wash from stirring up fine sediment in shallow water and being collected in the pumped sample. Order of the verticals was 7, 5, 6, 4, 3, 2, and 1.

Vertical	Distance from LEW (m)	Depth (m)	Mean velocity (m/s)	Discharge (m^3/s)	Temperature (°C)	pH	Specific conductance (μS/cm)
LEW	0	0.0	0.00				
X07	64	4.2	0.67	103	--	--	--
01A,B	73	4.4	0.72	172	11.2	8.5	439
02A,B	173	4.9	0.96	311	11.0	7.6	436
X06	205	5.6	1.00	274	--	--	--
03A,B	271	5.4	0.96	247	10.9	7.6	430
X08	300	5.6	1.10	268	--	--	--
X05	358	5.8	1.22	371	--	--	--
04A,B	405	5.8	1.21	316	11.0	7.5	428
X04	448	6.1	1.19	337	--	--	--
05A,B	498	6.6	1.16	282	10.7	7.8	423
X03	522	6.8	1.15	471	--	--	--
06A,B	619	6.4	1.18	558	11.1	7.7	421
X02	670	5.5	1.08	280	--	--	--
X01	713	5.0	0.84	109	--	--	--
07A,B	722	4.6	0.70	124	11.1	7.8	412
REW	790	0.0	0.00				
MEANS		5.1	1.05				
TOTAL	790			4,222			

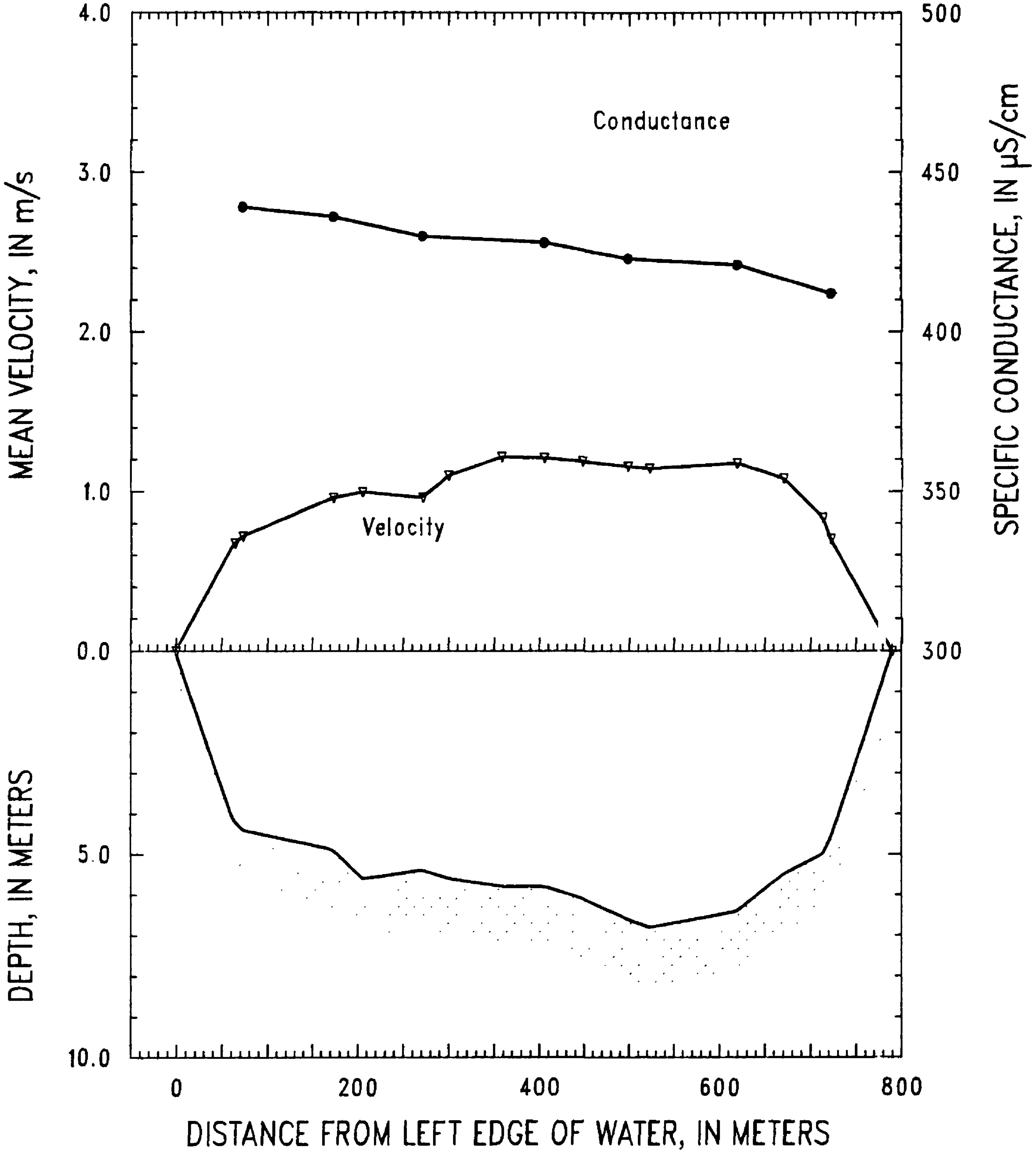

Figure 50. Mississippi River at Keokuk, Iowa, on April 23, 1992.

SITE: Mississippi River near Winfield, Mo.—Mile 239.2 04-26-92
PARTY: Moody, Krest, and Simoneaux
GAGE HEIGHT @ Dam 25 TW: 431.78 ft GAGE HEIGHT @ Grafton: 420.99 ft
RIVER SLOPE: 88.9 x 10^{-6}
SUSP. Bag sampler and 150-lb weight
PRICE AA CURRENT METER No: W-223906 DATE RATED: 06-91
CURRENT METER EQUATION: V(m/s)=Rev/s* 0.670 + 0.010
REMARKS:

Transit rate was 11.0 cm/s and nozzle was 1/4 inch. Unmeasured zone was 0.66 m. Order of verticals was 1, 2, 3, 7, 6, 5, 4, 8, 9, and 10.

Vertical	Distance from LEW (m)	Depth (m)	Mean velocity (m/s)	Discharge (m^3/s)	Temperature (°C)	pH	Specific conductance (µS/cm)
LEW	0	0.0	0.00				
01A	49	8.4	0.88	221	10.4	8.1	441
01B	60	10.4	1.08	259	--	--	--
02A,B	95	11.3	1.32	342	10.3	7.9	441
X02	106	11.2	1.35	417	--	--	--
03A,B	150	10.6	1.20	489	10.2	7.8	444
X03	183	10.8	1.32	450	--	--	--
04A,B	213	10.1	1.25	390	10.3	8.3	451
X04	245	10.0	1.15	294	--	--	--
05A,B	264	9.8	1.12	455	10.3	8.2	450
06A,B	328	8.5	1.06	366	10.5	8.2	449
X05	345	8.3	1.13	225	--	--	--
07A,B	376	7.7	1.00	358	10.4	8.0	445
08A,B	438	6.3	0.96	358	10.5	8.3	448
09A,B	495	5.7	0.91	213	10.6	8.3	448
X06	520	5.9	0.78	76	--	--	--
10A,B	528	5.8	0.90	157	10.7	8.3	450
REW	580	0.0	0.00				
MEANS		7.9	1.11				
TOTAL	580			5,070			

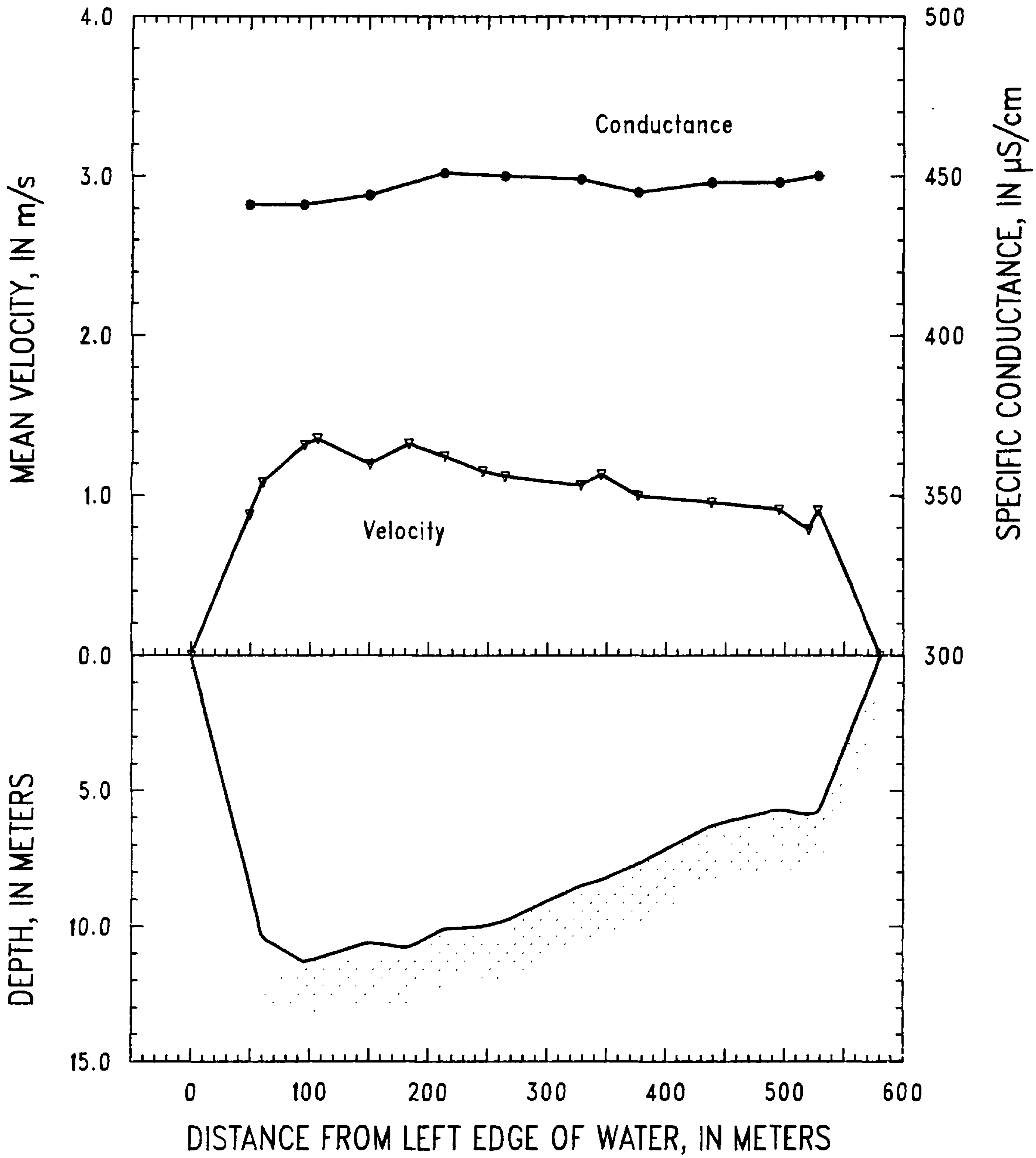

Figure 51. Mississippi River near Winfield, Missouri, on April 26, 1992.

SITE: Illinois River at Hardin, Ill.—Mile 21.8 04-27-92
PARTY: Moody, Krest, and Simoneaux
GAGE HEIGHT @ Meredosia: 446.5 ft GAGE HEIGHT @ Grafton: 421.0 ft
RIVER SLOPE: 97.0×10^{-6}
SUSP. Bag sampler and 150-lb weight
PRICE AA CURRENT METER No: W-223906 DATE RATED: 06-91
CURRENT METER EQUATION: V(m/s)=Rev/s* 0.670 + 0.010
REMARKS:

Transit rate was 5.0 cm/s and nozzle was 5/16 inch. Unmeasured zone was 0.66 m. Order of verticals was 5, 1, 3, 4, and 2.

Vertical	Distance from LEW (m)	Depth (m)	Mean velocity (m/s)	Discharge (m^3/s)	Temperature (°C)	pH	Specific conductance (μS/cm)
LEW	0	0.0					
01A,B	38	3.2	0.51	51	11.9	8.2	767
X05	62	4.5	0.58	82	---	---	---
02A,B	101	4.8	0.65	83	12.7	8.2	777
3B2	115	5.0	0.63	49	---	---	---
03A,B	132	5.1	0.69	62	11.9	8.2	779
X03	150	5.8	0.71	85	---	---	---
X06	173	6.8	0.73	74	---	---	---
04A,B	180	7.0	0.71	57	12.0	8.2	780
X02	196	6.9	0.70	99	---	---	---
X07	221	6.8	0.72	80	---	---	---
05A,B	229	6.5	0.71	53	11.8	7.8	778
X01	244	5.4	0.66	85	---	---	---
REW	277	0.0					
MEANS		4.7	0.66				
TOTAL	277			859			

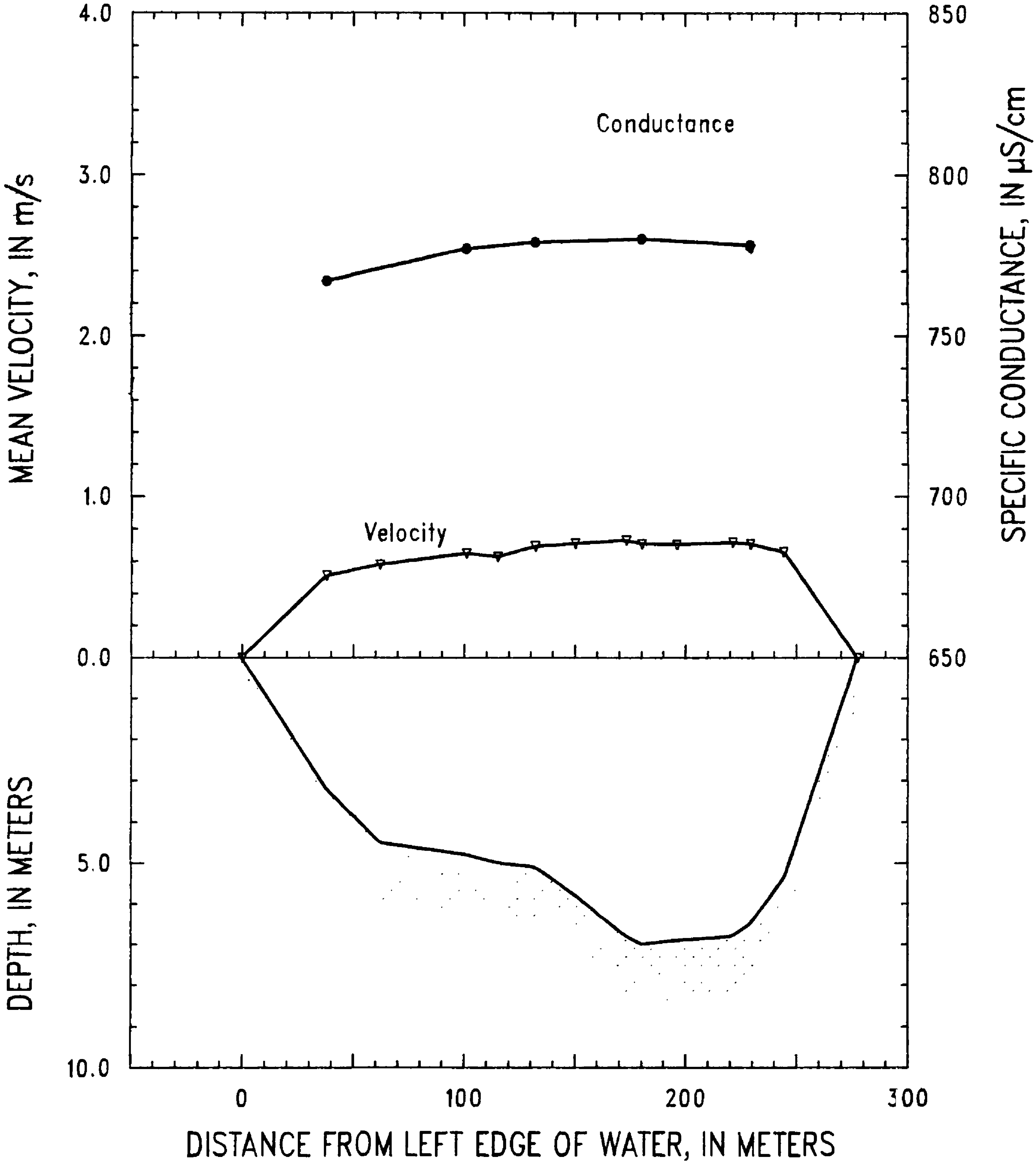

Figure 52. Illinois River at Hardin, Illinois, on April 27, 1992.

SITE: Missouri River at St. Charles, Mo.—Mile 29.4 04-29-92
PARTY: Moody, Krest, and Simoneaux
GAGE HEIGHT @ Hermann: 497.86 ft GAGE HEIGHT @ St. Charles: 442.10 ft
RIVER SLOPE: 149 x 10^{-6}
SUSP. Bag sampler and 150-lb weight
PRICE AA CURRENT METER No: W-223906 DATE RATED: 06-91
CURRENT METER EQUATION: V(m/s)=Rev/s* 0.670 + 0.010
REMARKS:

Transit rate was 8.0 cm/s and the nozzle was 3/16 inch for verticals 8, 7, 6, and 5, but was changed to 14.0 cm/s and 1/4-inch nozzle when numerous nozzle blocks were encountered at vertical 5 and vertical 4. The unmeasured zone was 0.66 m.

Vertical	Distance from LEW (m)	Depth (m)	Mean velocity (m/s)	Discharge (m^3/s)	Temperature (°C)	pH	Specific conductance (μS/cm)
LEW	0	0.0	0.00				
01A,B	45	3.8	0.65	117	13.5	7.9	399
02A,B	95	4.4	1.14	230	14.1	7.9	402
03A,B	137	5.5	1.09	177	13.4	7.9	401
X02	154	5.7	1.35	161	--	--	--
04A,B	179	6.6	1.69	190	13.3	7.9	399
04R	188	7.0	1.78	124	--	--	--
X03	199	7.7	1.83	204	--	--	--
5AR	217	7.7	1.86	172	--	--	--
05B	223	7.7	1.89	80	13.1	7.9	398
05A	228	7.5	1.87	358	--	--	--
06A,B	274	7.4	1.62	360	12.8	7.9	395
X04	288	6.5	1.76	280	--	--	--
07A,B	323	6.8	1.78	454	12.9	7.9	397
08A,B	363	8.2	1.57	283	12.4	8.0	395
X56	367	8.3	1.70	368	--	--	--
REW	415	0.0	0.00				
MEANS		5.6	1.54				
TOTAL	415			3,557			

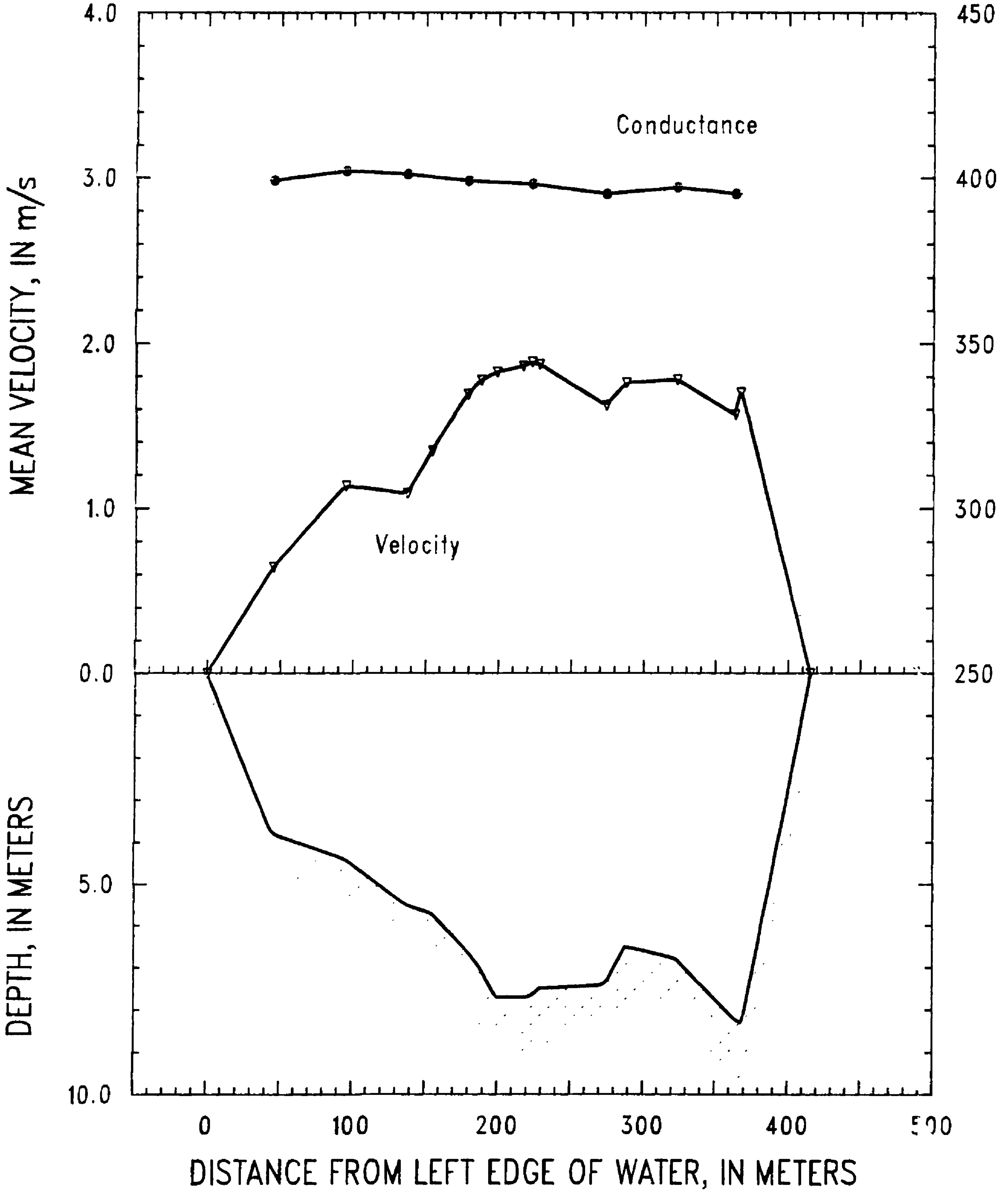

Figure 53. Missouri River at St. Charles, Missouri, on April 29, 1992.

SITE: Mississippi River at Thebes, Ill.—Mile 44.0 05-01-92
PARTY: Moody, Krest, and Simoneaux
GAGE HEIGHT @ Chester: 364.95 ft GAGE HEIGHT @ Cairo: 305.37 ft
RIVER SLOPE: 102.6×10^{-6}
SUSP. Bag sampler and 200-lb weight
PRICE AA CURRENT METER No: W-223906 DATE RATED: 06-91
CURRENT METER EQUATION: V(m/s)=Rev/s* 0.670 + 0.010
REMARKS:

Transit rate was 15 cm/s and the nozzle was 3/16 inch. The unmeasured zone was 0.66 m. Order of verticals was 1, 2, 3, 9, 8, 7, 6, 5, and 4. Specific conductance of vertical 9 was measured last.

Vertical	Distance from LEW (m)	Depth (m)	Mean velocity (m/s)	Discharge (m^3/s)	Temperature (°C)	pH	Specific conductance (μS/cm)
LEW	0	0.0	0.00				
X07	59	10.2	0.93	333	--	--	--
01A,B	70	10.9	0.92	292	13.4	8.3	464
02A,B	117	12.1	1.58	611	14.3	8.1	467
X06	134	13.3	1.67	811	--	--	--
03A,B	190	12.6	1.75	1,171	13.7	8.1	465
04A,B	240	12.1	2.02	1,492	14.4	8.1	462
05A,B	312	12.7	2.25	1,285	14.5	8.0	462
X04	330	13.4	2.29	751	--	--	--
06B	361	13.2	2.23	515	14.2	8.0	460
X10	365	12.7	2.11	134	--	--	--
06A	371	12.7	2.22	1,001	--	--	--
07A,B	436	10.5	1.70	1,019	14.0	8.0	455
08A	485	9.7	1.06	278	14.7	8.0	455
08B	490	9.4	1.24	326	--	--	--
X01	541	8.7	0.83	213	--	--	--
X02	549	8.3	0.77	54	--	--	--
09A,B	558	8.1	0.68	187	14.7	8.0	455
REW	617	0.0	0.00				
MEANS		10.2	1.66				
TOTAL	617			10,477			

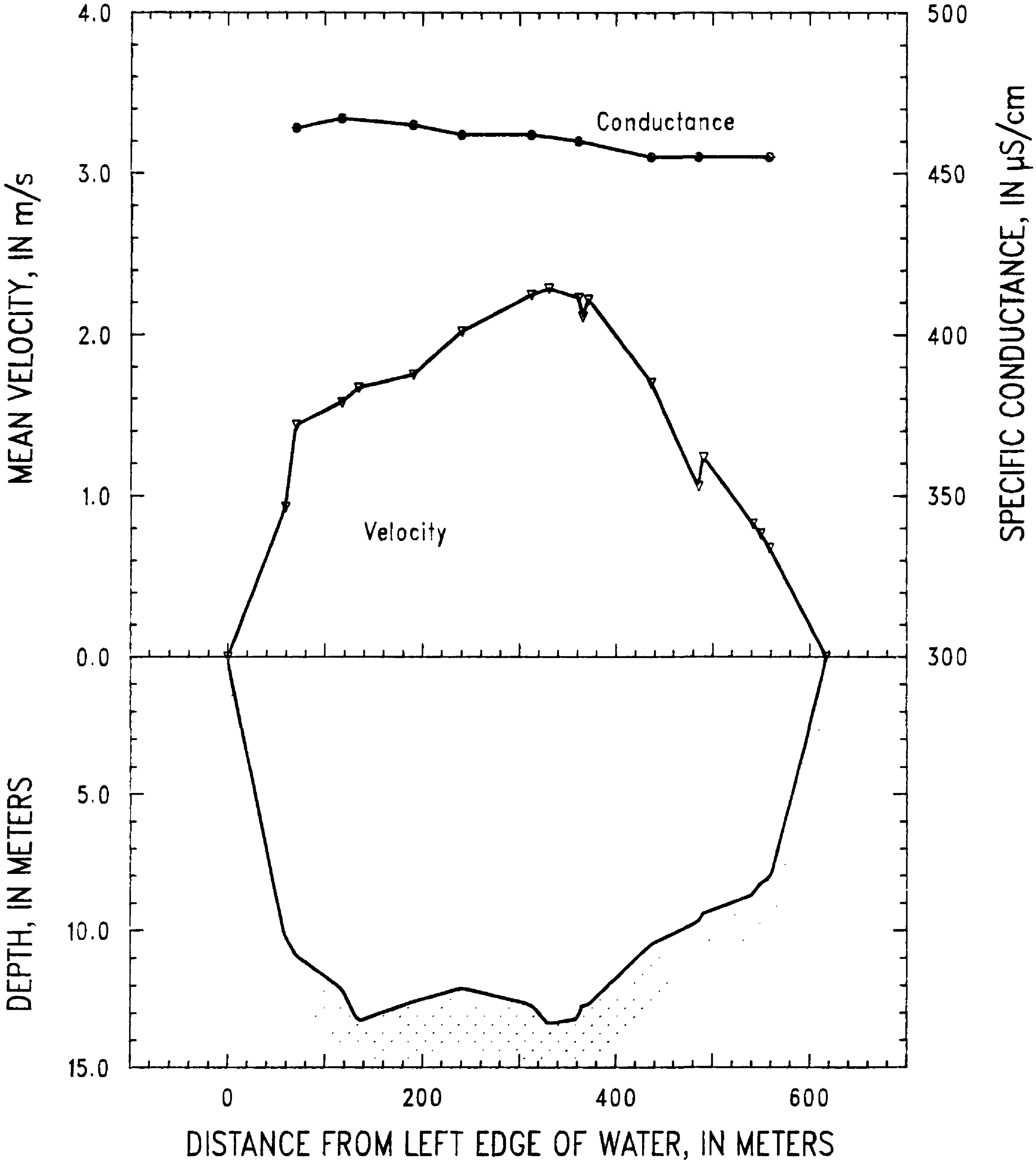

Figure 54. Mississippi River at Thebes, Illinois, on May 1, 1992.

SITE: Ohio River at Olmsted, Ill.—Mile 965.0 05-03-92
PARTY: Moody, Krest, and Simoneaux
GAGE HEIGHT @ Dam 53: 302.60 ft GAGE HEIGHT @ Cairo: 302.27 ft
RIVER SLOPE: 4.3×10^{-6}
SUSP. Bag sampler and 150-lb weight
PRICE AA CURRENT METER No: W-223906 DATE RATED: 06-91
CURRENT METER EQUATION: V(m/s)=Rev/s* 0.670 + 0.010
REMARKS:

Did not collected a depth-integrated composite sample. Transit rate was 5 cm/s. Unmeasured zone was 0.66 m. Order of verticals was 11–1.

Vertical	Distance from LEW (m)	Depth (m)	Mean velocity (m/s)	Discharge (m^3/s)	Temperature (°C)	pH	Specific conductance (μS/cm)
LEW	0	0.0	0.00				
01	91	6.9	0.52	173	17.8	8.0	344
X01	97	7.2	0.47	128	--	--	--
02	167	7.4	0.49	297	17.6	8.0	346
03	261	8.8	0.55	395	17.5	8.0	353
04	331	9.9	0.56	375	17.4	8.0	356
X02	397	11.3	0.60	277	--	--	--
05	413	10.8	0.61	351	17.4	8.0	358
06	504	12.4	0.62	636	17.5	8.0	366
07	578	12.7	0.68	372	17.4	8.0	374
X03	590	12.7	0.65	362	--	--	--
08	666	12.5	0.71	675	17.1	8.0	389
X04	743	11.3	0.79	405	--	--	--
09	757	11.7	0.79	446	16.9	8.0	404
10	840	12.3	0.71	705	17.0	7.9	412
11	919	13.2	0.49	270	16.9	7.8	412
X05	923	13.3	0.46	285	--	--	--
REW	1,012	0.0	0.00				
MEANS		9.9	0.62				
TOTAL	1,012			6,151			

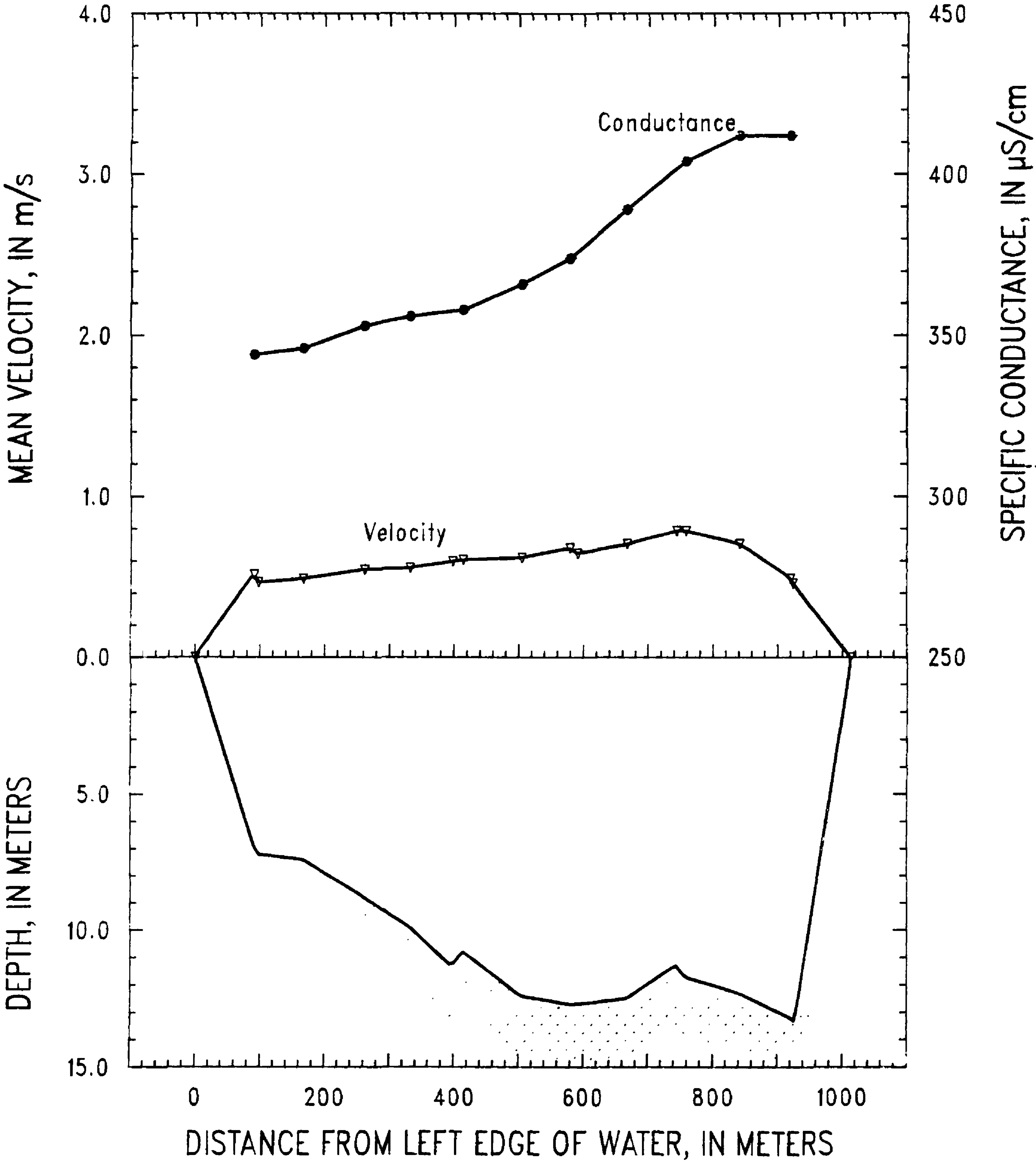

Figure 55. Ohio River at Olmsted, Illinois, on May 3, 1992.

SITE: Mississippi River below Vicksburg, Miss.—Mile 433.4 05-06-92
PARTY: Moody, Krest, and LeBoeuf
GAGE HEIGHT @ Greenville: 109.02 ft GAGE HEIGHT @ Natchez: 52.48 ft
RIVER SLOPE: 63.7×10^{-6}
SUSP. Bag sampler and 200-lb weight
PRICE AA CURRENT METER No: W-223906 DATE RATED: 06-91
CURRENT METER EQUATION: V(m/s)=Rev/s* 0.670 + 0.010
REMARKS:

Transit rate was 9.0 cm/s and the nozzle was 1/8 inch. Unmeasured zone was 0.66 m. Gage heights and slopes are for May 5, 1992.

Vertical	Distance from LEW (m)	Depth (m)	Mean velocity (m/a)	Discharge (m^3/s)	Temperature (°C)	pH	Specific conductance (μS/cm)
LEW	0	0.0	0.00				
X06	47	8.5	0.52	116	--	--	--
01A,B	53	9.2	0.72	234	17.3	8.0	385
X07	118	18.8	1.14	855	--	--	--
X05	133	19.5	1.41	288	--	--	--
02A,B	139	19.3	1.33	720	17.1	8.0	387
03A,B	189	18.3	1.50	1,390	17.3	8.0	388
04A,B	240	18.0	1.52	1,721	17.2	8.0	389
05A,B	315	18.1	1.50	1,388	17.1	8.0	392
X04	342	18.0	1.69	865	--	--	--
06A,B	372	18.0	1.55	1,477	17.3	8.0	393
07A,B	448	16.7	1.55	1,818	17.5	8.0	393
08A,B	512	16.6	1.62	1,602	17.3	8.0	395
09A,B	567	16.3	1.58	903	17.3	8.0	395
X09	582	16.8	1.57	621	--	--	--
X03	614	15.2	1.64	784	--	--	--
10A,B	645	15.3	1.53	1,100	17.5	8.0	396
11A,B	708	14.1	1.54	1,215	17.4	8.0	396
X10	757	13.3	1.37	510	--	--	--
12A,B	764	13.5	1.22	585	17.3	8.0	395
13A,B	828	12.0	1.20	847	17.5	8.0	396
14A,B	882	10.9	1.13	393	17.3	8.0	396
X02	892	10.5	1.19	350	--	--	--
15A,B	938	9.7	1.03	577	17.2	8.0	396
16A,B	1,008	7.8	1.11	591	17.4	8.0	396
17A,B	1,075	6.5	0.99	436	17.1	8.0	396
X01	1,144	6.6	0.77	189	--	--	--
18A,B	1,149	6.5	0.76	170	17.3	8.0	396
REW	1,213	0.0	0.00				
MEANS		13.0	1.37				
TOTAL	1,213			21,745			

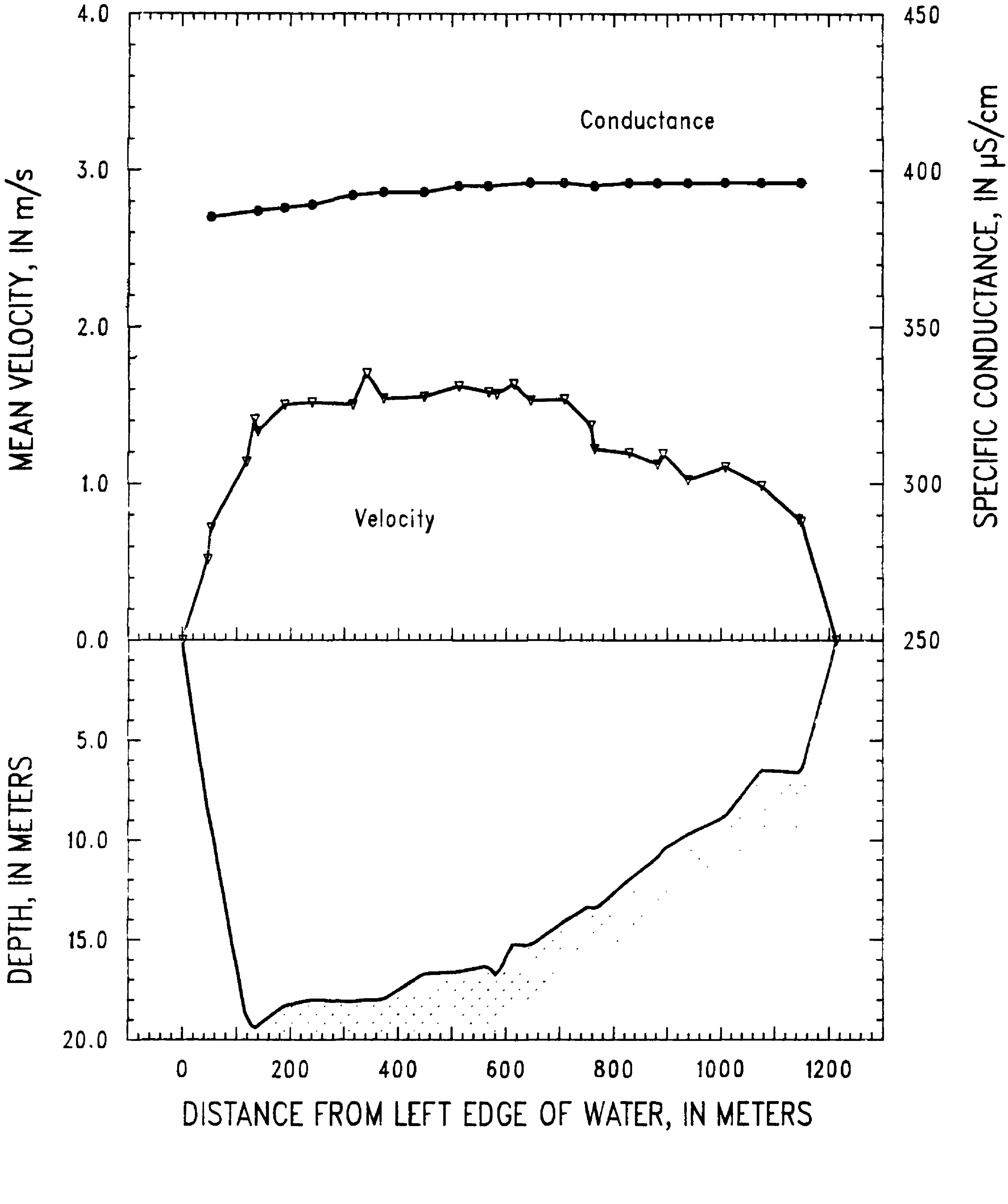

Figure 56. Mississippi River below Vicksburg, Mississippi, on May 6, 1992.

SITE: Mississippi River near St. Francisville, La.—Mile 266.4 05-08-92
PARTY: Moody, Krest, and LeBoeuf
GAGE HEIGHT @ Red River Landing: 37.3 ft GAGE HEIGHT @ Baton Rouge: 23.8 ft
RIVER SLOPE: 34.6 x 10^{-6}
SUSP. Bag sampler and 200-lb weight
PRICE AA CURRENT METER No: 90JM1 DATE RATED: 06-91
CURRENT METER EQUATION: V(m/s)=Rev/s* 0.667 + 0.006
REMARKS:

Transit rate was 13.0 cm/s and the nozzle was 3/16 inch. Unmeasured zone was 0.66 m. No clouds, no wind, mild temperatures—the best day so far of Cruise 92–1.

Vertical	Distance from LEW (m)	Depth (m)	Mean velocity (m/s)	Discharge (m^3/s)	Temperature (°C)	pH	Specific conductance (μS/cm)
LEW	0	0.0					
01A,B	65	8.2	0.83	246	17.6	8.0	390
X06	72	8.7	0.80	205	---	---	---
02A,B	124	11.2	0.78	470	17.6	8.0	391
03A,B	180	11.5	1.01	484	17.7	7.9	389
X05	207	10.9	1.05	400	---	---	---
04A,B	250	10.7	1.21	577	17.9	7.8	391
05A,B	296	11.4	1.27	794	17.8	7.9	390
06A,B	360	11.3	1.34	1019	17.8	7.9	390
07A,B	431	11.7	1.42	963	18.1	7.9	390
08A,B	476	11.4	1.35	874	17.8	7.9	390
09A,B	545	12.8	1.43	1125	17.9	7.9	389
X03	599	13.3	1.26	493	---	---	---
10A,B	604	13.3	1.20	568	17.7	7.9	392
11A,B	670	13.9	1.26	1013	17.7	7.9	389
12A,B	720	16.3	1.14	1062	18.0	7.9	389
13A,B	784	18.3	1.15	1325	18.5	7.9	389
14A,B	846	18.1	1.23	823	18.2	7.9	390
X02	858	18.0	1.29	606	---	---	---
15A,B	898	19.3	1.14	1089	17.7	7.9	390
16A,B	957	15.5	1.10	993	17.5	7.9	392
REW	1,015	0.0					
MEANS		12.6	1.18				
TOTAL	1,015			15,128			

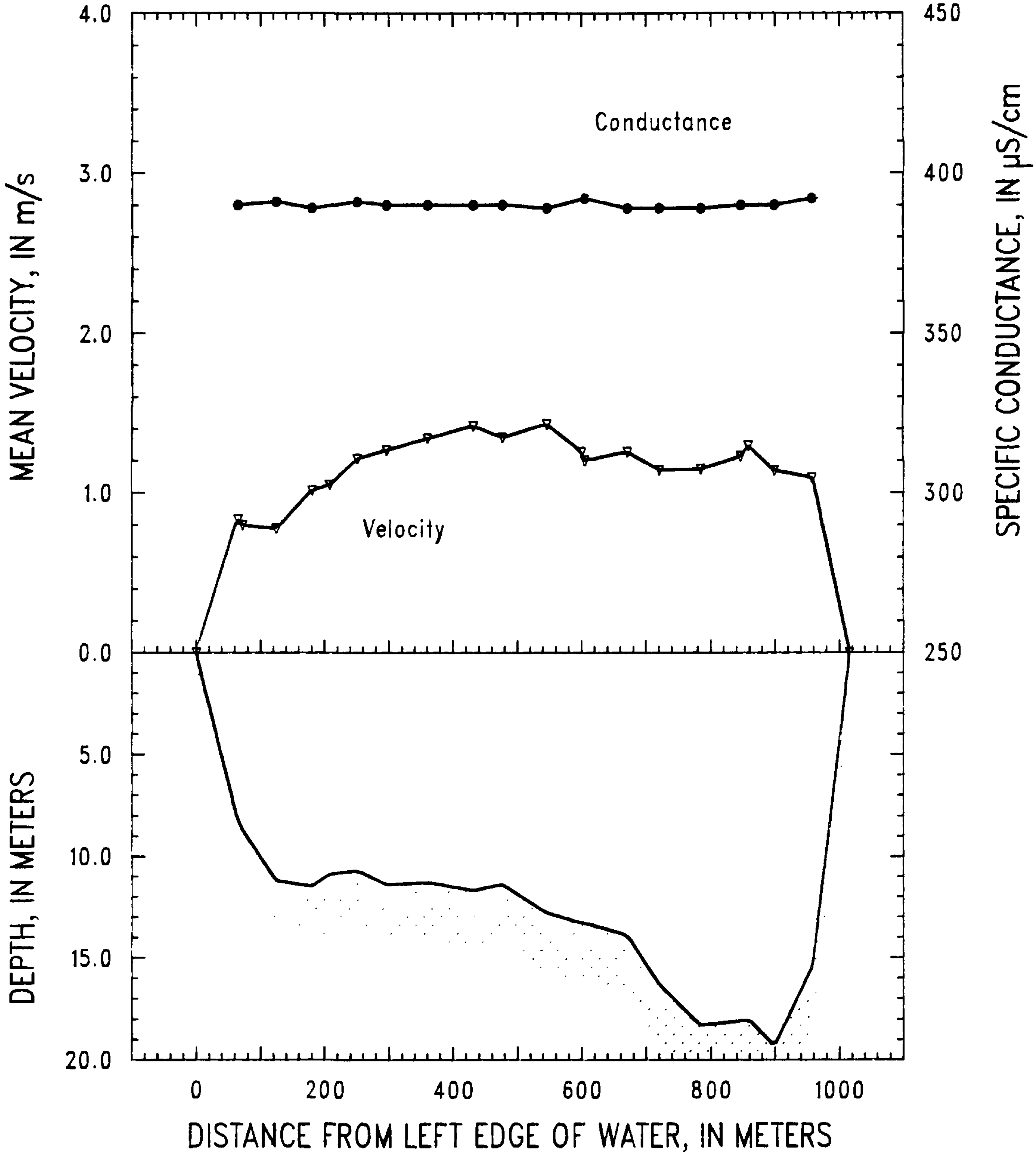

Figure 57. Mississippi River near St. Francisville, Louisiana, on May 8, 1992.

SITE: Mississippi River below Belle Chasse, La.—Mile 73.1 05-10-92
PARTY: Moody, Krest, and LeBoeuf
GAGE HEIGHT @ Baton Rouge: 23.8 ft GAGE HEIGHT @ New Orleans: 7.8 ft
RIVER SLOPE: 24.1 x 10^{-6}
SUSP. Bag sampler and 200-lb weight
PRICE AA CURRENT METER No: 90JM1 DATE RATED: 06-91
CURRENT METER EQUATION: V(m/s)=Rev/s* 0.667 + 0.006
REMARKS:

Transit rate was 13.0 cm/s and the nozzle was 3/16 inch. Unmeasured zone was 0.66 m. Gage heights and slope are for May 8, 1992. Order of verticals was 7–1.

Vertical	Distance from LEW (m)	Depth (m)	Mean velocity (m/s)	Discharge (m^3/s)	Temperature (°C)	pH	Specific conductance (μS/cm)
LEW	0	0.0	0.00				
X05	48	11.2	0.65	358	--	--	--
01B	98	18.0	0.80	380	--	--	--
01A	101	19.3	0.84	878	18.7	7.8	402
02A,B	207	21.3	1.06	2,299	18.6	7.7	402
03A,B	305	24.3	1.04	2,379	18.8	7.8	403
X03	396	25.3	0.95	1,228	--	--	--
04A,B	407	25.4	0.93	1,287	18.7	7.8	402
05A,B	505	25.5	0.89	2,171	18.5	7.8	400
X02	599	24.7	0.88	1,092	--	--	--
06A,B	606	24.2	0.81	1,027	18.5	7.8	400
07A,B	704	22.4	0.71	1,053	18.4	7.8	399
X01	738	15.0	0.57	391	--	--	--
REW	795	0.0	0.00				
MEANS		20.6	0.89				
TOTAL	795			14,542			

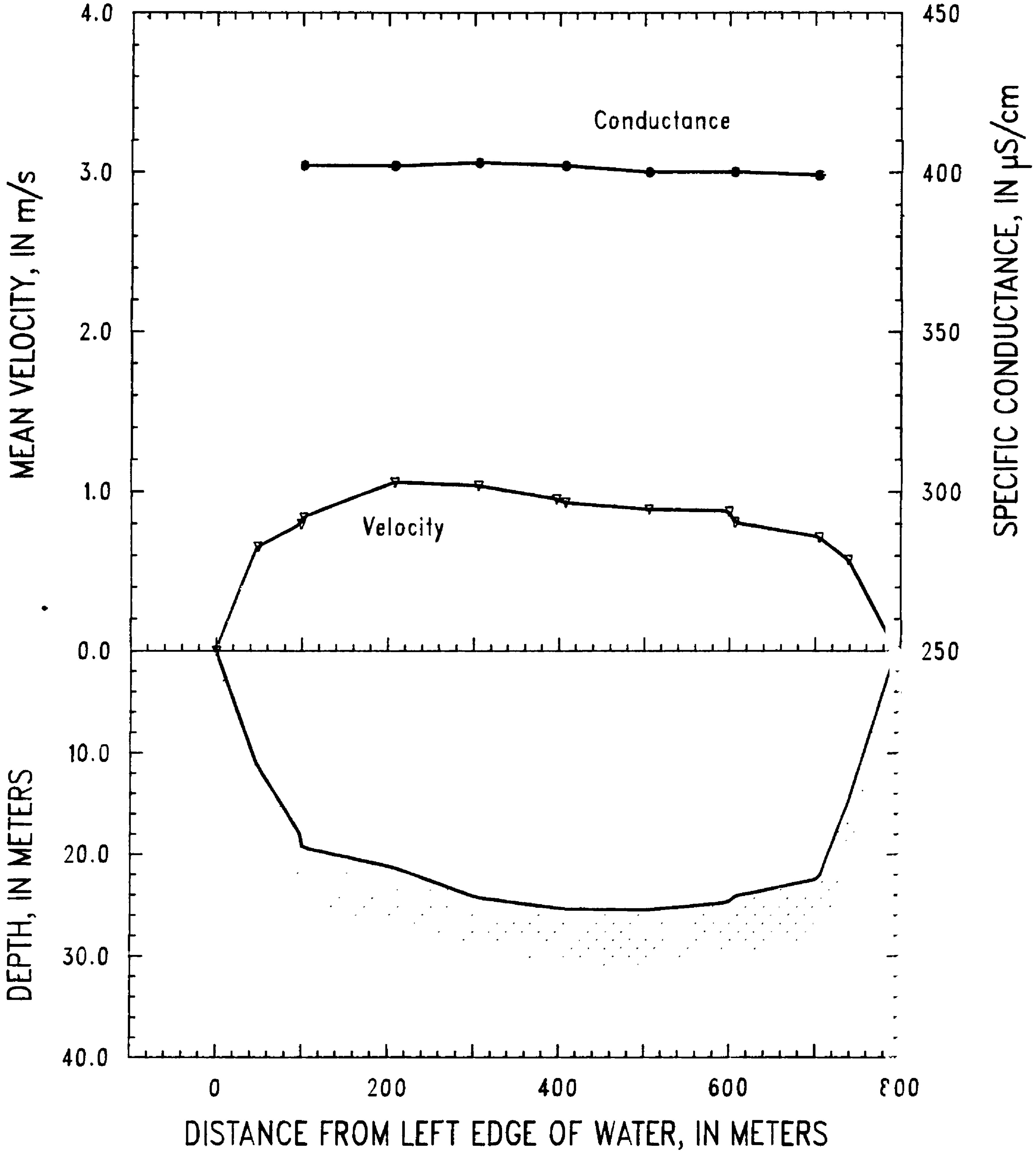

Figure 58. Mississippi River below Belle Chasse, Louisiana, on May 10, 1992.

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