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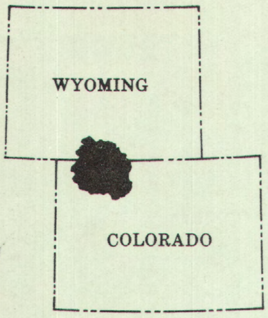

UNITED STATES
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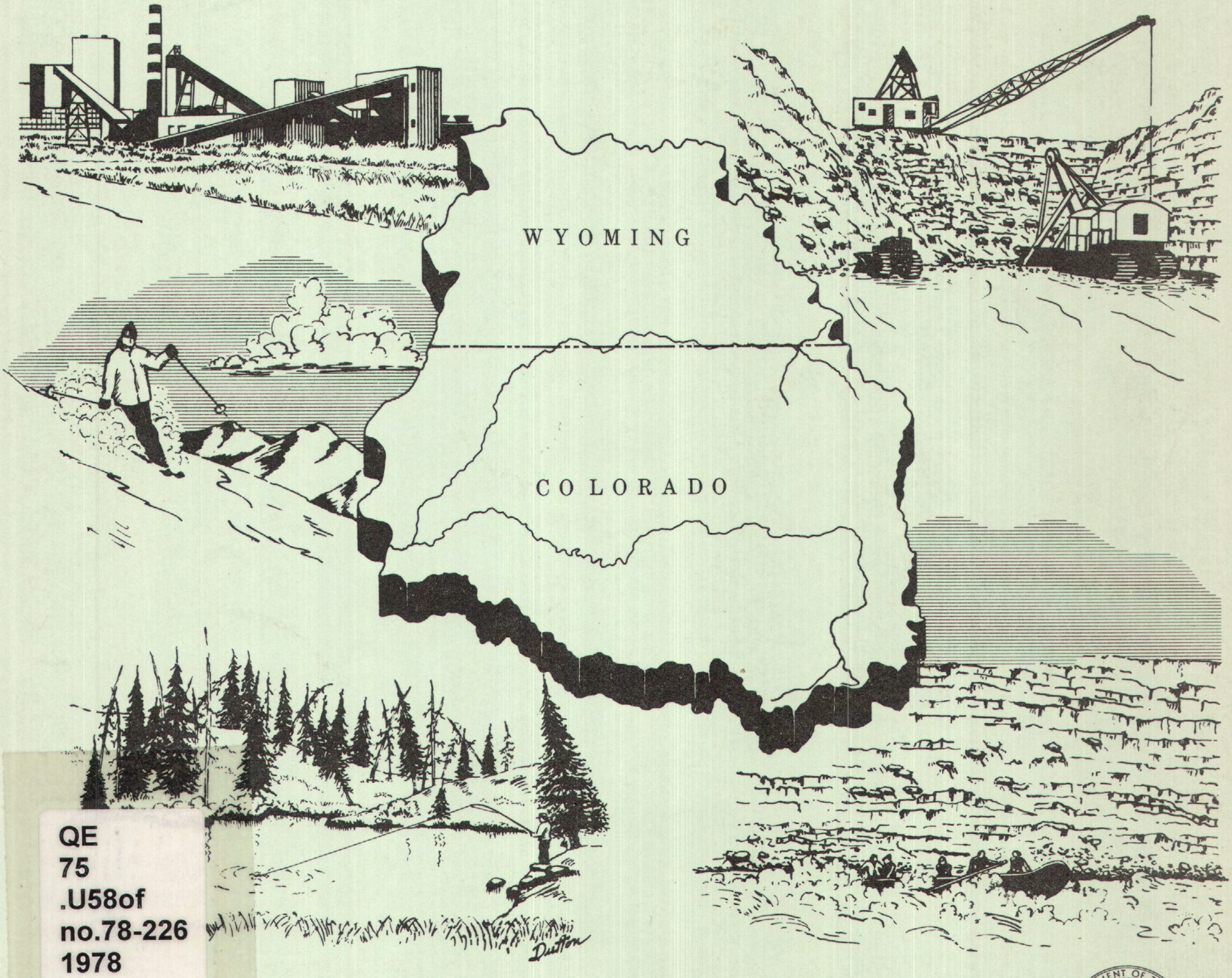

OPEN-FILE REPORT 78-226

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By Timothy Doak Steele, Dennis A. Wentz, and James W. Warner

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Lakewood, Colorado

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HYDROLOGIC RECONNAISSANCE OF THE YAMPA RIVER DURING LOW FLOW, DINOSAUR NATIONAL MONUMENT, NORTHWESTERN COLORADO

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ABSTRACT

A hydrologic reconnaissance of a 74-kilometer reach of the Yampa River in Dinosaur National Monument was made during low flow in mid-August 1976. Stream discharge, which was measured along this reach every 16 to 24 kilometers, ranged from 9.4 to 10.6 cubic meters per second. Variations in streamflow were explained, in part, by underflow, loss to ground water, and evaporation. Specific conductance was measured about every 2 kilometers and indicated a downstream increase on the order of 11 to 12 percent for the reach. Except for mercury, bottom-sediment trace-element concentrations in the study reach were less than maximum concentrations determined during August-September 1976 for bottom sediments at unperturbed sites upstream in the Yampa River basin. At one of five sampling sites, the mercury concentration in bottom sediments exceeded the maximum measured upstream level.

INTRODUCTION

Effects of regional economic development on water resources of the Upper Colorado River Basin, which extends upstream from Lees Ferry, Ariz., have been of great concern to downstream water users (Iorns and others, 1965; Upper Colorado River Commission, 1975; Weatherford and Jacoby, 1975). This concern has intensified in recent years, as the development of energy resources in the basin has progressed.

The U.S. Geological Survey currently (1977) is undertaking a detailed evaluation of the water resources of a subbasin of the Upper Colorado River--the Yampa River basin, Colorado and Wyoming, upstream from Dinosaur National Monument (Steele, Bauer, Wentz, and Warner, 1976; Steele, James, Bauer, and others, 1976; U.S. Geological Survey, 1976). The primary objective of the study is to assess water-related consequences of increasing coal-resource and associated economic development in the Yampa River basin. It is not anticipated that energy-resource development will occur in Dinosaur National Monument. However, as authorized in Public Law 90-542 and amended under Public Law 93-621, the lower Yampa River in the monument (fig. 1) is being evaluated by the U.S. Department of the Interior for possible inclusion in the

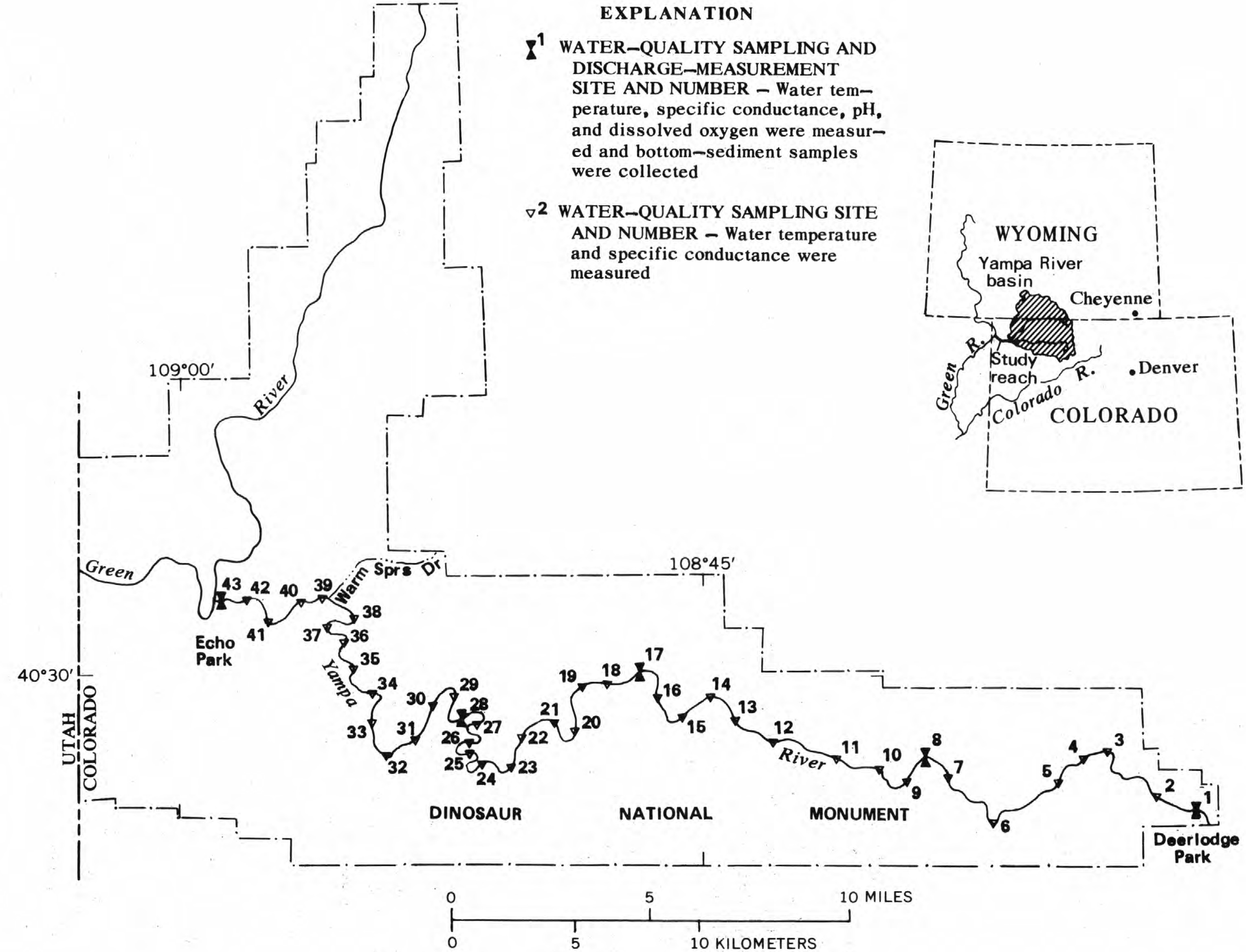


Figure 1.--Location of study reach and associated water–quality sampling and discharge–measurement sites.

National Wild and Scenic Rivers System (H. J. Belisle, U.S. Bureau of Outdoor Recreation, written commun., 1976; U.S. National Park Service, 1977). The reconnaissance survey described here was undertaken to obtain basic surface-water hydrologic information during low flow for the lower Yampa River in Dinosaur National monument.

Ground-water resources of Dinosaur National monument have been studied previously by Sumsion (1976). He found that all water used for public supply within the monument is from wells, and that most of the ground water is obtained from limestone and sandstone formations, such as the Morgan Formation and the Weber Sandstone (fig. 2), which yield a maximum of 0.6 to 1.3 m^3/s (cubic meters per second) to springs and wells in the monument. Alluvium along the major stream channels is the source of small amounts of water to wells, but some of this water is not of suitable chemical quality for public supply (Sumsion, 1976). Most of the ground water obtained from the limestone and sandstone aquifers is suitable for public supply.

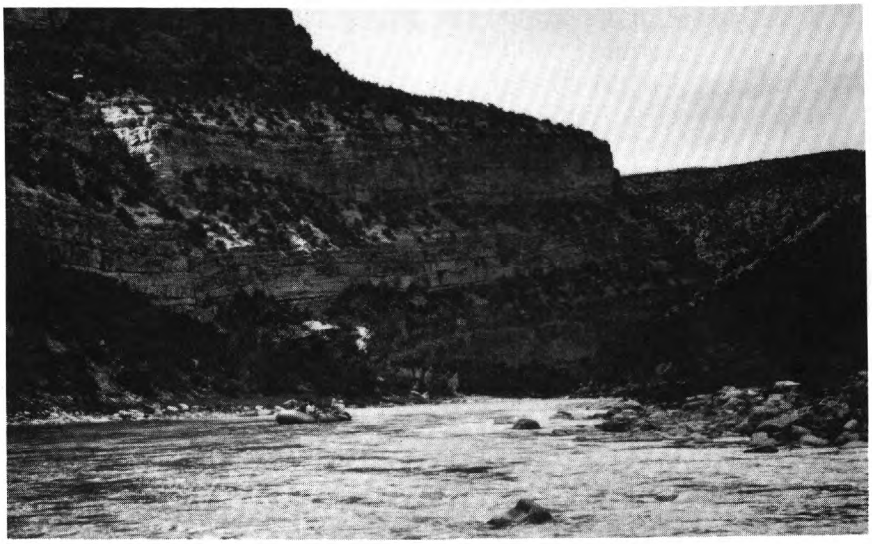
Surface-water resources of Dinosaur National monument were evaluated with respect to quantity by Sumsion (1976); however, the study reported here is the only known work that includes an assessment of surface-water quality in the monument.

HYDROLOGIC RECONNAISSANCE

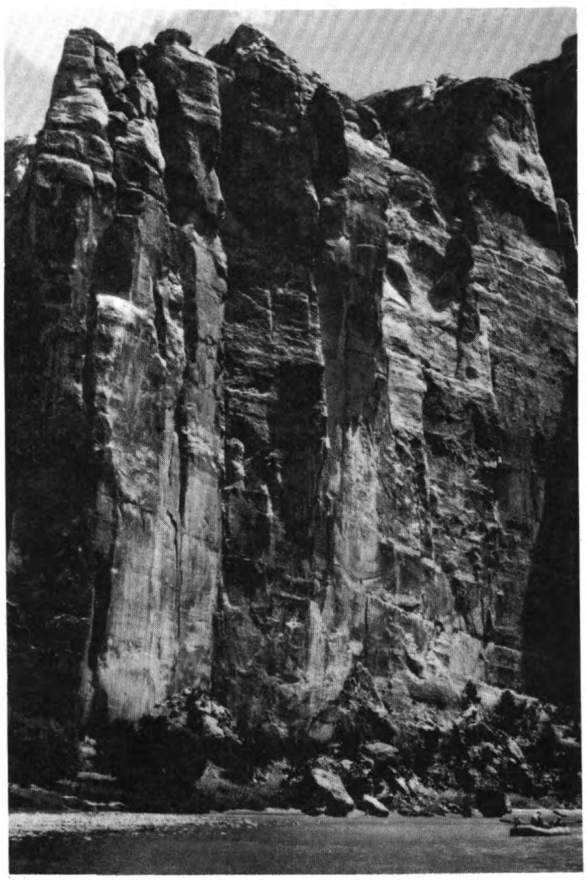
The hydrologic reconnaissance was conducted during August 1976 by R. C. Averett, R. E. Brogden, J. F. Gibbs, R. J. Pickering, T. D. Steele, and D. A. Wentz, of the U.S. Geological Survey. Transportation, guides, and supplies were provided by Adventure Bound, Inc. Permission to make the float trip on the lower Yampa River was granted by C. D. Lewis, Jr., Superintendent, Dinosaur National monument, and is gratefully acknowledged.

The reconnaissance began on August 17, 1976, at Deerlodge Park and ended on August 19 at Echo Park, where the Yampa River enters the Green River (fig. 1). The length of the study reach was approximately 74 river kilometers, and altitudes of the sampling sites ranged from about 1,710 m (meters) at the most upstream site to 1,540 m at the most downstream site (U.S. Geological Survey, 1966). River positions were determined from topographic and river-profile maps (U.S. Geological Survey, 1922; 1966). The stream generally consisted of a pool-and-riffle regime, with pools often exceeding 2 km (kilometers) in length. The reconnaissance was completed by rubber rafts, and, in numerous areas, the rafts had to be pulled over the shallow riffles. Stream-bottom materials varied from large boulders and cobbles to fine, shifting sands and silts.

The two dominant geologic formations forming the canyon walls of the lower Yampa River in Dinosaur National monument are the Morgan Formation and the Weber Sandstone (fig. 2), which are both of Pennsylvanian age. The Morgan Formation is a 30- to 460-m thick limestone interbedded with shales and sandstones. The Weber Sandstone is an approximately 300-m thick fine-grained



A. Morgan Formation



B. Weber Sandstone

Figure 2.--Major exposed geologic units in the Yampa River canyon, Dinosaur National Monument, Colo.

sandstone. In the eastern part of the monument, the Yampa River flows along the approximate contact between the Morgan Formation and the Weber Sandstone. Along this stream reach, the Morgan Formation can be seen as a series of stepped cliffs (fig. 2*A*). Downstream from this point, the Yampa River cuts across the Weber Sandstone, which forms the spectacular sheer cliffs of the lower Yampa Canyon (fig. 2*B*).

Water temperature and specific conductance were measured at about 2-km intervals within the study reach. At five sampling sites, ranging from 16 to 24 km apart (fig. 1), stream discharge, pH, and dissolved oxygen also were measured. In addition, bottom-sediment samples were collected. After extraction of the less than 208-micrometer fraction of the sediments in hot hydrochloric acid, antimony, arsenic, chromium, copper, iron, lead, mercury, and nickel were determined.

Only one tributary contributed inflow greater than 0.003 m^3/s. This was Warm Springs Draw (fig. 1), where surface flow coming from springs was estimated to be about 0.1 m^3/s. Several seeps were noticed along the canyon walls throughout the study reach; however, the effects of these on the flow and water quality of the Yampa River were considered to be minimal at the time of the reconnaissance.

RESULTS AND DISCUSSION

Water temperature and specific-conductance profiles for the study reach are shown on figure 3. The observed fluctuations in water temperature result primarily from normal diel variations as measured by the time-series pattern of sampling throughout a 10- to 12-hour period during each of the 3 days of the reconnaissance. Maximum daily water temperatures increased from 19°C (Celsius) in the upstream part of the study reach (sites 4-7) to 22°C in the downstream part (sites 36-41) (fig. 1). Neither Warm Springs Draw (fig. 1) nor other seeps in the monument had any pronounced effect on the water temperature of the Yampa River.

Specific conductance, measured along the study reach, increased in a downstream direction, although some degree of random fluctuation was noted (fig. 3). Measurements ranged from 445 micromhos per centimeter at 25°C at site 1 and at site 17 to 495 to 500 micromhos at the last three downstream sampling points (sites 41-43). This represents an 11- to 12-percent increase in specific conductance within the study reach. Evaporation and ground-water discharge probably accounted for much of this increase.

The data obtained at five selected sites within the study reach are summarized in table 1. Dissolved oxygen was slightly supersaturated during most of the daylight hours. Slight undersaturation was noted in early morning, and the same situation probably occurred at night. Such a diel pattern is common in mountain and hill-country streams (Reid and Wood, 1976, p. 215).

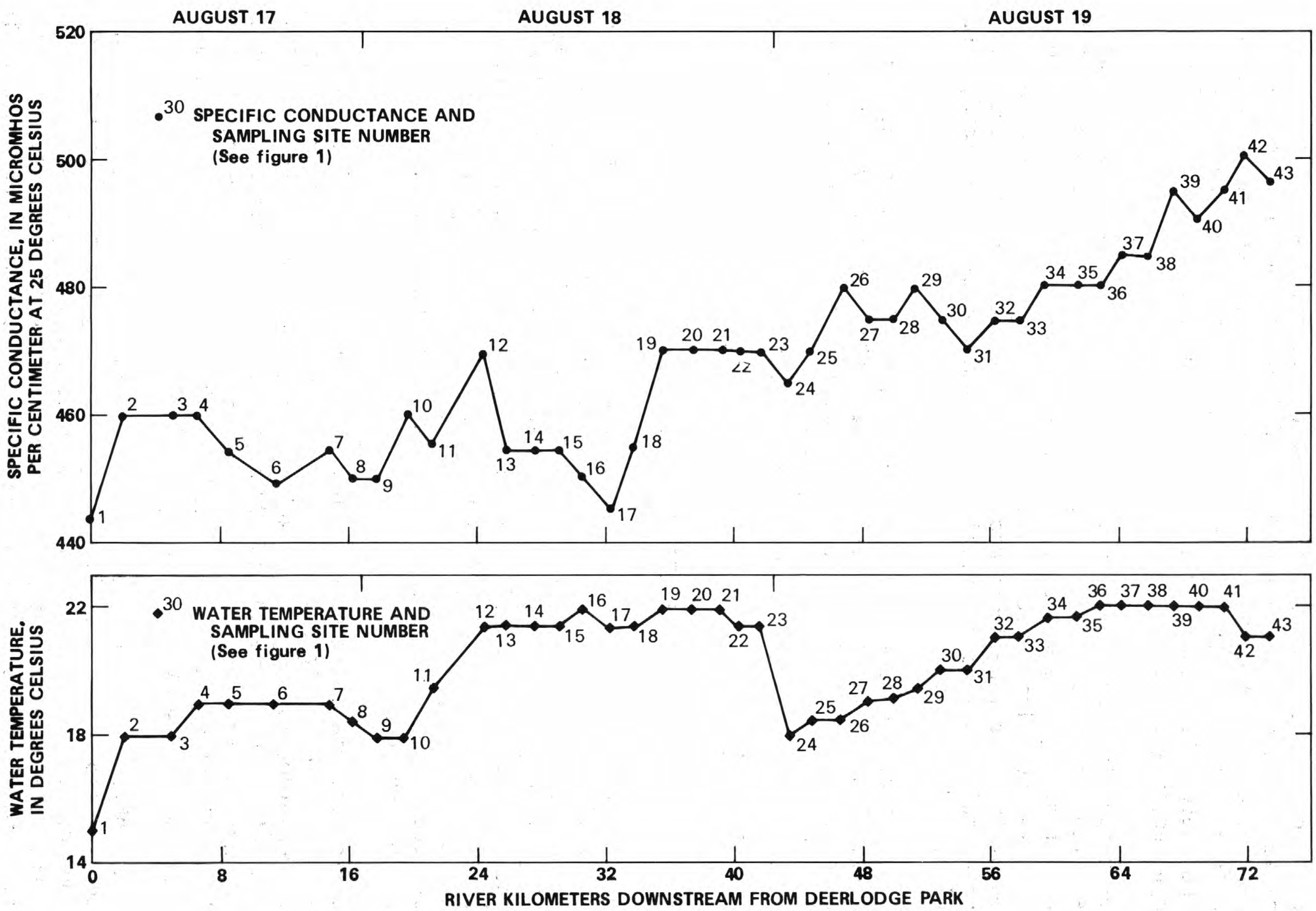


Figure 3.--Stream–reach profiles of water temperature and specific conductance, August 17–19, 1976.

Table 1.--*Water and bottom-sediment quality at selected sites, August 17-19, 1976*

Variable	Sampling site: Site-- 1, Day--- 17, Time-- 0800	Site-- 8, Day--- 17, Time-- 1830	Site-- 17, Day--- 18, Time-- 1700	Site-- 28, Day--- 19, Time-- 0900	Site-- 43, Day--- 19, Time-- 1900	Range of concentrations in streams of the Yampa River basin, August-September 1976
Water temperature, degrees Celsius-----	15.0	18.5	21.5	19.0	21.0	------------
Specific conductance, micromhos per centimeter at 25 degrees Celsius-----	445	450	445	475	495	------------
Dissolved oxygen, milligrams per liter-	7.4	7.8	7.6	7.5	8.0	------------
Dissolved oxygen, percent saturation---	90	103	106	97	108	------------
pH, standard units--------------------	8.6	8.4	8.8	8.5	8.6	------------
Discharge, cubic meters per second-----	10.6	9.8	9.4	10.0	10.1	------------
Trace-element concentration in bottom sediments (micrograms per gram)						
Antimony------------------------------	0	0	0	0	0	0
Arsenic-------------------------------	0	5	0	5	3	0-13
Chromium------------------------------	2	7	3	6	2	2-16
Copper--------------------------------	2	12	2	9	<2	3-16
Iron----------------------------------	1,500	6,500	2,400	5,500	2,600	1,600-11,000
Lead----------------------------------	<10	20	<10	20	<20	<10-30
Mercury-------------------------------	.09	.35	.16	.18	.02	.05-.28
Nickel--------------------------------	<10	15	5	15	<10	4-30

Values greater than the 100-percent saturation level during the day result when photosynthesis of attached algae occurs at a greater rate than biological respiration. Values less than the 100-percent saturation level are noted at night, when photosynthesis ceases but biological respiration continues. The magnitudes of the supersaturation and undersaturation levels often are ameliorated by stream turbulence, which tends to maintain an average of 100-percent saturation. Because of the long pools and relatively insignificant riffles in the lower Yampa River during the time of the reconnaissance, this effect was minimal. Thus, the degree of supersaturation and undersaturation with respect to dissolved oxygen indicates that biological activity was not great.

The above conclusion is corroborated by the relatively small range of pH (8.4 to 8.8) that was observed. In areas where biological activity is great, photosynthesis raises the pH during the day, whereas respiration lowers it at night. The actual pH values in the study reach compare quite favorably to the median pH of 8.4 (D. A. Wentz and T. D. Steele, written commun., 1978) measured in the Yampa River basin upstream from Dinosaur National monument during August-September 1976. Although it might be argued that pH's in the study reach were slightly larger than those measured upstream, this could be explained by dissolution of dolomite and limestone in the monument area.

Decreases in streamflow, on the order of 4 to 11 percent, were measured in a downstream direction in the study reach from site 1 to site 17. This downstream trend was apparent in spite of the estimated accuracy of ±10 percent for any single measurement. From site 17 to site 43 at the mouth of the Yampa River, streamflow increased from 1 to 7 percent. A net downstream decrease in stream discharge of 0.5 m^3/s (equal to 5 percent) was measured in the study reach. Variations in streamflow probably are due to a combination of effects, including unmeasured underflow in sandy parts of the stream channel, recharge to or discharge from ground-water aquifers transversing the stream channel, and evaporation.

The results of the analyses for trace elements in bottom-sediment samples (table 1) were compared with results for samples collected at sites upstream from the monument that were not affected by water-quality degradation during August-September 1976 (D. A. Wentz and T. D. Steele, written commun., 1978). Except for mercury, all bottom-sediment trace-element concentrations were less than the corresponding maximum concentration observed for streams of the Yampa River basin. However, one mercury concentration in bottom sediments of the Yampa River in Dinosaur National Monument was greater than the maximum recorded in bottom sediments throughout the rest of the basin upstream from the study reach.

The maximum concentrations of all trace elements sampled occurred at site 8, and all have secondary maximums at site 28. The maximum concentrations at site 8 might be explained by a source upstream from this point, but downstream from site 1. Easily eroded shales that crop out in the eastern part of the monument, but which do not crop out in the Yampa River basin upstream from the monument, are a probable source of the trace elements. Concentrations of trace elements would be expected to be larger just downstream from the source and should then decrease downstream because of dilution from sediments with smaller trace-element concentrations. The secondary bottom-sediment trace-element maximums at site 28 have no obvious explanation. Additional sampling at intervening sampling sites during low flow might establish the source of mercury in the bottom sediments and determine the credibility of the larger than expected mercury value observed at site 8 during this reconnaissance.

The study reported here describes selected water-quality characteristics during low-flow conditions which probably occur during late summer each year. Low-flow water-quality conditions during August-September 1975 in streams of the Yampa River basin upstream from the monument have been characterized by Wentz and Steele (1976). Supplemental data collected during January 21-22, 1978, at sites 1 and 43 (fig. 1) at the upper and lower ends of the study reach indicate a 36-percent downstream increase in stream discharge but no significant change in specific conductance at this time of year (table 2). Comparable data for the lower Yampa River study reach during other times of the year, particularly during peak-runoff conditions in May and June, would be useful. During periods of high flow, water-quality effects by tributary inflows from numerous side canyons within the monument may be more pronounced than the effects that were documented by the August 1976 reconnaissance.

Table 2.--*Supplemental hydrologic data, January 21-22, 1978*

Variable	Sampling site	
Site--	1	43
Day---	22	21
Time--	1800	1400
Water temperature, degrees Celsius-------------	0.5	1.5
Specific conductance, micromhos per centimeter at 25 degrees Celsius------------------------	520	525
Discharge, cubic meters per second-------------	7.2	9.8

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