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BEHAVIORAL AND CATASTROPHIC DRIFT OF INVERTEBRATES IN TWO STREAMS IN NORTHEASTERN WYOMING

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CONVERSION FACTORS

Metric units used in this report may be converted to inch-pound equivalents by the following conversion factors:

Multiply	By	To obtain
cubic meter per second (m^3/s)	35.31	cubic foot per second (ft^3/s)

BEHAVIORAL AND CATASTROPHIC DRIFT

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ABSTRACT

Invertebrate drift samples were collected during August 1977 from two streams in the Powder River structural basin in northeastern Wyoming. The streams are Clear Creek, a mountain stream, and the Little Powder River, a plains stream. Two major patterns of drift were recognized.

Clear Creek was sampled during a period of normal seasonal conditions. High drift rates occurred during the night indicating a behavioral drift pattern that is related to the benthic invertebrate density and the carrying capacity of the stream substrates. The mayfly *Baetis*, a common drift organism, dominated the peak periods of drift in Clear Creek, which resulted in low diversity during those periods.

A flood during the study period due to local rainstorms affected the physical, chemical, and biological conditions of the Little Powder River. The flood caused a catastrophic drift pattern. Midge larvae of the families Chironomidae and Ceratopogonidae, usually not common in drift, dominated the drift community. The dominance of midge larvae, the presence of several other organisms not common in drift, and the high diversity indices in the Little Powder River drift samples indicate a catastrophic drift pattern.

INTRODUCTION

The U.S. Geological Survey is studying the water resources of the Powder River structural basin in northeastern Wyoming in relation to energy-mineral development. One of the objectives of the study is to determine the distribution and behavior of organisms in streams in the basin.

The purpose of this report is to present and discuss the patterns of fluctuation of drift organisms in two streams, a mountain stream during base flow and a plains stream affected by rainfall runoff. Two types of drift, behavioral and catastrophic, occurred and are described in this report.

The aquatic insects and other invertebrates that normally inhabit stream substrates are called benthic invertebrates or, more broadly, benthic organisms. They are commonly referred to as drift organisms while they are temporarily suspended in the water and being transported downstream by the currents. Waters (1972) defined three invertebrate drift patterns: Catastrophic drift, which occurs as a result of a physical disturbance of the bottom fauna; behavioral drift, which occurs during the night or some consistent period of the day; and constant drift, which occurs at all times and involves a few occasional individuals of all species present.

Behavioral drift usually occurs in some type of 24-hour periodicity with significant increases in numbers usually occurring shortly after sunset and shortly before sunrise or both. The magnitude of this type of drift apparently is significantly affected by the carrying capacity of the stream (Waters, 1961; 1966) and light intensity (Holt and Waters, 1967). When the organism density exceeds the carrying capacity of the stream bed, excess organisms enter the drift community in search of a less populated or more suitable area. Therefore, drift becomes a function of the density of the benthic invertebrates and of the degree to which the carrying capacity tends to be exceeded (Dimond, 1967; Waters, 1966; 1972).

The carrying capacity is greatly dependent on the amount of available food. By varying food levels in an artificial stream, Hildebrand (1974) found that lower food levels cause greater rates of drift. When the density of the benthic invertebrate population exceeds the carrying capacity of the stream substrate, greater competition occurs for existing food. This results in increased foraging and movement, which results in increased incidence of dislodgement by the current. Organisms also can voluntarily enter or reenter the drift when conditions on the substrate are unsuitable.

Most drift organisms are night active, possibly as a mechanism for avoiding sight-feeding predators. The mayfly genus Baetis (Ephemeroptera) and the crustacean Gammarus commonly dominate the drift populations during the night. A few species, primarily caddis flies (Trichoptera), are day active, and their level of activity may be directly related to water temperature (Waters, 1968; 1972).

Invertebrate drift can rapidly recolonize unpopulated or depopulated reaches of streams. This is important in small plains streams that may be scoured of most fauna following each rain storm. Drift data can be used as a basis for comparing streams (Dimond, 1967), as an indicator of water quality (Larimore, 1974), and as an indicator of the effects of insecticides or other toxicants on the stream biota (Coutant, 1964; Dimond, 1967). Drift data also can indicate secondary production of biomass (Waters, 1962a; 1966). Some species of fish, such as brown trout, feed largely on drift organisms

DESCRIPTION OF STUDY AREA

Clear Creek

Clear Creek is a perennial mountain stream that has its headwaters in the Bighorn Mountains west of Buffalo, Wyo. (fig. 1). The sample site is in the foothills upstream from Buffalo and is characteristic of undeveloped mountain streams in the area. Mean discharge for water year 1977 was 1.23 m^3/s. The maximum discharge during 1977 was 18.6 m^3/s on May 10, and the minimum discharge was 0.11 m^3/s on January 17. Peak discharges generally occur during May and June due to snowmelt runoff, and smaller peaks may occur following rains during July and August.

Little Powder River

The Little Powder River is characteristic of many plains streams in the Powder River Basin of Wyoming (fig. 1). It has perennial reaches separated by ephemeral or intermittent reaches and has several ephemeral or intermittent tributaries. Mean discharge for water year 1977 was 0.25 m^3/s. The maximum discharge during 1977 was 7.99 m^3/s on April 7, and the minimum was no flow from August 30 to September 7. Two periods of peak discharge generally occur: One during snowmelt from February to April and one during spring and summer rains from May through August. Peak discharges cause the surface of the stream bed and margins to be scoured of most organisms. Biologic communities reestablish in the pools and in the riffles connecting the pools when the stream stage declines.

METHODS AND SCOPE OF INVESTIGATION

Samples for drift analyses were collected using a drift net having a mesh size of 0.363 millimeters and an opening of 0.300 by 0.415 meters. The drift net was placed in a riffle, perpendicular to the flow, and was anchored with steel stakes. The net was removed at selected intervals, the contents were rinsed into the retaining cup of the net, and the sample was transferred to a jar. The sample was preserved with 70-percent isopropyl alcohol as described by Slack and others (1973, p. 129). Samples were sorted and sent to the U.S. Geological Survey laboratory for counting and identification by genera. Diversity indices, a measure of the relative abundance of taxa within the sample, were calculated using the Shannon-Weaver method. The invertebrate data are published in U.S. Geological Survey (1979).

Drift invertebrate samples were collected from Clear Creek near Buffalo, Wyo., in 2-hour increments from 0900 to 1900 hours mountain daylight time, 1-hour increments from 1900 to 2100 hours, and 2-hour increments from 2100 to 0700 hours on August 2 and 3, 1977. The sample from the 1500- to 1700-hours increment was ruined during handling and results for this sample are not reported.

Beginning at 1800 hours on August 17, 1977, invertebrate drift in the Little Powder River was sampled in 1-hour increments until 2200 hours, then at 2400 hours, and at 0300 and 0600 hours on August 18, 1977.

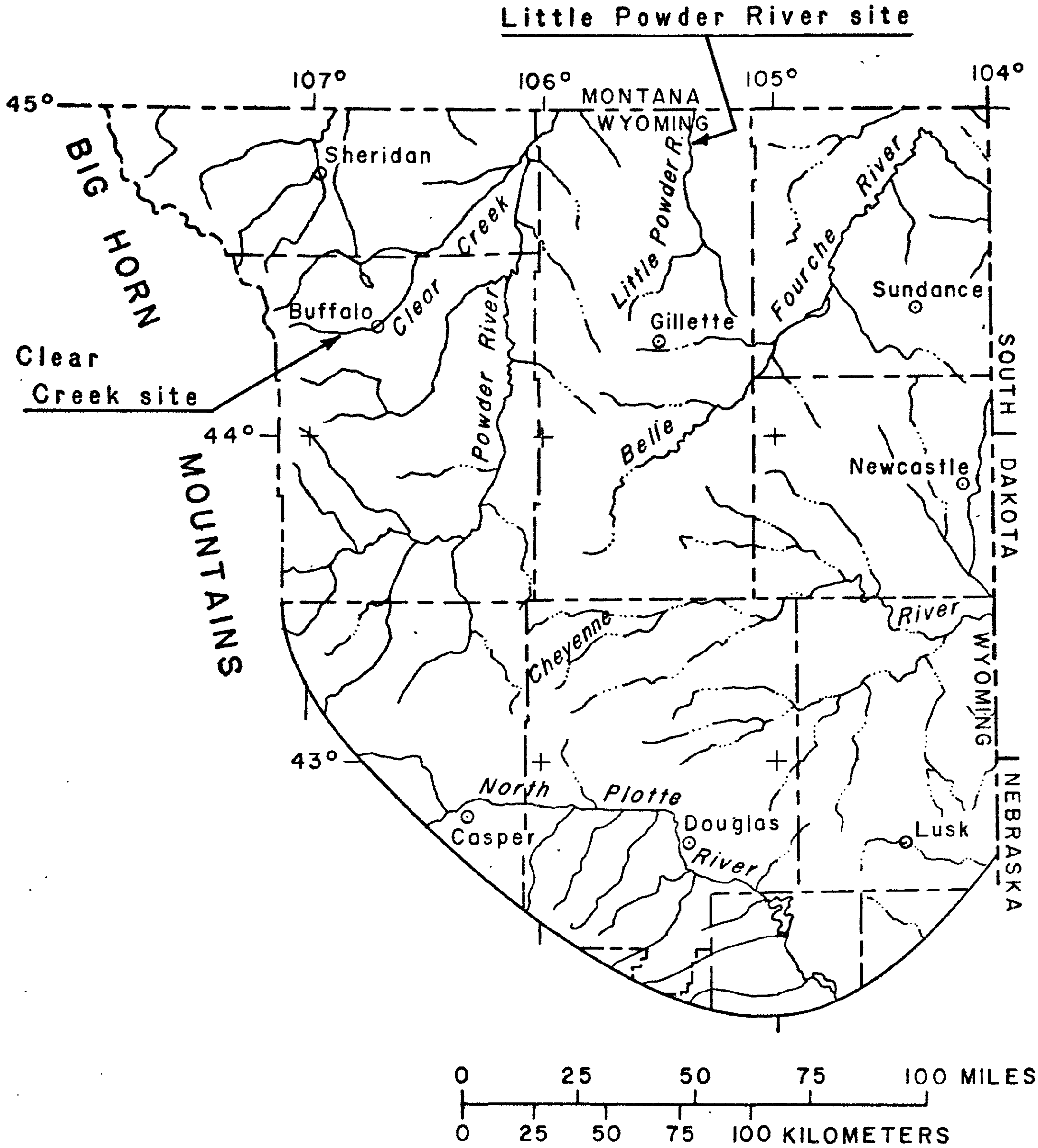

Figure 1.--Sampling sites in the Powder River structural basin in northeastern Wyoming.

On-site determinations of dissolved oxygen, water temperature, pH, and specific conductance were made in conjunction with each drift sample. All meters were calibrated at the sampling sites using techniques described by Brown and others (1970). Water temperatures were measured using a handheld thermometer. Discharge was determined from established rating tables using the gage heights at the time of each sample.

RESULTS AND CONCLUSIONS

Physical and Chemical Measurements

Clear Creek

Fluctuations in time of the physical and chemical measurements obtained from Clear Creek during the study period are shown in figure 2. Water temperature reached a maximum of 17.5°C during late afternoon and a minimum of 12.5°C during early morning. The maximum pH (8.0) occurred early in the morning. Specific conductance was 50 µmho (micromhos per centimeter at 25°Celsius), which is typical of a mountain stream. The specific conductance and the discharge (1.02 m^3/s) remained constant during the study period.

Dissolved-oxygen concentrations decreased during the day from a maximum of 9.0 mg/L (milligrams per liter) during the early morning to a minimum of 7.6 mg/L during the early night. The dissolved-oxygen concentrations were affected by water temperature, by oxygen produced by algae through photosynthesis during the day, and by oxygen used in respiration by the aquatic community during the night.

Little Powder River

The physical and chemical measurements obtained from the Little Powder River are shown in figure 3. The daytime water temperatures were warmer than 20°C, due partly to the lack of vegetative cover on the banks, which would have shaded the water. The pH did not fluctuate significantly during the study period, remaining between 7.5 and 7.7. The dissolved-oxygen concentrations during the study period showed little fluctuation, which may indicate that the amount of water discharge lessened the effects of photosynthesis and respiration.

During the study period, the Little Powder River had larger than normal flows due to rainfall runoff. The magnitude of the flood compared to the preceding low-flow condition is shown in figure 4.

Specific conductance during most low-flow periods in the Little Powder River ranges between 2,000 and 3,000 µmho, depending on the discharge. As discharge increases, the specific conductance usually decreases due to dilution. Because of the flood discharge during the study period, the specific conductance in the Little Powder River was less than average, ranging between 950 and 1,025 µmho.

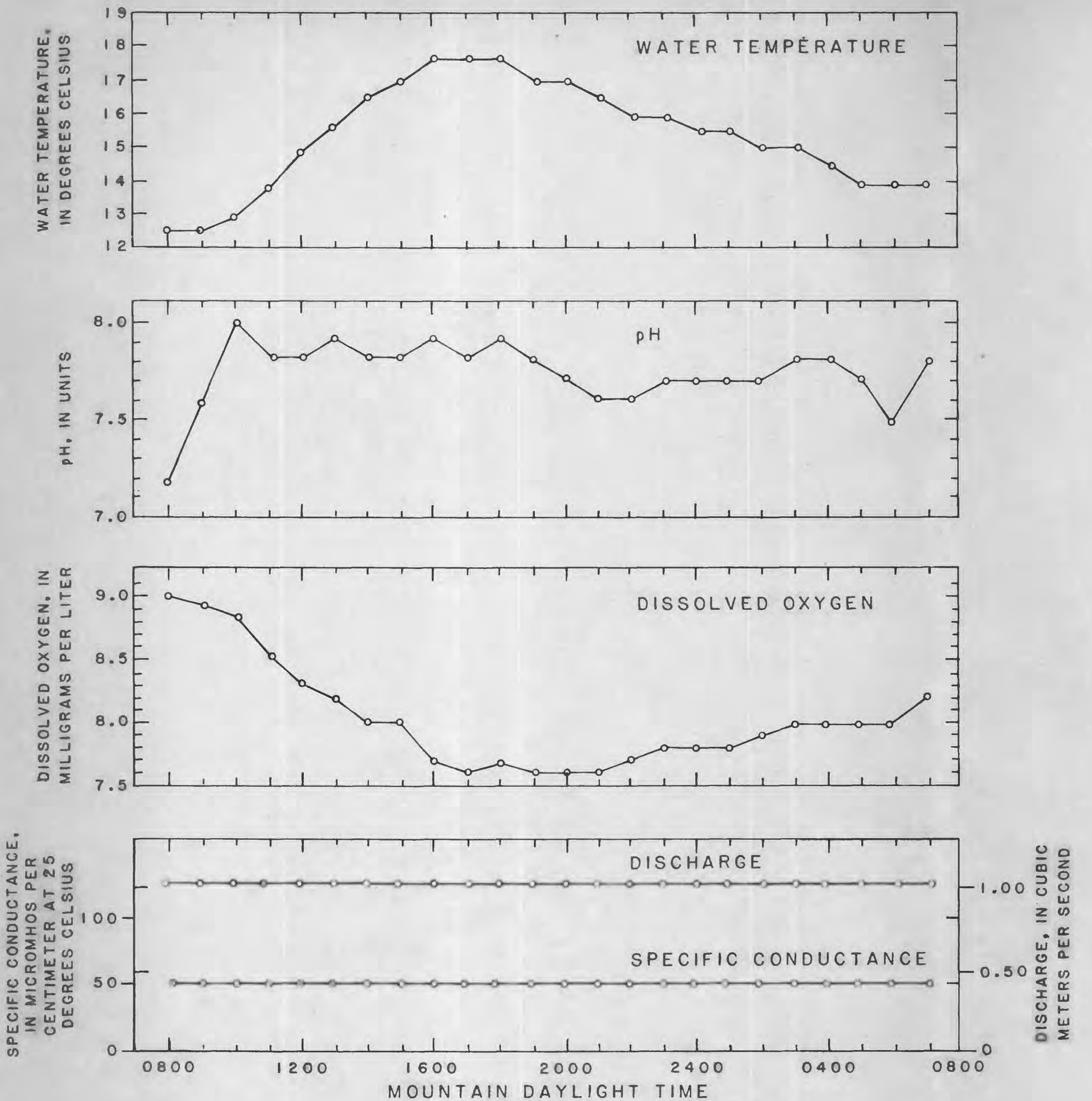

Figure 2.--Results of on-site physical and chemical measurements in Clear Creek, August 2 and 3, 1977.

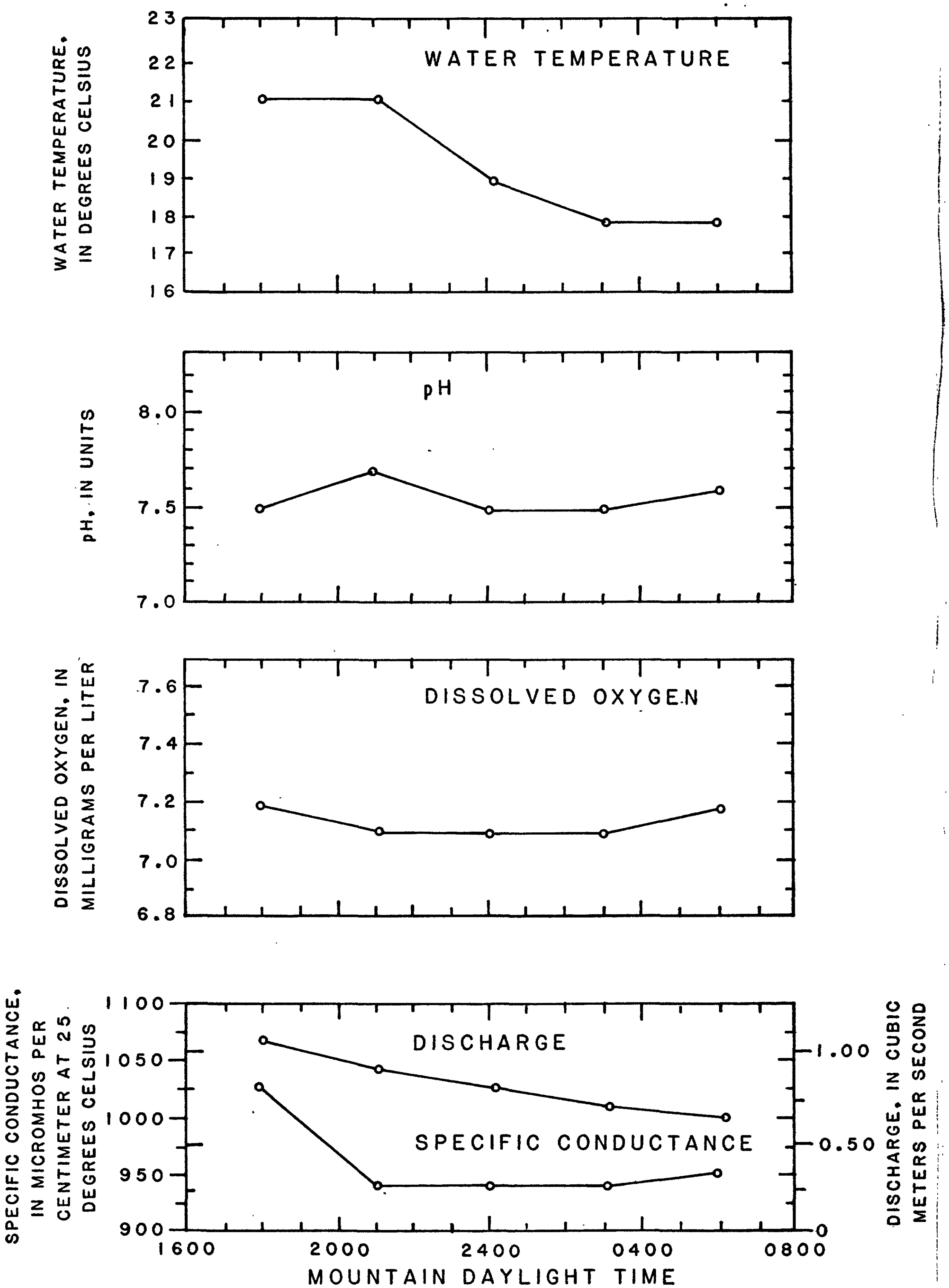

Figure 3.--Results of on-site physical and chemical measurements in the Little Powder River, August 17 and 18 1977.

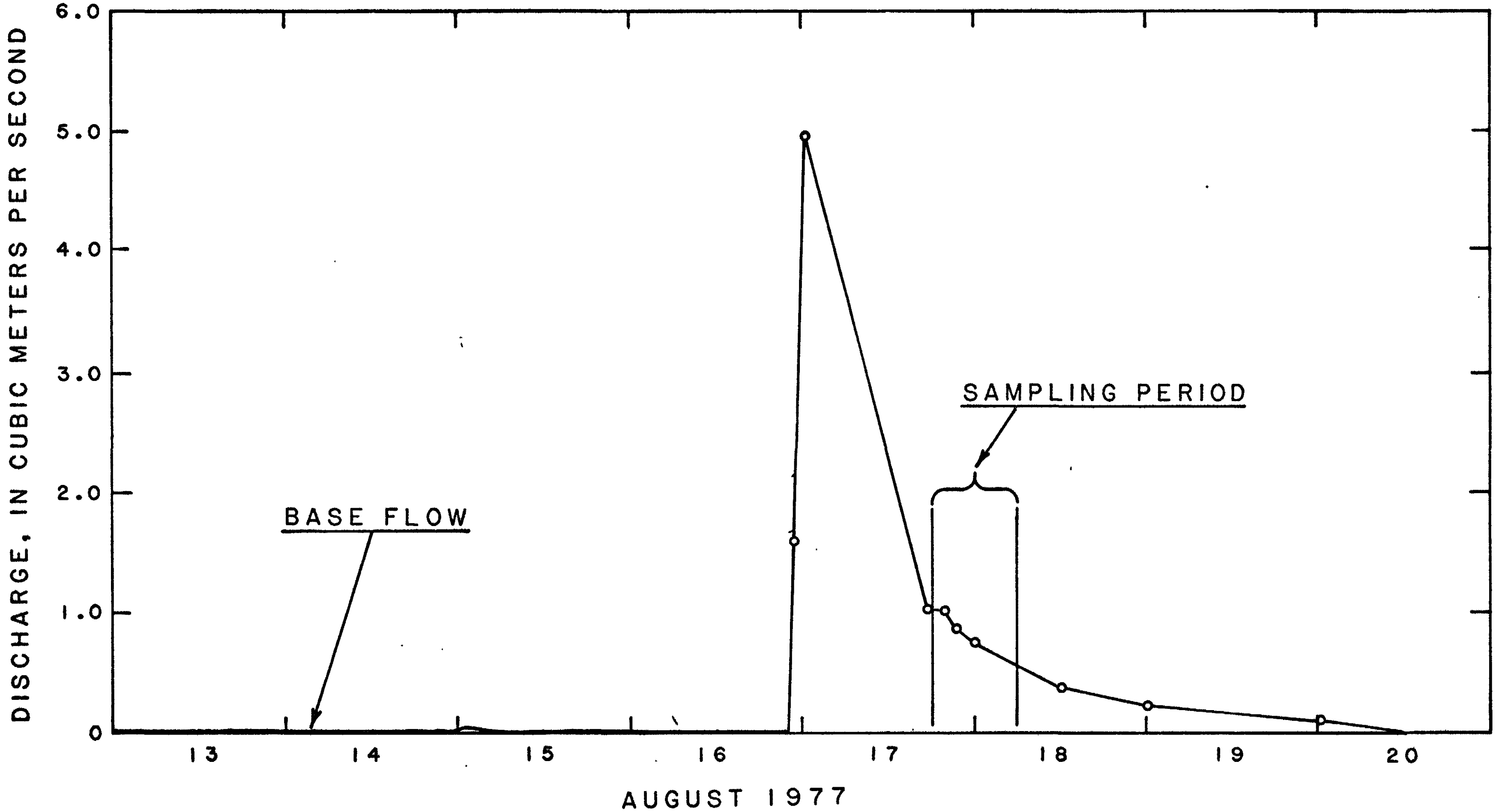

Figure 4.--Discharge of the Little Powder River, August 13-20, 1977.

Drift Relations in Time

Clear Creek

The fluctuation of total numbers of invertebrate organisms collected as stream drift in Clear Creek is shown in figure 5. The two drift peaks during the night indicate a behavioral pattern of drift. The total number of invertebrate organisms in the stream drift increased after sunset (2056 hours) to almost 7,000 organisms in a 2-hour sample and then decreased to less than 1,000 organisms at 0100 hours . A second peak occurred prior to sunrise (0611 hours) and reached a maximum of more than 10,000 organisms in a 2-hour sample. Waters (1962b), in a study of a small stream in Minnesota, noted only one peak that occurred shortly before midnight. Other investigators have noted two peaks during the night (Hynes, 1970). Later work by Waters (1972) determined that both patterns can occur. If the major peak occurs early in the night followed by a sudden decrease and then a minor peak before dawn, the pattern is termed "bigeminus". If the minor peak occurs early and the major peak shortly before dawn, the pattern is termed "alternans". Clear Creek had an alternans pattern, observed primarily in the mayfly genus *Baetis* which dominated the Clear Creek drift samples. Even when the hourly samples between 1900 and 2100 hours are combined to make one 2-hour increment, the total number of organisms is still greater in the peak prior to dawn, confirming the alternans pattern.

The diversity indices of samples from Clear Creek were very low during the night (fig. 5). *Baetis* dominated the peaks, causing the diversity indices to be at their minimum while the total number of drift organisms per sample was at a maximum. Low diversity during peak drift periods is a common feature of behavioral drift because a few taxa that exhibit behavioral drift dominate the chance drifters when they drift for behavioral reasons. Many researchers, such as Waters (1964), have noted the relative domination of drift by only a few taxa.

The relatively large drift rates in Clear Creek indicate that the number of organisms upstream from the sampling site was in excess of the carrying capacity of the stream. Benthic invertebrate densities immediately downstream from the drift sample station at the time of the study ranged from 9.3 to 1,300 organisms per 0.1 m^2. Average density was 156 organisms per 0.1 m^2.

Little Powder River

The numbers and types of organisms in the drift of the Little Powder River indicate a catastrophic drift pattern. Behavioral drift is usually dominated by organisms which are free ranging such as the mayfly *Baetis*, the amphipod *Gammarus*, and the dipteran *Simulium*. Case- or shell-bearing organisms such as snails and many caddis flies (Trichoptera) are uncommon in drift. Dragonfly nymphs (Odanata), beetles (Coleoptera), and substrate burrowers are also relatively rare in behavioral drift. Chironomid larvae (Diptera) are not usually behavioral drifters, although they may be an

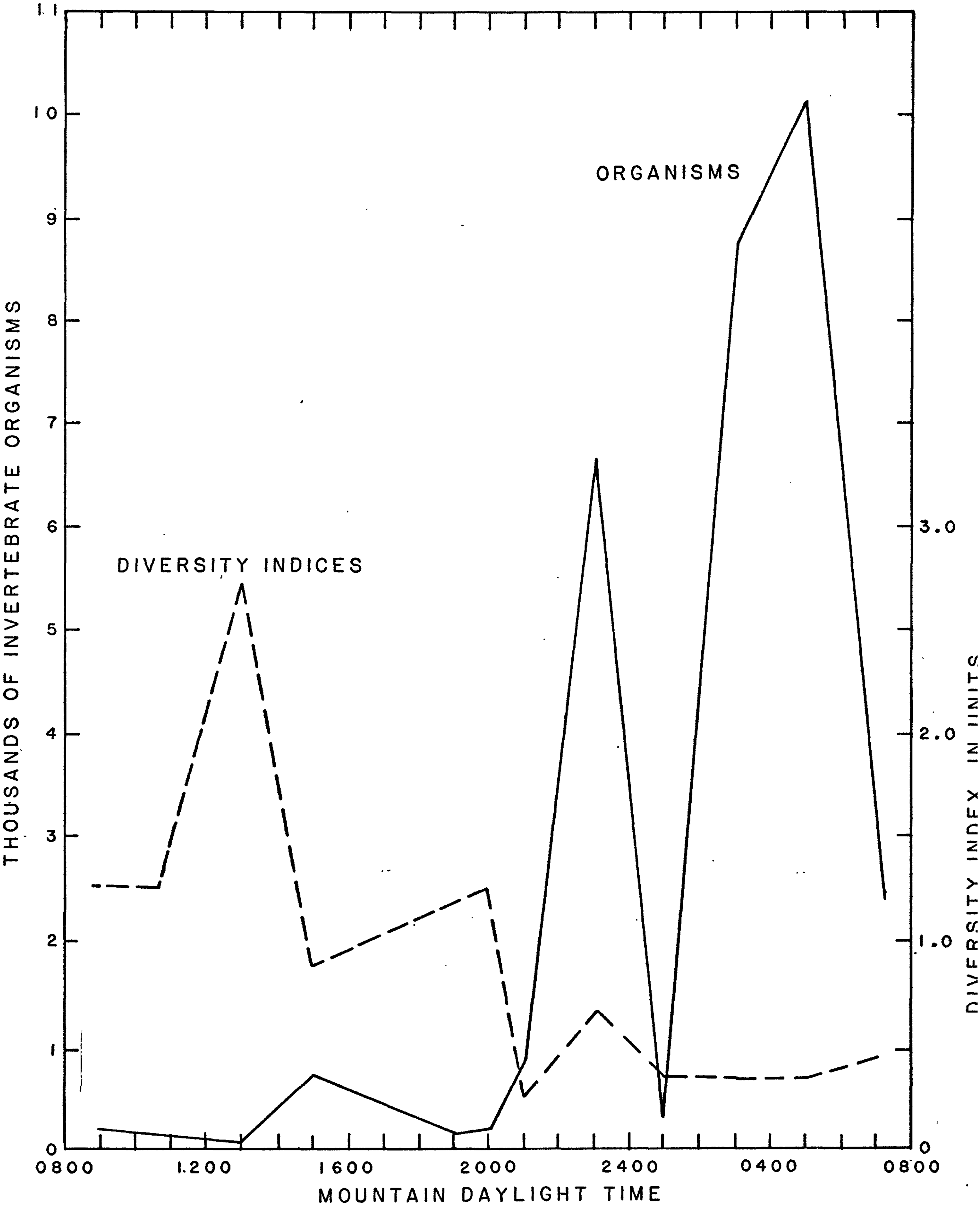

Figure 5.--Total numbers of invertebrate organisms as stream drift and diversity indices in Clear Creek, August 2 and 3, 1977.

abundant benthic organism (Waters 1972). The drift in the Little Powder River was dominated by Chironomidae, Ceratopogonidae (Diptera), Odanata, and strong swimmers of the order Hemiptera. Snails, beetle larvae, and Trichopterans also were present. The organisms common in behavioral drift were rare or absent in the samples. Hynes (1970) noted that floods usually cause an increase in invertebrate drift, at least initially, due to a washout effect. In a study of a Minnesota trout stream, Waters (1962b) noted that Diptera larvae normally inhabiting the stream edge and wet areas along the bank became more common in drift samples after a rainstorm.

Diversity indices in the drift samples of the Little Powder River were high due to the wide variety of organisms present (fig. 6). The stream substrates and the emergent macrophytes along the shore were being scoured by the flood discharge, and the organisms were being swept into the current. The two small decreases in the diversity index just after sunset and before sunrise could be due to a small behavioral drift response existing within the catastrophic drift pattern, but the data are inconclusive.

SUMMARY AND DISCUSSION

The physical and chemical measurements during the study period showed a relatively normal pattern in Clear Creek. The drift in Clear Creek was distinguished by two peaks during the night. A minor peak occurred after sunset and a major peak occurred prior to sunrise. This drift pattern is termed alternans. The magnitude of the two peaks indicate a behavioral drift pattern that is related to density and the carrying capacity of the stream substrate. The mayfly Baetis dominated the drift peaks in Clear Creek, causing the diversity indices during peak drift to be very low.

The stream discharge had a major impact upon the physical, chemical, and biological characteristics in the Little Powder River. An intense rainfall caused a flow of sufficient volume and velocity to dislodge invertebrates from their normal habitats. The drift in the Little Powder River was dominated by a variety of benthic organisms not commonly found in drift. Midge larvae of the families Chironomidae and Ceratopogonidae were major members of the drift, and several other organisms, such as the water boatman Cenocorixa (Hemiptera), the dragonfly Ishnura, caddis flies, snails, and beetles, were also present in samples collected throughout the study period. The variety of organisms present in the drift of the Little Powder River caused the diversity indices to be very high. The mixture of organisms not usually in drift, the high diversity indices, and the flood discharge indicate a catastrophic drift pattern.

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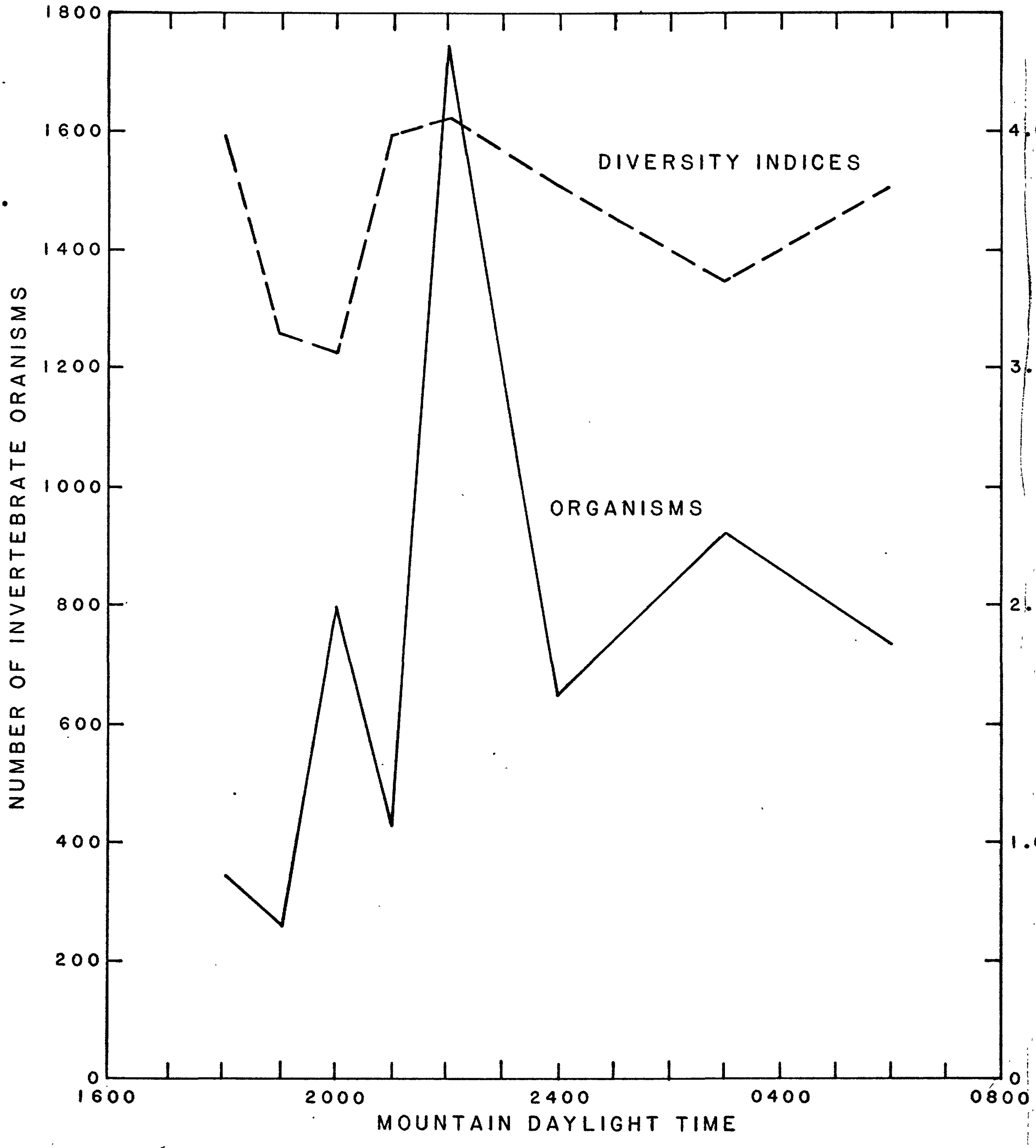

Figure 6 .--Total numbers of invertebrate organisms as stream drift and diversity indices in the Little Powder River, August 17 and 18, 1977.

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