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WATER QUALITY OF A LIMITED SEGMENT OF THE BIG BLUE RIVER IN NEBRASKA

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A water quality study was conducted on the Big Blue River in Nebraska, U.S.A., from the city of Seward to the Kansas state line. Fifty-one sites were sampled in a five-day period in August 1973; limited sampling was also done in May 1974. The primary purpose was to evaluate the effects of the effluent of eight sewage treatment plants, located along 196 km (122 miles) of the river upon water quality of the river and to collect baseline ecological data.

The following water quality constituents were evaluated: total P, NH_3-N, NO_3-N, O_2 (dissolved), pH, temperature, conductance, biological oxygen demand (BOD), coliform bacteria, phytoplankton numbers, pollution-indicator taxa, macroinvertebrate numbers, biomass, and diversity and pollution-tolerant taxa.

Phosphorus and total nitrogen levels were not markedly higher below the sewage treatment plants (STP). Also, STP effluent seemed to have little effect on temperature, pH, conductance, oxygen, or BOD of the river water.

Coliform bacteria levels were elevated downstream from some STPs, and were generally higher than the limit for Class A water quality.

Macroinvertebrate indices showed the Seward sites to have the best water quality, with deterioration of water quality especially prevalent at the Milford and Crete sites.

† † †

INTRODUCTION

The purpose of this study was to collect baseline biological and chemical data on a limited segment of the Big Blue River in Nebraska, from Seward to near the Kansas state line, a distance of 196 km (122 mi). The study was sponsored by the U.S. Environmental Protection Agency and the State of Nebraska Natural Resources Commission. Collections were made during August 1973 and May 1974; however, due to the volume of data, only those from 1973 will be reported except where 1974 data were useful for comparative purposes. Also, flooding conditions in the spring of 1974 may have affected some data.

The section of the Big Blue River studied between Seward and Wymore, for example, does not meet federal water quality standards for coliform bacteria, major nutrients, solids, or aesthetic qualities. Water quality in this river segment has been considered stable by the Environmental Protection Agency for the seven years from 1972-1978 (Anonymous, 1980).

MATERIALS AND METHODS

Water: Physical, Chemical, and Microbiological Properties

Sample sites are shown in Figures 1 and 2. In general, site selection was intended to include one site above each of the eight sewage treatment facilities, their effluent (+ on Fig. 2), a site from 0.8 km to about 1.6 km below the effluent, and several successive sites downriver, with the distance between sites depending on accessibility. Field collections (except for macroinvertebtates) and measurements were made during the period from 20 August through 24 August 1973.

Samples of water were taken from each of 51 sample sites, at 2-hr intervals, and composited over the 24-hr sampling period. The samples were collected near the center of the stream at mid-depth, whenever possible. Sewage treatment effluents were grab sampled from the end of the effluent pipe, except the Alpo plant samples (Al) which were taken from the mixing pit where processing and cooling waters mix prior to entering the effluent pipe. Sewage treatment effluents were

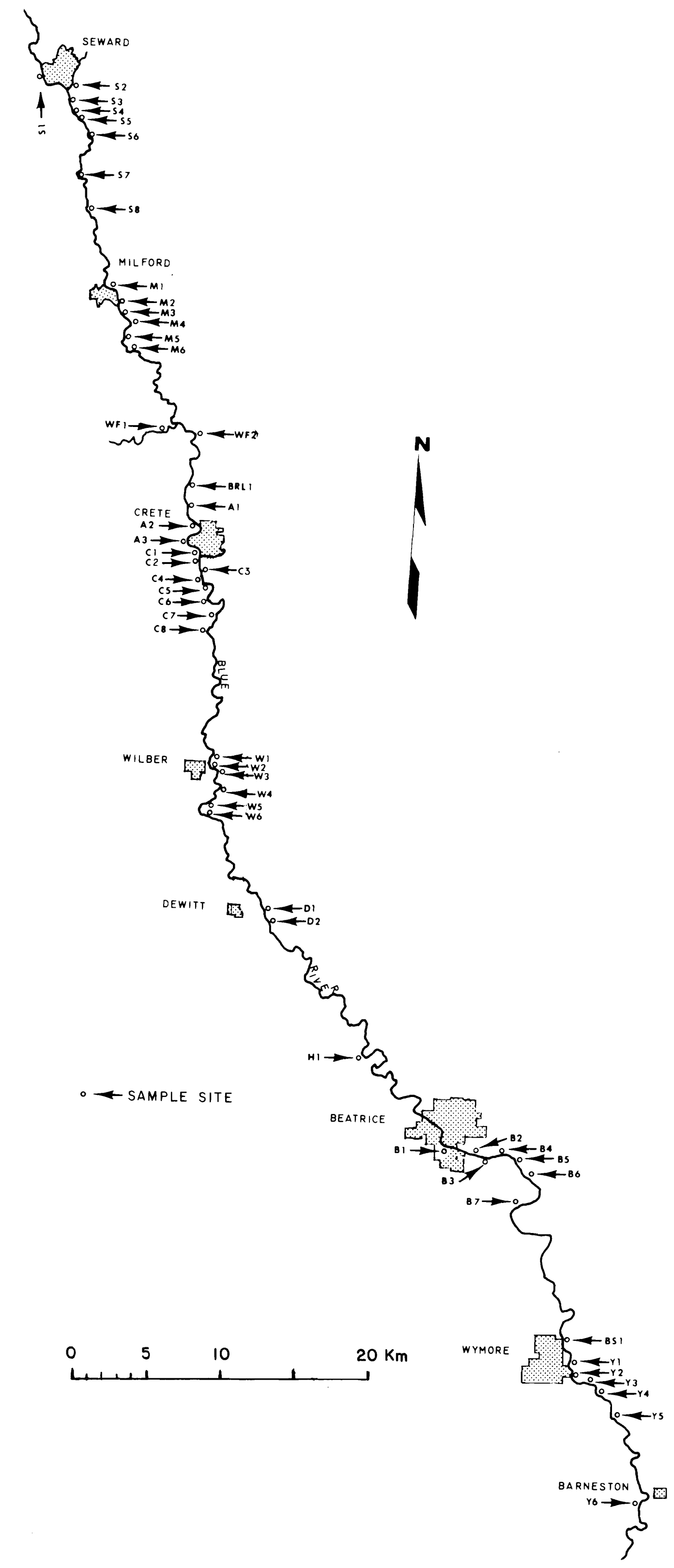

FIGURE 1. Water quality sample sites on the Big Blue River (August 1973).

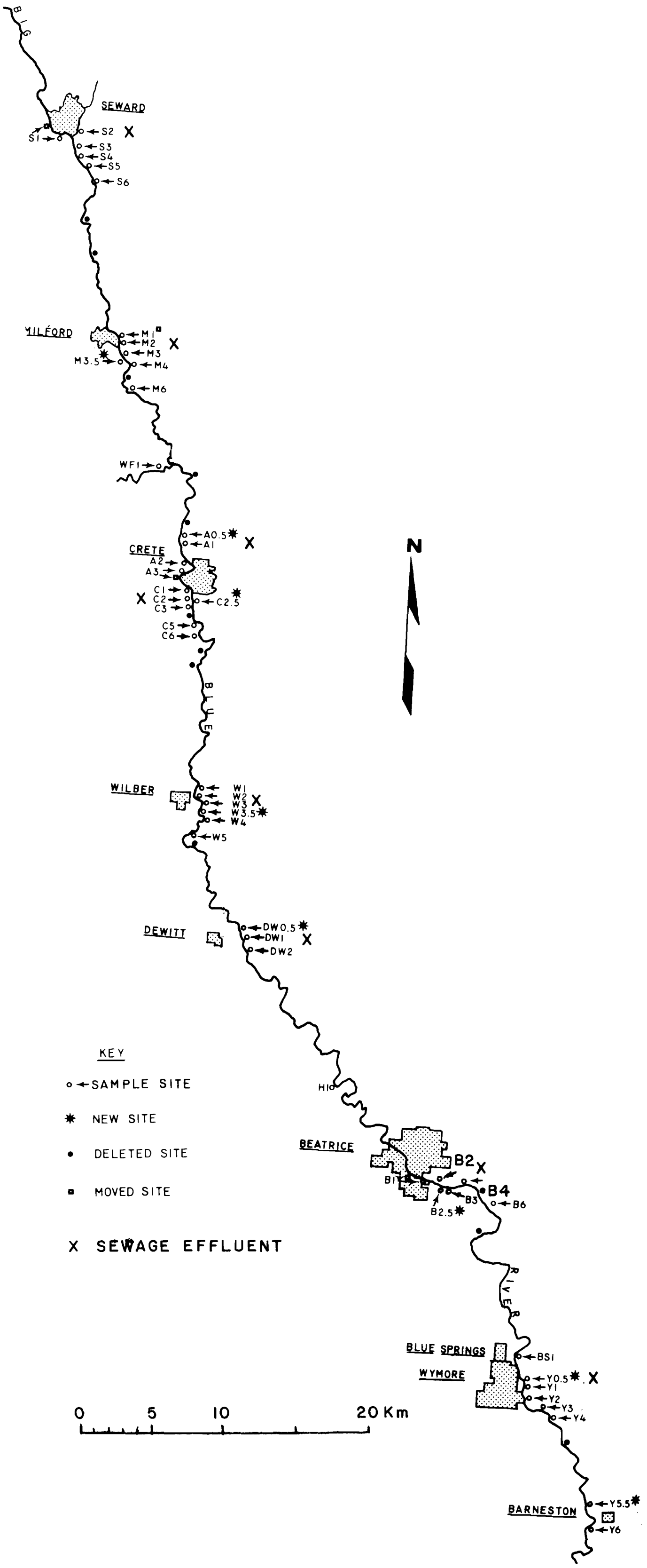

FIGURE 2. Water quality sample sites on the Big Blue River (May 1974).

composited on the basis of a "typical" municipal hydrograph (prepared by the Nebraska Natural Resources Commission) because the hourly rate of flow was unknown. Composite samples were stored on crushed ice and returned to the laboratory within 4 hr after the last sample was taken. Single samples for fecal coliform testing were taken when the last set of samples was collected; they were not composited.

On-site field analyses were made on water temperature, pH, specific conductance, and dissolved oxygen at 2-hr intervals over a 24-hr period. Water temperature and specific conductance were determined using Beckman, Model EV-6 "Environmeters." Water pH was determined by Heath portable pH meters (Model SM101A). Dissolved oxygen was determined by the modified Azide-Winkler method with drop count titration (using PAO), as described by the Hach Chemical Company DR colorimeter methods manual. At the end of the 24-hr sampling period, temperature, pH, and specific conductance of each composite sample were determined, and each sample was subsequently checked for the same parameters upon arrival at the laboratory. No significant change was found.

The laboratory bacteriological procedure was conducted as described for the biological analysis of wastewater in the Millipore filter application manual AM 302 using M-F-C ampouled broth and a 44.5 ± 0.5 C water bath for incubation. The samples were read 24 ± 2 hr after initial incubation. Every fifth sample was duplicated as a quality check. Plates with between 20 and 80 colonies were used to count. However, several sample plates contained in excess of 80 colonies at the highest dilution and in these cases were used for the count.

BOD analysis was conducted as described in *Standard Methods* (Anonymous, 1971) using a Yellow Springs Instrument Company dissolved oxygen meter, Model 54, to measure dissolved oxygen.

Algal samples were collected by filtering 30 liters of water through a standard plankton net to concentrate the phytoplankton. The samples were placed in 35-ml vials and kept on ice. The number of organisms per unit volume was counted using the millipore filter technique (millipore filter application manual AM 302). Generic identifications of algae were made using guides by Elmore (1921), Palmer (1962), Prescott (1970), Smith (1950), and Weber (1966).

Chemical analyses for nitrate-nitrogen, ammonia-nitrogen, suspended solids, and total phosphorus followed procedures described in *Standard Methods* (Anonymous, 1971). Ammonia-nitrogen was determined by the standard distillation method using spectrophotometric analysis. The standard brucine sulfate method was used for nitrate-nitrogen analysis.

Macroinvertebrates

1973. Nine 10 cm long x 5 cm^2 benthic stream sediment cores were taken from the collecting sites (Fig. 1) from 6–8 August 1973. Three transects, (5 m apart) of 3 cores each, were taken at each site. Two cores were taken 1/3 of the distance from each bank and the third in the center.

Core samples were sieved over 60 mesh/inch sieves, and invertebrates were hand picked under 7-30x magnification from material retained on the sieve. Macroinvertebrates were stored in water and refrigerated until identified; they were then separated by species, dried at 60 C for 24 hr and weighed to the nearest 10^{-6} g on a Cahn Gram Electrobalance. Organisms were identified to family level for most taxa.

Organic matter and texture was determined with material from 3–10-cm-deep cores taken near the center of the channel at each site according to methods of analysis by Cox (1972).

1974. Benthic core samples from 1973 produced relatively few taxa of macroinvertebrates. Therefore, larger samples were collected in 1974, including three Ekman dredges (15 cm x 15 cm) at each site; a drift net sample (where adequate flow was present); and aufwuchs collections from rocks, stems, and floating materials. These collections were made at sites shown in Figure 2, on 10–12 May 1974.

Dredge collections were washed over 60 mesh/inch sieves, identified, dried to constant weight, and weighed to the nearest 10^{-6} g. Organisms from all collection procedures were identified to generic level, except for Annelida, Nematoda, and pupae of Diptera. Identifications were made with the aid of works by Burks (1953), Edmondson (1959), Johannsen (1969), Mason (1973), Pennak (1953), Ross (1944), and Usinger (1963). Unpublished keys to aquatic invertebrates of Nebraska, prepared by Kenneth P. Pruess, Department of Entomology, University of Nebraska–Lincoln, were also used.

Shannon diversity indices were calculated from the number of species per transect in 1973 and from all collections at a site in 1974, using procedures described in Weber (1973). Coefficients of similarity were computed for each pair of sites, for both 1973 and 1974. These results are not reported here, but are available from an unpublished report (Nagel, 1974. Water Quality Limited Segment; Big Blue River Nebraska) to the Nebraska Resources Commission, Kearney State College, Kearney, Nebraska.

RESULTS AND DISCUSSION

Physiochemical Characteristics

Measurements of water temperature indicated that there was no significant thermal addition to the river at any of the sample sites during the sampling period. The pH ranged from 7.1 to 9.0 (Table I), with the exception of sites M-4 and M-5, which reached 9.3 between 2 and 6 p.m. These sites were located in a large pool area above the Milford Dam where a conspicuous algal bloom was in progress; the DO was more than 12 mg/liter and the phytoplankton organisms ca 2,000/ liter (Table II). The rapid consumption of CO_2 during this peak photosynthetic period could have elevated the pH at these times. No significant adverse alteration of stream pH was attributed to sewage effluents.

Less than 5 mg/liter of dissolved oxygen (the generally accepted minimum concentration required for healthy warm water aquatic life) occurred at several stream sites. These include the S-5, S-6, S-8, M-3, M-6, W-3, BS-1, Y-2, Y-3, Y-4, Y-5, and Y-6 sites. These low values usually occurred between 2 and 6 a.m. The reasons for these low values are not immediately evident but may have been due to the decomposition of settled organic matter which would not have shown up in the BOD samples and/or aerobic consumption by other aquatic organisms from these sites. The low values were found in May 1974 only at the S-6 and Y-6 sites.

Ammonia-nitrogen for the composited 24-hr samples ranged from 0.05 to 0.29 mg/liter (sewage effluent samples excluded). Nitrate-nitrogen varied from 0.0 to 4.5 mg/liter (sewage effluent samples excluded). Values for BOD_5, excluding sewage treatment plant effluents, ranged from 2.0 to 10.0 mg/liter. Values for BOD_5 at the first sampling site downstream from the sewage treatment plant effluent were generally not significantly higher than those farther downstream, indicating a good mixing and dilution in the river.

Densities of fecal coliforms (excluding sewage treatment plant effluents) ranged from 200 to 30,000 colonies/100 ml. All sites (Table II) exceeded the water quality standard for fecal coliform bacteria (200 colonies/100 ml) for category I, class "A" waters. Phosphorus ranged from 0.01 to 0.93 mg/liter (excluding sewage treatment plant effluents).

According to Palmer (1962), algae common in organically enriched areas are species of *Anacystis, Chlamydomonas, Chlorella, Chlorococcum, Euglena, Lepocinclis, Lyngbya, Melosira, Navicula, Nitzschia, Oscillatoria, Scenedesmus, Spirogyra, Stigeoclonium, Surirella,* and *Tetraedron.* As indicated in Table III, these genera were frequently present. Most notable are *Chlorococcum* (12 sites), *Melosira* (23 sites), *Navicula* (38 sites), and *Scenedesmus* (19 sites). *Cladophora* at M-6 and BS-1 is commonly associated with clean water (Palmer, 1962).

Substrate

Average channel substrate texture for the surface 10 cm at 37 sites sampled in 1973 was gravel 10.0% (standard deviation, 17.4), sand 60.6% (30.7), silt 10.0% (12.9), and clay 10.3% (16.7). Substrate organic matter content averaged 0.84% (± 1.05).

Most sites were coarse textured (except S1, S8, M3, MS, BRL, H1), and only the Seward and Milford sites had much organic matter, averaging about 2%. The remaining sites (except C1, C3, W4, W6, Y2, and Y4) had only a trace of organic matter.

Macroinvertebrate Populations

Fifty-six taxa were identified in this study (Table IV). Maret and Christiansen (1981) found at least 74 taxa of macroinvertebrates from artificial substrates and Ekman samples of the Big Blue River.

Midge larvae (Chironomidae) dominated collections in numbers of animals (Table V). Oligochaete (Annelida) worms were second in abundance, with mayflies (Ephemeroptera) third, and caddisflies (Trichoptera) fourth.

Oligochaetes contributed 52% of the total biomass; mayflies were second (12%), midges third (11.9%), dragon and damselflies (Odonata) fourth (7.6%), caddisflies fifth (5.4%), blackflies (Simulidae) sixth (3.2%), *Palpomyia* (Ceratopogonidae) seventh (2.9%), and leeches (Hirudinia) eighth (1.2%).

Of mayflies, *Stenonema* was most abundant; *Cheumatopsyche* was the dominant caddisfly. Maret and Christiansen (1981) found stoneflies and megalopterans to be rare in the Big Blue River. None was collected in the present study.

Maret and Christiansen (1981) found *Stenelmis* (Elmidae) to be the most abundant beetle larvae collected in the Big Blue River. Although we found *Stenelmis, Dubiraphia* was the dominant beetle larva collected. This difference was perhaps due to sampling procedures. *Stenelmis* occurs mostly in gravel substrate of streams while *Dubiraphia* is found in waterlogged wood and on stream vegetation (Hilsenhoff, 1975). Both of these habitats were sampled in this study, but not in the one by Maret and Christiansen (1981).

Dipterans were very abundant in the Big Blue River, with blackflies, several midge genera (*Chironomus, Cricotopus,* and *Polypedilum*), and punkies (Ceratopogonidae:*Palpomyia*) being most abundant.

Macroinvertebrate Standing Crop Biomass

Standing crop biomass data (dry weight) varied much more between sites in August 1973 than in May 1974. This probably was due to a smaller substrate sample in 1973

TABLE I. Physiochemical characteristics of 51 sites on the Big Blue River, August 1973.

Site	Total P (mg/l)	Water Temp. (C) $\bar{x}$ (Low–High, 24 hr)	pH $\bar{x}$ (Low–High, 24 hr)	Specific Conductance @ 25 C μmhos/cm (Low–High, 24 hr)	Dissolved Oxygen mg/l (Low–High, 24 hr)
S-1	0.35	28.1 (24.0–31.9)	8.3 (8.1–8.6)	500 (490– 516)	8.1 (6.6– 9.8)
*S-2	3.80	25.9 (23.5–30.0)	7.9 (7.0–8.1)	781 (704– 960)	7.5 (6.0– 9.0)
S-3	0.47	27.5 (25.5–30.0)	8.4 (8.3–8.5)	595 (500– 568)	6.6 (5.2– 9.2)
S-4	0.93	27.9 (26.0–30.0)	8.4 (8.2–8.7)	554 (514– 567)	6.6 (5.0– 8.8)
S-5	0.83	27.9 (26.0–30.0)	8.4 (8.3–8.7)	588 (553– 572)	6.0 (4.6– 7.6)
S-6	0.62	26.5 (24.0–29.0)	8.3 (8.1–8.6)	619 (608– 640)	6.1 (4.6– 7.0)
S-7	0.75	26.2 (23.0–30.0)	8.3 (8.1–8.7)	619 (595– 640)	6.3 (5.6– 7.8)
S-8	0.55	26.1 (23.5–28.0)	8.3 (8.1–8.6)	626 (617– 637)	6.3 (4.8– 8.0)
M-1	0.48	27.8 (25.5–30.5)	8.7 (8.4–8.9)	566 (490– 592)	8.1 (6.2–10.6)
*M-2	2.90	26.9 (26.0–29.0)	8.4 (8.1–8.5)	726 (582– 946)	6.0 (3.0–11.6)
M-3	0.46	29.1 (27.0–32.5)	8.6 (8.4–9.0)	544 (493– 582)	7.6 (4.6–13.4)
M-4	0.40	28.3 (25.0–32.5)	8.8 (8.3–9.3)	574 (506– 579)	12.6 (5.6–20.0)
M-5	0.38	27.3 (26.0–30.0)	8.8 (8.3–9.3)	566 (546– 581)	12.5 (6.4–21.0)
M-6	0.35	26.9 (25.0–30.0)	8.6 (8.4–8.7)	563 (525– 581)	6.4 (4.0– 7.2)
WF-1	0.25	28.3 (25.0–31.5)	8.6 (8.4–8.8)	492 (474– 527)	7.0 (5.4– 9.2)
WF-2	0.49	28.3 (25.0–31.5)	8.7 (8.4–9.0)	517 (490– 538)	7.2 (5.2– 9.2)
BRL-1	0.43	28.3 (25.0–32.0)	8.7 (8.5–9.0)	519 (495– 536)	7.1 (5.0– 9.0)
*A-1	2.90	35.4 (30.0–43.9)	7.8 (7.1–8.2)	2,222 (986–3,132)	3.6 (0.0– 6.4)
A-2	0.52	29.1 (25.0–34.0)	8.3 (7.1–8.5)	484 (451– 525)	8.3 (6.4–11.2)
A-3	0.50	28.9 (25.5–32.4)	8.3 (7.9–8.7)	490 (480– 504)	8.1 (6.4–11.6)
C-1	0.53	26.5 (24.0–29.0)	8.7 (8.2–9.0)	595 (592– 605)	7.1 (6.0– 8.8)
*C-2	3.60	25.2 (24.0–27.0)	7.7 (7.3–8.0)	1,081 (970–1,180)	0.0 (0.0– 0.0)
C-3	0.82	26.6 (24.0–29.0)	8.7 (8.4–9.0)	603 (592– 605)	6.5 (5.0– 9.8)
C-4	0.59	27.2 (24.0–31.0)	7.9 (7.7–8.3)	535 (500– 581)	7.3 (6.4– 9.2)
C-5	0.57	27.3 (25.0–29.0)	8.4 (8.2–8.5)	543 (510– 570)	7.7 (5.0–11.0)
C-6	0.61	29.5 (25.0–29.0)	8.3 (8.1–8.5)	563 (510– 570)	7.9 (5.2–10.8)
C-7	0.50	27.1 (25.0–29.0)	8.3 (8.2–8.5)	538 (515– 570)	7.1 (5.4–10.4)
C-8	0.50	26.9 (25.0–29.0)	7.8 (7.6–8.2)	531 (499– 558)	7.7 (6.0–10.0)
W-1	0.23	27.2 (25.0–30.5)	8.3 (8.2–8.7)	530 (490– 558)	6.5 (5.6– 7.8)
*W-2	1.10	24.9 (22.5–29.0)	7.5 (7.4–7.7)	679 (541– 721)	6.0 (5.4– 7.6)
W-3	0.11	27.4 (25.0–31.0)	8.3 (8.1–8.6)	537 (515– 553)	6.6 (4.6– 8.2)
W-4	0.11	27.2 (26.0–29.5)	8.2 (8.1–8.4)	544 (515– 570)	7.3 (5.0– 9.8)
W-5	0.10	27.3 (26.0–30.0)	8.3 (8.1–8.5)	537 (515– 570)	7.4 (5.4–10.8)
W-6	0.12	27.1 (25.0–30.0)	8.2 (8.0–8.5)	606 (588– 641)	7.4 (5.6–10.8)
*DW-1	0.19	24.9 (22.5–30.5)	8.2 (7.5–9.3)	1,373 (1,295–1,460)	4.6 (3.6– 5.0)
DW-2	0.19	28.8 (26.0–32.0)	8.4 (8.3–8.5)	570 (512– 585)	8.4 (6.0–11.0)
H-1	0.03	28.4 (25.8–31.0)	8.6 (8.5–8.8)	581 (570– 621)	8.5 (6.2–11.2)
B-1	0.21	26.7 (25.0–28.5)	8.6 (8.3–8.9)	654 (563– 676)	7.7 (6.4– 9.4)
*B-2	0.74	25.2 (24.0–27.0)	7.8 (7.6–8.0)	762 (696– 893)	6.7 (6.4– 7.4)
B-3	0.10	28.0 (26.5–30.5)	8.5 (8.2–8.7)	580 (524– 595)	7.7 (5.6–10.4)
B-4	0.02	26.7 (25.0–29.0)	8.6 (8.3–9.0)	660 (595– 680)	8.1 (5.8–10.8)
B-5	0.38	26.0 (23.0–30.5)	8.6 (8.1–8.8)	593 (575– 614)	8.7 (5.8–11.8)
B-6	0.06	26.9 (25.0–30.0)	8.4 (8.0–8.6)	571 (552– 590)	7.6 (5.8–10.8)
B-7	0.09	27.3 (25.0–30.0)	8.6 (8.1–8.9)	568 (553– 580)	9.0 (5.4–13.4)
BS-1	0.06	26.8 (25.5–28.0)	8.3 (7.1–8.5)	590 (578– 618)	6.1 (4.8– 7.8)
*Y-1	0.30	24.5 (23.0–25.5)	8.3 (7.3–7.8)	889 (858– 910)	3.8 (2.6– 4.6)
Y-2	0.10	26.8 (25.5–28.0)	8.3 (8.0–8.8)	580 (490– 618)	5.0 (3.0– 6.2)
Y-3	0.02	27.4 (26.0–29.0)	8.2 (8.0–8.6)	607 (580– 641)	5.9 (4.0– 7.2)
Y-4	0.07	27.5 (25.5–29.0)	8.2 (7.9–8.5)	597 (515– 631)	5.7 (4.2– 7.0)
Y-5	0.01	26.9 (26.0–28.0)	8.1 (8.0–8.5)	681 (670– 691)	5.5 (4.4– 7.0)
Y-6	0.06	26.4 (25.0–28.0)	8.1 (7.9–8.5)	679 (627– 690)	5.1 (4.4– 6.4)

*Sewage treatment plants.

TABLE II. Physiochemical and biological characteristics of 51 sites on the Big Blue River August 1973.

Sample Number	Coliforms/100 ml	BOD_5 (mg/l)	Phytoplankton (Organisms/l)	Nitrate N (mg/l)	Ammonia N (mg/l)
S-1	1,200	3.5	890	0.5	0.09
*S-2	100,000	49.0	NA†	7.8	5.30
S-3	690	3.8	840	0.5	0.14
S-4	6,500	3.8	1,080	0.9	0.27
S-5	7,500	3.6	1,110	0.8	0.15
S-6	2,800	4.4	600	0.7	0.11
S-7	1,100	4.2	720	0.7	0.12
S-8	650	4.0	1,510	0.8	0.11
M-1	2,700	4.0	1,100	0.8	0.06
*M-2	66,000	100.0	NA	0.3	12.00
M-3	21,000	3.8	710	3.0	0.31
M-4	30,000	7.2	1,900	0.9	0.14
M-5	30,000	10.0	2,170	0.8	0.09
M-6	2,000	5.2	520	0.5	0.19
WF-1	2,700	4.8	NA	0.9	0.11
WF-2	5,500	5.2	NA	0.8	0.06
BRL-1	2,400	4.8	690	0.9	0.09
*A-1	8,000	71.4	NA	0.0	1.80
A-2	450	4.3	1,480	0.9	0.10
A-3	1,300	3.4	890	1.0	0.05
C-1	490	4.0	1,006	1.1	0.06
*C-2	2,200,000	100.0	NA	0.0	10.00
C-3	23,000	5.3	600	0.8	0.17
C-4	16,000	5.6	1,060	0.8	0.14
C-5	12,000	3.4	1,320	0.8	0.13
C-6	13,000	5.9	440	1.1	0.13
C-7	13,000	4.6	780	0.8	0.08
C-8	13,700	4.0	850	1.0	0.28
W-1	1,100	3.4	830	0.8	0.08
*W-2	NA	60.0	NA	0.3	13.00
W-3	760	3.9	1,010	0.9	0.08
W-4	700	3.6	960	0.9	0.16
W-5	830	3.6	730	0.8	0.05
W-6	730	3.0	680	0.9	0.08
*DW-1	20,000	22.0	NA	1.5	6.30
DW-2	370	6.0	1,060	0.7	0.08
H-1	570	4.1	980	1.3	0.29
B-1	630	5.0	940	0.9	0.05
*B-2	170,000	13.4	NA	7.0	6.40
B-3	1,400	5.4	1,020	0.9	0.06
B-4	1,100	2.8	1,050	0.8	0.14
B-5	NA	5.2	760	2.0	0.10
B-6	2,300	4.4	770	1.0	0.12
B-7	1,000	8.0	850	0.9	0.07
BS-1	2,200	6.1	1,020	1.3	0.24
*Y-1	NA	26.0	NA	5.0	0.33
Y-2	5,500	3.2	1,190	0.8	0.24
Y-3	200	3.0	750	0.6	0.15
Y-4	330	4.1	800	1.1	0.21
Y-5	230	4.4	748	0.8	0.20
Y-6	580	2.0	NA	4.5	0.22

*STP effluents. †NA = Not available.

TABLE III. Phytoplankton of the Big Blue River, August 1973.

Genus	Sites Where Collected
Achnanthes	A-3
Actinastrum	S-5, M-3, B-1, B-5
Amphora	S-5, S-8, B-3, C-3, W-3, W-3d, Y-2
Anacystis	S-6
Ankistrodesmus	B-1, B-3, B-5
Anthrodesmus	B-5
Centritractus	S-5
Chlamydomonas	S-1, S-5, S-8, M-3
Chlorella	S-8, BRL-1, B-1, W-3d
Chlorococcum	S-5, S-6, S-7, M-4, M-6, C-6, C-8, B-3, B-7, DW-2, BS-1, Y-2
Chroococcus	S-5, BRL-1
Cladophora	M-6, BS-1
Closterium	M-3, A-3, B-1
Coelastrum	S-3, S-5, S-6d, M-1, C-1, C-3, C-4, C-5, C-7, A-2, A-3, B-1, B-3, B-4, B-5, W-1, W-3, W-3d, W-4, W-5, W-6, DW-2, BS-1, Y-4
Cosmarium	W-1, W-4, W-5
Crucigenia	S-1, S-5, S-6, S-7, S-8, M-1, C-7, A-2, BRL-1, B-4, B-6, B-7, W-1, W-3, W-5, W-6, DW-2, BS-1, Y-2, Y-3, Y-4
Cyclotella	S-1, S-3, S-4, S-5, S-6d, S-7, M-1, C-7, C-8, A-3, B-1, B-4, B-5, B-7, W-1, W-3, W-3d, W-4, W-5, BS-1, Y-3, Y-4
Cymbella	S-4, S-7, C-1, C-7, B-7, W-3, W-3d, DW-2, BS-1, Y-2
Cystopleura	M-1, C-1, C-3, C-4, C-5, C-8, A-2, A-3, B-1, B-4, B-5, W-3, W-3d, W-4, W-6, DW-2, BS-1, Y-4
Denticula	A-2, B-1
Diatoma	S-1, S-7, M-3, M-4, M-5, C-3, BRL-1, W-3d, W-4, W-5
Dichotomosiphon	M-6
Euastrum	DW-2
Euglena	C-3
Fragilaria	S-3, S-4, S-5, S-6, S-6d, S-7, M-4, C-3, C-4, C-5, C-6, A-2, A-3, B-1, B-4, B-5, B-6, W-3, W-3d, Y-4
Golenkinia	M-3, B-1, B-5, W-4
Gomphonema	S-4, S-5, S-6, S-6d, S-8, M-1, M-4, M-6, C-1, C-3, C-4, C-5, C-7, C-8, A-2, A-3, B-1, B-4, B-5, B-6, W-1, W-3, W-3d, W-4, W-5, DW-2, BS-1
Gomphosphaeria	M-5, B-7
Gonatozygon	M-6
Gonyaulax	M-3, M-4
Gyrosigma	S-3, S-4, S-5, S-6d, M-1, M-3, M-4, M-6, C-1, C-3, C-4, C-5, C-7, C-8, A-2, A-3, B-1, B-4, B-5, W-1, W-3, W-3d, W-4, W-5, W-6, DW-2, BS-1, Y-3, Y-4
Lepocinclis	B-4
Lyngbya	W-1
Melosira	S-1, S-4, S-5, S-6, S-6d, S-7, S-8, M-1, M-3, M-4, M-5, M-6, C-1, C-3, C-4, C-5, C-6, C-7, A-2, A-3, B-1, B-3, B-4, B-5, B-6, B-7, W-1, W-3, W-3d, W-4, W-5, W-6, DW-2, BS-1, Y-2, Y-3, Y-4
Meridion	C-4, B-7
Micractinium	M-3, A-3, B-1, B-3, B-5
Microspora	M-6
Navicula	S-1, S-3, S-4, S-5, S-6, S-6d, S-7, S-8, M-1, M-3, M-4, M-5, M-6, C-1, C-3, C-4, C-5, C-6, C-7, C-8, A-2, A-3, BRL-1, B-1, B-3, B-4, B-5, B-6, B-7, W-1, W-3, W-3d, W-4, W-5, W-6, DW-2, BS-1, Y-2, Y-3, Y-4
Nitzschia	S-3, S-5, S-6d, M-1, M-3, M-6, C-1, C-4, C-5, C-7, A-3, B-1, B-3, B-4, B-5, W-1, W-3d, W-4, W-5, DW-2
Oocystis	S-1, S-3, S-4, S-6, S-6d, M-4, M-5, C-3, C-5, C-7, C-8, A-2, A-3, B-1, B-4, B-5, B-7, W-3d, BS-1, Y-2, Y-4
Oscillatoria	S-5, S-6, M-3, M-6, BRL-1, W-3, W-4
Pediastrum	S-1, S-6, M-3, M-5, M-6, C-1, C-6, A-3, B-1, B-6, B-7, W-4, Y-2
Peridinium	M-3, C-6
Phacus	M-1, M-3
Pinnularia	S-6, C-5, C-7, Y-2
Pleurotaenium	B-1
Protococcus	S-4, B-3, BS-1, Y-3
Scenedesmus	S-3, S-4, S-6, M-1, M-3, M-6, A-3, B-1, B-3, B-5, B-6, B-7, W-1, W-3d, W-4, W-5, W-6, Y-2, Y-3
Sphaerocystis	B-6, B-7
Sphinctocystis	C-8, B-3, W-1
Spirogyra	W-3
Staurastrum	S-6d, M-6, B-3, DW-2, S-8, C-6, B-5, BS-1
Stigeclonium	BS-1
Surirella	S-3, S-4, S-5, S-6d, M-1, C-1, C-4, C-5, C-8, A-3, B-3, B-4, B-5, B-6, W-1, W-3, W-3d, W-4, W-6, DW-2, BS-1
Synedra	S-1, S-3, S-6d, S-8, C-1, A-2, A-3, B-5, W-1, W-3, W-3d, W-5, W-6, DW-2, BS-1
Tabellaria	S-7, Y-2
Tetraedron	S-5, M-3, B-1
Tetrastrum	S-5, A-3, B-5
Trachelomonas	S-1, S-3, S-4, S-5, S-6, S-6d, S-7, S-8, M-1, M-3, M-4, M-5, M-6, C-1, C-3, C-4, C-5, C-6, C-7, A-2, A-3, BRL-1, B-1, B-3, B-4, B-5, B-6, B-7, W-1, W-3, W-3d, W-4, W-5, W-6, DW-2, BS-1, Y-2, Y-3, Y-4
Treubaria	M-3, B-1

TABLE IV. Macroinvertebrate taxa from Big Blue River, August 1973 and May 1974.

Taxa	Sites Where Collected
Nematoda	S5, 6, 7, 8, M1, 4, 5
Nematomorpha	C5, B6
Annelida	
Hirudinea	S3, M6
Oligochaeta	All but Y5.5
Arthropoda	
Arachnida	
Hydracarina	S3
Insecta	
Collembola	
Poduridae	M5
Ephemeroptera	
Baetis	All Seward; M1, 3; A2; C1, 3, 5, 6; W1, 3.5; DW0.5; B1, 4, 6; BS1; Y0.5
Caenis	S1, 3, 4, 6; M1, 4; B2.5; BS1
Heptagenia	S3, 6; M4; A2; C1, 3, 5; W1, 3, 5; B1
Hexagenia	S1, 3; M4; C6
Paraleptophlebia	DW0.5
Pentagenia	A2; C6; W1; B6
Stenonema	All Seward, Alpo, Crete sites; M1, 3, 5; W1, 3, 5, DW0.5; B1, 2.5, 6; BS1
Odonata	
Argia	S5, 6; DW2
Gomphus	S1; W3; Y0.5, 2
Lestes	S1, 3, 6; C1
Hemiptera	
Sigara	S4, 6; C5; DW0.5
Trichoptera	
Cheumatopsyche	S5; A2; C1, 3, 5, 6; W1, 3; B6; BS1
Hydropsyche	S1; C3, 5; W1
Polycentropus	C3
Coleoptera	
Dubiraphia	S1, 3, 4, 6, 7, 8; M1; W3.5; DW2; B6; Y0.5
Dytiscus	B3
Heterocerus	C5
Hydrophilus	W3.5
Peltodytes	S5, C6, W6
Stenelmis	S5, 6; M6
Diptera	
Brillia	DW0.5; BS1
Chaoborus	S4; C5
Chironomus	S-6; M4, 6; A2; C1, 3, 5; W3, 3.5, 5; DW0.5, 2; B2.5, 3, 4, 6; BS1; Y0.5, 2, 4, 5.5
Cricotopus	S1–6; M4, 6; A3; C1, 3, 5; W1–5; DW0.5, 2; B6; BS1; Y0.5, 4
Cryptochironomus	S1, 6; M3.5, 4; C5; BS1
Diamesa	S3; C5
Dicrotendipes	S1, 3, 5; C1, 4
Dixa	S5
Erioptera	S5; W1
Eukiefferiella	M6
Glyptotendipes	Y2
Hexatoma	S3
Palpomyia	S1–8; M1, 3, 3.5, 4; A2, 3; C3, 5, 6; W1, 3, 5; DW2; B1, 3, 6, 7; Y0.5, 2, 4, 6
Paralauterborniella	S6; M3; W3.5
Polypedilum	S1–6; M4, 6; A2; C1, 3, 5; W1, 3, 5; B1, 2.5, 6; BS1; Y5.5
Potthastia	S6
Procladius	S1–6; M4; C1, 5; W3, 5
Prodiamesa	M3.5
Psectrocladius	S1–6; M3.5, 4, 6; A3; C3, 5, 6; B6
Psychoda	A3; C3, 5, 6; W3; B4, 6
Rheotanytarsus	S5
Scatella	W3.5
Simulium	S1, 4, 6; M1, 3; A2, 3; C1, 3, 5, 6, 7; W1, 3, 4, 5; DW0.5, 2; B1–6; BS1; Y0.5
Stratiomys	S1
Tanypus	S4, 5; M4; A2; W3.5; DW2; BS1
Tanytarsus	M6; C3, 5; W3.5; B6
Tipula	M6; A3; W3
Trichocladius	S6; C1; Y0.5
Trissocladius	C6
Xenochironomus	S1

(Table V). However, even in 1974, biomass ranged from 0.04 mg/225 cm^2 at Y5.5 site to a maximum of 23.06 mg/225 cm^2 at the S1 site. The S1 site had the greatest biomass in both years, probably a reflection of relatively clean water and a mud bottom.

The August 1973 biomass was 482 mg/m^2 and May 1974 mean biomass from all sites collected was 305 mg/m^2. The lower biomass in 1974 was probably due to the spring sampling date as compared to summer 1973 sampling, but it may have been partially due to flood waters in spring of 1974

TABLE V. Percentage of contribution to the total number from all sampling techniques and weight (mg) per dredge (225 cm^2) at sites collected in May 1974 (August 1973 biomass also given as mg per 225 cm^2).

	SEWARD SITES									
	S1		S3		S4		S5		S6	
Taxa	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.
Nematoda									0.6	
Oligochaeta	26.9	6.51	31.0	2.81	23.3	1.01	4.9	3.92	21.6	4.73
Hirudinea			0.6	4.09						
Hydracarina			0.6							
Baetis	16.0	0.03	15.4		17.8		0.4		5.4	
Caenis	2.5	1.16	1.9		2.3				0.6	
Heptagenia			0.6	0.01					1.8	
Hexagenia	1.4	1.63	1.9							
Stenonema	2.2	0.73	0.6		4.7		14.5		30.0	
Argia							0.7		1.8	
Gomphus	0.3	2.53								
Lestes	3.0	5.91	1.2	0.95					0.6	
Sigara					0.8				0.6	
Cheumatopsyche							2.3			
Hydropsyche	0.3	1.00								
Dubiraphia	8.7	1.61	6.0	0.3	5.4	0.81				
Harpalus-like					0.8	0.06				
Stenelmis							1.3		1.8	
Chaoborus					0.8					
Chironomidae*		1.42		1.95		0.37		0.56		0.86
Chironomus	6.7		8.0		3.1		7.2		1.8	
Cricotopus	2.5		4.9		1.6		0.7		1.2	
Cryptochironomus	4.5								1.2	
Diamesa			0.6							
Dixiidae							0.4	1.00		
Erioptera							0.4	0.13		
Hexatoma			0.6							
Palpomyia	1.1	0.26	0.6		3.9	0.17	0.7	0.28	5.4	0.26
Paralauterborniella									0.6	
Polypedilum	5.0		4.2		2.3		48.3		7.2	
Potthastia									0.6	
Procladius	2.2		6.0		0.8		0.7			
Psectrocladius	5.6		6.6		3.1		0.4		4.2	
Pupae (Chironomidae)	2.2		4.9		13.2				3.6	
Rheotanytarsus							4.2			
Simulium	1.7	0.02			0.8	0.02			0.6	
Stratiomys	0.3	0.25								
Tanypus					0.8		7.6			
Trichocladius									1.2	
TOTALS		23.06		10.11		2.44		5.89		5.86
1973 =		(291.10)		(0.42)		(4.13)		(2.30)		(0.74)

* S7 = 13.07; S8 = 8.03

	MILFORD SITES									
	M1		M3		M3.5		M4		M6	
Taxa	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.
Oligochaeta	60.9	5.27	84.9	2.76	68.4	5.50	33.2	4.07	55.8	1.16
Hirudinea									0.9	0.22

TABLE V. Continued.

	MILFORD SITES (Continued)									
	M1		M3		M3.5		M4		M6	
Taxa	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.
Baetis	8.7		5.7	0.09						
Caenis	2.2						1.6			
Heptagenia							0.5			
Hexagenia							0.5	3.27		
Stenonema	4.3		1.9	0.01			10.3			
Dubiraphia	2.2	0.8								
Stenelmis									0.9	0.02
Chironomidae						0.06				1.16
Chironomus							4.3		9.7	
Cricotopus							15.8		4.9	
Cryptochironomus					2.3		7.6			
Eukiefferiella									0.9	
Palpomyia					18.2	0.34	1.0	0.10		
Paralauterborniella			1.9							
Polypedilum							16.3		18.6	
Procladius							2.2			
Prodiamesa					2.3					
Pupae (Chironomidae)	10.9		3.8							
Psectrocladius					2.3		3.3		1.8	
Simulium	2.2		1.9							
Tanypus							3.3			
Tanytarsus									5.3	
Tipula									1.8	0.12
TOTALS		6.07		2.85		5.90		7.46		2.62
1973 =		(0.31)		(0.49)		---		(0.92)		

M5 = 0.03; BRL = 1.59

	BEATRICE SITES									
	B1		B2.5		B3		B4		B6	
Taxa	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.
Oligochaeta	31.6	0.13	40.0	0.43	15.4		14.3	0.01	40.6	2.67
Baetis	5.3						7.1		1.0	
Caenis			5.0	0.09						
Heptagenia	5.3	2.95								
Pentagenia									1.0	7.84
Stenonema	10.5	0.07	5.0						2.0	
Cheumatopsyche									1.0	
Dubiraphia									1.0	0.02
Chironomidae		0.01		0.38		0.32		0.13		
Chironomus			15.0		15.4		50.0		25.7	
Cricotopus									5.0	
Polypedilum	10.5		5.0						5.0	
Psectrocladius									1.0	
Psychoda							7.1		1.0	
Pupae (Chironomidae)	26.3		15.0		53.8		14.3		5.0	2.42
Palpomyia	5.3	0.04							1.0	0.01
Simulium	5.3		15.0		15.4		7.1		4.0	
Tanytarsus									6.0	
TOTALS		3.20		0.90		0.32		0.14		12.96
1973 =		(1.10)		----		(2.32)		(0.87)		(0.63)

B5 = 0.59; B7 = 0.02

TABLE V. Continued.

ALPO-CRETE SITES

Taxa	A2 No.	A2 Wt.	A3 No.	A3 Wt.	C1 No.	C1 Wt.	C3 No.	C3 Wt.	C5 No.	C5 Wt.	C6 No.	C6 Wt.
Oligochaeta	41.8	6.43	80.5	11.12	7.0	0.15	21.0	1.71	34.0	7.08	4.3	2.49
Baetis	5.2				7.9		7.4		3.9		10.0	0.17
Heptagenia	1.5				0.9	0.92	1.2		0.4			
Hexagenia											1.4	
Pentagenia	0.7	0.99									1.4	
Stenonema	6.7		7.8		5.6		1.7	0.20	0.4	0.96	7.1	
Lestes					0.5							
Sigara									0.4	0.71		
Cheumatopsyche	0.7	0.42			0.9		1.2		1.9	5.57	1.4	
Hydropsyche							0.4		0.4	0.69		
Polycentropus							0.4					
Heterocerus									0.4			
Peltodytes											1.4	
Chaoboris									0.8			
Chironomidae		0.59		0.04		0.74		0.24		1.77		0.05
Chironomus	1.5				0.5		1.2		1.5			
Cricotopus			1.3		1.9		2.1		4.2			
Cryptochironomus									1.9			
Diamesa									0.4			
Palpomyia	3.7	0.18	1.3	0.05			1.2		1.9	0.21	1.4	0.07
Polypedilum	14.1				5.1		7.8		3.4			
Procladius					3.3				6.9			
Psectrocladius			1.3				0.8		1.9		1.4	
Psychoda			1.3				9.8		13.4		18.6	
Pupae (Chironomidae)	6.7		1.3		1.9		2.5		1.5		5.7	
Simulium	16.4		2.6		63.7	5.61	38.7		13.8	0.83	28.5	0.17
Tanypus	0.7											
Tanytarsus							0.4		4.6			
Tipula			1.3									
Trissocladius											1.4	
Trichocladius					0.5							
TOTALS		8.61		11.21		7.42		2.15		17.82		2.95
1973 =		(0.27)		(0.04)		(4.43)		(1.44)		(0.05)		(0.43)

C4 = 0.29; C7 = 3.34; C8 = 0.59

WILBER-DEWITT SITES

Taxa	W1 No.	W1 Wt.	W3 No.	W3 Wt.	W3.5 No.	W3.5 Wt.	W5 No.	W5 Wt.	DW0.5 No.	DW0.5 Wt.	DW2 No.	DW2 Wt.
Oligochaeta	25.2	3.07	27.7	3.99	64.5	9.48	73.3	8.45	19.8	12.48	84.3	7.59
Podura									1.1			
Baetis	2.9				2.2	0.36			18.7			
Heptagenia	9.4				8.7							
Paraleptophlebia									2.2			
Pentagenia	0.7	3.96										
Stenonema	7.2	0.03			13.0	2.02			47.3			
Argia									1.1			
Gomphus			2.4	5.72								
Sigara									1.1			
Dubiraphnia					0.7	0.22					1.4	0.70
Hydrophilus					0.7							

TABLE V. Continued.

	WILBER-DEWITT SITES (Continued)											
	W1		W3		W3.5		W5		DW0.5		DW2	
Taxa	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.
Chematopsyche	0.7		1.2									
Hydropsyche	0.7											
Brillia									1.1			
Chironomidae	3.6	2.95		0.91		0.55		2.59		0.10		1.75
Chironomus			9.6		3.5		14.7		4.4		5.7	
Cricotopus	3.6		1.2		0.7		6.7		1.1		1.4	
Erioptera	0.7											
Palpomyia	0.7	0.08	42.2	3.22			4.0	0.37			4.3	0.26
Paralauterborniella					1.4							
Polypedilum	34.5				0.7							
Procladius			2.4				1.3					
Psychoda			1.2	0.16								
Pupae (Chironomidae)	1.4		1.2		0.7							
Scatella					1.4							
Simulium	8.6	0.53	7.2	0.20					2.2		1.4	
Tanypus					1.4						1.4	
Tanytarsus					0.7							
Tipula			3.6	0.92								
TOTALS		10.62		15.12		12.63		11.41		12.58		10.30
1973 =		(51.15)		(0.13)				(1.94)				(0.20)

W4 = 0.35; W6 = 3.23; H1 = 0.56

	WYMORE-BLUE SPRINGS SITES											
	BS1		Y0.5		Y2		Y4		Y5.5		Y6	
Taxa	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.	No.	Wt.
Oligochaeta	22.1	0.50	45.5	0.65	49.0	0.97	9.1	0.02			40.0	0.42
Baetis	3.0	0.04	1.5									
Caenis	1.0											
Stenonema	3.0	0.53										
Gomphus			1.5	1.85								
Cheumatopsyche	1.0	0.91										
Dubiraphnia			3.0	0.07								
Brillia	3.0											
Chironomidae		1.06		1.56		4.44		0.10		0.05		
Chironomus	15.8		28.8		49.0		27.3		75.0			
Cricotopus	5.0		7.6		2.0		18.2					
Cryptochironomus	3.0											
Palpomyia			6.0	0.22			36.4	0.17			60.0	0.17
Polypedilum	5.0								25.0			
Procladius	1.0						9.1					
Pupae (Chironomidae)	14.7											
Simulium	8.4		3.0									
Tanypus	12.6											
Trichocladius			3.0									
TOTALS		3.04		4.35		5.41		0.29		0.05		0.59
1973 =		(146.55)		---		(0.88)		(0.21)		---		---

Y3 = 3.08

*Midges were weighed to family only.

flushing invertebrates downstream. Chapman (1972) reported only 10 mg/m^2 in the sandy channel with swift flows but 580 mg/m^2 in pool habitats of the Platte River. Volesky (1969) reported about 10 mg/m^2 of invertebrates in Missouri River channel and 100 mg/m^2 in backwater areas. Dawson (1965) reported a mean of 10.5 g/m^2 from Verdigre Creek in northeastern Nebraska, much higher than our Big Blue River data. Hynes (1970) pointed out that the biomass of invertebrates in a stream is inversely related to the width of the stream and the speed of the current, especially where sandy substrate is present. This relationship may explain the higher biomass of macroinvertebrates at upstream sites (e.g., Seward and Crete) when compared to downstream sites (such as the Beatrice and Wymore–Blue Springs sites). There was a tenfold increase in the mean flow during water-year 1973 from Seward to Barneston (Table VI).

TABLE VI. Mean flow of the Big Blue River for the 1973 water-year (Anonymous, 1974).

Nebraska Gauging Site	m^3/Sec.
Big Blue River at Surprise	0.7
Lincoln Creek near Seward	1.2
Big Blue River at Seward	3.8
West Fork Big Blue near Dorchester	5.5
Big Blue River at Crete	12.5
Turkey Creek near Wilber	3.5
Big Blue River at Barneston	37.1

Organic Pollution Macroinvertebrate Indicators

Weber (1973) presented a list of invertebrate taxa tolerant, facultative, and intolerant to decomposable organic wastes. When comparing the list of taxa collected from the Big Blue River (Table V) to Weber's classification, the following sites contained predominately intolerant taxa and are considered clean water sites: Seward 1, 3, 4, 5, and 6; Crete 5; Wilber 1; Blue Springs 1; and Wymore 0.5. Except for the Seward sites, the cleaner water sites are primarily the sites upstream from the sewage treatment plants.

Macroinvertebrate Diversity

Shannon general diversity indices ($\overline{H}$) have been used to assess stress in the environment. According to Weber (1973) unstressed (and unpolluted) streams generally have an index value between 3 and 4, whereas polluted waters are less than 1. Weber also emphasized use of the evenness or equitability index (e) for study of stream pollution, with values of <0.5 indicating stress or pollution. However, most sites in the Big Blue River yielded a $e>0.5$ (except sites W4 and H1) which would indicate that most of the sites were unstressed and relatively unpolluted.

By comparing Shannon diversity indices computed for the Big Blue River sites (Table VII) with the standards given, the following clean water sites were identified ($H>3.0$ in at least one sample year): Seward 1, 3, 4, 5, 6, and 7; Crete 5 and 6; and Blue Springs 1. The following sites were considered potentially stressed (possibly by organic pollution): DeWitt 2; H1; and Wymore 5.5 and 6.

At the Milford, Alpo, Crete, and Blue Springs-Wymore sites, diversity was higher at the site upstream from the sewage treatment plant, perhaps indicating some reduction in water quality due to sewage effluents. The Wymore sites showed severe diversity reduction at W4 and W5. At Seward diversity was relatively high at all sites, indicating good water quality even below the sewage treatment plant. Maret and Christiansen (1981) also found greater diversity at their station 1, which was located about 15 river-miles upstream from our upstream sampling site at Seward.

Shannon diversity showed a strong positive correlation with organic matter content ($r = +.62$, $p<.01$) and a negative correlation with sand + gravel content of substrate ($r = -.32$, $p<.05$). These relationships with physical factors of the channel substrate overrode the effects of water quality.

CONCLUSIONS

1. The Seward sites seemed to have the most unstressed macroinvertebrate communities of all sites sampled. These sites had high diversity, a high standing crop biomass, a high percentage of pollution intolerant taxa, a low percentage of pollution tolerant taxa, and a relatively large number of organisms.

2. In addition to the Seward sites, only Crete 5, Wilber 1, and Blue Springs 1 had high diversity *and* a high percentage of pollution intolerant taxa of macroinvertebrates.

3. Numbers of fecal coliform organisms exceeded the limit for class A waters at essentially all sites sampled. Conductivity did not exceed the 900 μmhos/cm limit for class A waters. Dissolved oxygen was above 5 mg/liter (warm waters) except for several hours in the early morning at S-5, S-6, S-8, M-3, M-6, W-3, Y-2, Y-3, Y-4, Y-5, and Y-6. The river below Wymore showed the most persistently low DO readings. The temperature of receiving waters below sewage outfalls was within the limits of no more than a 2.8 C increase caused by the sewage effluent. The pH at some sites exceeded the upper limit of 8.5 for class A waters; however, it dropped to 8.5 or below during the 24-hr sampling period.

TABLE VII. Shannon general diversity indices for each site collected in August 1973 and May 1974. (Index calculated from all invertebrates collected at site.)

Site	1973*	1974
S1	1.24	3.55
S3	1.67	3.72
S4	2.54	3.65
S5	3.54	2.51
S6	3.06	3.56
S7	3.15	—
S8	2.87	—
M1	2.56	1.82
M3	1.92	1.56
M3.5	—	1.62
M4	1.94	2.90
M5	2.35	—
M6	—	2.40
BRL1	2.11	—
A2	1.99	2.61
A3	1.35	1.87
C1	2.40	2.30
C3	1.69	2.96
C4	1.07	—
C5	2.05	3.82
C6	2.17	3.14
C7	1.96	—
C8	1.55	—
W1	1.87	2.84
W3	2.48	2.40
W3.5	—	2.06
W4	1.09	—
W5	2.20	1.26
W6	2.87	—
D0.05	—	2.22
D2	0.37	1.30
H1	0.53	—
B1	1.35	2.61
B2.5	—	1.94
B3	2.12	1.73
B4	1.45	2.12
B5	1.39	—
B6	2.36	2.94
B7	1.33	—
BS1	—	3.43
Y0.5	—	2.30
Y2	2.21	1.12
Y3	1.51	—
Y4	2.81	2.12
Y5.5	—	0.81
Y6	—	0.97

*Based upon small samples ($\overline{x} = 29$) and should be used only for rough comparisons with other 1973 values.

4. The two sites with the greatest concentration of phytoplankton were M-4 and M-5. These sites were located in a pool above the Milford Dam where an algal bloom was in progress. These sites also showed the highest DO reading of any during the 24-hr period, 20.0 and 21.0 mg/liter respectively.

5. Ammonia-N did not exceed the maximum limit (1.4 mg/liter) for warm waters at any of the stream sites that were sampled.

6. The highest levels of phosphorus, expressed as total P (mg/liter), were found at S-4 (0.93) and S-5 (0.83).

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