



Effects of Bozemens increased sewage treatment on water quality and aquatic insects of the East Gallatin River, Montana
by Arthur Edwin Viola

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Fish and Wildlife Management
Montana State University
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Abstract:

The effects of applying enhanced secondary treatment to the Bozeman sewage effluent, upon the water quality and aquatic insect communities of the East Gallatin River were studied from September 1982 - October 1983. The main effect upon water quality in the river below the sewage outfall was a reduction in levels of un-ionized ammonia and nitrite. No changes in levels of nitrate, phosphate, pH, temperature, total alkalinity, hardness, dissolved oxygen, conductivity or turbidity were found in the river after the new treatment was applied. The only adverse effects of the sewage effluent on aquatic insect communities noted were reductions in the numbers of Plecoptera, specifically *Petronarcella badia*, and generic diversity below the outfall. However, numbers of Plecopterans and *P. badia* increased 200% at stations below the outfall by the end of the study, suggesting an improvement in those areas with time.

EFFECTS OF BOZEMAN'S INCREASED SEWAGE TREATMENT ON WATER QUALITY
AND AQUATIC INSECTS OF THE EAST GALLATIN RIVER, MONTANA

by

Arthur Edwin Viola

A thesis submitted in partial fulfillment
of the requirements for the degree

of

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in

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Bozeman, Montana

June 1986

APPROVAL

of a thesis submitted by

Arthur Edwin Viola

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ABSTRACT

The effects of applying enhanced secondary treatment to the Bozeman sewage effluent, upon the water quality and aquatic insect communities of the East Gallatin River were studied from September 1982 - October 1983. The main effect upon water quality in the river below the sewage outfall was a reduction in levels of un-ionized ammonia and nitrite. No changes in levels of nitrate, phosphate, pH, temperature, total alkalinity, hardness, dissolved oxygen, conductivity or turbidity were found in the river after the new treatment was applied. The only adverse effects of the sewage effluent on aquatic insect communities noted were reductions in the numbers of Plecoptera, specifically *Pteronarcella badia* and generic diversity below the outfall. However, numbers of Plecopterans and *P. badia* increased 200% at stations below the outfall by the end of the study, suggesting an improvement in those areas with time.

INTRODUCTION

The Bozeman Sewage Treatment plant has been identified as the major point source of pollution on the East Gallatin River. In the 1960's Bozeman's sewage was processed at a primary treatment plant which applied mechanical filtration and allowed some precipitation which resulted in increased effluent clarity. A number of studies have shown that during those years, the sewage effluent had an adverse effect upon the aquatic biota and water quality of the East Gallatin River. In 1966 Vincent reported the salmonid standing crop was low for several miles below the outfall of the primary plant (Stuart 1974) and in 1969 Avery found a reduction in clean water aquatic insect forms, altered fish populations and high ammonia concentrations below the outfall of the primary plant. Nitrite, nitrate and phosphate also were found in higher levels below the outfall (Soltero 1968; Bahls et al 1969; Avery 1969; Bahls 1971). Bahls et al. (1969) concluded that ammonia was the factor limiting fish populations below the primary plant.

In August 1971 the old primary plant was shut down, at that time a newly built treatment plant capable of providing both primary and secondary treatment to the sewage effluent began treating all of Bozeman's sewage. Thus application of biological degradation was added to the sewage treatment process. Size limitations

of the new plant allowed for only 50.- 80% of the effluent to receive secondary treatment and further studies showed that the domestic sewage still had an adverse effect upon the aquatic biota and water quality in the East Gallatin River. Reductions in clean water aquatic insect forms were found below the sewage outfall of the secondary plant by Glorvigen (1972) and Leudtke et al. (1974). Concentrations of ammonia and phosphate were 500 - 700% greater below the outfall than above (Russo and Thurston 1976). Matney (1978) found that the concentrations of un-ionized ammonia below the plant exceeded state and Environmental Protection Agency (EPA) standards of 0.02 mg/l (EPA 1976) for an average of 1.25 km downstream of the secondary plant.

In order to conform to minimum EPA water quality standards the secondary plant was expanded and upgraded in October 1982 to provide secondary treatment to all of the effluent. Also in February 1983 the effluent began receiving enhanced secondary treatment at infiltration percolation beds (IP beds), which resulted in further biological alteration of the effluent, particularly ammonia.

The purpose of this study was to evaluate the effectiveness of the new treatment on water quality and aquatic insect communities in the East Gallatin River. Field work was conducted from September 1982 through October 1983. This time period allowed for sampling both before and after the expansion and upgrading of the secondary treatment plant.

DESCRIPTION OF STUDY AREA

The East Gallatin River is located in southcentral Montana in Gallatin County, near Bozeman (Figure 1). It begins at the confluence of Rocky and Bozeman creeks at the north-east corner of Bozeman and meanders northwesterly for 59.5 kilometers (km) until it merges with the Gallatin River.

The East Gallatin River contains water of the calcium-magnesium bicarbonate type (Soltero 1968). It varied in width from approximately 2 meters (m) during fall and winter to 9 m during spring runoff (Bahls 1971). During a 21 year period (1939 - 1961) the average (range) discharge of the East Gallatin River, taken 0.2 km below the confluence of Bozeman and Rocky creeks was 2.4 (0.3 - 35.1) cubic meters per second (m^3/sec) (U.S.G.S 1964). During this study, the average (range) flow was 3.7 (1.8 - 5.7) m^3/sec . The minimum and maximum flows occurred in February and May 1983, respectively, (Figure 2). During the study period the sewage effluent added 10.8% ($0.186 \text{ m}^3/\text{sec}$), to the minimum river flows in February and 3.9% ($0.222 \text{ m}^3/\text{sec}$), to the maximum flows in May (Figure 2).

In the study area, the East Gallatin River flows in a well defined channel with stable banks. Riparian vegetation was mostly willows (*Salix*), cottonwoods (*Populus*), grasses, and several species of shrubs. Land use in the study area included homesites,

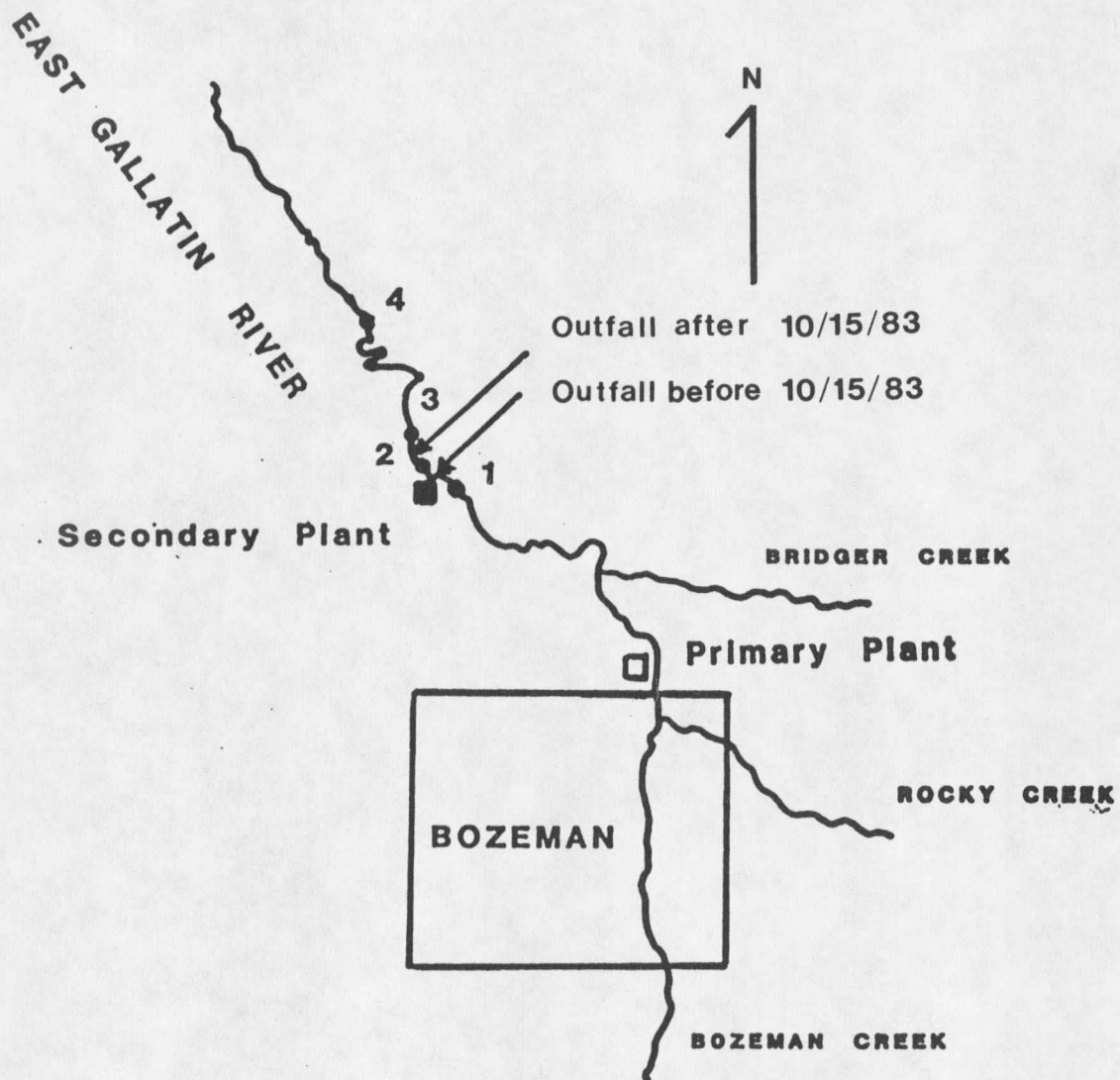


Figure 1. Map of the study area. Numbers indicate the location of the sampling stations.

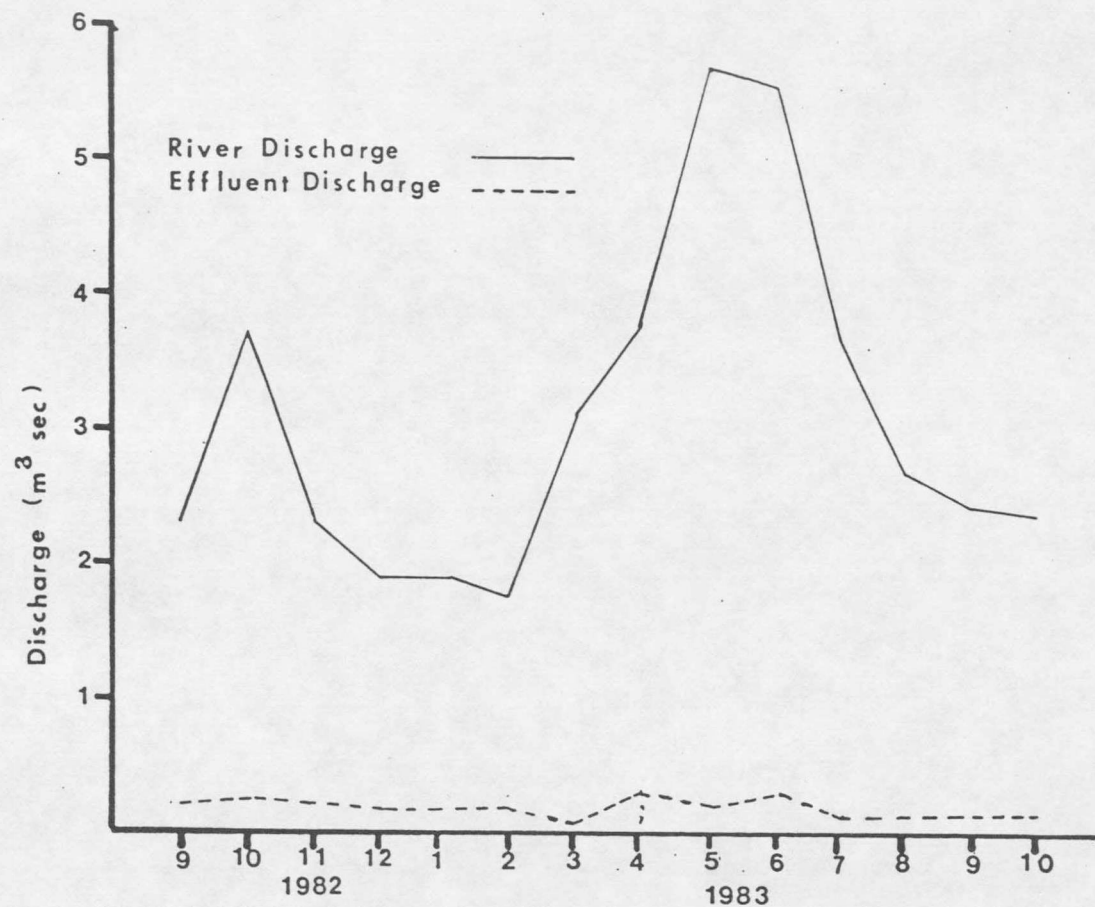


Figure 2. Mean monthly discharges of the East Gallatin River and Bozeman Sewage Treatment Plant September 1982 - October 1983.

a golf course, livestock grazing, wheat farming and haying.

The current Bozeman Sewage Treatment Plant was situated 9 km downstream from the headwaters of the East Gallatin River. Prior to October 15, 1982 the location of the sewage plant outfall was 0.2 km below the bridge on Spring Hill Road (Figure 1). After this date, the sewage outfall was moved downstream 1.3 km (Figure 1). This downstream shift was a result of plant expansion and the upgrading of its sewage treatment facilities.

Four sampling stations were established on the East Gallatin River. Prior to October 15, 1982 Station 1 was 0.4 km above the sewage outfall and Stations 2, 3 and 4 were 0.1 km, 1.4 km and 4.3 km below the outfall, respectively (Figure 1). After this date Stations 1 and 2 were 1.7 km and 1.3 km above the new position of the sewage outfall, respectively, and Stations 3 and 4 were 0.1 km and 3.0 km below the outfall, respectively (Figure 1).

METHODS

Water Chemistry

Water samples were collected monthly at each of the four sampling stations from September 1982 through October 1983. All samples were collected in containers that were rinsed three times with sample water prior to filling. Samples for dissolved oxygen (D.O.) determinations were collected in 500 ml glass D.O. bottles and all other water samples were collected in 1 liter (1) polyethylene bottles. Samples were filtered, except those for D.O. determinations. All samples were kept on ice until chemical analyses were completed. All tests were performed at Montana State University within 24 hours of the sample collection. Tests were conducted for total ammonia, nitrite, nitrate, orthophosphate, total phosphorus, pH, total alkalinities, hardness, dissolved oxygen, conductivity and turbidity.

Total ammonia concentrations were determined by the phenol-hypochlorite method (Solorzano and Lucia 1969) and new reagents were made for each test. Concentrations of un-ionized ammonia were calculated using the ammonia ionization chart in Piper (1982) from measurements of total ammonia concentrations, pH and temperatures. Nitrite concentrations were determined by the diazotization method (Hach Chemical Company 1969) using Hach Chemical Company reagents. Concentrations of nitrate were determined using

the cadmium reduction method (Lind 1974) and orthophosphates were measured by the ammonia molybdate method (APHA 1971). Total phosphorus were measured by the potassium persulfate digestion process and the ammonia molybdate method (APHA 1971). Concentrations of total ammonia, nitrite, nitrate, orthophosphate and total phosphorus were measured with a Fisher electrophotometer using standard curves of light transmission from concentrations made from analytical grade reagents and de-ionized distilled water. Glassware used in all tests were acid washed in 1:1 HCL and rinsed twice with distilled water. Hydrogen ion concentrations were measured with a Beckman Expanded scale (Model 76) pH meter. Total alkalinities were determined by titration with 0.02 normal (N) H_2SO_4 , to an endpoint of 4.5 (Lind 1974). Hardnesses were determined by the complexometric titration method (Hach Chemical Company 1969) using a 0.02 EDTA titrant. Dissolved oxygen measurements were made using the azide modification of the Winkler method (Hach 1969). Conductivities were measured with a Solu bridge (Model RB-3) conductivity meter and/or a Yellow Springs Instrument (Model 31 YSI) conductivity bridge. Measured conductivities were corrected for cell resistance and temperature. Turbidities were measured with a Hach (Model 2100) turbidimeter standardized at 60 Jackson Turbidity Units (JTU).

The range of water temperatures at each sampling station were recorded monthly on a Taylor maximum-minimum thermometer and point measurements at each station were made monthly with

a Taylor pocket thermometer. The discharges of the East Gallatin River were determined from a U.S.G.S. staff gauge, located just below Station 1 on the Spring Hill Road Bridge (Figure 1) and the U.S.G.S. discharge table for this site. Monthly effluent discharges and chlorine concentrations in the effluent were provided by the personnel at the Bozeman Sewage Treatment Plant (Armstrong, personal communications).

Aquatic Macroinvertebrates

Aquatic macroinvertebrate communities were sampled monthly from November 1982 - October 1983 using modified Hester and Dendy (1962) multiplate artificial substrate samplers. Samplers were constructed of seven 12.2 X 12.2 centimeter (cm) pressed hardboard plates so that each sampler had a surface area of 0.2 square meters (m^2). Plates were horizontally spaced 0.60 cm apart with the rough side down. The four samplers used at each station were anchored just above the substrate in riffles that were judged to have similar substrates, depths and velocities. On each sampling date the macroinvertebrates on each sampler were removed, placed in a separate plastic bag and preserved with 10% formalin. At Montana State University macroinvertebrates were separated from detritus by the sugar flotation technique (Anderson 1959) and preserved in 70% ethyl alcohol. Macroinvertebrates were identified to the lowest taxon practical, using keys by Pennak (1978), Merritt and Cummings (1978), Roemhild (1972), Hilsenhoff (1975), Edmunds et al. (1976), Baumann et al. (1977),

and Wiggins (1978). Identifications of macroinvertebrates were verified by Dr. George Roemhild, Biology Department, Montana State University. The number of individuals per taxon on each sampler were counted and recorded.

Statistical Analysis

Macroinvertebrate numbers were analyzed using analysis of variance (Neter and Wasserman 1974) and the Newman Keuls multiple comparison test (Dixon and Massey 1969). Statistical tests compared the mean number of macroinvertebrates per sampler at each station for the entire study period. Tests were performed on a Discovery Multiprocessor DPC 100 computer using multi-factor analysis of variance (AVMF) on MSUSTAT programs.

Biotic Index

The relative generic abundance at stations above and below the sewage outfall were analyzed with Kothe's Index (Campbell 1980):

$$I = [(A_1 - A_x) / A_1] (100)$$

Where I equals the biotic index, A_1 equals the number of genera present at a station above the outfall and A_x equals the number of genera present at a station below the outfall. A negative value of I indicates the station below the outfall has greater generic diversity. A zero value for I indicates no difference in diversity between the two stations being compared and a positive number indicates that the station above the outfall has greater generic diversity. The mean number of genera per sampler

were used in this index. Since no Chironomidae were identified to genus, they were excluded from the calculations.

RESULTS

Water Chemistry

Measurements of chemical and physical parameters of the East Gallatin River from September 1982 - October 1983 are shown in Appendix Tables 2 - 16. The highest level of un-ionized ammonia measured was 0.028 mg/l at Station 3 on October 15, 1982, the first day the new treatment was applied and the plant was not fully operational (Figure 3). Following this, concentrations of un-ionized ammonia at Stations 3 and 4 appeared to be similar or below upstream concentrations at Stations 1 and 2, except during August 1983, when the level at Station 3 peaked at 0.017 mg/l.

Nitrite concentrations at Stations 2, 3 and 4 were above 0.15 mg/l before the new treatment was applied. Following this, nitrite concentrations were 0.05 mg/l or less for the remainder of the study (Figure 4). The increase in nitrite concentrations in August coincided with a peak in un-ionized ammonia (Figure 2).

All nitrate concentrations (Figure 5) were below 1.3 mg/l. Levels were greater below the outfall and the pattern among stations did not change noticeably during the study. Levels below the outfall were frequently about 0.50 mg/l greater than above. A peak in nitrate concentrations at Stations 3 and 4 occurred in

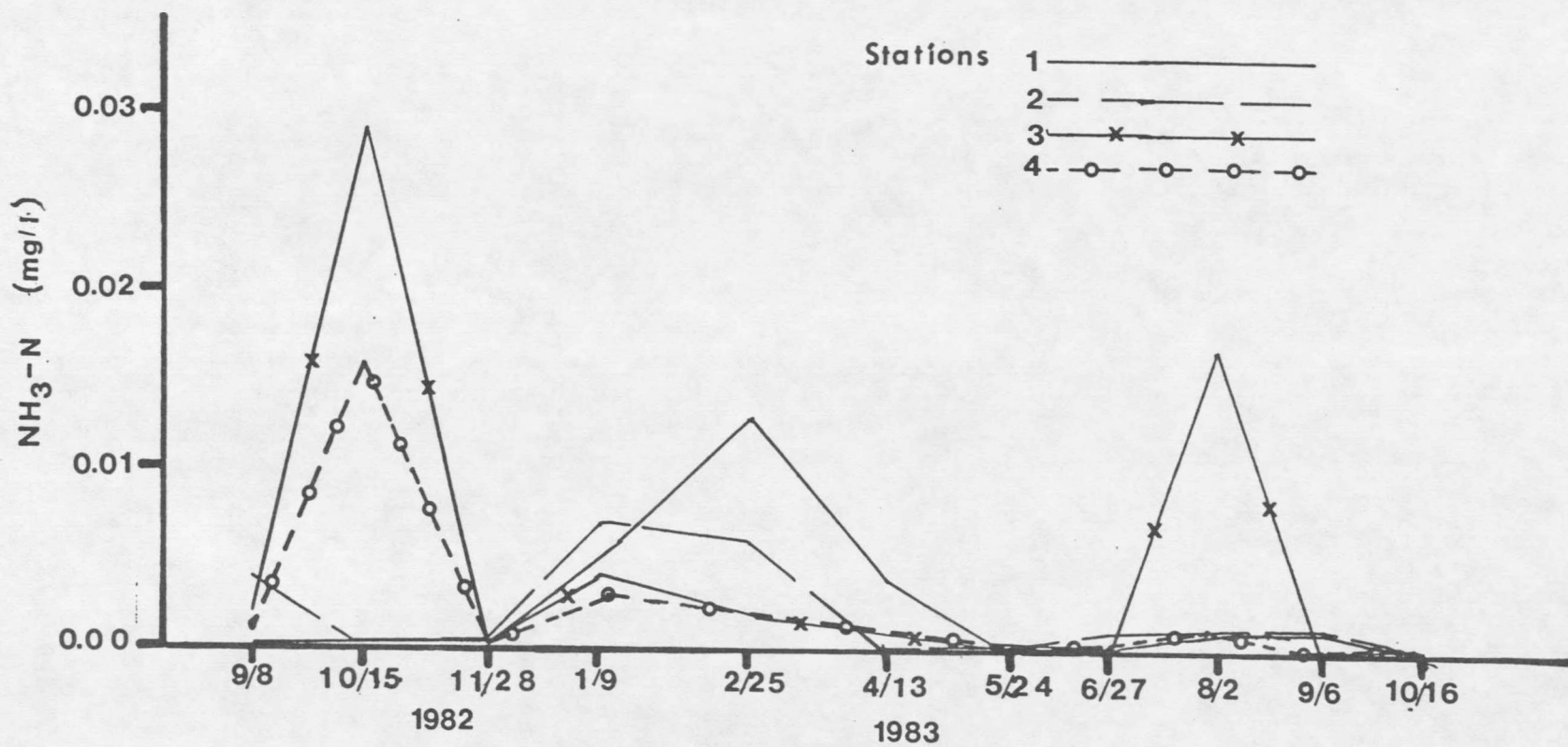


Figure 3. Un-ionized ammonia concentrations at sampling stations on the East Gallatin River from September 1982 - October 1983.

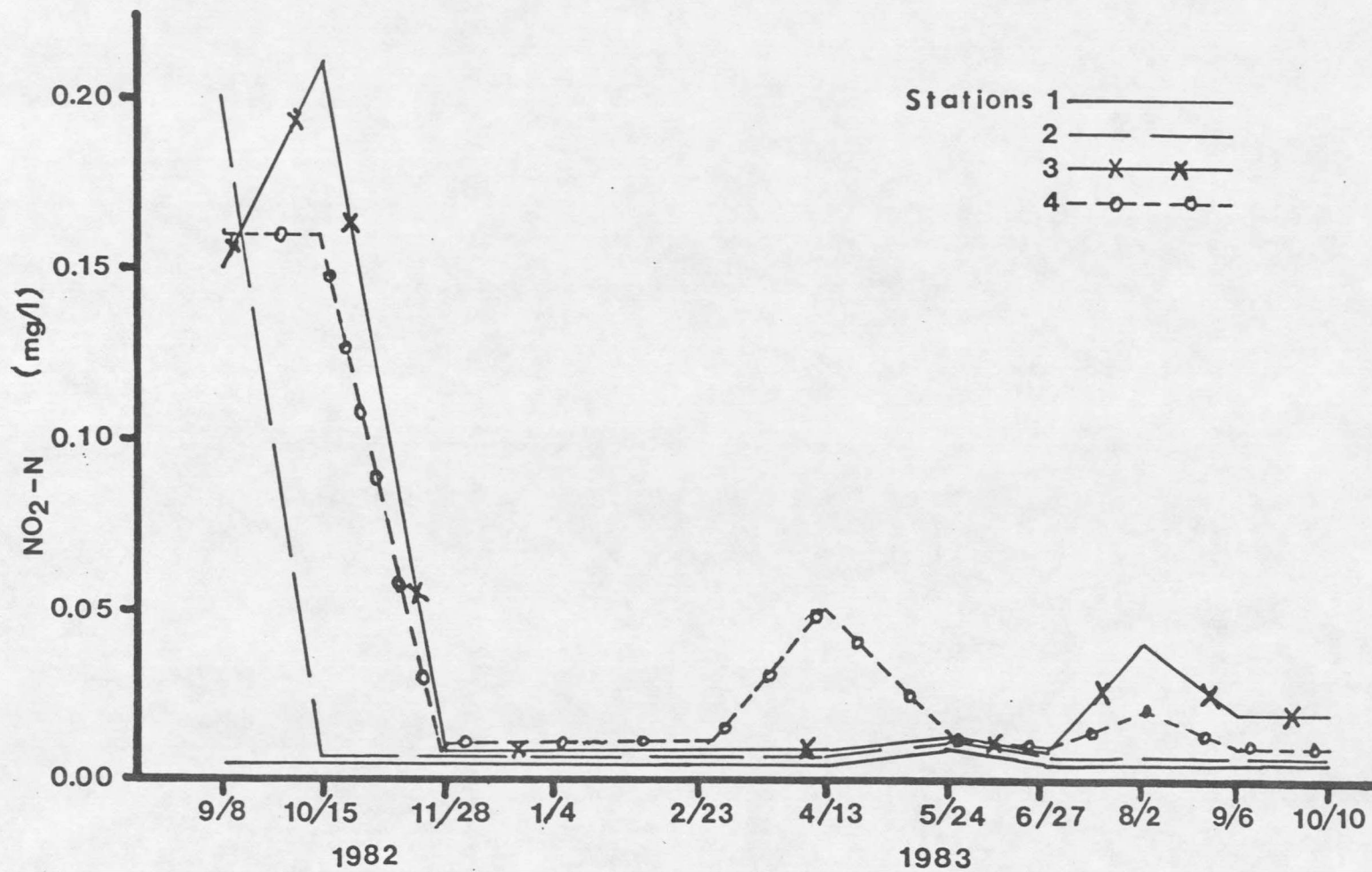


Figure 4. Nitrite concentrations at sampling stations on the East Gallatin River from September 1982 - October 1983.

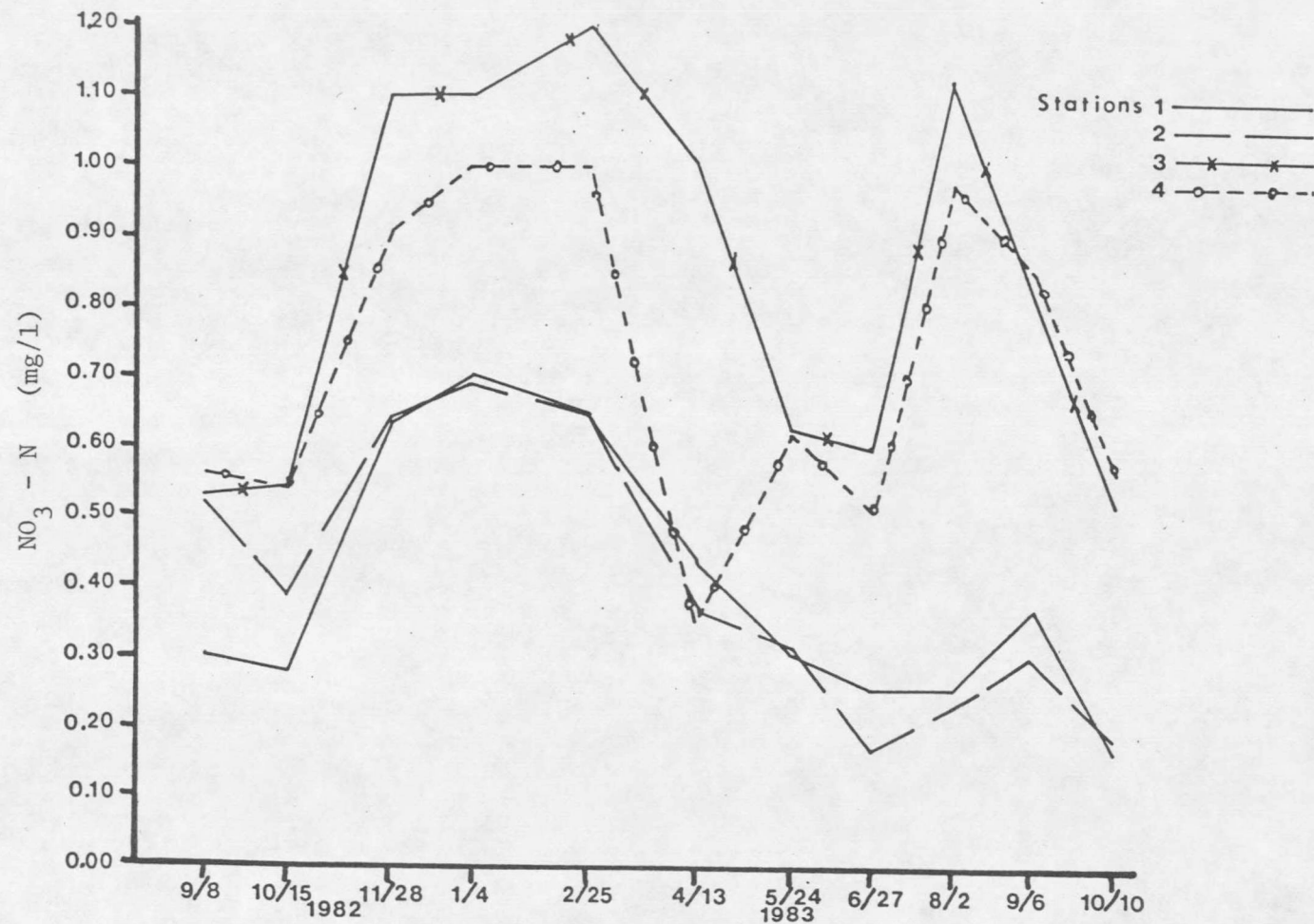


Figure 5. Nitrate concentrations at sampling stations on the East Gallatin River from September 1982 - October 1983.

August 1983 when peaks of un-ionized ammonia and nitrite occurred.

Concentrations of ortho-phosphate peaked at 0.30 and 0.35 mg/l at Stations 3 and 4, respectively (Figure 6). Concentrations at stations below the outfall ranged from 0.05 - 0.295 mg/l greater than stations above the outfall during most of the study except in May and June 1983 when concentrations at all stations were similar.

Concentrations of total phosphorus peaked between 0.3 and 0.4 mg/l at Stations 3 and 4 during September 1982 (Figure 7). Total phosphorus levels at stations below the outfall were frequently about 0.15 mg/l greater than those at stations above except in May and June 1983 when the concentrations at all stations were similar.

The patterns and relationships of pH values at all stations were similar and remained within the range of 7.4 - 8.8 throughout the study (Figure 8). The same was true for temperatures which ranged from 1.0°C - 17.8°C (Figure 9).

Total alkalinities from all stations during the study period ranged from 134 - 235 mg/l (Figure 10). They followed a similar pattern at all stations except on October 15, 1982 when the upstream stations diverged from each other.

Values for hardness from all stations during the study period ranged from 108 - 212 mg/l (Figure 11). All stations had similar values and patterns for hardness throughout the study except in October 1982 and January 1983. when values at Station 1 and Stations 1 and 4, respectively, were lower.

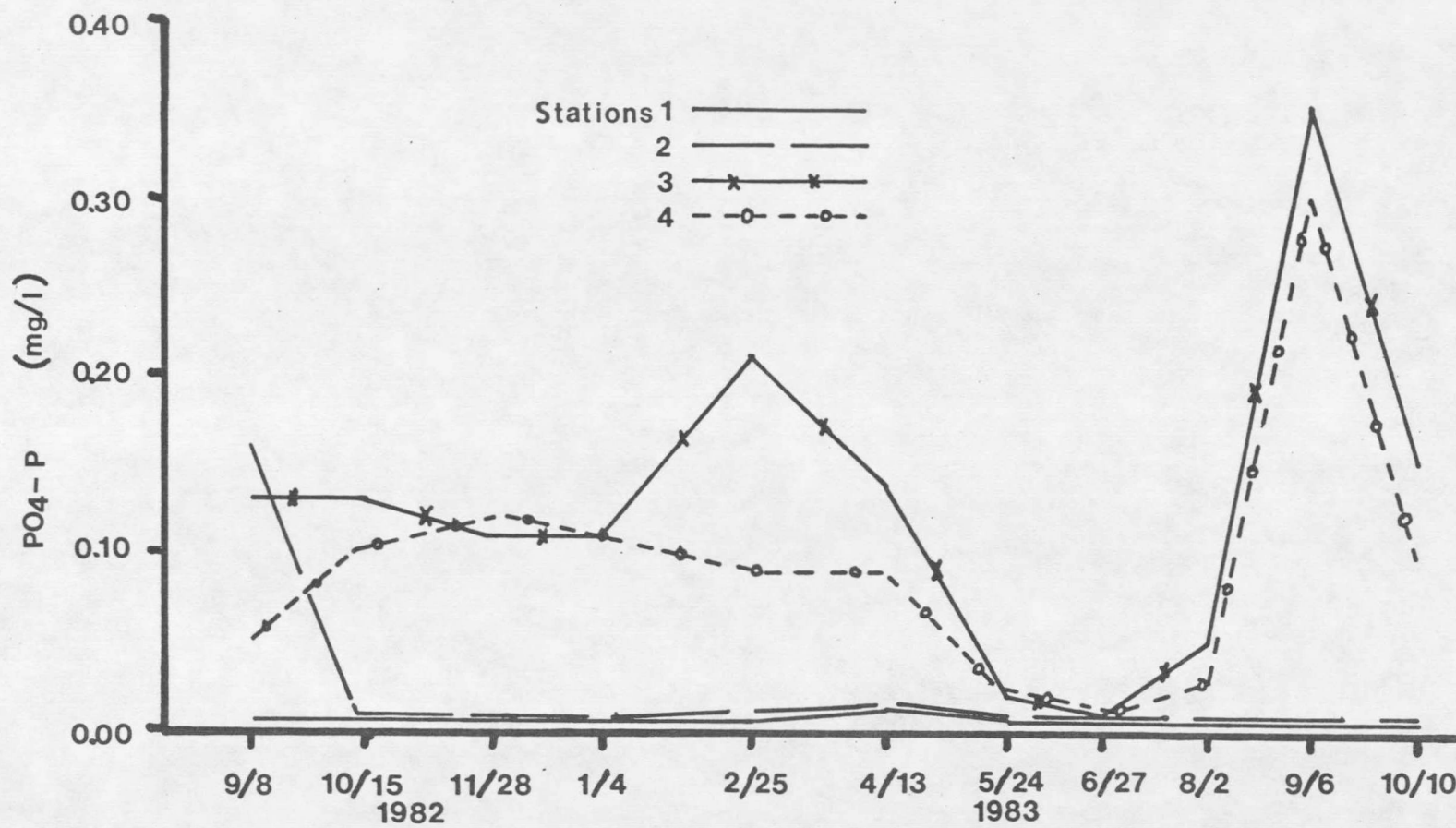


Figure 6. Orthophosphate concentrations at sampling stations on the East Gallatin River from September 1982 - October 1983.

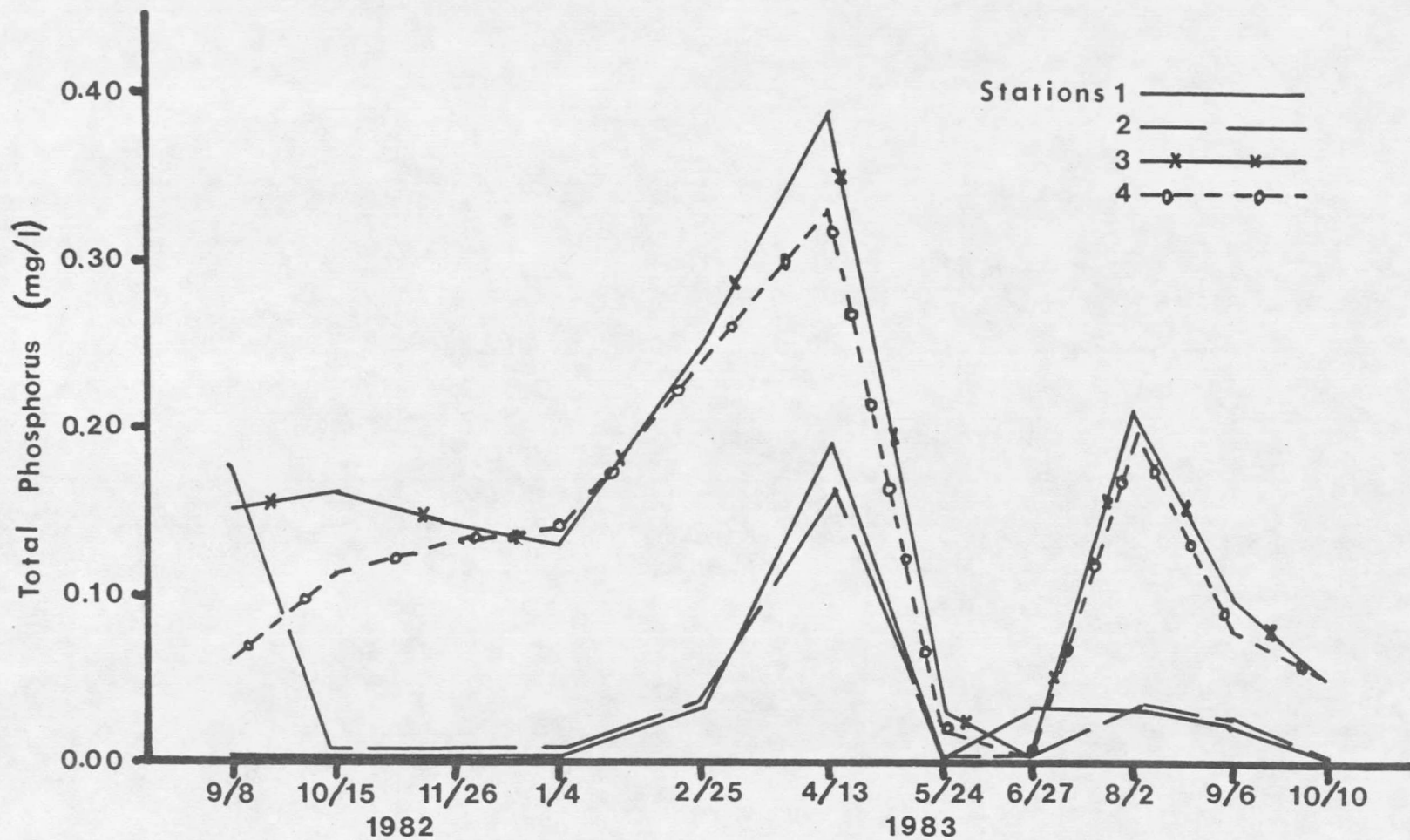


Figure 7. Total phosphorus concentrations at sampling stations on the East Gallatin River from September 1982 - October 1983.

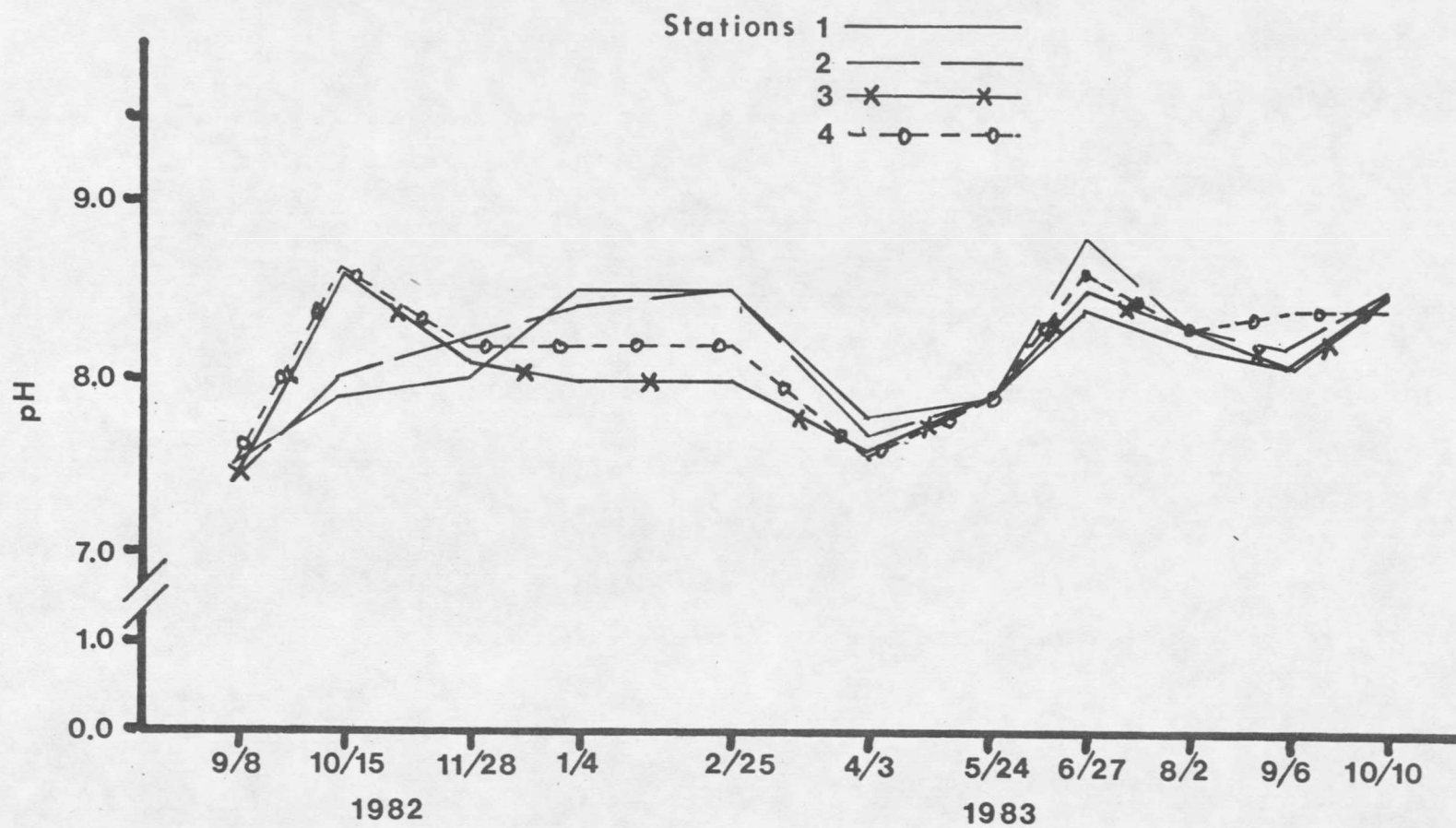


Figure 8. The pH measurements at sampling stations on the East Gallatin River from September 1982 - October 1983.

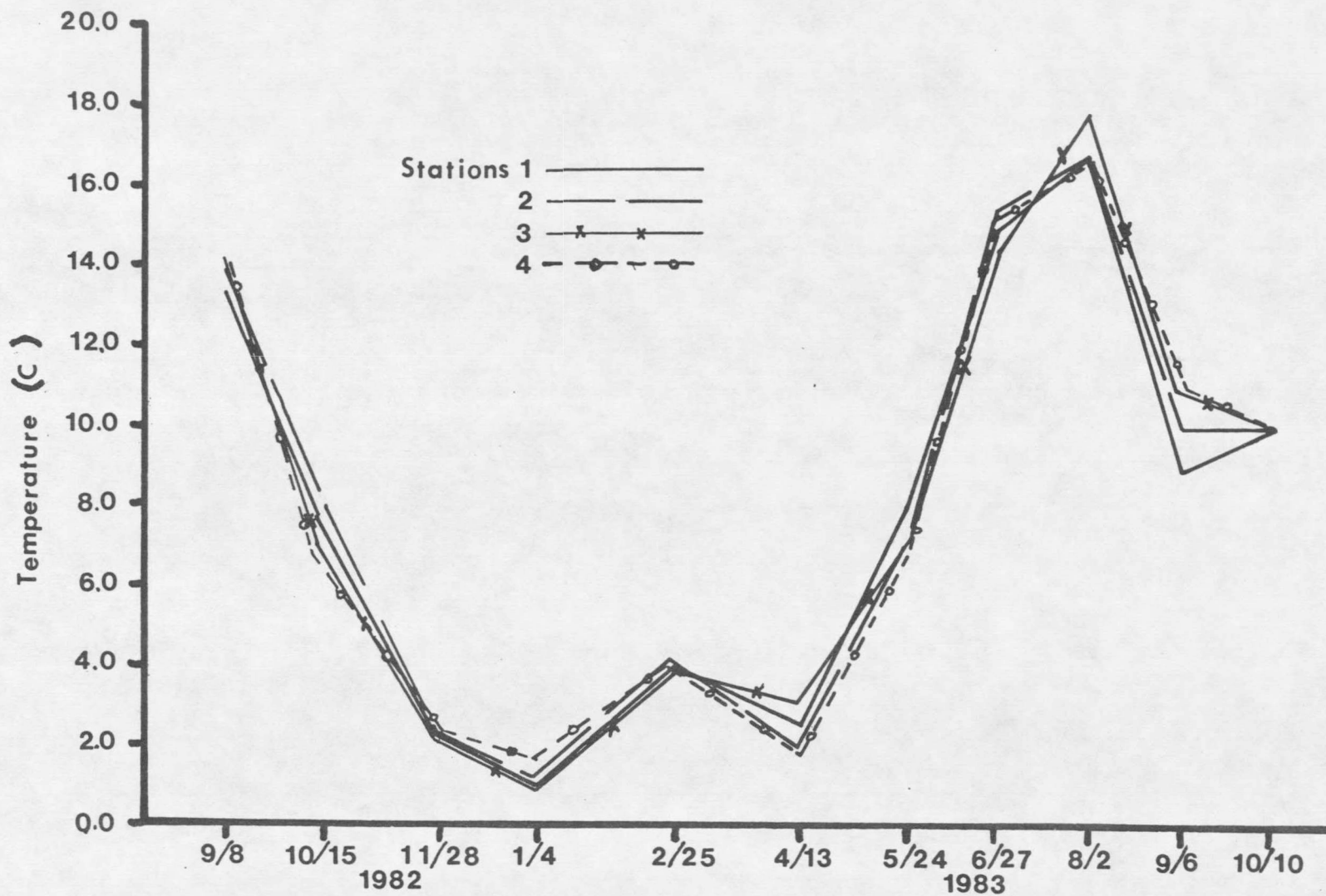


Figure 9. Temperatures on collecting dates at sampling stations on the East Gallatin River from September 1982 - October 1983.

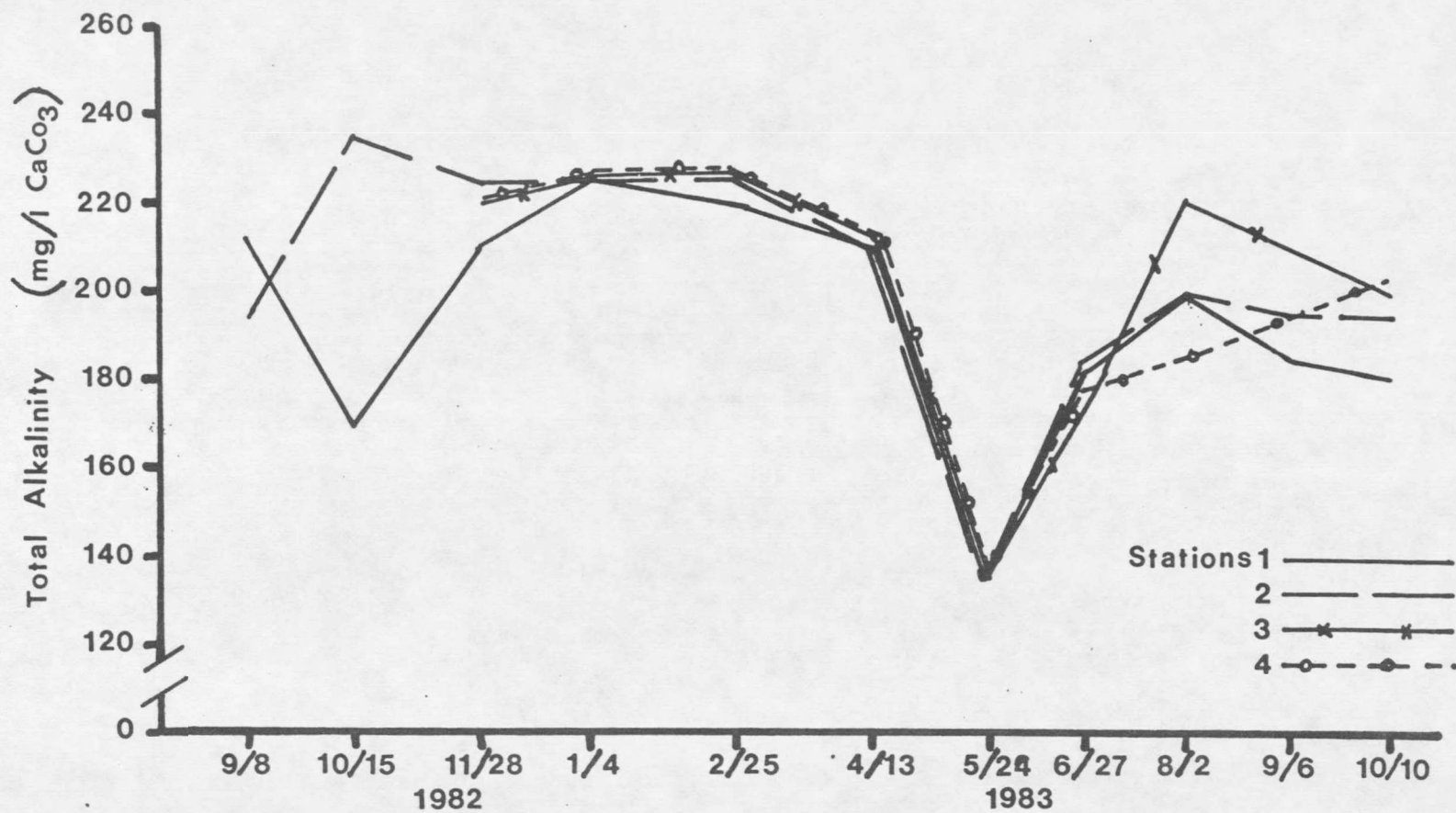


Figure 10. Total alkalinities at sampling stations on the East Gallatin River from September 1982 - October 1983.

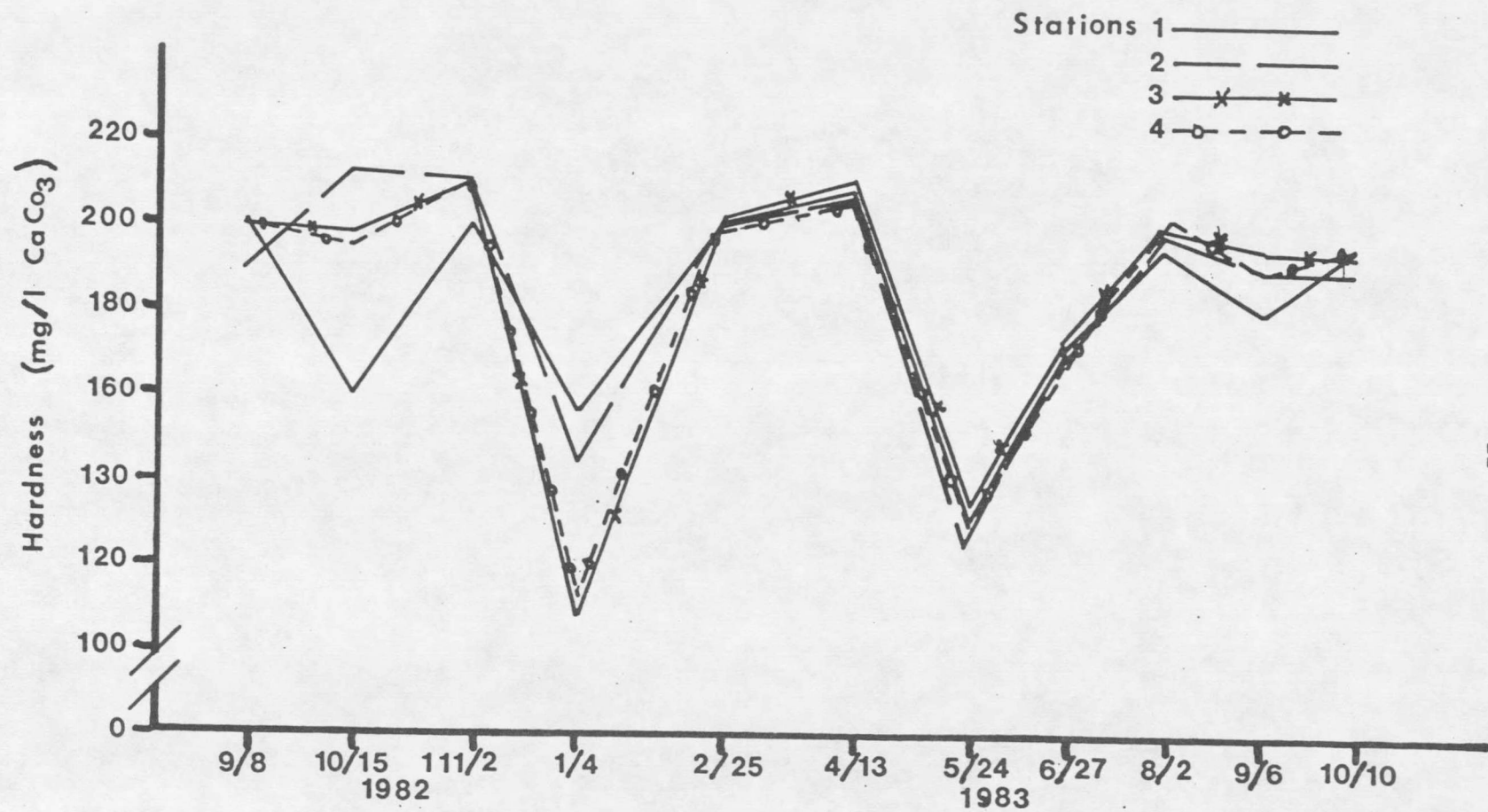


Figure 11. Hardness values at sampling stations on the East Gallatin River from September 1982 - October 1983.

Dissolved oxygen concentrations from all stations during the study ranged from 9 - 13 mg/l (Figure 12). The lowest levels of dissolved oxygen were recorded in September 1982 at Station 2 when the sewage outfall was just above it and on October 15, 1982 at Station 3 when the sewage outfall was moved to immediately above it.

Conductivities from all stations ranged from 250 - 513 μ mhos/cm at 25°C. The pattern and level among stations was similar throughout the study (Figure 13). Conductivities had a generally inverse relation to flows (Figure 2).

Values for turbidities from all stations during the study period ranged from 1.6 - 47 JTU (Figure 14). All stations had similar levels and patterns of turbidities throughout the study except in August 1983 when Station 2 had a turbidity value 100% greater than at all other stations.

Aquatic Macroinvertebrates

Seven monthly samples of macroinvertebrates were collected from November 1982 - October 1983. The taxa and numbers of macroinvertebrates from the 108 samplers collected throughout the study are given in the Appendix Tables 18 - 45. High water during spring runoff prevented the collection of macroinvertebrates from April - July 1983.

The highest mean numbers of macroinvertebrates per sampler at stations above the outfall occurred in February (Figure 15) while numbers at stations below the outfall peaked in September.

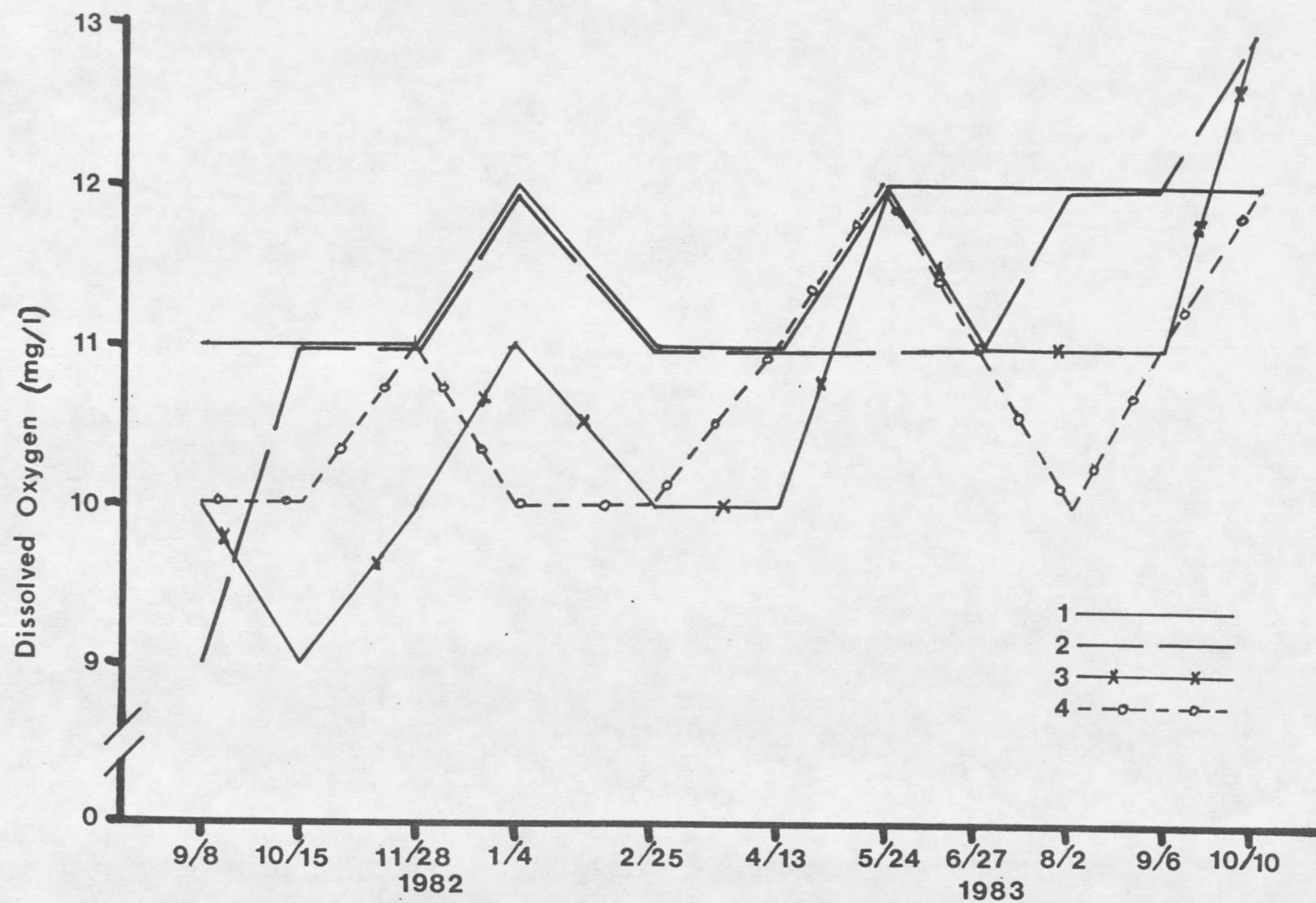


Figure 12. Dissolved oxygen concentrations at sampling stations on the East Gallatin River from September 1982 - October 1983.

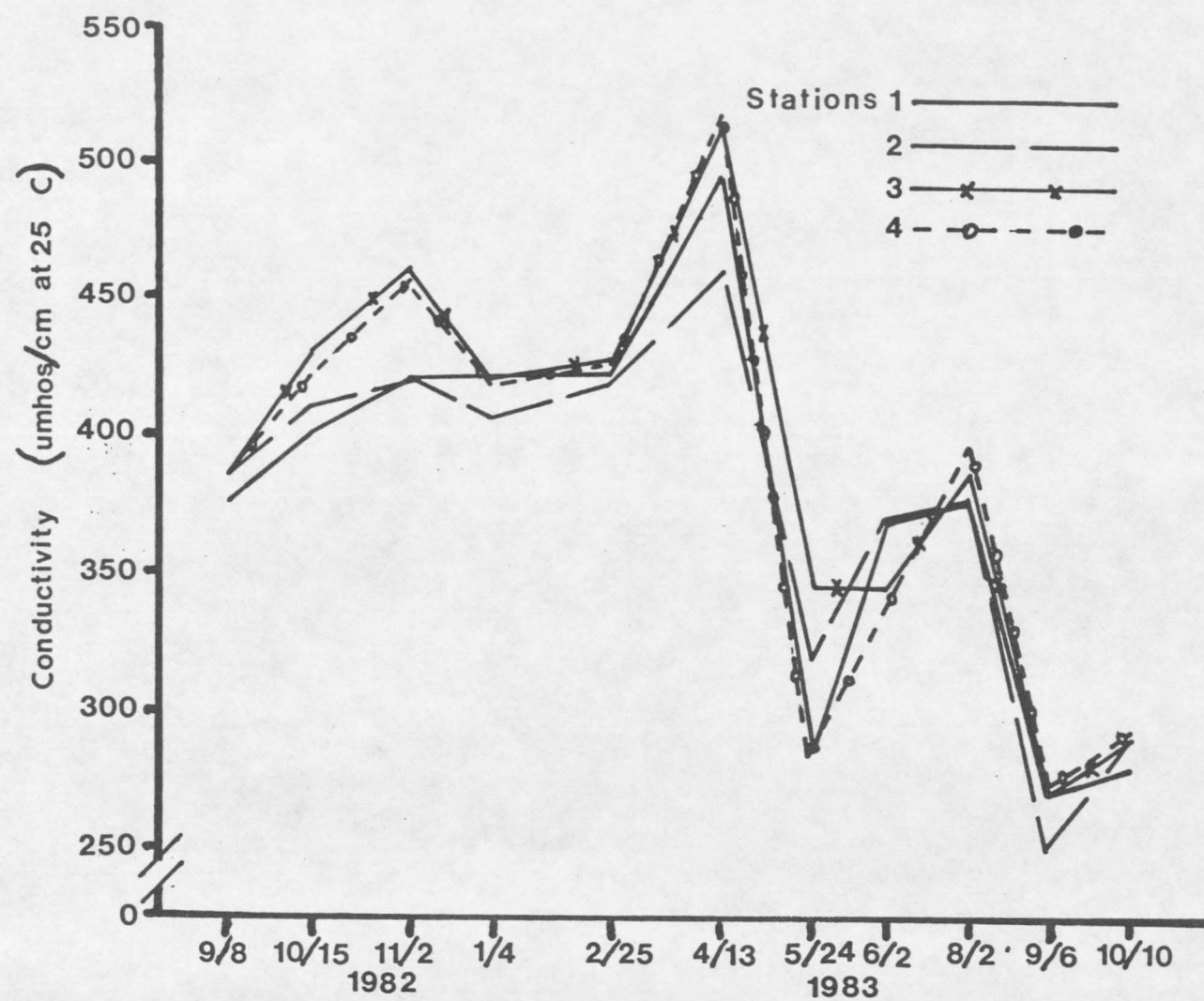


Figure 13. Conductivities at sampling stations on the East Gallatin River from September 1982 - October 1983.

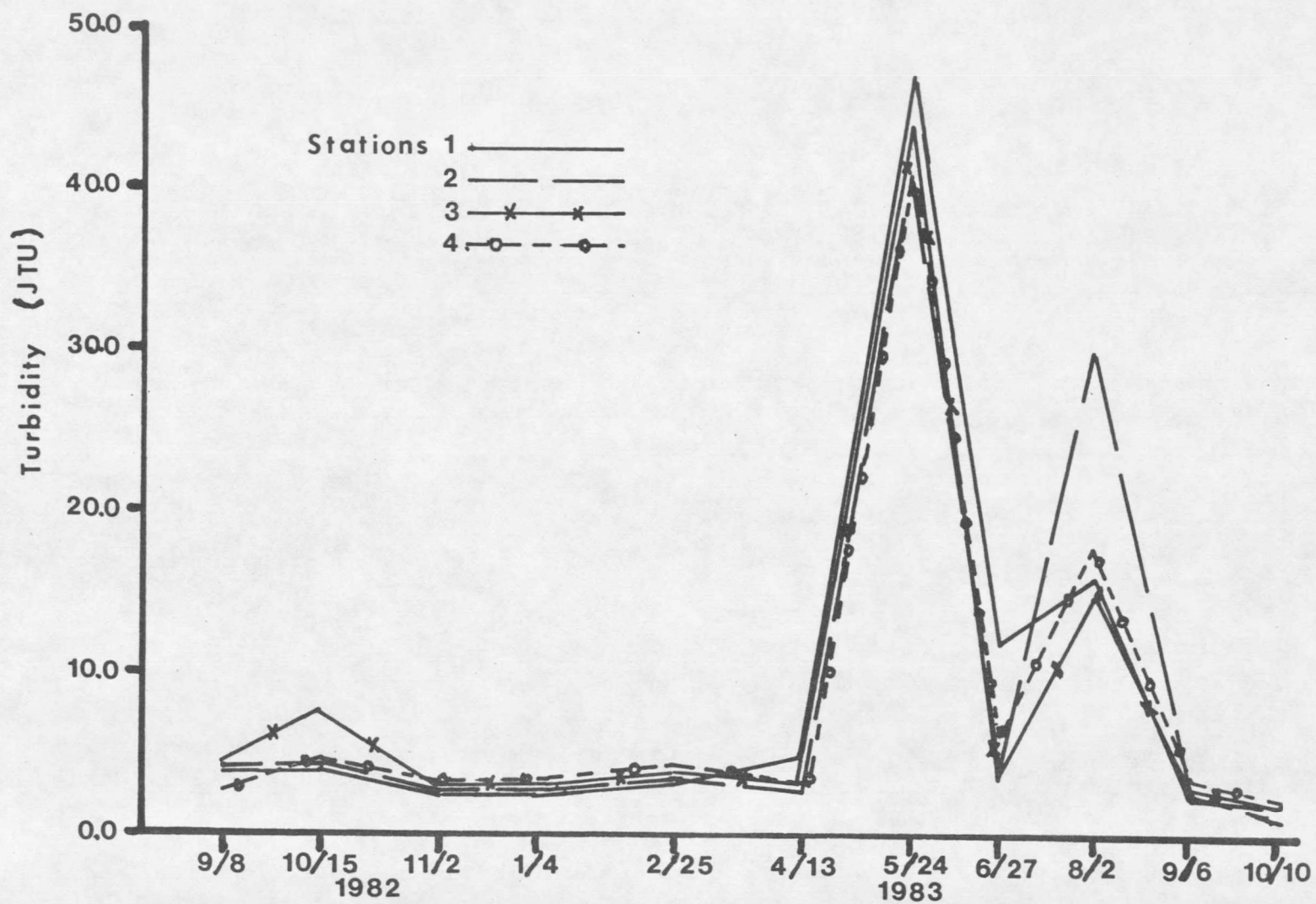


Figure 14. Turbidities at sampling stations on the East Gallatin River from September 1982 - October 1983.

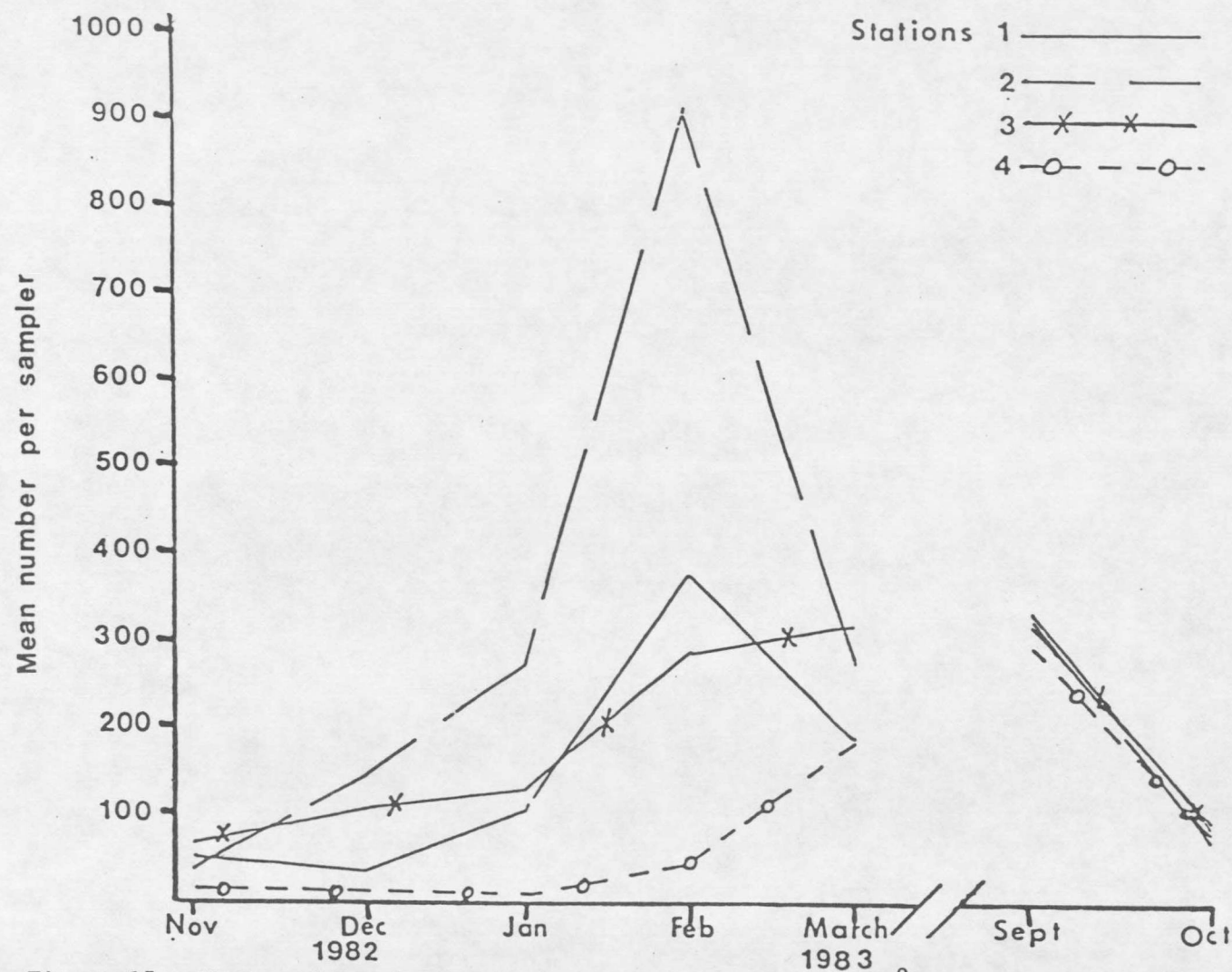


Figure 15. Mean number of aquatic insects per sampler (0.2m^2) at stations on the East Gallatin River from September 1982 - October 1983.

Station 4 had the lowest mean number of macroinvertebrates per sampler during all months except October. A comparison of mean number of macroinvertebrates per sampler at all stations over the entire study period showed Station 1 had a significantly greater number than Station 3 ($P < 0.05$) and Station 2 had a significantly greater number than Station 4 ($P < 0.05$). There were no other significant differences among stations.

The numbers of ephemeropterans at stations above the outfall peaked in February 1983 while those at stations below peaked in September 1983 (Figure 16). Station 4 had the lowest numbers of Ephemeroptera per sampler during all months except October 1983. A comparison of mean numbers of Ephemeroptera per sampler among stations, over the entire study period showed that Station 2 had significantly higher number than all other stations ($P < 0.05$). This higher number was due to an abundance of *Baetis tricaudatus*. (Appendix Tables 17 - 45).

The numbers of *Drunella grandis* at stations were examined because this species is ranked as a very pollution intolerant form (Winget and Mangum 1979). The numbers of *D. grandis* peaked sharply at Stations 1, 2 and 3 in March but only peaked slightly at Station 4 in February (Figure 17). A comparison of the mean number of *D. grandis* per sampler at all stations over the entire study period showed that Station 3 had significantly greater numbers than Stations 2 and 4 ($P < 0.05$).

Peak numbers of Plecoptera occurred at Stations 1 and 2 in February, Station 3 in March and Station 4 in September (Figure 18).

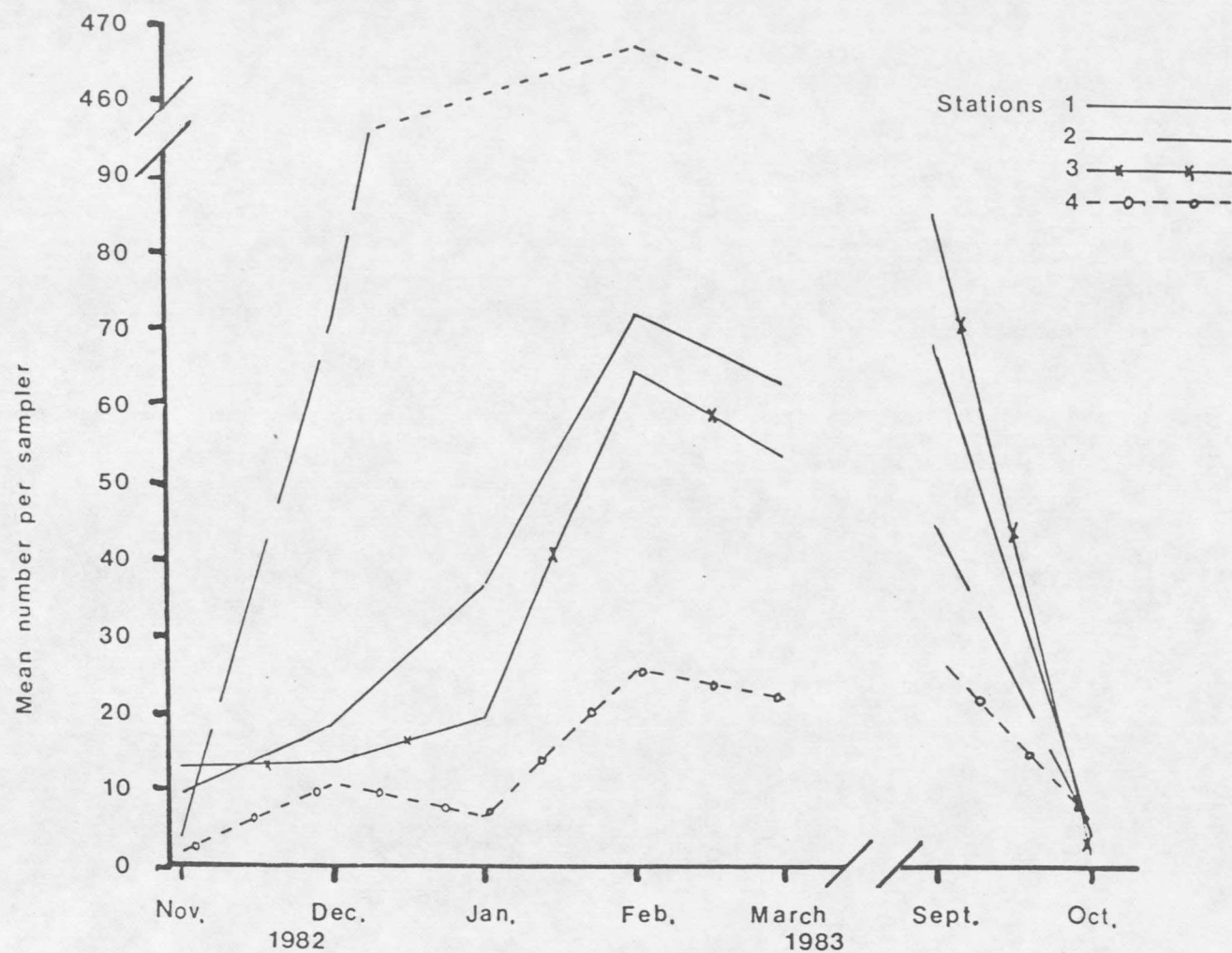


Figure 16. Mean number of Ephemeroptera per sampler ($0.2m^2$) at stations on the East Gallatin River from September 1982 - October 1983.

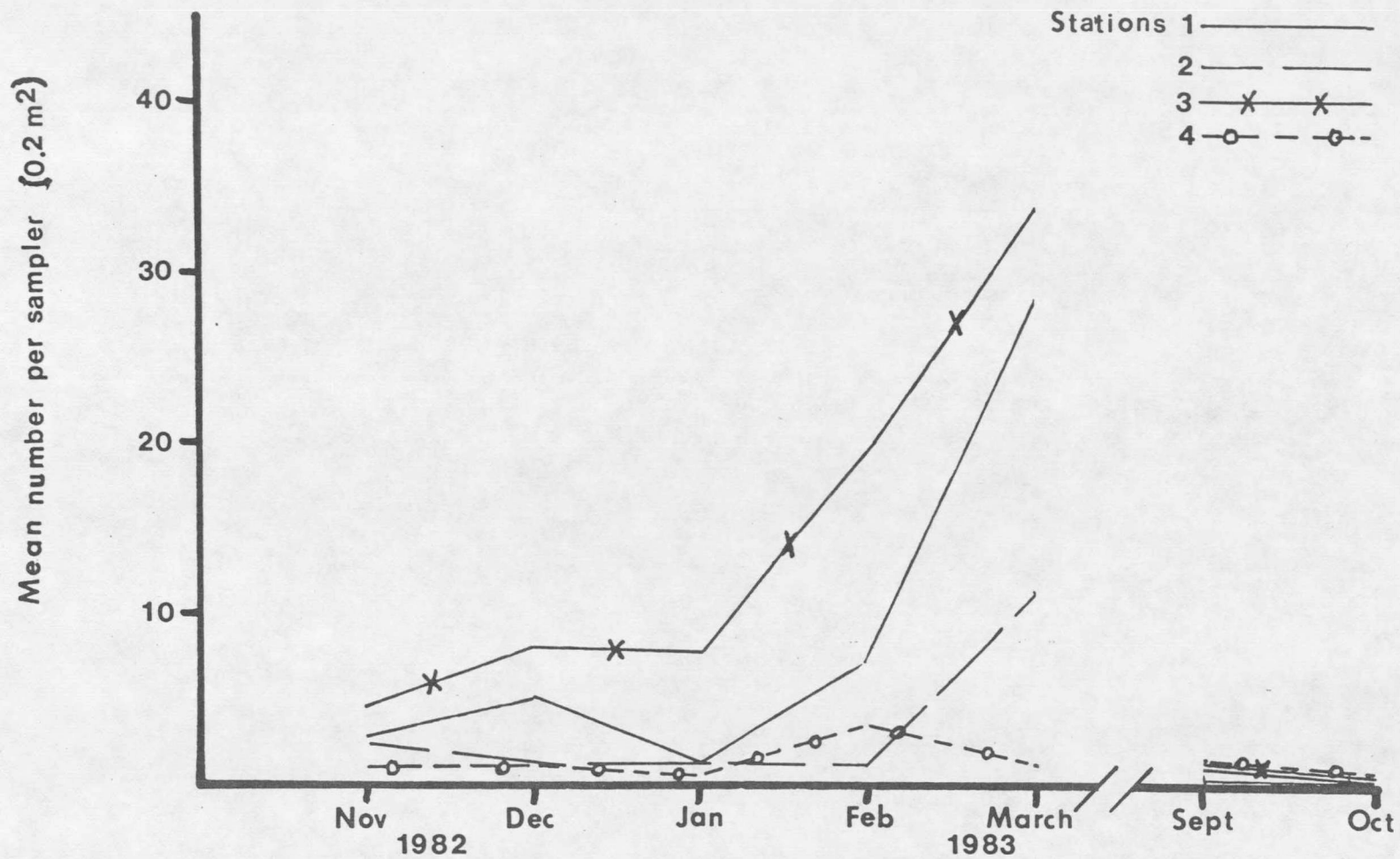


Figure 17. Mean number of *Drunella grandis* per sampler (0.2m²) at stations on the East Gallatin River from September 1982 - October 1983.

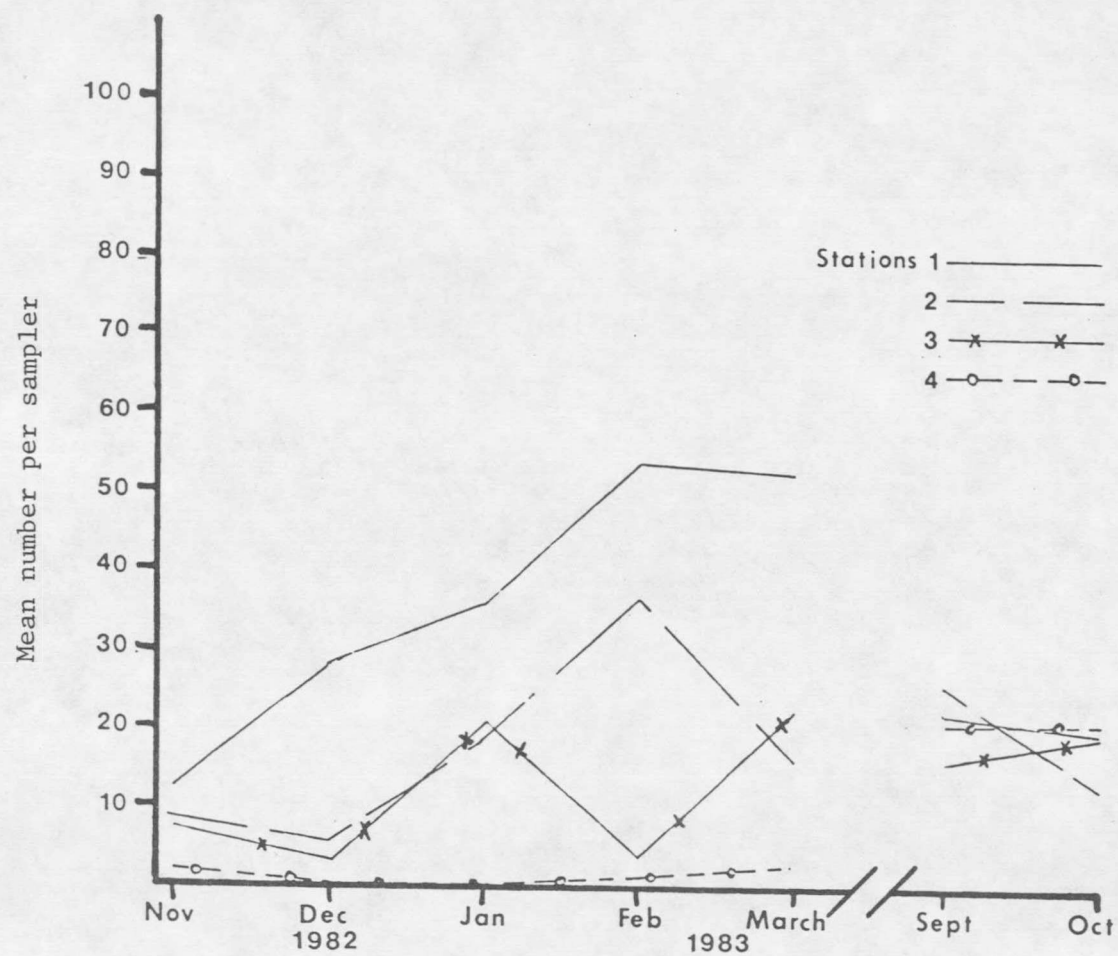


Figure 18. Mean number of Plecoptera per sampler(0.2m²) at stations on the East Gallatin River from September 1982 - October 1983.

Station 1 had the highest numbers and Station 4 the lowest during all months except September and October. Stations 2 and 3 have similar numbers except in February. The mean number of Plecoptera per sampler at Station 1 was significantly greater than at all other stations ($P < 0.05$).

The numbers of the plecopteran *Pteronarcella badia* were of interest because it also is ranked as a very pollution intolerant form (Winget and Mangum 1979). As was found with Plecoptera, Station 1 had the highest numbers of *P. badia* and Station 4 the lowest in all months except September and October (Figure 19). The mean number of *P. badia* collected at Station 1 was significantly greater than at all other stations ($P < 0.05$).

The numbers of Trichoptera at all stations peaked in September (Figure 20). There were no significant differences in the mean numbers of Trichoptera collected from all stations throughout the entire study period.

The numbers of *Hydrophysche* were examined because this form is ranked as a very pollution tolerant form (Winget and Mangum 1979). The findings on *Hydrophysche* parallels those for Trichoptera with the numbers peaking at all stations in September and analysis showing no significant difference among stations (Figure 21).

The numbers of Diptera at Stations 1, 2 and 3 peaked in February while Station 4 peaked in March (Figure 22). A comparison of mean numbers of Diptera per sampler collected at all stations showed no significant differences among stations.

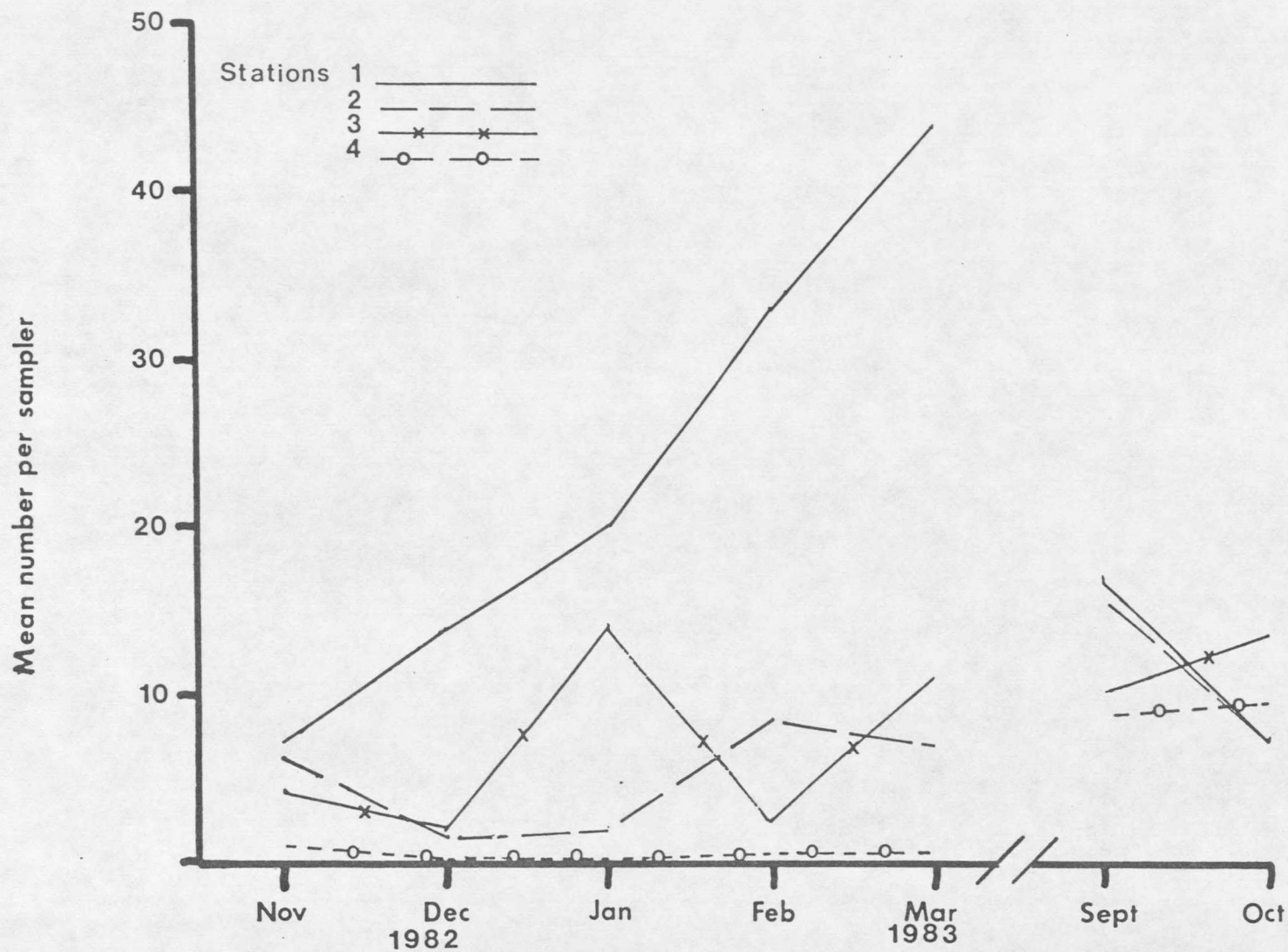


Figure 19. Mean number of *Pteronarcella badia* per sampler (0.2m^2) at stations on the East Gallatin River from September 1982 - October 1983.

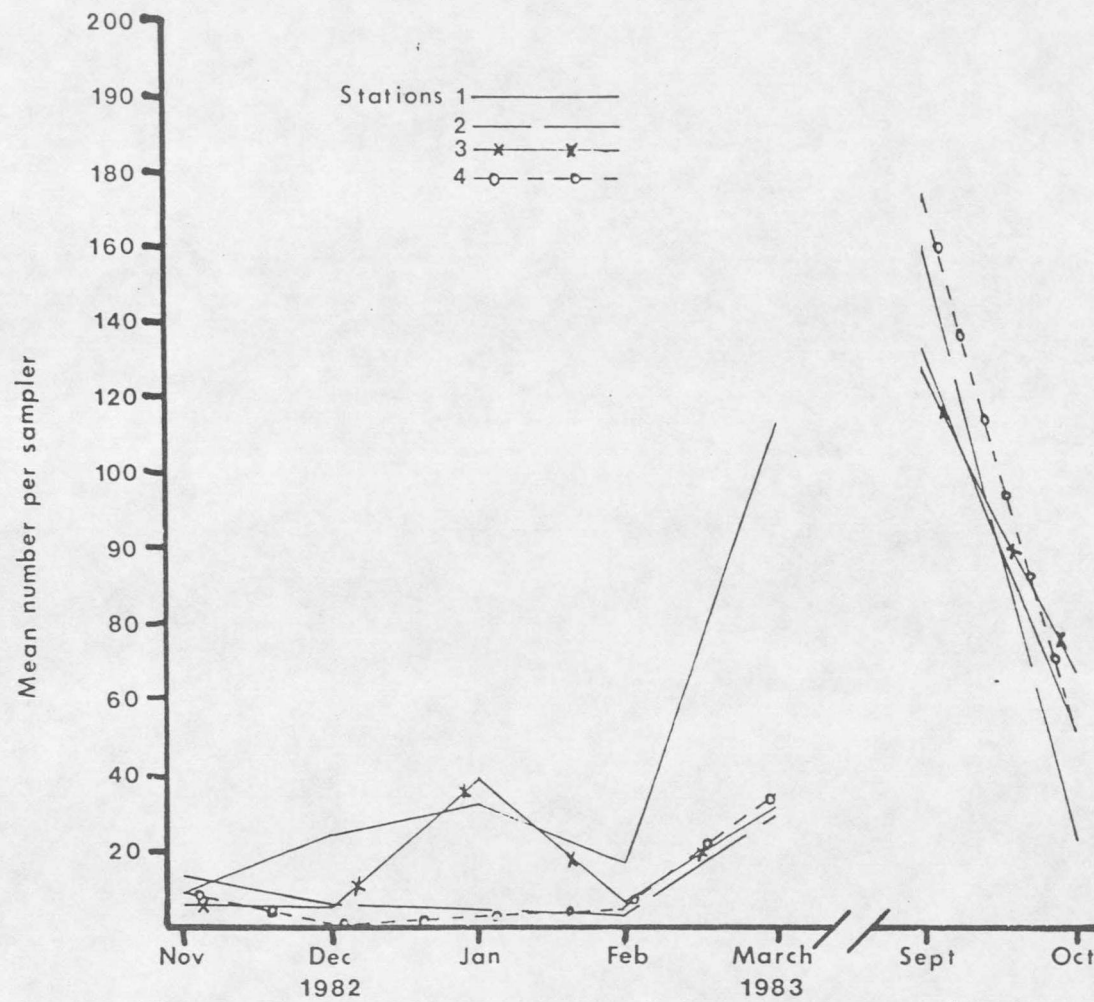


Figure 20. Mean number of Trichoptera per sampler (0.2m^2) at stations on the East Gallatin River from September 1982 - October 1983.

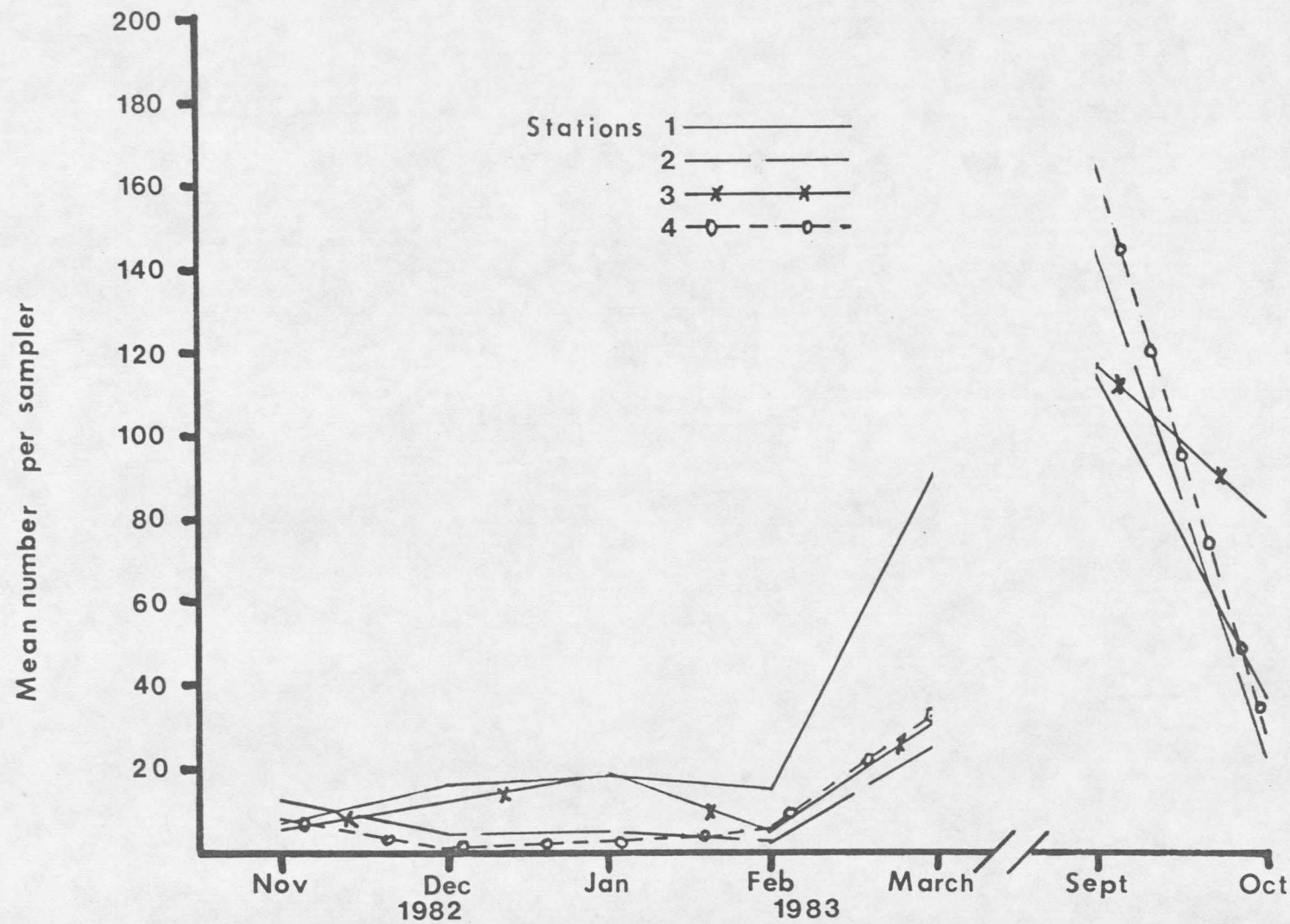


Figure 21. Mean number of *Hydrophyche* per sampler (0.2m^2) at stations on the East Gallatin River from September 1982 - October 1983.

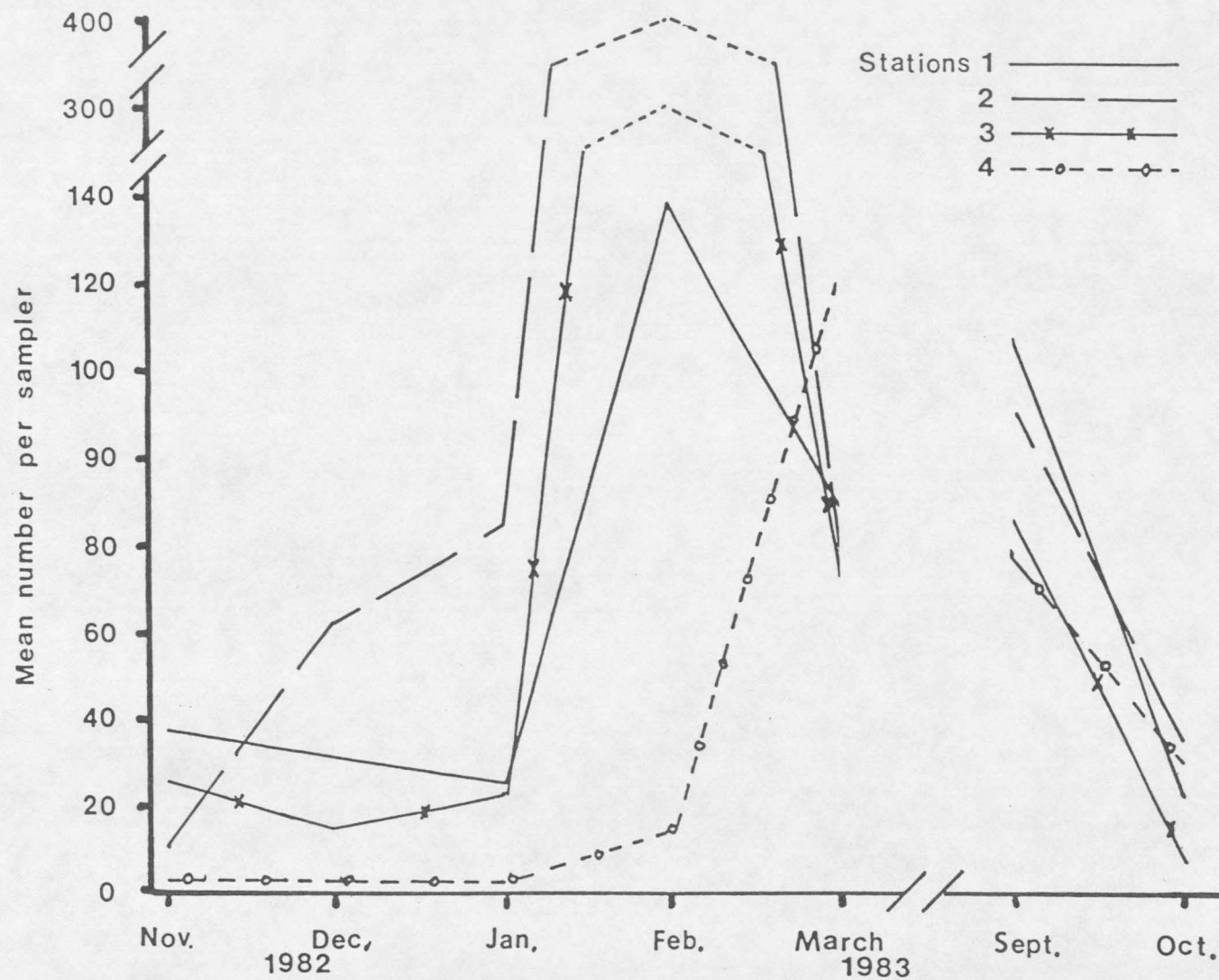


Figure 22. Mean number of Diptera per sampler ($0.2m^2$) at stations on the East Gallatin River from September 1982 - October 1983.

Chironomidae are ranked as very pollution tolerant forms (Winget and Mangum 1979). As with Diptera, their numbers peaked at Stations 1, 2 and 3 in February and at Station 4 in March (Figure 23). There were no significant differences among stations in mean numbers of chironomids.

Results of the application of the Kothe's Index to this study indicate that 71% of the comparisons showed more generic diversity above the sewage outfall, while 21% showed no difference and only 7% showed more diversity below the outfall (Table 1).

Table 1. Kothe's Index calculated using mean number of genera per sampler.

Station comparisons	DATE						
	NOV	DEC	JAN	FEB	MAR	SEPT	OCT
1 and 3	0	0	-11	14	33	21	29
1 and 4	0	25	33	43	27	0	0
2 and 3	9	27	0	-33	43	8	11
2 and 4	9	45	40	11	21	17	56

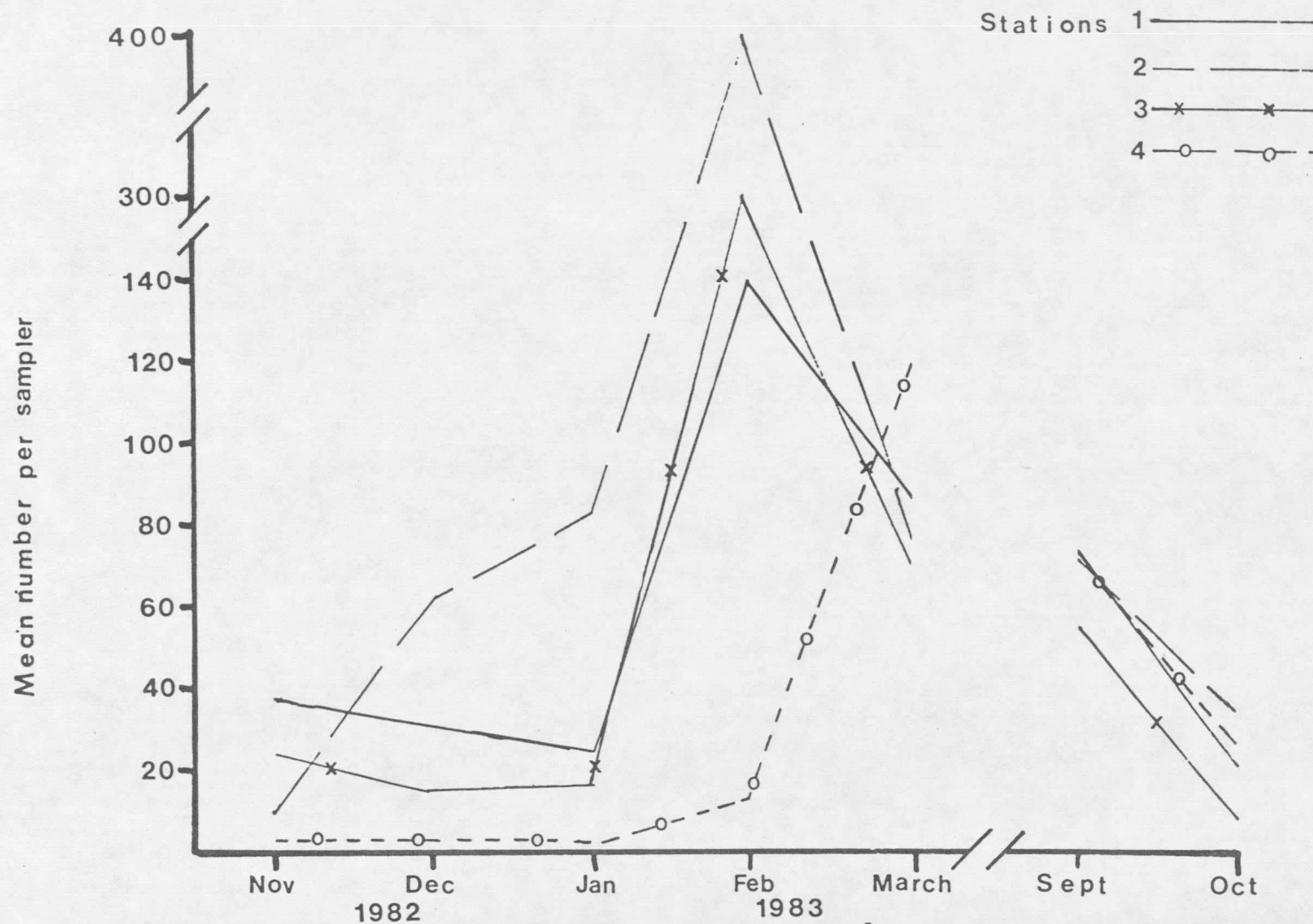


Figure 23. Mean number of Chironomidae per sampler (0.2m²) at stations on the East Gallatin River from September 1982 - October 1983.

DISCUSSION

From August 1971 - October 1982, the Bozeman Sewage Treatment Plant applied secondary treatment to only part of its effluent. Starting in October 1982 the plant began to provide secondary treatment to all of its effluent to meet minimum secondary standards required by the EPA.

The new treatment reduced levels of un-ionized ammonia at stations below the sewage outfall. During the period when the effluent received only partial secondary treatment un-ionized ammonia levels at stations below the outfall ranged from 0 - 600% of the EPA (1976) maximum limit of 0.02 mg/l (Russo and Thurston 1974; Matney 1978). Concentrations of un-ionized ammonia at stations below the outfall ranged from 0 - 800% greater than concentrations above the outfall during this time. After the enhanced treatment was applied, un-ionized ammonia concentrations conformed to the EPA criteria. Levels at stations below the outfall ranged from less than 25 - 85% of the EPA (1976) maximum limit and concentrations at stations above and below the sewage outfall were within 0.015 mg/l of each other. However, recently the EPA criteria for un-ionized ammonia has been questioned. Mead (1985) cites numerous contradicting studies on ammonia toxicity and suggests that a safe maximum concentration for un-ionized ammonia still is not known.

A beneficial by-product of the upgrading of the Bozeman Sewage Treatment Plant is that chlorination of the effluent was discontinued. Chlorine readily reacts with un-ionized ammonia, forming chloramine which is toxic to fish (EPA 1976). The effects of chloramines have not been measured in any studies on the East Gallatin River, but the potential effects of chloramines have been removed by discontinuing chlorination and lowered un-ionized ammonia levels.

The enhanced sewage treatment also reduced levels of nitrite at stations below the sewage outfall. During partial secondary treatment, nitrite concentrations at stations below the outfall ranged from 16 - 350% of the limit 0.06 mg/l suggested by Russo et al. (1974) and Russo and Thurston (1975). Concentrations were 0 - 400% greater below the outfall than above (Glorvigen 1972; Russo and Thurston 1974; Matney 1978). After the enhanced treatment was applied, nitrite concentrations at stations below the outfall ranged from 8 - 83% of the suggested limit and levels above and below the sewage outfall were within 0.04 mg/l of each other.

The enhanced sewage treatment did not significantly change the levels of nitrate, phosphate, pH, temperature, total alkalinity, hardness, dissolved oxygen, conductivity or turbidity in the river below the outfall from the values reported for these parameters during partial secondary treatment. When the effluent received only partial secondary treatment, nitrate concentrations

at stations below the sewage outfall ranged from 0 - 11% of the EPA (1976) maximum limit of 10 mg/l and were 0 - 1100% greater at stations below the outfall than above (Glorvigen 1972; Russo and Thurston 1974; Matney 1978). After the enhanced treatment was applied, nitrate concentrations at stations below the outfall ranged 4 - 12% of the EPA limit, and only 200 - 300% greater than at stations above the outfall.

The enhanced treatment did not reduce phosphate levels from the study performed during the period of partial secondary treatment (Russo and Thurston 1974) but did reduce concentrations below those reported by Glorvigen (1972) when the partial secondary treatment first began. Phosphate concentrations at stations below the outfall were 90 - 208% (Russo and Thurston 1974) and 600 - 700% (Glorvigen 1972) of the limit 0.10 mg/l suggested by Mackenthum (1973). When the effluent received only partial secondary treatment, concentrations at stations below the outfall were 150 - 700% greater than at stations above (Glorvigen 1972; Russo and Thurston 1974). After the enhanced treatment was applied, phosphate concentrations at stations below the sewage outfall ranged 5 - 290% of the suggested limit and were 0 - 400% greater than at stations above the outfall.

Total phosphorus is the sum of particulate phosphorus, dissolved inorganic phosphorus (phosphate) and dissolved organic phosphorus. It is a truer estimate of phosphorus within a system than merely phosphate, which is quickly used by aquatic vegetation when available and therefore varies seasonally. Concentrations of

total phosphorus that were measured during this study ranged from 0 - 200% greater below the sewage outfall than above. This parameter was not measured in earlier studies and there is no EPA criterion for it in flowing waters. However, the high levels of total phosphorus measured during this study could cause nuisance growths of algae and vascular aquatic plants. Only a tertiary treatment system can reduce levels of phosphorus in the effluent.

Values for pH at stations below the outfall were within the EPA (1976) limit (6.5 - 9.0) during both the period of partial secondary treatment (Glorvigen 1972; Russo and Thurston 1974) and after the enhanced treatment was applied. Values at stations above and below the sewage outfall during both periods were within approximately 1 pH unit of each other.

The two EPA (1976) maximum limits for short term exposure and maximum weekly average temperature are 19C and 24C respectively, for both rainbow and brook trout. These temperatures were not exceeded during the period of partial secondary treatment (Glorvigen 1972; Russo and Thurston 1974) or after the enhanced treatment was applied. Temperatures at stations above and below the outfall were within approximately 2C of each other during partial secondary and enhanced treatment.

During the period when the effluent received only partial secondary treatment, total alkalinity values were 600 - 1100% of the EPA (1976) minimum of 20 mg/l CaCO_3 at stations below the sewage outfall and values at stations above and below the outfall were within 10 mg/l of each other (Glorvigen 1972; Russo and

Thurston 1974) indicating that the effluent did not increase the concentrations of this parameter. After the enhanced treatment was applied, total alkalinities still ranged from 670 - 1100% of the EPA (1976) minimum at stations below the outfall and values above and below the outfall were still within 10 mg/l of each other.

Hardness values were not reported for the period of partial secondary treatment but alkalinities measured during this period (Glorvigen 1972; Russo and Thurston 1976) suggest that hardness values were similar to those found in the present study. Little difference was seen at stations above and below the outfall which had hardness values within 2 mg/l of each other.

During the period of partial secondary treatment, D.O. concentrations ranged from 120 - 260% of the EPA (1976) minimum of 5.0 mg/l at stations below the sewage outfall (Glorvigen 1972; Russo and Thurston 1974). Concentrations at stations above and below the outfall were within 1 mg/l of each other, except during a 24 hour sampling period when oxygen at stations below sagged to 66% of the minimum and were up to 3 mg/l lower than stations above (Matney 1978). This oxygen sag was correlated with low flows occurring in August 1977. After the enhanced treatment was applied, D.O. concentrations again were 180 - 260% of the EPA (1976) minimum and concentrations at stations above and below the outfall were within 1 mg/l of each other. No 24 hour sampling was undertaken during this study.

The conductivity values at stations below the outfall during the period when the effluent received only partial secondary treatment (Russo and Thurston 1976) were within 25 μ mhos (at 25C) of those found at stations below the outfall after the enhanced sewage treatment was applied. During this study, conductivity values above and below the outfall were mostly within 50 μ mhos (at 25C) of each other.

Turbidity at stations below the outfall during the period of partial secondary treatment was measured only for 2 days. Matney (1978) indicated that it was related to river flow rather than effluent discharge. After the enhanced treatment was applied, the same pattern was observed. The effluent had very little affect upon river turbidity and turbidities at stations below the outfall were usually within 1 - 2 JTU of values at stations above the outfall.

Examination of macroinvertebrate communities on the East Gallatin River indicated that the sewage effluent was less detrimental to the macroinvertebrates after the enhanced treatment began than before. Negative effects were found primarily upon the most pollution intolerant forms, the plecopterans and in particular *P. badia*. Plecopteran numbers were significantly greater above the sewage outfall when the effluent received only partial secondary treatment (Glorvigen 1972). After the enhanced treatment was applied numbers of plecopterans varied from 0 - 400% greater at Station 1 above the sewage outfall compared to below.

Numbers of plecopterans were statistically similar at Station 2 above the outfall and Stations 3 and 4 below the outfall. Numbers of plecopterans at these stations were approximately 200% greater in October 1983 than November 1982 suggesting an improvement in all three areas.

Number of *P. badia* were 0 - 400% greater above the sewage outfall than below when only partial secondary treatment was given (Leudtke et al. 1974). After the enhanced treatment was applied numbers of *P. badia* were also 0 - 400% greater at Station 1 above the sewage outfall than at those below. Numbers of *P. badia* were statistically similar at Station 2 above the outfall and Stations 3 and 4 below the outfall and were also approximately 200% greater in October 1983 than in November 1982 again suggesting an improvement in all three areas.

The sewage effluent apparently reduced generic diversity below the outfall. Kothe's Index which was specifically designed to compare relative diversity above and below a sewage outfall, indicated that diversity was greater in aquatic insect communities above the sewage outfall in nearly 75% of the samples.

A significant reduction in numbers of Ephemeroptera was found below the sewage outfall during partial secondary treatment (Glorvigen 1972). After the enhanced secondary treatment, there were no significant differences in numbers of Ephemeroptera among Stations 1, 3 and 4 but numbers at Station 2 were significantly greater due to an abundance of *B. tricaudatus*.

Numbers of *D. grandis* were reduced below the sewage outfall when the effluent received only partial secondary treatment (Leudtke et al. 1974). However, during this study numbers of the pollution intolerant *D. grandis* were significantly greater at Station 3 below the outfall than at Station 2 above and were statistically similar to Station 1 above the outfall. This suggests that the sewage effluent had little detrimental effect upon this macro-invertebrate.

Glorvigen (1972) and Leudtke et al. (1974) found a reduction in numbers of Trichoptera below the sewage outfall before the enhanced treatment was applied. However, afterwards the numbers of Trichoptera showed no significant differences between stations above and below the sewage outfall.

Before enhanced secondary treatment was used, Glorvigen (1972) found higher numbers of Dipterans below the sewage outfall while Leudtke et al. (1974) found no difference in numbers of Diptera or Chironomidae at stations above and below. In this study, after enhanced treatment, numbers of Diptera and Chironomidae were not significantly different at stations above and below the sewage outfall.

The numbers of aquatic insects collected in this study could not be compared to previous investigations due to differences in sampling equipment and methods used among studies. During this study aquatic insects were collected on artificial substrates. In previous studies sampling was done on natural substrates.

Also, the area of substrate sampled differ among this study and all previous studies.

In summary, the results of this study indicate that enhanced secondary treatment caused improvements in both water quality and macroinvertebrate communities in the East Gallatin River. Levels of un-ionized ammonia and nitrite were lowered. Negative effects were found only in plecopterans and generic diversity, whereas past studies indicated adverse effects upon ephemeropterans and trichopterans as well as plecopterans.

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APPENDIX

Table 2. Flow gauge measurements and river discharge of the East Gallatin River at approximately 120 m upstream from the Bozeman Sewage Treatment Plant, September 1982 - October 1983.

Date	Flow gauge (ft)	Discharge (m ³ /sec)
9/8/82	1.37	2.31
10/9/82	1.66	3.71
11/21/82	1.37	2.31
12/21/82	1.27	1.91
1/15/83	1.27	1.91
2/21/83	1.23	1.76
3/30/83	1.54	3.09
4/13/83	1.67	3.77
5/23/83	2.07	5.66
6/27/83	2.05	5.55
7/21/83	1.66	3.71
8/24/83	1.46	2.70
9/6/83	1.40	2.44
10/5/83	1.39	2.39

Table 3. Total ammonia concentrations $\text{NH}_3 + \text{NH}_4^+$ (mg/l)
the East Gallatin River from September 1982
- October 1983.

DATE	STATIONS			
	1	2	3	4
9/8/82	0.005	0.620	0.250	0.090
10/15/82	0.005	0.010	0.530	0.300
11/28/82	0.005	0.005	0.005	0.005
1/4/83	0.170	0.290	0.470	0.190
2/25/83	0.370	0.160	0.170	0.130
4/13/83	0.210	0.080	0.250	0.270
5/24/83	0.005	0.005	0.005	0.005
6/27/83	0.005	0.005	0.005	0.005
8/2/83	0.020	0.010	0.270	0.020
9/6/83	0.030	0.020	0.020	0.010
10/10/83	0.005	0.005	0.005	0.005

Table 4. Un-ionized ammonia concentrations $\text{NH}_3\text{-N}(\text{mg/l})$ on the East Gallatin River from September 1982 - October 1983.

DATE	STATIONS			
	1	2	3	4
9/8/82	0.000	0.004	0.002	0.001
10/15/82	0.000	0.000	0.029	0.016
11/28/82	0.000	0.000	0.000	0.000
1/4/83	0.005	0.007	0.004	0.003
2/25/83	0.013	0.006	0.002	0.002
4/13/83	0.004	0.000	0.001	0.001
5/24/83	0.000	0.000	0.000	0.000
6/27/83	0.000	0.001	0.000	0.000
8/2/83	0.001	0.001	0.017	0.001
9/6/83	0.001	0.001	0.000	0.000
10/10/83	0.000	0.000	0.000	0.000

Table 5. Nitrite concentrations $\text{NO}_2\text{-N}$ (mg/l) at study stations
on the East Gallatin River from September 1982 -
October 1983.

DATE	STATIONS			
	1	2	3	4
9/8/82	0.005	0.200	0.150	0.160
10/15/82	0.005	0.005	0.210	0.160
11/28/82	0.005	0.005	0.005	0.005
1/4/83	0.005	0.005	0.005	0.005
2/25/83	0.005	0.005	0.005	0.005
4/13/83	0.005	0.005	0.010	0.050
5/24/83	0.005	0.005	0.010	0.050
6/27/83	0.005	0.005	0.005	0.005
8/2/83	0.005	0.005	0.040	0.020
9/6/83	0.005	0.005	0.020	0.010
10/10/83	0.005	0.005	0.020	0.010

Table 6. Nitrate concentrations $\text{NO}_3\text{-N}$ (mg/l) at study stations
on the East Gallatin River from September 1982 -
October 1983.

DATE	STATIONS			
	1	2	3	4
9/8/82	0.30	0.52	0.53	0.56
10/15/82	0.28	0.39	0.54	0.54
11/28/82	0.63	0.64	1.10	0.90
1/4/83	0.70	0.69	1.10	1.00
2/2/83	0.70	0.69	1.10	1.00
4/13/83	0.44	0.37	1.01	0.35
5/24/83	0.31	0.32	0.63	0.62
6/27/83	0.26	0.17	0.60	0.51
8/2/83	0.26	0.23	1.13	0.98
9/6/83	0.37	0.30	0.79	0.85
10/10/83	0.17	0.19	0.52	0.57

Table 7. Orthophosphate concentrations $\text{PO}_4\text{-P(mg/l)}$ at study stations on the East Gallatin River from September 1982 - October 1983.

DATE	STATIONS			
	1	2	3	4
9/8/82	0.005	0.165	0.130	0.050
10/15/82	0.005	0.005	0.130	0.100
11/28/82	0.005	0.005	0.110	0.120
1/4/83	0.005	0.005	0.110	0.110
2/25/83	0.005	0.010	0.210	0.090
4/13/83	0.010	0.010	0.140	0.090
5/24/83	0.005	0.005	0.020	0.020
6/27/83	0.005	0.005	0.005	0.005
8/2/83	0.005	0.005	0.050	0.025
9/6/83	0.005	0.005	0.350	0.300
10/10/83	0.005	0.005	0.150	0.100

Table 8. Total phosphorus concentrations (mg/l) at study stations on the East Gallatin River from September 1982 - October 1983.

DATE	STATIONS			
	1	2	3	4
9/8/82	0.005	0.180	0.150	0.060
10/15/82	0.005	0.005	0.160	0.110
11/28/82	0.005	0.005	0.140	0.130
1/4/83	0.005	0.005	0.130	0.140
2/25/83	0.030	0.032	0.250	0.110
4/13/83	0.190	0.165	0.390	0.330
5/24/83	0.005	0.005	0.030	0.020
6/27/83	0.030	0.005	0.005	0.005
8/2/83	0.030	0.030	0.210	0.200
9/6/83	0.020	0.020	0.100	0.080
10/10/83	0.005	0.005	0.050	0.050

Table 9. The hydrogen ion concentrations at study stations on the East Gallatin River from September 1982 - October 1983.

DATE	STATIONS			
	1	2	3	4
9/8/82	7.5	7.4	7.4	7.5
10/15/82	7.9	8.0	8.6	8.6
11/28/82	8.0	8.2	8.1	8.12
1/4/83	8.5	8.4	8.0	8.2
2/25/83	8.5	8.5	8.0	8.2
4/13/83	7.8	7.7	7.6	7.6
5/24/83	7.9	7.9	7.9	7.9
6/27/83	8.4	8.8	8.5	8.6
8/2/83	8.2	8.3	8.3	8.3
9/6/83	8.1	8.2	8.1	8.4
10/10/83	8.5	8.5	8.5	8.4

Table 10. The total alkalinities (mg/l CaCO_3) at study stations on the East Gallatin River from September 1982 - October 1983.

DATE	STATIONS			
	1	2	3	4
9/8/82	211	194	211	211
10/15/82	170	235	---	---
11/28/82	210	225	220	220
1/4/83	225	225	225	225
2/25/83	220	225	225	225
4/13/83	210	210	213	214
5/24/83	138	135	134	136
6/27/83	182	184	174	178
8/2/83	199	198	220	185
9/6/83	185	195	210	195
10/10/83	181	195	200	203

Table 11. Measurements of hardness (mg/l CaCO_3) at study stations on the East Gallatin River from September 1982 - October 1983.

DATE	STATIONS			
	1	2	3	4
9/8/82	200	189	200	200
10/15/82	160	212	198	195
11/28/82	200	210	210	210
1/4/83	156	144	108	108
2/25/83	200	200	200	200
4/13/83	208	208	210	206
5/24/83	130	126	130	134
6/27/83	170	168	170	168
8/2/83	194	198	200	202
9/6/83	180	190	195	190
10/10/83	196	190	194	196

Table 12. The dissolved oxygen concentrations (mg/l) at study stations
on the East Gallatin River from September 1982 - October 1983.

DATE	STATIONS			
	1	2	3	4
9/8/82	11	9	10	10
10/15/82	11	11	9	10
11/28/82	11	11	10	11
1/4/83	12	12	11	10
2/25/83	11	11	10	10
4/13/83	11	11	10	11
5/24/83	12	12	12	12
6/27/83	12	11	11	11
8/2/83	12	12	11	10
9/6/83	12	12	11	11
10/10/83	12	13	13	12

Table 13. The conductivities ($\mu\text{mhos/cm}$ at 20 C) at study stations on the East Gallatin River from September 1982 - October 1983.

DATE	STATIONS			
	1	2	3	4
9/8/82	375	385	385	385
10/15/82	400	410	430	420
11/28/82	420	420	460	455
1/4/83	420	407	420	418
2/25/83	422	418	428	425
4/13/83	490	460	510	513
5/24/83	285	318	345	285
6/27/83	370	370	345	342
8/2/83	376	376	385	395
9/6/83	270	250	270	270
10/10/83	280	289	289	289

Table 14. The turbidities (Jackson Turbidity Units) at study stations
on the East Gallatin River from September 1982 - October 1983.

DATE	STATIONS			
	1	2	3	4
9/8/82	3.9	3.9	4.3	2.7
10/15/82	3.9	4.2	7.5	4.6
11/28/82	2.5	2.5	2.7	2.5
1/4/83	2.4	2.4	2.6	2.5
2/25/83	3.2	3.2	3.7	3.6
4/13/83	4.9	2.7	3.2	2.7
5/24/83	47.0	41.0	44.0	44.0
6/27/83	12.0	4.0	3.5	5.0
8/2/83	16.0	30.0	15.0	18.0
9/6/83	2.5	2.7	3.1	3.0
10/10/83	2.0	1.6	1.9	2.0

Table 15. Mean chlorine concentrations (mg/l) in the effluent of the
Bozeman Treatment Plant from September 1982 - October 1983.

<u>Date</u>	<u>mg/l</u>
9/82	0.14
10/82	0.12
11/82	0.19
12/82	0.16
1/83	0.23
2/83	0.00
3/83	0.00
4/83	0.07
5/83	0.02
6/83	(meter broken)
7/83	0.00
8/83	0.00
9/83	0.00
10/83	0.00

Table 16. Temperatures on collection dates at study stations on the East Gallatin River from September 1982 - October 1983. Temperatures in parentheses are ranges since the previous collection.

DATE	STATIONS			
	1	2	3	4
9/8/82	13.5 --	14.0 --	14.0 --	14.5 --
10/15/82	7.8 (7.0-20.0)	8.3 (7.0-15.0)	7.2 (6.0-18.0)	6.7 (0.0-11.0)
11/28/82	2.2 (6.0-15.0)	2.2 --	2.2 (0.0-12.0)	2.2 (13.0-15.0)
1/4/83	1.0 --	1.0 (1.0-5.0)	1.0 (0.0-5.0)	1.7 --
2/25/83	4.0 --	4.0 (0.0-5.0)	4.0 (1.0-5.0)	4.0 --
4/13/83	2.5 --	2.0 --	3.0 --	2.0 --
5/24/83	8.0 --	7.0 --	7.0 --	7.0 --
6/27/83	14.8 --	15.0 --	14.2 --	15.3 --
8/2/83	16.7 --	16.7 --	17.8 --	16.7 --
9/6/83	9.0 --	10.0 --	11.0 --	11.0 --
10/10/83	10.0 --	10.0 --	10.0 --	10.0 --

Table 17. Mean chlorine concentrations (mg/l) in the effluent of the Bozeman Treatment Plant from September 1982 - October 1983.

Date	mg/l
9/82	0.14
10/82	0.12
11/82	0.19
12/82	0.16
1/83	0.23
2/83	0.00
3/83	0.00
4/83	0.07
5/83	0.02
6/83	(meter broken)
7/83	0.00
8/83	0.00
9/83	0.00
10/83	0.00

Table 18. Numbers and taxa of aquatic insects collected on four
 0.2m² artificial substrate samplers from the East
 Gallatin River at Station 1 on November 21, 1982.

STATION 1				
Taxon	Samplers A	B	C	D
Ephemeroptera				
Baetidae				
<i>Baetis tricaudatus</i>	3	7	5	4
<i>Ephemerella infrequens</i> - <i>E. inermis</i>	0	5	1	1
<i>Drunella grandis</i>	5	5	0	1
Plecoptera				
Pteronarcidae				
<i>Pteronarcella badia</i>	5	16	2	6
Perlodidae				
<i>Skwala parallela</i>	0	9	0	2
<i>Isoperla</i> sp.	0	0	0	1
<i>Isogenus</i> sp.	1	3	0	5
Trichoptera				
Brachycentridae				
<i>Brachycentrus</i>	1	1	5	2
Hydropsychidae				
<i>Hydropsyche</i> sp.	4	12	6	3
Glossosomatidae				
<i>Glossosoma</i> sp.	0	1	0	0
Diptera				
Chironomidae	57	59	14	21
Coleoptera				
Elmidae				
<i>Cleptelmis</i> sp.	0	1	0	0

Table 19. Numbers and taxa of aquatic insects collected on
four 0.2m² artificial substrate samplers from the East
Gallatin River at Station 2 on November 21, 1982.

STATION 2				
Taxon	Samplers A	B	C	D
Ephemeroptera				
Baetidae				
<i>Baetis tricaudatus</i>	0	1	0	0
Ephemerellidae				
<i>Ephemerella infrequens</i> - <i>E. inermis</i>	0	0	2	0
<i>Drunella grandis</i>	3	1	3	2
Heptageniidae				
<i>Rhithrogena hagenii</i> - <i>R. morrisoni</i>	2	0	4	0
Plecoptera				
Pteronarcidae				
<i>Pteronarcella badia</i>	16	1	4	4
Perlodidae				
<i>Skwala parallela</i>	2	0	1	5
<i>Isogenus</i> sp.	0	1	0	0
Trichoptera				
Brachycentridae				
<i>Brachycentrus</i>	0	0	0	1
Hydropsychidae				
<i>Hydropsyche</i> sp.	14	13	8	14
<i>Cheumatopsyche</i> sp.	1	0	0	0
Diptera				
Chironomidae	11	2	6	20
Tipulidae				
<i>Tipula</i> sp.	1	0	0	0

Table 20. Numbers and taxa of aquatic insects collected on
four 0.2m² artificial substrate samplers from the
East Gallatin River at Station 3 on November 21, 1982.

STATION 3				
Taxon	Samplers A	B	C	D
Ephemeroptera				
Baetidae				
<i>Baetis tricaudatus</i>	29	3	0	0
Ephemerellidae				
<i>Drunella grandis</i>	10	3	1	4
Heptageniidae				
<i>Rhithrogena hagenii-R. morrisoni</i>	1	0	0	0
Plecoptera				
Pteronarcidae				
<i>Pteronarcella badia</i>	4	2	3	8
Perlodidae				
<i>Skwala parallela</i>	1	2	3	5
<i>Isoperla</i> sp.	1	0	0	0
Trichoptera				
Brachycentridae				
<i>Brachycentrus</i> sp.	2	0	0	0
Hydropsychidae				
<i>Hydropsyche</i> sp.	11	10	0	1
Diptera				
Chironomidae	38	34	21	4
Tipulidae				
<i>Tipula</i> sp.	0	1	0	1
Athericidae				
<i>Antherix pachypus</i>	0	1	0	0

Table 21. Numbers and taxa of aquatic insects collected on
four 0.2m² artificial substrate samplers from the
East Gallatin River at Station 4 on November 21, 1982.

STATION 4				
Taxon	Samplers A	B	C	D
Ephemeroptera				
Baetidae				
<i>Baetis tricaudatus</i>	0	0	1	0
Ephemerellidae				
<i>Drunella grandis</i>	3	0	2	0
Heptageniidae				
<i>Rhithrogena hagenii-R. morrisoni</i>	0	0	1	0
Plecoptera				
Pteronarcidae				
<i>Pteronarcella badia</i>	0	0	3	1
Perlodidae				
<i>Skwala parallela</i>	1	1	1	1
Trichoptera				
Hydropsychidae				
<i>Hydropsyche</i> sp.	2	9	20	1
<i>Cheumatopsyche</i> sp.	0	0	1	0
Diptera				
Chironomidae	0	5	4	0
Tipulidae				
<i>Tipula</i> sp.	0	5	0	0
Athericidae				
<i>Antherix pachypus</i>	1	0	0	0

Table 22. Numbers and taxa of aquatic insects collected on
four 0.2m² artificial substrate samplers from the
East Gallatin River at Station 1 on December 27, 1982.

STATION 1				
Taxon	Samplers A	B	C	D
Ephemeroptera				
Baetidae				
<i>Baetis tricaudatus</i>	30	15	2	7
Ephemerellidae				
<i>Drunella grandis</i>	2	15	3	0
Plecoptera				
Pteronarcidae				
<i>Pteronarcella badia</i>	22	18	13	3
Perlodidae				
<i>Skwala parallela</i>	16	27	11	2
Trichoptera				
Brachycentridae				
<i>Brachycentrus</i>	9	1	4	18
Hydropsychidae				
<i>Hydropsche</i> sp.	17	23	23	0
<i>Cheumatopsyche</i> sp.	0	1	1	0
Diptera				
Chironomidae	25	21	48	27
Athericidae				
<i>Antherix pachypus</i>	2	0	0	0

Table 23. Numbers and taxa of aquatic insects collected on
four 0.2m² artificial substrate samplers from the
East Gallatin River at Station 2 on December 27, 1982.

STATION 2				
Taxon	Samplers A	B	C	D
Ephemeroptera				
Baetidae				
<i>Baetis tricaudatus</i>	110	33	0	125
Ephemerellidae				
<i>Drunella grandis</i>	0	1	3	1
Heptageniidae				
<i>Rhithrogena hagenni-R. morrisoni</i>	4	2	1	1
Tricorythidae				
<i>Tricorythodes minutus</i>	1	0	0	0
Plecoptera				
Pteronarcidae				
<i>Pteronarcella badia</i>	2	1	3	0
Perlodidae				
<i>Skwala parallela</i>	4	4	6	3
Trichoptera				
Brachycentridae				
<i>Brachycentrus</i> sp.	1	2	2	1
Hydropsychidae				
<i>Hydropsyche</i> sp.	6	5	3	4
Diptera				
Chironomidae	56	52	54	84
Simuliidae				
<i>Simulium</i> sp.	1	0	0	0
Tipulidae				
<i>Dicranota</i> sp.	0	0	0	1

Table 24. Numbers and taxa of aquatic insects collected on four 0.2m² artificial substrate samplers from the East Gallatin River at Station 3 on December 27, 1982.

STATION 3				
Taxon	Samplers A	B	C	D
Ephemeroptera				
Baetidae				
<i>Baetis tricaudatus</i>	0	20	0	0
Ephemerellidae				
<i>Drunella grandis</i>	10	14	4	4
Heptageniidae				
<i>Rhithrogena hagenni</i> - <i>R. morrisoni</i>	0	1	0	0
Plecoptera				
Pteronarcidae				
<i>Pteronarcella badia</i>	1	4	3	1
Perlodidae				
<i>Skwala parallela</i>	1	0	1	3
Trichoptera				
Brachycentridae				
<i>Brachycentrus</i> sp.	2	0	1	3
Hydropsychidae				
<i>Hydropsyche</i> sp.	3	12	1	1
Diptera				
Chironomidae	23	23	6	7
Athericidae				
<i>Antherix pachypus</i>	0	0	0	1

Table 25. Numbers and taxa of aquatic insects collected on
four 0.2m² artificial substrate samplers from the
East Gallatin River at Station 4 on December 27, 1982.

STATION 4				
Taxon	Samplers A	B	C	D
Ephemeroptera				
Baetidae				
<i>Baetis tricaudatus</i>	16	12	4	1
Ephemerellidae				
<i>Drunella grandis</i>	0	2	2	0
Heptageniidae				
<i>Rhithrogena hagenii</i> - <i>R. morrisoni</i>	2	1	2	0
Plecoptera				
Pteronarcidae				
<i>Pteronarcella badia</i>	0	0	1	0
Trichoptera				
Hydropsychidae				
<i>Hydropsyche</i> sp.	1	1	1	1
Diptera				
Chironomidae	4	6	2	0

Table 26. Numbers and taxa of aquatic insects collected on
four 0.2m² artificial substrate samplers from the
East Gallatin River at Station 1 on January 15, 1983.

STATION 1				
Taxon	Samplers A	B	C	D
Ephemeroptera				
Baetidae				
<i>Baetis tricaudatus</i>	36	26	35	19
Ephemerellidae				
<i>Ephemerella infrequens</i> - <i>E. inermis</i>	10	8	7	0
<i>Drunella grandis</i>	1	2	2	0
Plecoptera				
Pteronarcidae				
<i>Pteronarcella badia</i>	26	10	27	17
Perlodidae				
<i>Skwala parallela</i>	17	21	11	13
Trichoptera				
Brachycentridae				
<i>Brachycentrus</i> sp.	2	2	52	0
Hydropsychidae				
<i>Hydropsyche</i> sp.	18	15	25	15
<i>Cheumatopsyche</i> sp.	0	0	1	0
Diptera				
Chironomidae	45	22	0	32
Simuliidae				
<i>Simulium</i> sp.	1	0	0	0

Table 27. Numbers and taxa of aquatic insects collected on
four 0.2m² artificial substrate samplers from the
East Gallatin River at Station 2 on January 15, 1983.

STATION 2				
Taxon	Samplers A	B	C	D
Ephemeroptera				
Baetidae				
<i>Baetis tricaudatus</i>	129	313	53	130
Ephemerellidae				
<i>Ephemerella infrequens</i> - <i>E. inermis</i>	10	0	2	0
<i>Drunella grandis</i>	3	0	2	0
Heptageniidae				
<i>Rithrogena hagenii</i> - <i>R. morrisoni</i>	0	10	0	6
Plecoptera				
Pteronarcidae				
<i>Pteronarcella badia</i>	4	1	2	1
Perlodidae				
<i>Skwala parallela</i>	37	15	8	6
Trichoptera				
Hydropsychidae				
<i>Hydropsyche</i> sp.	7	0	8	2
Diptera				
Chironomidae	143	46	75	70
Tipulidae				
<i>Tipula</i> sp.	0	2	0	0
Simuliidae				
<i>Simulium</i> sp.	0	0	1	0

Table 28. Numbers and taxa of aquatic insects collected on
four 0.2m² artificial substrate samplers from the
East Gallatin River at Station 3 on January 15, 1983.

STATION 3				
Taxon	Samplers A	B	C	D
Ephemeroptera				
Baetidae				
<i>Baetis tricaudatus</i>		13	1	21
Ephemerellidae				
<i>Drunella grandis</i>		7	5	11
Heptageniidae				
<i>Rhithrogena hagenii</i> - <i>R. morrisoni</i>		0	0	1
Plecoptera				
Pteronarcidae				
<i>Pteronarcella badia</i>		7	48	2
Perlodidae				
<i>Skwala parallela</i>		0	1	1
Nemouridae				
<i>Nemoura</i> sp.		0	3	0
Trichoptera				
Brachycentridae				
<i>Brachycentrus</i> sp.		0	59	3
Hydropsychidae				
<i>Hydropsyche</i> sp.		19	27	8
<i>Cheumatopsyche</i> sp.		1	2	0
Diptera				
Chironomidae		16	6	46
Tipulidae				
<i>Tipula</i> sp.		0	1	0

SAMPLERS DESTROYED

Table 29. Numbers and taxa of aquatic insects collected on
four 0.2m² artificial substrate samplers from the
East Gallatin River at Station 4 on January 15, 1983.

STATION 4				
Taxon	Samplers A	B	C	D
Ephemeroptera				
Baetidae				
<i>Baetis tricaudatus</i>	11	5	1	1
Ephemerellidae				
<i>Drunella grandis</i>	0	0	1	1
Heptageniidae				
<i>Rhithrogena hagenii</i> - <i>R. morrisoni</i>	3	0	1	1
Plecoptera				
Perlodidae				
<i>Skwala parallela</i>	1	0	0	0
Trichoptera				
Hydropsychidae				
<i>Hydropsyche</i> sp.	6	0	2	1
Diptera				
Chironomidae	5	3	1	1

Table 30. Numbers and taxa of aquatic insects collected on
four 0.2m² artificial substrate samplers from the
East Gallatin River at Station 1 on February 21, 1983.

STATION 1				
Taxon	Samplers A	B	C	D
Ephemeroptera				
Baetidae				
<i>Baetis tricaudatus</i>	26	58	30	77
Ephemerellidae				
<i>Ephemerella infrequens</i> - <i>E. inermis</i>	15	23	16	13
<i>Drunella grandis</i>	6	5	8	10
Heptageniidae				
<i>Rhithrogena hagenii</i> - <i>R. morrisoni</i>	0	0	1	0
Plecoptera				
Pteronarcidae				
<i>Pteronarcella badia</i>	40	34	29	30
<i>Pteronarcys californica</i>	1	0	0	0
Perlodidae				
<i>Skwala parallela</i>	2	3	4	17
<i>Isoperla</i> sp.	0	9	9	0
<i>Isogenus</i> sp.	6	1	12	0
Taeniopterygidae				
<i>Taenionema</i> sp.	0	12	1	5
Trichoptera				
Brachycentridae				
<i>Brachycentrus</i> sp.	0	1	2	3
Hydropsychidae				
<i>Hydropsyche</i> sp.	7	12	21	21
<i>Cheumatopsyche</i> sp.	0	0	0	1
Glossosomatidae				
<i>Glossosoma</i> sp.	0	0	1	1
Diptera				
Chironomidae	289	161	10	94

Table 31. Numbers and taxa of aquatic insects collected on
four 0.2m² artificial substrate samplers from the
East Gallatin River at Station 2 on February 21, 1983.

STATION 2				
Taxon	Samplers A	B	C	D
Ephemeroptera				
Baetidae				
<i>Baetis tricaudatus</i>	507	395		
Ephemerellidae				
<i>Ephemerella infrequens</i> - <i>E. inermis</i>	8	20		
<i>Drunella grandis</i>	1	1		
Heptageniidae				
<i>Rhithrogena hagenii</i> - <i>R. morrisoni</i>	1	1		
Plecoptera				
Pteronarcidae				
<i>Pteronarcella badia</i>	1	16		
Perlodidae				
<i>Skwala parallela</i>	32	20		
Taeniopterygidae				
<i>Taenionema</i> sp.	1	3		
Trichoptera				
Hydropsychidae				
<i>Hydropsyche</i> sp.	4	0		
<i>Cheumatopsyche</i> sp.	0	2		
Diptera				
Chironomidae	283	515		

SAMPLERS DESTROYED

SAMPLERS DESTROYED

Table 32. Numbers and taxa of aquatic insects collected on
four 0.2m² artificial substrate samplers from the
East Gallatin River at Station 3 on February 21, 1983.

STATION 3				
Taxon	Samplers A	B	C	D
Ephemeroptera				
Baetidae				
<i>Baetis tricaudatus</i>	33	22	47	67
Ephemerellidae				
<i>Ephemerella infrequens</i> - <i>E. inermis</i>	5	5	1	1
<i>Drunella grandis</i>	21	24	23	9
Plecoptera				
Pteronarcidae				
<i>Pteronarcella badia</i>	1	3	5	1
Perlodidae				
<i>Skwala parallela</i>	1	1	1	0
Taeniopterygidae				
<i>Taenionema</i> sp.	0	0	2	0
Trichoptera				
Brachycentridae				
<i>Brachycentrus</i> sp.	1	0	3	1
Hydropsychidae				
<i>Hydropsyche</i> sp.	9	0	0	11
<i>Cheumatopsyche</i> sp.	0	0	0	1
Diptera				
Chironomidae	240	320	366	273
Simuliidae				
<i>Simulium</i> sp.	0	0	0	2
Tipulidae				
<i>Tipula</i> sp.	1	0	0	0
Athericidae				
<i>Antherix pachypus</i>	0	0	0	1

Table 33. Numbers and taxa of aquatic insects collected on
four 0.2m² artificial substrate samplers from the
East Gallatin River at Station 4 on February 21, 1983.

STATION 4				
Taxon	Samplers A	B	C	D
Ephemeroptera				
Baetidae				
<i>Baetis tricaudatus</i>	33	15	16	12
Ephemerellidae				
<i>Ephemerella infrequens</i> - <i>E. inermis</i>	0	3	3	1
<i>Drunella grandis</i>	0	5	8	1
Heptageniidae				
<i>Rhithrogena hagenii</i> - <i>R. morrisoni</i>	0	3	2	1
Plecoptera				
Pteronarcidae				
<i>Pteronarcella badia</i>	2	0	0	0
Perlodidae				
<i>Skwala parallela</i>	1	0	1	1
Trichoptera				
Hydropsychidae				
<i>Hydropsyche</i> sp.	4	2	5	6
Diptera				
Chironomidae	31	7	12	4
Simuliidae				
<i>Simulium</i> sp.	0	2	0	0

Table 34. Numbers and taxa of aquatic insects collected on four 0.2m² artificial substrate samplers from the East Gallatin River at Station 1 on March 31, 1983.

STATION 1				
Taxon	Samplers A	B	C	D
Ephemeroptera				
Baetidae				
<i>Baetis tricaudatus</i>	13	8	26	20
Ephemerellidae				
<i>Ephemerella infrequens</i> - <i>E. inermis</i>	15	10	24	15
<i>Drunella grandis</i>	35	30	28	20
Heptageniidae				
<i>Rhithrogena hagenii</i> - <i>R. morrisoni</i>	2	1	2	2
Plecoptera				
Pteronarcidae				
<i>Pteronarcella badia</i>	23	57	57	38
Perlodidae				
<i>Skwala parallela</i>	12	0	3	3
<i>Isoperla</i> sp.	1	3	0	0
<i>Isogenus</i> sp.	2	2	3	6
Trichoptera				
Brachycentridae				
<i>Brachycentrus</i> sp.	17	14	30	11
Hydropsychidae				
<i>Hydropsyche</i> sp.	91	66	92	113
<i>Cheumatopsyche</i> sp.	4	2	4	5
Glossosomatidae				
<i>Glossosoma</i> sp.	0	0	3	0
Diptera				
Chironomidae	128	63	85	71
Athericidae				
<i>Antherix pachypus</i>	1	0	0	0
Coleoptera				
Elmidae				
<i>Lara</i> sp.	0	0	1	0
<i>Zaitzevia</i> sp.	1	0	0	1

Table 35. Numbers and taxa of aquatic insects collected on
four 0.2m² artificial substrate samplers from the
East Gallatin River at Station 2 on March 31, 1983.

STATION 2				
Taxon	Samplers A	B	C	D
Ephemeroptera				
Baetidae				
<i>Baetis tricaudatus</i>	115	67	160	161
Ephemerellidae				
<i>Ephemerella infrequens</i> - <i>E. inermis</i>	20	13	8	15
<i>Drunella grandis</i>	9	13	11	11
Heptageniidae				
<i>Rhithrogena hagenii</i> - <i>R. morrisoni</i>	3	1	3	3
Plecoptera				
Pteronarcidae				
<i>Pteronarcella badia</i>	7	15	0	6
Perlodidae				
<i>Skwala parallela</i>	3	3	4	2
<i>Isoperla</i> sp.	1	3	6	7
<i>Isogenus</i> sp.	0	2	2	0
Taeniopterygidae				
<i>Taenionema</i> sp.	0	1	0	1
Trichoptera				
Brachycentridae				
<i>Brachycentrus</i> sp.	5	1	1	3
Hydropsychidae				
<i>Hydropsyche</i> sp.	27	28	19	30
<i>Cheumatopsyche</i> sp.	1	1	0	1
Glossosomatidae				
<i>Glossosoma</i> sp.	0	0	1	0
Diptera				
Chironomidae	76	83	17	129
Athericidae				
<i>Antherix pachypus</i>	1	0	0	0

Table 36. Numbers and taxa of aquatic insects collected on
four 0.2m² artificial substrate samplers from the
East Gallatin River at Station 3 on March 31, 1983.

STATION 3				
Taxon	Samplers A	B	C	D
Ephemeroptera				
Baetidae				
<i>Baetis tricaudatus</i>	8	14	17	10
Ephemerellidae				
<i>Ephemerella infrequens</i> - <i>E. inermis</i>	3	8	7	5
<i>Drunella grandis</i>	32	32	27	44
Heptageniidae				
<i>Rhithrogena hagenii</i> - <i>R. morrisoni</i>	4	1	0	0
Leptophlebiidae				
<i>Paraleptophlebia</i> sp.	1	0	0	0
Plecoptera				
Pteronarcidae				
<i>Pteronarcella badia</i>	9	14	13	9
<i>Pteronarcys californica</i>	0	0	0	2
Perlodidae				
<i>Skwala parallela</i>	7	1	7	5
<i>Isoperla</i> sp.	9	0	5	0
<i>Isogenus</i> sp.	0	4	2	0
Taeniopterygidae				
<i>Taenionema</i> sp.	1	0	2	0
Trichoptera				
Brachycentridae				
<i>Brachycentrus</i> sp.	0	7	2	5
Hydropsychidae				
<i>Hydropsyche</i> sp.	36	26	24	37
<i>Cheumatopsyche</i> sp.	1	1	1	0
Glossosomatidae				
<i>Glossosoma</i> sp.	1	0	0	0

Table 36. Numbers and taxa of aquatic insects collected on
 (continued)
 four 0.2m² artificial substrate samplers from the
 East Gallatin River at Station 3 on March 31, 1983.

STATION 3				
Taxon	Samplers A	B	C	D
Diptera				
Chironomidae	7	57	82	134
Tipulidae				
<i>Tipula</i> sp.	3	1	1	0
<i>Hexatoma</i> sp.	3	0	0	0
Athericidae				
<i>Antherix pachypus</i>	0	2	0	0
Coleoptera				
Elmidae				
<i>Lara</i> sp.	0	0	0	1
<i>Zaitzevia</i> sp.	0	2	0	0

Table 37. Numbers and taxa of aquatic insects collected on
four 0.2m² artificial substrate samplers from the
East Gallatin River at Station 4 on March 31, 1983.

STATION 4				
Taxon	Samplers A	B	C	D
Ephemeroptera				
Baetidae				
<i>Baetis tricaudatus</i>	17	14	10	17
Ephemerellidae				
<i>Ephemerella infrequens</i> - <i>E. inermis</i>	7	1	6	7
<i>Drunella grandis</i>	0	0	4	0
Heptageniidae				
<i>Rhithrogena hagenii</i> - <i>R. morrisoni</i>	1	0	2	2
Plecoptera				
Pteronarcidae				
<i>Pteronarcella badia</i>	0	1	1	0
Perlodidae				
<i>Skwala parallela</i>	3	0	2	0
<i>Isoperla</i> sp.	0	1	1	2
Taeniopterygidae				
<i>Taenionema</i> sp.	0	0	0	1
Trichoptera				
Brachycentridae				
<i>Brachycentrus</i> sp.	1	1	2	0
Hydropsychidae				
<i>Hydropsyche</i> sp.	38	40	26	28
<i>Cheumatopsyche</i> sp.	2	2	1	1
Diptera				
Chironomidae	127	98	98	155

Table 33. Numbers and taxa of aquatic insects collected on
four 0.2m² artificial substrate samplers from the
East Gallatin River at Station 1 on September 23, 1983.

STATION 1				
Taxon	Samplers A	B	C	D
Ephemeroptera				
Baetidae				
<i>Baetis tricaudatus</i>	4	111	140	6
Ephemerellidae				
<i>Ephemerella infrequens</i> - <i>E. inermis</i>	1	0	0	0
<i>Drunella grandis</i>	0	0	1	0
Heptageniidae				
<i>Rhithrogena hagenii</i> - <i>R. morrisoni</i>	0	2	0	3
Tricorythidae				
<i>Tricorythodes minutus</i>	0	4	1	0
Plecoptera				
Pteronarcidae				
<i>Pteronarcella badia</i>	13	17	29	9
Perlodidae				
<i>Skwala parallela</i>	9	3	3	6
Trichoptera				
Brachycentridae				
<i>Brachycentrus</i> sp.	11	23	15	12
Hydropsychidae				
<i>Hydropsyche</i> sp.	82	155	108	112
<i>Cheumatopsyche</i> sp.	1	7	5	4
Diptera				
Chironomidae	96	57	39	105
Simuliidae				
<i>Simulium</i> sp.	3	51	66	12
Tipulidae				
<i>Hexatoma</i> sp.	0	1	0	0
Coleoptera				
Elmidae				
<i>Lara</i> sp.	0	0	0	1
<i>Cleptelmis</i> sp.	0	0	2	0

Table 39. Numbers and taxa of aquatic insects collected on
four 0.2m² artificial substrate samplers from the
East Gallatin River at Station 2 on September 23, 1983.

STATION 2				
Taxon	Samplers A	B	C	D
Ephemeroptera				
Baetidae				
<i>Baetis tricaudatus</i>	30	49	18	74
Ephemerellidae				
<i>Drunella grandis</i>	1	0	0	2
Heptageniidae				
<i>Rithrogena hagenii</i> - <i>R. morrisoni</i>	0	1	0	2
Tricorythidae				
<i>Tricorythodes minutus</i>	1	0	0	0
Plecoptera				
Pteronarcidae				
<i>Pteronarcella badia</i>	14	16	19	15
Perlodidae				
<i>Skwala parallela</i>	11	11	10	6
Trichoptera				
Brachycentridae				
<i>Brachycentrus</i> sp.	3	8	17	6
Hydropsychidae				
<i>Hydropsyche</i> sp.	108	137	194	144
<i>Cheumatopsyche</i> sp.	4	6	8	6
Diptera				
Chironomidae	156	53	30	51
Simuliidae				
<i>Simulium</i> sp.	1	6	12	59
Athericidae				
<i>Antherix pachypus</i>	6	1	4	0
Coleoptera				
Elmidae				
<i>Lara</i> sp.	0	0	1	0

Table 40. Numbers and taxa of aquatic insects collected on
four 0.2m² artificial substrate samplers from the
East Gallatin River at Station 3 on September 23, 1983.

STATION 3				
Taxon	Samplers A	B	C	D
Ephemeroptera				
Baetidae				
<i>Baetis tricaudatus</i>	23	128	64	112
Ephemerellidae				
<i>Drunella grandis</i>	0	1	0	2
Heptageniidae				
<i>Rhithrogena hagenii</i> - <i>R. morrisoni</i>	2	6	1	1
Tricorythidae				
<i>Tricorythodes minutus</i>	2	0	0	0
Plecoptera				
Pteronarcidae				
<i>Pteronarcella badia</i>	9	3	8	21
Perlodidae				
<i>Skwala parallela</i>	5	7	6	5
Trichoptera				
Brachycentridae				
<i>Brachycentrus</i> sp.	3	8	11	13
Hydropsychidae				
<i>Hydropsyche</i> sp.	86	97	140	146
<i>Cheumatopsyche</i> sp.	0	4	3	6
Diptera				
Chironomidae	56	87	24	56
Simuliidae				
<i>Simulium</i> sp.	29	26	26	37
Athericidae				
<i>Antherix pachypus</i>	1	0	1	1

Table 41. Numbers and taxa of aquatic insects collected on
four 0.2m² artificial substrate samplers from the
East Gallatin River at Station 4 on September 23, 1983.

STATION 4				
Taxon	Samplers A	B	C	D
Ephemeroptera				
Baetidae				
<i>Baetis tricaudatus</i>	22	44	9	17
Ephemerellidae				
<i>Drunella grandis</i>	3	2	1	0
Heptageniidae				
<i>Rhithrogena hagenii</i> - <i>R. morrisoni</i>	1	1	5	1
Tricorythidae				
<i>Tricorythodes minutus</i>	0	1	0	1
Plecoptera				
Pteronarcidae				
<i>Pteronarcella badia</i>	9	1	2	23
Perlodidae				
<i>Skwala parallela</i>	16	10	16	5
Perlidae				
<i>Hesperoperla pacifica</i>	0	0	1	0
Trichoptera				
Brachycentridae				
<i>Brachycentrus</i> sp.	1	2	2	4
Hydropsychidae				
<i>Hydropsyche</i> sp.	198	55	80	327
<i>Cheumatopsyche</i> sp.	8	2	4	13
Diptera				
Chironomidae	104	74	76	41
Simuliidae				
<i>Simulium</i> sp.	3	0	0	0
Tipulidae				
<i>Tipula</i> sp.	0	0	2	2
<i>Hexatoma</i> sp.	0	0	1	1
Athericidae				
<i>Antherix pachypus</i>	8	0	0	2

Table 42. Numbers and taxa of aquatic insects collected on
four 0.2m² artificial substrate samplers from the
East Gallatin River at Station 1 on October 20, 1983.

STATION 1				
Taxon	Samplers A	B	C	D
Ephemeroptera				
Baetidae				
<i>Baetis tricaudatus</i>	1	0	0	1
Ephemerellidae				
<i>Ephemerella infrequens</i> - <i>E. inermis</i>	2	0	1	1
Heptageniidae				
<i>Rhithrogena hagenii</i> - <i>R. morrisoni</i>	1	0	1	2
Leptophlebiidae				
<i>Paraleptophlebia</i> sp.	0	1	2	2
Plecoptera				
Pteronarcidae				
<i>Pteronarcella badia</i>	1	9	6	14
Perlodidae				
<i>Skwala parallela</i>	4	16	11	18
Trichoptera				
Brachycentridae				
<i>Brachycentrus</i> sp.	7	18	18	12
Hydropsychidae				
<i>Hydropsyche</i> sp.	18	35	45	49
<i>Cheumatopsyche</i> sp.	0	1	2	2
Diptera				
Chironomidae	1	28	40	14
Tipulidae				
<i>Tipula</i> sp.	1	0	0	0
<i>Hexatoma</i> sp.	0	1	0	0
Athericidae				
<i>Antherix pachypus</i>	0	0	0	1
Coleoptera				
Elmidae				
<i>Lara</i> sp.	0	3	0	1
<i>Cleptelmis</i> sp.	0	0	1	0

Table 43. Numbers and taxa of aquatic insects collected on
four 0.2m² artificial substrate samplers from the
East Gallatin River at Station 2 on October 20, 1983.

STATION 2				
Taxon	Samplers A	B	C	D
Ephemeroptera				
Baetidae				
<i>Baetis tricaudatus</i>	3	4	3	0
Ephemerellidae				
<i>Ephemerella infrequens</i> - <i>E. inermis</i>	1	0	0	0
Heptageniidae				
<i>Rhithrogena hagenii</i> - <i>R. morrisoni</i>	2	5	0	0
Plecoptera				
Pteronarcidae				
<i>Pteronarcella badia</i>	5	5	9	10
Perlodidae				
<i>Skwala parallela</i>	5	5	6	4
Trichoptera				
Brachycentridae				
<i>Brachycentrus</i> sp.	1	1	2	0
Hydropsychidae				
<i>Hydropsyche</i> sp.	5	34	30	18
<i>Cheumatopsyche</i> sp.	0	1	1	0
Diptera				
Chironomidae	29	22	28	59
Athericidae				
<i>Antherix pachypus</i>	1	0	1	0

Table 44. Numbers and taxa of aquatic insects collected on
four 0.2m² artificial substrate samplers from the
East Gallatin River at Station 3 on October 20, 1983.

STATION 3				
Taxon	Samplers A	B	C	D
Ephemeroptera				
Baetidae				
<i>Baetis tricaudatus</i>	1	0		0
Ephemerellidae				
<i>Drunella grandis</i>	0	1		0
Heptageniidae				
<i>Rhithrogena hagenii-R. morrisoni</i>	1	3		0
Plecoptera				
Pteronarcidae				
<i>Pteronarcella badia</i>	12	12	SAMPLERS DESTROYED	17
Perlodidae				
<i>Skwala parallela</i>	11	10		14
Trichoptera				
Brachycentridae				
<i>Brachycentrus</i> sp.	1	11		5
Hydropsychidae				
<i>Hydropsyche</i> sp.	42	99		100
<i>Cheumatopsyche</i> sp.	2	4		4
Glossosomatidae				
<i>Glossosoma</i> sp.	0	0		1
Diptera				
Chironomidae	9	12		7
Simuliidae				
<i>Simulium</i> sp.	0	1		0

Table 45. Numbers and taxa of aquatic insects collected on
four 0.2m² artificial substrate samplers from the
East Gallatin River at Station 4 on October 20, 1983.

STATION 4				
Taxon	Samplers A	B	C	D
Ephemeroptera				
Baetidae				
<i>Baetis tricaudatus</i>	0	0	1	1
Ephemerellidae				
<i>Ephemerella infrequens</i> - <i>E. inermis</i>	0	0	3	0
<i>Drunella grandis</i>	0	1	1	0
Heptageniidae				
<i>Rhithrogena hagenii</i> - <i>R. morrisoni</i>	0	13	5	0
Leptophlebiidae				
<i>Paraleptophlebia</i> sp.	0	0	1	0
Plecoptera				
Pteronarcidae				
<i>Pteronarcella badia</i>	28	0	7	4
Perlodidae				
<i>Skwala parallela</i>	14	5	15	10
Trichoptera				
Brachycentridae				
<i>Brachycentrus</i> sp.	5	1	1	1
Hydropsychidae				
<i>Hydropsyche</i> sp.	45	29	30	7
<i>Cheumatopsyche</i> sp.	2	0	0	0
Diptera				
Chironomidae	6	48	44	9
Simuliidae				
<i>Simulium</i> sp.	0	1	4	0
Tipulidae				
<i>Tipula</i> sp.	1	0	0	1
Athericidae				
<i>Antherix pachypus</i>	0	0	0	1
Coleoptera				
Elmidae				
<i>Lara</i> sp.	1	0	2	0

Table 46. Mean number of genera per samplers at study stations
on the East Gallatin River from November 1982 - October
1983.

DATE	STATIONS			
	1	2	3	4
11/82	2.50	2.75	2.50	2.50
12/82	2.00	2.75	2.00	1.50
1/83	2.25	2.50	2.50	1.50
2/83	3.50	2.25	3.00	2.00
3/83	3.75	3.50	5.00	2.75
9/83	3.50	3.00	2.75	3.50
10/83	3.50	2.25	2.50	3.50

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