Nitrate Nitrogen

Introduction

Nitrate-N is the fully oxidized form of nitrogen, therefore, except under conditions of pollution (reduced environment), will occur naturally in streams (Hynes, 1970). The main sources of Nitrate-N in streams are rainfall, groundwater and the land surface (Hynes, 1970). Nitrate-N is the most readily available form of nitrogen to photosynthetic autotrophs, and in some cases it has been identified as a growth-limiting nutrient (APHA, 1980). The safe drinking water limit is 10 mg/L N-NO_3 and this is exceeded a number of times in our area in the spring and fall. Nitrate-N is very soluble in water and does not attach to soil or sediment very well.

Baseline

Concentrations of N-NO_3 in1984 followed the historic data fairly closely (Figure 16). Greater concentrations occurred in June with a steady decrease as the summer progressed. Minimum concentrations occurred in September followed by increasing concentrations in October. The increase in October and November, during normal low flow, is most likely due to the decomposition of leaf litter and the application of N-NH_3 followed by conversion of some to NO_3.

The increase in concentration, which occurred on the 7-23 sampling date, may be associated with the sampling occurring on the ascending leg of a hydrologic event due to rain fall in the Iowa/Minnesota border stretch of the Blue Earth River. An increase in flow from the previous day was recorded on the sampling date at the USGS flow station just below the Rapidan Dam. Although flow was abnormally high in May, June, and July, concentrations were only slightly greater than historic concentrations for the same months.

In 1985, minimum concentrations occurred much earlier than historic patterns. This is due to the abnormally low flow in July and early August. The increase in concentration, which the historic data depicts as beginning in October, occurs in late August of 1985. This again, is attributed to flow, which was very high in late August.

No impacts by either the reservoir or the two tributaries on mainstem concentrations were observed.

Peaks

Nitrate-N concentrations followed flow very closely. Concentrations at S5 did not appear to be significantly different when comparing all three peak-events (Figures 17,18,19). Site S3 concentrations during the 8-30 peak-event were much greater than the other three sites involved, and cannot be explained at this time. As the initial water surge moved downstream, concentrations at S6 (8-26 event), and S6 and S8 (both of the 8-30 event), show significant increases in Nitrate-N. Recruitment from bank storage and scouring of stream sediments can be attributed to these increases in concentration.

The increases of Nitrate-N at sites S6 and S8 may appear to be significant, but when compared to the baseline data they actually are not. The minimum baseline concentration for the entire sampling periods of 1984 and 1985 at sites S5, S6, and S8 were approximately equal to the maximum concentrations occurring at these sites during each peak-event. Baseline maximums at these three sites during the entire sampling periods of 1984-1985 ranged between 10.00 mg/l to 13.99 mg/l N-NO_3. Peak concentrations at S5, S6, and S8 during all three peak events, did not reach or exceed the minimum historic baseline concentration of 0.43 mg/l during the months of June through October. Therefore, it can be concluded that the peaking operation of the dam was not affecting Nitrate-N concentration to any significant degree.

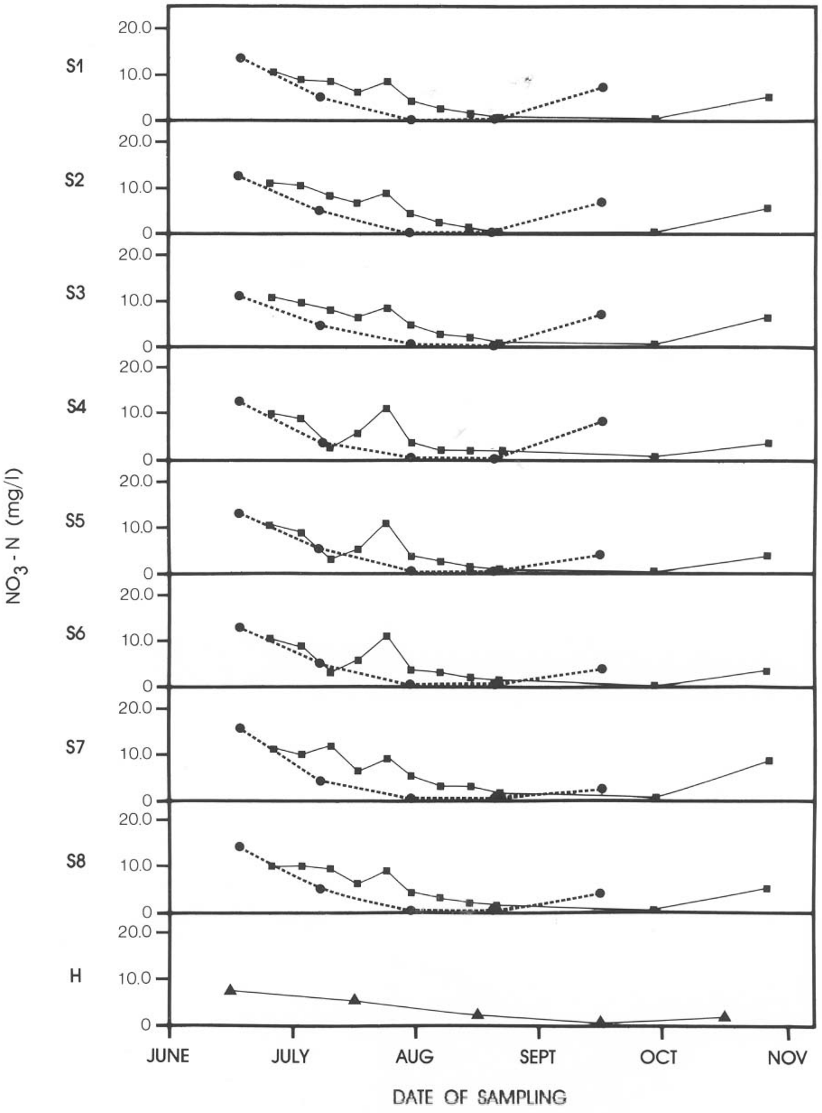

Figure 16. Baseline Nitrate-Nitrogen for 1984 (■) and 1985 (●) sampling seasons at Sites S1-S8, and historic record for Blue Earth – 0 (▲).

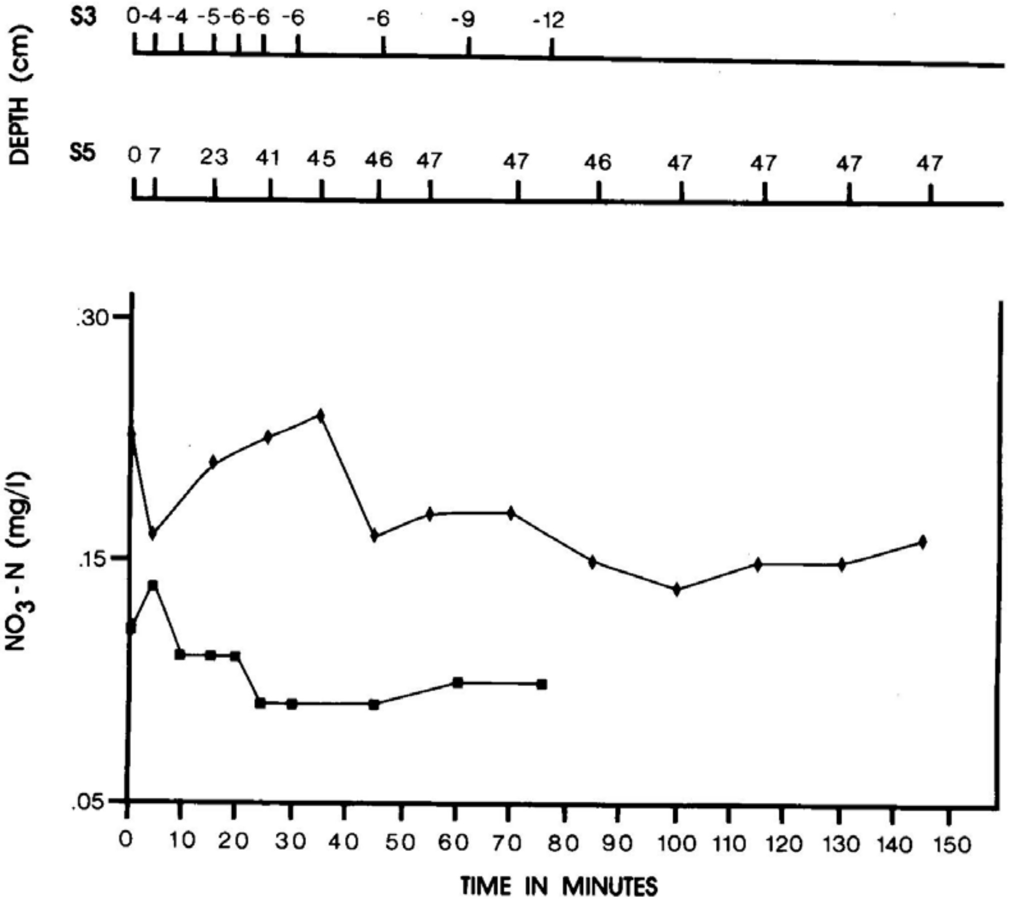

Figure 17. Nitrate-Nitrogen for peak event of August 9, 1985 at Sites S3 (■) and S5 (♦).

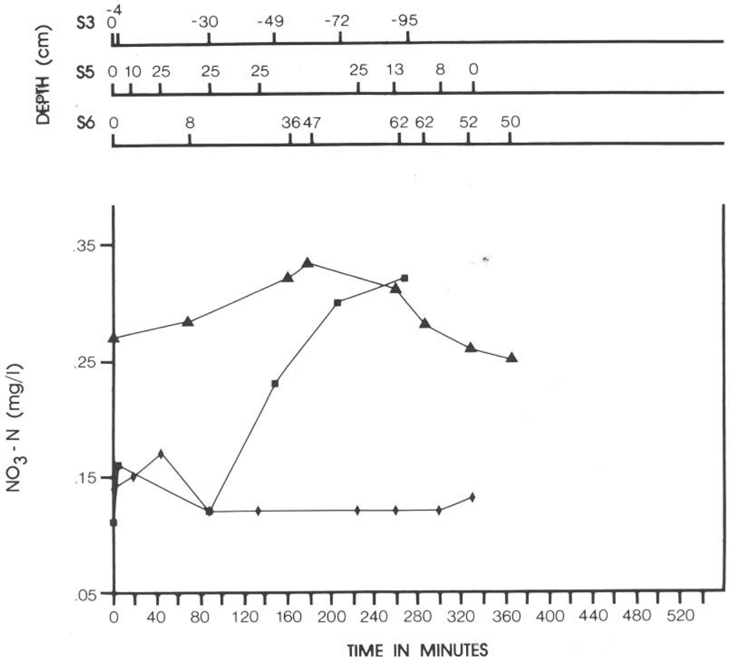

Figure 18. Nitrate-Nitrogen for peak event of August 26, 1985 at Sites S3 (■), S5 (♦) and S6 (▲).

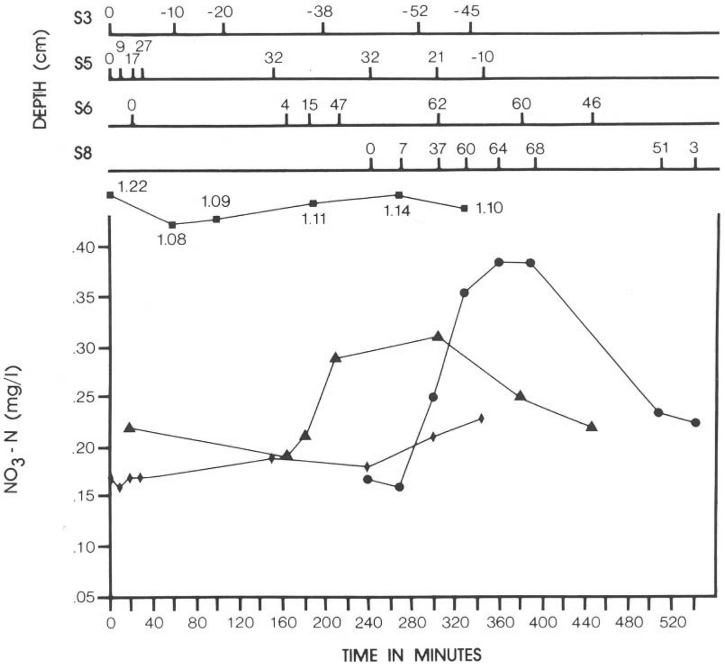

Figure 19. Nitrate-Nitrogen for peak event of August 30, 1985 at Sites S3 (■), S5 (♦), S6 (▲) and S8 (●) .

Nitrite-Nitrogen

Introduction

Nitrite-N is an intermediate oxidation state of nitrogen, both in the oxidation of ammonia to Nitrite, and in the reduction of nitrate (APHA, 1976). Concentrations of nitrite are usually very low unless organic pollution is high such as in the interstitial waters of sediments in eutrophic lakes (Wetzel, 1983). This could be the case in the interstitial waters (hyporheic zone) of nutrient laden rivers.

Baseline

Concentrations (in units of ppb) in 1984 followed historic data patterns closely except for a sharp increase at all sites in October (Figure 20). An increase in Nitrite-N during August was especially evident at sites S4 through S8. Increased rates of decomposition may have been occurring within the reservoir, thereby producing the higher concentrations of Nitrite-N than at sites upstream of the reservoir.

There does not appear to be any consistent impact by the tributaries on mainstem concentrations, however the reservoir does appear to impact mainstem concentrations by increasing them in its tailwaters during the months of August in 1984, and July in 1985.

Peaks

Concentrations at S3 during the 8-26 peak-event followed a very similar pattern, as did Nitrate-N, where an increase was seen throughout the decrease in water level at the site. Concentrations were also very high at S3 during the 8-30 event. The high concentrations could have been due to nitrification occurring at the site (Figures 21, 22, 23).

The peaks in concentration at sites S6 and S8 during the 8-26 and 8-30 events did not show the increases that were seen with Nitrate-N, however, less dramatic increases were present at these sites.

The greatest concentration which occurred downstream of the reservoir during all three peak-events was 1.91ug/l at S5 during the 8-9 event (a 65% increase). A decrease of 83% in concentration occurred with the onset of the peak plateau. This concentration was much lower than the maximum concentrations occurring during the entire sampling period of 1984-1985 at S5, S6, and S8. The range of maximum baseline concentrations at these three sites was 11.00 ug/l to 28.00 ug/l. The minimum, historic baseline monthly mean concentration at BE-0, for the months of June through October was 18 ug/l. Therefore, the maximum peak event concentration of 1.91 ug/l is insignificant. It can be concluded that the peaking operation of the Rapidan Dam has no significant impact on downstream Nitrite-N concentrations.

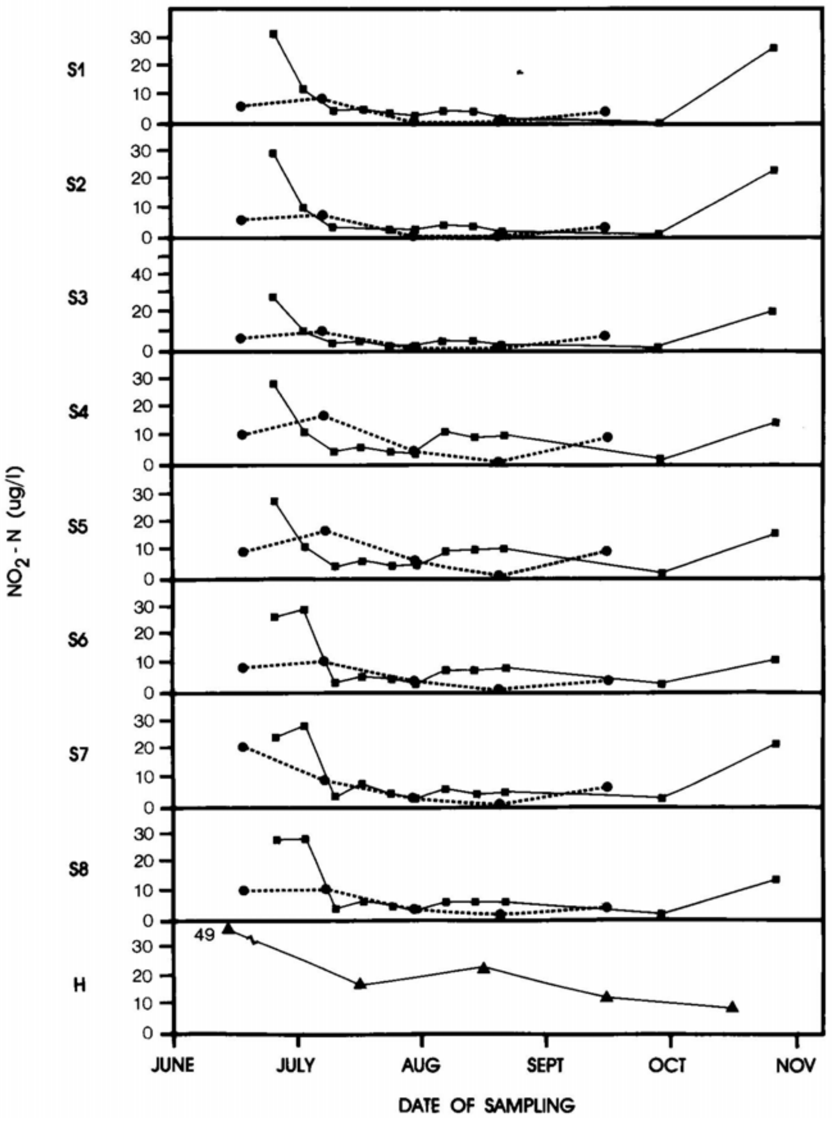

Figure 20. Baseline Nitrite-Nitrogen for 1984 (■) and 1985 (●) sampling seasons at Sites S1-S8, and historic record for Blue Earth – 0 (▲).

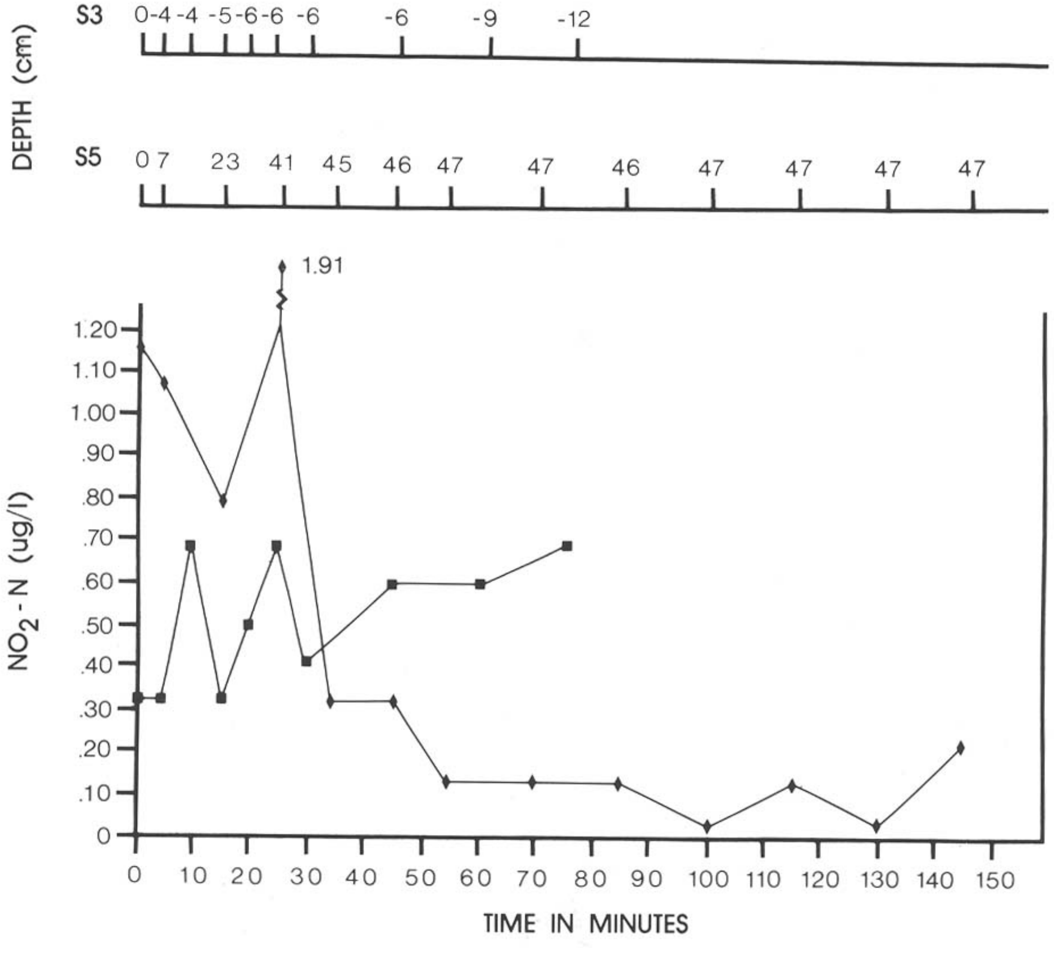

Figure 21. Nitrite-Nitrogen for peak event of August 9, 1985 at Sites S3 (■) and S5 (♦).

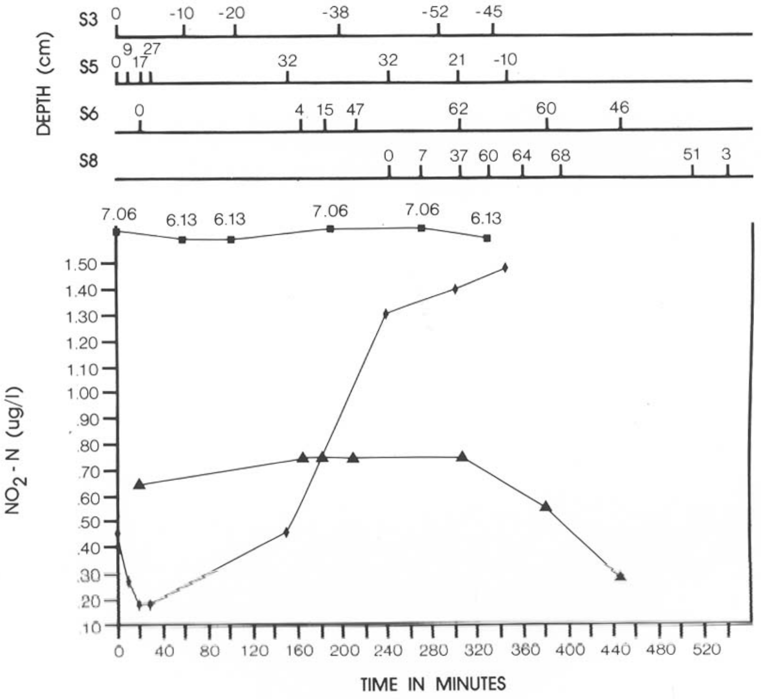

Figure 22. Nitrite-Nitrogen for peak event of August 26, 1985 at Sites S3 (■), S5 (♦) and S6 (▲).

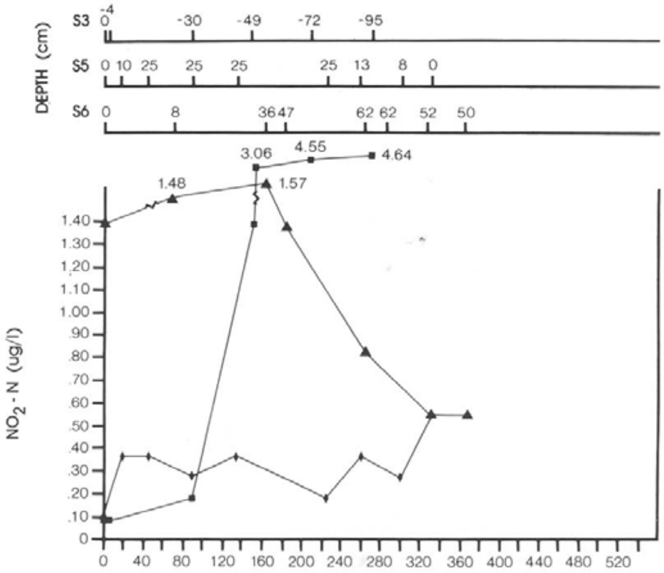

Figure 23. Nitrite-Nitrogen for peak event of August 30, 1985 at Sites S3 (■), S5 (♦), S6 (▲) and S8 (●) .

Total Phosphorus

Introduction

Phosphorus can be found in natural systems as inorganic forms and incorporated into organic compounds (APHA, 1980), both of which can be precipitated out of the water column within a reservoir.

Baseline

Historic Total-P at BE-0 was high in June and gradually decreased throughout the summer months, and continued to decrease into the month of October (Figure 24). Surprisingly, concentrations during June of 1984 were lower at most sites than historic values, despite the very high flow rates occurring at this time. Total-P in 1984 did follow historic patterns rather well in terms of a gradual decrease throughout summer. However, the decrease did lead to below historic concentrations. Concentrations did begin to increase to historic levels in October at all sites.

Despite a relatively normal flow year up until the month of June in 1985 concentrations began the sample period in June lower than historic means. Total-P at all sites except S4, followed the usual decrease as the summer progressed to below normal concentrations. Concentrations at S4 increased slightly between June and August. This increase could be attributed to the drought conditions occurring during July and early August, and the subsequent concentrating of Total-P due to evaporation within the reservoir, and/or high rates of decomposition within the reservoir. Total-P between the 7/30 and 9/15 sampling dates, did increase to greater than historic concentrations. This increase is most likely due to the abnormally high rainfall and subsequent increasing overland flow causing more runoff and an increased amount of TSS. Also if dissolved oxygen levels in the reservoir became limiting, phosphorus would have been released by the sediments.

The reservoir did show evidence of acting as a trap for Total-P by lowering mainstem concentrations downstream during a majority of the sampling dates.

Peaks

Total phosphorus concentrations reached or exceeded baseline maximums during all three peak-events at various downstream sites, but did not reach the mean monthly historic maximum for June through October at BE-0 at 0.51 mg/l.

> August 9: Total-P concentrations at S5 saw an increase during the ascending leg of 80% (Figure 25). Concentrations decreased with the onset of the peak plateau. Concentrations at S3 showed an initial decrease during the ascending leg and then a rise with a gradual rise through the remaining peak plateau.
>
> August 26: Pre sample concentrations were very similar at all sites (Figure 26). Total Phosphorus concentrations at S5 increased 23%, at S6-138% and at S3-43%.
>
> August 30: Pre sample concentrations were fairly similar. Total Phosphorus concentrations at S5 increased 18%, at S6-160%, and at S8-125% and decreased 19% at S3 (Figure 27).

One must keep in mind that flow rates in the Blue Earth River were on the increase, beginning approximately one week prior to the 8-26 event, and continued into the 8-30 peak-event with record rainfall occurring for the month of August in 1985. This may account for the greater concentrations during the 8-30 event when compared to the 8-26 peak-event.

The initial downstream surge of water released from the turbine outlets produced an increase in Total-P comparable to a natural hydrologic event caused by approximately one to two inches of rainfall. However, the significant increases in Total-P were seen 13.1 river km to 16.0 river km (8.1 river mi to 9.9 river mi) downstream with insignificant increases occurring 0.6 river km (0.4 river mi) downstream of the dam. The greater concentrations occurring downstream of S5 may have been attributed to sources including scouring of sediments and recruitment from bank storage as downstream water levels increased.

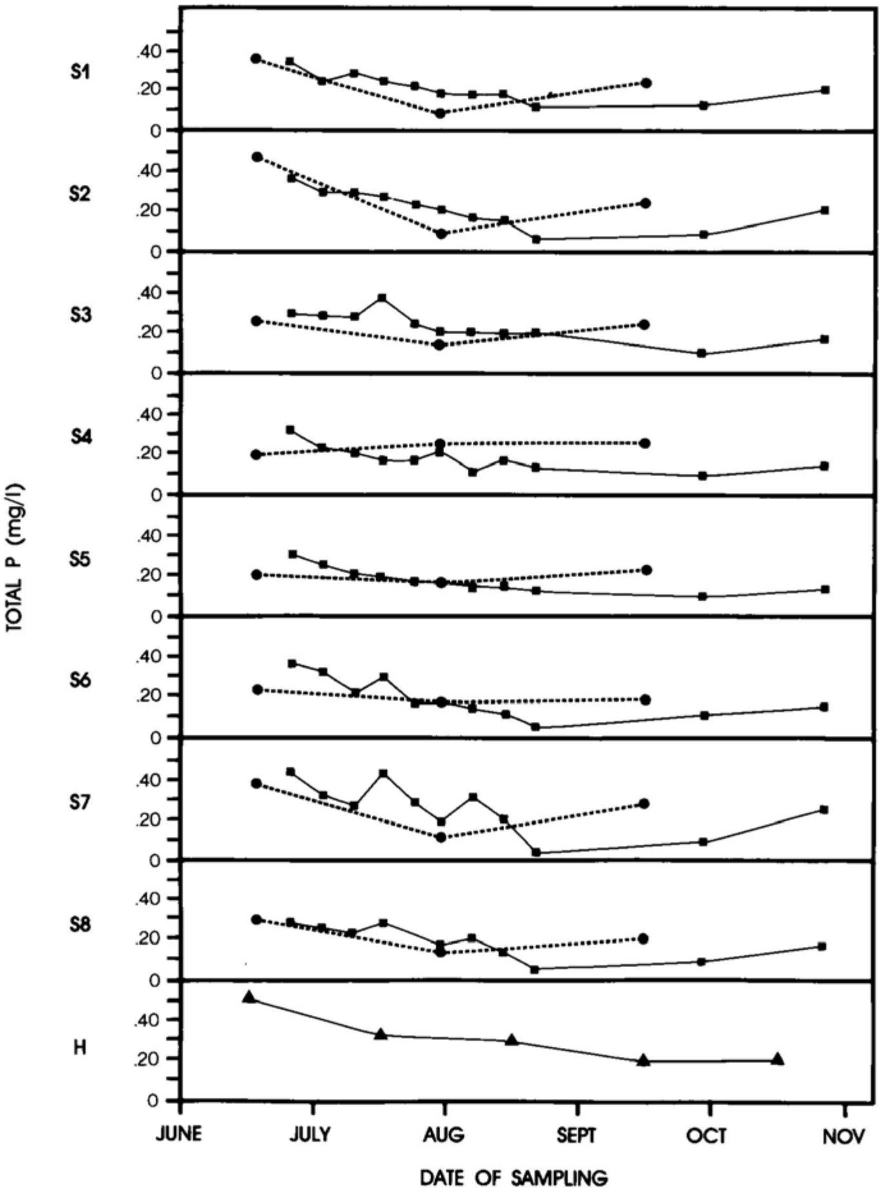

Figure 24. Baseline Total Phosphorus for 1984 (■) and 1985 (●) sampling seasons at Sites S1-S8, and historic record for Blue Earth- 0 (▲).

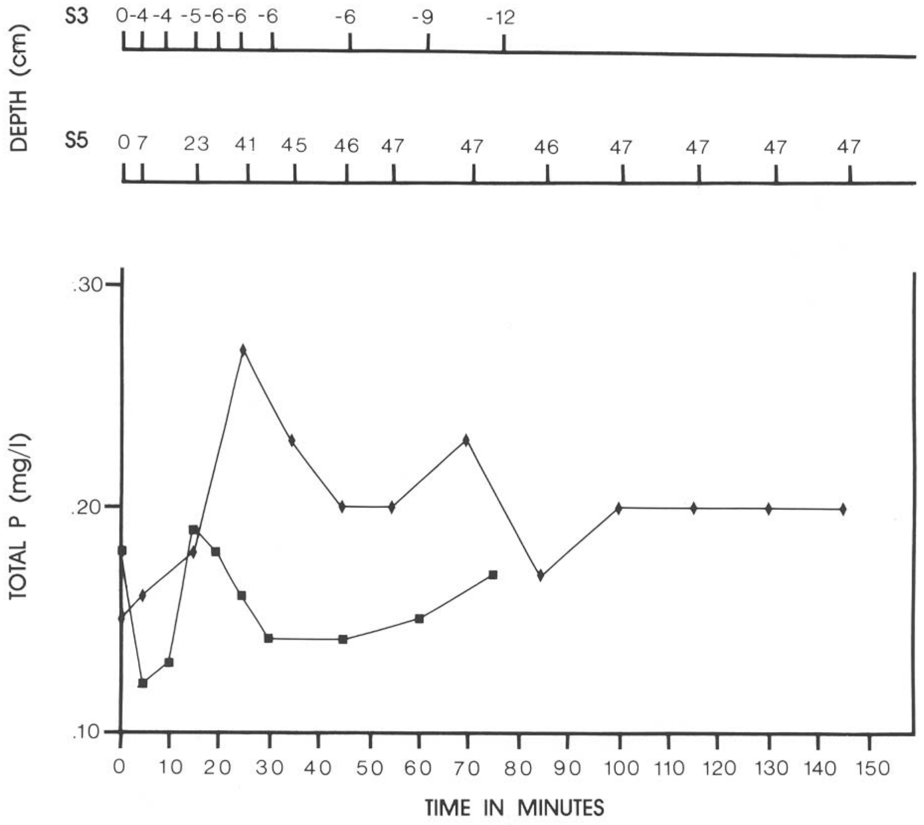

Figure 25. Total Phosphorus for peak event of August 9, 1985 at Sites S3 (■) and S5 (♦).

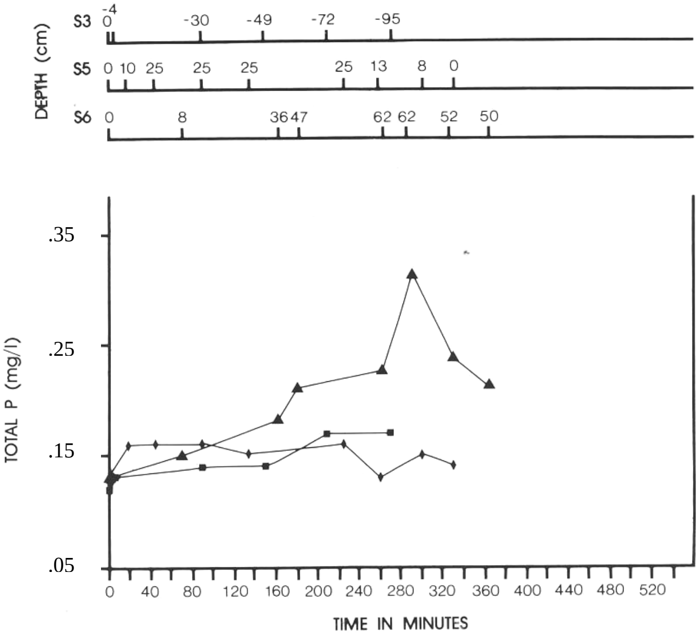

Figure 26. Total Phosphorus for peak event of August 26, 1985 at Sites S3 (■), S5 (♦) and S6 (▲).

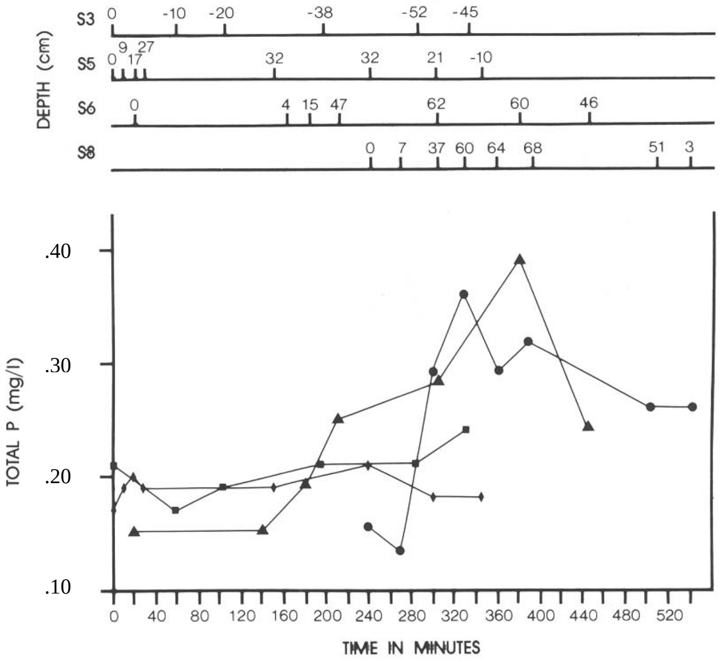

Figure 27. Total Phosphorus for peak event of August 30, 1985 at Sites S3 (■), S5 (♦), S6 (▲) and S8 (●) .

Filterable Phosphorus

Introduction

Filterable Phosphorous (Orthophosphate PO_4^{3-}) is the only directly utilizable from of soluble inorganic phosphorous. Phosphate is extremely reactive and interacts with Fe and Ca, under oxidizing conditions, to from insoluble compounds. Filterable phosphate is also reduced by adsorption to inorganic colloids and particulate compounds such as clays, carbonates and hydroxides (Wetzel, 1983). Algae can at time remove almost all Filterable Phosphorous from the water. Filterable phosphorus concentrations are usually expressed in parts per billion (ug/l) because 10 ug/L is the Minnesota Pollution Control Agency Action level for P- PO_4^{3-}. The reader should be cautious when reading this section that there is 1000 fold difference between parts per million (mg/l) used to express Total Phosphorus and parts per billion (ug/L) used to express levels of P- PO_4^{3-}. For example 1 mg/l (part per million) equals 1000 ug/l (parts per billion)

Baseline

The limited baseline data (many samples below detection) that exists for Filterable-P shows a minimum concentration of 40 ug/l (0.040 mg/l) and a maximum concentrations of 120 ug/l (0.120 mg/l) , at S5.

Peaks

During the 8-9 event, the pre sample concentration at S5 (58 ug/l) was greater than the minimum baseline value (Figure 28). However, the peak concentration (74 ug/l) at S5 during the same peak-event did not reach the maximum baseline value. The great increase in Filterable-P at S5 (857 ug/l) during the 8-26 event was due to oil, suspended within the water column, passing through the site. The oil resulted from an oil spill at the dam. The peak concentration at S3 (49 ug/l) was below the minimum baseline concentration of 60 ug/l for this site.

Peak concentrations during the 8-26 and 8-30 events at S6 (49 ug/l and 75 ug/l respectively) and S8 (44 ug/l), resembled an increase in concentration one would normally expect following one to two inches of rainfall (Figure 29, 30). These peak concentrations did not reach the maximum baseline values of 110 ug/l and 130 ug/l at S6 and S8 respectively. The affect of the peaking operation of the dam was magnified as you moved farther downstream, but only as far as S6 (13./1 river km, 8.1 river mi downstream of the dam). The peak concentrations at S8 were much lower than at S6. This could have been due to a diluting affect by the Le Sueur River on S8 Filterable-P concentrations. Similar to the 8-9 event, peak concentrations at S3 during the 8-26 and 8-30 events (42 ug/l and 49 ug/l respectively) never reached the minimum baseline concentration for the site (60 ug/l). The peak concentrations for the latter two events were actually the pre-sample concentrations. Filterable-P possessed an overall decrease during both events, possibly indicating dilution from upstream as flow increased.

The lack of a sufficient number of data points for Filterable-P gives an unclear picture as to the baseline characteristics of this parameter. However, when looking at existing baseline data, Filterable-P did not appear to be impacted as significantly, nor as consistently, as was Total-P downstream of the Rapidan Reservoir due to the peaking operation of the dam.

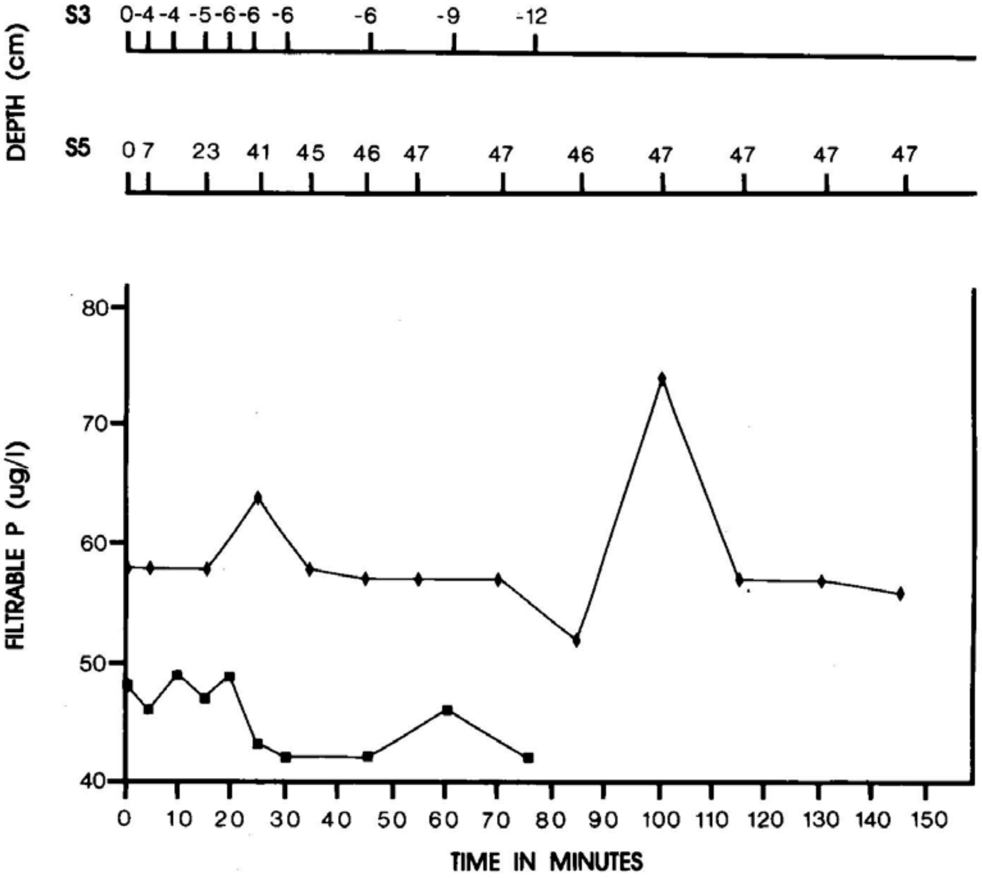

Figure 28. Filterable Phosphorus for peak event of August 9, 1985 at Sites S3 (■) and S5 (♦)

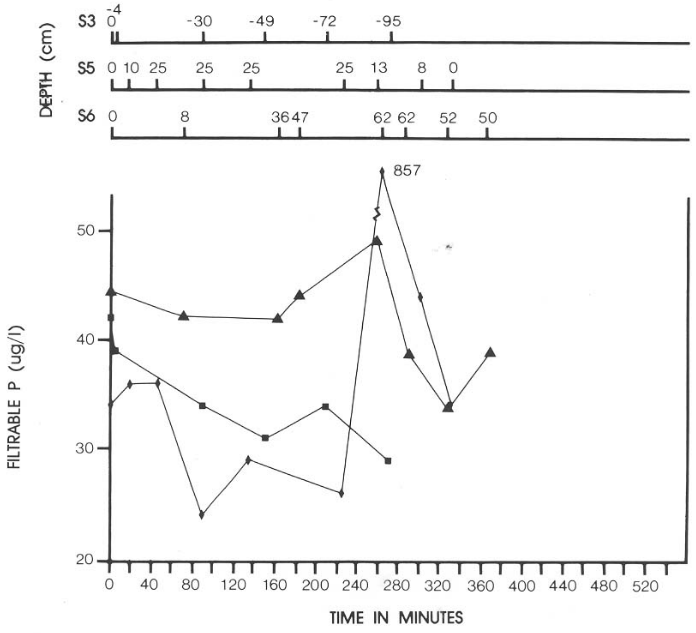

Figure 29. Filterable Phosphorus for peak event of August 26, 1985 at Sites S3 (■), S5 (♦) and S6 (▲)

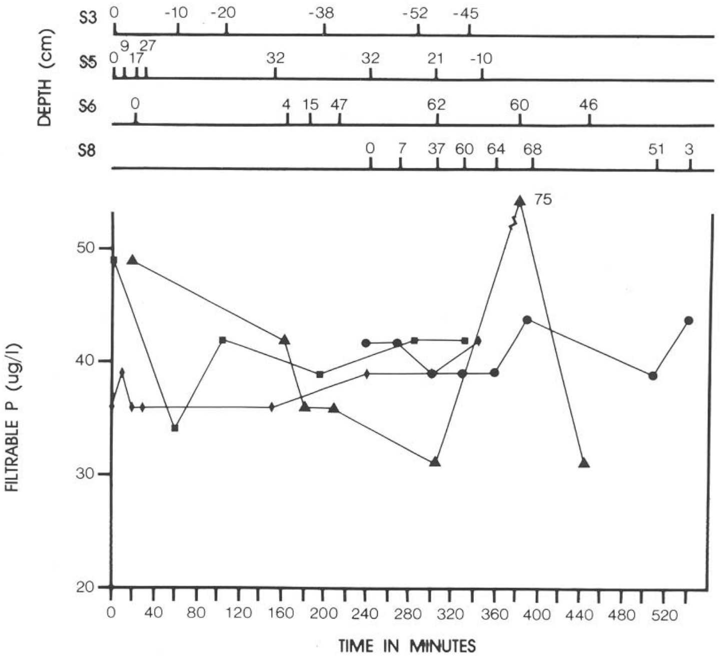

Figure 30. Filterable Phosphorus for peak event of August 30, 1985 at Sites S3 (■), S5 (♦), S6 (▲) and S8 (●).

Total Non-Filterable Residue (TNFR)

Introduction

The term “residue” refers to solid material, organic or inorganic, suspended or dissolved in water. The phrase “total non-filterable residue” refers to the solid material (organic or inorganic) which will not filter through a 0.45 um glass-fiber filter, and therefore becomes trapped in the fibers of the filter (suspended solid material), (APHA, 1980). Turbidity and TNFR are closely correlated, but measured differently. At times of low flow, most streams are normally less turbid than during hydrologic events when large amounts of TNFR may be carried in the water column (Hynes, 1970). Today, TNFR is referred to as Total Suspended Solids or TSS. The relationship between TSS and flow is a fairly well documented phenomenon. Lakes or reservoirs on the course of a stream allow great amounts of TNFR to settle out by reducing the velocity of the stream, thus clarifying the water (Symons et al., 1964).

Baseline

Historic data at BE-0 demonstrates the relationship between flow and TSS very well (Figure 31). TNFR concentrations were greater in June with high flow, gradually decreasing with flow through the months of July and August, and remaining low with flow into October.

In 1984, concentrations were lower at all sites than the historic data, even though flow was above historic records on the 6-25 sampling date. The lower concentrations could be attributed to the fact high flows in March through May resulted in a scouring and flush of the stream resulting in lower TNFR in June. Looking at TNFR concentrations a week later further strengthens this hypothesis. On the 7-2 sampling date, flow decreased and TNFR increased at all sites except S3. Site S3 TNFR increases again on the 7-16 sampling which correlates well with the closing of the dam’s tainter gates to flood the reservoir. The reservoir did show evidence of acting as a trap for TNFR, because sites upstream of the reservoir had greater concentrations than did the sites downstream.

In 1985, TNFR reduced considerably within the reservoir on the first sampling in June. The reservoir appeared to stabilize TNFR at S5 and S6 throughout the entire sample period. Concentrations at all sites began to increase in late August/early September, contrary to historic patterns. This is believed to have occurred due to the abnormally high flow occurring at this time.

The Le Sueur River did contribute elevated TNFR to mainstem concentrations in the Blue Earth River during the entire 1984 and the early season of 1985. This did not happen throughout the 1985 sampling period because of the abnormally low flows. .

Peaks

Overall impacts on TNFR caused by the initial downstream surge of water resembled a natural hydrologic event. Increases in TNFR at S5 were more pronounced during the 8-9 event than the 8-26 and 8-30 peak-events (Figures 32, 33, 34). The maximum baseline concentrations at S5 were 226 mg/l and 84 mg/l in 1984 and 1985 respectively. The historic maximum mean monthly concentration, during June through October, at BE-0 was 274 mg/l. The peak concentration at S5 during the 8-9 event (142 mg/l), was approximately one-half the historic maximum. Peak concentrations at S5 during the 8-26 (46 mg/l) and 8-30 (73 mg/l) events were considered insignificant. The pre-sample concentrations at this site during all three peak-events, were fairly similar (49 mg/l, 38 mg/l, and 57 mg/l respectively), and were less than the mean historic reading at BE-0 for the month of August. Site S3 concentrations tended to decrease during the event from pre-sample of 75 mg/l, which was also the peak concentration. Baseline maximums for this site were 229 mg/l and 108 mg/l in 1984 and 1985 respectively.

The affects of a power generation water release on downstream water quality after many consecutive days of no power generation, compared to a water release preceded by a run-of-the-river operating mode, is evident when comparing the peak TNFR concentrations for the three peak-events. The increase in TNFR during the 8-9 event is much more abrupt than the 8-26 and 8-30 events, and the peak concentration is much greater (142 mg/l compared to 46 mg/l and 73 mg/l respectively). The increase in TNFR at S5 during the 8-9 event could be contributed to three possible sources, scouring of the substrate between the dam and S5, recruitment of sediment from bank storage, and the re-suspension of sediments believed to have been deposited immediately upstream of the dam, within the reservoir, near the turbine intakes.

As seen with the parameter Total-P, TNFR peak concentrations at S6 during the 8-26 and 8-30 events (157 mg/l and 150 mg/l respectively), and S8 during the 8-30 event (310 mg/l) were much greater than at S5 (46 mg/l, 73 mg/l) during the same peak-events. Peak concentrations at S6, during the 8-26 and 8-30 events, resembled that of the peak concentration occurring at S5 during the 8-9 event. Similar to the S5 peak concentration, the S6 concentration resembled an increase one would expect to see with a natural hydrologic event produced by one to two inches of precipitation. Concentrations at S3 during the 8-26 event tended to increase with a peak concentration of 62 mg/l, again well below the baseline maximums. The 8-30 event at S3 peaked at 63 mg/l with an overall decrease for the sampling period.

The increase of TNFR at S8 during the 8-30 event (peak concentration of 310 mg/l), resembles concentrations one would observe during early summer high water levels. Site S8 concentrations could be a culmination of the scouring of the streambed along a 16.0 river km (9.9 river mi) stretch downstream of the dam by the initial water surge, the recruitment of suspended sediment from bank storage along the stretch, and loading of TNFR from the Le Sueur River which possessed high maximum baseline values during 1984 and1985.

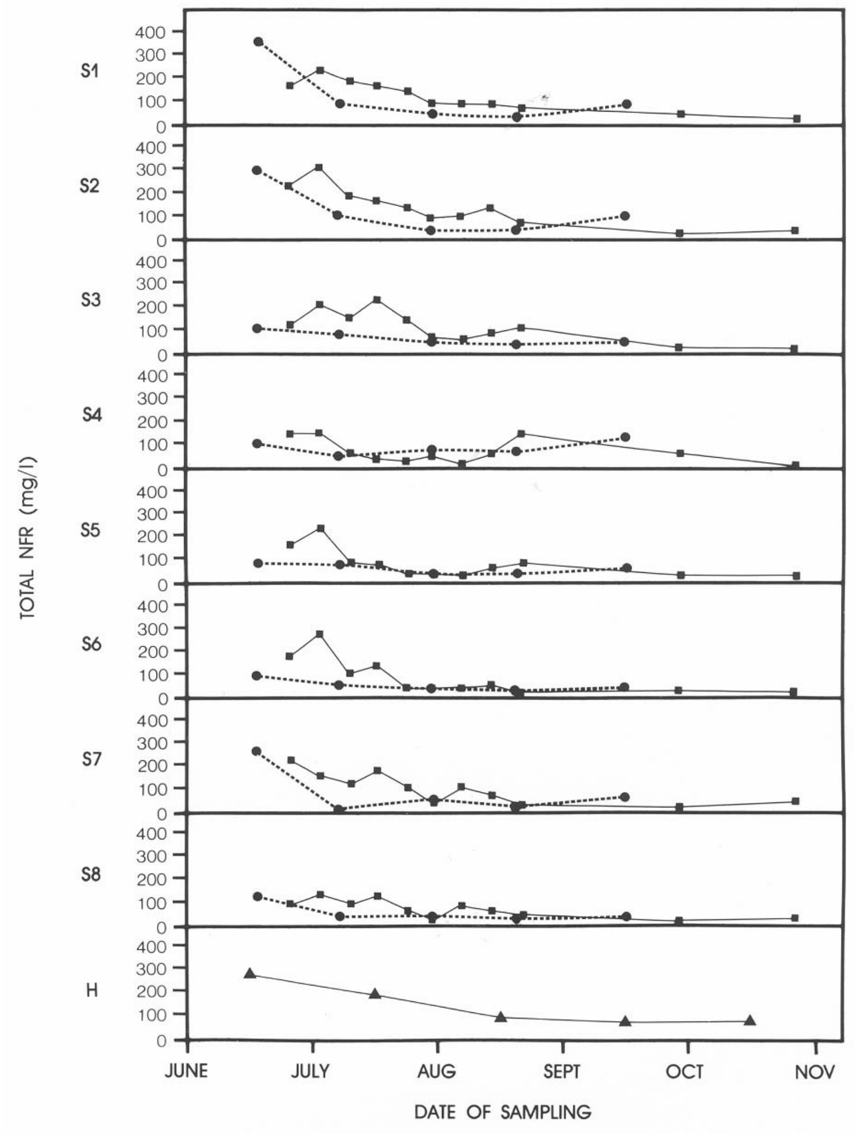

Figure 31. Baseline Total Non-Filterable Residue for 1984 (■) and 1985 (●) sampling seasons at Sites S1-S8, and historic record for Blue Earth – 0 (▲).

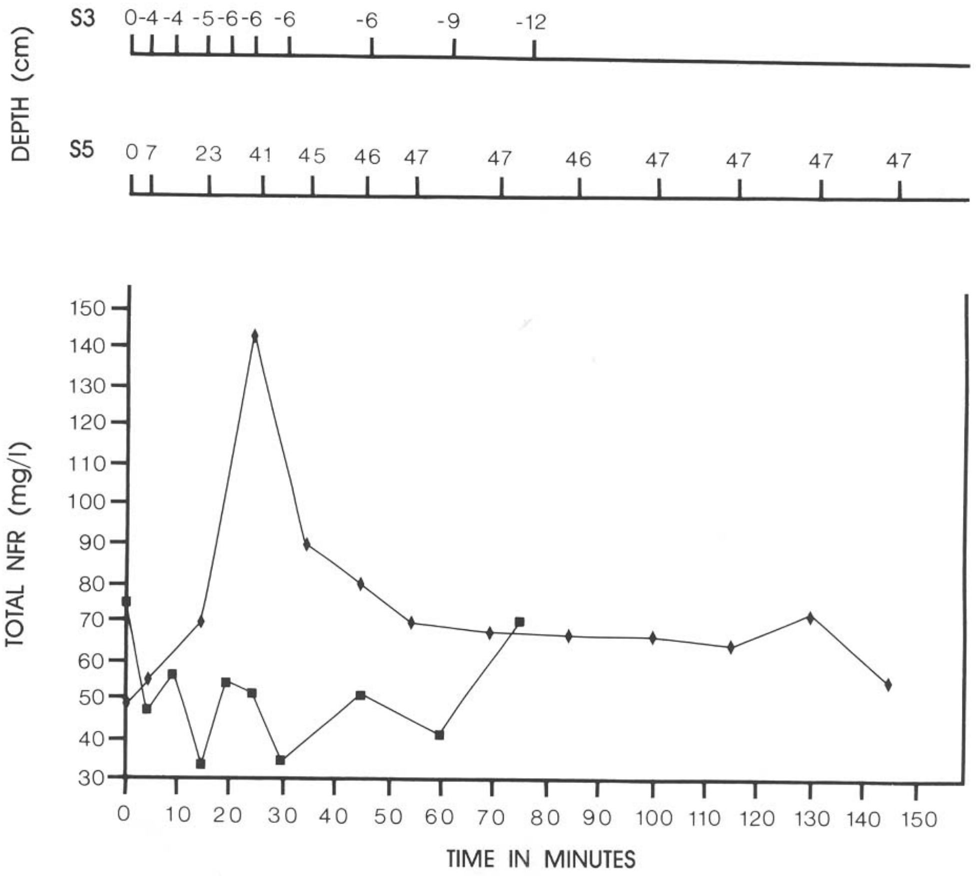

Figure 32. Total Non-Filterable Residue for peak event of August 9, 1985 at Sites S3 (■) and S5 (♦)

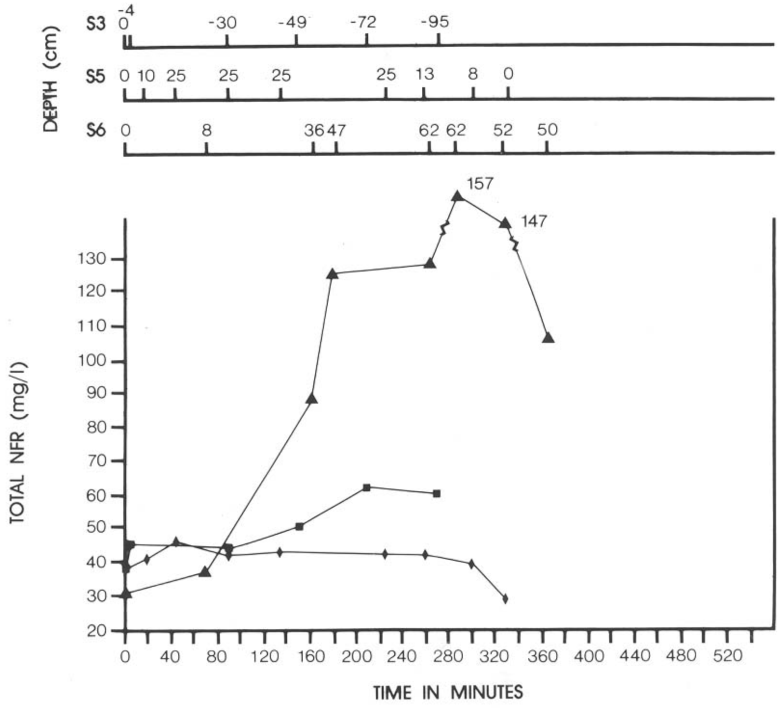

Figure 33. Total Non-Filterable Residue for peak event of August 26, 1985 at Sites S3 (■), S5 (♦) and S6 (▲)

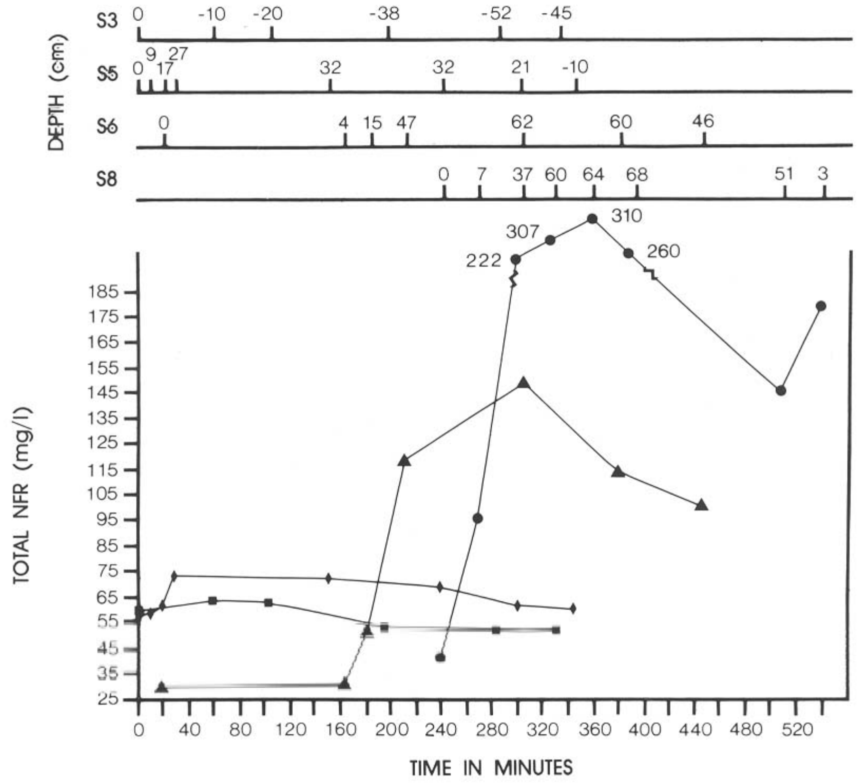

Figure 34. Total Non-Filterable Residue for peak event of August 30, 1985 at Sites S3 (■), S5 (♦), S6 (▲) and S8 (●) .

Total Volatile Non-Filterable Residue

Introduction

Most of the organic carbon (TVNFR) in running-water ecosystems in is the dissolved form rather than the particulate (6:1 to 10:1) (Wetzel, 1983). Further, living particulate organic carbon (POC) constitutes a very small portion of the total POC. However, POC is important in mediating carbon fluxes. The phrase "total volatile non-filterable residue" refers to that portion of TNFR which is solely organic in composition. Today TNFR is usually referred to as Total Suspended Volatile Solids (TSVS).

Baseline

Historical trends at BE-0 show TVNFR increasing in July, then decreasing and leveling out through October (Figure 35). This increase in July can be attributed to an increase in productivity that may have occurred within the river due to lower flow, increased water clarity, and increasing water temperature. Baseline TVNFR graphs appear similar to TNFR baseline graphs in terms of increases and decreases in concentration throughout the sampling period. Similar to TNFR, concentrations for the first sampling date of 1984 were lower than the sampling occurring one week later. The increase in TVNFR during July was observed at all sites except S4, the reservoir, which would be expected due to the settling basin affect. Similar to TNFR, increase in concentration is seen in late August at sites S3, S4, and S5. Concentrations then steadily decreased into October.

In 1985, as with TNFR, concentrations are greater at sites upstream of the reservoir than downstream, and S7 was increasing mainstem concentrations. Concentrations remained low due to the low flow occurring at this time, and began to increase during the latter part of August into September. This increase is believed to have been caused by an increase in flow.

The trapping affect of the reservoir on TVNFR is evident, but is far more subtle than for TNFR

Peaks

The historic baseline, maximum monthly mean at BE-0 was 44 mg/l, while the minimum was 20 mg/l. The peak concentration at S5 during the 8-9 event was 19 mg/l (Figure 36). During the 8-26 and 8-30 peak events, peak concentrations at S5 repeated this pattern with near minimum historic concentrations (Figures 37, 38).

The increase in concentration at S5 during the 8-9 event was greater in magnitude than during the latter two events, however it still was considered insignificant. When comparing these observations with the TNFR peak-event data, it can be concluded that the sediment re-suspended by the initial water surge was primarily inorganic in composition. The peak concentration at S3 (23 mg/l) was greater than the maximum baseline concentration of 20 mg/l at this site. However, the maximum historic concentration of 44 mg/l, and the maximum baseline concentration of 40 mg/l, demonstrates the insignificance of concentration. The normal concentration, as indicated by historic data, for August, at BE-0 was 25 mg/l.

Site S3 concentrations during the 8-26 and 8-30 events were greater than at S5. This may have been due to the reservoir acting a trap for TVNFR during these two events, and thereby decreasing concentrations at S5. Sites S6 and S8 once again demonstrated the magnification affect as the water surge moved farther downstream from the dam. This is evident by the greater peak concentration at 56 and S8, than at S5, during the 8-26 and 8-30 events. Peak concentrations at S6 during the latter two events (35 mg/l and 37 mg/l respectively), which exceeded maximum baseline concentrations for 1984 (32 mg/l) and 1985 (21 mg/l), can be compared to increases in concentration on may observe during a natural hydrologic event produced by approximately one to two inches in rainfall. The peak concentration at S8 (54 mg/l) (170% increase) did exceed the baseline maximums for 1984 (30 mg/l) and 1985 (21 mg/l) for the site, and the historic maximum for BE-0. As the water surge moved towards S8, it may have re-suspended large amounts of organic material both from the streambed and bank storage. It can also be assumed that the Le Sueur River may have contributed a proportion of S8's TVNFR during the peak-events.

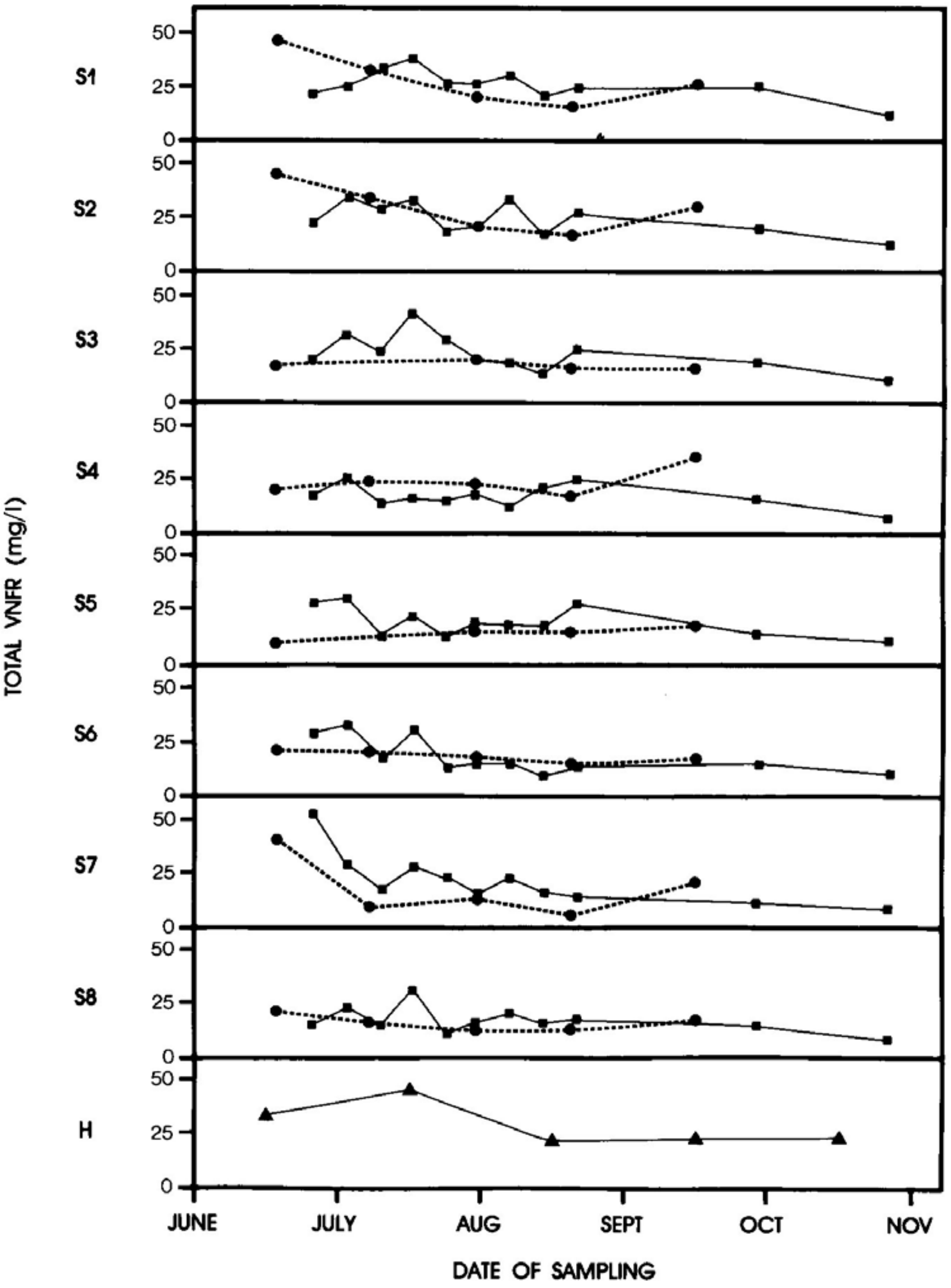

Figure 35. Baseline Total Volatile Non-Filterable Residue for 1984 (■) and 1985 (●) sampling seasons at Sites S1-S8, and historic record for Blue Earth – 0 (▲).

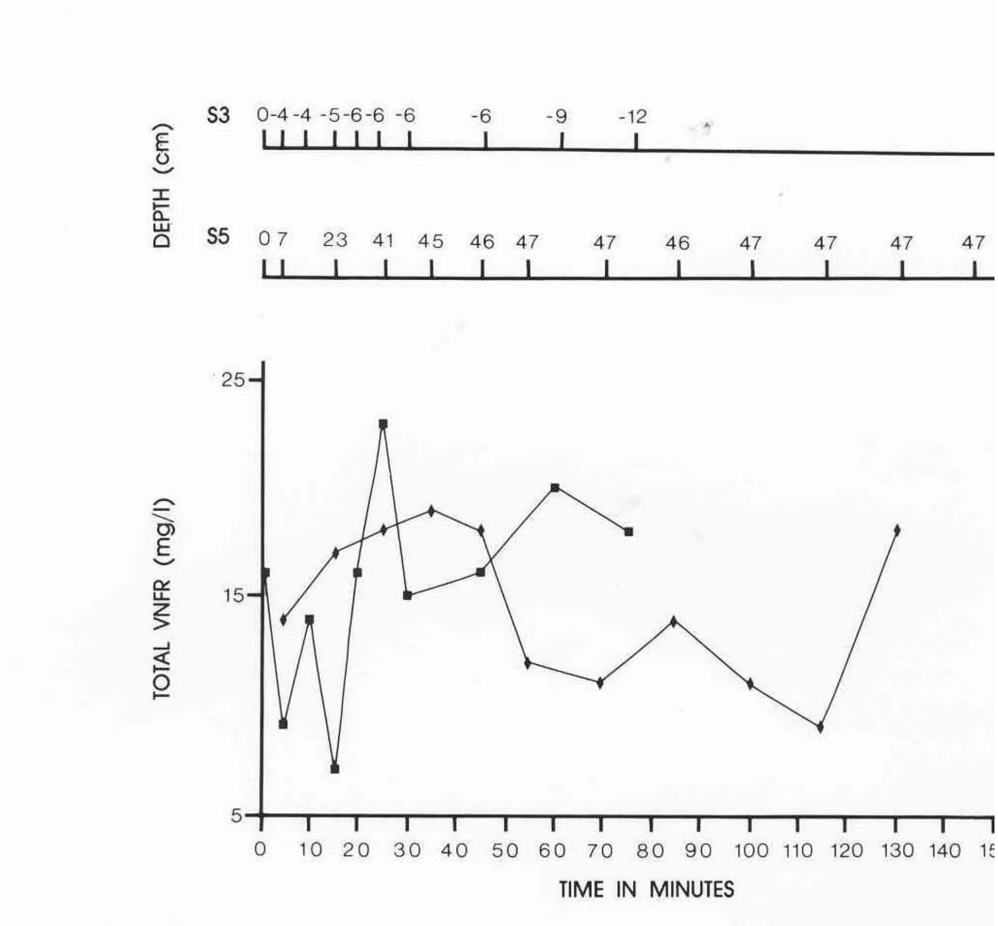

Figure 36. Total Volatile Non-Filterable Residue for peak event of August 9, 1985 at Sites S3 (■) and S5 (♦)

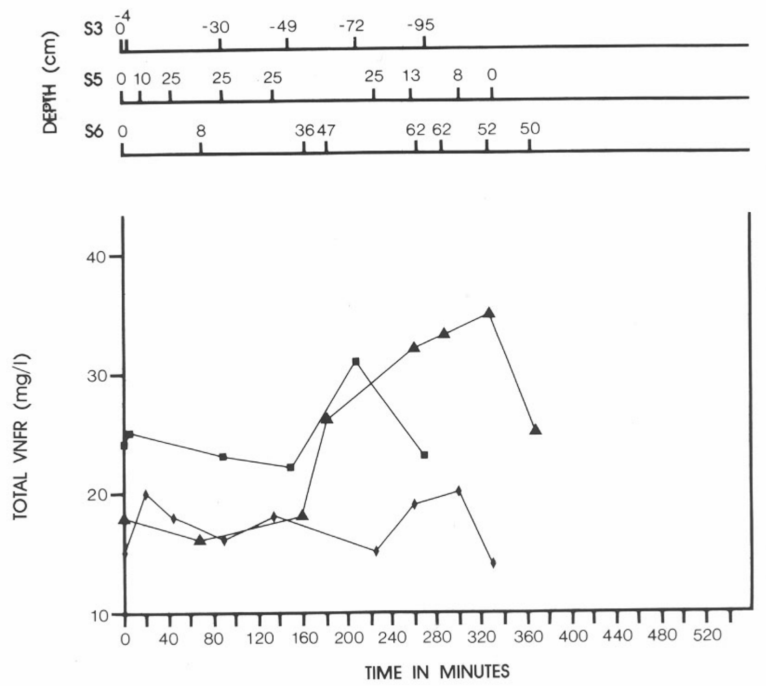

Figure 37. Total Volatile Non-Filterable Residue for peak event of August 26, 1985 at Sites S3 (■), S5 (♦) and S6 (▲)

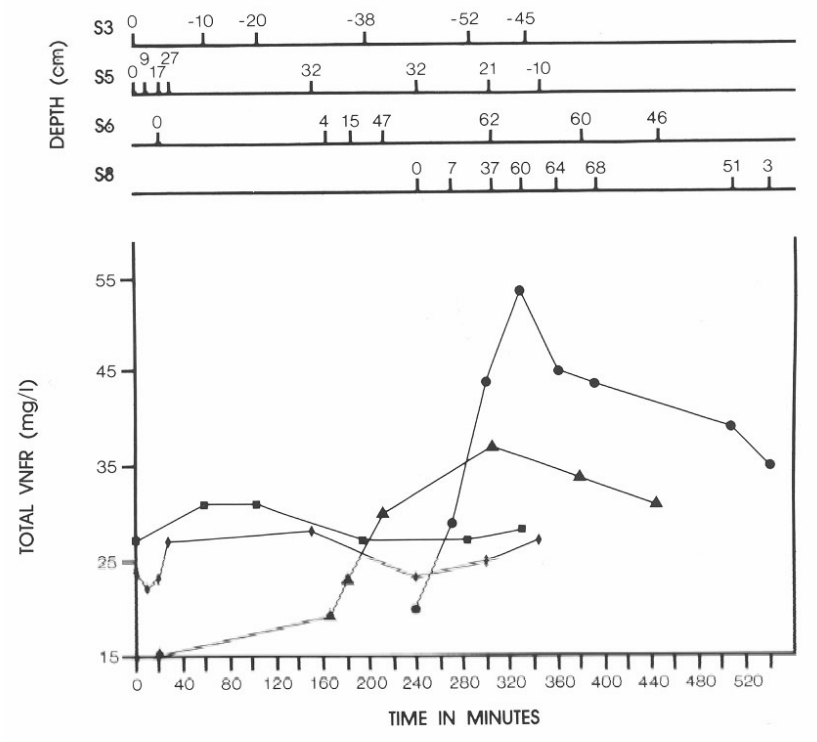

Figure 38. Total Volatile Non-Filterable Residue for peak event of August 30, 1985 at Sites S3 (■), S5 (♦), S6 (▲) and S8 (●).

Conductivity

Introduction

Conductivity is a numerical expression which describes the ability of an aqueous solution to conduct an electric current. This ability depends on the presence of ions in the solution, their total concentration, their mobility, valence, and the temperature of the solution (APHA, 1980). Solutions containing primarily inorganic salts are relatively good conductors and would possess a high conductivity reading, while molecules of organic compounds, which do not disassociate in aqueous solution, are poor conductors possessing low conductivity readings.

Baseline

Lower Conductivity readings in 1984 than in 1985, could have been caused by the abnormally high flow during the months of April through June in 1984 (Figure 39). The high flow during this time could have had a dilution affect on Conductivity.

In 1985, despite drought conditions in the latter part of June, the entire month of July and the first half of August, Conductivity followed historic patterns closely. The onset of the above normal flow in August may have caused Conductivity to increase earlier in the season than historic data does. The increase in flow at this time probably produced, with subsequent scouring of the streambed and banks, may have caused an influx of high concentrations of inorganic salts from overland flow plus scouring of stream banks... This influx may have lead to greater Conductivity readings. A more gradual increase in flow followed by sustained high flow over several months (similar to the early period of 1984) would tend to dilute Conductivity causing lower readings.

Impacts by the reservoir or the two tributaries on mainstem Conductivity were not apparent.

Peaks

Low flow and high water temperatures could have contributed to a pre-sample reading of 751 at S5 during the 8-9 peak-event (Figure 40). This reading is comparable to the maximum baseline readings at S5 in 1984 and 1985 of 750 umhos/cm and 740 umhos/cm respectively. The maximum historic, mean monthly conductivity reading at BE-0 during June through October was 759 umhos/cm. During the 8-26 and 8-30 events, the range of conductivity observed was lower than the 8-9 event at S5 (Figure 41, 42). Significant changes in conductivity at S5 for all three peak-events were not observed. Site S8 readings showed no significant differences from readings at S5. Conductivity at S3 during the 8-9 event was not available. Site S3 Conductivity during the 8-26 event decreased sharply. This may be due to dilution from upstream as flow increased. Conductivity was not impacted consistently, or to any great degree, by the peaking operation of the Rapidan Dam.

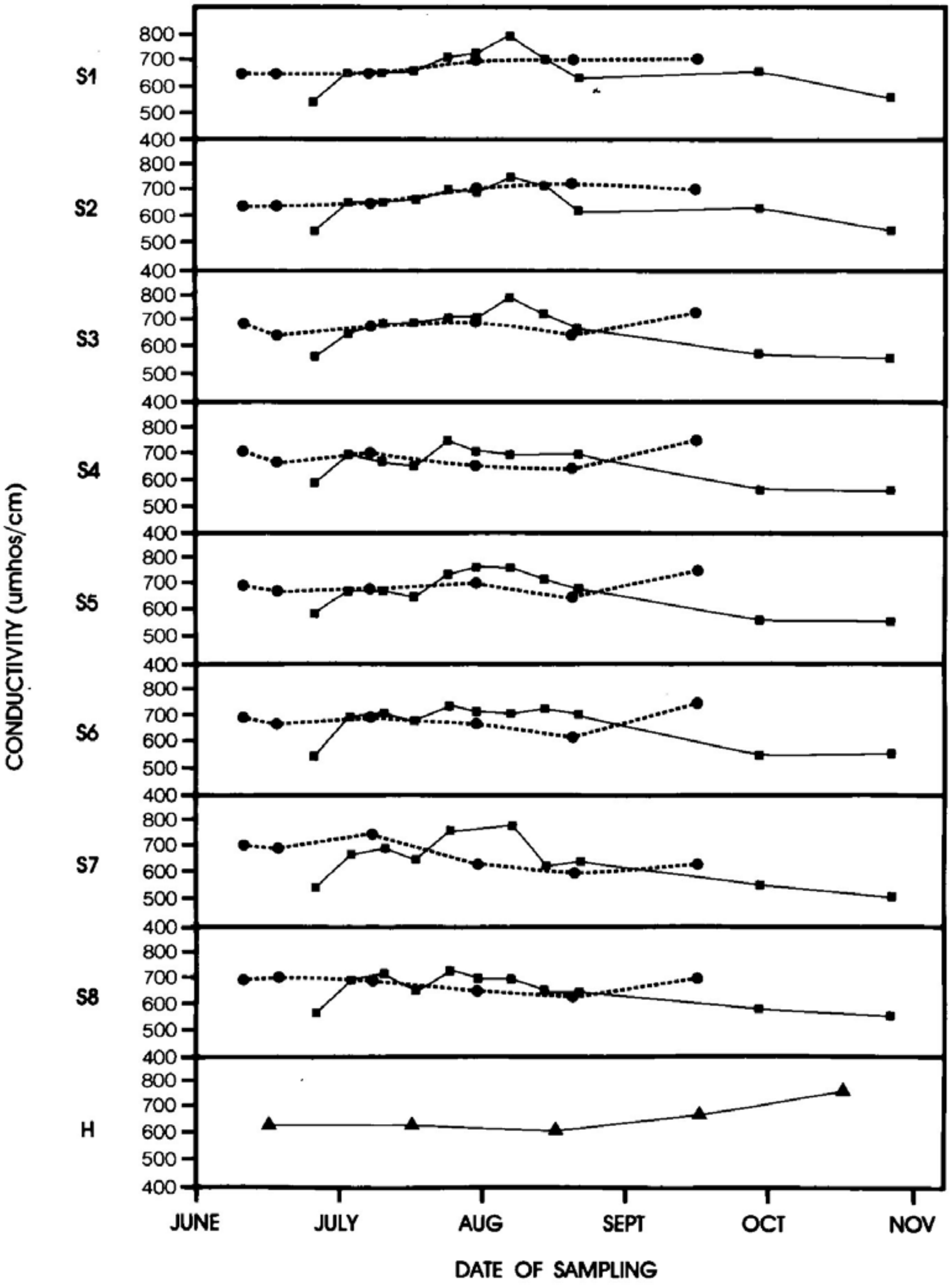

Figure 39. Baseline Conductivity for 1984 (■) and 1985 (●) sampling seasons at Sites S1-S8, and historic record for Blue Earth – 0 (▲).

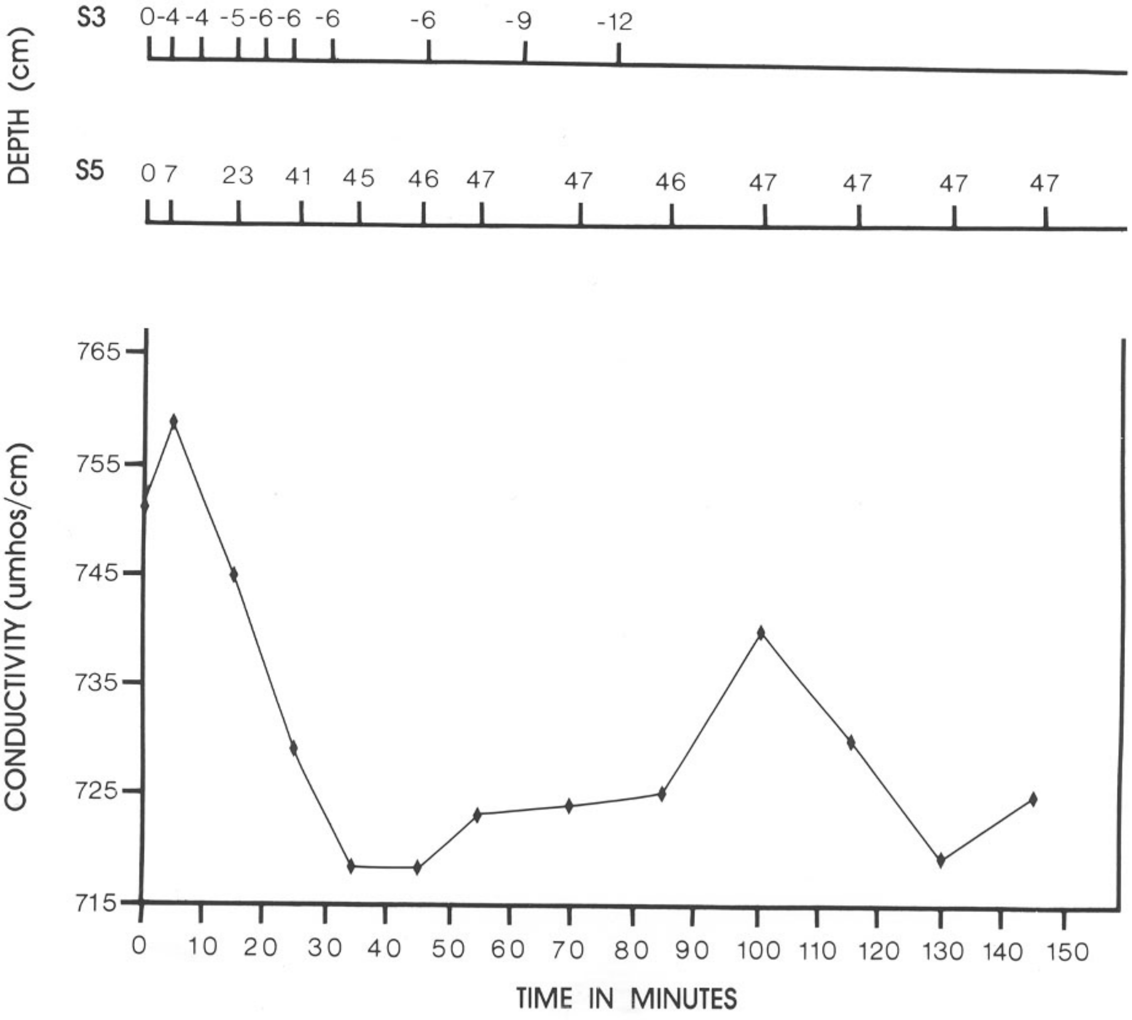

Figure 40. Conductivity for peak event of August 9, 1985 at Site S5 (♦)

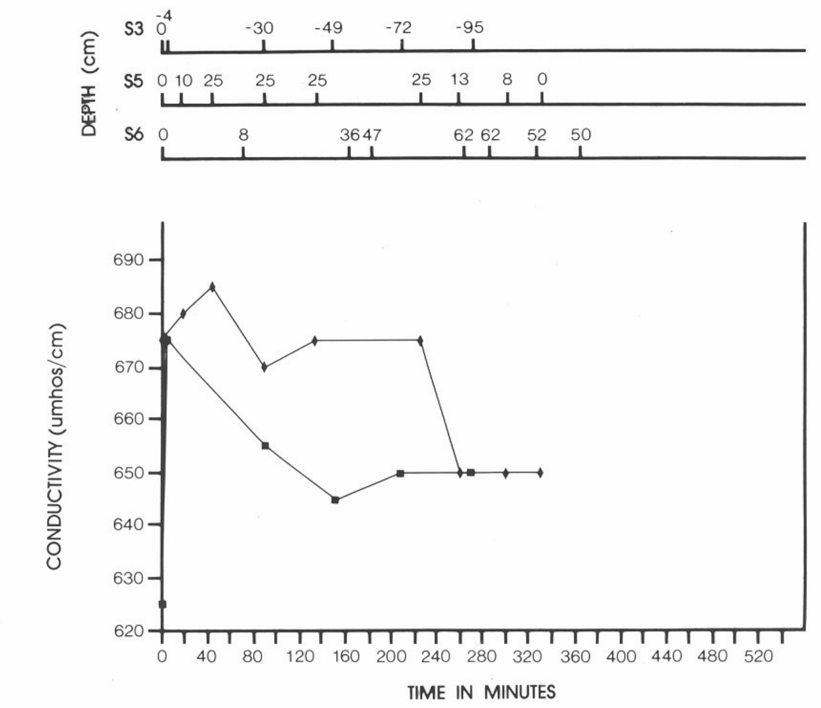

Figure 41. Conductivity for peak event of August 26, 1985 at Sites S3 (■), S5 (♦)

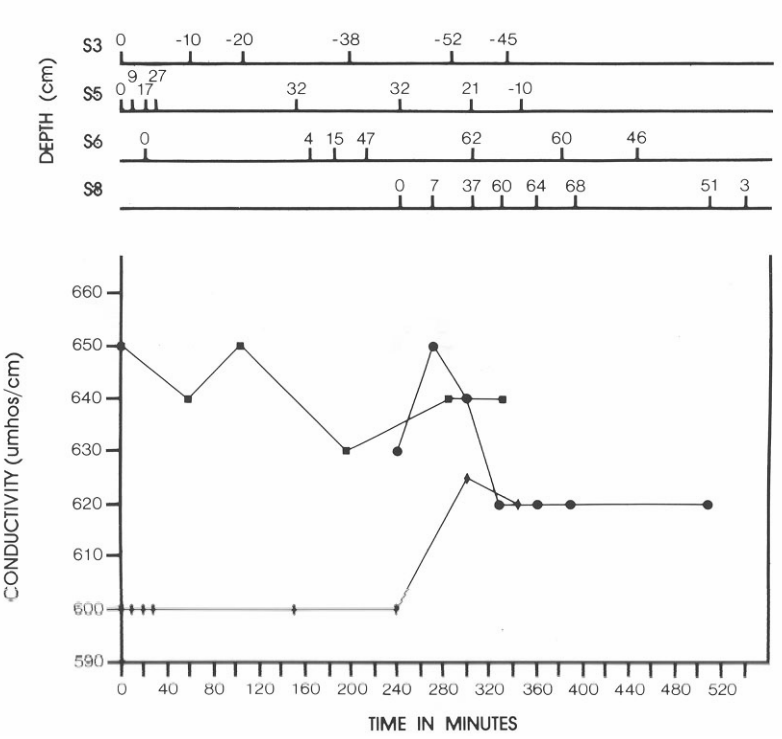

Figure 42. Conductivity for peak event of August 30, 1985 at Sites S3 (■), S5 (♦) and S8 (●)