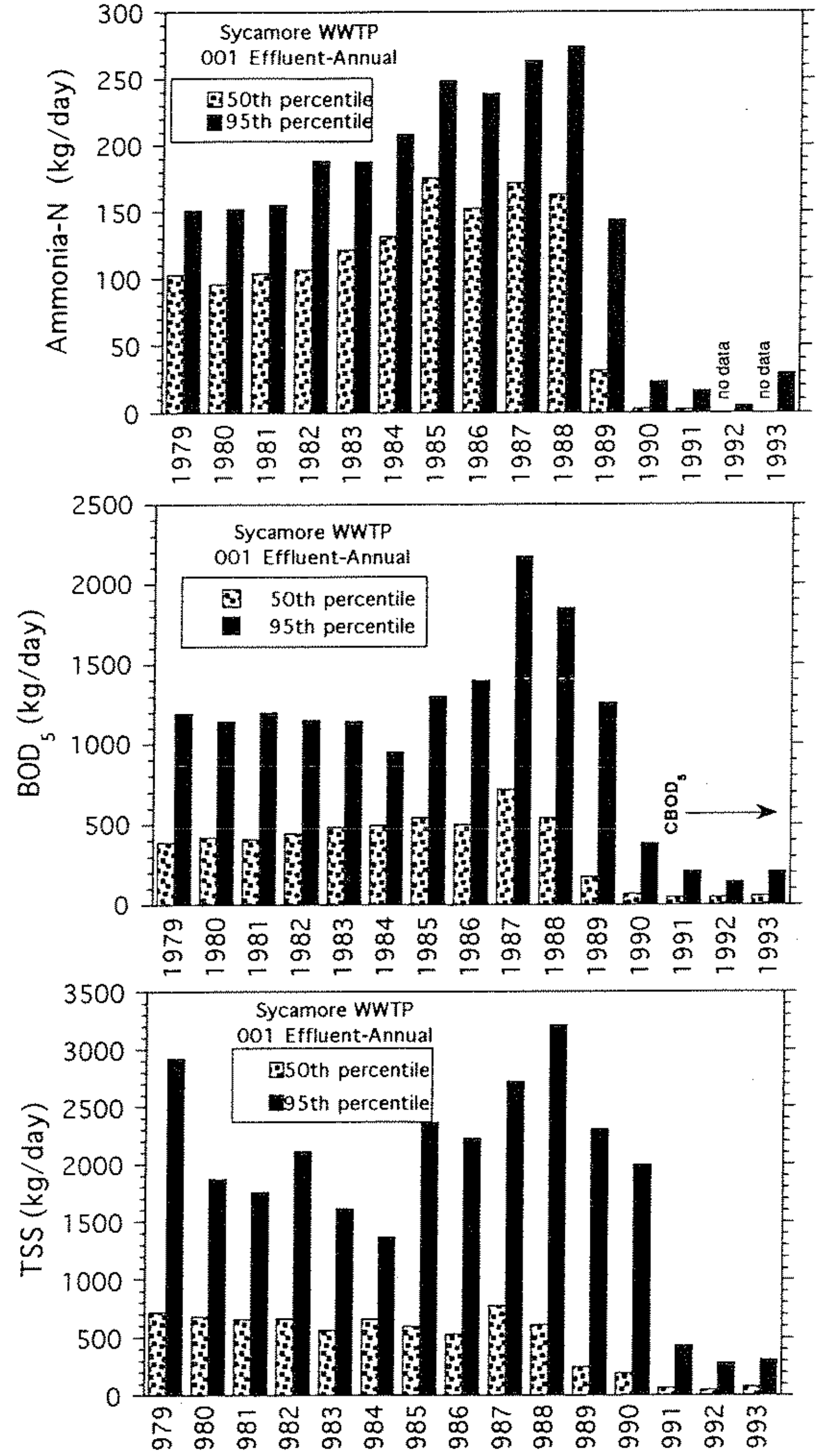


Figure 16. Median and 95th percentile annual loadings (kg/day) of ammonia-N, BOD_5, and total suspended solids (TSS) from the Sycamore Creek WWTP (001 outfall).

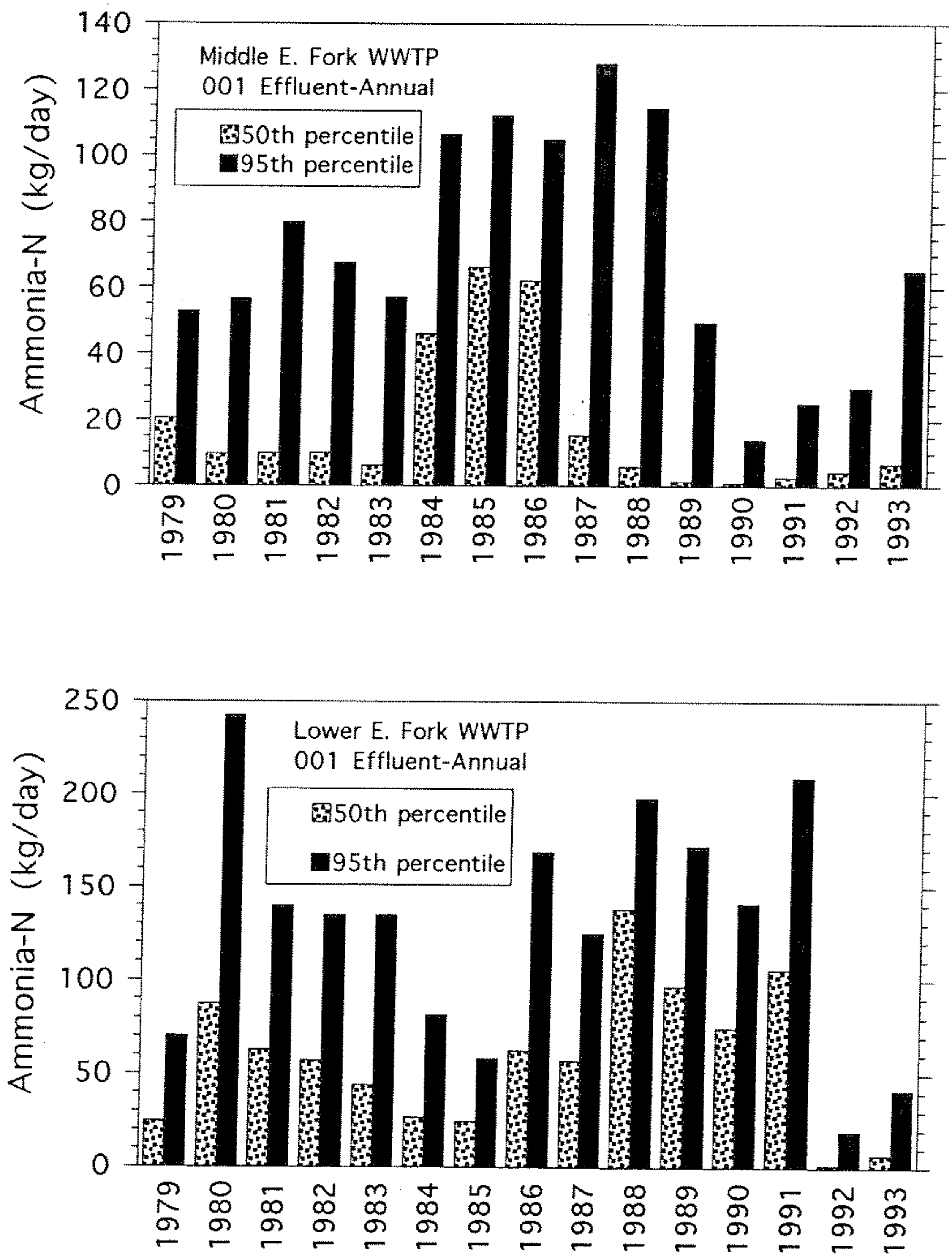


Figure 17. Median and 95th percentile annual loadings (kg/day) of ammonia-N from the Clermont Co. Middle and Lower East Fork WWTPs (001 outfall).

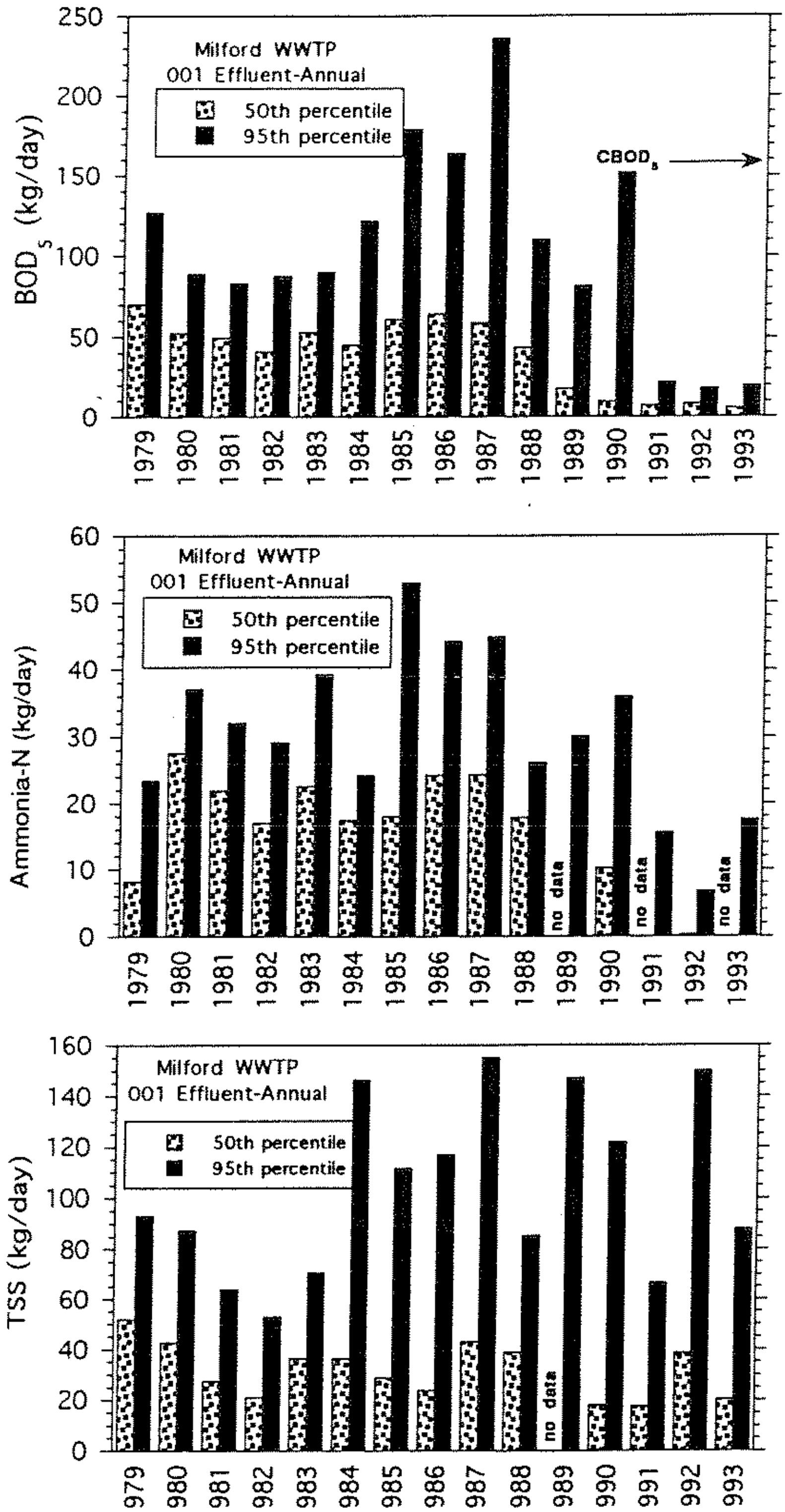


Figure 18. Median and 95th percentile annual loadings (kg/day) of BOD_5, ammonia-N, and total suspended solids (TSS) from the Milford WWTP (001 outfall).

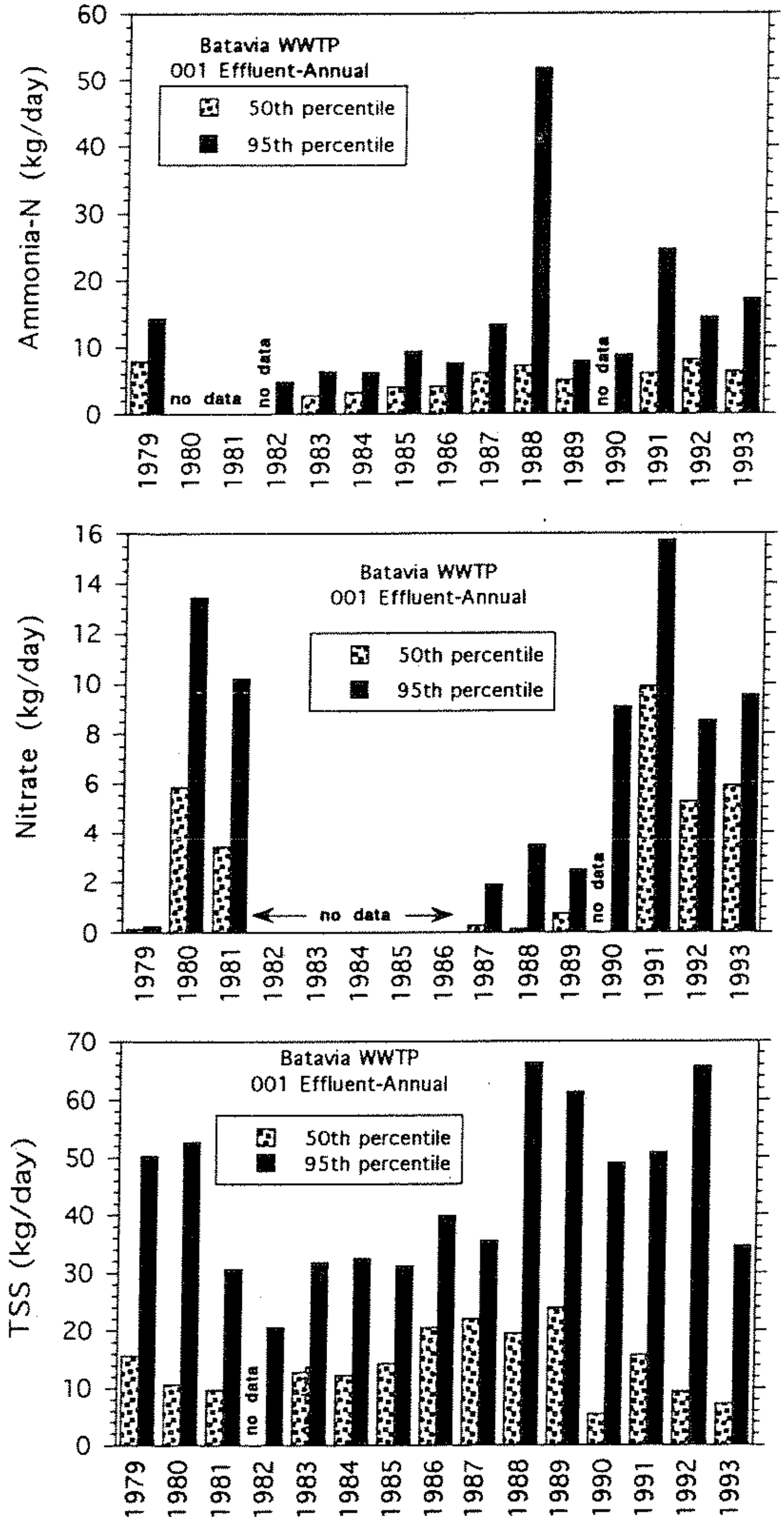


Figure 19. Median and 95th percentile annual loadings (kg/day) of ammonia-N, nitrate, and total suspended solids (TSS) from the Batavia WWTP (001 outfall).

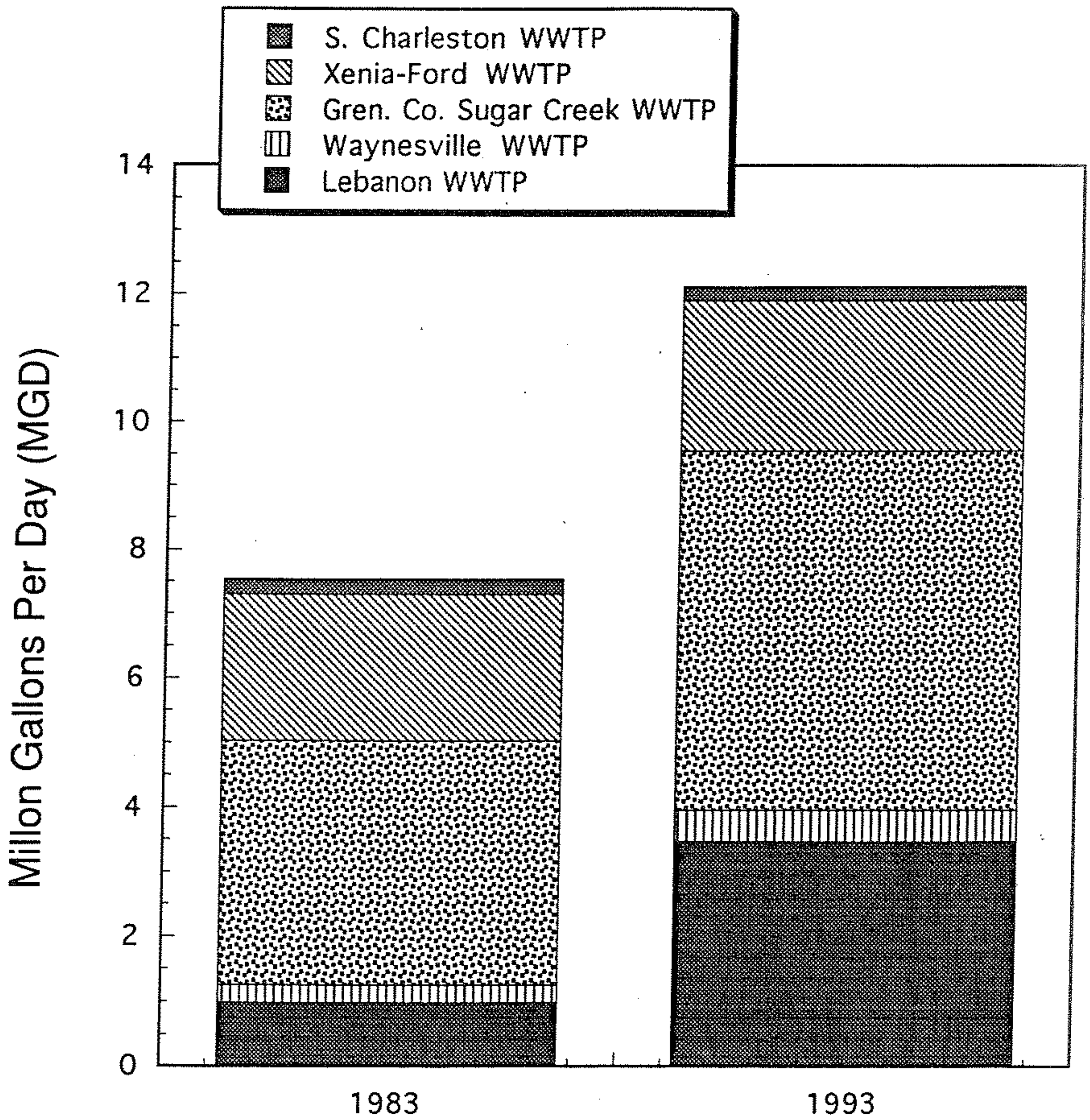


Figure 20. Stacked bar graphs comparing the 1983 and 1993 total cumulative average annual effluent flow (MGD, 001 outfall) from 5 dischargers located in the Little Miami River watershed. The total cumulative volume from the 5 WWTPs increased from 7.545 MGD in 1983 to 12.134 MGD in 1993.

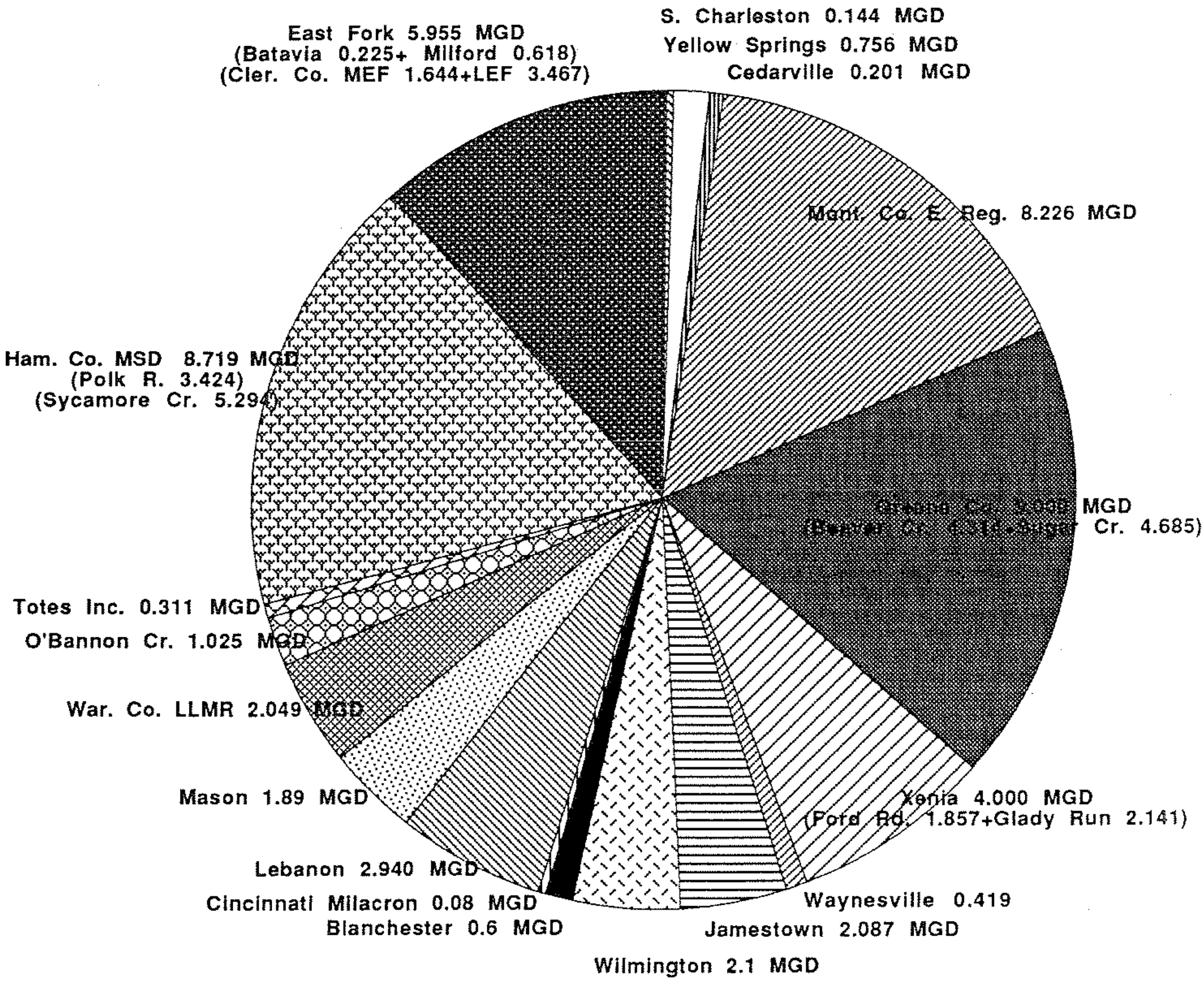


Figure 21. Pie graph of the total average third quarter 1993 conduit flow (MGD, 001 outfall) from 24 dischargers located throughout the Little Miami River watershed. The total cumulative volume is 50.5 MGD.

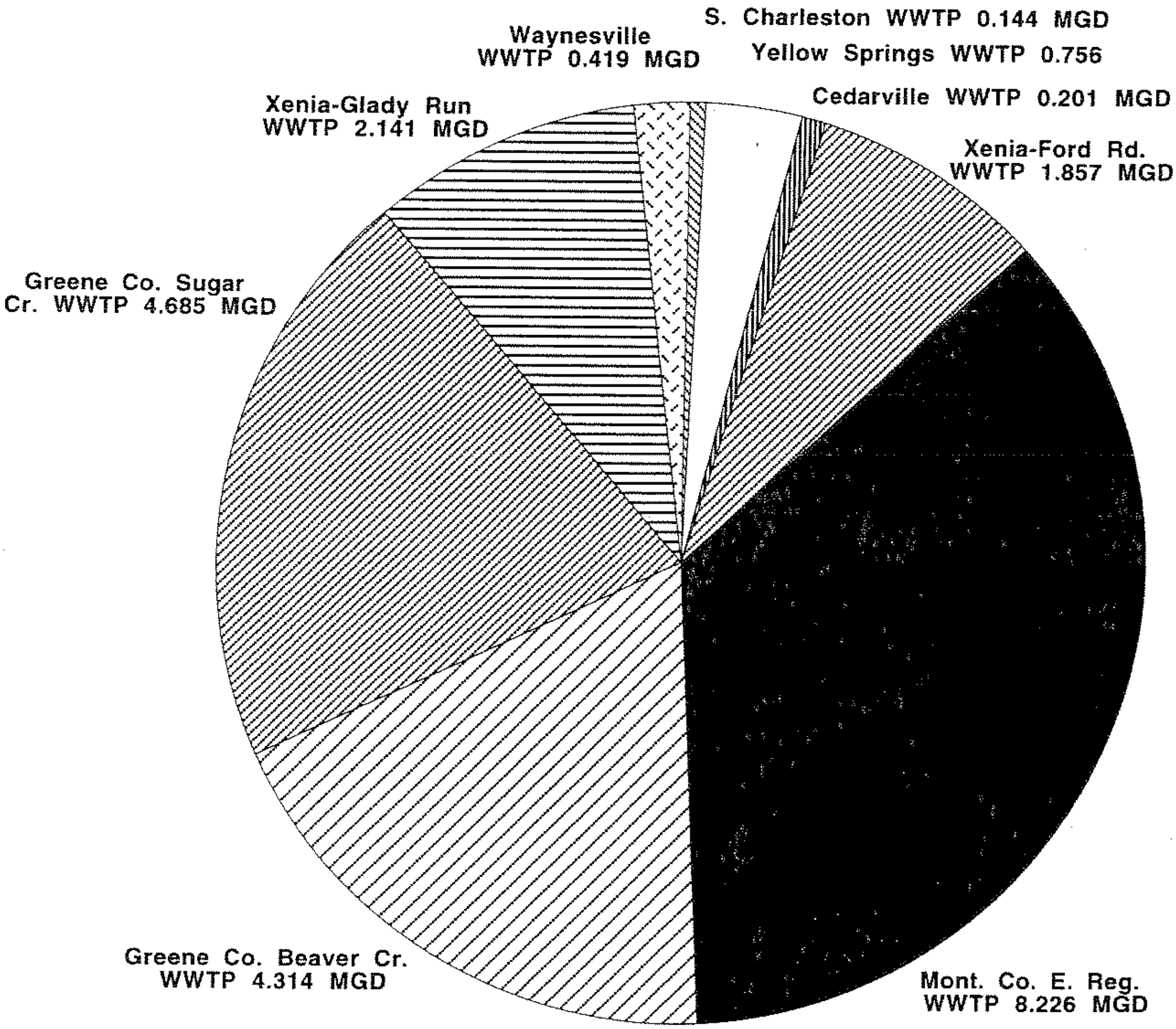


Figure 22. Pie graph of the total average third quarter 1993 conduit flow (MGD, 001 outfall) from 9 dischargers located in the upper half of the Little Miami River watershed. The total cumulative volume is 22.74 MGD.

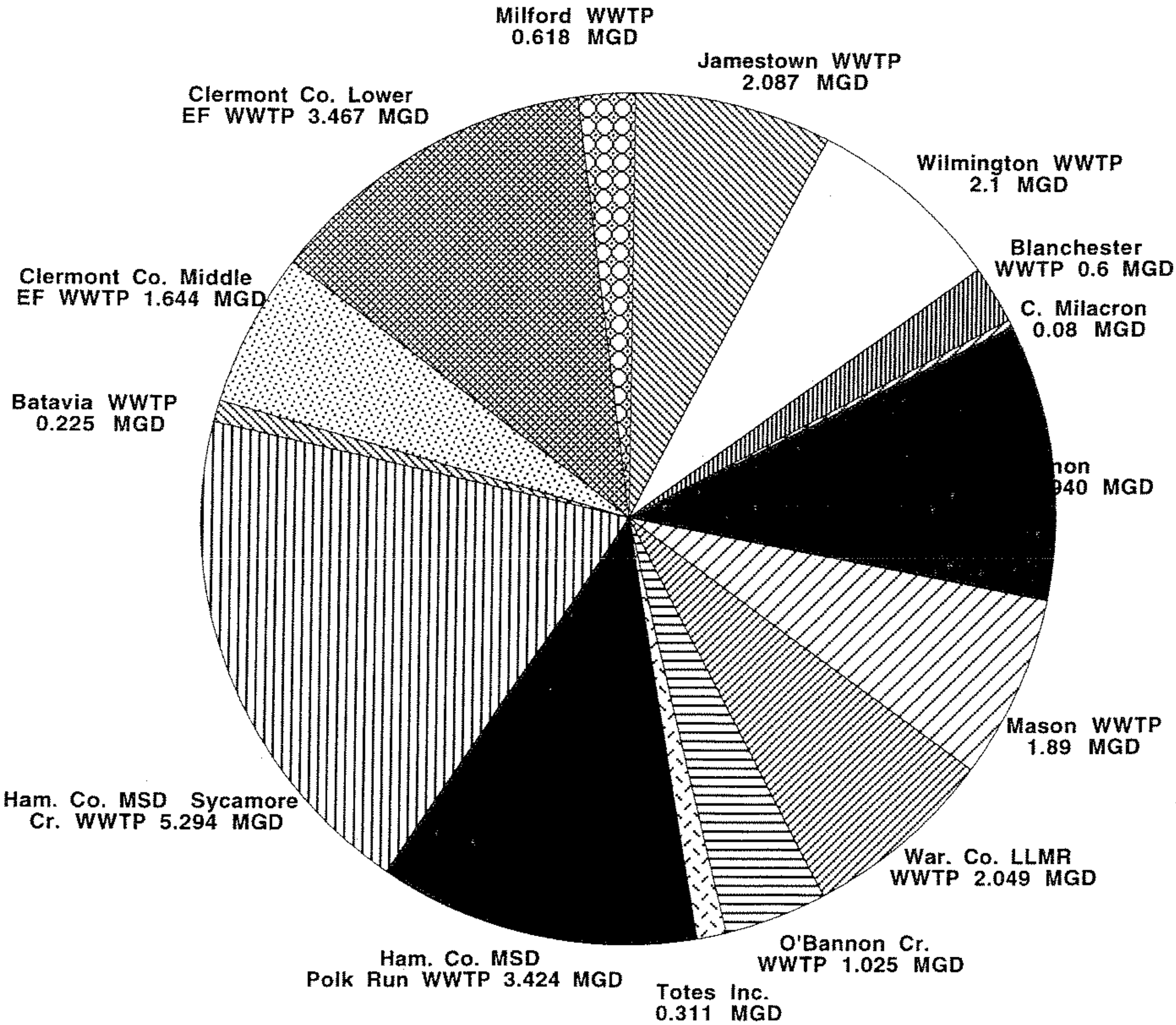


Figure 23. Pie graph of the total average third quarter 1993 conduit flow (MGD, 001 outfall) from 15 dischargers located in the lower half of the Little Miami River watershed. The total cumulative volume is 27.8 MGD.

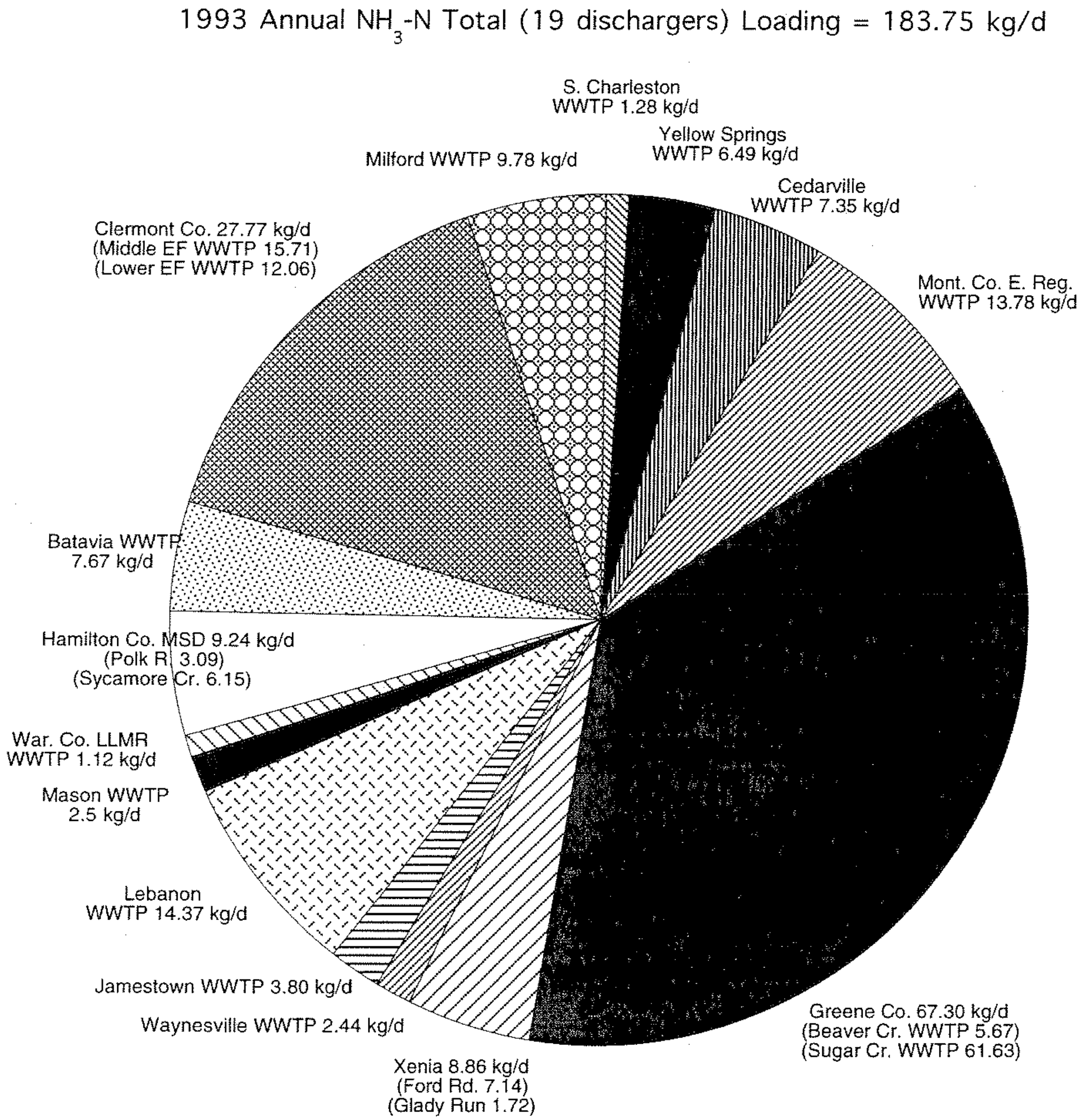


Figure 24. Pie graph of the total average annual 1993 ammonia-N (kg/day) loadings (001 outfall) for 19 dischargers within the Little Miami River watershed.

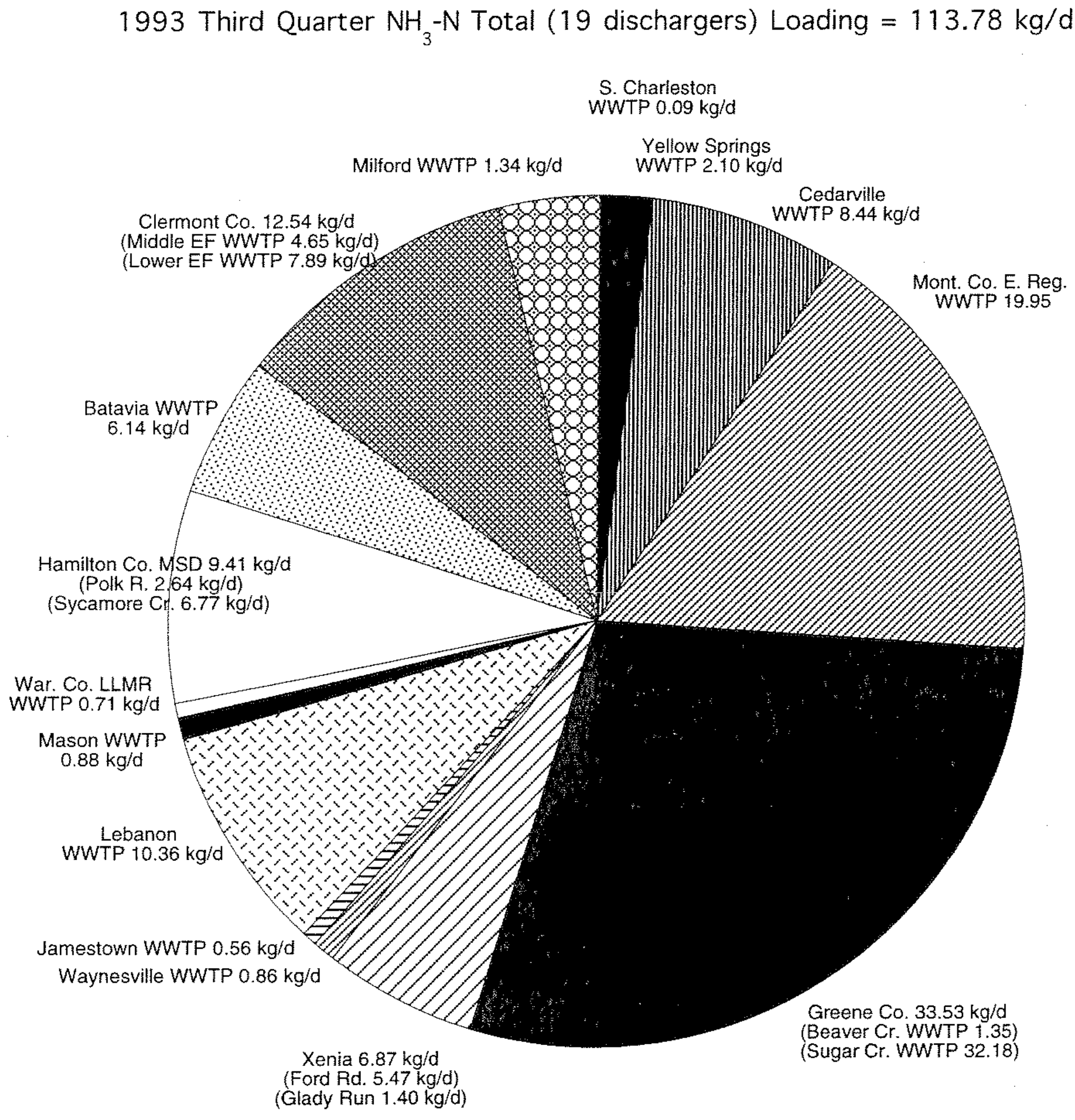


Figure 25. Pie graph of the total average third quarter (1993) ammonia-N (kg/day) loadings (001 outfall) for 19 dischargers within the Little Miami River watershed.

Spills, Overflows, and Unauthorized Releases

- Pollutant discharges from spills, overflows, permit violations, and other unauthorized releases are a significant source of lethal and sublethal stresses for aquatic communities in the Little Miami River watershed. Approximately 1500 incidents have been recorded by the Ohio EPA Emergency Response Section during the 10 year period between from 1983 to 1993. During the 10 year period, 241 of the most significant events (*i.e.*, releases greater than 100 gallons or could have exhibited an acutely toxic impact to surface water) cumulatively released more than 78,393,659 gallons and 48,326 pounds of pollutants (Appendix Table A-1).

- Sewage releases through unauthorized bypasses, SSOs, and CSOs events, was the leading spill pollutant discharged to the Little Miami River by volume (76,916,405 gallons = 98.1%) and frequency (127 events = 53%). The largest source of sewage spills was the Clermont County Sewer Department which had 86 spills (36%) of the significant releases. Fifteen (15) of the 86 spills released more than 1,000,000 gallons and 55 spills exceeded 100,000 gallons. The Hamilton County Metropolitan Sewer District (MSD) had the next highest rate of release with 14 discharges to the Little Miami River. Eight of the events were in excess of 1,000,000 gallons. Since 1989, the total quantity of sewage released to the watershed has declined and both Clermont and Hamilton Counties have shown marked improvement in attempting to comply with the Clean Water Act. Also point source related, the second highest spill type was industrial and other types of wastewater which discharged 1,268,620 gallons (1.6%) and 47,876 pounds (99.1%) of pollutants.

- Agricultural related spills (*i.e.*, fertilizer, pesticides, herbicides and manure) accounted for 9% (21 events) of the most significant spills. By volume, fertilizer and other agricultural products/chemicals accounted for more than 122,730 gallons and 450 pounds of pollutants.

- Petroleum related spills released 45,040 gallons and accounted for 22% (52 events) of the most significant spills. Diesel fuel was the most common petroleum contaminant spilled. Airborne Express in Clinton County had 16 spill events recorded, but only 6 listed a quantity, all of which were recorded as significant. The other spill reports failed to report any quantities. Jet Fuel "A", urea, and monomethyl diethyleneglycol were the primary spill contaminants released by Airborn Express and detected in Cowan and Lytle creeks.

- Chemical spills released 40,864 gallons (< 0.1%) of pollutants and accounted for 13% (32 events) of the significant spills during the 10 year period. The General Motors Delco plant in Montgomery County had 29 spill events recorded during this time frame, unfortunately no volume of discharge was given to many of the spills. Therefore, the true volume and associated impacts are under-estimated. Elevated concentrations of hexavalent chromium is a characteristic water quality violation from the G.M.-Delco facility. Pre-treatment violations for hexavalent chromium and zinc are also common in wastewater discharged from the G.M.-Delco plant to the Montgomery County Eastern Regional WWTP.

- The Ohio Attorney General issued the Montgomery County Eastern Regional WWTP (which discharges to Little Beaver Creek) an eighteen count complaint for injunctive relief and civil penalties for violations of water quality (Chapter 6111 of the Ohio Revised Code). The case was settled in April 1992 with Montgomery County agreeing to pay $50,000 in Civil penalties.

Sanitary Sewer Overflows (SSOs)

- The Little Miami River watershed also receives periodic discharges of untreated sewage and other pollutants through SSOs within the Hamilton County Metropolitan Sewer District's Sycamore Creek and Polk Run WWTP systems (Plate 13). The Hamilton Co. MSD has recently installed new sewer lines with sealed lids within the Sycamore Creek basin to reduce the number of overflows. Sanitary Sewer Overflows (SSO) also enter the mainstem via the Beechmont interceptor gate. When the Ohio River reaches 42 feet the interceptor gate must be closed to prevent flooding of the sewer system. Sewage then backs up in the lines north of Beechmont Avenue and discharges through CSO's and the SSO's within the Little Miami River. The periodic discharge of raw sewage and other pollutants to the mainstem and tributaries contribute to the Partial and NON attainment recorded in the Little Miami River within Hamilton and Clermont Counties.

Combined Sewer Overflows (CSOs)

- In addition to SSO discharges, the lower 13 miles of the Little Miami River also receives periodic discharges of untreated wastewater from 55 identified Combined Sewer Overflows (CSO) within southern Hamilton and Clermont Counties (Plate 13). The two most upstream CSOs are located in the City of Milford and 53 structures are located within the Hamilton County Metropolitan Sewer District (MSD) (Appendix Tables 2a-c). Five of the CSOs discharge directly to the mainstem, 48 structures are located within the Duck Creek basin, and two discharge to Clough Creek. The periodic discharge of raw sewage and other pollutants to the mainstem and tributaries through these CSOs also contribute to the Partial and **NON** attainment recorded downstream from Milford.

- Milford's two CSO structures are located near the US 50 bridge and discharge intermittently through a 27" pipe at RM 13.0 (CSO #002) and a 54" pipe at RM 13.1 (CSO #003). Monitoring data collected during the last three years reveals the CSOs discharged more frequently (59 events) and a larger total volume (90.3 million gallons [MG]) in 1990 due to the high amounts of rain. Both structures, however, discharged considerably lower amounts during the subsequent years with more normal rainfall amounts (14.8 MG, 16 events in 1992 and 16.7 MG through 18 events in 1993). Throughout the three year period, the structures discharged a cumulative total of 121.8 MG during 93 events.

- Within the Hamilton Co. MSD, 13 of the 53 CSOs have been recently monitored (Appendix Tables 2a-b) as part of a 12 month study. Data collected from the 13 structures during October 1993 through February 1994 show they discharged 295 times and released more than 232.2 MG (cumulative total). The data also shows that 70% (170.6 MG) of the total discharge came from one structure (CSO #549) located at Williams Road and Duck Creek. Rainfall events greater than .08" have been shown to be the threshold of CSO occurrences. CSO # 656 is also suspected to be a major contributor to the total flow due to its position next to a major trunk sewer.

Wild Animal Kills

- Pollution discharges from spills frequently result in toxic impacts to fish and other aquatic life. Water Pollution, Fish Kill, and Stream Litter Investigations Reports (ODNR 1983 - 1990, Division of Wildlife unpublished data) from the same 11 year period (1983 through 1993) lists 49 incidents within the Little Miami River watershed that killed a total of 58,590 wild animals. The leading cause was agricultural related activities (primarily manure runoff from animal husbandry operations and fertilizer spills) which accounted for 37.3% of the total kill followed by chemical/industrial sources (primarily petroleum products and chemicals; 26.7%), public services (primarily municipal sewage; 21.7%), and unknown causes (14.3%). By county, the highest number of incidents occurred in Greene (13), Clinton (12), and Clermont (11) followed by Montgomery (4), Warren (4), Clark (2), and Hamilton (2).

- All but three of kills occurred in tributaries as opposed to the mainstem. Sub-basins (tributaries and their tributaries) with the highest number of kill incidents were: Todds Fork basin (12) in Clinton Co.; East Fork basin (8) in Clermont Co.; Shawnee Creek basin (6) in Greene Co.; Caesar Creek basin (6) in Greene Co. and Clinton Co.; and the Little Beaver Creek basin (3) in Greene Co.and Montgomery Co. Single kills in the Little Miami River were reported for in Clark, Warren, and Clermont counties.

Fluvial Sediment

- Fluvial sediment, a widely recognized pollutant, is sediment that is suspended in, transported, or deposited by water (Hindall 1989). Fluvial sediment data from the Little Miami River at Milford between 1977 and 1986 shows a mean annual suspended sediment discharge of 474,000 tons. Per square mile of watershed, the Little Miami River had the third highest rate (394 tons/year/square mile) of the 10 streams reported with daily data between 1977 and 1986 (Hindall 1989). It had the highest rate for the four large rivers within the Ohio River basin. Major sources includes soil erosion from new sediment from agricultural fields and construction sites, but can also include re-suspension and downstream export of existing deposits within the main channel. Severely eroding banks can also contribute significant amounts, especially during extended periods of high flow (Plate 12 and 14).

Chemical Water Quality (Plates 6,10-13; Figs. 26-66, Tables 5-6,A4-A6)

Little Miami River

- Flows in the Little Miami River from May through September 1993 remained above the $Q_7 10$ values, but exhibited general declining trends (with the exception of several rain events) in both the upper and lower halves (Figures 26-27).

- The minimum day time dissolved oxygen (D.O.) concentrations (grab samples) in the Little Miami River remained above 6.0 mg/l (EWH minimum water quality criterion) at most locations, but was measured below the standard upstream from Clifton (RM 101.30 - 89.12), and downstream from the Lebanon WWTP (Figure 28a, Table 6). The lower levels appear to be caused by excessive fecal contamination, possibly from a commercial manure/composting operation's stormwater runoff. Minimum values increased slightly downstream from Gilroy Ditch (S. Charleston WWTP), but remained below 6.0 mg/l. Channelization, uncontrolled livestock access, and secondary effects of these activities (i.e., low flows) are the principal sources associated with the lower than expected concentrations.

- Datasonde continuous monitors also recorded D.O. levels below 6.0 mg/l in the mainstem during August 31-September 2, 1993 in a 2.5 mile segment (RM 26.65-29.20) extending downstream from Muddy Creek to downstream from Simpson Creek (Figure 28b, Table A-6). The majority of the below standard oxygen values were recorded at night when respiration exceeds photosynthesis. Excessive nutrient loadings from the Lebanon, Mason, and Warren Co. Lower Little Miami River WWTPs may be contributing to the D.O. exceedences.

- An exceptionally high $CBOD_5$ value (53.0 mg/l) was recorded in Tote's mixing zone (RM 22.20) on September 8, 1993 (Figure 29). Zinc concentrations (1010 μg/l) also exceeded the final acute value (FAV) and phosphorus levels were above the WQS guideline the same day (Figure 32, Table 6). Field notes indicate that the discharge on this day was white and very foamy.

- Ammonia-N concentrations were elevated in some mixing zone samples, but there were no exceedences of any chronic or maximum criterion detected elsewhere in the Little Miami River mainstem (Figure 30).

- The average and maximum nitrate+nitrite-N values in the upper half of Little Miami River were higher than in the lower half possibly due to a greater influence of agriculture (Figure 31). The highest values, however, were recorded at RM 98.98, downstream from the South Charleston WWTP discharge to Gilroy Ditch.

- Maximum phosphorus levels at four ambient mainstem sites (RMs 74.46, 63.28, 28.00, 1.45) were higher than the WQS guideline of 1.0 mg/l (Figure 32, Table 6). The highest average

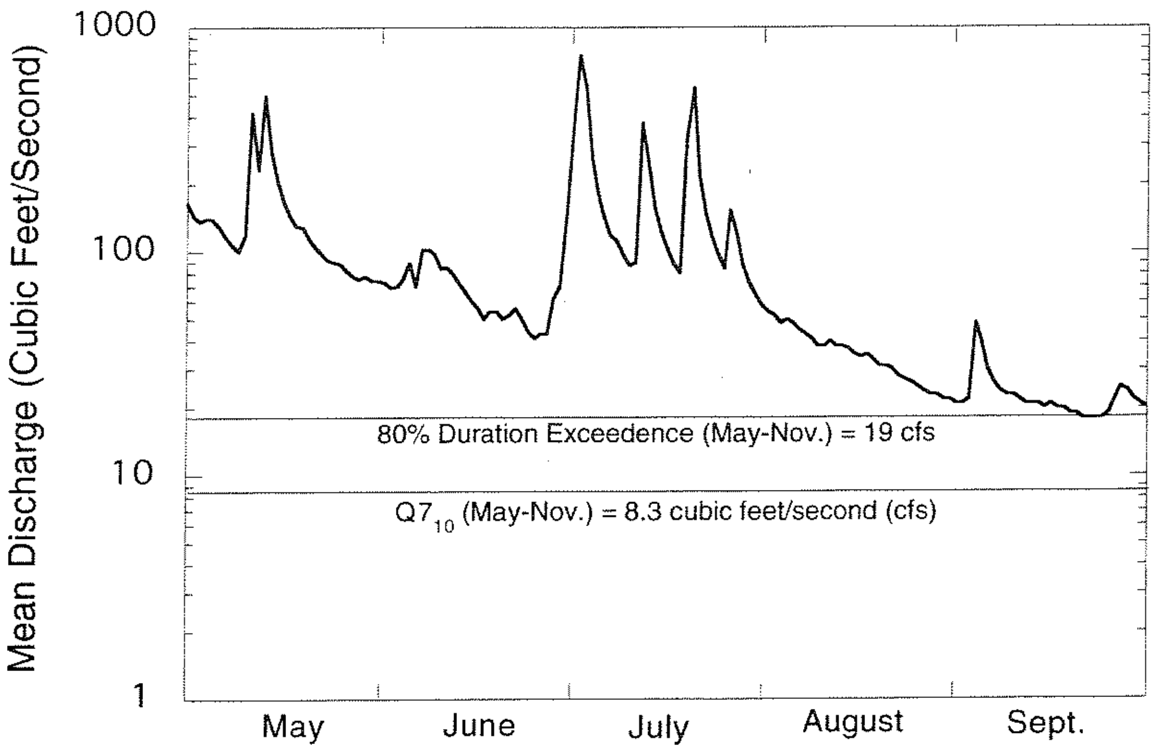


Figure 26. May through September, 1993, flow hydrograph for the upper Little Miami River near Oldtown, Greene Co.(RM 80.63). Low flow conditions ($Q7_{10}$ [8.3 cubic feet/second (cfs)] and 80% duration exceedence flow [19 cfs]) are based on the USGS gage station #03240000. Period of record: 1952 until present.

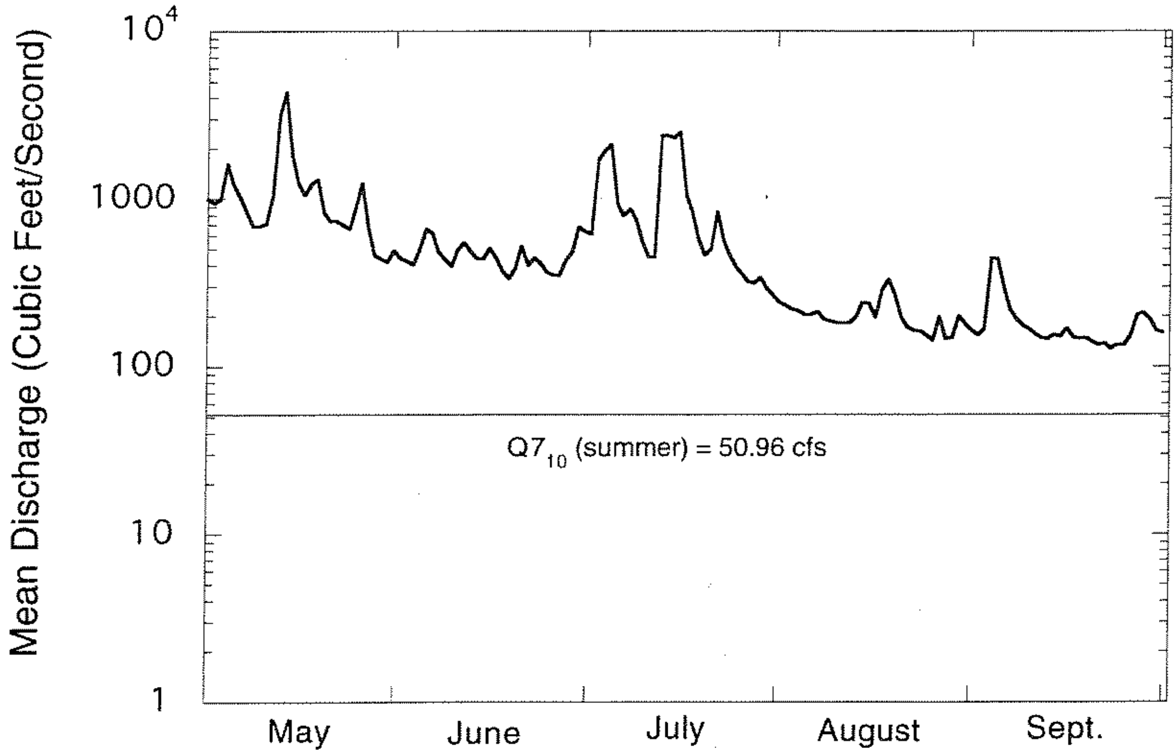
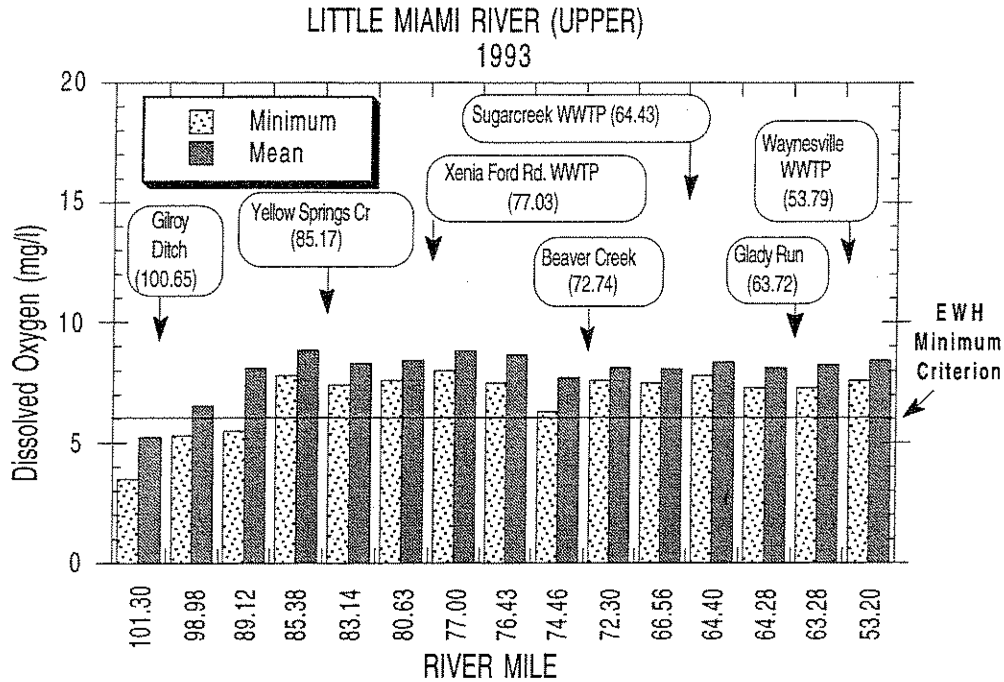


Figure 27. May through September, 1993, flow hydrograph for the lower Little Miami River near Milford, Clermont Co. (RM 13.07). Low flow conditions ($Q7_{10}$ [50.96 cubic feet/second (cfs)] is based on the USGS gage station #03245500. Period of record: 1938 until present. Eighty percent duration exceedence data is not available.



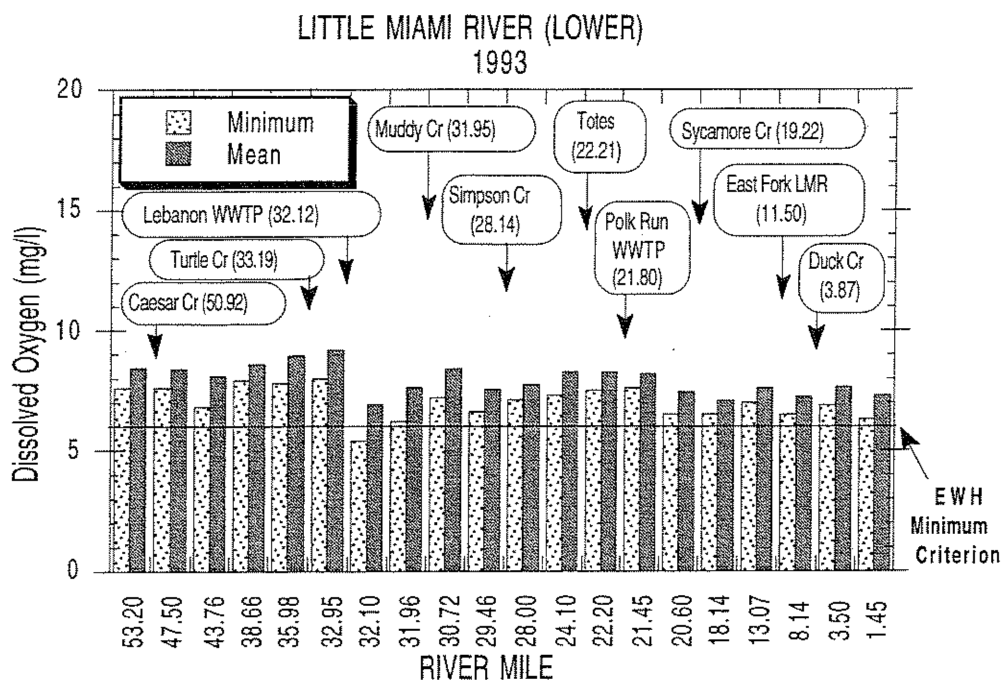
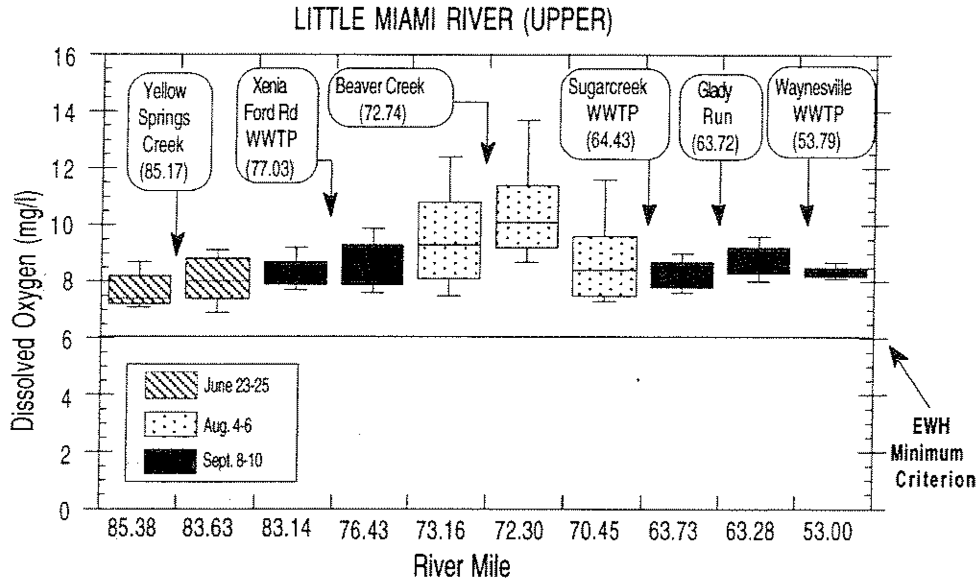


Figure 28a. Longitudinal summary of dissolved oxygen concentrations (minimum and mean values, daytime grab samples) in the upper and lower Little Miami River during the 1993 survey. Mixing zone values are shown for RMs 77.00, 64.40, 32.10, and 22.20.



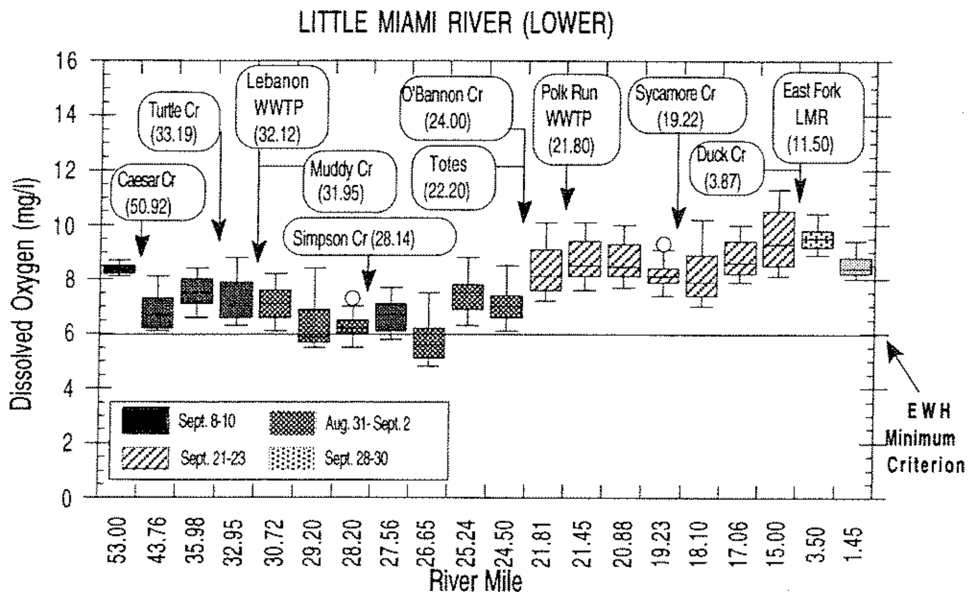


Figure 28b. Longitudinal summary of dissolved oxygen concentrations recorded with Datasonde continuous monitors in the upper and lower Little Miami River during the 1993 survey.

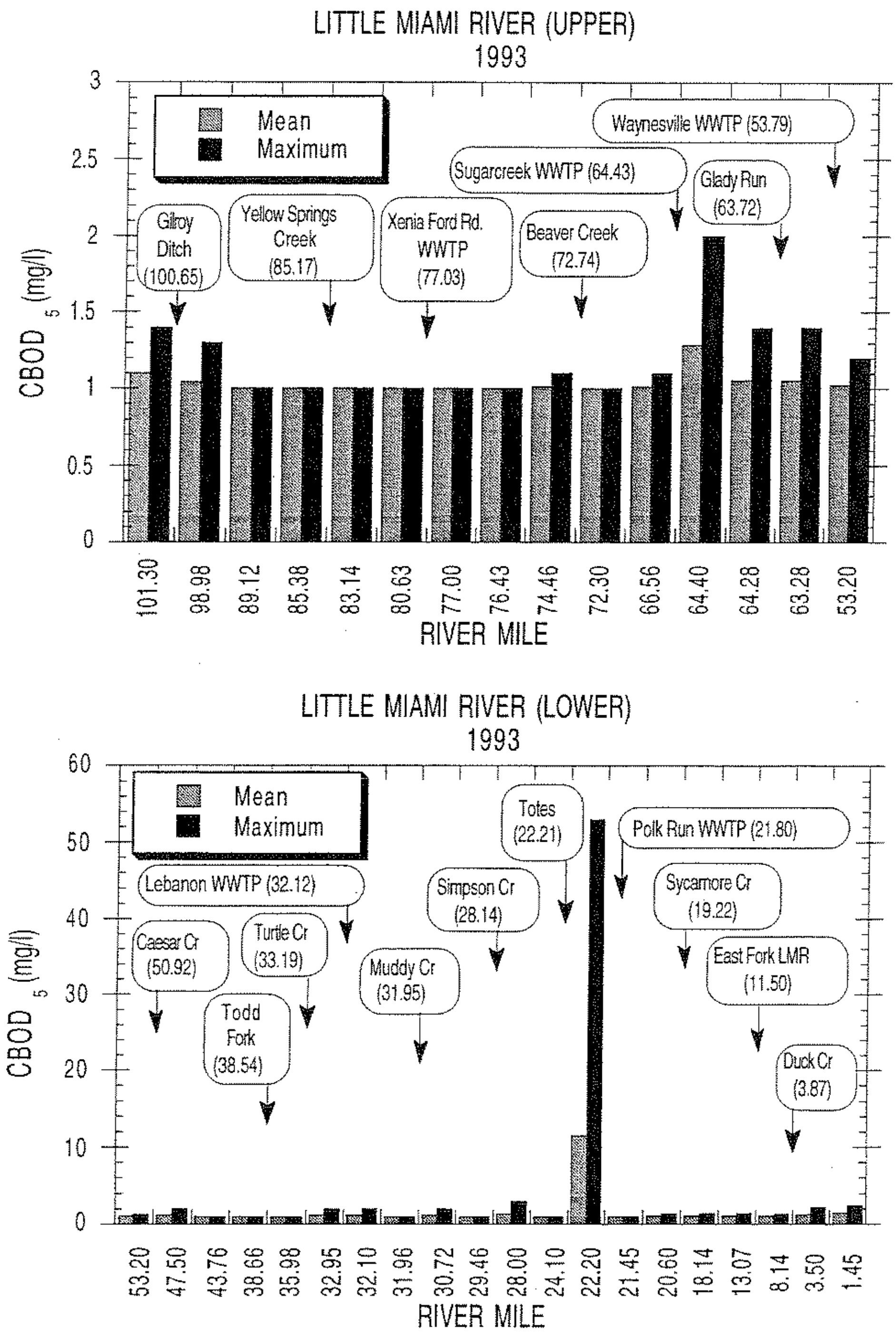


Figure 29. Longitudinal summary of $CBOD_5$ concentrations (mean and maximum values) in the upper and lower Little Miami River during the 1993 survey. Mixing zone values are shown for RMs 77.00, 64.40, 32.10, and 22.20.

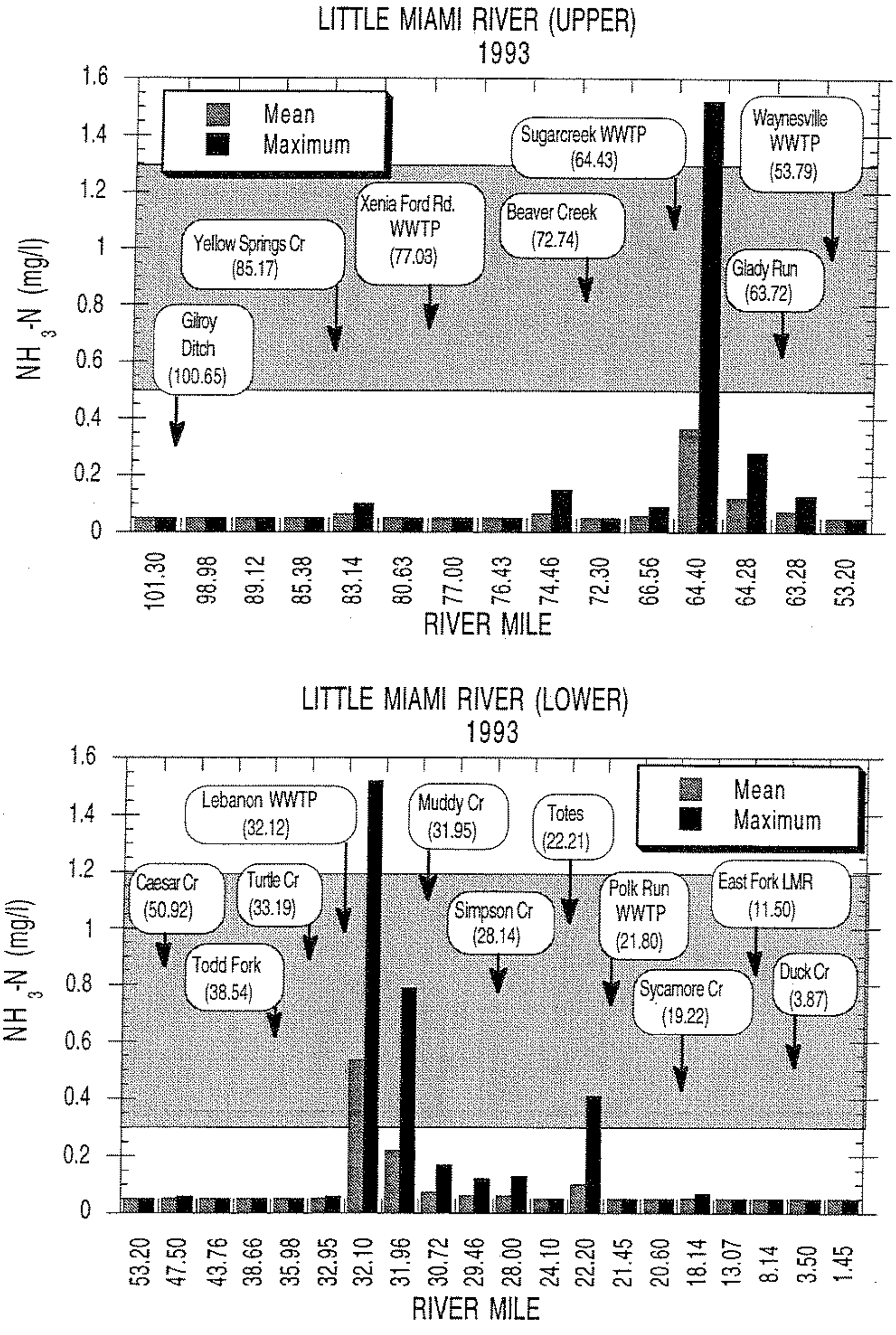


Figure 30. Longitudinal summary of ammonia-N concentrations (mean and maximum values) in the upper and lower Little Miami River during the 1993 survey *(shaded area is the ammonia-N water quality criteria range between the 25th and 90th percentile pH and temperature recorded during sample collection)*. The criteria does not apply for the mixing zone values shown for RMs 77.00, 64.40, 32.10, and 22.20.

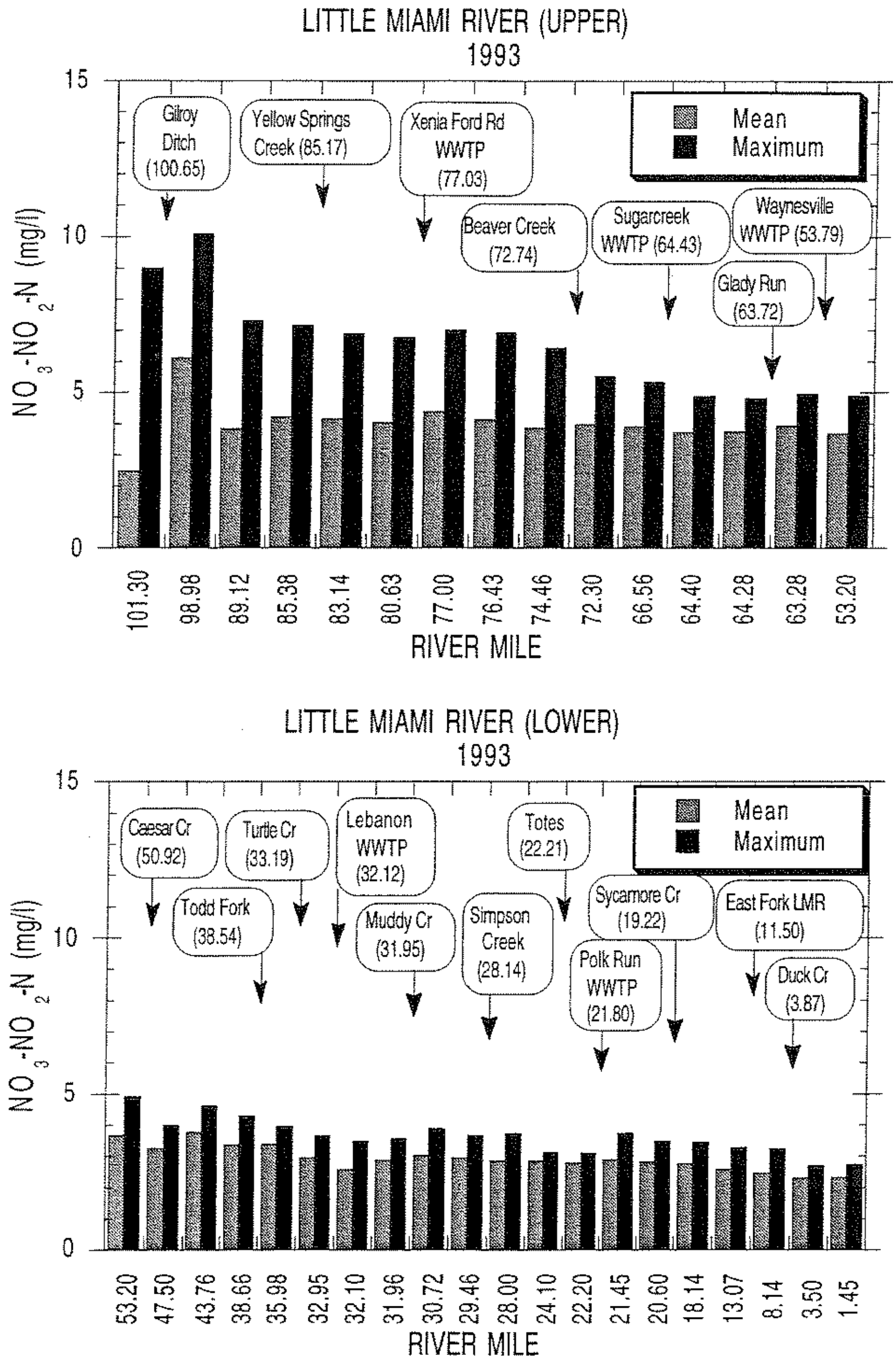
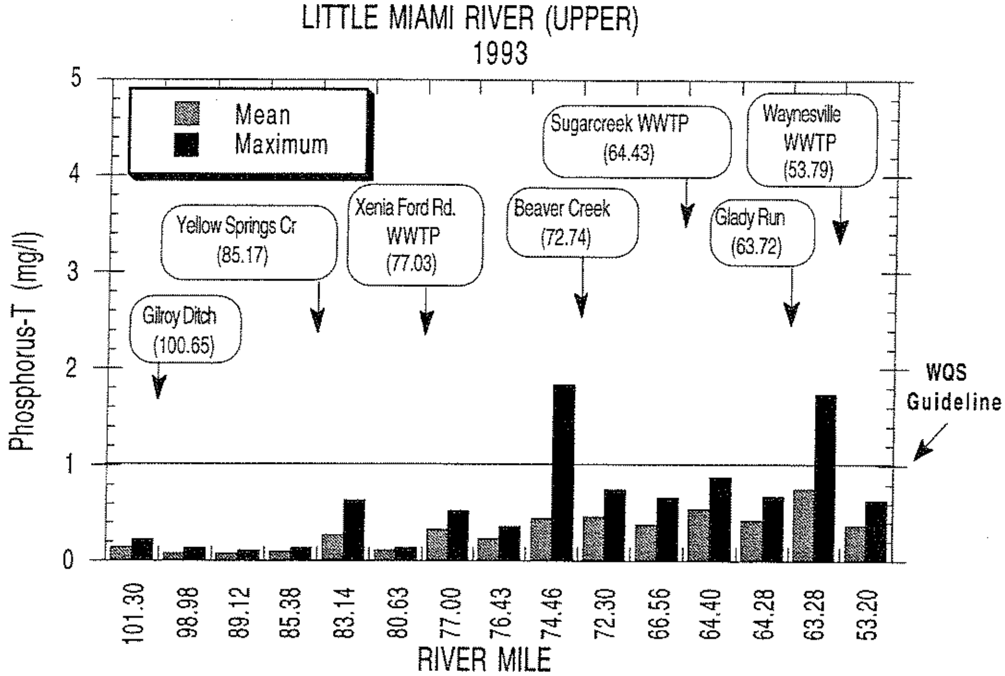


Figure 31. Longitudinal summary of nitrate+nitrite-N concentrations (mean and maximum values) in the upper and lower Little Miami River during the 1993 survey. Mixing zone values are shown for RMs 77.00, 64.40, 32.10, and 22.20.



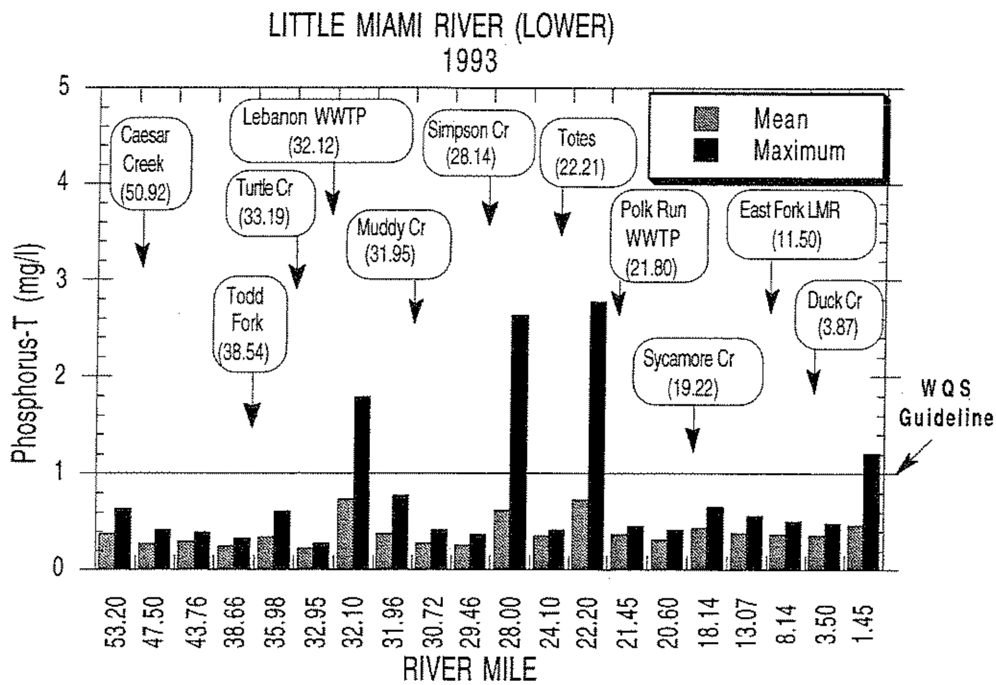


Figure 32. Longitudinal summary of total phosphorus concentrations (mean and maximum values) in the upper and lower Little Miami River during the 1993 survey. Mixing zone values are shown for RMs 77.00, 64.40, 32.10, and 22.20.

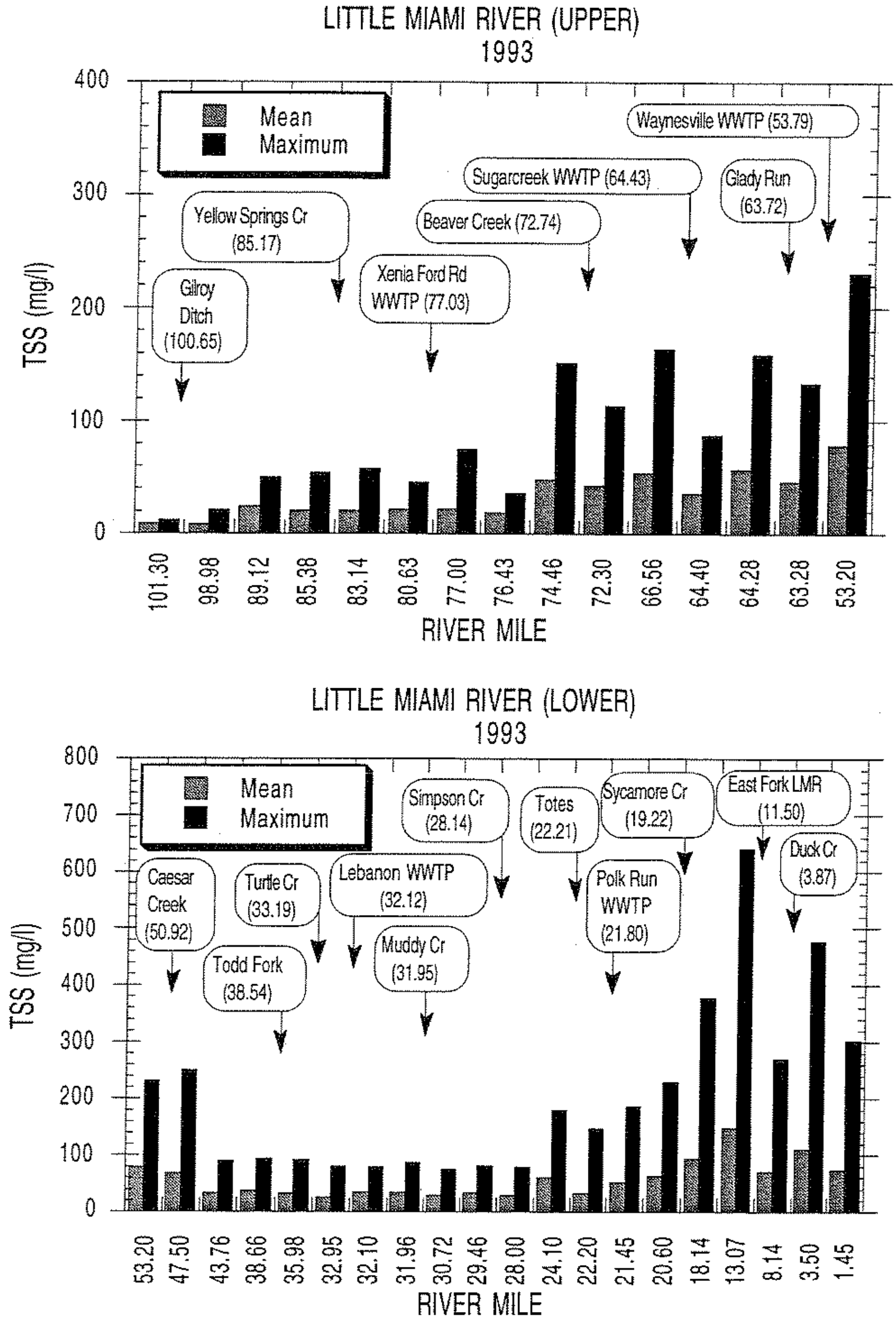


Figure 33. Longitudinal summary of total suspended solids concentrations (mean and maximum values) in the upper and lower Little Miami River during the 1993 survey. Mixing zone values are shown for RMs 77.00, 64.40, 32.10, and 22.20.

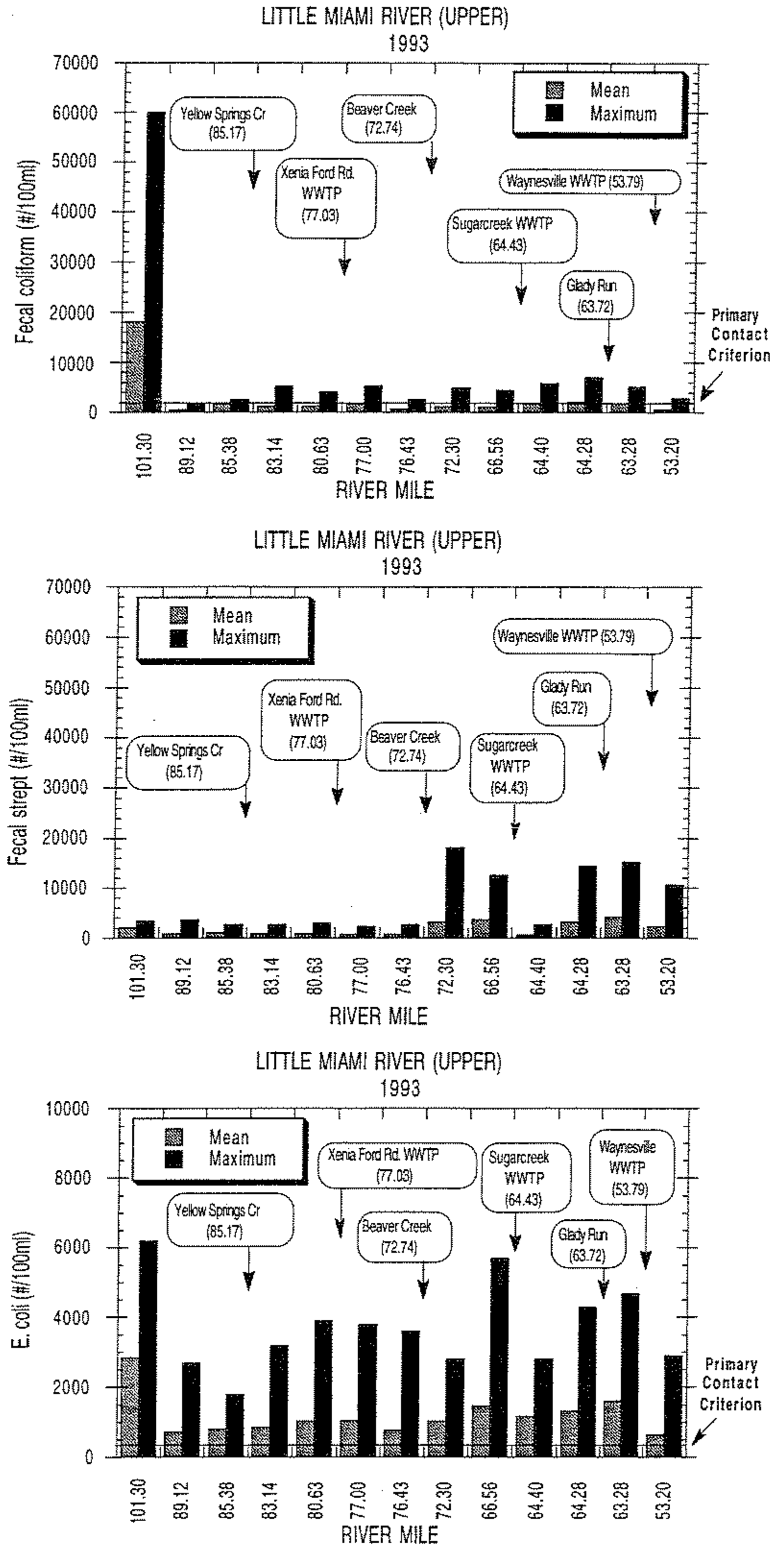


Figure 34. Longitudinal summary of fecal coliform, fecal strept, and *E. coli* concentrations (mean and maximum counts) in the upper Little Miami River during the 1993 survey. Mixing zone values are shown for RMs 77.00 and 64.40.

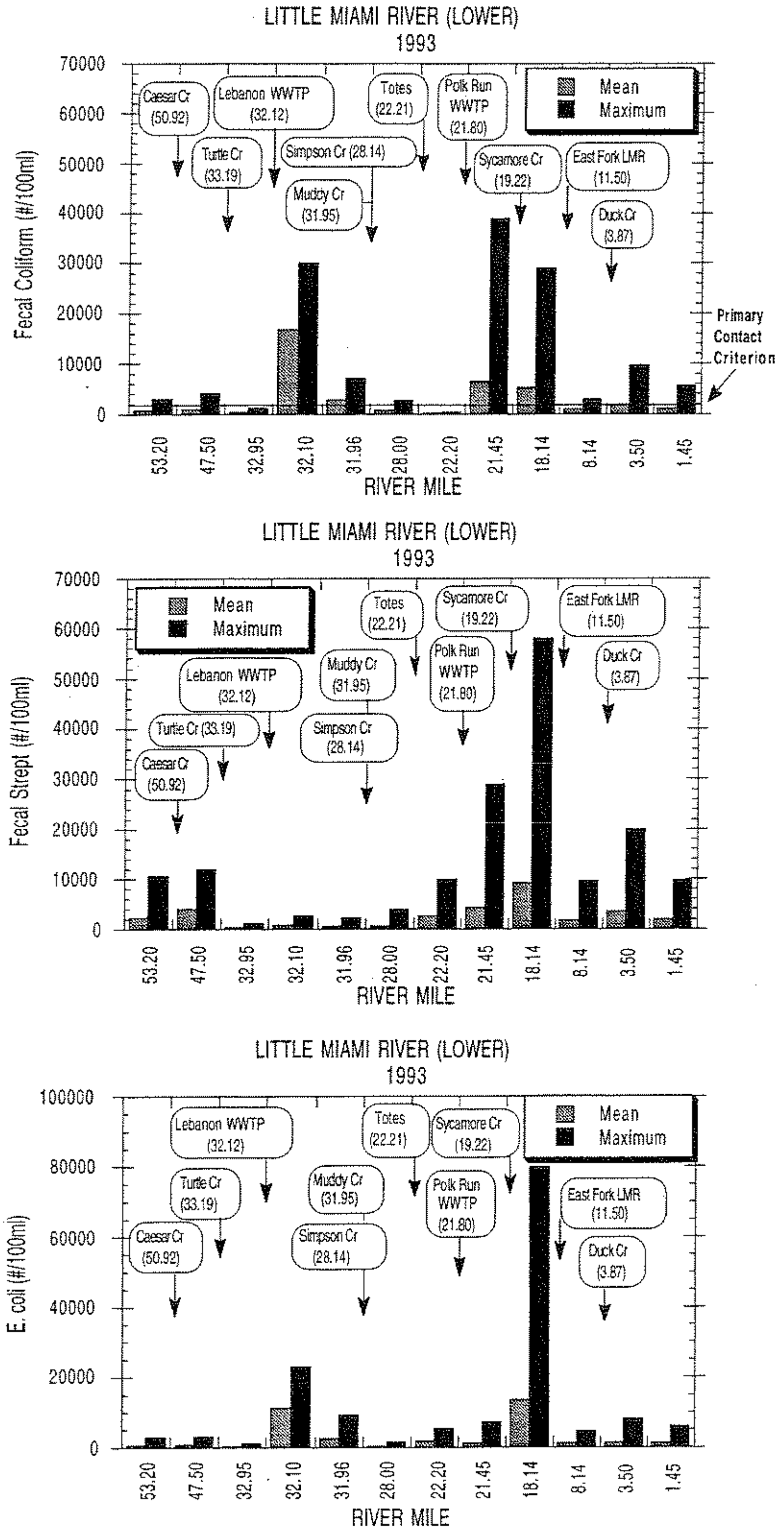


Figure 35. Longitudinal summary of fecal coliform, fecal strept, and *E. coli* concentrations (mean and maximum counts) in the lower Little Miami River during the 1993 survey. Mixing zone values are shown for RMs 32.10 and 22.20.

phosphorus concentration (0.76 mg/l) in the mainstem was recorded downstream from Glady Run (RM 63.28).

- Most (91%) of the high total suspended solids (TSS) concentrations were recorded during periods of heavy rain and high flows between July 13-15 (Figure 26-27,33). TSS were highest in the lower mainstem (RMs 18.14 - 1.45) and increased substantially downstream from Sycamore Creek (RM 19.22) to Milford (RM 13.07). Suspended sediment from excessive soil erosion appeared to be the primary source contributing to the high TSS concentrations in the lower mainstem.

- Almost every non-mixing zone sampling site on the mainstem had numerous exceedences of the primary contact recreation criterion due to elevated fecal coliform and *E. coli* counts (Figures 34-35, Table 6). The highest fecal coliform concentrations of the study area were recorded at Clifton Road (RM 101.30). Runoff from a manure composting operation and livestock pasturing near S. Charleston are likely responsible for the consistently higher fecal coliform levels at this site. The highest fecal concentrations (non-mixing zone) in the lower mainstem were recorded downstream from the Polk Run WWTP (RM 21.45) and Sycamore Creek (RM 18.14; Hamilton Co. Sycamore Creek WWTP). This segment receives untreated and partially treated sewage discharges from combined sewer (CSOs), sanitary sewer overflows (SSOs), and leaking sewer lines in tributaries. The high fecal values at RM 18.14 in particular may be a reflection of the combined impact of SSOs, the MSD Sycamore Creek WWTP, and sewer line leaks and replacement in the Sycamore Creek watershed.

- All mainstem sites sampled for organic compounds revealed exceedences of various water quality criteria (Table 6, A-5). Several exceedences of water quality criteria for selected pesticides occurred immediately downstream from WWTPs, although these same compounds were detected in upstream areas as well. Previous usage of organochlorine pesticides for agricultural purposes may also account for the compounds which were detected in the water column.

- Other mainstem water quality exceedences included a copper value of 137 µg/l at S.R. 72 (RM 89.12), a cadmium value of 6.4 µg/l at S.R. 48 (RM 32.95), and a mercury value of 1.8 µg/l downstream from Simpson Creek (RM 28.00).

Yellow Springs Creek

- All average and minimum dissolved oxygen values (daytime grabs and Datasonde) recorded in Yellow Springs Creek were above the 6.0 mg/l EWH water quality criteria (Figures 36a-36b, Tables 6, A-4, A-6).

- Ammonia-N levels markedly increased in Yellow Springs Creek downstream from the Yellow Springs WWTP. The mixing zone (RM 0.42) samples contained one highly elevated ammonia-N concentration and phosphorus levels frequently above 1.0 mg/l (Figures 37-38). One ammonia-N value also exceeded the chronic aquatic criterion (CAC) downstream from the WWTP (RM 0.10, Figure 37, Table 6). The quality of the effluent is improved as it flows over the high gradient cascading falls before entering Yellow Springs Creek.

- Moderate to high nitrate+nitrite-N concentrations were recorded at all sites reflecting a combined impact of nutrient loading from non-point agricultural runoff, other upstream point sources, and the WWTP (Figure 37). Longitudinally, TSS concentrations remained similar (Figure 38).

- Numerous exceedences of the primary contact recreation criteria for fecal coliform and *E. coli* were recorded both upstream (RM 0.44) and downstream (RM 0.10) of the Yellow Springs WWTP (Figure 39, Table 6). Fecal strept concentrations were also elevated at these sites. Overflows from a lift station upstream and agricultural runoff may account for the elevated fecal bacteria levels at the upstream site.

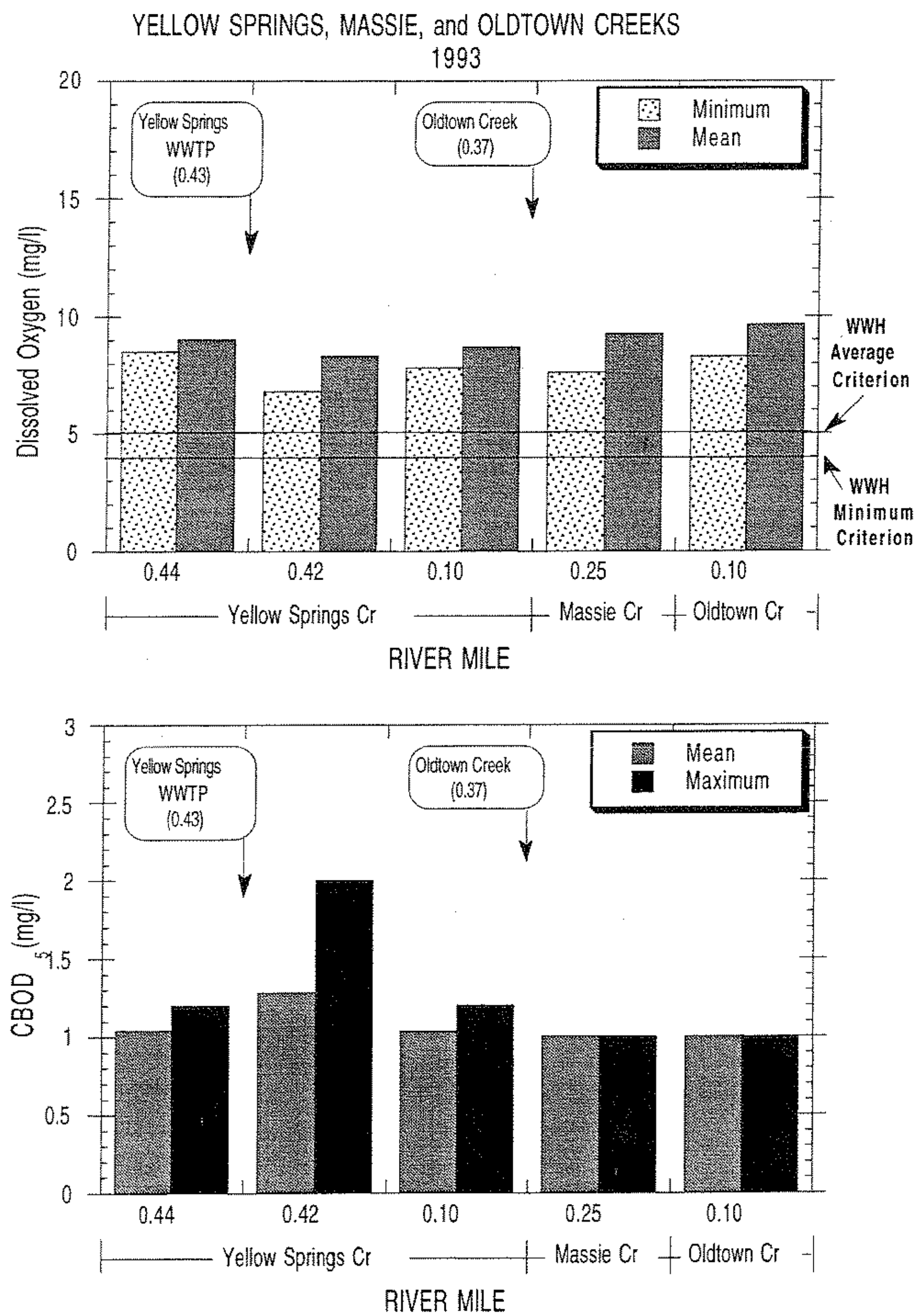


Figure 36a. Daytime grab dissolved oxygen concentrations (minimum and mean values) and $CBOD_5$ concentrations (mean and maximum values) in Yellow Springs, Massies, and Oldtown creeks during the 1993 survey. Mixing zone values are shown for RM 0.42.

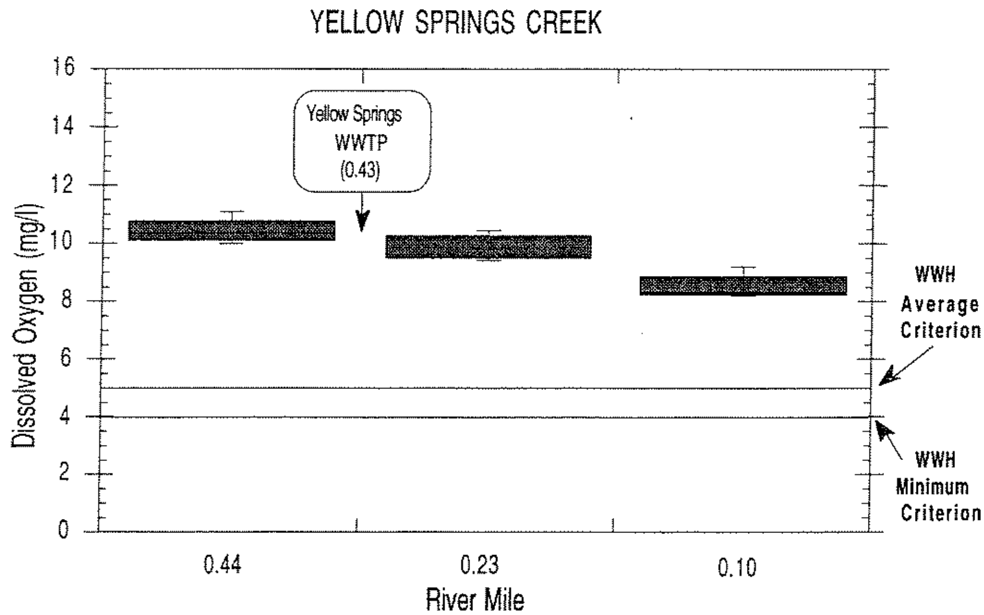
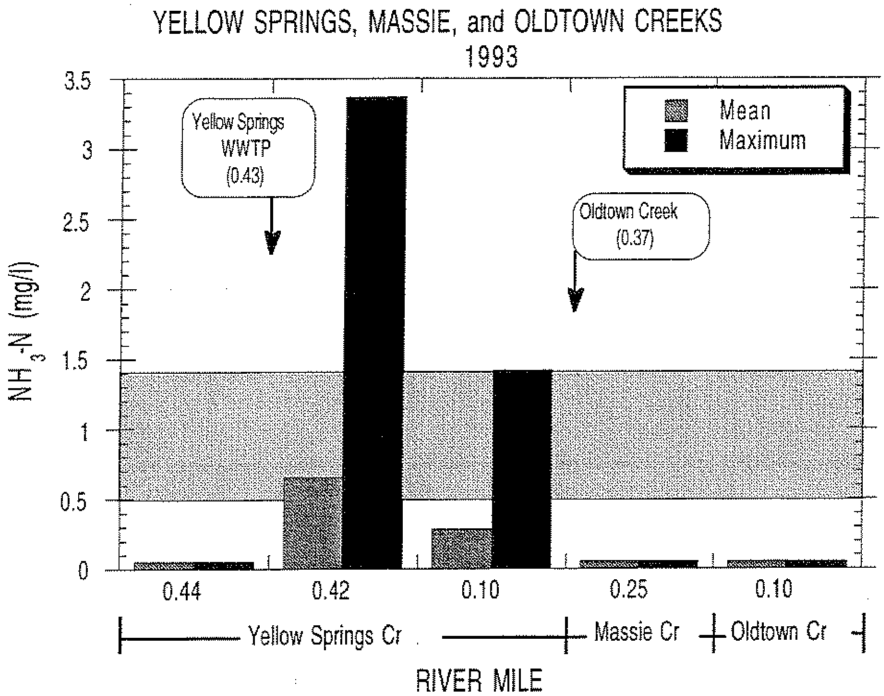


Figure 36b. Box and whisker plots of dissolved oxygen concentrations recorded with Datasonde continuous monitors in Yellow Springs Creek from September 29 - 30, 1993.



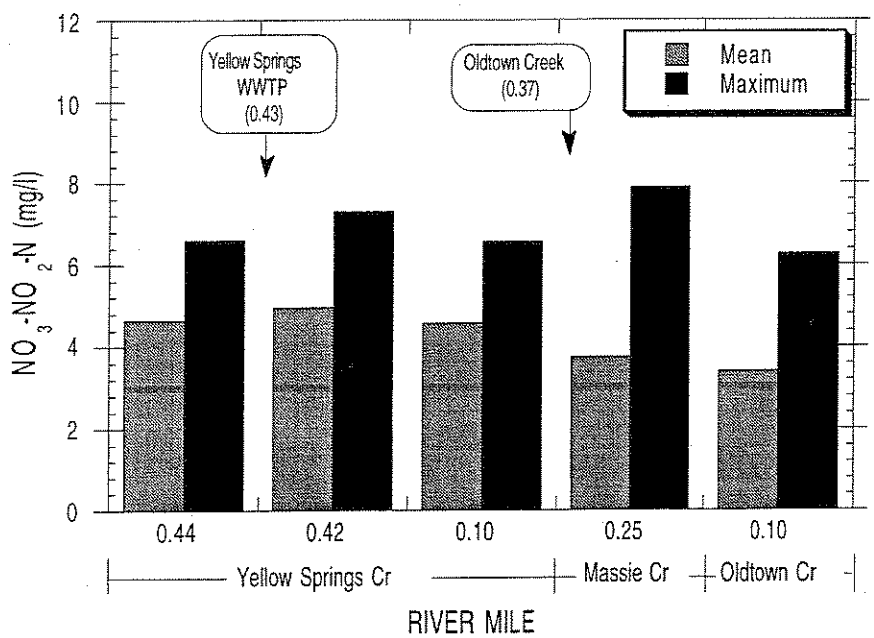
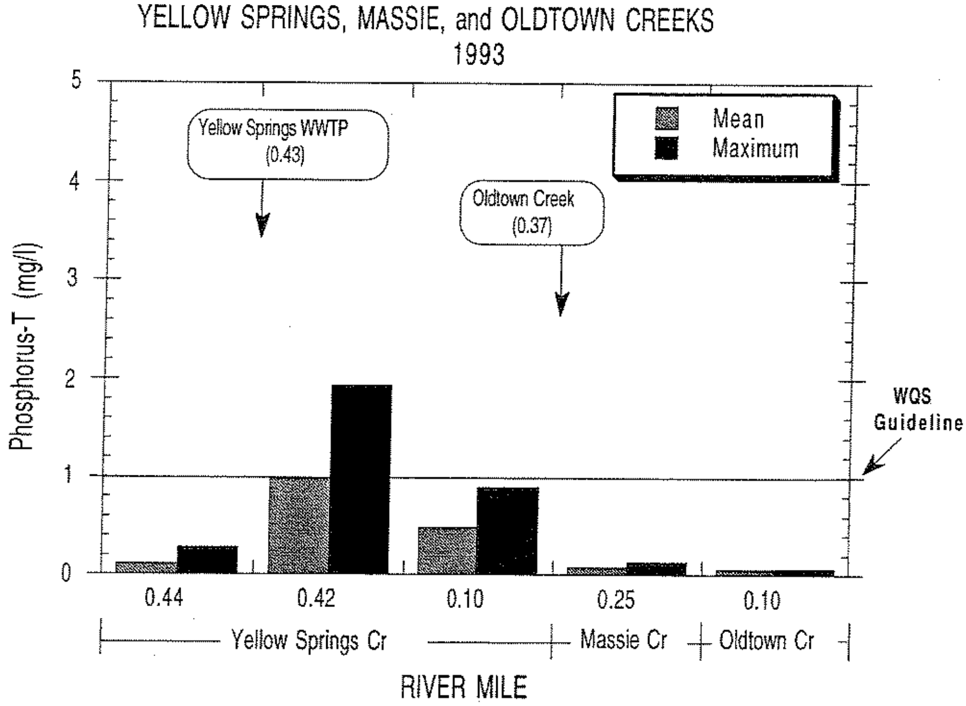


Figure 37. Longitudinal summary (mean and maximum values) of ammonia-N and nitrate+nitrite-N concentrations in Yellow Springs Creek, Massies Creek and Oldtown Creek during the 1993 survey (*shaded area is the ammonia-N water quality criteria range between the 25th and 90th percentile pH and temperature recorded during sample collection*). The criteria does not apply for the ammonia-N mixing zone values shown for RM 0.42.



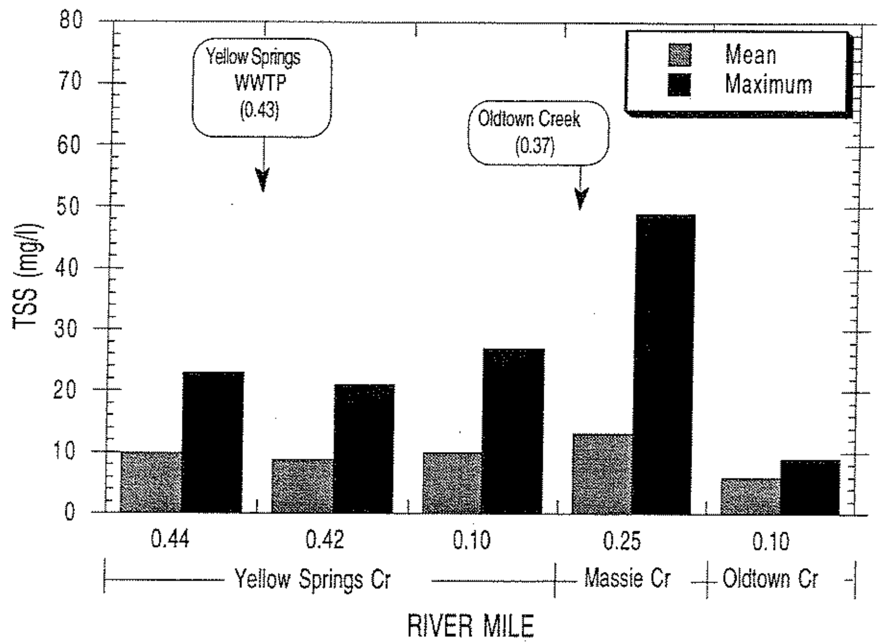


Figure 38. Longitudinal summary (mean and maximum values) of total phosphorus and total suspended solids concentrations in Yellow Springs Creek (mixing zone value shown for RM 0.42), Massies Creek and Oldtown Creek during the 1993 survey.

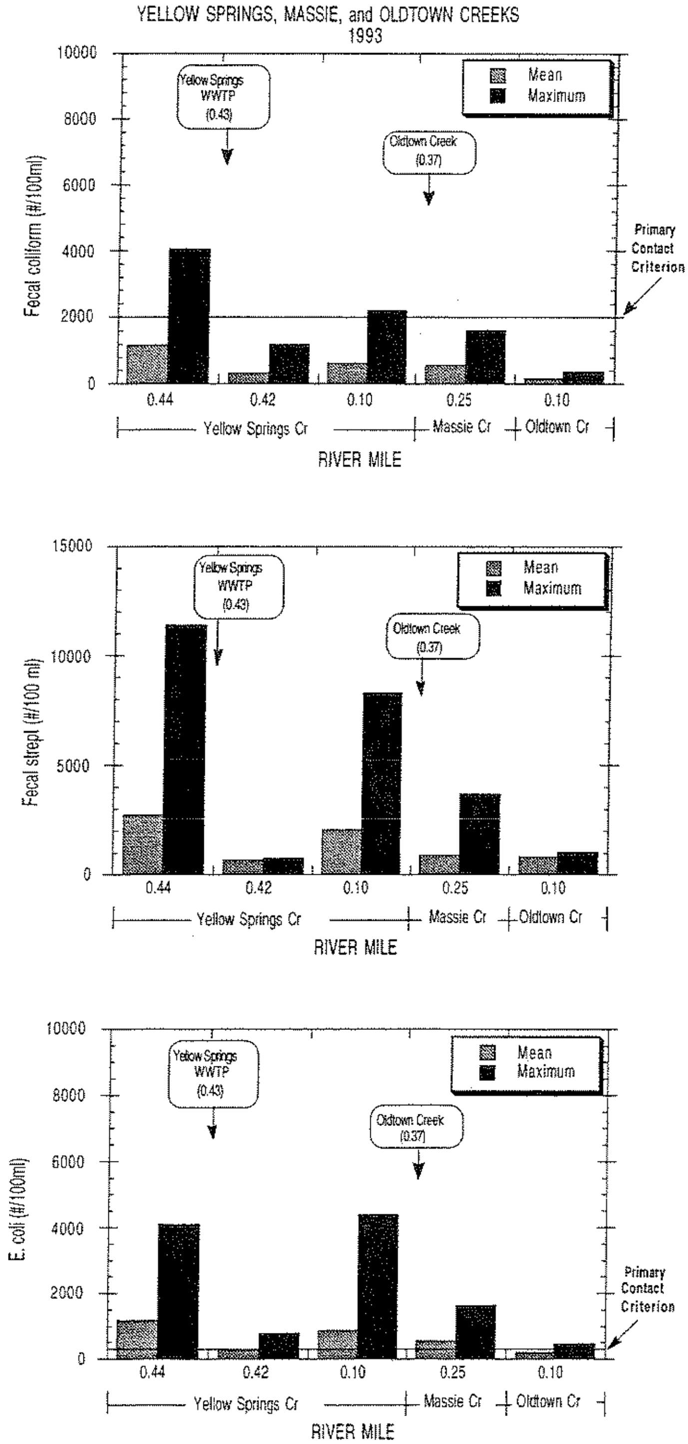


Figure 39. Longitudinal summary (mean and maximum values) of fecal coliform, fecal strep, and *E. coli* counts in Yellow Springs Creek (mixing zone value shown for RM 0.42), Massies Creek and Oldtown Creek during the 1993 survey.

- Organic sampling at RM 0.1 also detected low concentrations of organochlorine pesticides and volatile organic compounds (Table A-5). Only dieldrin exceeded water quality criteria.

Oldtown Creek

- Oldtown Creek had general good water quality with markedly lower concentrations of ammonia-N, total phosphorus, and fecal counts than Yellow Springs Creek (Figures 36a-39, Tables 6, A-4, A-5). Several *E. coli* counts exceeded the primary contact recreation criteria near the mouth. Low concentrations of organochlorine pesticides were also detected in one sample. No other parameters were elevated at RM 0.10.

Massies Creek

- Water quality in Massies Creek at U.S. 68 (RM 0.25) was also good and similar to Oldtown Creek except for moderate to high nitrate+nitrite-N levels and several exceedences of the primary contact recreation criteria for fecal coliform and *E. coli* (Figures 36a-39, Tables 6, A-4). The maximum TSS concentration recorded (49 mg/l) coincided with the higher flows experienced during the second week of the survey (Figure 38).

Beaver Creek

- Dissolved oxygen concentrations measured in Beaver Creek (daytime grabs and Datasonde) were above the WWH water quality criteria at all four locations (Figures 40a-40b, Table A-6).

- Ammonia-N levels at all sites were very low. Longitudinally, nitrate+nitrite-N concentrations in Beaver Creek increased downstream of the Little Beaver Creek (due to levels discharged by the Montgomery Co. Eastern Regional WWTP), peaked in the Greene Co. Beaver Creek WWTP mixing zone (RM 0.39) and remained in the moderate to high range downstream from both WWTPs (RM 0.20, Figure 41).

- Further evidence of nutrient enrichment is shown by phosphorus levels which follow the same general longitudinal pattern as nitrate+nitrite-N. Phosphorus values frequently exceeded the WQS guideline of 1.0 mg/l. (Figure 42, Table 6).•Turbidity levels in Beaver Creek were consistently higher at RM 1.57 than downstream from the confluence of Little Beaver Creek (Figure 42). Poor soil erosion control at upstream development sites likely account for the increased suspended sediment levels. Little Beaver Creek's flow, however, is dominated by WWTP effluent which contains very low amounts of solids when the plant is efficiently operating.

- Fecal bacteria counts in Beaver Creek detected frequent exceedences of the *E. coli* secondary contact recreation criterion at all sites and one fecal coliform exceedence of the secondary contact recreation criterion upstream from both major WWTPs (RM 1.57, Figure 43, Table 6).

- Organochlorine pesticides and volatile organic compounds were detected in water samples immediately downstream of the Beaver Creek WWTP (RM 0.20). Several exceedences of water quality criteria for endrin, dieldrin, and endosulfan II were observed (Tables 6, A-5).

Little Beaver Creek

- Similar to Beaver Creek, minimum dissolved oxygen values (daytime grabs or Datasonde) in Little Beaver Creek did not drop below WWH water quality criteria (Figures 40a-40b,Tables 6, A-6).

- Ammonia-N concentrations increased downstream from the Montgomery Co. Eastern Regional WWTP, but remained below WWH water quality criteria (Figure 41). Nutrient enrichment from the WWTP is also apparent in the sustained, elevated nitrate+nitrite-N and phosphorus concentrations downstream from the WWTP (Figures 41-42, Table 6).

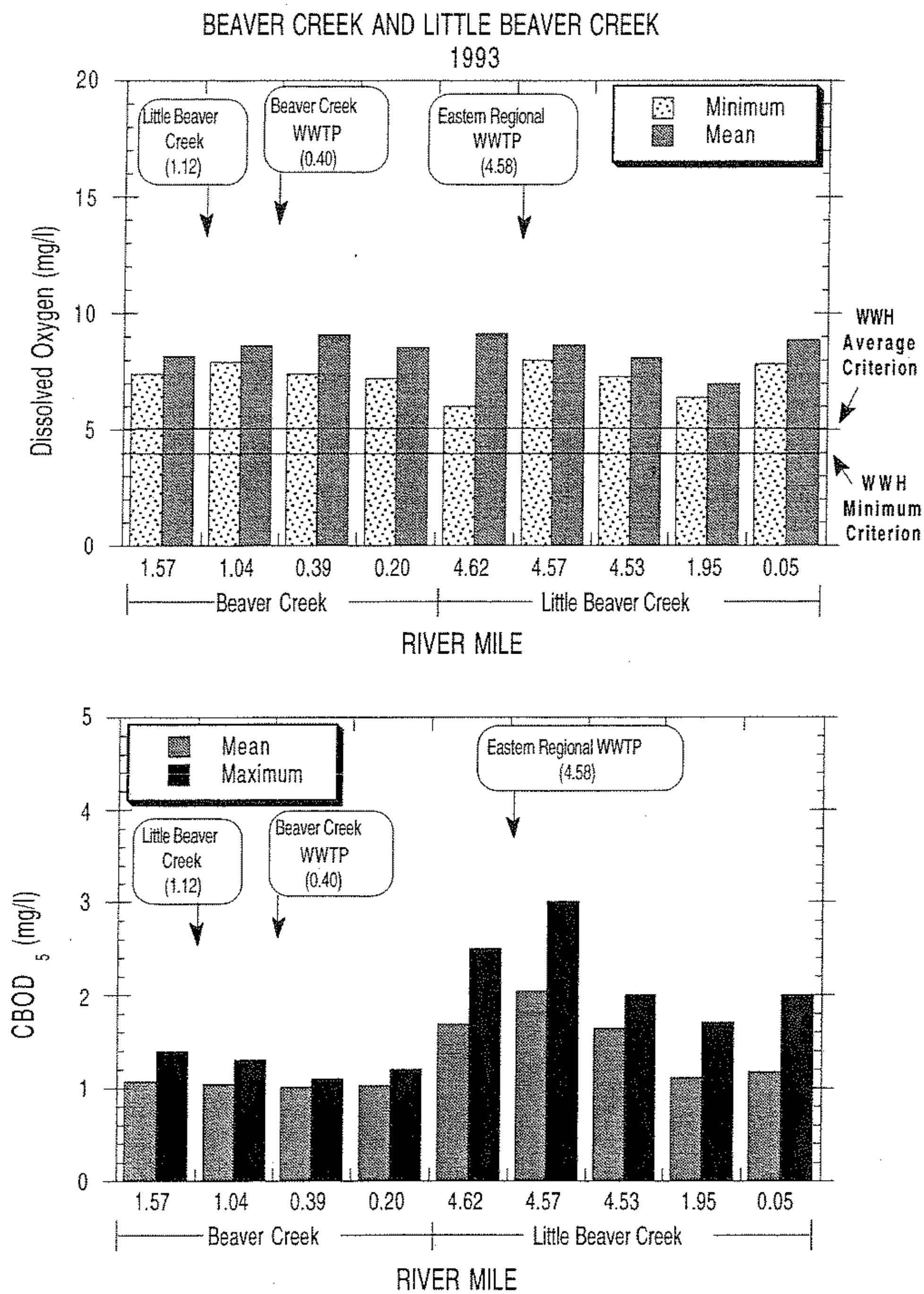


Figure 40a. Longitudinal summary of dissolved oxygen (daytime grab mean and minimum values) and $CBOD_5$ (mean and maximum) concentrations in Beaver Creek and Little Beaver Creek during the 1993 survey. Mixing zone values are shown for RMs 0.39 and 4.57.

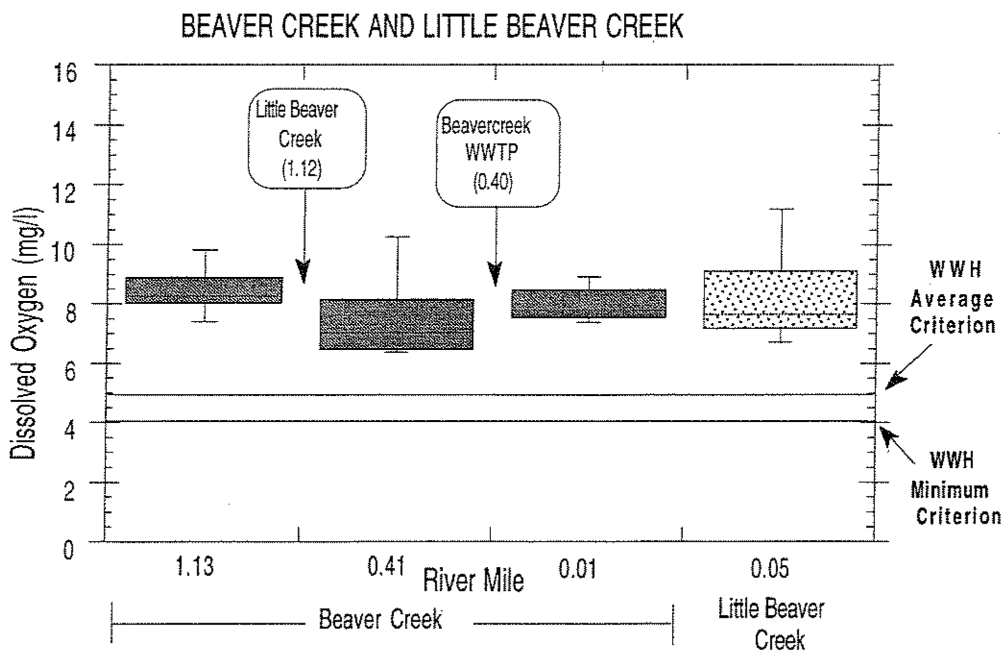


Figure 40b. Longitudinal summary of dissolved oxygen (box and whisker plots) concentrations recorded by Datasonde continuous monitors in Beaver Creek and Little Beaver Creek from August 4-6, 1993.

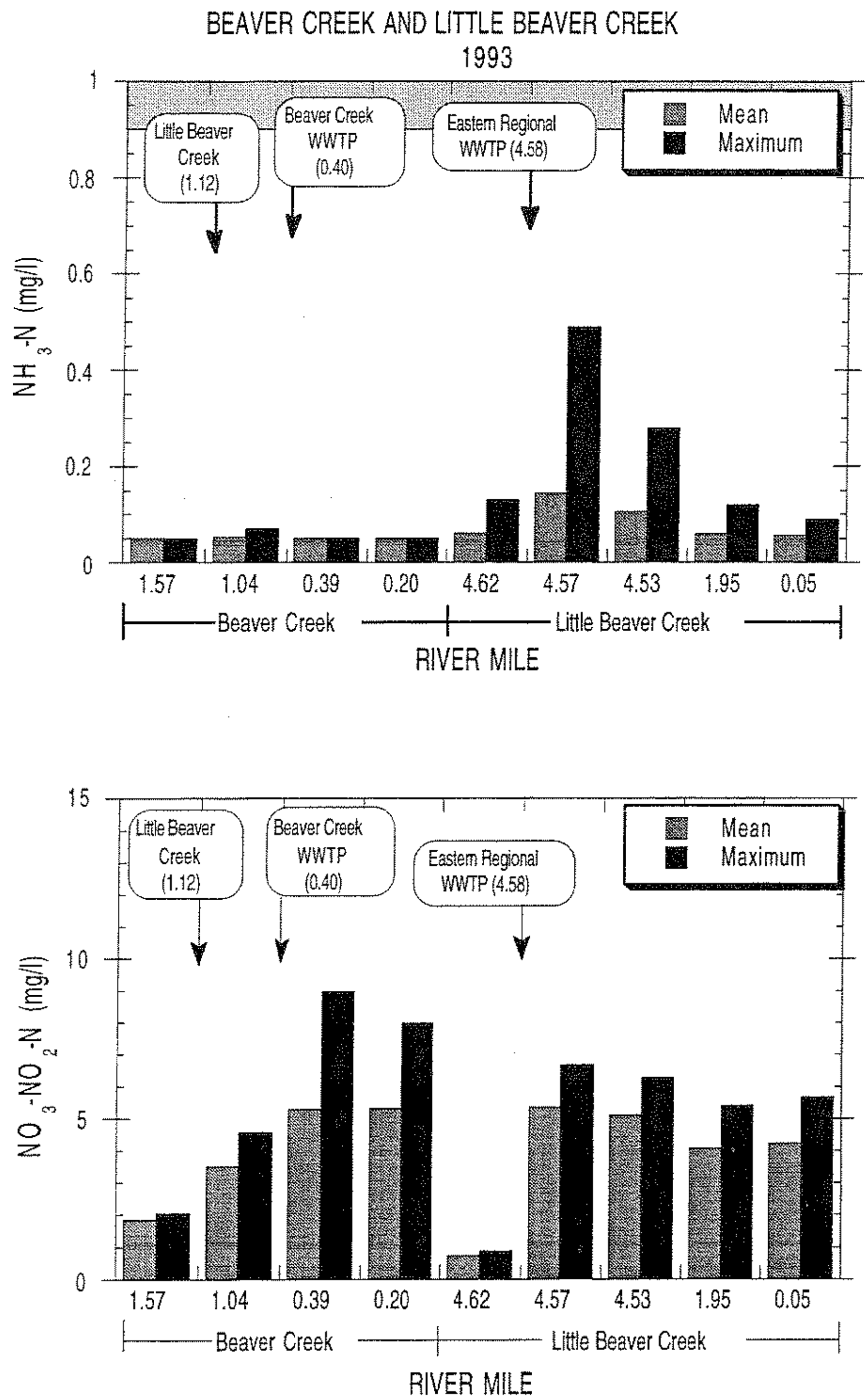
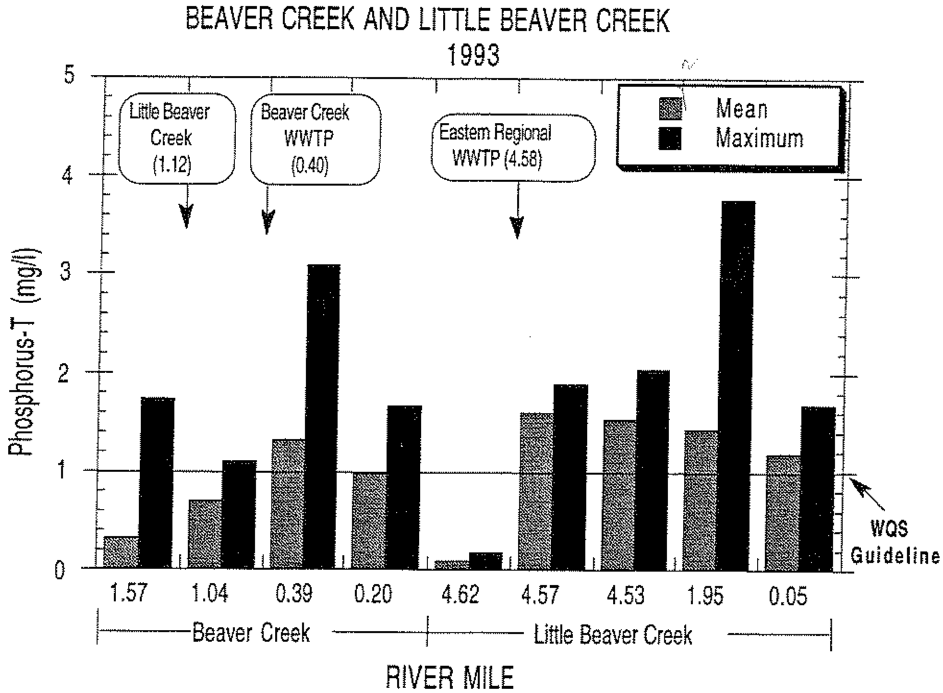


Figure 41. Longitudinal summary of ammonia-N and nitrate+nitrite-N concentrations (mean and maximum values) in Beaver Creek and Little Beaver Creek during the 1993 survey (*shaded area is the ammonia-N water quality criteria range between the 25th and 90th percentile pH and temperature recorded during sample collection*). The ammonia-N criteria does not apply to the mixing zone values shown for RMs 0.39 and 4.57.



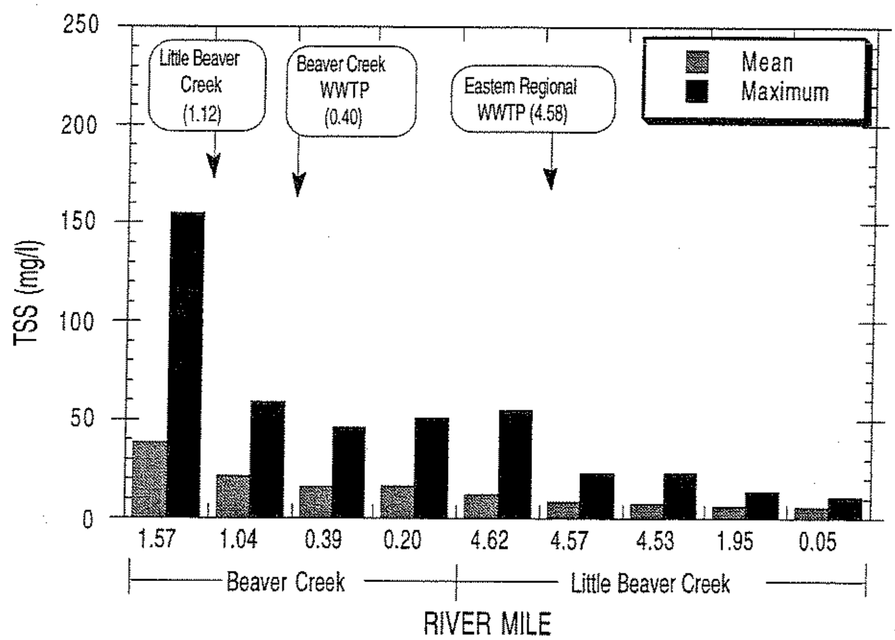


Figure 42. Longitudinal summary of total phosphorus and total suspended solids concentrations (mean and maximum values) in Beaver Creek and Little Beaver Creek during the 1993 survey. Mixing zone values shown for RMs 0.39 and 4.57.

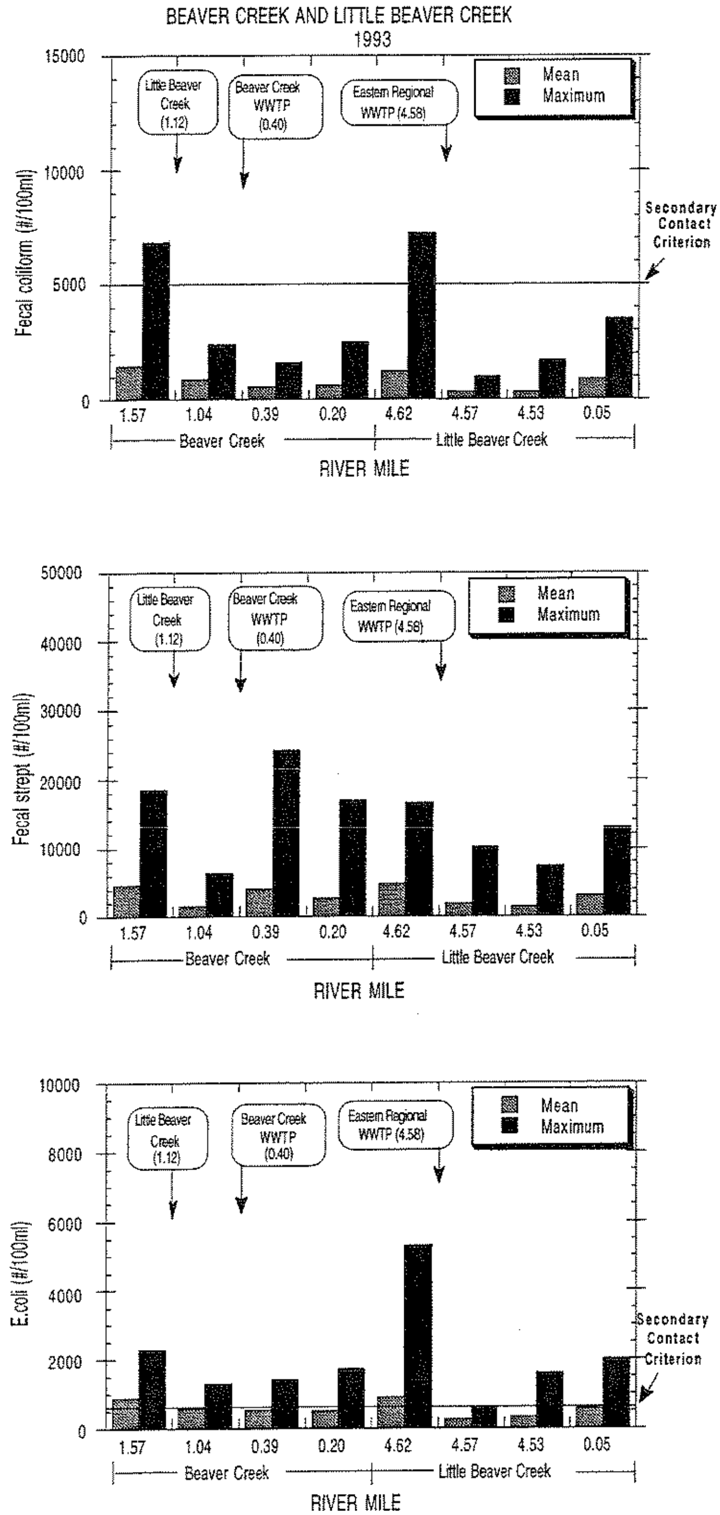
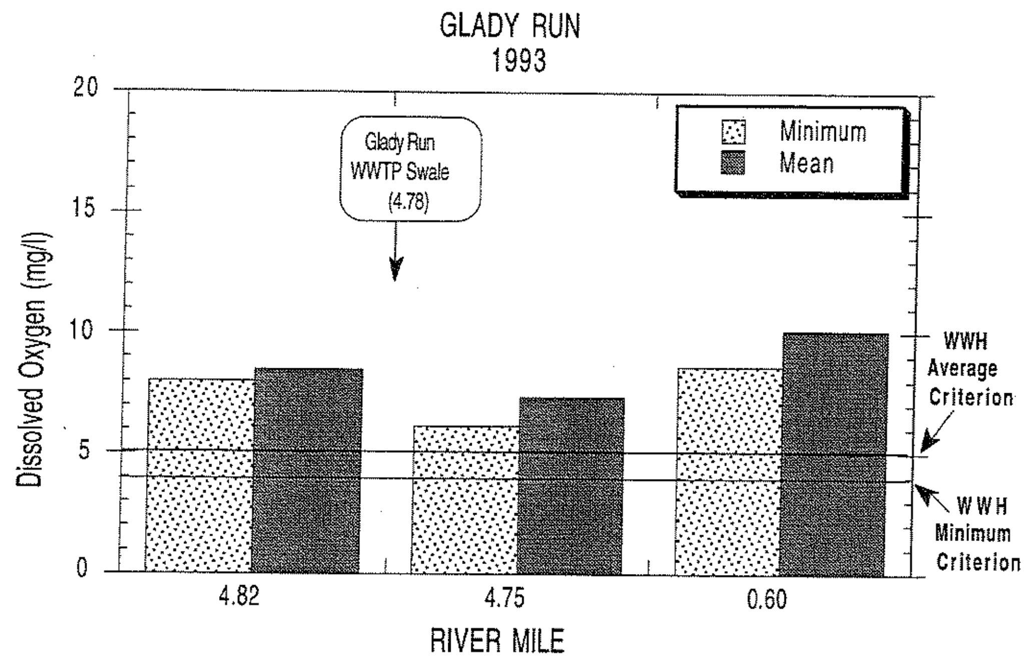


Figure 43. Longitudinal summary of fecal coliform, fecal strep, and *E. coli* concentrations (mean and maximum values) in Beaver Creek and Little Beaver Creek during the 1993 survey. Mixing zone values shown for RMs 0.39 and 4.57.



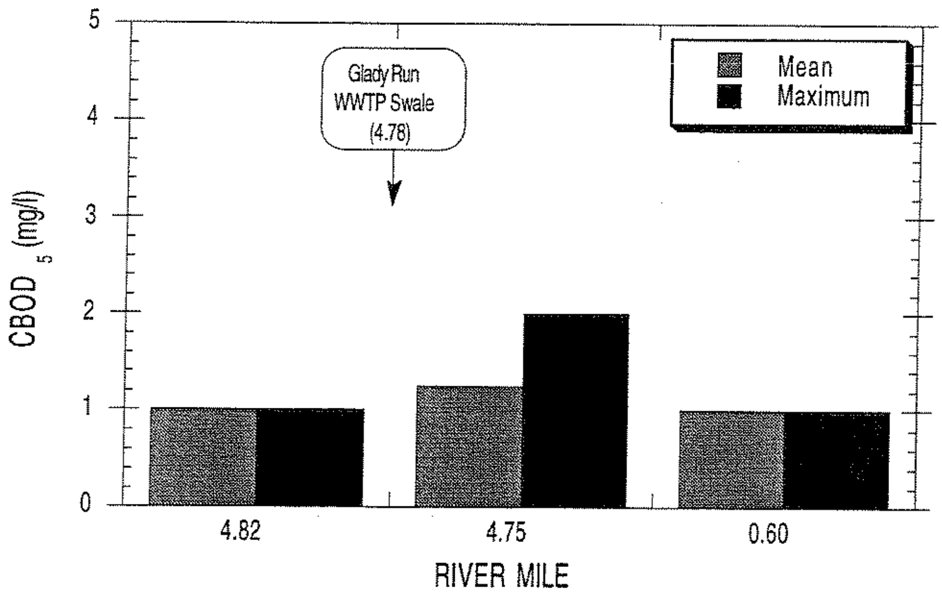


Figure 44a. Longitudinal summary of dissolved oxygen (daytime grab mean and minimum values) and $CBOD_5$ (mean and maximum values) concentrations in Glady Run during the 1993 survey.

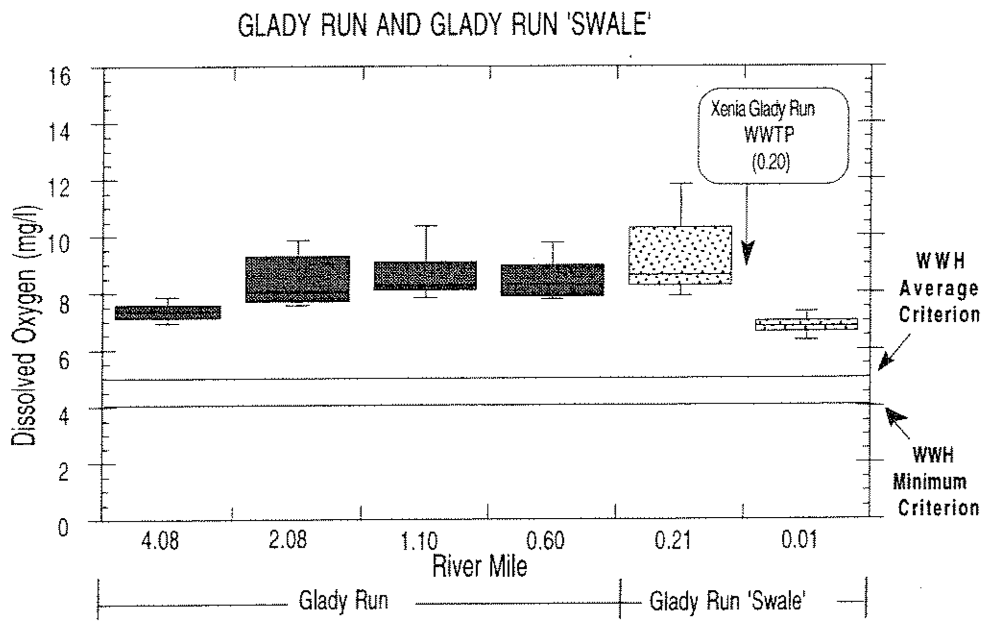
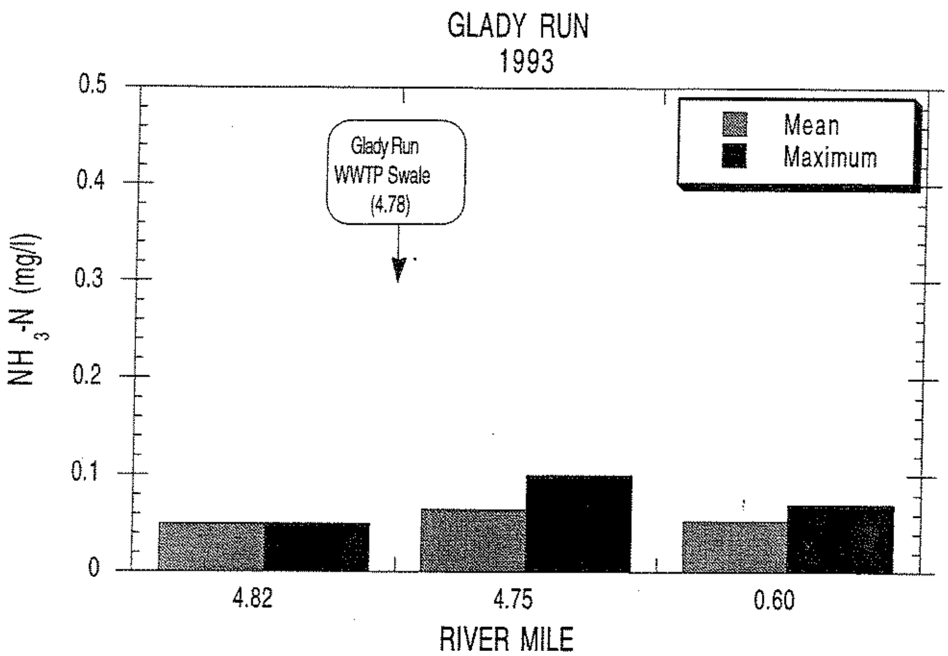


Figure 44b. Longitudinal summary of dissolved oxygen concentrations (box and whisker plots) recorded with Datasonde continuous monitors in Glady Run and Glady Run "Swale" from September 8-10, 1993.



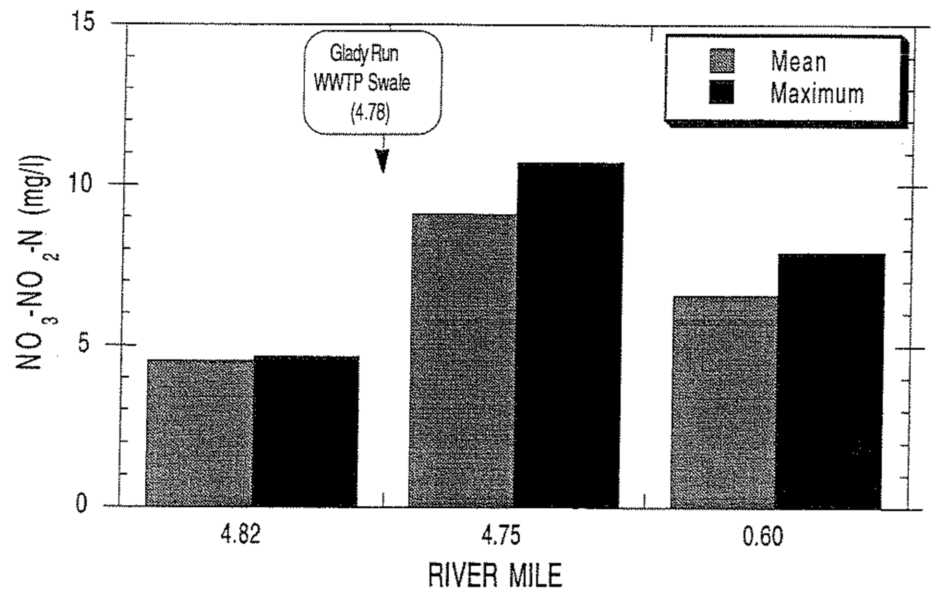


Figure 45. Longitudinal summary of ammonia-N and nitrate+nitrite-N concentrations (mean and maximum values) in Glady Run during the 1993 survey.

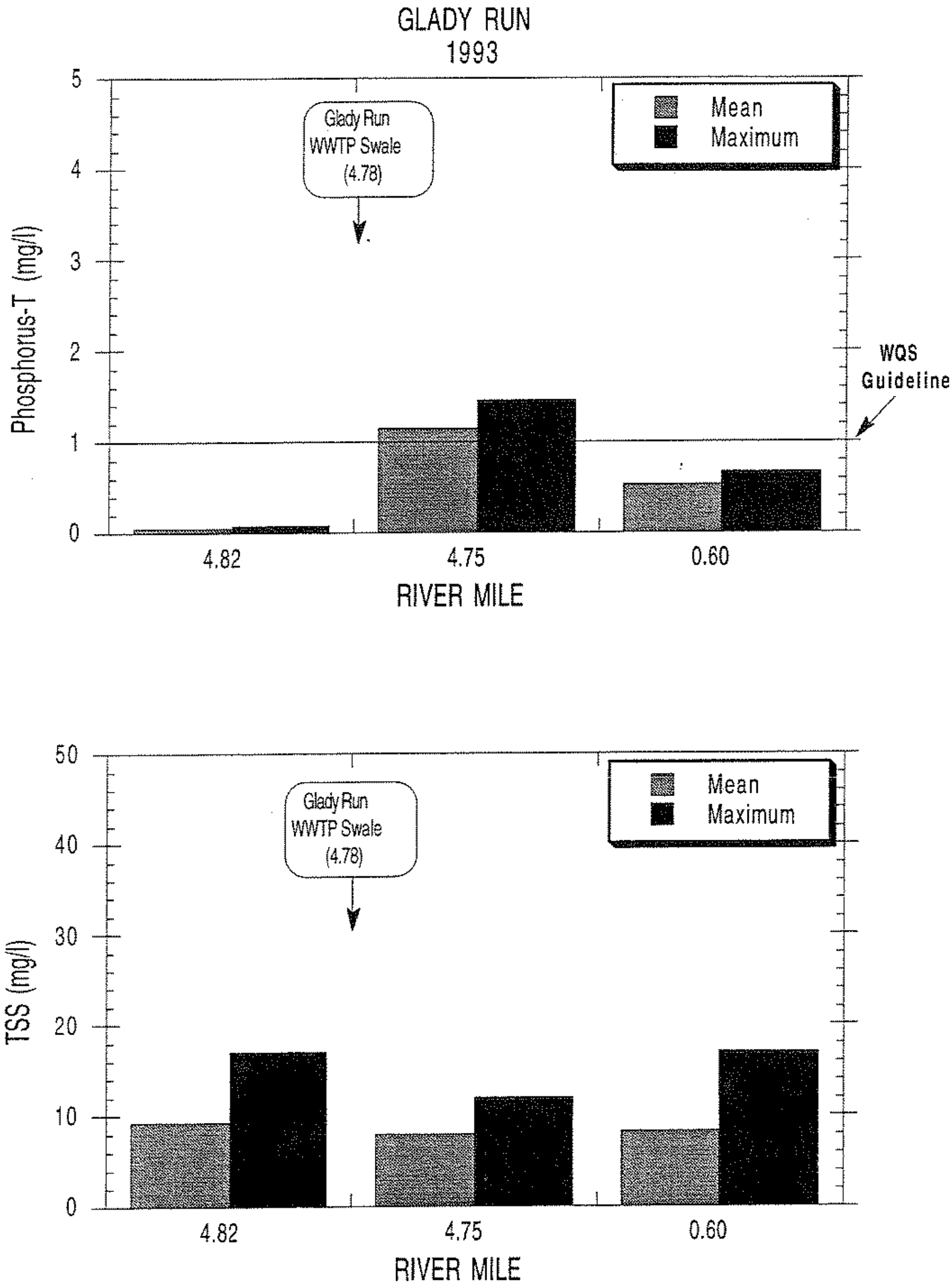


Figure 46. Longitudinal summary of total phosphorus and total suspended solids (TSS) concentrations (mean and maximum values) in Glady Run during the 1993 survey.

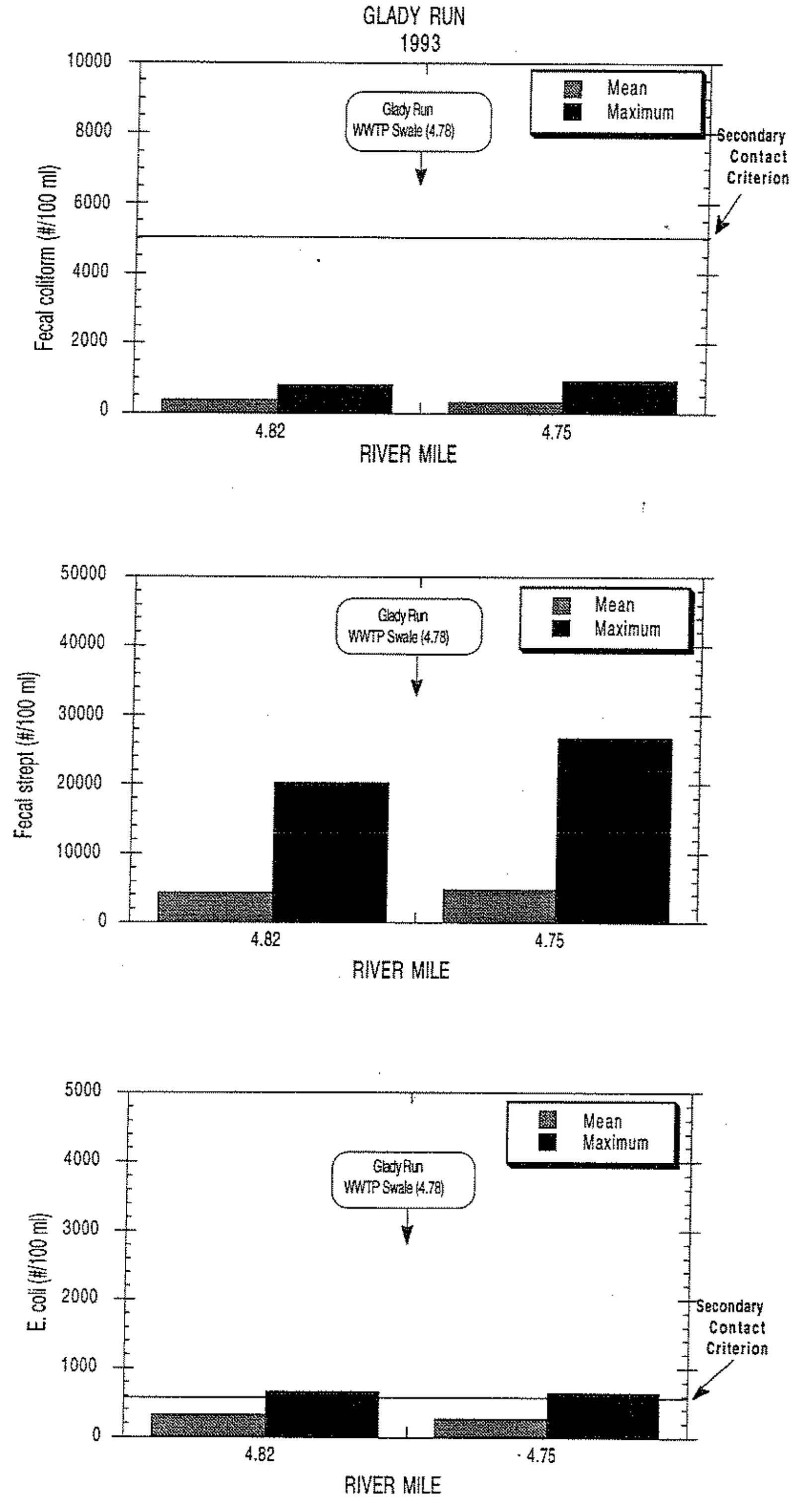


Figure 47. Longitudinal summary of fecal coliform, fecal strep, and *E. coli* counts (mean and maximum values) in Glady Run during the 1993 survey.

- Fecal coliform counts upstream from the WWTP (RM 4.62) exceeded the secondary contact recreation criterion on one occasion. *E. coli* counts frequently exceeded secondary contact recreation criterion at all sites. Most high fecal coliform and TSS values recorded in both Beaver Creek and Little Beaver Creek occurred on June 29, a day after localized heavy rains. Elevated levels of fecal coliform and TSS are most common after rain events, reflecting contributions from nonpoint urban and agricultural stormwater runoff (Figures 42-43, Table 6).

- Organic sampling downstream from the Montgomery Co. Eastern Regional WWTP (RM 4.53) detected the presence of organochlorine pesticides and volatile organic compounds. Several pesticide concentrations exceeded water quality criteria (Tables 6, A-5).

Glady Run and Glady Run Swale

- Glady Run has recently changed course to intercept the Glady Run swale upstream from the Xenia Glady Run WWTP. The swale was previously an unnamed tributary to Glady Run to which the Xenia Glady Run WWTP discharges. Further investigation revealed that subsequent to the dismantling of the railroad between Glady Run and the Glady Run swale, Glady Run has eroded through the old railroad grade to capture the swale upstream from the WWTP.

- Datasonde continuous monitors detected a marked decline in dissolved oxygen levels in the Glady Run swale downstream of the Xenia Glady Run WWTP (RM 0.01). However, dissolved oxygen values in both Glady Run and the swale remained above the WWH water quality criteria (Figure 44b, Table A-6). Daytime grab dissolved oxygen values in Glady Run downstream from the swale (RM 4.75) also showed a slight decline (Figure 44a).

- Most ammonia-N concentrations were below the minimum detection limit in both streams. Nutrient enrichment from the Xenia-Glady Run WWTP increased nitrate+nitrite-N and phosphorus concentrations significantly increased in Glady Run downstream of the swale, and remained moderately to highly elevated to RM 0.60 (Figures 45-46, Table 6,A-4).

- Fecal coliform counts remained well below the secondary contact criterion both upstream and downstream from the Glady Run swale (RMs 4.82-4.75). *E. coli* counts, however, exceeded the criterion once at both sites and suggest human fecal contamination. An elevated fecal strep count also suggests potential contributions from non-point agricultural runoff (Figure 47, Table 6).

- Organic samples taken in Glady Run at RM 4.75 downstream of the mouth of the swale revealed various organochlorine pesticides and low levels of volatile organic compounds (Table A-5). Several concentrations of pesticides exceeded water quality criteria (Table 6).

Anderson Fork

- Water samples from one site in Anderson Fork (RM 4.90) revealed good water quality with concentrations of most parameters well within water quality criteria. A daytime grab dissolved oxygen value, however, dropped below the EWH minimum water quality criterion (Figure 48, Table 6). $CBOD_5$ and ammonia-N concentrations were below the minimum detection limits. Elevated nitrite nitrate-N and TSS concentrations were recorded on July 15 after heavy rains in the area. Dieldrin and endosulfan II concentrations also exceeded water quality criteria (Table 6, A-5).

Caesar Creek

- Water samples collected at the upstream Caesar Creek site (RM 16.52) had one daytime grab dissolved oxygen value below 6.0 mg/l and one phosphorus value above 1.0 mg/l (Figures 48-49, Table 6). This was the only location in the study area where no organic compounds were

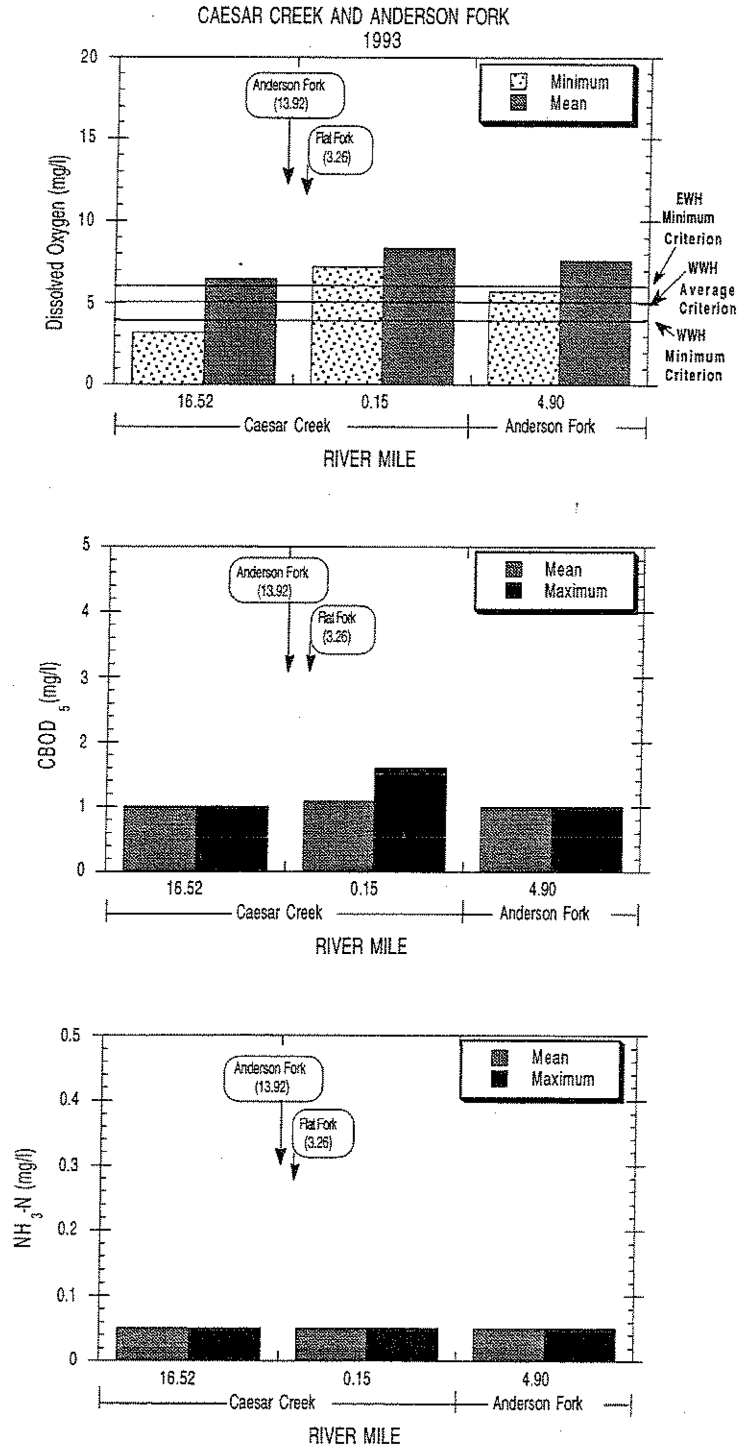


Figure 48. Longitudinal summary of dissolved oxygen (daytime grab mean and minimum values), $CBOD_5$, and ammonia-N(mean and maximum values) concentrations in Caesar Creek and Anderson Fork during the 1993 survey.

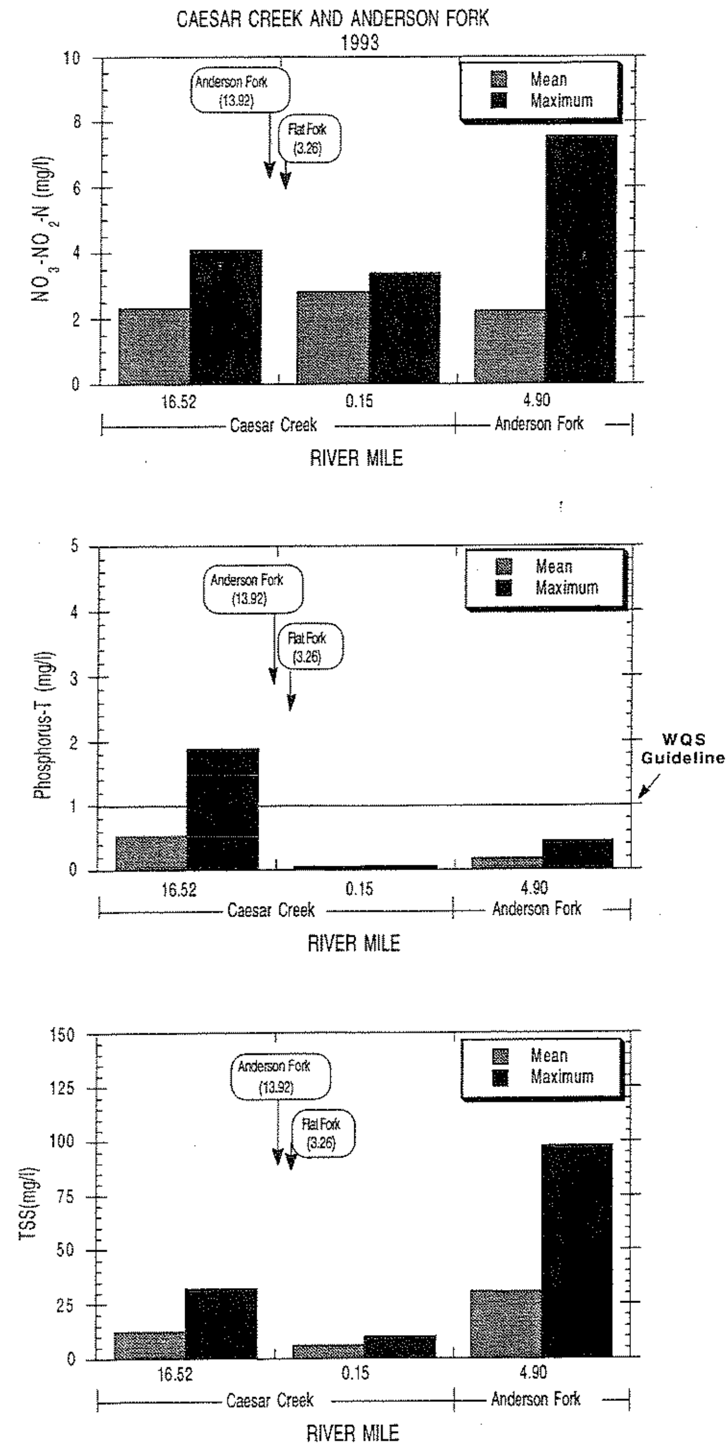


Figure 49. Longitudinal summary of nitrate+nitrite-N, total phosphorus, and total suspended solids (TSS) concentrations (mean and maximum values) in Caesar Creek and Anderson Fork during the 1993 survey.

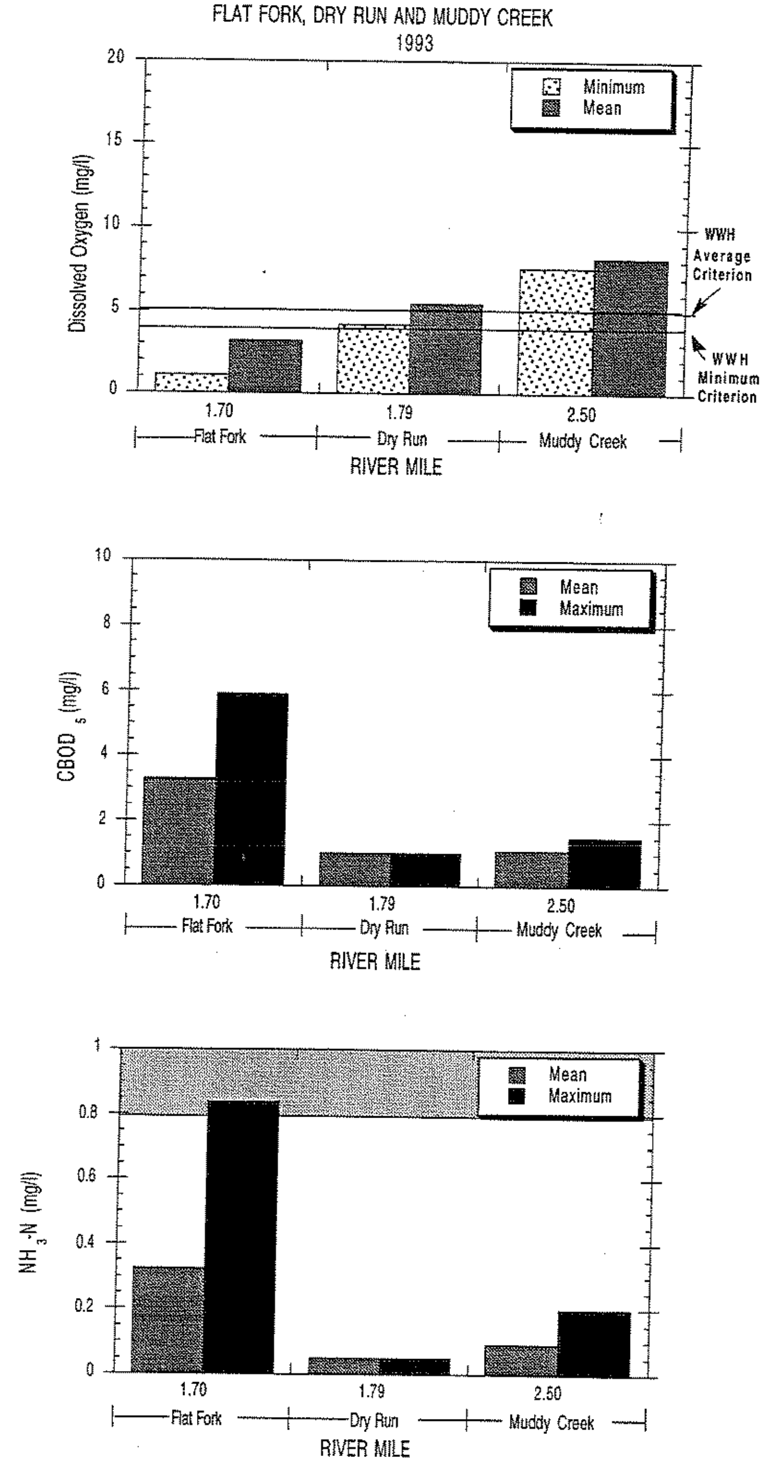


Figure 50. Longitudinal summary of dissolved oxygen (daytime grab minimum and mean values), $CBOD_5$, and ammonia-N (mean and maximum) concentrations in Flat Fork, Dry Run and Muddy Creek during the 1993 survey (*shaded area is the ammonia-N water quality criteria range between the 25th and 90th percentile pH and temperature recorded during sample collection*).

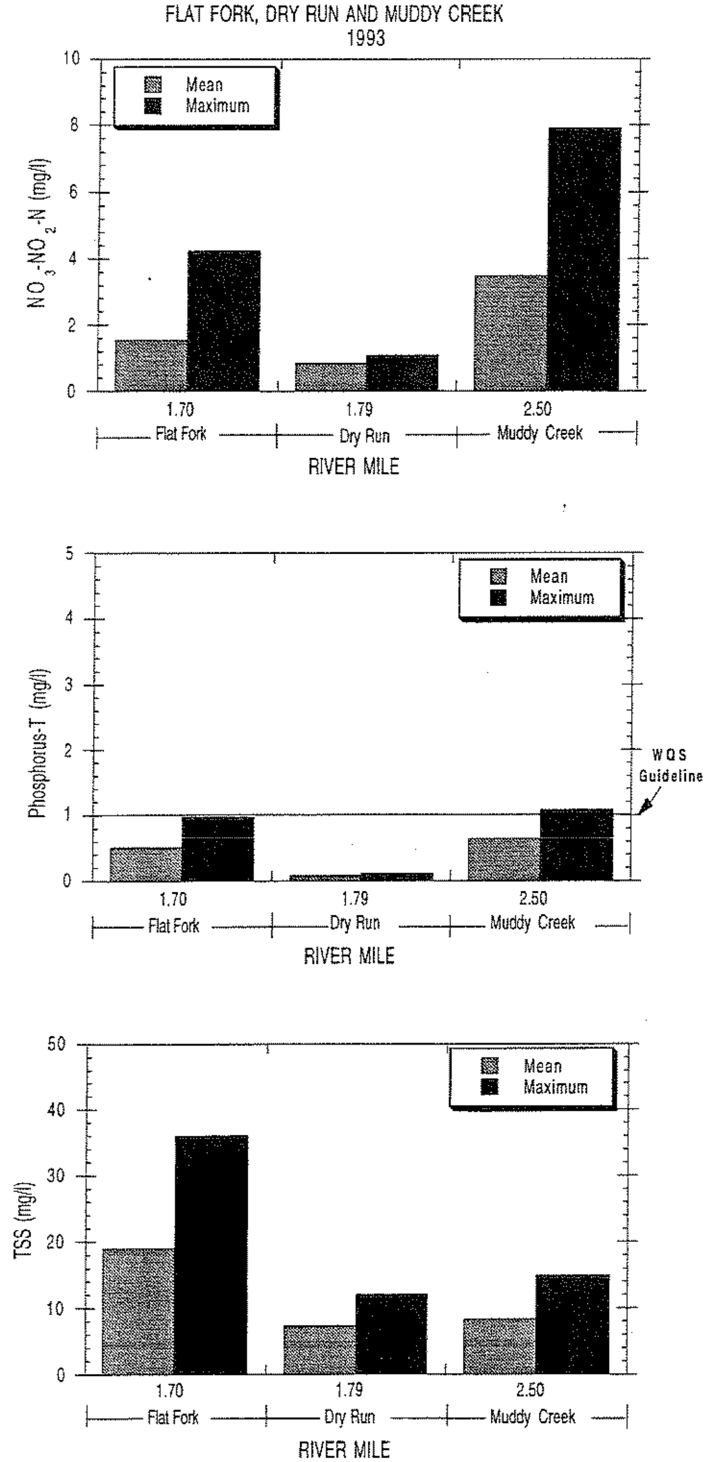


Figure 51. Longitudinal summary of nitrate+nitrite-N, total phosphorus, and total suspended solids (TSS) concentrations (mean and maximum values) in Flat Fork, Dry Run and Muddy Creek during the 1993 survey.

detected in the water column (Tables A-3 and A-5). Both locations in Caesar Creek (RMs 16.52 and 0.15) had higher average concentrations of nitrate+nitrite-N than the Anderson Fork site, but lower maximum values (Figure 49).

Flat Fork

- Low daytime grab dissolved oxygen values and moderate to high concentrations of $CBOD_5$, ammonia-N, TSS, fecal coliform, and *E. coli* in Flat Fork (RM 1.70) indicate degraded water quality. Various organochlorine pesticides, including dieldrin and endrin, were also detected (Figures 50-51, Tables 6, A-5). The sources of impact appear related to agricultural activities, the predominant land use within the watershed.

Dry Run

- Dry Run, a small tributary to Turtle Creek, had better water quality than Flat Fork. However, one daytime grab dissolved oxygen violation was detected at RM 1.7 (Figures 50-51, Table 6). Low flow conditions may have caused the below standard concentration.

Muddy Creek

- Water samples from Muddy Creek were collected at RM 2.50, approximately 0.7 miles downstream from the Mason WWTP. Sampling detected moderate to high levels of nitrate+nitrite-N and phosphorus (Figure 51). Dissolved oxygen values remained above the WWH minimum of 4.0 mg/l for all grab and datasonde samples. The 24 hour average concentrations for the 45 hourly values recorded by datasonde continuous monitors also remained above the 5.0 mg/l 24 hour average criterion (Figures 50 & 52a, Tables 6 & A-6).

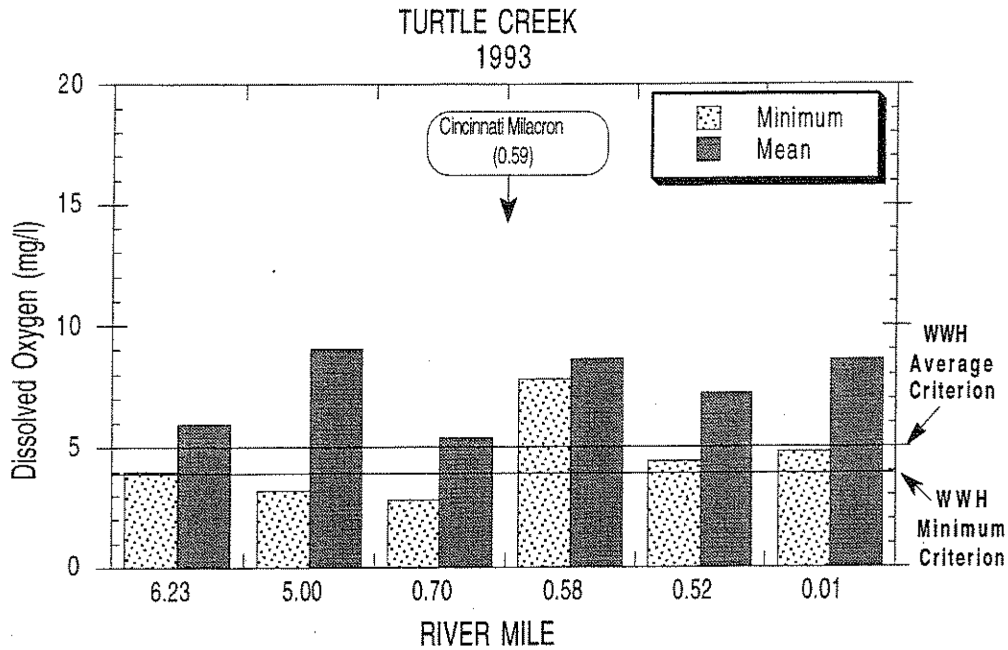
- Frequent exceedences of the fecal coliform and *E. coli* primary contact recreation criteria and for residual chlorine were detected. Organic water column sampling also detected exceedences for dieldrin and endrin (*i.e.*, concentrations above detection limits are exceedences; Table 6, A-5). An extremely elevated copper value (486 µg/l) in excess of the final acute value (FAV) was recorded at RM 2.50 on August 26 (Table 6). All other copper levels recorded at this location, however, were below the minimum detection limit.

Turtle Creek

- Although no flow measurements were taken, visual observations in Turtle Creek suggest flows downstream from Mason Road (RM 0.70) were substantially lower in 1993 than during previous sampling years (1989-1992; the sites upstream and downstream from Cincinnati Milacron were sampled each year). The significantly lower water levels suggests localized dewatering of Turtle Creek has occurred. The source of the dewatering is unknown, but possibly includes well water withdrawals) and/or quarrying. This situation requires further investigation.

- In May of 1993, Cincinnati Milacron changed their discharge configuration to Turtle Creek from a high gradient, cascading falls (similar to the Yellow Springs Creek WWTP discharge) to an instream multi-port diffuser (Plate 11). During the summer of 1993, numerous chemical criteria exceedences were detected within and downstream from the diffuser mixing zone (RM 0.58-0.52, Figures 52a-56, Table 6). Copper levels consistently exceeded the final acute value (FAV) from the mixing zone to State Route 48 (RM 0.58-0.52), but declined by RM 0.01. One elevated mercury concentration (1.35 µg/l) was also recorded in the mixing zone. Ambient chemical concentrations downstream from the Cincinnati Milacron effluent may have been higher than predicted due to less dilution caused by the lower flows in Turtle Creek during 1993.

- Dissolved oxygen levels in Turtle Creek were detected below 4.0 mg/l both upstream and downstream from Cincinnati Milacron (RMs 5.0-0.1). Below standard values were detected in daytime grab samples between RMs 5.0-0.7 and by datasonde continuous monitors from



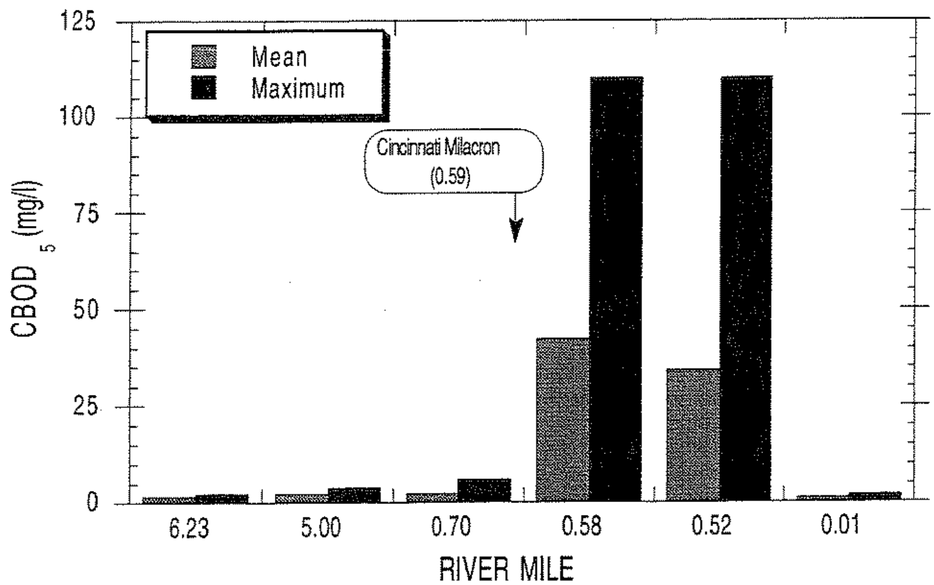


Figure 52a. Longitudinal summary of dissolved oxygen (daytime grab minimum and mean values) and $CBOD_5$ (mean and maximum values) concentrations in Turtle Creek during the 1993 survey. The Cincinnati Milacron diffuser mixing zone values are shown for RM 0.58.

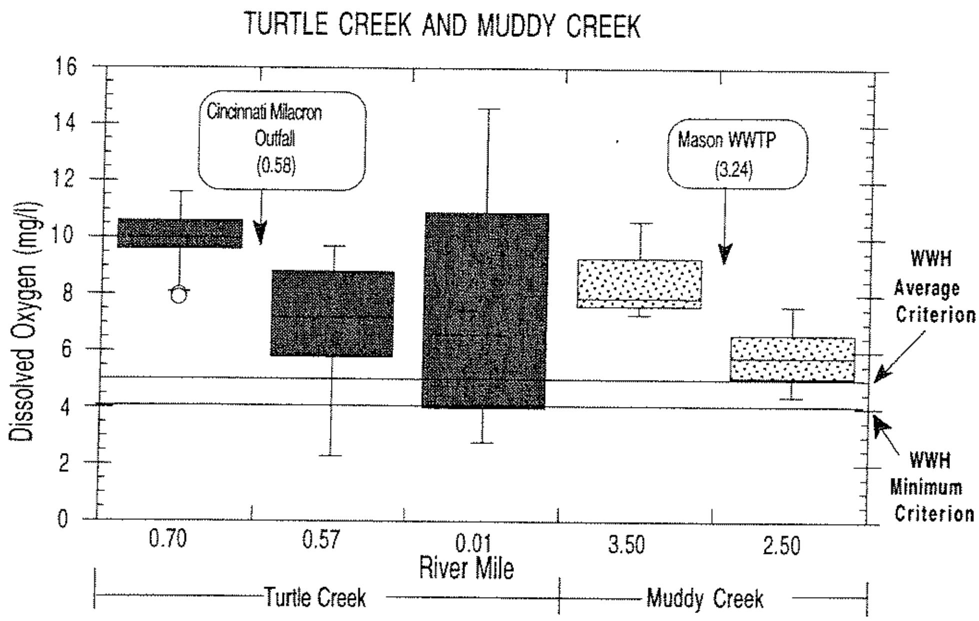
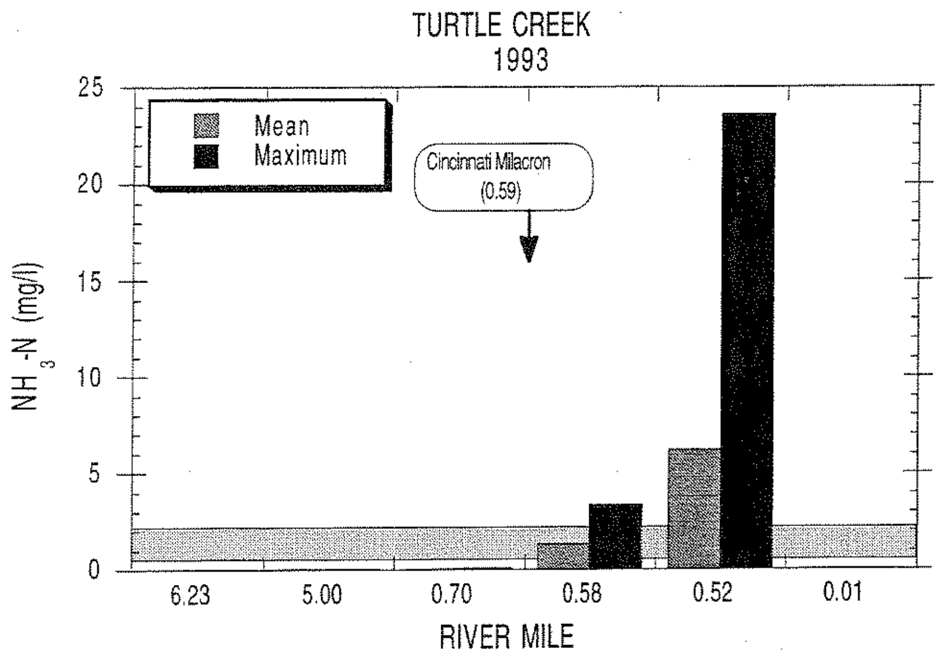


Figure 52b. Longitudinal summary (box and whisker plots) of dissolved oxygen concentrations recorded with Datasonde continuous monitors in Turtle Creek from September 28-October 1, 1993 and in Muddy Creek from August 31-September 2, 1993.



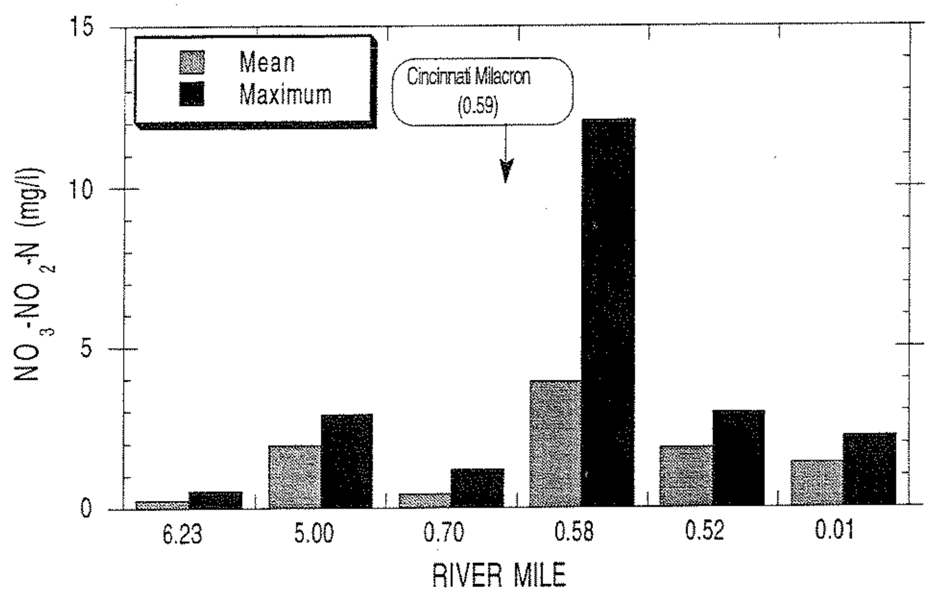
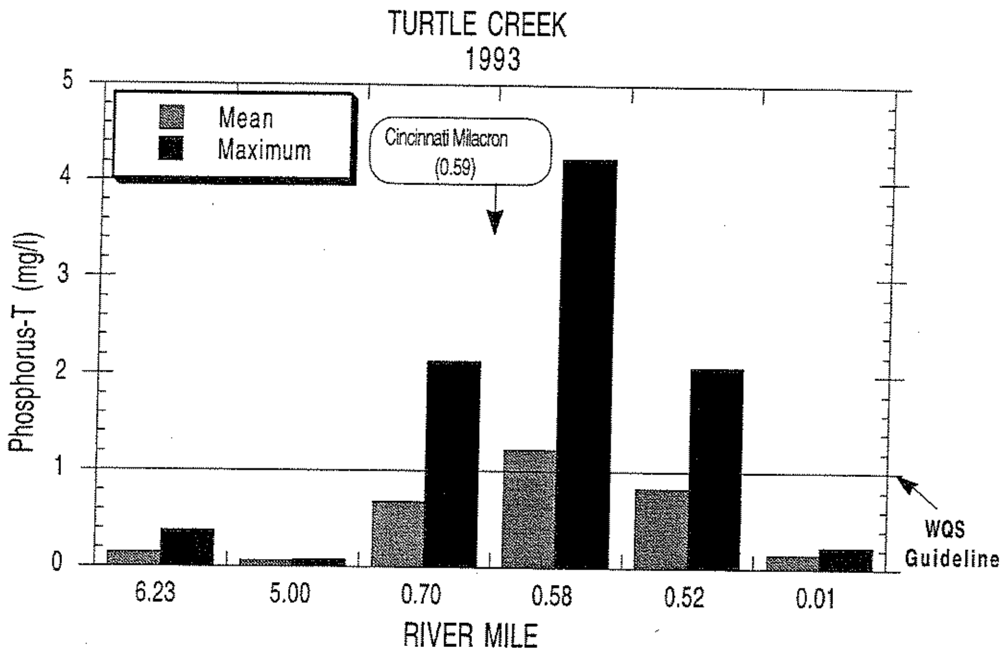


Figure 53. Longitudinal summary of ammonia-N and nitrate+nitrite-N concentrations (mean and maximum values) in Turtle Creek during the 1993 survey (*shaded area is the ammonia-N water quality criteria range between the 25th and 90th percentile pH and temperature recorded during sample collection*). The Cincinnati Milacron diffuser mixing zone values are shown for RM 0.58.



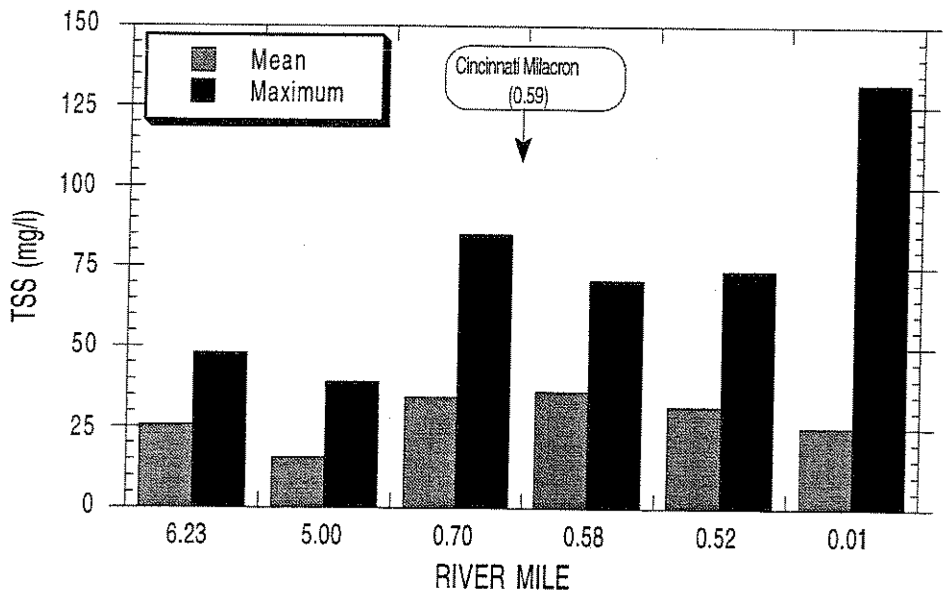


Figure 54. Longitudinal summary of total phosphorus and total suspended solids TSS) concentrations (mean and maximum values) in Turtle Creek during the 1993 survey. The Cincinnati Milacron diffuser mixing zone values are shown for RM 0.58.

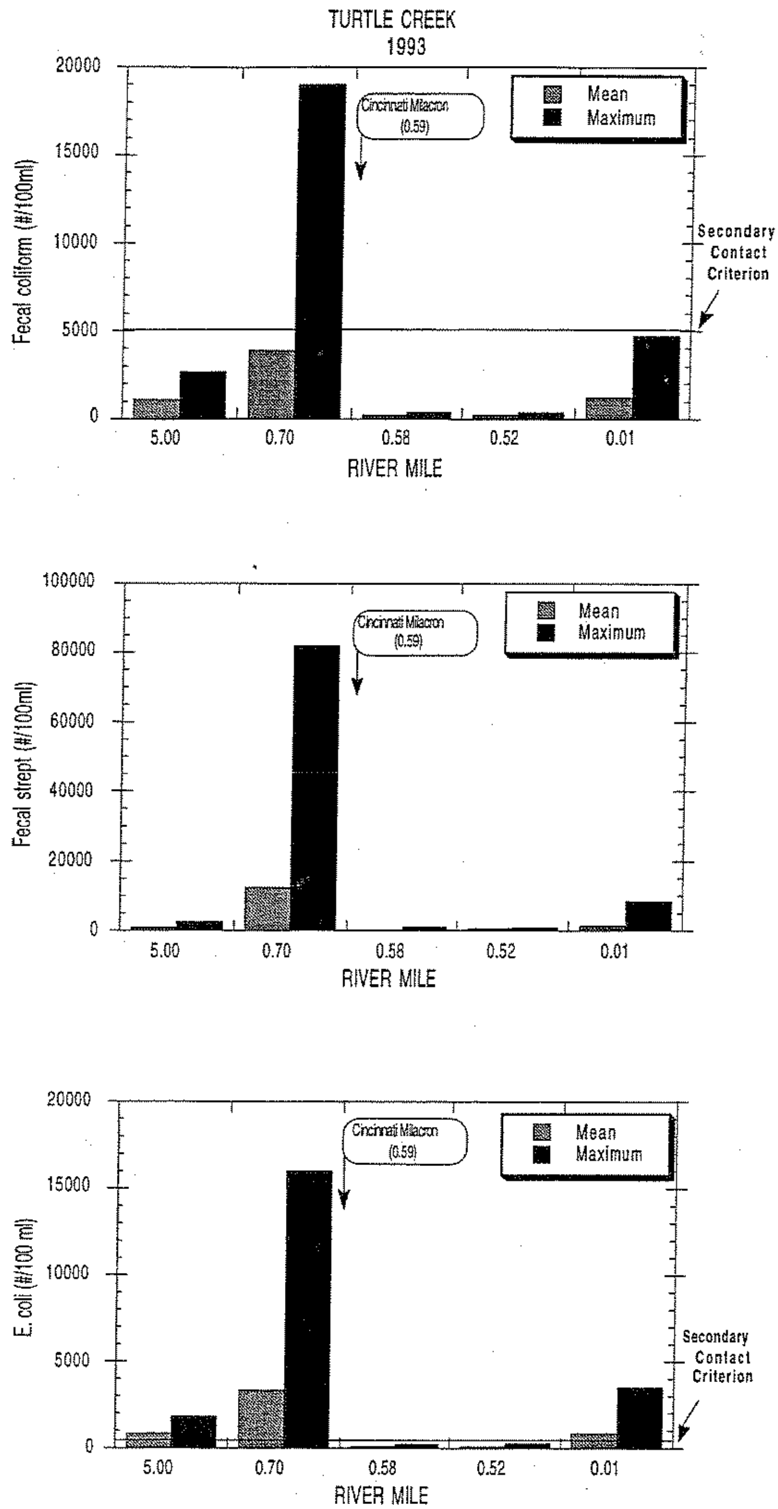


Figure 55. Longitudinal summary of fecal coliform, fecal strept and E. coli concentrations (mean and maximum values) in Turtle Creek during the 1993 survey. The Cincinnati Milacron diffuser mixing zone values are shown for RM 0.58.

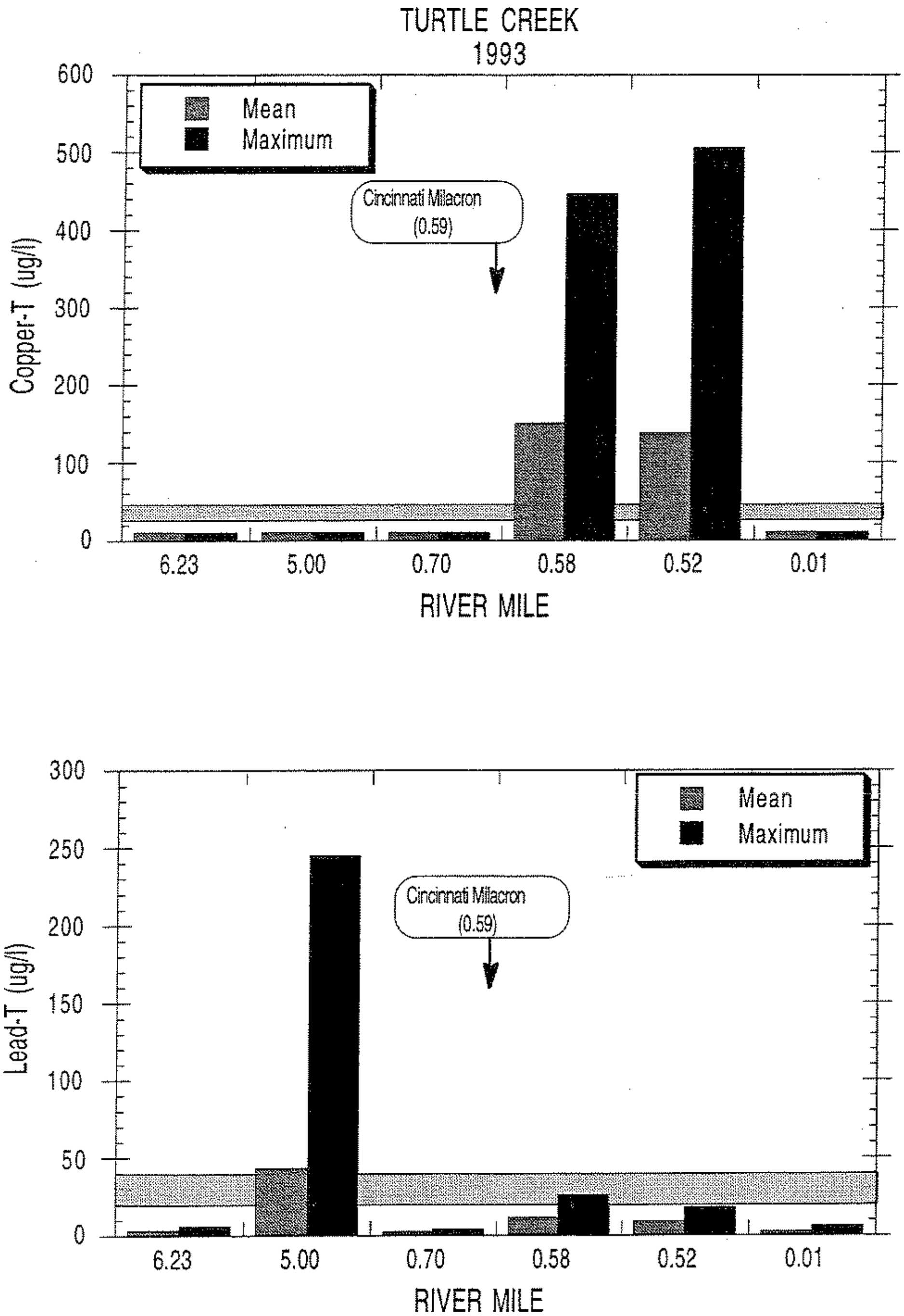


Figure 56. Longitudinal summary of copper and lead concentrations (mean and maximum values) in Turtle Creek during the 1993 survey (*shaded area is the water quality criteria range between the 25th and 90th percentile hardness recorded during sample collection*). The Cincinnati Milacron diffuser mixing zone values are shown for RM 0.58.

Cincinnati Milacron to the mouth (RMs 0.57-0.01, Figures 52a-52b, Table 6, A-6). The 24 hour continuous data also revealed a larger diel fluctuation (*i.e.*, the difference between day and night values) in D.O. concentrations downstream from the industrial discharge. The minimum to maximum difference increased from 3.7 mg/l at Mason-Morrow Road to 7.4-11.8 mg/l downstream from the industry (the first and third largest range in datasonde values of the 55 locations monitored throughout the study area). The larger variation between day and night values is indicative of excessive algal production which is the result of nutrient enrichment.

- Exceptionally high $CBOD_5$ values were also recorded downstream from the diffuser (RMs 0.58 and RM 0.52, Figure 52a). Ammonia-N concentrations were also elevated in the mixing zone and frequently exceeded water quality criteria downstream at RM 0.52 (Table 6, Figure 53). Water samples also indicated elevated levels of total dissolved solids, chemical oxygen demand (COD), total organic carbon (TOC), chlorides, and phosphorus (Figure 54, Tables 6, A-4).

- Except for lead, chemical sampling sites upstream from Cincinnati Milacron generally had fewer elevated concentrations than sites downstream. Concentrations of $CBOD_5$, ammonia-N, and nitrate+nitrite-N at the three upstream sites (RMs 6.23, 5.00, and 0.70) were consistently low throughout the survey. Phosphorus levels at RM 0.70 increased above the WQS guideline of 1.0 mg/l on one occasion (Figures 52a-56).

- The *E. coli* secondary contact recreation criterion was frequently exceeded at RMs 5.00, 0.70, and 0.01. The highest bacterial counts of fecal coliform, fecal strep, and *E. coli* in Turtle Creek during the survey occurred on July 14 during a high flow event. The values were highest at RM 0.70, upstream from the industrial discharge (Figure 55, Table 6).

- A total of 10 and 11 organochlorine pesticides, semi-volatile, and volatile organic compounds were detected in Turtle Creek at Glosser Road and the Cincinnati Milacron diffuser mixing zone, respectively (RMs 6.23 and 0.58, Tables 6, A-5). Notable differences included the presence of benzene, bromoform, and phthalates at RM 0.58 and toluene and dieldren at RM 6.23.

Sycamore Creek

- No dissolved oxygen violations were detected in Sycamore Creek, but Datasonde continuous monitors documented a sharp decline downstream from the Hamilton Co. MSD Sycamore Creek WWTP (RM 0.05, Figures 57a-57b, Table A-6). The 24-hour continuous monitors also detected a large diel swing in D.O. values (9.3 mg/l, the second largest minimum to maximum range in the study area) at RM 0.27 indicating the presence of excessive nutrient loadings upstream from the WWTP as well. Sludge deposits were observed downstream from the WWTP, but were not evident immediately upstream.

- Low $CBOD_5$ and ammonia-N concentrations were recorded at all three sampling locations. Nutrient loadings from the Hamilton Co. MSD Sycamore Creek WWTP were indicated by elevated nitrate+nitrite-N and phosphorus levels within and downstream from the mixing zone (RM 0.25-0.05). Total suspended solids concentrations remained fairly constant throughout the stream (Figures 57a, 58).

- Elevated counts of fecal coliform, fecal strept, and *E. coli* bacteria were recorded both upstream and downstream from the WWTP. Sanitary sewer overflows (SSOs) and leaking sewer lines upstream from the WWTP are the likely sources of the elevated fecal bacteria counts recorded at RM 0.40 (Figure 59, Table 6).

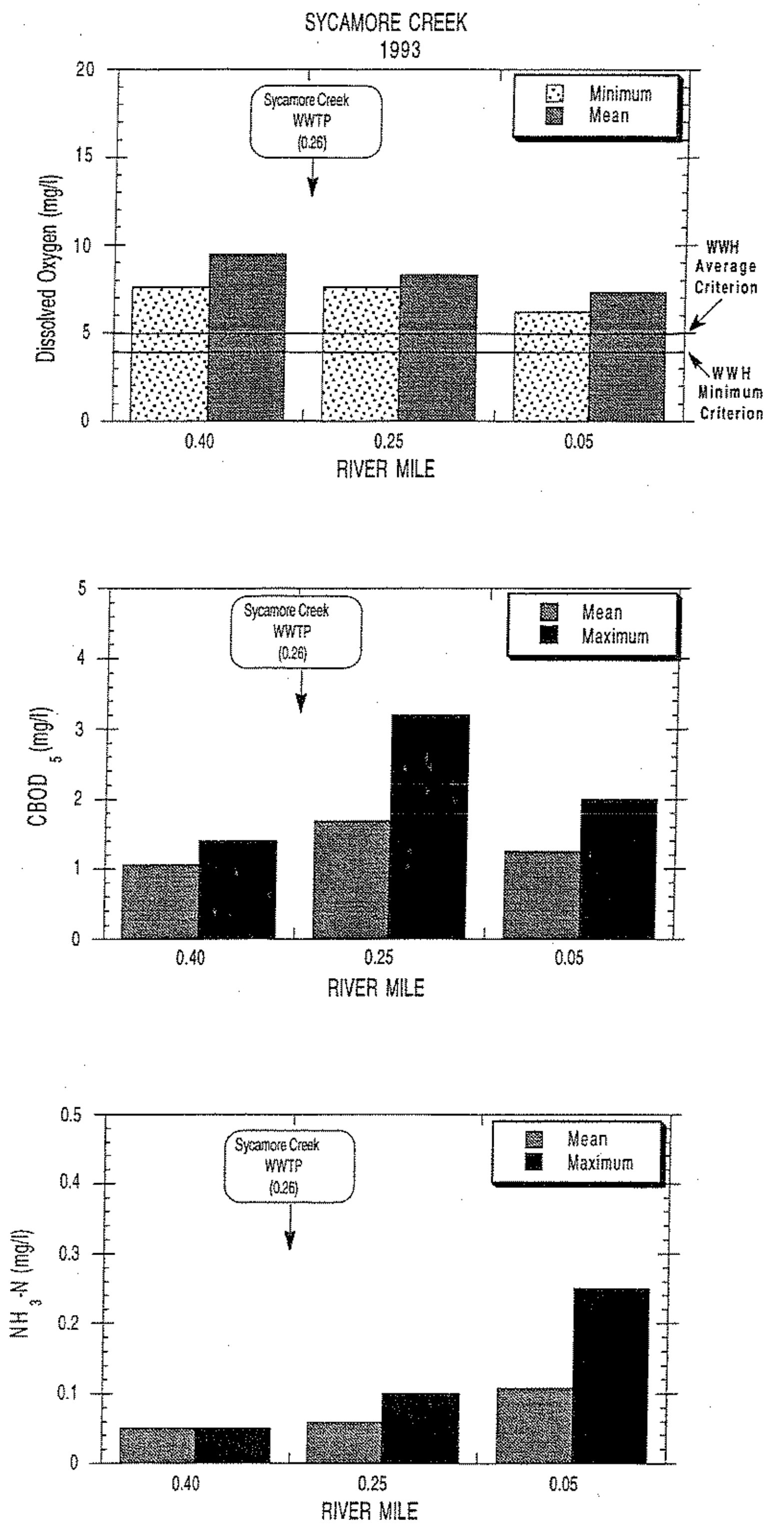


Figure 57a. Longitudinal summary of dissolved oxygen (daytime grab minimum and mean values), $CBOD_5$, and ammonia-N (mean and maximum values) concentrations in Sycamore Creek during the 1993 survey. Mixing zone values are shown for RM 0.25.

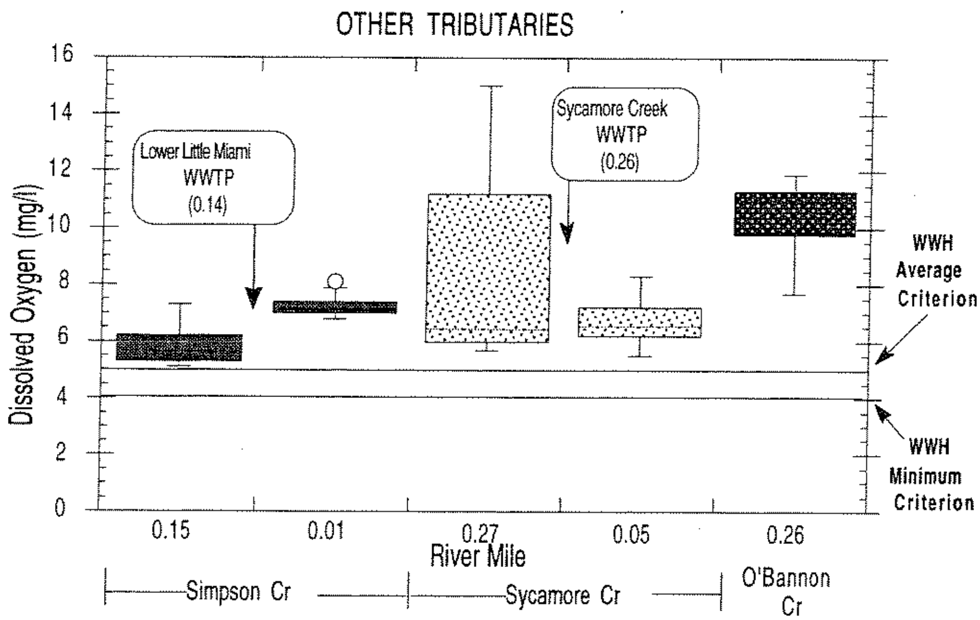


Figure 57b. Longitudinal summary (box and whisker plots) of dissolved oxygen concentrations recorded with Datasonde continuous monitors in Simpson Creek from August 31-September 2, 1993 and in Sycamore and O'Bannon creeks from September 21-23, 1993.

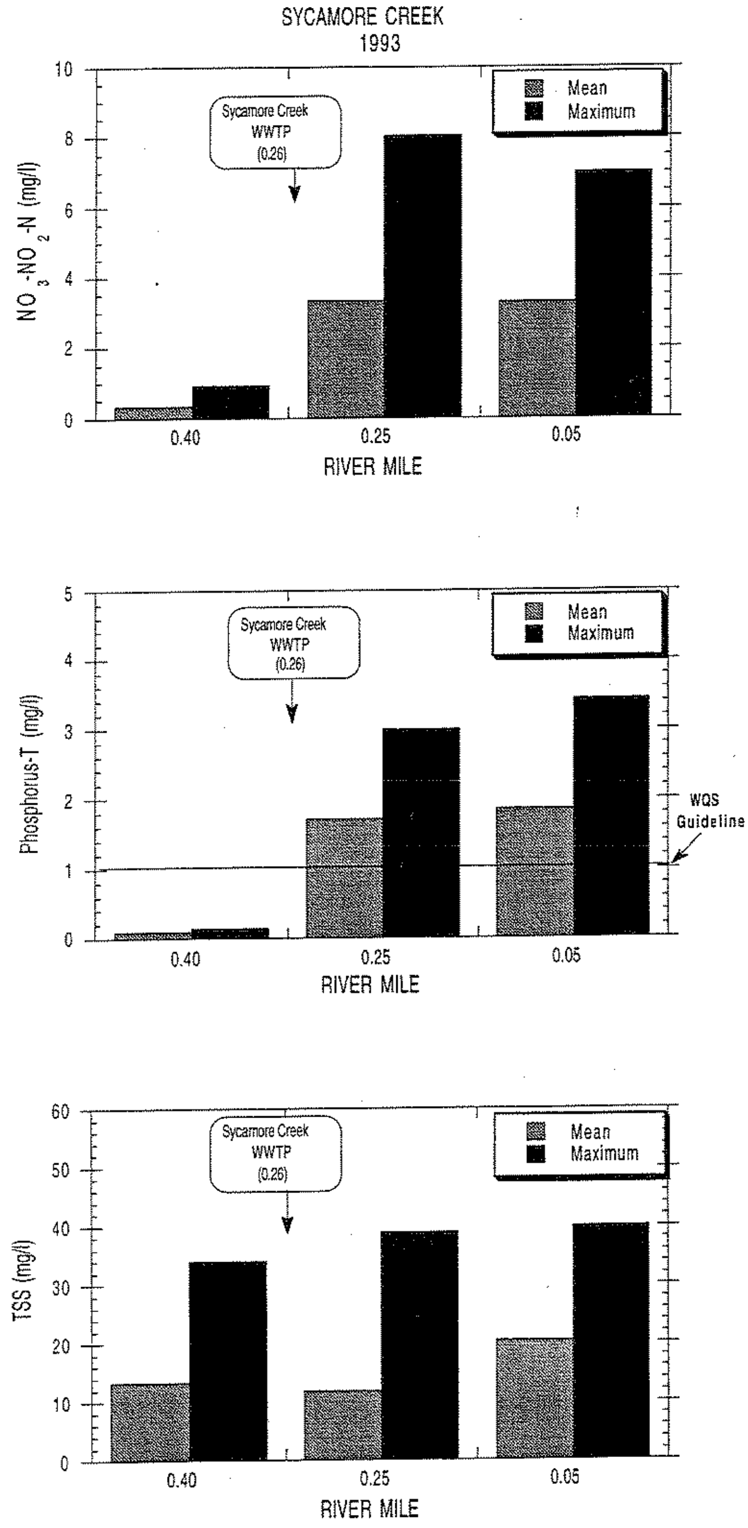


Figure 58. Longitudinal summary of nitrate+nitrite-N, total phosphorus, and total suspended solids (TSS) concentrations (mean and maximum values) in Sycamore Creek during the 1993 survey. Mixing zone values are shown for RM 0.25.

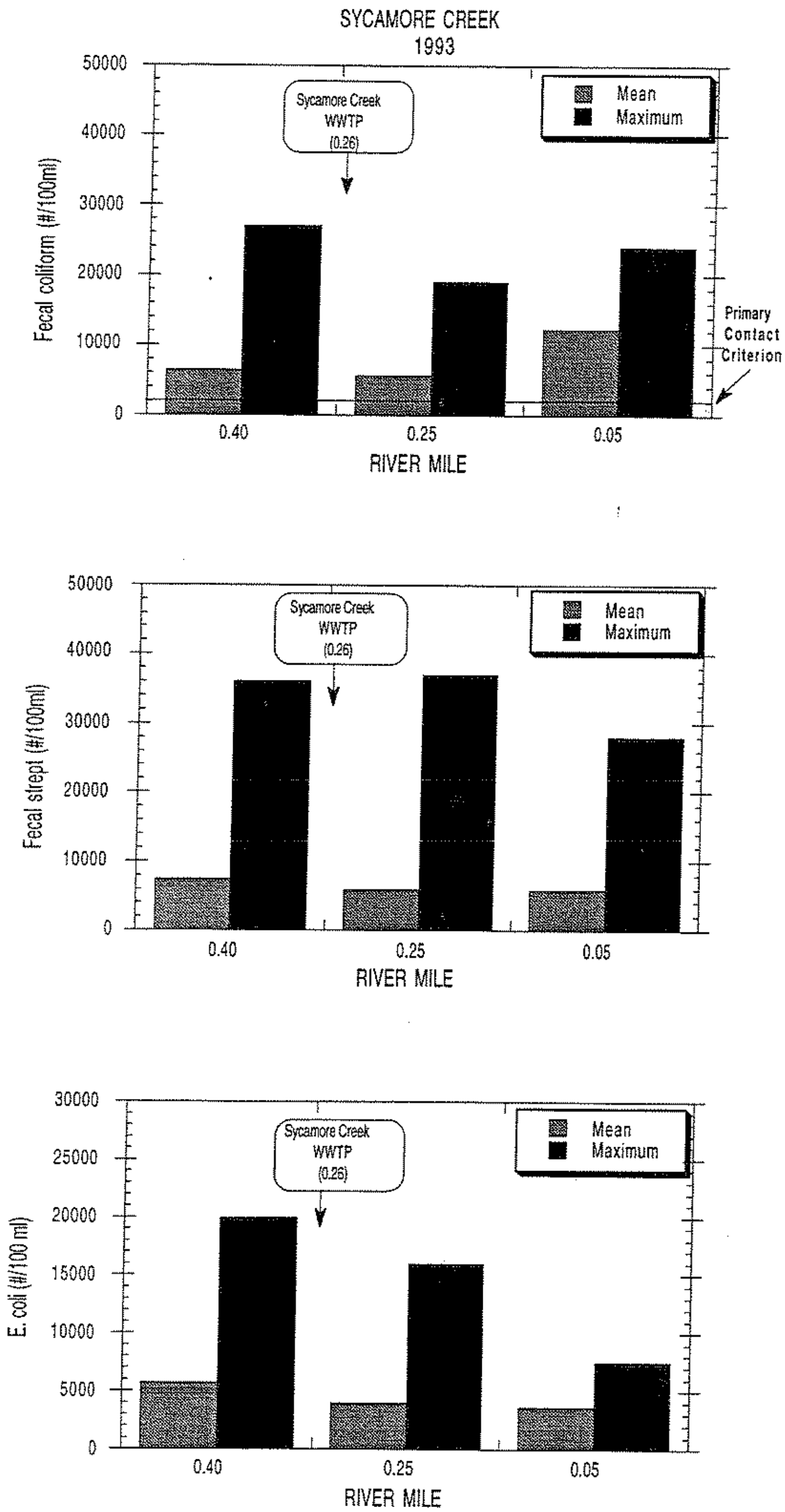


Figure 59. Longitudinal summary of fecal coliform, fecal strep, and *E. coli* concentrations (mean and maximum values) in Sycamore Creek during the 1993 survey. Mixing zone values are shown for RM 0.25.

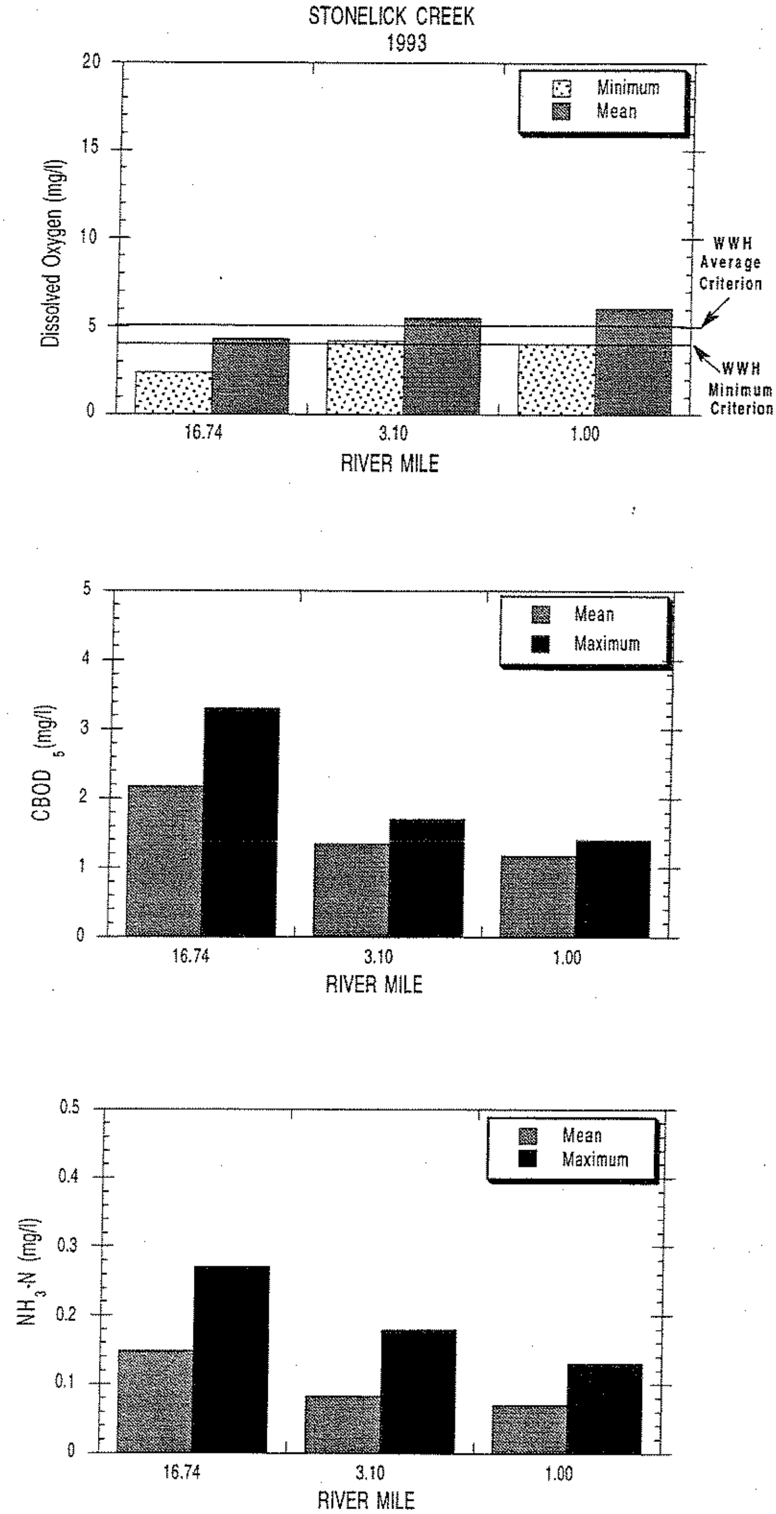


Figure 60. Longitudinal summary of dissolved oxygen (daytime grab minimum and mean values), $CBOD_5$, and ammonia-N (mean and minimum values) concentrations in Stonelick Creek during the 1993 survey.

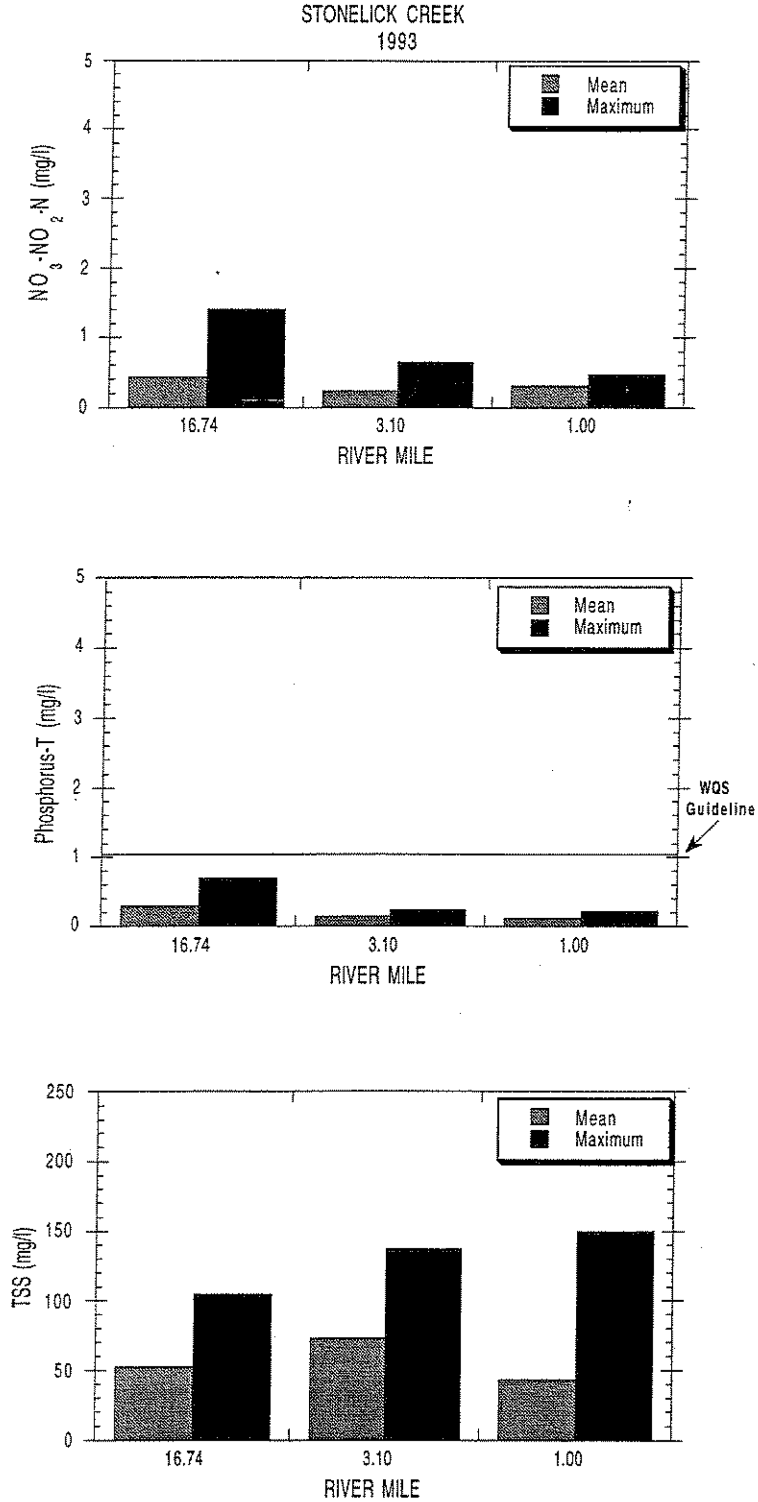


Figure 61. Longitudinal summary of nitrate+nitrite-N, total phosphorus, and total suspended solids (TSS) concentrations (mean and maximum values) in Stonelick Creek during the 1993 survey.

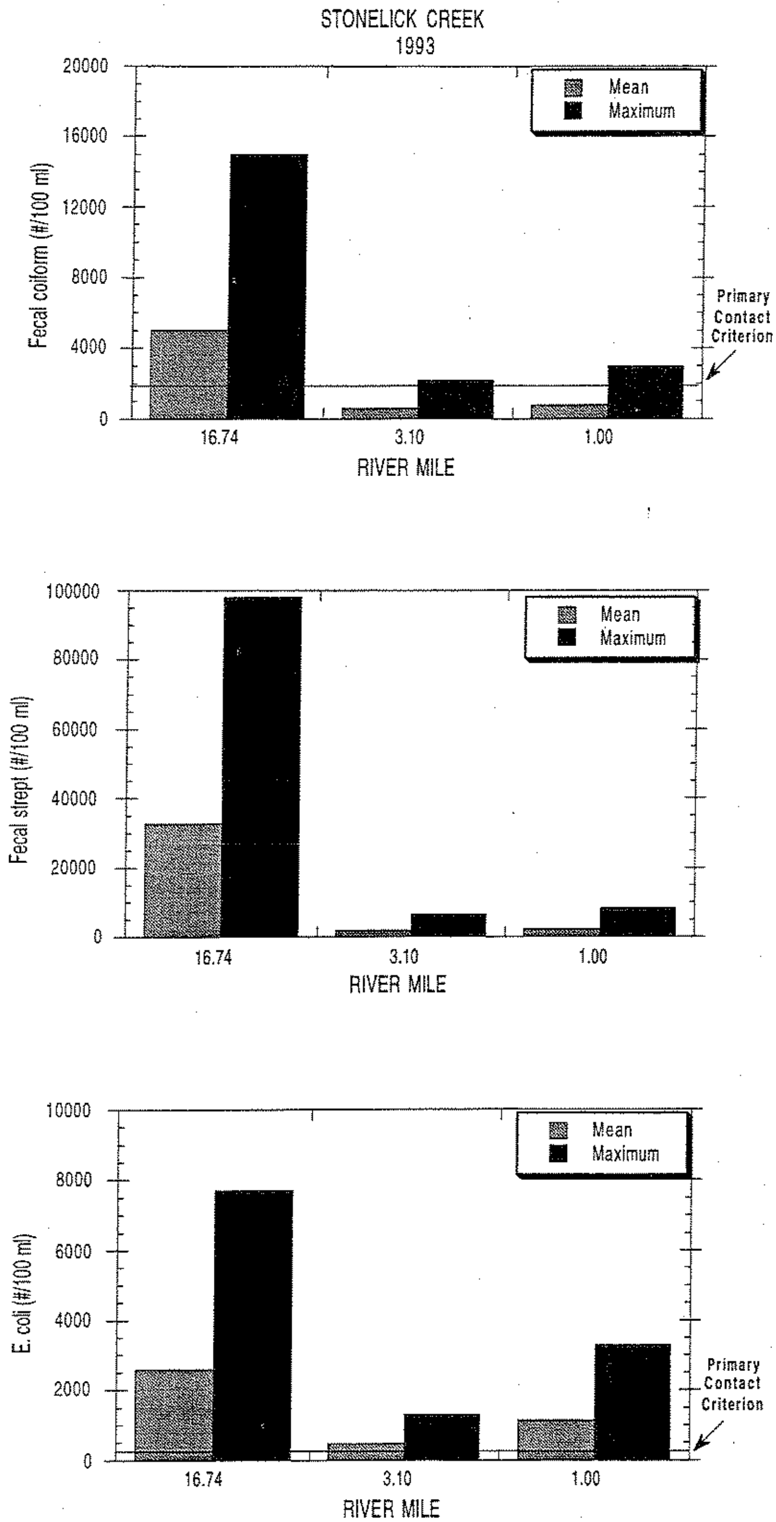


Figure 62. Longitudinal summary of fecal coliform, fecal strep, and *E. coli* concentrations (mean and maximum values) in Stonelick Creek during the 1993 survey.

- A total of 12 organochlorine pesticides and volatile organic compounds were detected in water samples collected downstream from the WWTP. Concentrations of four different pesticides exceeded water quality criteria (Tables 6, A-5). The water column was not tested for organic compounds in Sycamore Creek upstream from the WWTP.

Stonelick Creek

- Daytime grab D.O. concentrations declined to less than 4.0 mg/l only at the upstream sampling location within the impoundment influence of Stonelick Lake (RM 16.74, Figure 60, Table 6).

- Concentrations of $CBOD_5$, ammonia-N, nitrate+nitrite-N, and phosphorus were highest at RM 16.74, but remained relatively low throughout the creek (Figures 60,61).

- Fecal coliform, fecal strep, and *E. coli* bacteria counts were highest in the upper end of Stonelick Lake (RM 16.74). The highest values were recorded during high flows on July 15, 1993 (Figure 62, Table 6). Fecal bacteria counts on all other days were relatively low, indicating the source is predominantly nonpoint i origin (Table A-4).

- A total of 7 to 9 organochlorine pesticides and volatile organic compounds were detected at each of the three sampling locations (Table A-5). Organochlorine pesticide concentrations exceeded water quality criteria at all three sites (Table 6). Low levels of volatile organic compounds were also detected at RM 16.74 and RM 3.10 (Table A-5).

- One water sampled collected from Stonelick Lake contained a slightly elevated lead concentration (5 µg/l) that exceeded the chronic water quality criterion (Table 6). The hardness was unusually low (63 mg/l) which contributed to this low value being an exceedence.

East Fork Little Miami River

- Stream flows in the East Fork near Batavia from May through September 1993 followed an overall pattern of declining values (Figure 63a). However, lower than normal flows of less than 30 cfs ($Q_{7,10}$ = 30 cfs) were recorded during the last two weeks of July. Stream flow in the East Fork is regulated by releases from the Harsha Reservoir (East Fork Lake).

- Daytime grab D.O. values at two sites in the East Fork (RMs 9.10 and 0.77) were below the minimum EWH water quality criterion of 6.0 mg/l on one day (Figure 63b, Table 6). A below standard value was also measured in the Batavia WWTP mixing zone (RM 13.35). Datasonde continuous samplers set at RMs 6.57, 4.30, and 2.50 recorded dissolved oxygen concentrations well above 6.0 mg/l during September 28 - October 1, 1993 (Figure 63c, Table A-6). Lower D.O. values, however, may have occurred during late July when low flow values were below the $Q_{7,10}$ flow of 30 cfs.

- $CBOD_5$ concentrations were generally low, but showed a slight increase downstream from the Clermont Co. Lower East Fork Regional WWTP outfall (RM 4.85, Figure 63b).

- The majority of ammonia-N concentrations recorded in the East Fork were at or below the minimum detection limit of 0.05 mg/l (Table A-4). Ammonia-N concentrations were frequently elevated in the Batavia WWTP mixing zone (RM 13.35, Figure 64).

- Nitrate+nitrite-N and total phosphorus concentrations increased in the Batavia WWTP mixing zone (RM 13.35), peaked in the Middle East Fork WWTP mixing zone (RM 12.59), and were also elevated downstream from the Clermont Co. Lower East Fork Regional WWTP. Lower concentrations reflecting background conditions were recorded between RMs 9.10 - 6.57 and RMs 4.00 - 0.77 (Figures 64-65, Table 6).

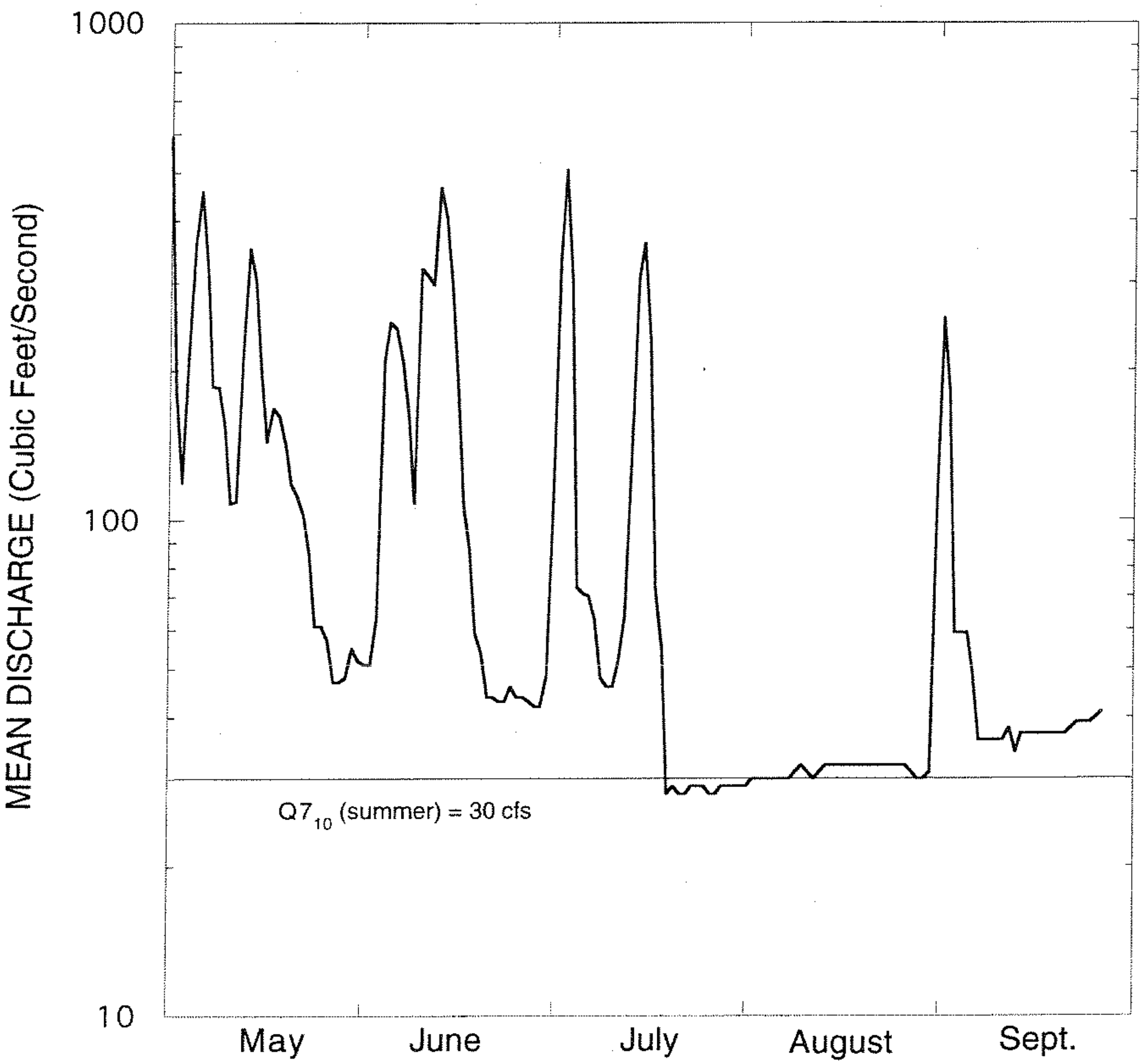


Figure 63a. May through September, 1993, flow hydrograph for the East Fork Little Miami River near Batavia, Clermont Co. (RM 15.6). Low flow conditions ($Q7_{10}$ [30 cubic feet/second (cfs)] is based on the USGS gage station #03247050. Period of record: 1965 until present. Eighty percent duration exceedence data is not available.

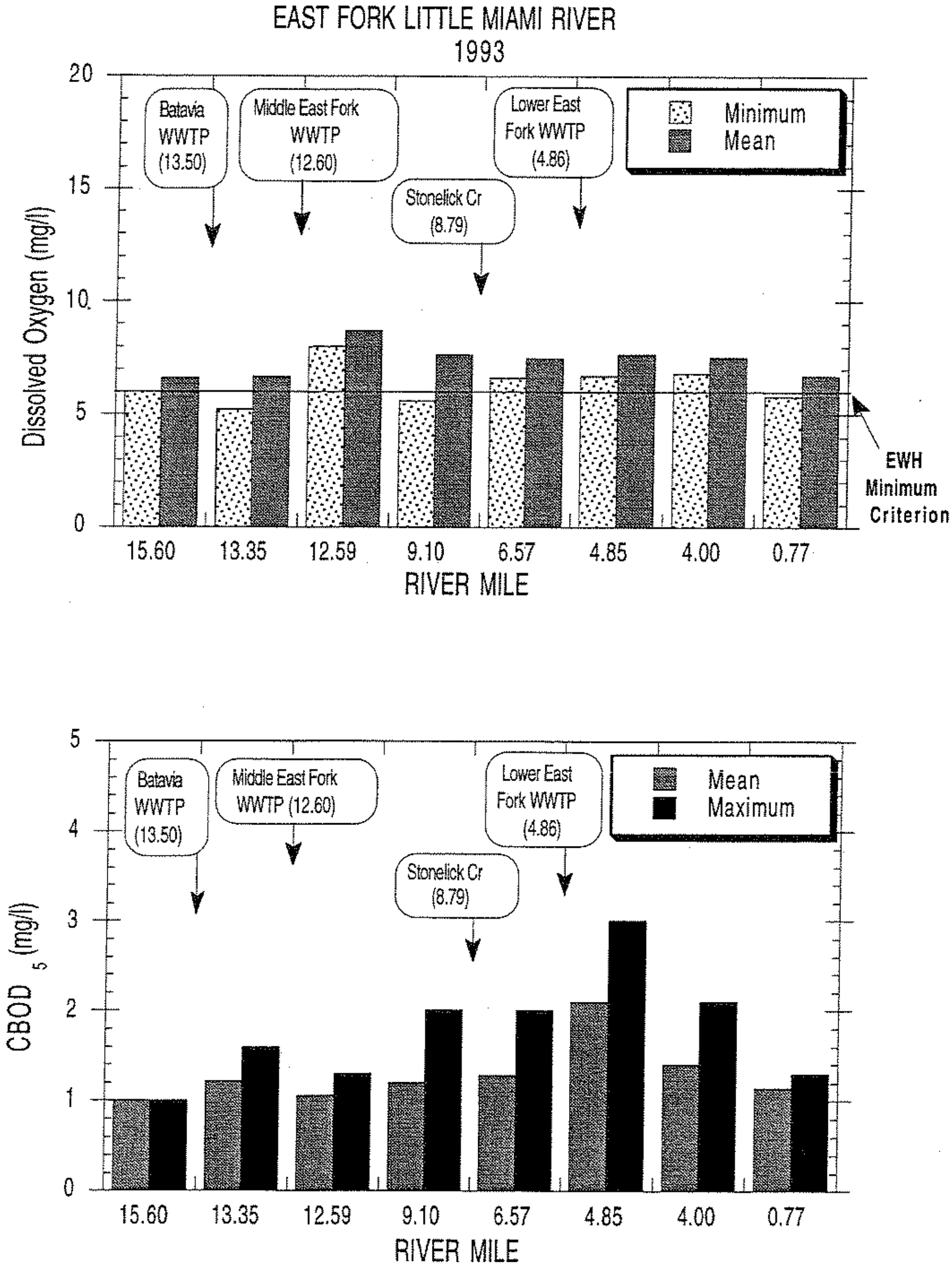


Figure 63b. Longitudinal summary of dissolved oxygen (daytime grabs) and $CBOD_5$ concentrations (mean and maximum values) in the East Fork Little Miami River during the 1993 survey. Mixing zone values are shown for RMs 13.35 and 12.59.

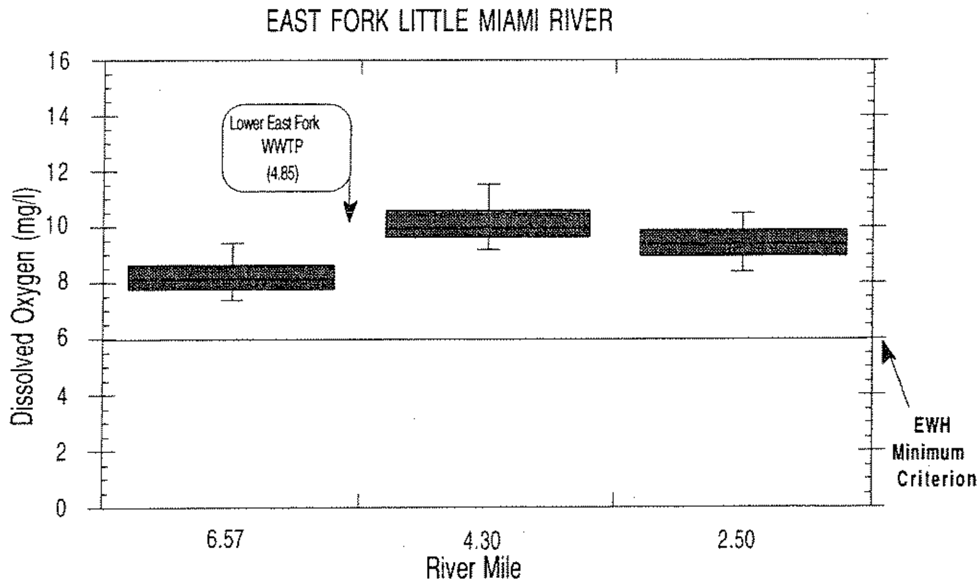


Figure 63c. Longitudinal summary (box and whisker plots) of dissolved oxygen concentrations recorded with Datasonde continuous monitors in the East Fork Little Miami River during from September 28 - October 1, 1993.

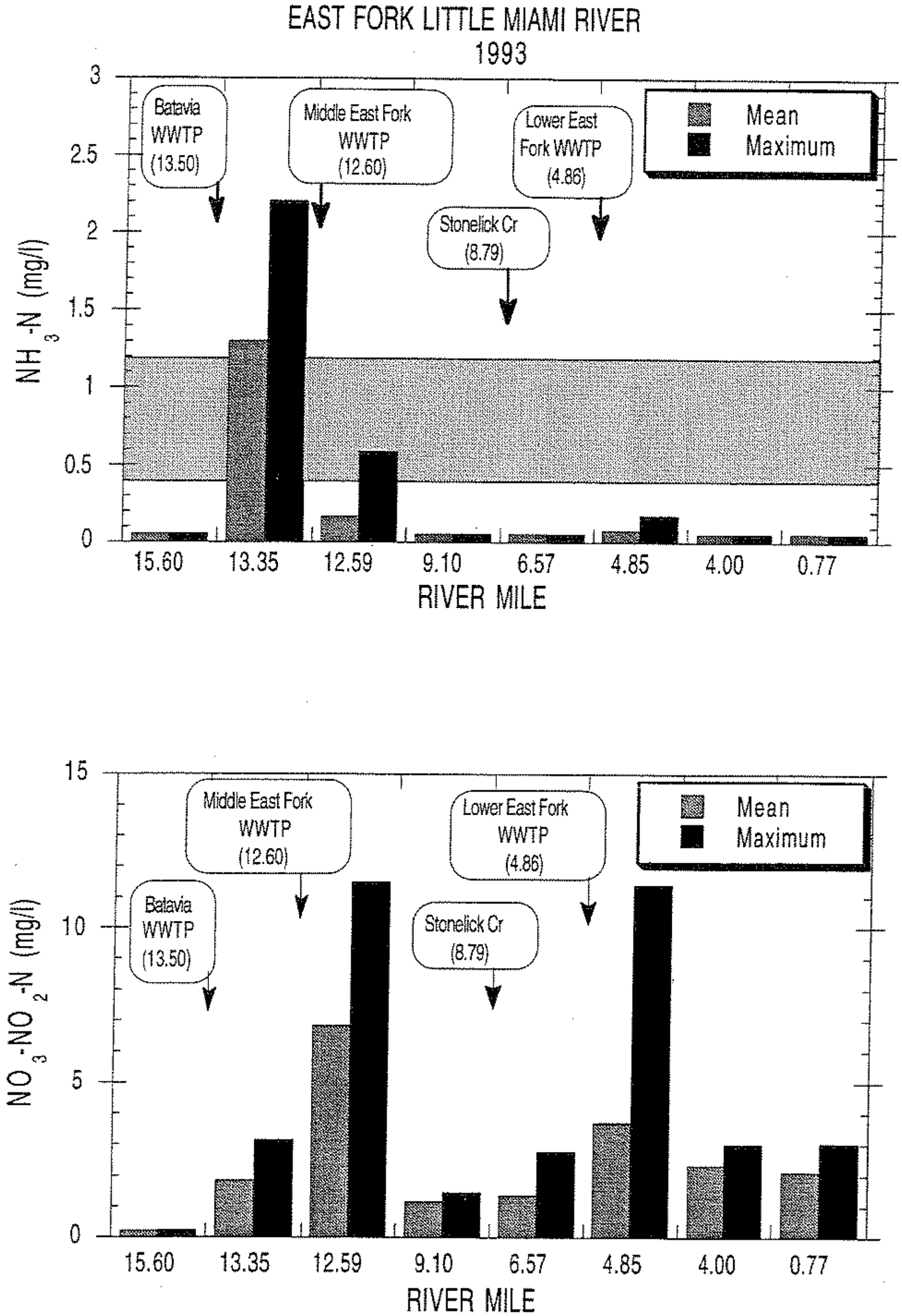
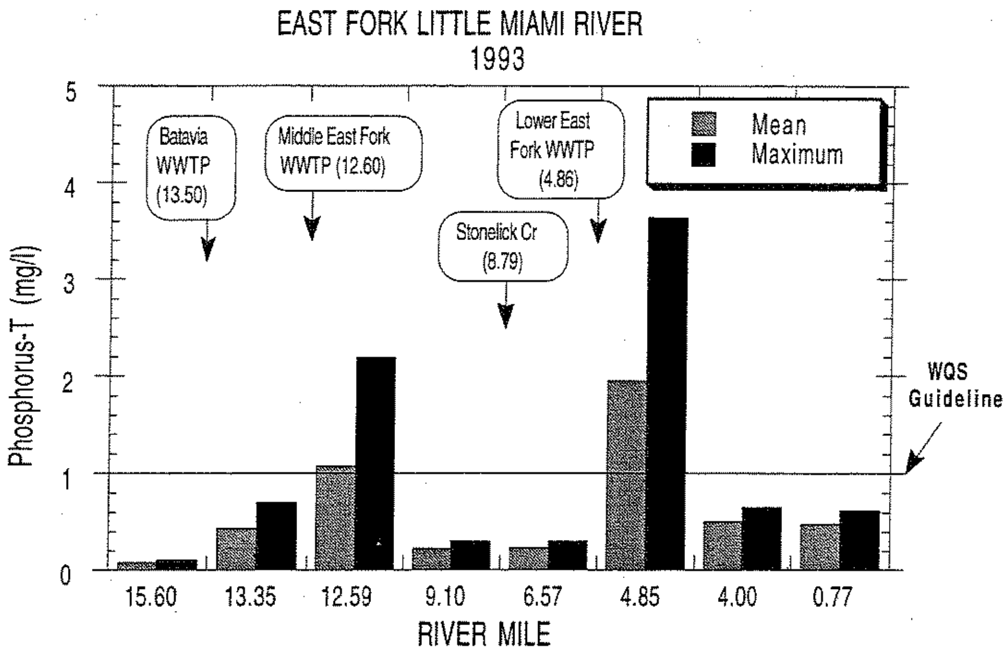


Figure 64. Longitudinal summary of ammonia-N and nitrate+nitrite-N concentrations in the East Fork Little Miami River during the 1993 survey *(shaded area is the ammonia- -N water quality criteria range between the 25th and 90th percentile pH and temperature recorded during sample collection).* The criteria does not apply for mixing zone values shown for RM 13.35 and 12.59.



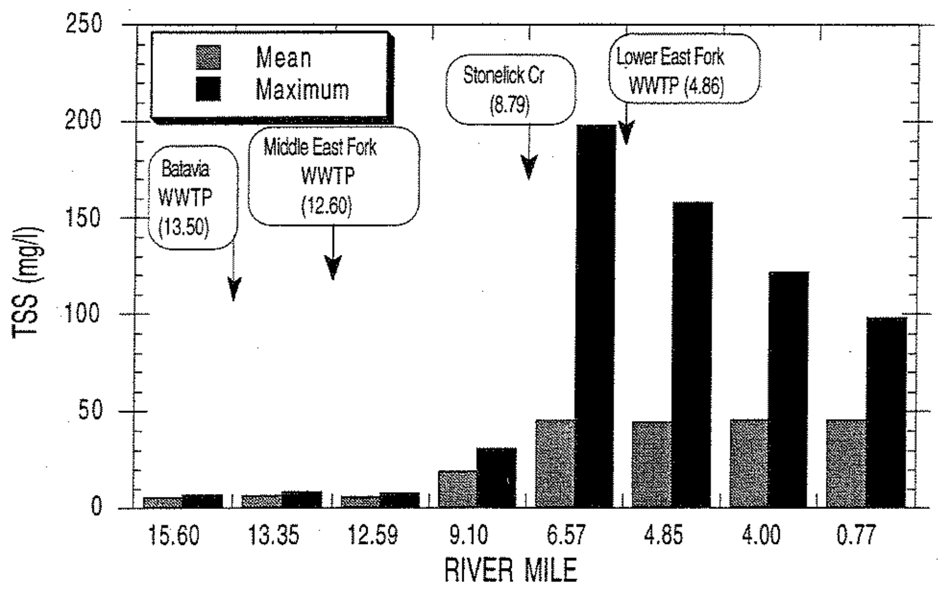


Figure 65. Longitudinal summary (mean and maximum values) of total phosphorus and total suspended solids (TSS) concentrations in the East Fork Little Miami River during the 1993 survey. Mixing zone values are shown for RMs 13.35 and 12.59.

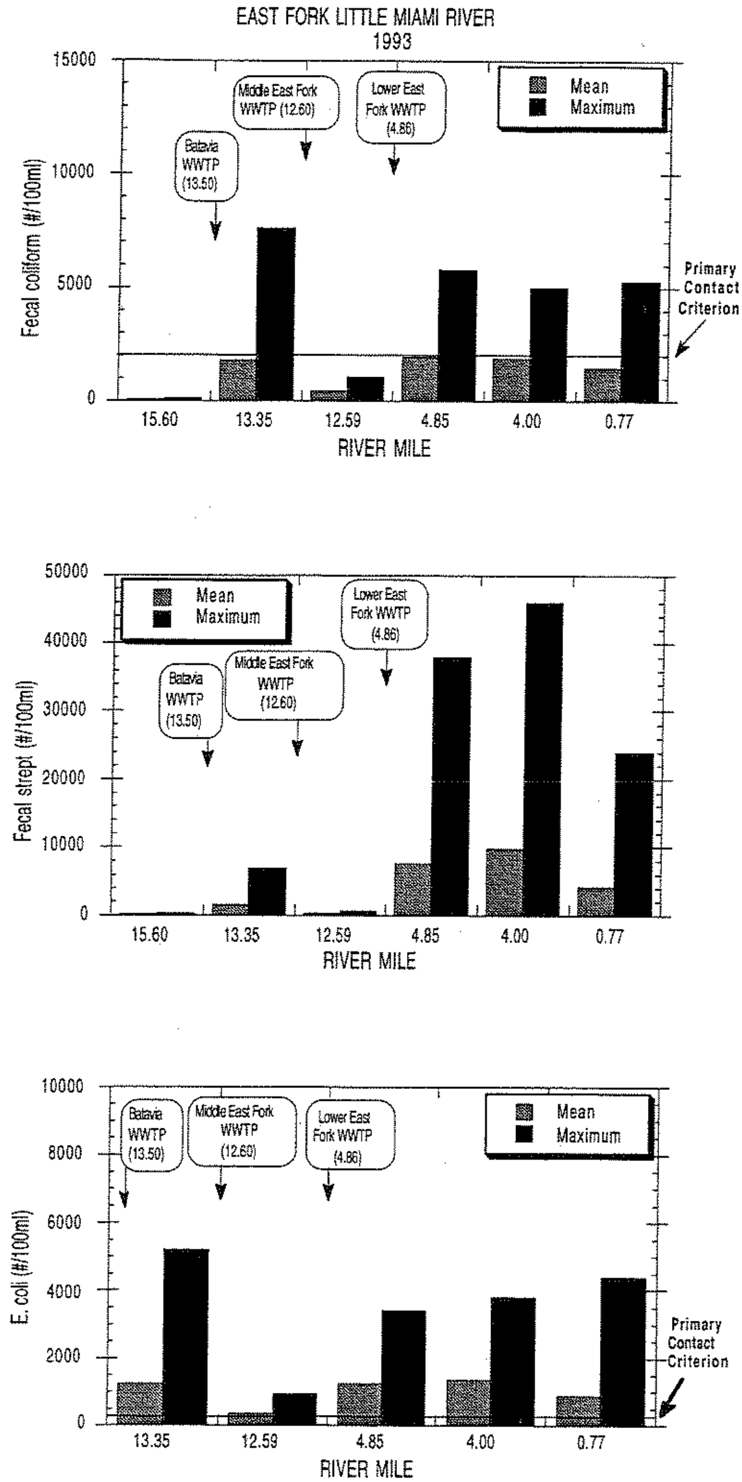


Figure 66. Longitudinal summary (mean and maximum values of fecal coliform, fecal strept, and *E. coli* concentrations in the East Fork Little Miami River during the 1993 survey. Mixing zone values are shown for RMs 13.35 and 12.59.

Table 6. Exceedences of Ohio EPA Exceptional Warmwater Habitat and Warmwater Habitat criteria (OAC 3745-1) for chemical/physical water parameters measured in grab samples taken from the Little Miami River study area during 1993 (units are µg/l for metals and organics, # colonies/100ml for fecal coliform and *E. coli*, µmhos/cm for conductivity, °C for temperature, and mg/l for all other parameters). Mixing zone samples are shown in *italics*.

Stream	River Mile	Parameter (value)
Little Miami River	101.30	Dissolved Oxygen (5.1‡‡‡, 3.5‡‡‡, 4.2‡‡‡); Fecal coliform (3800◊◊, >60000◊◊, 6820◊◊, 2100◊◊); E.coli (2400◊◊, 1050◊◊, 6200◊◊, 1700◊◊); Dieldrin (0.002#, 0.004#, 0.003#)
	98.98	Dissolved Oxygen (5.6‡‡‡, 5.6‡‡‡, 5.3‡‡‡)
	89.12	Dissolved Oxygen (5.5‡‡‡); Fecal coliform (1600◊, 1130◊); E.coli (230◊, 560◊◊, 1100◊◊, 2700◊◊, 420◊◊); Copper (137***)
	85.38	Fecal coliform (2800◊◊, 2500◊◊); E.coli (1800◊◊, 580◊◊); Dieldrin (0.002#)
	83.14	Fecal coliform (5400◊◊); E.coli (140◊, 3200◊◊); Dieldrin (0.002#, 0.006#*); Endrin (0.004*)
	80.63	Fecal coliform (1400◊, 3700◊◊, 4200◊◊); E.coli (1500◊◊, 3900◊◊, 1600◊◊)
	76.43	Fecal coliform (1300◊, 2800◊◊); E.coli (270◊, 140◊, 1000◊◊, 3600◊◊, 400◊◊); Dieldrin (0.007#*); Bis (2-ethylhexyl) phthalate (18.5*)
	74.46	Residual Chlorine (0.08**); Phosphorus (1.84†)
	72.30	Fecal coliform (2000◊, 1700◊, 5000◊◊); E.coli (220◊, 130◊, 1430◊◊, 2800◊◊, 2500◊◊); Dieldrin (0.005#, 0.003#, 0.004#); Endosulfan II (0.005*, 0.006*); Endrin (0.004*)
	66.56	Fecal coliform (3400◊◊, 4650◊◊); E.coli (130◊, 260◊, 5700◊◊, 3650◊◊, 420◊◊); Iron (6600Δ)

Table 6. Continued.

Stream	River Mile	Parameter (value)
Little Miami River	64.28	Fecal coliform (6180[◊◊], 7090[◊◊]); E.coli (210[◊], 3550[◊◊], 4300[◊◊], 900[◊◊], 305[◊◊]); Dieldrin (0.003[#], 0.003[#]); Endrin (0.008[*]); Bis (2-ethylhexyl) phthalate (98.7[#*]); Iron (5810[Δ], 7340[Δ])
	63.28	Phosphorus (1.29[†], 1.74[†]); Fecal coliform (5200[◊◊], 4600[◊◊]); E.coli (180[◊], 4700[◊◊], 4200[◊◊], 420[◊◊]); Iron (6850[Δ])
	53.20	Fecal coliform (3000[◊◊]); E.coli (170[◊], 2900[◊◊]); Iron (8000[Δ], 8280[Δ])
	47.50	Fecal coliform (1600[◊], 4200[◊◊]); E.coli (240[◊], 3200[◊◊], 1200[◊◊]); Iron (10500[Δ])
	43.76	Dieldrin (0.005[#], 0.005[#]); Endosulfan II (0.005[*]); Endrin (0.003[*], 0.004[*], 0.003[*])
	35.98	Dieldrin (0.005[#]); Endosulfan II (0.004[*], 0.005[*]); Endrin (0.003[*], 0.006[*]); gamma-Hexachlorocyclohexane (0.012[*])
	32.95	Fecal coliform (1300[◊]); E.coli (320[◊◊], 1300[◊◊]); Cadmium (6.4[*])
	32.10	*Phosphorus (1.79[†], 1.23[†])*
	31.96	Fecal coliform (2800[◊◊], 2700[◊◊], 7180[◊◊], 4550[◊◊]); E.coli (240[◊], 1000[◊◊], 1300[◊◊], 3400[◊◊], 9270[◊◊]); Dieldrin (0.005[#], 0.006[#*], 0.010[#*]); Endrin (0.009[*], 0.008[*])

Table 6. Continued.

Stream	River Mile	Parameter (value)
Little Miami River	28.00	Temperature (27.9*, 28.1*); Residual Chlorine (0.09**, 0.12**, 0.09**, 0.07**, 0.11**, 0.05**); Phosphorus (2.63†); Mercury (1.8**); Fecal coliform (2800◊◊); E.coli (480◊◊, 1700◊◊); Dieldrin (0.005#, 0.003#, 0.006#*); Endrin (0.004*); Methoxychlor (0.040*)
	24.10	Dieldrin (0.003#, 0.002#); Endrin (0.005*)
	22.20	*Phosphorus (2.77†);* *Zinc (1010***)*
	21.45	Temperature (28.0*); Fecal coliform (39000◊◊); E.coli (130◊, 330◊◊, 7100◊◊);
	18.14	Fecal coliform (1300◊, 29000◊◊); E.coli (180◊, 510◊◊, >80000◊◊, 510◊◊, 390◊◊); Dieldrin (0.004#, 0.005#); Endrin (0.003*); Endosulfan II (0.004*); Iron (20900Δ)
	13.07	Temperature (28.0*); Iron (15700Δ)
	8.14	Fecal coliform (3000◊◊, 2500◊◊); E.coli (230◊, 370◊◊, 4700◊◊, 2000◊◊); Iron (10200Δ)
	3.50	Temperature (28.0*); Fecal coliform (9730◊◊); E.coli (140◊, 210◊, 210◊, 420◊◊, 8000◊◊, 360◊◊); Dieldrin (0.002#, 0.003#); Endosulfan II (0.006*, 0.006*); Iron (15200Δ)

Table 6. Continued.

Stream	River Mile	Parameter (value)
Little Miami River	28.00	Temperature (27.9*, 28.1*); Residual Chlorine (0.09**, 0.12**, 0.09**, 0.07**, 0.11**, 0.05**); Phosphorus (2.63†); Mercury (1.8**); Fecal coliform (2800◊◊); E.coli (480◊◊, 1700◊◊); Dieldrin (0.005#, 0.003#, 0.006#*); Endrin (0.004*); Methoxychlor (0.040*)
	24.10	Dieldrin (0.003#, 0.002#); Endrin (0.005*)
	22.20	*Phosphorus (2.77†);* *Zinc (1010***)*
	21.45	Temperature (28.0*); Fecal coliform (39000◊◊); E.coli (130◊, 330◊◊, 7100◊◊);
	18.14	Fecal coliform (1300◊, 29000◊◊); E.coli (180◊, 510◊◊, >80000◊◊, 510◊◊, 390◊◊); Dieldrin (0.004#, 0.005#); Endrin (0.003*); Endosulfan II (0.004*); Iron (20900Δ)
	13.07	Temperature (28.0*); Iron (15700Δ)
	8.14	Fecal coliform (3000◊◊, 2500◊◊); E.coli (230◊, 370◊◊, 4700◊◊, 2000◊◊); Iron (10200Δ)
	3.50	Temperature (28.0*); Fecal coliform (9730◊◊); E.coli (140◊, 210◊, 210◊, 420◊◊, 8000◊◊, 360◊◊); Dieldrin (0.002#, 0.003#); Endosulfan II (0.006*, 0.006*); Iron (15200Δ)

Table 6. Continued.

Stream	River Mile	Parameter (value)
Little Miami River	1.45	Temperature (28.0*, 28.5*); Phosphorus (1.21†); Fecal coliform (5600$^{\Diamond\Diamond}$); E.coli (270$^{\Diamond}$, 430$^{\Diamond\Diamond}$, 6000$^{\Diamond\Diamond}$, 390$^{\Diamond\Diamond}$); Dieldrin (0.002$^{\#}$, 0.004$^{\#}$); Endosulfan II (0.006*, 0.006*); Iron (10100$^{\Delta}$)
Yellow Springs Creek	0.44	Fecal coliform (4050$^{\Diamond\Diamond}$, 2600$^{\Diamond\Diamond}$); E.coli (190$^{\Diamond}$, 140$^{\Diamond}$, 4100$^{\Diamond\Diamond}$, 1400$^{\Diamond\Diamond}$)
	0.42	*Phosphorus (1.07†, 1.93†, 1.24†)*
	0.10	Ammonia-N (1.42*); Fecal coliform (1240$^{\Diamond}$, 2200$^{\Diamond\Diamond}$); E.coli (4400$^{\Diamond\Diamond}$, 580$^{\Diamond\Diamond}$); Dieldrin (0.003$^{\#}$, 0.003$^{\#}$, 0.004$^{\#}$)
Oldtown Creek	0.10	E.coli (170$^{\Diamond}$, 140$^{\Diamond}$, 460$^{\Diamond\Diamond}$); Dieldrin (0.002$^{\#}$)
Massies Creek	0.25	Fecal coliform (1210$^{\Diamond}$, 1620$^{\Diamond}$); E.coli (160$^{\Diamond}$, 1630$^{\Diamond\Diamond}$, 910$^{\Diamond\Diamond}$, 470$^{\Diamond\Diamond}$, 540$^{\Diamond\Diamond}$)
Beaver Creek	1.57	Phosphorus (1.74†); Fecal coliform (6820$^{\Diamond\Diamond\Diamond}$); E.coli (2300$^{\Diamond\Diamond\Diamond}$, 2100$^{\Diamond\Diamond\Diamond}$, 630$^{\Diamond\Diamond\Diamond}$); Iron (5290$^{\Delta}$)
	1.04	Phosphorus (1.10†); E.coli (1300$^{\Diamond\Diamond\Diamond}$, 1010$^{\Diamond\Diamond\Diamond}$, 650$^{\Diamond\Diamond\Diamond}$)
	0.39	*Phosphorus (3.09†, 1.22†, 1.27†, 1.07†, 1.89†)*
	0.20	Phosphorus (1.01†, 1.26†, 1.19†, 1.67†); E. coli (1700$^{\Diamond\Diamond\Diamond}$, 1200$^{\Diamond\Diamond\Diamond}$) Dieldrin (0.002$^{\#}$, 0.005$^{\#}$, 0.002$^{\#}$); Endosulfan II (0.006*, 0.011*); Endrin (0.005*)

Table 6. Continued.

Stream	River Mile	Parameter (value)
Little Beaver Creek	4.62	Temperature (28.8*); Fecal coliform (7270◊◊◊); E. coli (5300◊◊◊)
	4.57	*Phosphorus (1.01†, 1.28†, 1.72†, 1.78†, 1.89†, 1.64†, 1.86†)*
	4.53	Phosphorus (1.23†, 1.35†, 1.62†, 2.04†, 1.68†, 1.82†); E. coli (1600◊◊◊); Dieldrin (0.011#*, 0.012#*); Endosulfan I (0.006*); Endrin (0.008*, 0.006*); Heptachlor (0.014#*, 0.016#*); gamma-Hexachlorocyclohexane (0.011*, 0.023*)
	1.95	Phosphorus (3.77†, 1.15†, 1.20†, 1.12†, 1.45†)
	0.05	Phosphorus (1.68†, 1.56†, 1.15†, 1.07†, 1.44†); E. coli (2000◊◊◊, 610◊◊◊)
Glady Run	4.82	E. coli (660◊◊◊)
	4.75	Residual chlorine (0.16**, 0.15**, 0.10**, 0.24**, 0.14**, 0.10**); Phosphorus (1.05†, 1.38†, 1.33†, 1.46†); E. coli (640◊◊◊); Dieldrin (0.015#*, 0.013#*, 0.008#*); Endosulfan II (0.005*); Heptachlor (0.031#*, 0.012#*); gamma-Hexachlorocyclohexane (0.067*, 0.034*, 0.049*); Endrin (0.009*)
	4.08	Phosphorus (1.28†, 1.32†)
Glady Run Swale	0.01	Phosphorus (1.72†, 1.64†)
Anderson Fork	4.90	Dissolved Oxygen (5.7‡‡‡); Dieldrin (0.005#, 0.006#*); Endosulfan II (0.005*)
Caesar Creek	16.52	Dissolved Oxygen (3.2‡‡‡); Phosphorus (1.89†)
	0.15	Temperature (28.0*)

Table 6. Continued.

Stream	River Mile	Parameter (value)
Flat Fork	1.70	Dissolved Oxygen (2.9‡‡, 1.1‡‡); Fecal coliform (1320◊); E. coli (210◊, 1130◊◊); Dieldrin (0.007#**); Endrin (0.004*)
Dry Run	1.79	Dissolved Oxygen (4.2‡)
Turtle Creek	6.23	Temperature (28.1*); Dissolved Oxygen (4.0‡); Dieldrin (0.004#); Endosulfan II (0.005*)
	5.00	Temperature (29.0*); Dissolved Oxygen (4.8‡, 3.2‡‡); E. coli (1400◊◊◊, 1800◊◊◊, 800◊◊◊); Lead (245*Δ)
	0.70	Dissolved Oxygen (2.8‡‡, 3.2‡‡, 4.2‡); Phosphorus (2.14†); Fecal coliform (19000◊◊◊); E. coli (3200◊◊◊, 16000◊◊◊)
	0.58	*Phosphorus (4.24†, 1.31†);* *Copper (447***, 128***, 374***, 43***)*
	0.52	Dissolved Oxygen (4.4‡); Conductivity (3900*, 2890*); Total Dissolved Solids (1530*, 1690*, 2370*, 1760*); Ammonia-N (3.33*, 8.91*, 23.60**); Phosphorus (2.09†); Copper (506***Δ, 111**, 135**, 50*)
	0.01	Dissolved Oxygen (4.8‡); E. coli (790◊◊◊, 3500◊◊◊)
Muddy Creek	2.50	Residual Chlorine (0.09**, 0.07**, 0.14**); Phosphorus (1.08†); Fecal coliform (1430◊, 4200◊◊); E. coli (190◊, 310◊◊, 780◊◊, 480◊◊, 300◊◊); Copper (486***); Dieldrin (0.005#); Endrin (0.006*)

Table 6. Continued.

Stream	River Mile	Parameter (value)
Simpson Creek	0.01	Phosphorus (1.63†)
Stonelick Creek	16.74	Dissolved Oxygen (4.2‡, 2.4‡‡, 4.4‡); Fecal coliform (15000◊◊); E. coli (7700◊◊); Lead (5*); Dieldrin (0.002#); Iron (6900Δ)
	3.10	Dissolved Oxygen (4.8‡, 4.2‡); Fecal coliform (2200◊◊); E. coli (1300◊◊); Dieldrin (0.002#, 0.003#); Aldrin (0.005#); Endosulfan II (0.005*)
	1.00	Dissolved Oxygen (4.0‡); Fecal coliform (3000◊◊); E. coli (3300◊◊); Dieldrin (0.004#, 0.004#); Endosulfan II (0.004*)
Sycamore Creek	0.40	Fecal coliform (27000◊◊, 11000◊◊); E. coli (300◊◊, 20000◊◊, 8000◊◊, 150◊)
	0.25	*Phosphorus (1.92†, 1.41†, 3.00†, 1.92†, 2.97†)*
	0.05	Phosphorus (2.83†, 2.90†, 3.43†, 2.43†, 2.22†); Fecal coliform (1650◊, 1280◊, 17000◊◊, 8640◊◊, 24000◊◊, 21000◊◊); E. coli (765◊◊, 6000◊◊, 7200◊◊, 7500◊◊, 220◊, 230◊); Dieldrin (0.005#, 0.005#); Endosulfan I (0.005*, 0.006*); Endrin (0.004*, 0.005*); gamma-Hexachlorocyclohexane (0.012*)
O'Bannon Creek	0.26	Phosphorus (2.25†)
East Fork	15.60	Temperature (28.0*); Dieldrin (0.004#, 0.003#); Bis (2-ethylhexyl) phthalate (10.6*)
	12.59	*Phosphorus (1.29†, 1.10†, 2.19†)*

Table 6. Continued.

Stream	River Mile	Parameter (value)
East Fork	9.10	Temperature (29.5**, 28.5*); Dissolved Oxygen (5.6‡‡‡)
	6.57	Temperature (29.6**, 28.5*); Iron (6990Δ)
	4.85	Phosphorus (1.49†, 3.09†, 2.30†, 3.64†)
	4.00	Temperature (29.9**); Fecal coliform (5000◊◊, 3900◊◊); E. coli (2700◊◊, 3800◊◊, 160◊); Iron (5750Δ)
	0.77	Temperature (27.9*); Dissolved Oxygen (5.8‡‡‡) Fecal coliform (5300◊◊, 2500◊◊); E. coli (460◊◊, 4400◊◊, 130◊, 200◊); Dieldrin (0.003#); Endrin (0.006*)

* exceedence of numerical criteria for prevention of chronic toxicity (Chronic Aquatic Concentration [CAC]).
** exceedence of numerical criteria for prevention of acute toxicity (Acute Aquatic Concentration [AAC]).
*** exceedence of numerical criteria for prevention of lethality (Final Acute Value [FAV]).
# exceedence of numerical criteria for human health 30-day average.
‡ exceedence of the average warmwater habitat dissolved oxygen (D.O.) criterion (5.0 mg/l).
‡‡ exceedence of the minimum warmwater habitat dissolved oxygen (D.O.) criterion (4.0 mg/l).
‡‡‡ exceedence of the exceptional warmwater habitat minimum dissolved oxygen (D.O.) criterion (6.0 mg/l).
◊ exceedence of the average Primary Contact Recreation criterion (fecal coliform 1000/100ml; E. coli 126/100ml).
◊◊ exceedence of the maximum Primary Contact Recreation criterion (fecal coliform 2000/100ml; E. coli 298/100ml).
◊◊◊ exceedence of the maximum Secondary Contact Recreation criterion (fecal coliform 5000/100ml; E. coli 576/100ml).
† exceedence of WQS guideline for daily average phosphorus (1 mg/l).
Δ exceedence of agricultural water supply 30-day average (copper 500 µg/l; lead 100 µg/l; iron 5000 µg/l).

NOTE: Iron exceeded 1.0 mg/l (the CAC) in 130 of 392 (33%) non-mixing zone samples in the study area.

- Total suspended solids concentrations increased markedly in the lower reaches of the East Fork downstream from Stonelick Creek (RMs 6.57 - 0.77, Figure 65). Similar to other tributaries, the maximum concentrations occurred on July 15 during elevated flow conditions following heavy rainfall. Soil erosion from agricultural fields and construction sites were the likely sources of the increased TSS.

- Elevated fecal coliform, fecal strep, and *E. coli* bacteria counts were recorded at RMs 13.35, 4.85, 4.00, and 0.77 (Figure 66, Table 6). The highest counts again generally occurred on July 15 during high flows.

- Two sites (RMs 15.60 and 0.77) were sampled for organics. Results revealed exceedences of water quality criteria for dieldrin at both sites, endrin at RM 0.77, and one semi-volatile compound (bis [2-ethylhexyl] phthalate) at RM 15.60 (Table 6,A-5). Overall, the results showed no appreciable differences in the number of compounds detected at the upstream site compared to the four downstream sites.

Chemical Sediment Quality (Tables 6-8, A-7,A-8a)

- During the summer of 1993 sediment samples were collected from 39 locations in the study area to assess levels of contaminants present in stream sediments in the Little Miami River and tributaries. Whenever possible, composite samples of the channel cross-section were collected. All samples were analyzed for heavy metals, pesticides, polychlorinated biphenyls (PCBs), and semi-volatile and volatile organic compounds. Sediment levels were classified according to a scheme developed by Kelly and Hite (1984).

Little Miami River

- Sediment results for heavy metals from 12 sites in the Little Miami River mainstem showed only one site, Beechmont Avenue (RM 3.50), with highly elevated concentrations (lead = 87.8 mg/kg, Table 7). The highly elevated lead level was attributed to urban runoff and combined sewer overflow (CSO) discharges to Duck Creek. Elevated lead levels also appeared downstream from the Warren Co. Lower LMR WWTP (Simpson Creek, RM 28.00). Other elevated heavy metals included arsenic at Dolly Varden Rd. (RM 98.98) and zinc at Beechmont Avenue (RM 3.50). *Mercury* analyses (conducted at only two mainstem sites) showed a non-elevated concentration (0.053 mg/kg) downstream from Simpson Creek (RM 28.0), but an extremely elevated level (0.485 mg/kg) at Beechmont Avenue (RM 3.5). Beechmont Avenue was the only site at which more than one elevated heavy metal was detected. Values at all of the other sediment sampling sites were indicative of either slightly or non-elevated concentrations.

- Sediment scans for priority pollutants detected one or more semi-volatile compounds at all 12 mainstem sites. Similar to the heavy metals, Beechmont Avenue (RM 3.50) contained the highest number of pesticides (4) and polycyclic aromatic hydrocarbons (9 PAHs; Tables 8, A-8a). Probable sources of the contaminants are in the Duck Creek subbasin and include the Norwood/Duck Creek landfill, urban runoff, spills, and numerous CSOs. The landfill is closed, but has been exposed by erosion along Duck Creek. Sediments at Spring Valley (RM 63.28) contained the second highest quantity of PAHs (6) in the mainstem. Indian Ripple Rd. (RM 72.30) data included two PAH compounds. PAH compounds were not detected at the other nine mainstem sites. The most frequently detected organic compounds were bis (2-ethylhexyl) phthalate, benzo [B&K] fluoranthene, and fluoranthene.

- One or more pesticides were detected at all 12 mainstem sites (Table 8). Dieldrin was the most frequently detected pesticide occurring at nine (9) locations. It was the only pesticide found at a highly elevated concentration (Dolly Varden Rd., RM 98.98). Other locations contained non to slightly elevated values. The summed total of DDT compounds (total of 4,4'-DDE, 4,4'-DDD and 4,4'-DDT-sum of DDT and metabolites) was the second most frequently detected pesticide, but most values were non-elevated. No polychlorinated biphenyl (PCB) compounds were detected.

Tributaries

- Sediment analyses for heavy metals at 27 tributary sites showed elevated levels of zinc in Oldtown Creek (RM 0.10) and Turtle Creek (RM 6.23) and an elevated arsenic value in Turtle Creek (RM 0.52, Table 7).

- Sediment in Sycamore Creek (RM 0.05; downstream the Sycamore WWTP) contained the highest number and concentrations of PAHs of the 27 tributary sampling sites (Table A-8a). Thirteen (13) PAH compounds and one volatile organic compound (toluene) were detected. Turtle Creek (RM 6.23) near Lebanon yielded the second highest number of organic compounds (8). Four semi-volatile organic compounds were detected in Glady Run (RM 4.75) and Beaver Creek (RM 0.20). The most commonly detected organic compounds in tributaries were bis (2-ethylhexyl) phthalate, fluoranthene, and benzo [B&K] fluoranthene.

- Pesticide analyses showed non-elevated levels with dieldrin and endosulfan II the most frequently detected. Only one stream, Flat Fork, had a slightly elevated concentration of dieldrin. Non-elevated levels of PCBs were detected at three sites.

Table 7. Concentrations of heavy metals in sediments of the Little Miami River study area, 1993. (All parameter concentrations, excluding aluminum and nickel, were ranked based on a stream sediment classification system described by Kelly and Hite [1984]. The Kelly and Hite classification system addresses relative concentrations, but does not directly assess toxicity.)

Stream			**Sediment Concentration (mg/kg dry weight)**						
River Mile	**As**	**Cu**	**Cd**	**Cr**	**Fe**	**Pb**	**Ni**	**Zn**	**Hg**
Little Miami River									
98.98	*11.5*[c]	11.7[a]	0.265[a]	13.0[a]	14900[a]	10.5[a]	6.8[a]	*81.7*[b]	-
85.38	5.0[a]	14.4[a]	0.317[a]	12.9[a]	17600[a]	13.5[a]	7.1[a]	61.4[a]	-
76.43	4.4[a]	7.1[a]	0.165[a]	5.8[a]	9690[a]	4.8[a]	2.2[a]	28.5[a]	-
72.30	4.9[a]	17.4[a]	0.302[a]	13.5[a]	12600[a]	17.7[a]	5.2[a]	65.6[a]	-
64.28	5.2[a]	18.6[a]	0.353[a]	12.4[a]	16400[a]	17.6[a]	6.0[a]	77.9[a]	-
63.28	7.8[a]	13.8[a]	0.210[a]	13.0[a]	13900[a]	13.1[a]	7.4[a]	60.4[a]	-
43.76	4.9[a]	9.9[a]	0.155[a]	10.8[a]	10900[a]	10.9[a]	4.3[a]	44.9[a]	-
35.98	4.6[a]	10.3[a]	0.140[a]	10.5[a]	13400[a]	10.2[a]	5.1[a]	42.3[a]	-
31.96	*9.8*[b]	13.9[a]	0.119[a]	14.8[a]	*19700*[b]	11.5[a]	8.7[a]	53.9[a]	-
28.00	5.6[a]	13.3[a]	0.152[a]	8.9[a]	7480[a]	*42.9*[c]	4.2[a]	47.6[a]	0.053[a]
24.10	5.6[a]	13.2[a]	0.183[a]	12.6[a]	15500[a]	13.6[a]	7.5[a]	60.1[a]	-
3.50	*10.5*[b]	*41.8*[b]	0.628[a]	*18.6*[b]	15400[a]	***87.8***[d]	11.6[a]	*129.0*[c]	***0.485***[e]
Yellow Springs Creek									
0.10	*8.1*[b]	29.3[a]	0.372[a]	15.7[a]	16900[a]	23.3[a]	7.7[a]	*96.7*[b]	-
Oldtown Creek									
0.10	6.7[a]	14.1[a]	0.240[a]	13.3[a]	16500[a]	14.2[a]	5.7[a]	*114.0*[c]	-

Table 7. Continued.

Stream River Mile	As	Cu	Cd	Cr	Fe	Pb	Ni	Zn	Hg
			Sediment Concentration (mg/kg dry weight)						
Glady Run									
4.82	10.2[a]	16.0[a]	0.314[a]	*20.2*[b]	*18600*[b]	15.2[a]	9.0[a]	77.8[a]	-
4.75	6.5[a]	*44.7*[b]	0.322[a]	13.2[a]	11800[a]	40.2[a]	7.5[a]	*84.8*[b]	0.0613[a]
Anderson Fork									
4.90	4.5[a]	8.9[a]	0.133[a]	10.5[a]	10700[a]	7.8[a]	6.0[a]	34.0[a]	<0.0137[a]
Newman Run									
0.27	*10.7*[b]	20.7[a]	0.269[a]	*19.8*[b]	*24700*[c]	18.9[a]	10.2[a]	*92.9*[b]	-
Caesar Creek									
16.52	3.7[a]	7.6[a]	0.156[a]	9.8[a]	10100[a]	6.6[a]	5.2[a]	42.9[a]	-
Flat Fork									
1.70	*11.7*[c]	17.2[a]	0.258[a]	*17.5*[b]	*26400*[c]	17.1[a]	9.1[a]	-	-
Dry Run									
1.79	*8.8*[b]	16.6[a]	0.167[a]	*18.8*[b]	*18200*[b]	16.7[a]	10.0[a]	78.3[a]	-
Stonelick Creek									
1.0	5.8[a]	14.8[a]	0.173[a]	*18.1*[b]	*20500*[b]	13.5[a]	6.20[a]	55.3[a]	-
Turtle Creek									
6.23	*10.9*[b]	20.9[a]	0.369[a]	*19.3*[b]	*22400*[b]	40.4[a]	8.04[a]	*140.0*[c]	-
0.70	7.37[a]	12.2[a]	0.160[a]	11.2[a]	5940[a]	36.8[a]	5.49[a]	74.9[a]	-
0.58	6.86[a]	16.2[a]	0.051[a]	15.4[a]	*23900*[c]	28.2[a]	11.4[a]	56.1[a]	-
0.52	*12.5*[c]	24.9[a]	0.245[a]	14.5[a]	15500[a]	36.9[a]	10.4[a]	64.0[a]	0.0377[a]
0.01	6.98[a]	15.6[a]	0.183[a]	*18.5*[b]	16800[a]	18.5[a]	5.52[a]	66.5[a]	-
Sycamore Creek									
0.40	*9.91*[b]	11.4[a]	0.179[a]	15.0[a]	*22000*[b]	17.5[a]	5.56[a]	54.7[a]	-
0.05	7.0[a]	20.9[a]	0.349[a]	15.1[a]	*24300*[c]	25.5[a]	7.77[a]	*82.3*[b]	0.0321[a]
East Fork Little Miami River									
15.60	3.3[a]	8.0[a]	0.147[a]	8.0[a]	11400[a]	12.1[a]	4.40[a]	42.4[a]	-
13.35	2.5[a]	5.5[a]	0.061[a]	8.0[a]	11100[a]	11.5[a]	3.70[a]	23.0[a]	-
12.59	1.9[a]	7.2[a]	0.072[a]	7.2[a]	10100[a]	11.8[a]	3.82[a]	43.8[a]	-
4.85	3.1[a]	10.4[a]	0.125[a]	10.3[a]	14500[a]	9.2[a]	5.27[a]	34.3[a]	0.0148[a]
0.77	5.1[a]	15.6[a]	0.157[a]	14.2[a]	*19200*[b]	17.6[a]	8.42[a]	54.6[a]	-

a Non-elevated.
b Slightly elevated.
c Elevated.
d Highly elevated.
e Extremely elevated.

Table 8. Concentration (µg/kg) of pesticides in the sediments of the Little Miami River study area during1993.[1,2,3]

Stream Location	River Mile	*Hepta-chlor	*Aldrin	Dieldrin	*Endo-sulfan II	*Endosulfan sulfate	DDT Total
Little Miami River							
Dolly Vardin Rd.	98.98	-	3.89	**20.71d**	-	-	-
Grinnel Rd.	85.38	-	-	*4.43*[b]	-	-	-
ust. Shawnee Ck.	76.43	-	-	-	0.76	-	-
Indian Ripple Rd.	72.30	-	-	*5.38*[b]	-	-	2.86[a]
dst. Sugarcrk WWTP	64.28	-	-	2.76[a]	-	-	-
SpringValley Rd. Park	63.28	-	-	-	-	-	2.34[a]
S.R 350/Ft. Ancient	43.76	-	-	1.26[a]	-	-	2.19[a]
Stubbs Mill Rd.	35.98	-	-	2.73[a]	-	-	2.73[a]
ust. Muddy Cr.	31.96	-	-	-	-	-	2.08[a]
dst. Simpson Cr.	28.00	-	-	1.68[a]	-	-	-
ust. conf. O'Bannon Cr	24.10	-	-	0.73[a]	-	-	-
Beechmont Ave.	3.500	-	1.52	*4.26*[b]	7.79	-	*12.73*[c]
Yellow Springs Creek							
Grinnel Rd.	0.10	-	-	2.80[a]	0.85	-	-
Oldtown Creek							
near mouth, U.S. 68	0.10	-	-	1.48[a]	-	-	-
Beaver Creek							
Dayton-Xenia Rd.	1.57	-	-	0.96[a]	1.27	-	-
dst. little Bvrcrk @ U.S 35	1.04	-	1.12	-	4.51	-	-
dst. Beaver Cr. WWTP	0.20	-	-	1.09[a]	-	-	-
Little Beaver Creek							
ust. Mnt Co.E.Reg. WWTP	4.62	-	-	-	0.65	-	3.36[a]
dst. Mnt Co.E.Reg. WWTP	4.53	-	-	1.74[a]	-	-	3.41[a]
Glady Run							
ust. Xenia Glady Rn Swale	4.82	-	-	-	-	-	-
dst. Xenia Glady Rn Swale	4.75	-	-	1.83[a]	-	-	-
Anderson Fork							
Old Winchester Trail	4.90	-	-	0.74[a]	-	-	-
Newman Run							
Adj. Pekin-Waynsvle Rd.	0.27	-	-	-	-	-	-
Caesar Creek							
Paintersville Rd.	16.52	-	-	-	-	-	-
Flat Fork							
Oregonia Rd.	1.70	-	-	*3.49*[b]	-	-	-

Table 8. Continued.

Location	River Mile	Hepta-chlor	*Aldrin	Dieldrin	*Endo-sulfan II	*Endosulfan sulfate	DDT Total
Dry Run							
Snook Rd.	1.79	-	-	3.19[a]	-	-	-
Turtle Creek							
Glosser Rd.	6.23	-	-	-	-	-	4.48[a]
Mason Rd.	0.70	-	-	1.03[a]	1.05	-	-
Cin.Milacron Mix Zone	0.58	-	-	-	-	-	-
S.R. 48	0.52	-	-	-	0.63	-	-
mouth, dst. Dry Run	0.01	-	-	3.43[a]	-	-	-
Stonelick Creek							
U.S.Rt. 50	1.00	-	-	-	-	-	-
Sycamore Creek							
ust. Sycamore Cr. WWTP	0.40	-	-	1.70[a]	-	-	-
dst. Sycamore Cr. WWTP	0.05	-	0.93	2.29[a]	-	-	-
East Fork Little Miami River							
S.R. 222	15.60	-	-	-	-	-	-
Batavia WWTP mix zone	13.35	-	-	-	-	-	-
Middle E. FWWTPmix zone	12.59	-	-	-	-	-	-
dst. Lower E. F. WWTP	04.85	-	-	-	-	-	-
Cleveland Ave.	00.77	-	-	-	-		

1 All concentrations were ranked on a stream sediment classification system described by Kelly and Hite (1984). The system addresses relative concentrations, but does not directly assess toxicity.
a Non-elevated.
b *Slightly elevated.*
c *Elevated.*
d Highly elevated.
e Extremely elevated.
* Not evaluated by Kelly and Hite (1984).
2 No PCB's detected in sediment samples.
3 Sum DDT is total of 4,4'-DDE, 4,4'-DDT, 4,4'-DDD.

Fish Tissue (Table A-8b)

- Chemical analyses of 34 fish tissue samples for selected metals, pesticides, and PCBs showed relatively little chemical contamination of fish throughout the Little Miami River mainstem (based on cumulative data from a total of eight (8) species and 11 locations between RM 83.1 and RM 3.5, Table A-8b). All detected concentrations from seven (7) sport species (composite fillet samples) and common carp (composite whole body) were below U.S. FDA Action Levels (Appendix Table A-8b; Estenik and Smith 1992). No pesticides or PCBs were detected in composite fillet samples of smallmouth bass, sauger, and channel catfish at RM 31.9; spotted bass and sauger at RM 18.5; smallmouth bass and freshwater drum at RM 8.0; and smallmouth bass at RM 3.5. Chlordane, a historical insecticide used for termite control, was not detected in any of the 34 mainstem tissue samples.

- A total of seven (7) pesticides and their derivatives were detected. Similar to the water and sediment scans, dieldrin was the most frequently occurring pesticide with a detection rate of 76.5%. This rate is higher than the statewide detection rate of 48.1% report by Estenik and Smith (1992). The highest dieldrin concentration, 68.7 ug/kg, was found in a whole body sample of common carp from Jacoby Road (RM 83.1). The second most frequently detected organic compound was 4,4'-DDE with a detection rate of 73.5% (compared with a 60.5% statewide rate of detection). The whole body common carp sample from Beechmont Avenue (RM 3.5) contained the only detected concentration of 4,4'-DDT (suggests a recent exposure), the highest levels of 4,4'-DDE and 4,4'-DDD (total DDT = 183.3 ug/kg), and all seven (7) of the detected pesticides and derivatives. It was also the only sample containing mirex and methoxychlor, two rarely detected pesticides in Ohio. Heptachlor epoxide was detected in 29.4% of the samples compared to a statewide detection rate of 15.6%.

- The total PCB detection rate in the mainstem was considerably lower than the reported statewide rate of 97.6%. PCB-1260, the most resilient PCB and the only PCB mixture detected, occurred above detection in 64.7% of the Little Miami River samples. Slightly elevated (*i.e.*, >50 ≤ 300 ug/kg) concentrations of PCB's were detected in two of two (2 of 2) white bass samples (*i.e.*, locations), one of three (1 of 3) freshwater drum samples, and three of six (3 of 6) channel catfish samples. Whole body composite values for eight (8) common carp samples were slightly elevated at six (6) locations, elevated (*i.e.*, >300≤1000 ug/kg) at one location, and highly elevated (*i.e.*, >1000<50000 ug/kg) at Beechmont Avenue.

- The highest mercury concentration (0.7 ug/g) occurred in spotted bass fillets collected downstream from the confluence of Sycamore Creek (RM 18.5). This value is below the U.S. FDA criteria of 1.0 ug/g, but greater than the extremely elevated status Kelly and Hite (1984) report for sediment concentrations. It represents the highest concentration recorded to date in the Ohio EPA statewide database and may be related to the recurring mercury exceedences at the Sycamore Creek WWTP. The value also appears highly elevated when compared to studies conducted by the U.S. EPA where mercury was detected in 92% of the fish tissue samples analyzed (maximum value = 1.80 ppm, mean = 0.26 ppm, median = 0.17 ppm; J. Estenik pers. comm). Concentrations of cadmium and lead (maximum values = 0.046 and 1.88 ug/g, respectively) appeared low throughout the mainstem compared to sediment criteria.

Physical Habitat for Aquatic Life (Plates 1-6, 12; Figures 67-68; Tables 9-10)

Little Miami River

- Throughout most of its 105 mile length, the Little Miami River is free-flowing with a natural pool-run-riffle morphology (Plates 1-4). The mainstem has an average gradient of 6.5 feet/mile and flows through a series of broad floodplains and constricted valleys. The river has a complex geologic history with sections occupying pre-, inter-, and post-glacial valleys (Stansbery and Lafferty 1979). As a cross-boundary stream which flows from the E. Cornbelt Plains ecoregion into the Interior Plateau ecoregion, the Little Miami River contains diverse physical attributes and some of the highest quality riverine habitat found in Ohio.

- Physical habitats are predominantly natural with less than four percent of the mainstem directly affected by impoundments or channelization. The longest modified segment, the lower three miles, is inundated by the Markland Dam on the Ohio River. Two shorter sections are impounded by dams in the upper half of the mainstem. The tallest dam (approximately 35 feet high) is located at Clifton Mill (RM 89.3) and a small low head dam is located near Waynesville (RM 55.3). An old dam at Foster was removed.

- Flows in the Little Miami River are becoming increasingly regulated, particularly during low flows. The East Fork and Caesar Creek contain large flood control reservoirs with regulated releases and approximately 50 MGD (77 cfs) of municipal wastewater effluent are discharged in the watershed(third quarter of 1993). Due to increasing suburban development throughout the watershed many of the WWTPs have requested increased design flows. The lowest recorded stream flows (lowest daily mean) for the two operating USGS gaging stations on the upper and lower mainstem, respectively, are 3.5 cfs near Oldtown (September 2, 1988; RM 82.3) and 27 cfs near Milford (September 18, 1954; RM 12.9).

Upper Mainstem - South Charleston to Waynesville

- As the Little Miami River flows from South Charleston to Waynesville the mainstem changes from a small spring-fed creek into a moderately large river. Excluding mixing zones, all of the fish sampling locations contained alternating series of pools, riffles and runs. Substrates were predominated by sand and gravel, but generally contained more than four types of material. Shallow water depths and low turbidity levels made substrates visible at most sites upstream from Waynesville.

- Based on similar QHEI scores, four relatively homogenous segments of physical habitats were identified in the upper half of the mainstem (Table 9). In the most upstream segment, located between U.S. Rt. 42 and Pitchin Road, the stream flows through gently rolling agricultural land and the QHEI scores from three sites ranged from 62.0 to 75.0 (mean = 68.5). The quality of habitat improved downstream from Clifton where the mainstem descends through a steep gradient, constricted gorge. The QHEI value at Grinnel Road was 87.0, the highest value recorded in the mainstem (Figure 67). Downstream from the gorge from Jacoby Road to Spring Valley, the river valley widens into a broad flood plain where it retains good to exceptional quality physical habitats (QHEI range = 62.5-78.0; mean = 73.0).

- The QHEI matrix analysis illustrates the overwhelming predominance of positive warmwater habitat attributes throughout the upper half of the mainstem (Table 10). Five sampling locations (three between Clifton Gorge and Xenia Ford Road, U.S. Rt. 35, and upstream of the Sugar Creek WWTP) contained 9-10 warmwater habitat attributes with no influence from modified habitat attributes. Severely eroding banks, however, were observed on the mainstem where agricultural activities have eliminated woody riparian vegetation (Plate 12).

Lower Mainstem - Oregonia to the Ohio River

- The lower half of the Little Miami River mainstem flows into and through the Interior Plateau ecoregion and also contains a diverse mixture of aquatic habitats in the free-flowing segments. Similar to the upper half, most sampling locations contained a good mixture of pool, riffle, and run habitats. Pools in the lower mainstem are typically longer and wider than in the upper half, but are interspersed with well defined riffle/run complexes. Pool sizes varied from less than 100 meters to more than 800 meters in length, usually exceeded 30 meters in width, and had water depths from 0.5- 2.0 meters. The size of the riffle-run complexes varied from less than 50 meters to more than 200 meters in length. Substrates throughout were predominated by sand, gravel and fragmented slabs of limestone. However, heavy silt deposits were observed in most of the large pools. Large, vegetated gravel/boulder bars, islands, and high flow channels (all positive warmwater habitat attributes) were common in the lower mainstem. Dense patches of water-willow and lizard tail (two pollution sensitive macrophytes) were also common on bars and along the channel margins downstream from Oregonia (Plate 4).

- Only two relatively homogenous segments of habitat were identified between Oregonia and the Ohio River (Table 9). The upstream segment includes the 18 free-flowing sites and the downstream segment contains the two sites which are impounded by the Ohio River backwater effect. The mean QHEI score of 77.6 in the free-flowing segment is indicative of very good to exceptional habitat quality. QHEI scores at the two impounded sites were considerably lower (QHEI = 57.5 at RM 28.2 and 63.5 at RM 22.1; Figure 67). Two other locations, RM 47.5 at Oregonia and RM 8.4 located upstream from Bass Island near Newtown, were predominantly pooled, but contained short lengths of run habitat. QHEI scores from nine locations were greater than or equal to 80 and indicative of exceptional quality habitat. The total number of warmwater habitat attributes ranged from seven to nine (7-9) and were higher than the number of modified habitat attributes at all of the free-flowing sites. Higher numbers of modified attributes were recorded at the two predominantly pooled sites (RM 28.2 and RM 22.1).

- The diversity of habitat declined markedly in the lower three miles of the mainstem due to the impoundment effect by the Markland Dam on Ohio River. The two sampling locations had the lowest QHEI values on the mainstem (50 and 51). Typical of Ohio River backwater areas, these sites consisted of uniformly deep pooled habitat with soft hardpan and silt substrates and slow current. In contrast to the free-flowing mainstem, the total number of modified habitat attributes ranged from seven to eight and outnumbered the warmwater habitat attributes (only 4 were observed). Flotsam in the form of urban trash and debris from stormwater (Plate 13) noticeably increased in the backwater segment. The last outside bend of the mainstem, near the confluence with the Ohio River, had a severely eroding bank.

Yellow Springs Creek

- Yellow Springs Creek had wide, wooded riparian zones and QHEI scores (range = 73.5 - 80.0) indicative of very good to exceptional quality physical habitat. Instream habitats contained pools interspersed by riffle-run complexes, clear water, and substrates predominated by cobble, gravel, and sand (Plate 5). A few sludge deposits, however, were observed downstream from the Yellow Springs Creek WWTP. This tributary had a high number of warmwater habitat attributes (8 or 9 per site) and few or no modified habitat influences.

Oldtown Creek

- Near its confluence with Massies Creek, Oldtown Creek meanders through a wooded floodplain and contains exceptional quality physical habitat (QHEI = 82.5). The natural channel contained pools interspersed by riffles and runs, a predominantly loose (not embedded) gravel substrate, and abundant instream cover. A channelized segment, however, was located immediately upstream adjacent to an abandoned railroad grade.

South Fork of Massies Creek

- At RM 1.1, the South Fork flows through a wooded strip adjacent to a quarry and contains relatively good stream morphology, despite historical channel modifications. Instream habitats consisted of alternating series of pools and riffles with substrates predominated by limestone bedrock and cobble sized fragments. This section of the stream had good riparian cover, stable banks, and diverse aquatic habitats including deep pools. Upstream from the wooded segment, the South Fork flows through an open field and appeared to have been recently channelized. The QHEI scored 66.5 an indication that the WWH use is appropriate.

Massies Creek

- Massies Creek was evaluated downstream from the confluence of Old Town Creek (RM 0.3). This section of the stream may have been previously modified during bridge construction and contained primarily pooled habitat. The QHEI scored 67.5, similar to the South Fork. Hardpan and gravel were the predominant substrates. The site exhibited seven warmwater habitat attributes and four modified habitat attributes, including sparse amounts of instream cover.

Beaver Creek

- The quality of physical habitats in Beaver Creek improved downstream from the confluence of Little Beaver Creek possibly due to increased flows from an upstream WWTP (Plate 11). QHEI scores increased from 54.5 upstream of Little Beaver Creek to 74.0 and 70.5, respectively, upstream and downstream from the Greene Co. Beavercreek WWTP (the mixing zone QHEI was 64.0).

Little Beaver Creek

- Throughout its length, Little Beaver Creek is a headwater tributary based on drainage area, but contains instream habitats more similar to larger streams due to the large volume of flow discharged by the Montgomery Co. Eastern Regional WWTP (3rd quarter 1993 mean daily discharge = 12.7 cfs; Figure 22, Plate 11). QHEI scores were indicative of good quality habitat at four of the sampling locations (QHEIs = 67.5-76.0), but poor quality habitat was evident downstream from the WWTP due to a shallow, uniform channel with little instream cover (QHEI = 48.5).

Glady Run

- Glady Run was sampled upstream and downstream from the WWTP swale and downstream from St.Rt. 725 near the mouth. QHEI scores increased from 54.0 upstream from the WWTP swale to 69.0 near the mouth. The lower score at upstream site was due primarily to a lack of flow caused the diversion of most of the Glady Run flow into the swale upstream from the WWTP.

Glady Run Swale

- The WWTP tributary (the swale) to Glady Run was also sampled at three locations, upstream from the WWTP, downstream from the diversion of Glady Run, the WWTP mixing zone, and near the mouth. The tributary appeared to have been channelized throughout the segment and exhibited considerable recovery downstream from the old railroad grade (RM 0.1). QHEI scores increased from 49-53 upstream from the WWTP and in the mixing zone to 66 near the mouth. The swale contained a low diversity of substrate types at all three locations and was dominated by sand and small gravel.

Newman Run

- Newman Run is a small headwater tributary which joins the Little Miami River upstream from Waynesville. It contained good quality physical habitat (QHEI = 76.0) in early July, but became mostly dry by September due to a lack of surface water flow. Substrates were dominated by limestone fragments and gravel.

Anderson Fork

- Anderson Fork, a tributary of Caesar Creek, contained good quality physical habitat as indicated by a QHEI score of 75.0 (Table 10). The site had an average width of seven meters and alternating series of riffles, runs, and pools. One pool was particularly extensive and deep (>1 meter). Typical of small streams within the Eastern Corn Belt Plains ecoregion, the predominant substrates were cobble and gravel.

Flat Fork

- By the middle of August, aquatic habitats in Flat Fork (a headwater tributary of Caesar Creek) were reduced to isolated, shallow pools due to a lack of surface water flow. The QHEI scored a 50.0 suggesting marginal WWH. Although technically in the Eastern Corn Belt Plain, aquatic habitats in Flat Fork were more typical of Ohio's southwestern Interior Plateau streams. The most common substrate types were limestone bedrock and cobble size fragments.

Caesar Creek

- Caesar Creek contained very good to exceptional quality physical habitats both upstream and downstream from the reservoir. The QHEI increased from 76.0 upstream from the reservoir to 81.5 near the mouth. Silt-free substrates comprised of sand, gravel, and cobble were the predominant types. Both locations contained eight (8) warmwater habitat attributes and only one to two (1-2) modified habitat attributes. Water willow patches were observed only at the site near the mouth.

Dry Run

- Dry Run contained relatively poor habitat for a reference site. While the channel exhibited a predominance of limestone bedrock fragments, it was very shallow with a maximum depth of less than 40 cm. The QHEI score reflected the relatively low quality (54.5) for a WWH stream due principally to poor to fair development, moderate to heavy silt deposits, moderately embedded substrates, low to no sinuosity, narrow riparian corridors, and sparse amounts of instream cover.

Turtle Creek

- Longitudinally, QHEI scores were similar ranging from 68.0 to 75.5 (mean = 69.8; Figure 68, Plate 5). Substrates were predominated by sand and gravel near the mouth and at McClure Road (RM 4.7), cobble and hardpan at Glosser Road (RM 6.3), limestone slabs and gravel downstream from Mason-Morrow Road (RM 0.7), boulder and cobble sized limestone slabs at the two sampling locations between Cincinnati Milacron and SR 48 (RM 0.5 and 0.4), and a mixture of sand and gravel near the mouth (RM 0.1). Deep pools were present at all locations except RM 0.5 and 0.4. Water depths were considerably lower downstream from RM 0.7 in 1993 than during the previous four years. Low flow (0.050 cfs) was recorded at Mason-Morrow Road. However, on June 30, 1988 during a severe drought, flows were higher suggesting an external impact in 1993. The number of warmwater habitat attributes was considerably higher than the number of modified habitat attributes at RM 0.6 (7 compared to 2), but only slightly higher or equal to the number of modified habitat attributes at the other locations. Black, mucky sediment deposits observed in a pool upstream from Glosser Road suggested possible sewage contamination.

Muddy Creek

- Muddy Creek contained very good quality physical habitat at RM 1.6 (QHEI = 78.0) as characterized by a predominantly gravel substrate, a diverse mixture of cover, deep pools, and well defined riffle-run complexes. Physical habitats in the lower section of Muddy Creek were more typical of a wadeable size stream as opposed to smaller headwater tributaries due to the augmenting flow from the Mason WWTP.

Stonelick Creek

- Typical of Interior Plateau streams, the three free-flowing sites in Stonelick Creek contained good to very good quality physical habitat as evidenced by QHEIs of 69.0 - 78.0 (Plate 5). Substrates were comprised of limestone bedrock, bedrock fragments, and gravel. The quality of habitat was markedly lower (QHEI = 48.0) in the upper end of Stonelick Lake, reflecting the effect of the impoundment. This site contained soft and highly embedded substrates, a thick layer of silt and organic muck, and no flow or riffle-run habitats. The site did, however, contain abundant instream cover, a wooded riparian zone, and a high degree of channel sinuosity.

Sycamore Creek

- Physical habitat was evaluated at the three adjacent sampling locations. QHEI scores were similar and ranged from 70.5 - 76.0. Deep pools were absent in the Sycamore Creek WWTP mixing zone, but present both upstream and downstream from the WWTP discharge.

East Fork Little Miami River

- With a 500 square mile watershed (28.5% of the Little Miami River watershed), the East Fork of the Little Miami River is the largest mainstem tributary. Physical habitats were evaluated at the eight fish sampling locations downstream from East Fork Lake (Plate 5). QHEI scores suggest two relatively homogenous segments, RM 15.5 - 6.6 and RM 4.7 - 1.4 (Figure 67). The upstream segment exhibited the highest QHEI scores (mean = 85.9, range 83.5 - 87.0) indicating higher quality than the lower segment (mean = 68.0, range = 65.0 - 70.5; Figure 68). The three upstream locations (RMs 15.5 - 12.4) contained eight to nine (8-9) warmwater habitat attributes and no modified habitat influences.

- Aquatic habitats in the East Fork were similar to those found in the lower half of the Little Miami River within the Interior Plateau ecoregion. Habitat typically consisted of large pools interspersed by high gradient, fast flowing riffle-run complexes. The pools were generally more than 100 meters in length, 50 to 80 meters wide, and 0.3 to >1.0 meter deep. Riffle-run complexes were approximately 65 to 100 meters in length, 10 to 33 meters wide, and <1.0 meter deep. Substrates in the upper segment were predominated by limestone bedrock, bedrock fragments (boulder and cobble sized slabs), and gravel. Dense patches of water-willow were common along the channel margins and numerous sand, gravel, and rock bars. Within the lower five miles, however, pools became deeper, substrates were predominated by smaller sizes (gravel, sand, hardpan, and silt), and the large riffle-run complexes were replaced by smaller riffles and runs. Severely eroding banks also appeared to be more common in the lower segment due to increased riparian encroachment. Dense patches of water-willow were also noticeably lacking on gravel bars downstream from the Clermont Co. Lower East Fork WWTP suggesting a possible toxic impact to these pollution sensitive macrophytes.

Table 9. Mean 1993 Qualitative Habitat Evaluation Index (QHEI) scores for homogenous segments of the Little Miami River and East Fork.

Stream **Segment Description**	Sampling Location (RM)	QHEI	**Segment Mean QHEI**
Upper Little Miami River			
SR42 to Pitchin Road (RM 102.1 - 92.2)			
	102.1	62.0	**68.5**
	98.3	75.0	
	92.2	68.5	
Clifton Gorge at Grinnel Road (RM 85.4)			
	85.4	87.0	**87.0**
Jacoby Road to Spring Valley (RM 83.1 - 63.4)			
	83.1	76.5	**73.0**
	77.3	78.0	
	77.0	*63.5*	
	76.8	76.0	
	74.5	77.5	
	71.8	77.5	
	64.7	73.0	
	64.4	*62.5*	
	64.2	74.0	
	63.4	71.0	
Waynesville (RM 53.5)			
	53.5	65.0	**65.0**
Lower Little Miami River			
Oregonia to SR 125 (RM 47.5 - 3.5)			
	47.5	76.5	**77.6**
	44.2	83.5	
	38.6	83.5	
	35.5	76.5	
	32.9	74.0	
	32.1	*77.0*	
	31.9	86.5	
	28.2	57.5	