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# CSO Impact Assessment for the Licking River

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# CSO IMPACT ASSESSMENT FOR THE LICKING RIVER

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by

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# EXECUTIVE SUMMARY

This report contains the results of a combined sewer overflow (CSO) impact assessment study for a four-mile section of the Licking River just south of its confluence with the Ohio River and between Kenton and Campbell counties in Northern Kentucky. This study is a component of a larger study that was conducted to determine the general impact of CSOs in the Northern Kentucky region. The study was conducted through the Kentucky Water Resources Research Institute of the University of Kentucky and was funded by the Kentucky Natural Resources and Environmental Protection Cabinet through a grant from the United States Environmental Protection Agency.

The objective of this study was to quantify the impact of combined sewer overflows on the Licking River. This was accomplished by analyzing water quality samples that were taken from combined sewers that discharge directly into the Licking River along with stream samples that were taken from eight separate stream locations. The combined sewer discharge samples were taken from the Eighth Street overflow pipe, which conveys combined sewage from Covington, Kentucky. This pipe was chosen for sampling because of its size and accessibility. The eight different stream sampling sites were chosen at various places along the Licking River starting just south of the confluence of Banklick Creek and continuing north to the confluence with the Ohio River.

This report contains the results of two separate sampling efforts for the periods of 5/5/93-8/26/93 and 6/7/94-8/21/94. During the summer of 1993, samples were collected for 17 baseline events while during the summer of 1994, samples were collected for 10 baseline events, 4 sequential events, and 4 CSO events. A total of 266 separate stream samples and 7 separate CSO samples were collected. In each case, the sample was analyzed for one or more of the following parameters: 1) Dissolved Oxygen (mg/l), 2) Conductivity, 3) Temperature (C), 4) PH, 5) Fecal Coliform (colonies/100 ml), 6) Fecal Strep (colonies/100 ml), 7) Biochemical Oxygen Demand - BOD (mg/l), 8) Total Suspended Solids - TSS (mg/l), and 9) Volatile Suspended Solids - VSS (mg/l). In addition, one priority pollutant sample was collected from the Eighth Street outfall during 1993, while two additional priority pollutant samples were collected from the Eighth Street outfall during 1994.

Measured discharges from the Eighth Street outfall contained BOD, TSS, and fecal concentrations well above the average monthly maximum limits for municipal discharges. BOD concentrations ranged from a minimum of 10 mg/l to a maximum of 68 mg/l. TSS concentrations ranged from a minimum of 33 mg/l to a maximum of 342 mg/l. Finally, fecal coliform contamination levels varied from a minimum of 212,000 colonies/100 ml to a maximum of 3 million colonies/100 ml. Priority pollutant scans of the discharges from the Eighth Street outfall failed to identify any significant levels of priority pollutants although trace amounts of cyanide, heavy metals, bis-phthalate, and toluene were detected.

The results of this study indicate that the Licking River was significantly impacted by fecal contamination during both the summer of 1993 and 1994. In general, the level of contamination increased from the confluence of Banklick River to the confluence of the Ohio River indicating the presence of significant sources of biological contamination. The aggregate average fecal coliform level for 1993 was 3400 c/100 ml, while the average aggregate level for 1994 was 1942 c/100 ml. Correspondingly, the average fecal strep level for 1994 was 887 c/100 ml. In general, the ratio of fecal coliform to fecal strep populations increased from Banklick Creek to the Ohio River, thus indicating that the increase in fecal contamination was most likely from domestic sewage sources such as combined sewer overflows. During 1993, a maximum fecal coliform count of 40,000 c/100 ml was observed, while during 1994, a maximum fecal coliform count of 26,000 c/100 ml was observed.

Although significant bacteriological contamination has been identified in both Banklick Creek and Three Mile Creek, it does not appear that either creek is having a significant impact on the concentrations in the Licking River. Indeed, the largest percentage increase in bacteria appears to occur between Three Mile Creek and the Ohio River. In 1993, the majority of the contamination appears to occur downstream of Newport Steel, while in 1994, the majority of the contamination appears to have shifted upstream of Newport Steel.

While significant fecal contamination was identified within the Licking River study area, observed biochemical oxygen demand (i.e. BOD) levels were much lower. Average aggregate BOD levels were observed to be 2.0 mg/l with an absolute maximum of only 6.0 mg/l.

Correspondingly, the observed dissolved oxygen levels generally remained well above the minimum level of 5 mg/l. The average aggregate DO levels were observed to be 7.2 mg/l for 1993 and 8.4 mg/l for 1994. In only one event in 1994 and two events in 1993 did the dissolved oxygen levels drop below 5 mg/l.

In summary, although it would appear that the Licking River continues to experience significant bacteriological contamination, the impacts on dissolved oxygen appear to be minimal. While the results from 1993 show a significant drop in dissolved oxygen between Three Mile Creek and the 4th Street Bridge, the average results for 1994 are less dramatic. In addition, whatever sources are contributing to the fecal contamination do not appear to be generating either significant BOD loadings or solid loadings within the actual river. These results appear to be consistent with other similar studies on the impacts of CSO discharges on rivers and streams and may provide insights on the appropriate technology for use in mitigating the resulting effects.

While it may not be concluded conclusively, it would appear that the source of the biological contamination is from domestic sewage sources. The hypothesis is supported by the ratio of fecal coliform to fecal strep and the ratio of volatile suspended solids to total suspended solids. The most likely source of such contamination would be from the numerous CSOs that are located along the Licking River between the confluence of Banklick Creek and the confluence with the Ohio River. Attempts to segregate the impacts of dry weather events from wet weather events proved generally unsuccessful. However, it does appear that the highest level of bacteriological pollution occurs during periods of low streamflow. This would tend to imply that there may be significant dry weather CSO discharges occurring during low-flow periods that are not receiving sufficient dilution to mitigate the impacts. Such discharges were observed for the Eighth Street outfall. Observations at other CSO outfalls were hampered by the fact that the majority of the outfalls were submerged during the sampling period.

# I. INTRODUCTION

## 1.1. Background

The Federal Clean Water Act of 1972 established the National Pollutant Discharge Elimination System (NPDES) for use in limiting pollutant discharges to the nation's waterways. In the past, the primary application of this legislation has been on controlling pollutant discharges from wastewater treatment facilities (WWTF). In recent years, EPA has extended the enforcement of this legislation to include discharges from combined sewer overflows (CSOs). Combined sewers are sewers that collect and convey both stormwater and domestic sewage. During dry periods the sewers are used to convey domestic sewage to wastewater treatment facilities. However, during storm events, the capacity of the collection systems are frequently exceeded so that the excess flows are diverted untreated to receiving waters through various overflow points along the collection system.

As of July 1995, Kentucky contained approximately 354 CSOs associated with 16 separate wastewater systems (KYDOW, 1995). The majority of the CSOs are located in those cities that are located along the Ohio River. In 1990, the Kentucky Division of Water (DOW) prepared and submitted to EPA the Kentucky Combined Sewer Overflow Control Strategy, which established a uniform, statewide approach to developing and issuing KPDES permits for Combined Sewer Overflows (CSOs). Since that time, the program has been implemented as each municipality and sanitation district renews their KPDES permits. The purpose of the permit program is to 1) insure that any CSO is a result of wet weather flow only, 2) bring all wet weather CSOs into compliance with technology-based requirements and applicable water quality standards, and 3) minimize water negative quality, aquatic biota and human health impacts due to wet weather overflows.

The CSO permit program involves two separate phases. The first phase of the program requires each municipality or sanitation district to 1) identify the receiving water for each overflow, 2) update the existing sewer use ordinance so as to prohibit the construction of any new combined sewers and minimize any new flows into existing combined sewers, and 3) develop a comprehensive Combined Sewer Operational Plan (CSOP) for the system. The first phase of the program is to be completed within 15 months of the issuance of the permit. The second phase of the program involves the implementation of a Combined Sewer Operational Plan (CSOP) so as to reduce the total loading of pollutants entering receiving streams from the combined sewer system.

To develop a relevant set of CSO permit requirements associated with each KPDES permit, some understanding of the basic characteristics and impacts of CSOs is needed. To obtain a basic understanding of these impacts, at least in Kentucky, the Kentucky Natural Resources and Environmental Protection Cabinet secured a grant from the United States Environmental Protection Agency to investigate and characterize these impacts. The resulting grant was used to study two separate areas within the state that had been identified as having significant CSO impacts. These two areas included the Jefferson County region and the Northern Kentucky region, which includes Boone County, Campbell County, and Kenton County.

The CSO study for Jefferson County was conducted for the Louisville and Jefferson County Metropolitan Sewer District by Tenney Pavoni Associates, Inc. The results of this investigation have been reported elsewhere (Tenney Pavoni, 1994). The CSO study for the Northern Kentucky region was conducted by the Kentucky Water Resources Research Institute of the University of Kentucky. The CSO study for the Northern Kentucky region has been conducted in two separate phases. In the first phase, the impacts of CSO discharges on Banklick Creek were evaluated. The results of this report have been presented previously in a separate report (Ormsbee, et al;. 1994). In the second phase, the impacts of CSO discharges on the Licking River were evaluated. The results of this study are presented in this report.

## 1.2. Purpose

The objective of this report is to provide a summary of the methodology and results associated with a water quality sampling effort for the Licking River. In recent years, significant levels of bacteriological contamination have been identified on the lower reach of the Licking River, in particular, just south of its confluence with the Ohio River. One of the most likely sources of such contamination comes from combined sewer overflows that exist along the banks of the river and its tributary creeks. As a result, this study was initiated in an attempt to identify potential pollutant sources and to measure their associated impact. As discussed previously, this effort was one component of a larger effort to determine the impact of CSO discharges on the Northern Kentucky region.

## 1.3. Overview

This report has been divided into eight chapters. Chapter 1 provides an introduction and background with regard to the associated study. Chapter 2 provides a description of the study area. Chapter 3 provides a discussion of the water quality parameters analyzed as part of the study. Chapter 4 provides a discussion of the sampling protocol and associated results for the 1993 baseline sampling effort. Chapter 5 presents the results of the baseline sampling effort for 1994 along with a discussion of the observed results. Chapter 6 presents the results of the CSO sampling effort for 1994 along with a discussion of the observed results. Chapter 7 provides a discussion of the correlation analyses of the various water quality parameters, while Chapter 8 provides a summary of the results along with the conclusions of the study. Logs and figures of the collected data are provided in the report Appendices.

# II. STUDY AREA

## 2.1. General Description of the Licking River Basin

The Licking River basin is located in the center of the state of Kentucky and encompasses 3,707 square miles including parts of 21 Kentucky counties (see Figure 2.1). The Licking River originates in southeastern Kentucky and flows north to its confluence with the Ohio River in the Covington-Newport area directly across the river from Cincinnati. The maximum elevation in the headwaters is 1000 feet above msl and the average slope for the main stem of the Licking River is 2.26 feet/mile. The river contains two principal tributaries: the North Fork and the South Fork. There are 2,034 miles of streams in the basin. Cave Run Reservoir, near Farmers, Kentucky, provides a major impoundment of the river (Kentucky Department for Environmental Protection, 1991).

The Licking River Basin contains a wide variation of land uses and many potential sources of both point and non-point pollution. Land use in the headwaters of the basin tends to involve resource extraction, whereas land use in the rest of the basin tends to be related to agriculture. The last few miles of the Licking Basin drain a highly industrialized and urbanized region and have been associated with significant levels of bacteriological pollution. It has been speculated that a major source of pollution is due to the numerous CSOs that discharge into the river from both Newport and Covington, as well as from many of the surrounding municipalities.

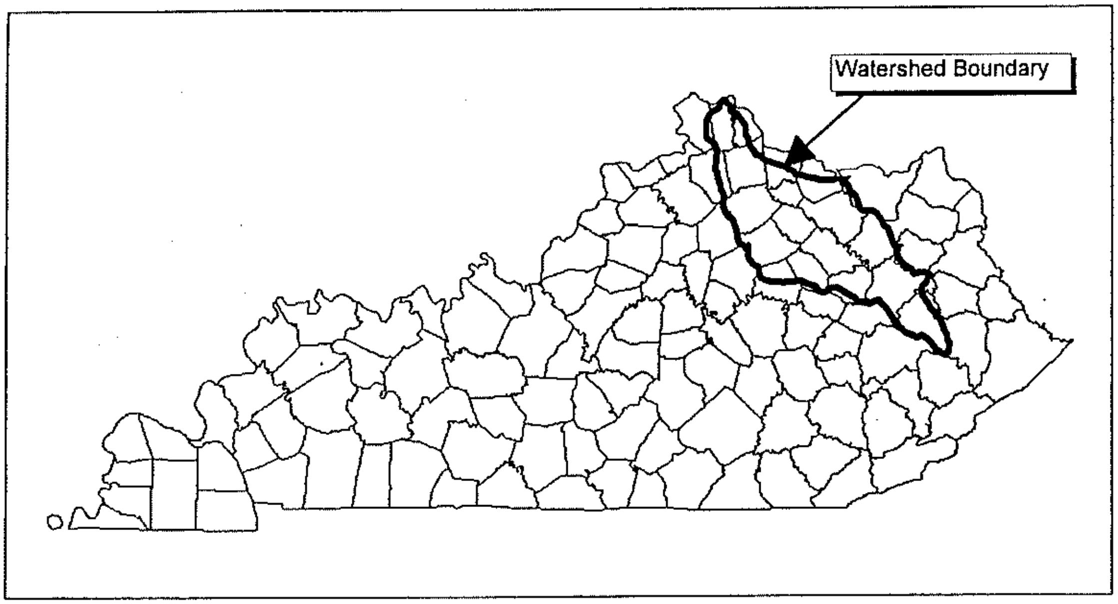


Figure 2.1 Map of the Licking River Basin

## 2.2. Northern Kentucky Region

The purpose of this project is to shed light on the impact of CSOs on various water quality problems that have been observed in the Northern Kentucky region. The Northern Kentucky region is located within the Greater Cincinnati, Ohio area and includes Kenton, Campbell and Boone counties (see Figure 2.2). Information from the 1990 census shows that the population of this area is approximately 300,000.

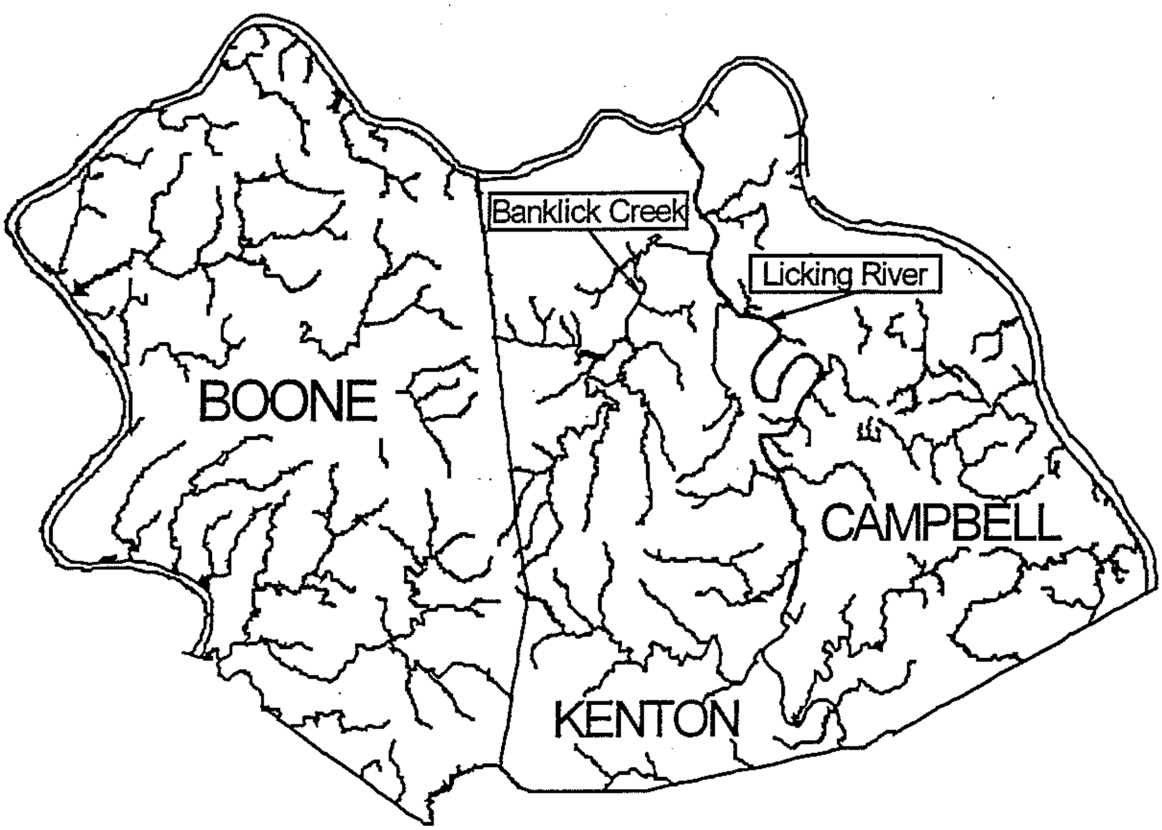


Figure 2.2  Map of the Northern Kentucky Area

The climate of the Northern Kentucky region is temperate and humid. Average monthly temperatures range from a low of 23 F (January) to a high of 87 F (July). Precipitation is fairly well distributed throughout the year. The average annual rainfall is approximately 40 in. The average monthly rainfall for the 1993 and 1994 sampling periods is shown in Figures 2.3 and 2.4, respectively.

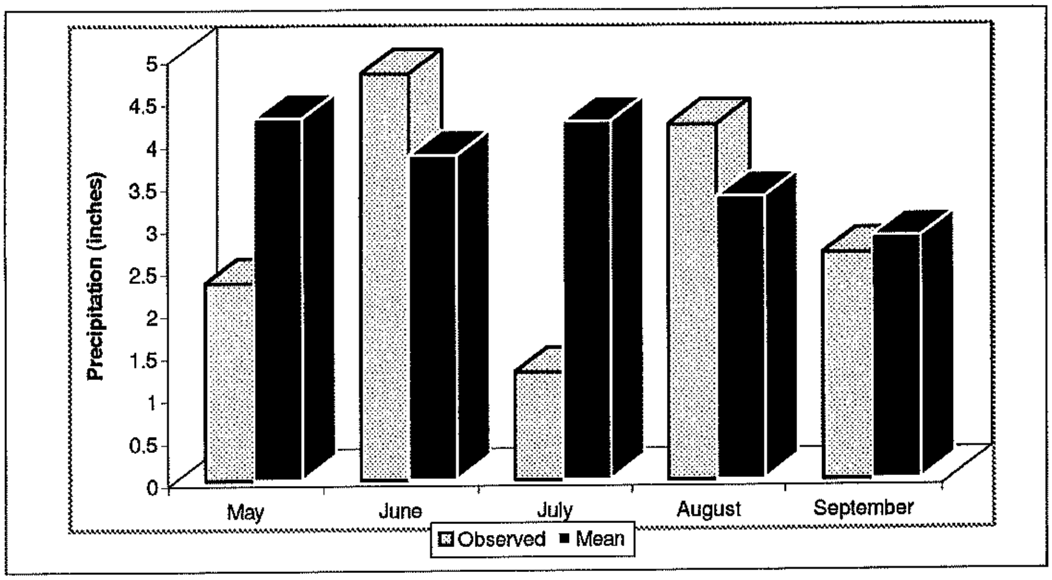


Figure 2.3 1993 Average Monthly Rainfall

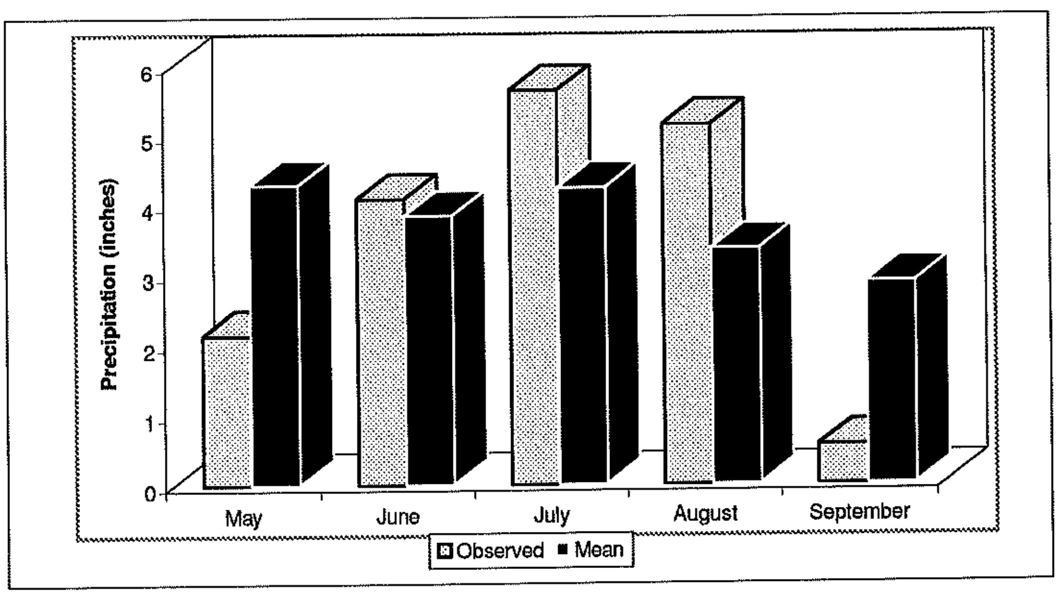


Figure 2.4 1994 Average Monthly Rainfall

## 2.3. Sanitation District No. 1 of Campbell and Kenton Counties

Over 75% of all wastewater flows generated in Boone, Kenton, and Campbell Counties are treated by the Dry Creek Wastewater Treatment Plant. The plant has a current capacity of 46.5 MGD. The Dry Creek Wastewater Treatment Plant is operated by the Sanitation District No.1 of Campbell and Kenton Counties. The District was established in 1946 by Chapter 220 of the Kentucky Revised Statutes and given the responsibility to "prevent and correct the pollution of streams, to improve stream channels for sanitary purposes and to provide for the collection and disposal of sewage produced within the district." By the late 1980s, the District was serving the needs of a steadily growing population of more than 200,000 people in Kenton and Campbell Counties and a portion of Boone County. Currently, the District receives and treats sanitary sewage from 31 separate cities located in these three counties. In turn, each city pays the District a fee for conveyance and treatment of their sewage. In each case, the sewage is collected through a network of collection sewers owned by each municipality and then conveyed to the Dry Creek Wastewater Treatment Plant by a network of trunk main sewers that are owned and operated by the District.

In 1991, the Kentucky Division of Water issued a draft CSO permit to the Sanitation District that identified in excess of 90 CSOs as belonging to the District. The District identified only 3 CSOs under their ownership, and claimed that the remaining CSOs were the responsibility of 9 of the 31 cities served by the District. Following an investigation, the Division of Water agreed with the findings of the District and then moved to permit the remaining CSOs directly through the individual cities (see Table 2.1). In response to the development of permits for these nine cities, several issues were raised with regard to the responsibility of those additional municipalities that did not possess CSOs, but whose sanitary sewage passed through and contributed to the loadings of those cities that contained CSOs. Finally, in 1994, these issues and concerns led to the development of a state statute that allowed all 31 cities (see Table 2.2) to transfer ownership of their collection systems (including all CSOs) to the Sanitation District. This agreement was finally implemented on July 1, 1995, and thus provides for a comprehensive and coordinated effort to address the problems of CSOs in the Northern Kentucky region.

Table 2.1 Table of Northern Kentucky Cities With CSOs

| City | KPDES Number | Number of CSOs |
|---|---|---|
| Bellevue | KY0098337 | 15 |
| Bromley | KY0098428 | 2 |
| Covington | KY0098272 | 63 |
| Dayton | KY0098299 | 2 |
| Ft. Wright | KY0098311 | 2 |
| Ludlow | KY0098281 | 6 |
| Newport | KY0098264 | 16 |
| Park Hills | KY0098256 | 8 |
| Taylor Mill | KY0098302 | 1 |

Table 2.2 Cities Within the Northern Kentucky Area

| City | KPDES Number |
|---|---|
| Bellevue | KY0098337 |
| Bromely | KY0098248 |
| Cold Spring | KYP000021 |
| Covington | KY0098272 |
| Crescent Park | KYP000014 |
| Crestview | KYP000022 |
| Crestview Hill | KYP000013 |
| Dayton | KY0098299 |
| Edgewood | KYP000026 |
| Elsmere | KYP000011 |
| Florence | KYP000016 |
| Ft. Mitchell | KYP000017 |
| Ft. Thomas | KYP000010 |
| Ft. Wright | KY0098311 |
| Highland Heights | KYP000023 |
| Independence | KYP000019 |
| Kenton Vale | KYP000028 |
| Lakeside Park | KYP000018 |
| Latonia Lakes | KYP000031 |
| Ludlow | KY0098281 |
| Melbourne | KYP000030 |
| Newport | KY0098264 |
| Park Hills | KY0098256 |
| Silver Grove | KYP000024 |
| Southgate | KYP000016 |
| Taylor Mill | KY0098302 |
| Villa Hills | KYP000020 |
| Wilder | KYP000012 |
| Woodlawn | KYP000029 |

## 2.4. Study Area

In order to obtain an initial understanding of the impacts of CSOs on the lower reach of the Licking River, a four mile section was chosen for investigation. The selected reach begins south of the confluence with Banklick Creek and extends to the confluence of the Ohio River (see Figure 2.5). This section was chosen to evaluate the impacts of CSOs along the banks of the river and to also allow an evaluation of the impacts of inflows from the two main tributaries (i.e. Banklick Creek and Three Mile Creek).

## 2.5. Licking River Discharges

The streamflow in the study area is not known with certainty. The USGS has streamflow gages located in the basin, but none within the study area. The closest gage to the study area is located at Catawba (USGS# 03253500), River Mile 48, which is approximately 44 miles upstream from the southern boundary of the study area. To approximate the daily stream flows that occurred within the study area during the study period, a proportional area approach was used (Gupta, 1989). The two gaging stations used in the analysis were the USGS gaging station at Catawba (USGS# 03253500), with a total watershed area of 3300 square miles, and McKinnesysburg (USGS# 03251500), with a total watershed area of 2326 square miles. Use of these gaging stations resulted in the streamflow values shown in Tables 2.3 and 2.4 and Figures 2.6 and 2.7 for the periods of May-September for 1993 and 1994, respectively.

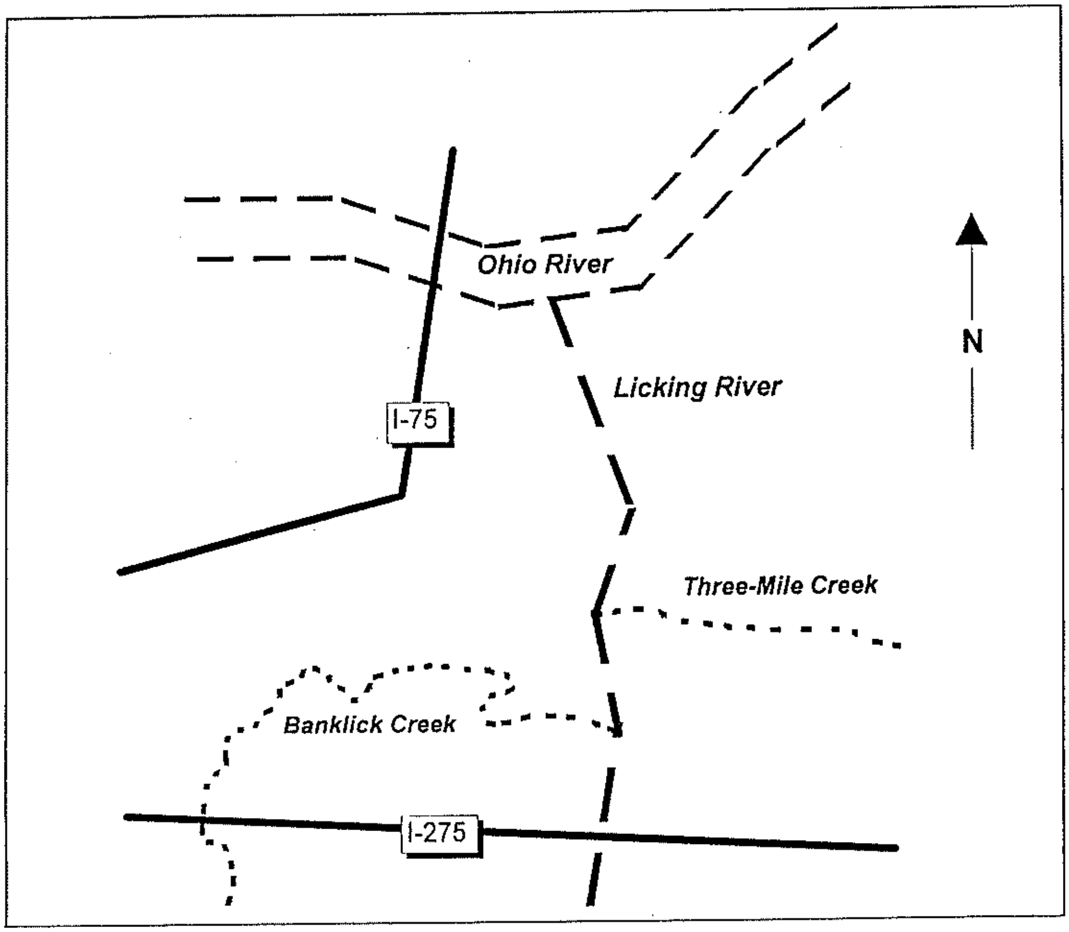


Figure 2.5 Map of Lower Reach of the Licking River

Table 2.3 1993 Daily Streamflow Estimates for the Licking River

| APRIL | | MAY | | JUNE | | JULY | | AUGUST | |
|---|---|---|---|---|---|---|---|---|---|
| Day | Flow (cfs) | Day | Flow (cfs) | Day | Flow (cfs) | Day | Flow (cfs) | Day | Flow (cfs) |
| 1 | 10544 | 1 | 4798 | 1 | 492 | 1 | 815 | 1 | 303 |
| 2 | 12276 | 2 | 4230 | 2 | 476 | 2 | 935 | 2 | 348 |
| 3 | 11664 | 3 | 3807 | 3 | 464 | 3 | 1118 | 3 | 342 |
| 4 | 8673 | 4 | 3380 | 4 | 1247 | 4 | 1672 | 4 | 341 |
| 5 | 7651 | 5 | 5531 | 5 | 5220 | 5 | 1504 | 5 | 343 |
| 6 | 7172 | 6 | 4212 | 6 | 12191 | 6 | 1117 | 6 | 341 |
| 7 | 6785 | 7 | 2474 | 7 | 11332 | 7 | 874 | 7 | 339 |
| 8 | 6438 | 8 | 1889 | 8 | 6353 | 8 | 738 | 8 | 333 |
| 9 | 6196 | 9 | 1590 | 9 | 4714 | 9 | 616 | 9 | 277 |
| 10 | 8268 | 10 | 1425 | 10 | 4468 | 10 | 535 | 10 | 225 |
| 11 | 6987 | 11 | 1393 | 11 | 4055 | 11 | 487 | 11 | 213 |
| 12 | 6295 | 12 | 1258 | 12 | 4538 | 12 | 450 | 12 | 236 |
| 13 | 5777 | 13 | 1022 | 13 | 7318 | 13 | 414 | 13 | 3538 |
| 14 | 5701 | 14 | 953 | 14 | 9617 | 14 | 396 | 14 | 15248 |
| 15 | 6509 | 15 | 869 | 15 | 12747 | 15 | 396 | 15 | 11069 |
| 16 | 7640 | 16 | 822 | 16 | 12177 | 16 | 381 | 16 | 4408 |
| 17 | 4503 | 17 | 778 | 17 | 7852 | 17 | 618 | 17 | 3837 |
| 18 | 4060 | 18 | 813 | 18 | 4926 | 18 | 514 | 18 | 4212 |
| 19 | 3517 | 19 | 1260 | 19 | 2923 | 19 | 506 | 19 | 3604 |
| 20 | 3106 | 20 | 1024 | 20 | 2072 | 20 | 408 | 20 | 2640 |
| 21 | 3231 | 21 | 1454 | 21 | 1287 | 21 | 341 | 21 | 2053 |
| 22 | 2398 | 22 | 1244 | 22 | 1059 | 22 | 309 | 22 | 1243 |
| 23 | 2111 | 23 | 1093 | 23 | 988 | 23 | 285 | 23 | 828 |
| 24 | 2231 | 24 | 979 | 24 | 800 | 24 | 266 | 24 | 580 |
| 25 | 4972 | 25 | 901 | 25 | 654 | 25 | 233 | 25 | 417 |
| 26 | 15698 | 26 | 853 | 26 | 823 | 26 | 191 | 26 | 320 |
| 27 | 11440 | 27 | 819 | 27 | 884 | 27 | 154 | 27 | 276 |
| 28 | 10558 | 28 | 682 | 28 | 1207 | 28 | 137 | 28 | 265 |
| 29 | 7268 | 29 | 561 | 29 | 1231 | 29 | 253 | 29 | 254 |
| 30 | 5641 | 30 | 518 | 30 | 858 | 30 | 563 | 30 | 234 |
| | | 31 | 522 | | | 31 | 338 | 31 | 211 |

Table 2.4 1994 Daily Streamflow Estimates for the Licking River

| APRIL | | MAY | | JUNE | | JULY | | AUGUST | |
|---|---|---|---|---|---|---|---|---|---|
| Day | Flow (cfs) | Day | Flow (cfs) | Day | Flow (cfs) | Day | Flow (cfs) | Day | Flow (cfs) |
| 1 | 10761 | 1 | 17813 | 1 | 729 | 1 | 310 | 1 | 837 |
| 2 | 9895 | 2 | 11765 | 2 | 624 | 2 | 314 | 2 | 1091 |
| 3 | 9259 | 3 | 9066 | 3 | 551 | 3 | 317 | 3 | 811 |
| 4 | 8545 | 4 | 7956 | 4 | 461 | 4 | 319 | 4 | 631 |
| 5 | 8041 | 5 | 7506 | 5 | 371 | 5 | 309 | 5 | 1398 |
| 6 | 7722 | 6 | 7217 | 6 | 339 | 6 | 1549 | 6 | 3911 |
| 7 | 11860 | 7 | 13785 | 7 | 335 | 7 | 245 | 7 | 2416 |
| 8 | 14171 | 8 | 24580 | 8 | 163 | 8 | 219 | 8 | 1298 |
| 9 | 10605 | 9 | 28541 | 9 | 528 | 9 | 201 | 9 | 906 |
| 10 | 13778 | 10 | 19413 | 10 | 1485 | 10 | 192 | 10 | 660 |
| 11 | 16613 | 11 | 9867 | 11 | 1252 | 11 | 191 | 11 | 615 |
| 12 | 14670 | 12 | 7739 | 12 | 1130 | 12 | 194 | 12 | 553 |
| 13 | 16171 | 13 | 7261 | 13 | 936 | 13 | 196 | 13 | 642 |
| 14 | 12345 | 14 | 6859 | 14 | 776 | 14 | 672 | 14 | 615 |
| 15 | 10918 | 15 | 10263 | 15 | 661 | 15 | 1128 | 15 | 493 |
| 16 | 17969 | 16 | 12149 | 16 | 569 | 16 | 1525 | 16 | 471 |
| 17 | 24007 | 17 | 11619 | 17 | 486 | 17 | 1130 | 17 | 423 |
| 18 | 17580 | 18 | 9305 | 18 | 425 | 18 | 745 | 18 | 403 |
| 19 | 9992 | 19 | 6967 | 19 | 405 | 19 | 676 | 19 | 388 |
| 20 | 8698 | 20 | 6370 | 20 | 376 | 20 | 537 | 20 | 386 |
| 21 | 7916 | 21 | 8015 | 21 | 342 | 21 | 485 | 21 | 333 |
| 22 | 7340 | 22 | 5838 | 22 | 315 | 22 | 551 | 22 | 419 |
| 23 | 6962 | 23 | 5613 | 23 | 294 | 23 | 1890 | 23 | 712 |
| 24 | 6707 | 24 | 5414 | 24 | 281 | 24 | 4682 | 24 | 1187 |
| 25 | 6452 | 25 | 5235 | 25 | 270 | 25 | 4296 | 25 | 960 |
| 26 | 6208 | 26 | 6640 | 26 | 268 | 26 | 1475 | 26 | 678 |
| 27 | 6418 | 27 | 4869 | 27 | 302 | 27 | 990 | 27 | 515 |
| 28 | 7161 | 28 | 3001 | 28 | 320 | 28 | 723 | 28 | 431 |
| 29 | 16912 | 29 | 1303 | 29 | 322 | 29 | 809 | 29 | 382 |
| 30 | 24826 | 30 | 1034 | 30 | 317 | 30 | 1182 | 30 | 347 |
| | | 31 | 928 | | | 31 | 929 | 31 | 338 |

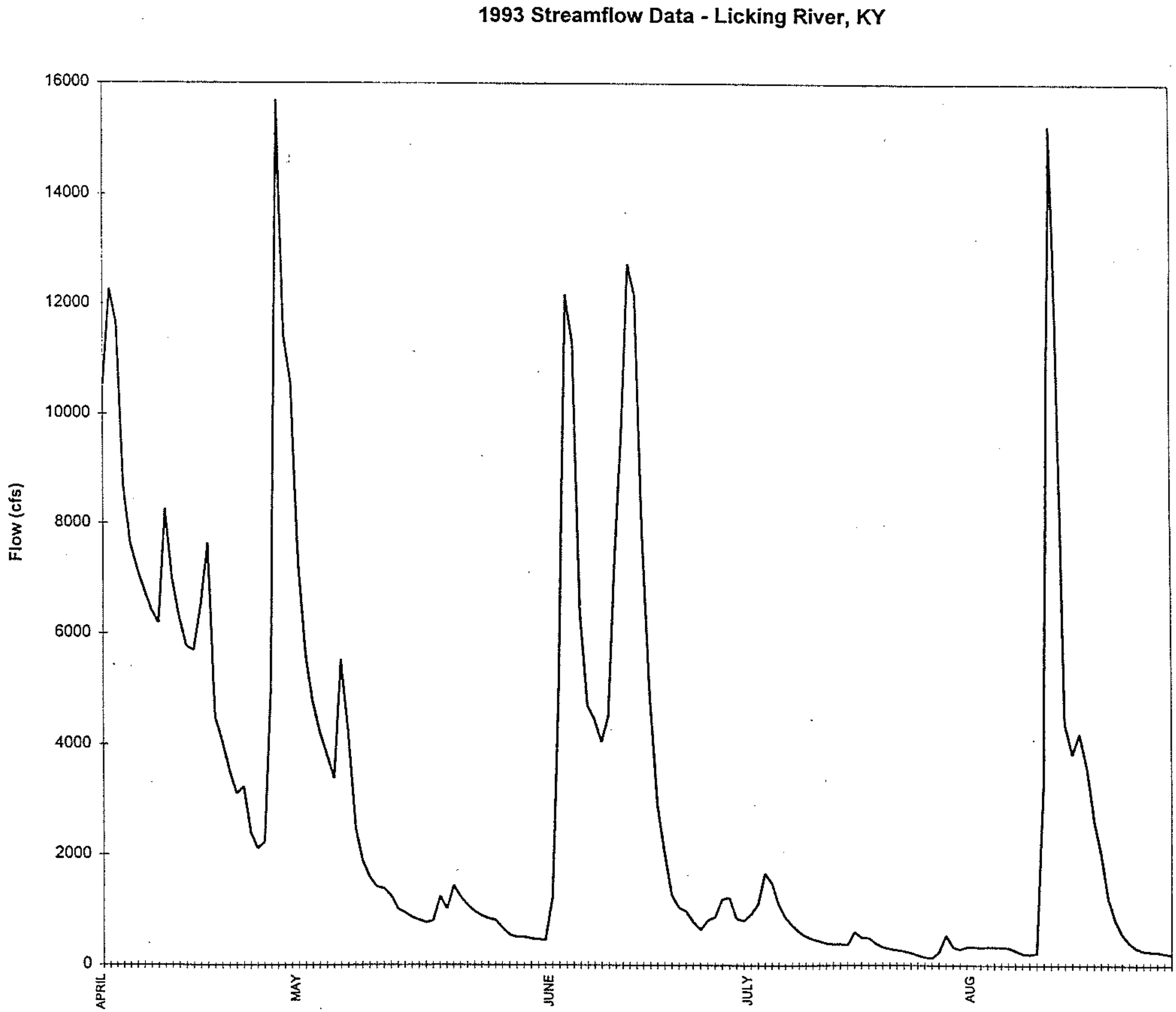


Figure 2.6 1993 Daily Streamflow Estimates for the Licking River

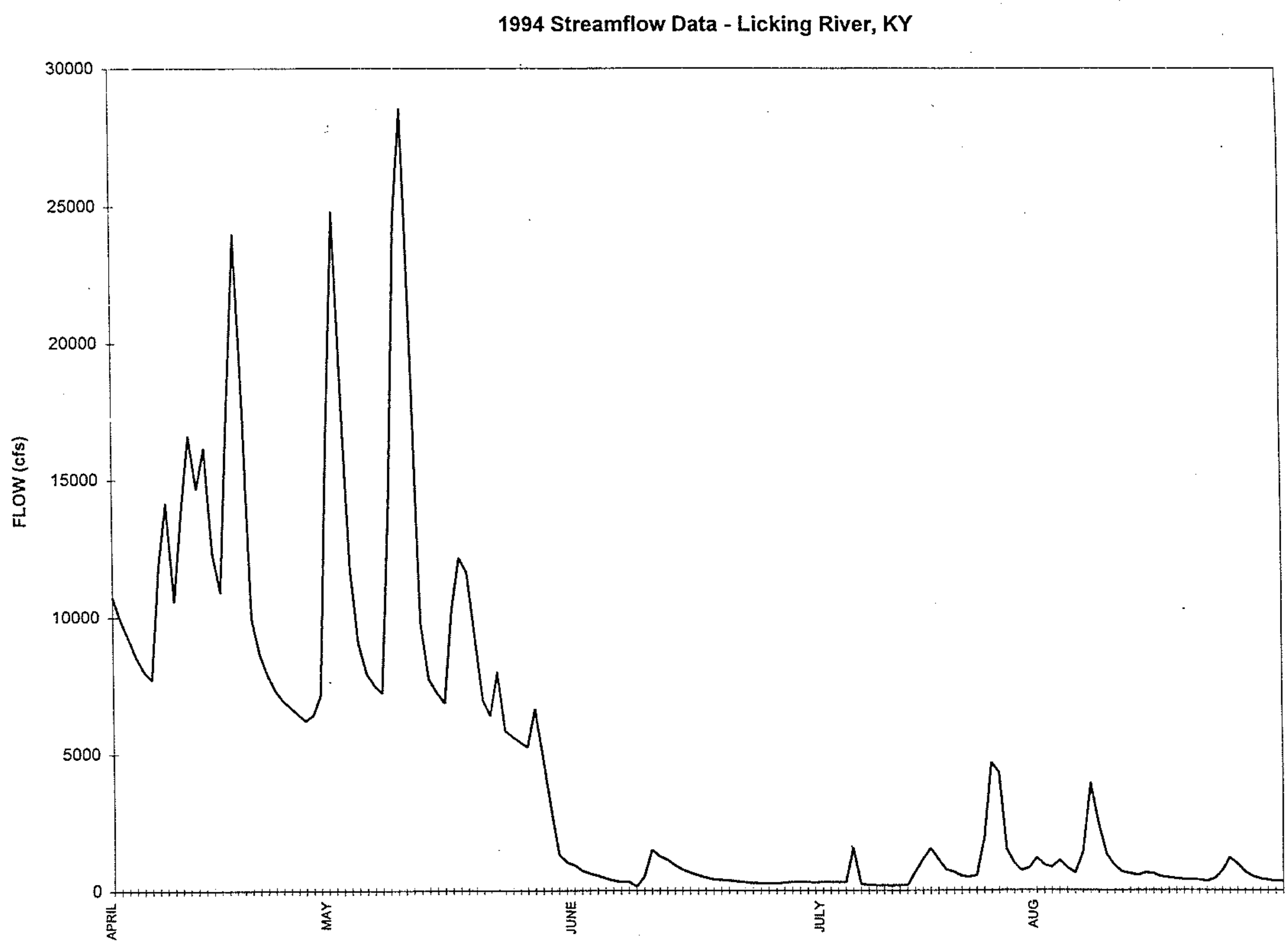


Figure 2.7 1994 Daily Streamflow Estimates for the Licking River

# III. WATER QUALITY PARAMETERS

## 3.1. General Parameters

There are numerous physical, chemical, and biological parameters that can be monitored in a stream system. These parameters can provide clues as to the source of pollution entering the system. They are also useful tools for characterizing the overall health of a surface water and predicting its response to pollutant loads. The parameters monitored in the Northern Kentucky Combined Sewer Overflow (CSO) Study for the Licking River consisted of:

| | | |
|---|---|---|
| 1) | Physical Parameters: | Temperature |
| | | Flow |
| 2) | Chemical Parameters: | Dissolved Oxygen (DO) |
| | | pH |
| | | Conductivity |
| | | Five Day BOD |
| | | Total Suspended Solids (TSS) |
| | | Volatile Suspended Solids (VSS) |
| | | Priority Pollutants |
| 3) | Biological Parameters: | Fecal Coliform (FC) |
| | | Fecal Streptococcus (FS) |

Although suspended solids are often considered a physical parameter, they will be classified in this report as a chemical parameter. This is done because the relationship between TSS and VSS is indicative of the chemical composition of the suspended solid. Following is a brief summary of the significance of each parameter as well as the type of information that may be obtained by studying them. In addition, a brief discussion of the expected parameter correlations is provided.

### 3.1.1. Flow

Flow estimates for the Licking River within the study area were extrapolated using a proportional analysis in conjunction with two upstream gaging stations. The two gaging stations utilized in the analysis were the USGS gaging station at Catawba (USGS# 03253500) and the USGS gaging station at McKinneysburg (USGS# 03251500). Use of these gaging stations resulted in the streamflow values previously presented in Tables 2.3 and 2.4, and Figures 2.6 and 2.7. Flow is a crucial variable because pollutant loading and transport is entirely dependent upon it. Flow also effects how sensitive the water system is to pollutant stress. Also, when receiving water flow rate is estimated, the location of critical (or minimum) dissolved oxygen content can be predicted.

### 3.1.2. Temperature

Temperature is a very important parameter because of its effects on the ability of various chemical reactions to occur, as well as corresponding reaction rates. The dissolved oxygen content of water varies with temperature, as does biological activity.

### 3.1.3. Dissolved Oxygen

Dissolved Oxygen (DO) is one of the most useful indicators of the health of a water system. DO is required for the respiration of aerobic microorganisms that consume organic pollutants in water, as well as all other aerobic life forms. It also represents the receiving water's ability to recover from organic pollutant loadings, such as CSO discharges.

### 3.1.4. pH

Like temperature, pH has important effects on the survival and growth rate of microorganisms. The optimum pH for growth is 6.5-7.5. Measured pH values less than 4 and greater than 9 are harmful to aquatic life. The pH also affects the formation of various chemical complexes. The forming of complexes can place toxic constituents into a form that is not bioavailable, and therefore, no longer toxic.

### 3.1.5. Conductivity

The conductivity of water indicates the amount of free ions in solution. Water that is free of dissolved mineral salts has little capacity for carrying electric current, making its conductivity low.

### 3.1.6. Biological Oxygen Demand, 5-day

Five-day BOD is the most widely used measure of organic pollution. It determines the quantity of oxygen that will be required to biologically stabilize the organic matter present. This parameter is valuable for predicting the oxygen depletion that the water system will experience.

3.1.7. Total Suspended Solids

Total Suspended Solids (TSS) is the solid matter in water that will not settle out and cannot be removed by filtration. The material is removed by biological oxidation. Because of this, when there is an increase in TSS, there will generally be a decrease in DO. High TSS will also affect water color and reduce plant photosynthesis. In contrast, high TSS can reduce the toxicity of metals. Dissolved metals tend to adsorb onto particles of suspended matter, making them unavailable to aquatic life.

3.1.8. Volatile Suspended Solids

Volatile Suspended Solids (VSS) is a portion of TSS. It represents the organic content (versus the mineral content) of TSS. High VSS indicates that the pollution source is organic in nature, such as domestic sewage. The biological oxidation associated with high VSS loading will reduce the DO concentration.

3.1.9. Fecal Coliform

Fecal Coliform (FC) is an indicator organism that lives in the intestinal tract of humans and other animals. Its presence in water indicates that other pathogens (such as salmonella) may also be present. Due to its origin, increased FC counts indicate increased organic pollutant loading. The water quality standard for water contact is 200 colonies/100 ml.

3.1.10. Fecal Streptococcus

Fecal Streptococcus (FS), like FC, is an indicator organism that lives in the intestinal tract of humans and animals. Of the two, FS is more indicative of animal waste. This is because the quantity of fecal coliform and fecal streptococci that are discharged by humans are significantly different from the quantities discharged by animals. The ratio of FC/FS can indicate if the source of pollution tends to be from animal or human waste.

3.1.11. Priority Pollutants

Priority Pollutants include those pollutants that are suspected to be a carcinogen, mutagen, geratogen, or have a high acute toxicity. The presence of a high concentration of a priority pollutant can provide clues regarding the source of pollution. It could also indicate appropriate locations to focus pollutant elimination/minimization efforts. A complete Priority Pollutant scan was conducted from three different samples from the Eighth Street outfall on the Licking River.

# IV. 1993 STREAM SAMPLING

## 4.1. Introduction

During the spring and summer of 1993, 17 separate sets of baseline samples were collected from the Licking River in conjunction with Division of Water personnel to assess the general condition of the river. The stream sampling locations for this effort are shown in Figure 4.1. A description of each sample location is provided in Table 4.1. Each sample was collected from the stream using a Division of Water boat. Separate grab samples were taken for fecal coliform analysis. A Hydrolab H20 transmitter was used to obtain measured values of dissolved oxygen, temperature, conductivity, and pH.

## 4.2. Description of Sampling Events

A total of 17 sets of baseline stream samples were collected from the Licking River from the period between May 5, 1993 and August 31, 1993. As illustrated in Figure 2.6, this period contained higher flows during June with much lower flows during July. The sampling effort resulted in a total of 136 samples (8 samples per set) and 680 separate analyses (5 analyses per set). A summary of the various events is provided in Table 4.2. Detailed data summaries of each event are provided in Appendix A. Summary plots of both dissolved oxygen - DO (mg/l) and fecal coliform - FC (colonies/100 ml) for each event are provided in Appendix B.

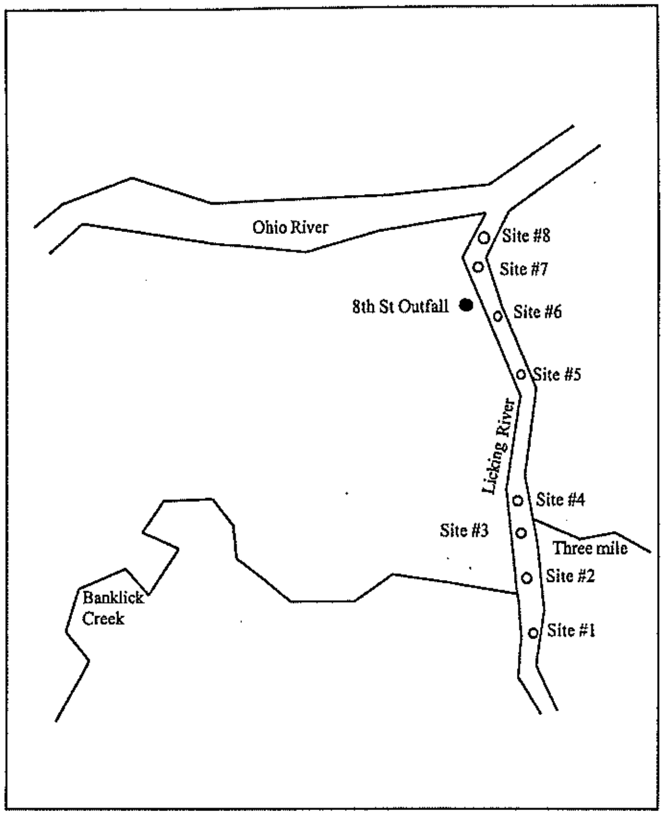


Figure 4.1 Map of 1993 Licking River Sampling Locations

Table 4.1 Description of Stream Sampling Locations

| Station Number | Description |
|---|---|
| 1 | Upstream of Banklick Creek |
| 2 | Downstream of Banklick Creek |
| 3 | Upstream of Three Mile Creek |
| 4 | Downstream of Three Mile Creek |
| 5 | Newport Steel |
| 6 | 12th Street |
| 7 | 4th Street |
| 8 | Confluence With Ohio River |

Table 4.2 Summary of 1993 Baseline Stream Sampling

| Event | Date | 24 hour * Antecedent Rainfall (inches) | Average Daily Streamflow (cfs) |
|---|---|---|---|
| 1 | 05/05/93 | 0.12 | 5531 |
| 2 | 05/21/93 | 0.01 | 1454 |
| 3 | 05/25/93 | 0.04 | 901 |
| 4 | 05/27/93 | 0.00 | 819 |
| 5 | 06/10/93 | 0.20 | 1425 |
| 6 | 06/16/93 | 0.00 | 12177 |
| 7 | 06/24/93 | 0.00 | 800 |
| 8 | 06/28/93 | 0.18 | 1207 |
| 9 | 06/30/93 | 0.05 | 858 |
| 10 | 07/08/93 | 0.00 | 738 |
| 11 | 07/23/93 | 0.00 | 285 |
| 12 | 07/27/93 | 0.00 | 154 |
| 13 | 07/29/93 | 0.00 | 253 |
| 14 | 08/20/93 | 0.10 | 2640 |
| 15 | 08/23/93 | 0.00 | 828 |
| 16 | 08/26/93 | 0.00 | 320 |
| 17 | 08/31/93 | 0.00 | 211 |

* Rainfall gage operated by University of Kentucky personnel, located at Covington water treatment plant.

## 4.3. Constituent Analysis

Generally, temperature (degrees Celsius), conductivity (ms/cm), pH, and DO (mg/l) were recorded for each sample at the time of collection using a Hydrolab H20 transmitter. Grab samples at each sample site were collected and analyzed for fecal coliform by Dr. David Lye of Northern Kentucky University. Average, maximum, and minimum values of DO (mg/l) and fecal coliform (colonies/100 ml) for all 8 sites for each sampling event are shown in Tables 4.2 and 4.3, respectively. Plots of the average DO and fecal coliform values at each sampling point are provided in Figures 4.2 and 4.3 for the following cases: 1) 10 dry weather events, 2) 7 wet weather events, and 3) 17 total events.

Table 4.3 DO Extremes for 1993 Licking River Samples

| Date | Average DO (mg/l) | Maximum DO (mg/l) | Minimum DO (mg/l) |
|---|---|---|---|
| 05/05/93 | 7.82 | 8.80 | 7.03 |
| 05/21/93 | 8.45 | 8.90 | 7.73 |
| 05/25/93 | 8.93 | 9.20 | 8.73 |
| 05/27/93 | 8.47 | 8.95 | 8.18 |
| 06/10/93 | 7.31 | 7.50 | 7.08 |
| 06/16/93 | 5.62 | 5.90 | 5.50 |
| 06/24/93 | 7.06 | 7.50 | 5.10 |
| 06/28/93 | 6.48 | 7.00 | 5.60 |
| 06/30/93 | 6.89 | 7.25 | 6.53 |
| 07/08/93 | 6.29 | 6.90 | 5.79 |
| 07/23/93 | 5.49 | 7.30 | 3.58 |
| 07/27/93 | 6.23 | 9.00 | 4.49 |
| 07/29/93 | 5.70 | 7.20 | 4.26 |
| 08/20/93 | 6.91 | 7.10 | 6.70 |
| 08/23/93 | 7.51 | 7.67 | 7.30 |
| 08/26/93 | 8.60 | 10.70 | 7.00 |
| 08/31/93 | 8.23 | 9.42 | 7.00 |
| Average: | 7.18 | 8.02 | 6.33 |

Table 4.4 FC Extremes for 1993 Licking River Samples

| Date | Average FC (c/100 ml) | Maximum FC (c/100 ml) | Minimum FC (c/100 ml) |
|---|---|---|---|
| 05/05/93 | 5250 | 8000 | 400 |
| 05/21/93 | 3700 | 17000 | 100 |
| 05/25/93 | 734 | 1600 | 30 |
| 05/27/93 | 740 | 3200 | 10 |
| 06/10/93 | 1700 | 3400 | 600 |
| 06/16/93 | 16000 | 30000 | 3300 |
| 06/24/93 | 14400 | 105000 | 900 |
| 06/28/93 | 1800 | 4400 | 310 |
| 06/30/93 | 10000 | 32000 | 500 |
| 07/08/93 | 8200 | 40000 | 190 |
| 07/23/93 | 3000 | 14000 | 20 |
| 07/27/93 | 2400 | 10000 | 30 |
| 07/29/93 | 970 | 5100 | 70 |
| 08/20/93 | 3200 | 7600 | 600 |
| 08/23/93 | 310 | 1100 | 60 |
| 08/26/93 | 7400 | 13900 | 10 |
| 08/31/93 | 1700 | 6300 | 90 |
| Average: | 4800 | 17800 | 425 |

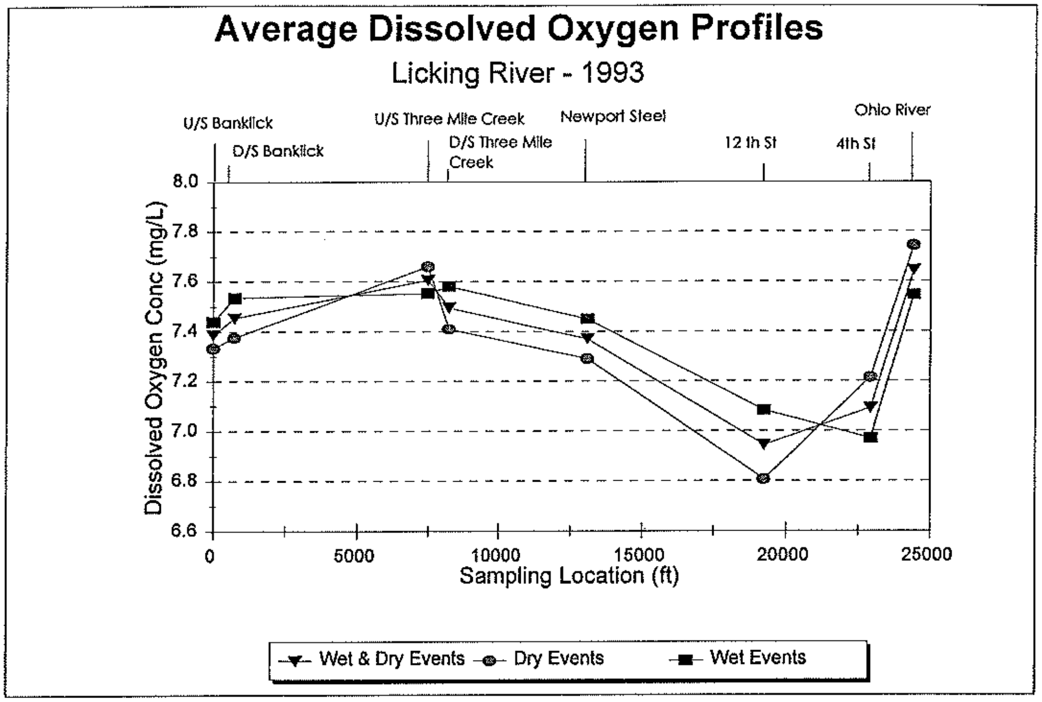


Figure 4.2 Average DO (mg/l) Levels at Each Sampling Location

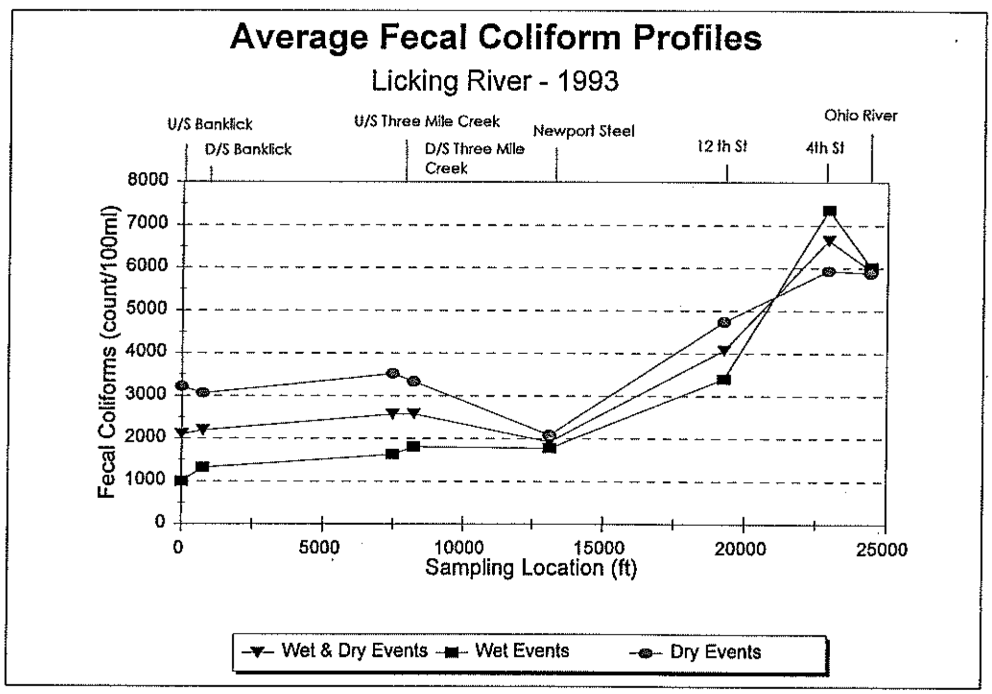


Figure 4.3 Average Fecal Coliform Values (c/100 ml) at Each Sampling Location

## 4.4. Discussion

As can be seen from Table 4.3, the measured DO values vary from 4.5 mg/l to 10.7 mg/l with an average value of 7.2 mg/l. In only two instances did the DO values fall below the minimum of 5.0 mg/l. As a result, it would appear that the CSO discharges did not cause significant impairment of the dissolved oxygen levels. An examination of Figure 4.2 reveals that, in general, the Licking River had slightly higher average DO readings during wet events as opposed to dry events. It may be speculated that this is due to increased aeration that may result during storm events. This would appear to be confirmed by the slight increase in dissolved oxygen as a result of the inflows from both Banklick Creek and Three Mile Creek. As can be seen from the figure, a significant decrease in dissolved oxygen is apparent between Three Mile Creek and 4th Street, while a corresponding increase is observed between 4th Street and the Ohio River. It is assumed that the decrease is attributable to the increased loadings along the reach. The increased levels of dissolved oxygen between 4th Street and the Ohio River may be attributable to DO recovery or due to backwater effects from the Ohio River.

As can be seen from Table 4.4, the measured fecal values vary from a minimum of 10 c/100 ml to a maximum of 400,000 c/100 ml with an average value of 3400 c/100 ml. The average values for each day varied between 310 c/100 ml and 16,000 c/100 ml indicating significant bacteriological pollution. Somewhat surprisingly, an examination of Figure 4.3 reveals that the fecal contamination is generally more severe for dry events than wet events. This may be attributable to the lack of significant dilution during the dry events and/or the occurence of dry weather CSOs or the occurence of discharges from broken sanitary sewers.

The main exception to this trend is the reach between 12th Street and 4th Street, which contains the 8th Street outfall. In general, fecal coliform averages gradually increase downstream, thus indicating an increase in fecal loadings. The observed decrease at the confluence with the Ohio River is assumed to be due to dilution effects of the Ohio River. Dry weather dishcarges were observed from both the Eigth Street outfall and from CSOs along Banklick Creek. On at least one occasion, a dry weather discharge was observed from a hole in the bank of Banklick Creek. On two other occasions, a red plume was observed to occur in the Licking River just upstream of the Eighth Street outfall.

In summary, although the dissolved oxygen levels along the Licking River do show a uniform drop between Three Mile Creek and the 12th Street Bridge, the average values still remain above a minimum value of 5 mg/l. Thus, although the dissolved oxygen levels are being impaired, the impact does not appear to be severe. Conversely, the same reach of the Licking River does contain significant increases in levels of fecal contamination. Given the high degree of urbanization in this area, it is logically assumed that the source of this increase is from both wet and dry weather discharges from CSOs.

# V. 1994 STREAM SAMPLING

## 5.1. Random Baseline Samples

During the spring and summer of 1994, 10 separate random sets of baseline samples of the Licking River were collected in conjunction with Division of Water personnel to assess the general condition of the river. The stream sampling locations for this effort are shown in Figure 5.1. A description of each sample location is provided in Table 5.1. Each stream sample was collected from the stream using a Division of Water boat. Separate grab samples were taken for fecal coliform and fecal strep analysis, as well as for solids analysis and BOD analysis. A Hydrolab H20 transmitter was used to obtain measured values of dissolved oxygen, temperature, conductivity, and pH.

## 5.2. Description of Sampling Events

A total of 10 sets of baseline stream samples were collected from the Licking River from the period between June 7, 1994, and July 28, 1994. As noted from Figure 2.7, this period corresponded to the time of lowest summer streamflow. Based on the results of 1993, it was anticipated that this would correspond to the period of the most significant levels of pollution. The sampling effort resulted in a total of 80 samples (8 samples per set) and 640 separate analyses (8 analyses per set). A summary of the various events is provided in Table 5.2. Detailed data summaries of each event are provided in Appendix C. Summary plots of dissolved oxygen, BOD, fecal coliform, fecal strep, total suspended solids and volatile suspended solids are provided in Appendix D.

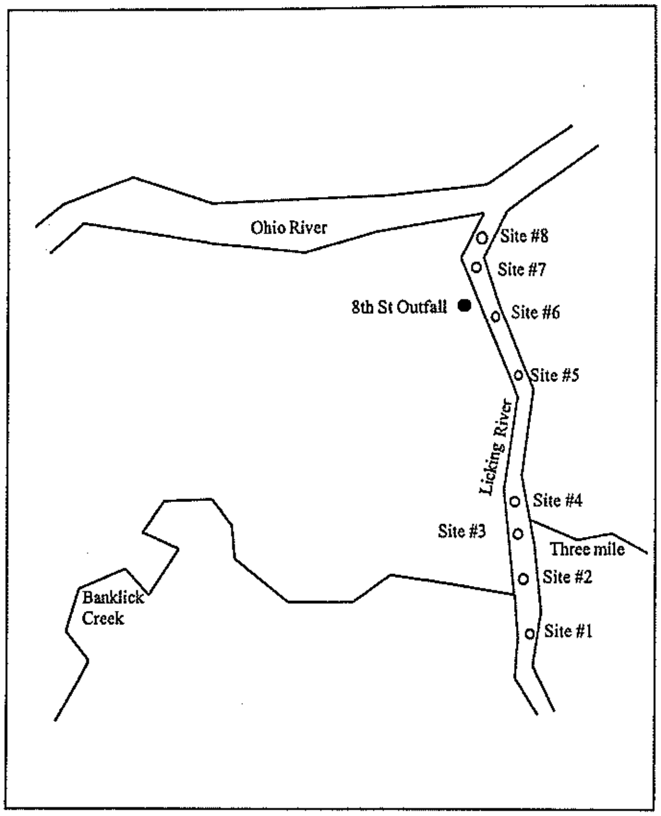


Figure 5.1 Map of 1994 Licking River Sampling Locations

Table 5.1 Description of Stream Sampling Locations

| Station Number | Description |
|---|---|
| 1 | Upstream of Banklick Creek |
| 2 | Downstream of Banklick Creek |
| 3 | Upstream of Three Mile Creek |
| 4 | Downstream of Three Mile Creek |
| 5 | Newport Steel |
| 6 | 12th Street |
| 7 | 4th Street |
| 8 | Confluence With Ohio River |

Table 5.2 Summary of 1994 Baseline Stream Sampling

| Event | Date | 24 hour * Antecedent Rainfall (inches) | Average Daily Streamflow (cfs) |
|---|---|---|---|
| 1 | 06/07/94 | 0.20 | 335 |
| 2 | 06/09/94 | 0.00 | 528 |
| 3 | 06/14/94 | 0.00 | 776 |
| 4 | 06/16/94 | 0.01 | 569 |
| 5 | 06/21/94 | 0.16 | 342 |
| 6 | 06/27/94 | 0.00 | 302 |
| 7 | 07/02/94 | 0.07 | 314 |
| 8 | 07/06/94 | 0.20 | 1549 |
| 9 | 07/14/95 | 0.05 | 672 |
| 10 | 07/28/94 | 0.00 | 723 |

* Rainfall gage operated by University of Kentucky personnel, located at the Covington water treatment plant

## 5.3. Constituent Analysis

Generally, temperature (degrees Celsius), conductivity (ms/cm), pH, and DO (mg/L) were recorded for each sample at the time of collection using a Hydrolab H20 transmitter. Laboratory analyses usually included fecal coliform, fecal streptococcus, biochemical oxygen demand, total suspended solids, and volatile suspended solids. These parameters were selected in order to best depict the influence of CSOs on the water quality of receiving streams. All fecal coliform and fecal streptococcus samples were analyzed by Dr. David Lye of the Northern Kentucky University, while both BOD and solids samples were analyzed in the water quality laboratory of the University of Kentucky. Average, maximum, and minimum values of DO, BOD, fecal coliform, fecal strep, total suspended solids, and volatile suspended solids for all 8 samples for each event are shown in Tables 5.3-5.8, respectively.

Table 5.3 DO Extremes for 1994 Licking River Samples

| Date | Average (mg/l) | Maximum (mg/l) | Minimum (mg/l) |
|---|---|---|---|
| 06/07/94 | 14.0 | 15.1 | 12.1 |
| 06/14/94 | 8.3 | 8.6 | 8.1 |
| 06/16/94 | 7.4 | 8.3 | 6.6 |
| 06/21/94 | 7.0 | 8.4 | 5.8 |
| 06/27/94 | 4.7 | 6.3 | 3.5 |
| 07/02/94 | 7.7 | 9.8 | 5.6 |
| 07/06/94 | 11.0 | 12.0 | 9.4 |
| 07/14/94 | 9.4 | 11.7 | 7.6 |
| 07/28/94 | 6.5 | 7.1 | 6.1 |
| Average: | 8.4 | 9.7 | 7.2 |

Table 5.4 BOD Extremes for 1994 Licking River Samples

| Date | Average (mg/l) | Maximum (mg/l) | Minimum (mg/l) |
|---|---|---|---|
| 06/07/94 | 2.0 | 6.0 | 1.0 |
| 06/09/94 | 1.6 | 2.0 | 1.0 |
| 06/14/94 | 1.3 | 2.0 | 1.0 |
| 06/21/94 | 2.0 | 5.0 | 1.0 |
| 06/27/94 | 4.0 | 5.0 | 3.0 |
| 07/06/94 | 3.0 | 5.0 | 2.0 |
| 07/14/94 | 3.0 | 4.0 | 2.0 |
| 07/28/94 | 1.8 | 3.0 | 1.0 |
| Average: | 2.3 | 4.0 | 1.5 |

Table 5.5 Fecal Coliform Extremes (colonies/100 ml) for 1994 Licking River Samples

| Date | Average | Maximum | Minimum |
|---|---|---|---|
| 06/07/94 | 2250 | 8600 | 20 |
| 06/09/94 | 1000 | 4000 | 0 |
| 06/14/94 | 650 | 3000 | 48 |
| 06/16/94 | 180 | 480 | 36 |
| 06/21/94 | 860 | 3600 | 20 |
| 06/27/94 | 11000 | 26000 | 200 |
| 07/02/94 | 1320 | 3600 | 40 |
| 07/06/94 | 540 | 1200 | 20 |
| 07/14/94 | 1500 | 5600 | 80 |
| 07/28/94 | 75 | 420 | 6 |
| Average: | 1938 | 5650 | 47 |

Table 5.6 Fecal Strep Extremes (colonies/100 ml) for 1994 Licking River Samples

| Date | Average | Maximum | Minimum |
|---|---|---|---|
| 06/07/94 | 620 | 1360 | 60 |
| 06/09/94 | 28 | 100 | 0 |
| 06/14/94 | 40 | 100 | 4 |
| 06/16/94 | 200 | 1000 | 30 |
| 06/21/94 | 260 | 1000 | 10 |
| 06/27/94 | 6000 | 13200 | 1600 |
| 07/02/94 | 600 | 2200 | 100 |
| 07/06/94 | 120 | 320 | 2 |
| 07/14/94 | 800 | 2000 | 100 |
| 07/28/94 | 200 | 560 | 30 |
| Average: | 887 | 2184 | 194 |

Table 5.7 TSS Coliform Extremes for 1994 Licking River Samples

| Date | Average (mg/l) | Maximum (mg/l) | Minimum (mg/l) |
|---|---|---|---|
| 06/09/94 | 13.5 | 18.0 | 7.0 |
| 06/21/94 | 5.6 | 14.0 | 1.0 |
| 06/27/94 | 57.0 | 97.0 | 36.0 |
| 07/02/94 | 20.0 | 22.0 | 11.0 |
| 07/06/94 | 14.0 | 20.0 | 3.0 |
| 07/14/94 | 14.0 | 27.0 | 1.0 |
| 07/28/94 | 36.0 | 47.0 | 26.0 |
| Average: | 22.9 | 35.0 | 12.1 |

Table 5.8 VSS Extremes for 1994 Licking River Samples

| Date | Average (mg/l) | Maximum (mg/l) | Minimum (mg/l) |
|---|---|---|---|
| 06/09/94 | 8.0 | 39.0 | 2.0 |
| 06/21/94 | 1.2 | 5.0 | 0.0 |
| 06/27/94 | 11.5 | 22.0 | 5.0 |
| 07/02/94 | 6.5 | 11.0 | 5.0 |
| 07/06/94 | 5.2 | 7.0 | 0 |
| 07/14/94 | 5.0 | 7.0 | 0 |
| 07/28/94 | 4.0 | 5.0 | 3.0 |
| Average: | 5.9 | 13.7 | 2.1 |

Plots of the average DO, BOD, fecal coliform, fecal strep, TSS, and VSS values at each sampling point are provided in Figures 5.2-5.7 for the following cases: 1) 4 dry weather events, 2) 6 wet weather events, and 3) 10 total events.

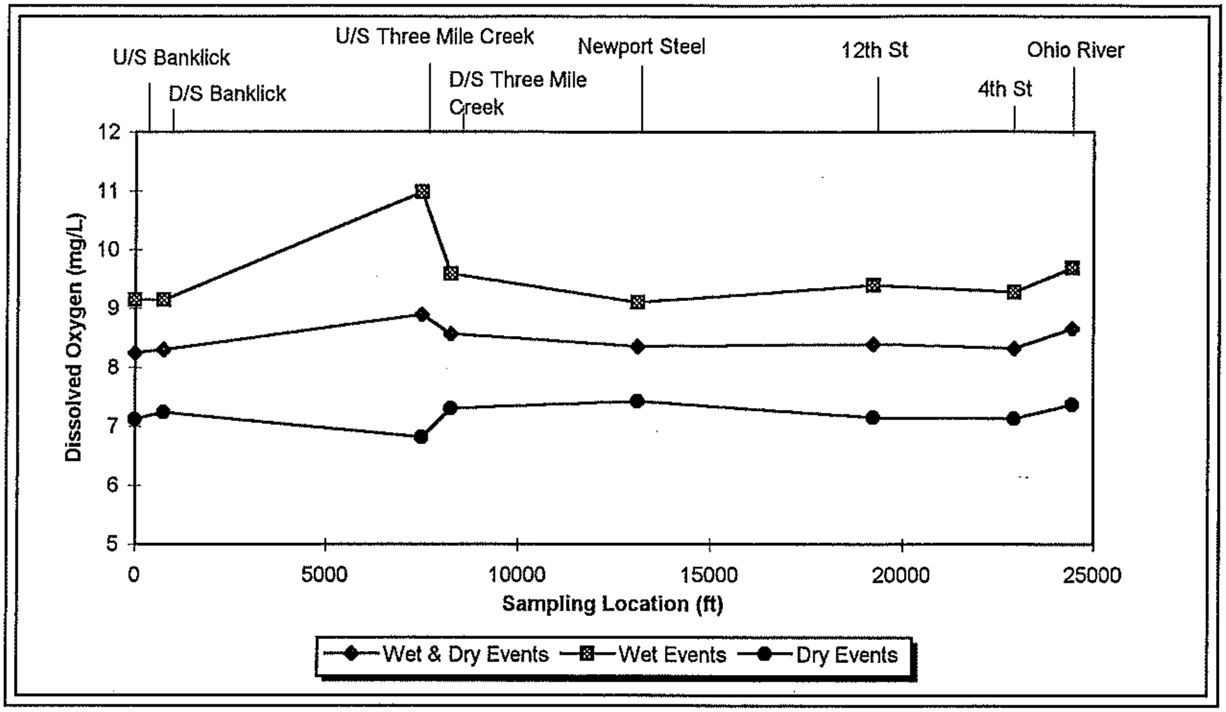


Figure 5.2 Average DO Levels (mg/l) at Each Sampling Location

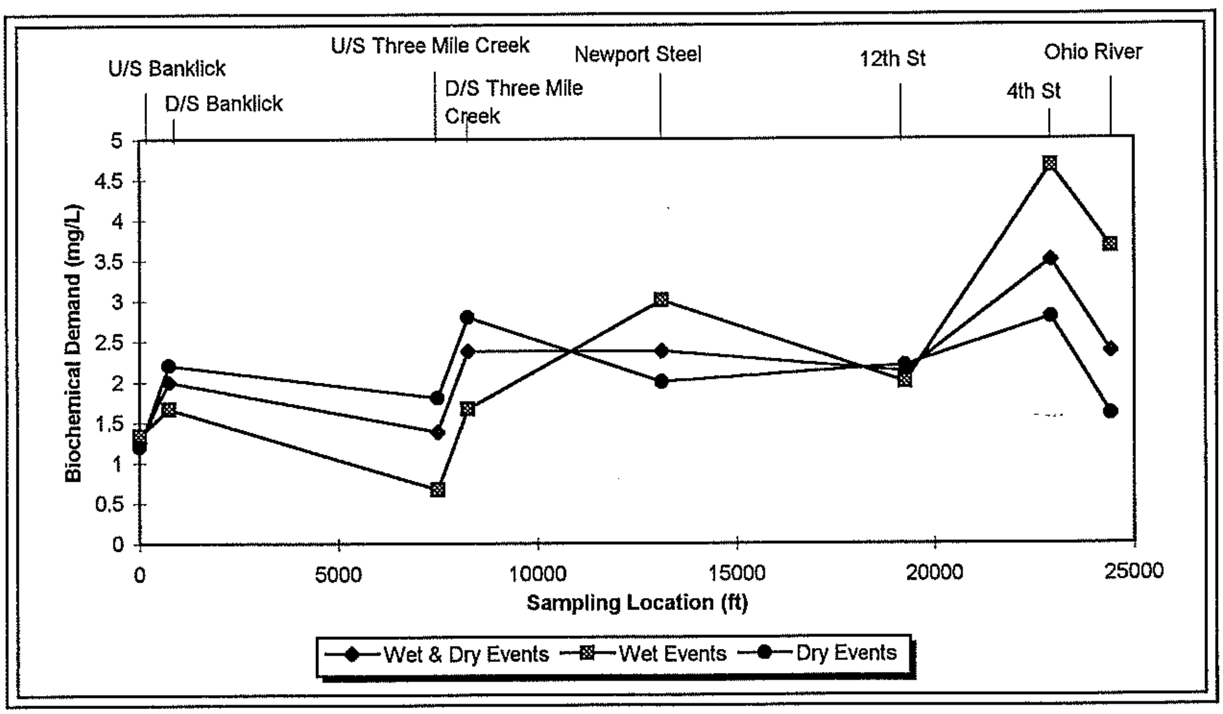


Figure 5.3 Average BOD Levels (mg/l) at Each Sampling Location

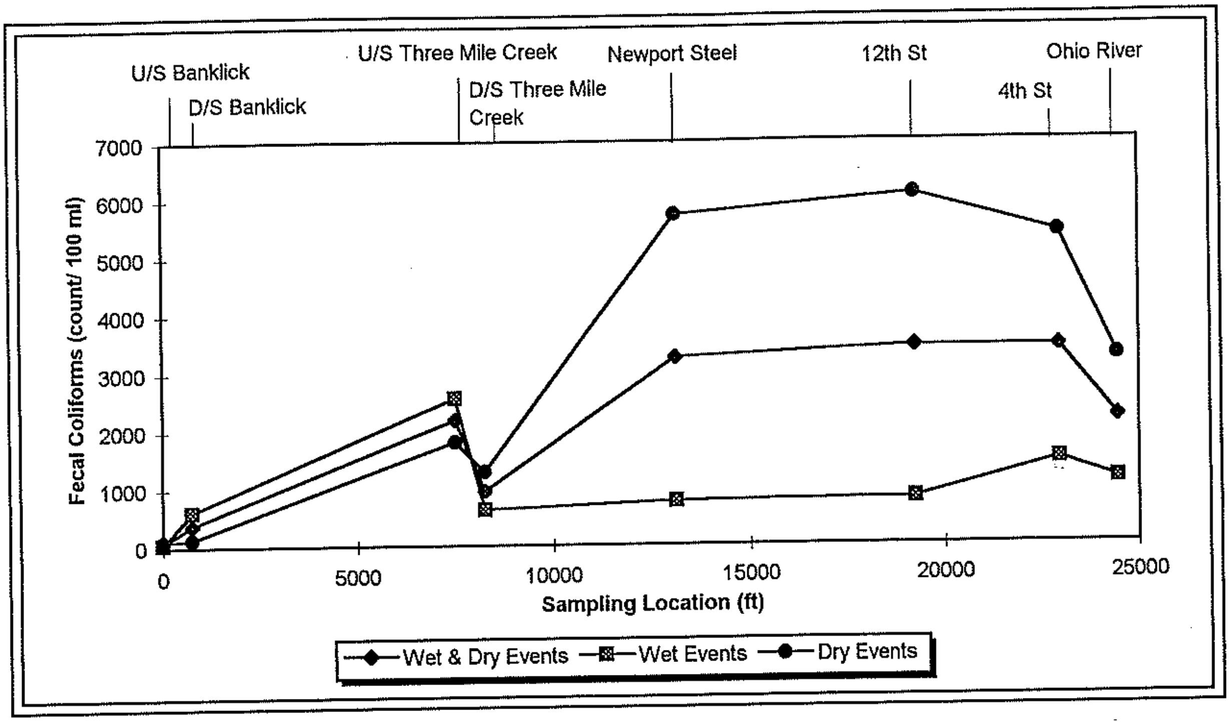


Figure 5.4 Average Fecal Coliform Counts (c/100 ml) at Each Sampling Location

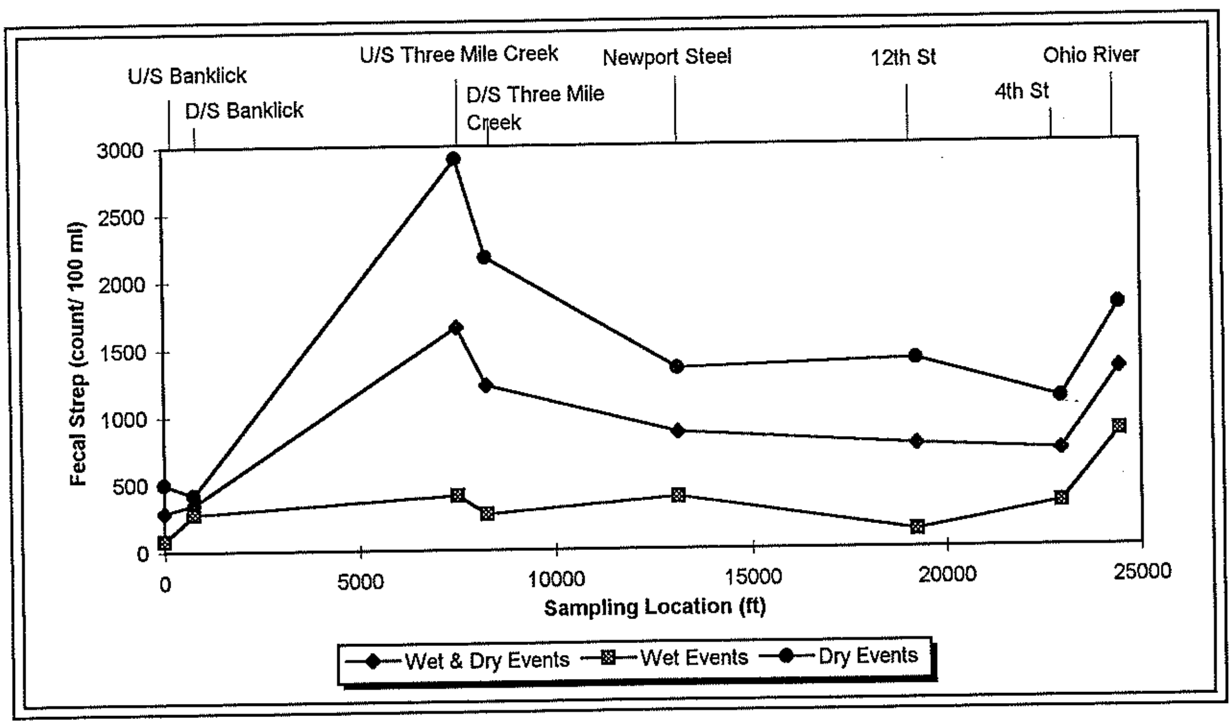


Figure 5.5 Average Fecal Strep Counts (c/100 ml) at Each Sampling Location

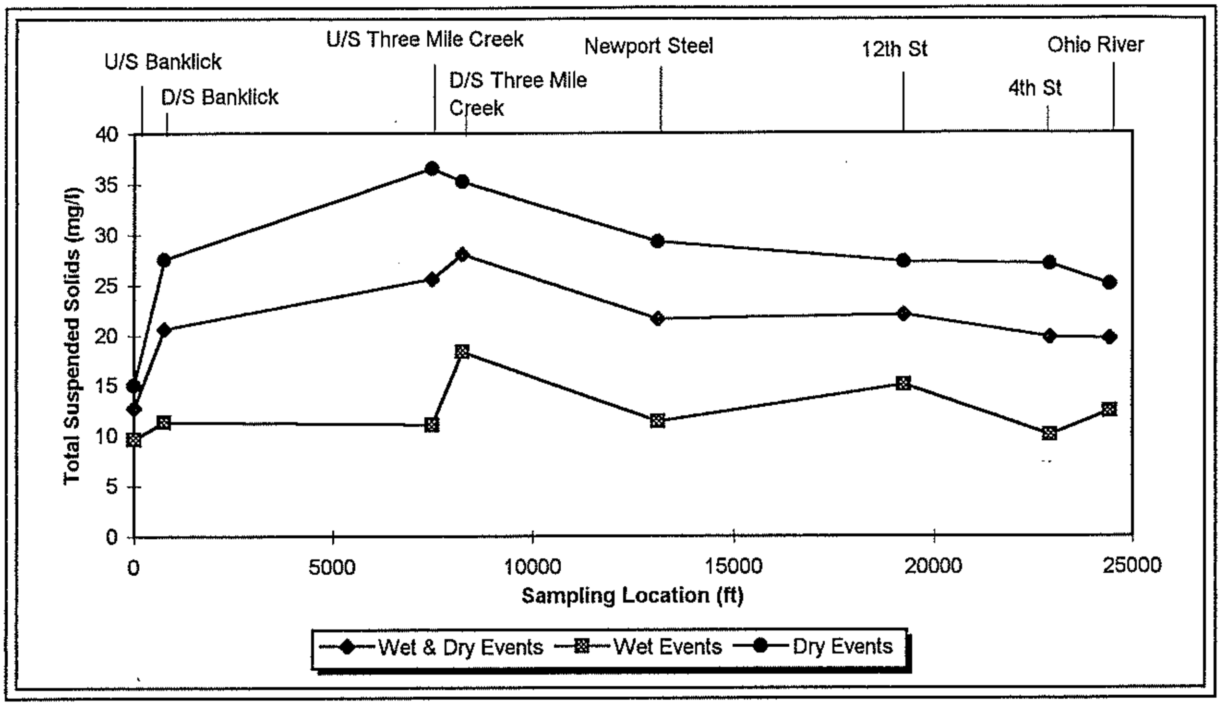


Figure 5.6 Average Total Suspended Solids (mg/l) at Each Sampling Location

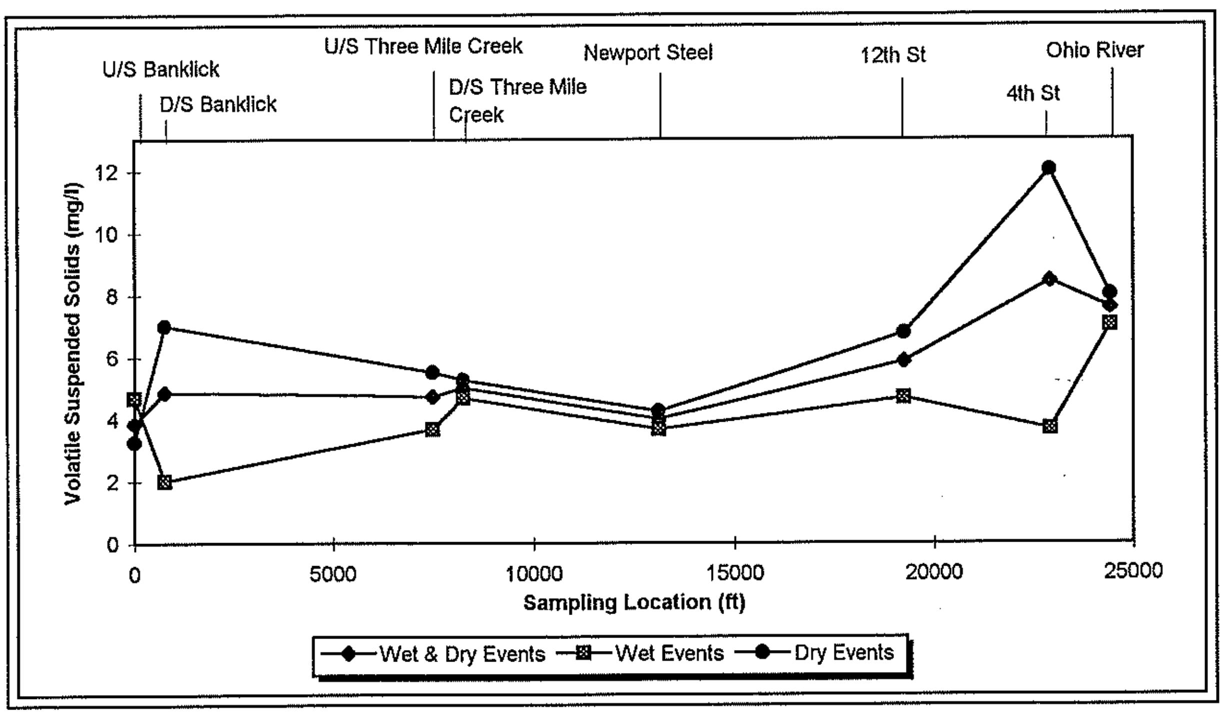


Figure 5.7 Average Volatile Suspended Solids (mg/l) at Each Sampling Location

As can be seen from Table 5.3, the measured dissolved oxygen values vary from a minimum of 3.6 mg/l to a maximum of 15.1 mg/l with an average value of 8.4 mg/l. In only one case did the DO values fall below a minimum of 5.0 mg/l. As a result, it would appear that the CSO discharges did not cause any significant impairment of the dissolved oxygen levels on the Licking River. An examination of Figure 5.2 reveals that the Licking River had higher average DO readings during wet events as opposed to dry events. This same trend was observed for the 1993 sample results as well. As before, it is speculated that this is due to increased aeration that may result during storm events.

As can be seen from Table 5.4, the measured BOD values vary from a minimum of 1 mg/l to a maximum of 6 mg/l with an average value of 2.3 mg/l. The average values for each day varied between 1.3 mg/l and 4.0 mg/l indicating that the BOD loadings on the Licking River are minimal. In general, no specific trends were identified that related wet and dry events to the resulting BOD loadings (see Figure 5.3), although in general, BOD loadings did increase downstream.

As can be seen from Table 5.5, the measured fecal values vary from a minimum of 0 to a maximum of 26,000 (c/100 ml) with an average value of 1942 (c/100 ml). The average values for each day varied between 75 (c/100 ml) and 11,000 (c/100 ml) indicating significant bacteriological pollution. As with the 1993 data, the fecal contamination is generally more severe for dry events than wet events (see Figure 5.4). This may be attributable to the lack of significant dilution during the dry events and the possible discharge of raw sewage during high river stages when the pumping stations along the Licking River were shut down. One point of interest was the significant drop in fecal levels downstream of Three Mile Creek. It is speculated that this decrease may be attributable to flow dilution. In any event, the fecal coliform concentrations increase from an average minimum of 100 (c/100 ml) upstream of Banklick Creek to an average maximum of 3300 (c/100 ml) at 4th Street, indicating significant fecal contamination in between. The observed drop in the observed values between 4th Street and the confluence of the Ohio River is again attributed to backwater mixing effects. The observed average 1994 increases in fecal contamination between Banklick Creek and 4th Street are thus seen to be very similar for those observed for 1993 (see Figure 4.4).

As can be seen from Table 5.6, the measured fecal strep values vary from a minimum of 0 (c/100 ml) to a maximum of 13,200 (c/100 ml) with an average value of 887 (c/100 ml). The average values for each day varied between 28 (c/100 ml) and 6,000 (c/100 ml) indicating significant bacteriological pollution. As with the fecal coliform data, the fecal strep contamination is higher for dry events than wet events (see Figures 5.4 and 5.5). In general, the ratio of fecal coliform to fecal strep varied between 2:1 to 3:1, indicating that the majority of the coliform loading could be attributed to domestic sewage.

As can be seen from Tables 5.7 and 5.8, the measured total and volatile suspended solids loadings vary from a minimum of 1.0 mg/l and 0.0 mg/l, respectively, to a maximum of 97.0 mg/l and 39.0 mg/l, respectively, with an average value of 23 mg/l for suspended solids and 6 mg/l for volatile suspended solids. The average values for each day varied between 5.6 mg/l and

As can be seen from Tables 5.7 and 5.8, the measured total and volatile suspended solids loadings vary from a minimum of 1.0 mg/l and 0.0 mg/l, respectively, to a maximum of 97.0 mg/l and 39.0 mg/l, respectively, with an average value of 23 mg/l for suspended solids and 6 mg/l for volatile suspended solids. The average values for each day varied between 5.6 mg/l and 57.0 mg/l for total suspended solids and between 1.2 mg/l and 11.5 mg/l for volatile suspended solids. While the average values for total suspended solids remained fairly constant along the study reach, the average volatile solids loadings increased, indicating that the majority of the additional pollutant loadings could be attributable to a domestic source (see Figures 5.6 and 5.7).

## 5.4. Sequential Baseline Samples

In addition to the 10 separate random sets of baseline samples discussed previously, four separate sets of stream samples were collected between August 19, 1994 and August 21, 1994. The sampling protocol for these baseline samples was the same as for the random samples. The 4 sequential baseline samples were collected immediately preceding and then following a rainfall event of 0.81 inches that occurred on August 21, 1994. The purpose of this sampling effort was to examine the effect of a rainfall on the river event over an extended period (i.e., 2 days).

A summary of the four events is provided in Table 5.9. Detailed data summaries of each event are provided in Appendix E. Summary plots of dissolved oxygen, BOD, fecal coliform, fecal strep, total suspended solids, and volatile suspended solids are provided in Appendix F. Average, maximum, and minimum values of DO, BOD, fecal coliform, fecal strep, total

Table 5.9. Summary of Licking River Sequential Stream Sampling

| Event | Date | Time | Average Daily Streamflow (cfs) |
|---|---|---|---|
| 1 | 08/19/94 | 6:00 pm | 388 |
| 2 | 08/20/94 | 5:00 pm | 333 |
| 3 | 08/21/94 | 2:00 pm | 419 |
| 4 | 08/21/94 | 6:00 pm | 419 |

Table 5.10 DO (mg/l) Extremes for 1994 Licking River Samples

| Date | Average | Maximum | Minimum |
|---|---|---|---|
| 08/19/94 | 11.6 | 15.0 | 9.0 |
| 08/20/94 | 10.6 | 13.5 | 9.0 |
| 08/21/94 | 9.0 | 10.6 | 8.0 |
| 08/21/94 | 10.8 | 12.1 | 10.0 |

Table 5.11 BOD (mg/l) Extremes for 1994 Licking River Samples

| Date | Average | Maximum | Minimum |
|---|---|---|---|
| 08/19/94 | 5.3 | 8.0 | 2.0 |
| 08/20/94 | 5.4 | 9.0 | 2.0 |
| 08/21/94 | 4.4 | 6.0 | 3.0 |
| 08/21/94 | 4.8 | 5.0 | 3.0 |

Table 5.12 Fecal Coliform Extremes (c/100 ml) for 1994 Licking River Samples

| Date | Average | Maximum | Minimum |
|---|---|---|---|
| 08/19/94 | 52.0 | 180.0 | 0.0 |
| 08/20/94 | 30.0 | 100.0 | 0.0 |
| 08/21/94 | 375.0 | 1480.0 | 2.0 |
| 08/21/94 | 30.0 | 166.0 | 0.0 |

Table 5.13 Fecal Strep Extremes (c/100 ml) for 1994 Licking River Samples

| Date | Average | Maximum | Minimum |
|---|---|---|---|
| 08/19/94 | 62.0 | 80.0 | 20.0 |
| 08/20/94 | 120.0 | 200.0 | 60.0 |
| 08/21/94 | 250.0 | 700.0 | 20.0 |
| 08/21/94 | 64.0 | 90.0 | 30.0 |

Table 5.14 TSS Extremes (mg/l) for 1994 Licking River Samples

| Date | Average | Maximum | Minimum |
|---|---|---|---|
| 08/19/94 | 11.5 | 16.0 | 1.0 |
| 08/20/94 | 16.5 | 22.0 | 11.0 |
| 08/21/94 | 15.0 | 20.0 | 9.0 |
| 08/21/94 | 13.5 | 17.0 | 8.0 |

Table 5.15 VSS Extremes (mg/l) for 1994 Licking River Samples

| Date | Average | Maximum | Minimum |
|---|---|---|---|
| 08/19/94 | 3.8 | 5.0 | 1.0 |
| 08/20/94 | 2.0 | 6.0 | 0.0 |
| 08/21/94 | 5.5 | 6.0 | 3.0 |
| 08/21/94 | 4.4 | 5.0 | 4.0 |

## 5.5 Discussion

While the BOD loadings on the Licking River did not show any significant impacts as a result of the storm event, the dissolved oxygen levels did experience a uniform drop of approximately 1 mg/l between 8/19 and 8/20 and then again between 8/20 and 8/21 (2:00 pm).

5.5 Discussion

While the BOD loadings on the Licking River did not show any significant impacts as a result of the storm event, the dissolved oxygen levels did experience a uniform drop of approximately 1 mg/l between 8/19 and 8/20 and then again between 8/20 and 8/21 (2:00 pm). This was followed by a uniform dissolved oxygen recovery of approximately 1 mg/l at 6:00 pm on August 21 (see Figure F.1). Fecal coliform results were somewhat inconclusive due to some problems in processing the data for August 21. However, for those sites at which samples were available, the maximum fecal counts tended to increase on August 21 at 2:00 pm followed by a drop at 6:00 pm. In general, the fecal strep values followed a similar pattern. While the total suspended solids concentrations remained fairly constant before and after the storm event, the volatile suspended solids concentrations showed a significant increase following the storm event, which is indicative of domestic sewage contamination.

# VI. LICKING RIVER CSO SAMPLING

The CSO impact assessment of the Licking River was accomplished by sampling from the largest CSO outfall (i.e., the Eighth Street outfall of the Covington side of the Licking River), along with stream samples upstream and downstream of the outfall.

## 6.1. Location of CSO Sample Sites

To determine a set of CSO sampling sites, all CSOs were first identified on available sewer maps and then verified in the field. Originally, it was planned to instrument several CSOs along the bank of the Licking River for automated sampling. Unfortunately, this plan had to be abandoned because of several problems that prevented the effective and safe instrumentation of these sites. Instead, a single CSO site (i.e., the Eighth Street CSO) was finally used. In the end, the Eighth Street outfall was chosen because of its size (it is the largest CSO on the Licking River), ease of access, and location between the Fourth Street Bridge and the Twelfth Street Bridge (which were originally to be used as platforms for upstream and downstream sampling). Because of the inability to instrument an automatic sampler upstream of the outfall location, samples from the Eighth Street CSO were taken directly from the discharge point. A map illustrating the location of the Eighth Street outfall is shown in Figure 6.1.

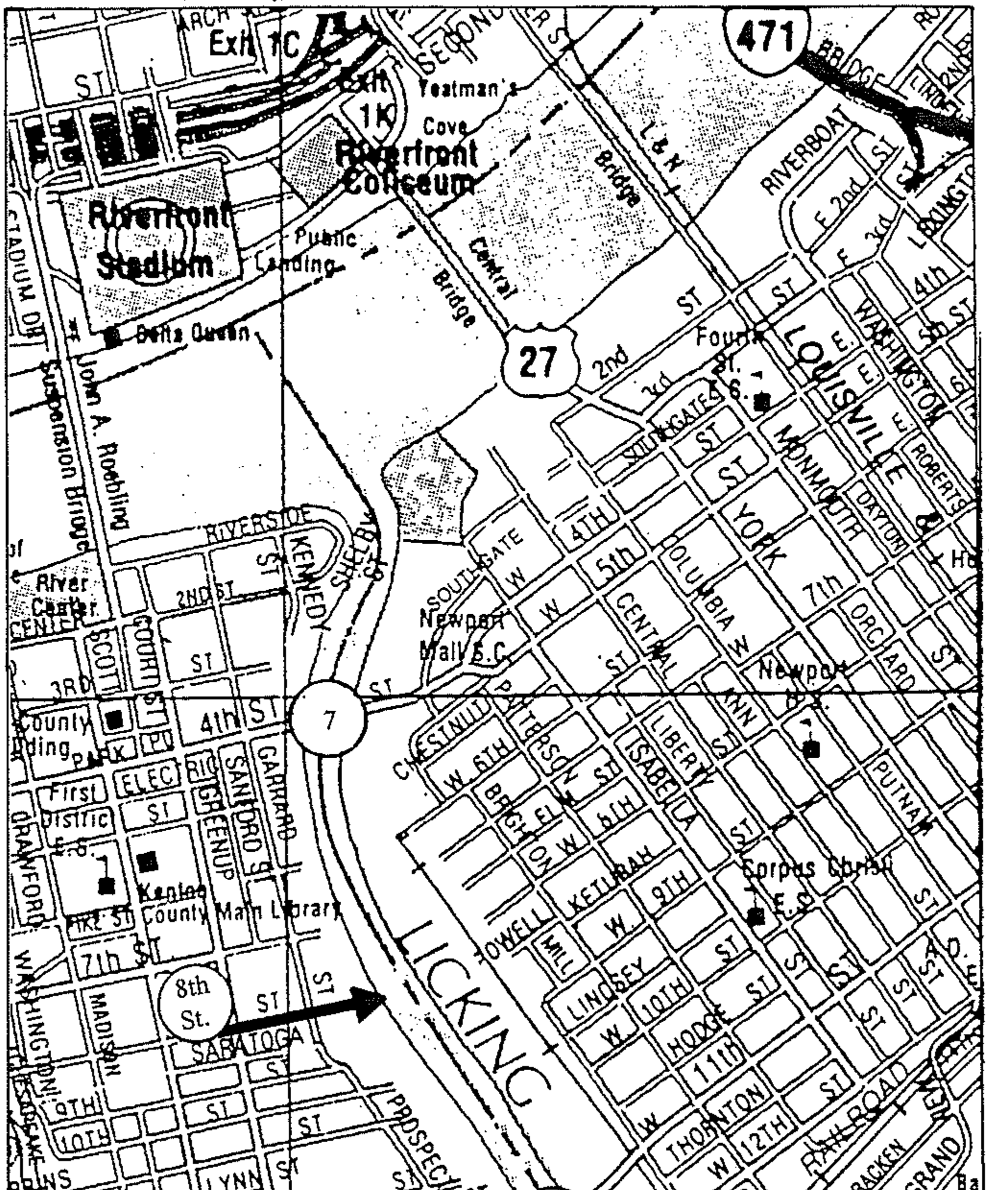


Figure 6.1 Map of Eighth Street Outfall

## 6.2. Location of CSO Impact Stream Sampling Sites

Following the decision to sample from the Eighth Street CSO, a decision was made to obtain multi-cross-sectional stream samples from the Licking River directly above and below the Eighth Street outfall by sampling from both the Fourth Street Bridge and the Twelfth Street Bridge. This plan had to be abandoned because of both logistic and safety concerns. Instead, a decision was made to perform the associated stream sampling using a boat.

## 6.3. CSO Sampling Equipment

The CSO sampling at the Eighth Street CSO was performed using an ISCO Model 3700 Portable Sampler that was transported to the site via a Division of Water boat immediately preceding a storm event. The sampler was configured to collected 850 ml of sample every 15 minutes for the first 4 hours of an overflow. The samples collected during each hour were combined into a single composite sample for subsequent laboratory analyses.

## 6.4. Stream Sampling Equipment

Each stream sample was collected directly from the stream using a Division of Water boat. Separate grab samples were taken for Fecal and Fecal Strep analysis, as well as for Solids analysis and BOD analysis. A Hydrolab H20 transmitter was used to obtain measured values of dissolved oxygen, temperature, conductivity, and pH.

## 6.5. Sampling Protocol

Depending on the probability of rain in sampling area, the sampling team would assemble in Lexington, and then drive to the EPA state office in Florence, Kentucky. Upon arrival in Florence, the team would collect the necessary equipment and then proceed to the Licking River. Once on the Licking River, the team would proceed to the Eighth Street CSO site where the automatic sampler would be setup and initialized. Following the initialization of the sampler, the team would proceed with the collection of a series of baseline samples from the Licking River using the boat. Depending upon the existing weather conditions, the baseline samples would be immediately transported for fecal analysis or held in an ice bath for later transport. Following the collection of the baseline samples, the team would then wait for the occurrence of an overflow event at the Eighth Street outfall. When an overflow event occurred, the team would then proceed to collect a second series of stream samples along with the CSO samples collected by the automatic sampler. Following the collection of the CSO event samples, the team would then transport the fecal samples to Northern Kentucky University for analysis by Dr. Dennis Lye, and the remaining samples to the University of Kentucky for subsequent BOD and solids analysis.

## 6.6. Analysis of Samples

Generally, temperature (degrees Celsius), conductivity (ms/cm), pH, and DO (mg/L) were recorded for each sample at the time of collection using a Hydrolab H20 transmitter. Laboratory analyses usually included fecal coliform, fecal streptococcus, biochemical oxygen demand, total demand, total suspended solids, and volatile suspended solids. These parameters were selected to best depict the influence of CSOs on the water quality of receiving streams. Scans for priority pollutants were conducted on samples obtained from the Eighth Street CSO on three separate occasions. All fecal coliform and fecal streptococcus samples were analyzed by Dr. David Lye of Northern Kentucky University, while both BOD and solids samples were analyzed in the water quality laboratory at the University of Kentucky. Each priority pollutant analysis was performed by Commonwealth Technology Inc. of Lexington, Kentucky.

## 6.7. Description of Samples

Four separate CSO events were observed and sampled during the summer of 1994. All four events occurred from the Eighth Street outfall sewer as discussed previously. The results of each event are summarized in the following sections.

### 6.7.1. Event 1: June 23, 1994

The first CSO event occurred on June 23, 1994 in response to a rainfall of .43 inches. The CSO discharge continued for approximately 30 minutes and resulted in the collection of two separate CSO samples. In addition to the CSO samples, more stream samples were collected immediately upstream and downstream of the CSO at stream sampling sites 6 and 7, respectively (see Figure 6.1). The average streamflow on that day was 294 cfs. A summary of the results are shown in Table 6.1. As can be seen from the table, BOD, total suspended solids loadings, and fecal coliform counts for the CSO discharge are all above the state monthly average maximum municipal discharge values of 30 mg/l, 30 mg/l, and 200 colonies/100 ml, The parameter with the highest level of exceedance is obviously fecal coliform. While the impact of wet weather impacts is clearly apparent from the table, somewhat surprisingly, the fecal coliform and total suspended solids loadings are higher upstream of the Eighth Street outfall. These values may be attributed to the loadings from upstream CSOs or due to observed backwater conditions on the Licking River.

### 6.7.2. Event 2: June 24, 1994

The second CSO event occurred on June 24, 1994 in response to a rainfall of 0.10 inches. The CSO discharge continued for approximately 1 hour and resulted in the collection of two separate CSO samples. In addition to the CSO samples, more stream samples were collected immediately upstream and downstream of the CSO at stream sampling sites 6 and 7, respectively (see Figure 6.1). The average streamflow during the sampling effort was 281 cfs. A summary of the results are shown in Table 6.2. As can be seen from the table, both the BOD concentrations and the fecal coliform counts were well above the maximum levels for municipal discharges. Unfortunately, for this event, the CSO was already discharging when the team arrived at the site, and thus, initial baseline values were not obtained. However, this event occurred on the day following the previous collection effort for which values were presented. The fact that the observed stream values were worse than on June 23, may be attributable to the occurrence of a wet weather event on the preceding day. For the first set of samples, the impact of the CSO discharge was clearly observed. However, for the second set of samples, the downstream parameter values were slightly lower than the upstream values.

### 6.7.3. Event 3: July 7, 1994

The third CSO event occurred on July 7, 1994 in response to a rainfall of 0.2 inches. The CSO discharge continued for approximately 30 minutes and resulted in the collection of one CSO sample. In addition to the CSO sample, more stream samples were collected immediately upstream and downstream of the CSO at stream sampling sites 6 and 7, respectively (see Figure 6.1). The average streamflow was 245 cfs. A summary of the results are shown in Table 6.3. As can be seen from the table, the discharge from the CSO contained total suspended solids loadings and fecal counts well above the municipal discharge limits. While the downstream dissolved oxygen readings were worse than those upstream of the CSO, the BOD, TSS, and fecal coliform counts were all superior.

### 6.7.4. Event 4: July 8, 1994

The fourth CSO event occurred on July 8, 1994 in response to a rainfall of 0.02 inches. The CSO discharge continued for approximately 60 minutes and resulted in the collection of two CSO samples. In addition to the CSO samples, more stream samples were collected immediately upstream and downstream of the CSO at stream sampling sites 6 and 7, respectively (see Figure 6.1). The average streamflow was 219 cfs. A summary of the results are shown in Table 6.4. As before, the BOD, TSS, and fecal coliform counts associated with the CSO discharges were well above municipal discharge limits. Once again, significantly elevated levels of fecal coliform contamination were observed. The results from this sample provided a much clearer picture of the impacts of the CSO on both stream BOD and fecal coliform loadings.

Table 6.1. CSO and Stream Quality Parameters on June 23, 1994

| ID | Time | DO | BOD | FC | FS | TSS | VSS | TMP | CON |
|---|---|---|---|---|---|---|---|---|---|
| 6 | 1135 | 5.0 | 4 | 500 | 74 | 11 | 4 | 29 | 336 |
| 7 | 1130 | 5.2 | 4 | 720 | 108 | 18 | 10 | 29 | 363 |
| CSO | 1555 | 6.6 | 34 | 420,000 | ... | 104 | 54 | 28 | 190 |
| 6 | 1600 | 5.3 | 7 | 88,000 | ... | 23 | 5 | 29 | 319 |
| 7 | 1605 | 6.8 | 7 | 50,000 | ... | 16 | 8 | 29 | 363 |
| CSO | 1620 | 3.2 | 27 | 500,000 | ... | 33 | 3 | 26 | 304 |
| 6 | 1630 | 5.7 | 6 | 37,000 | ... | 37 | 9 | 29 | 340 |
| 7 | 1625 | 6.5 | 7 | 13,000 | ... | 22 | 6 | 29 | 358 |

Table 6.2. CSO and Stream Quality Parameters on June 24, 1994

| ID | Time | DO | BOD | FC | FS | TSS | VSS | TMP | CON |
|---|---|---|---|---|---|---|---|---|---|
| CSO | 1420 | 5.8 | 50 | 600,000 | 60,000 | ... | ... | 26 | 232 |
| 6 | 1455 | 4.4 | 2 | 2,400 | 440 | ... | ... | 28 | 365 |
| 7 | 1440 | 4.7 | 5 | 17,000 | 26,000 | ... | ... | 27 | 299 |
| CSO | 1530 | 6.7 | 16 | 280,000 | 22,000 | ... | ... | 25 | 229 |
| 6 | 1545 | 4.0 | 3 | 10,000 | 4,800 | ... | ... | 28 | 259 |
| 7 | 1540 | 3.5 | 2 | 9,600 | 3,200 | ... | ... | 28 | 365 |

Table 6.3. CSO and Stream Quality Parameters on July 7, 1994

| ID | Time | DO | BOD | FC | FS | TSS | VSS | TMP | CON |
|---|---|---|---|---|---|---|---|---|---|
| CSO | 1506 | 2.5 | 10 | 3,004,000 | 110,000 | 46 | 36 | 24 | 722 |
| 6 | 1514 | 12.8 | 1 | 5,200 | 100 | 12 | 5 | 31 | 363 |
| 7 | 1517 | 10.4 | 2 | 800 | 0 | 13 | 4 | 32 | 363 |

Note: Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Total Suspended Solids (TSS), and Volatile Suspended Solids (VSS) all measured in mg/l. Fecal coliform (FC) and fecal strep (FS) measured in colonies/100 ml. Temperature measured in degree celsius and conductivity (CON) measured in ms/cm.

Table 6.4. CSO and Stream Quality Parameters on July 8, 1994

| ID | Time | DO | BOD | FC | FS | TSS | VSS | TMP | CON |
|---|---|---|---|---|---|---|---|---|---|
| CSO | 1700 | 3.9 | 68 | 400,000 | 21,200 | 342 | 108 | 28 | 195 |
| 6 | 1720 | 11.9 | 7 | 700 | 300 | 25 | 6 | 29 | 385 |
| 7 | 1723 | 11.3 | 2 | 14,800 | 240 | 19 | 7 | 29 | 394 |
| 8 | 1727 | 12.5 | 1 | 700 | 240 | 20 | 7 | 29 | 405 |
| CSO | 1745 | 5.3 | 34 | 212,000 | 15,600 | 50 | 18 | 27 | 256 |
| 6 | 1802 | 8.1 | 7 | 780 | 180 | 17 | 11 | 29 | 390 |
| 7 | 1802 | 11.8 | 4 | 16,000 | 1,900 | 29 | 14 | 29 | 405 |
| 8 | 1811 | 10.9 | 2 | 600 | 380 | 20 | 6 | 29 | 409 |

## 6.8. Priority Pollutant Events

Three separate priority pollutant samples were collected during the study. Analyzed parameters included 1) total cyanide, 2) ammonia nitrogen, 3) phenols, 4) total phosphorus, 5) metals, 6) organic pesticide/herbicides, 7) organic pesticides/pcbs, 8) organic semivolatiles, and 9) organic volatiles. The results of each of the three samples are discussed in the following sections. The results of three scans indicate that significant concentrations of Priority Pollutants are not present in the CSO discharges entering the Licking River at least from the Eighth Street outfall during the sampling period.

### 6.8.1. June 9, 1993

The first sample was taken from the Eighth Street outfall on June 9, 1993. All parameter values that were measured above detectable limits are shown in Table 6.5. The complete set results of the analysis are provided in Appendix G.

Table 6.5 Priority Loadings for Eighth Street CSO (6/09/93)

| Parameter | Results (mg/l) |
|---|---|
| Cyanide | 0.004 mg/l |
| Nitrogen Ammonia | 1.500 mg/l |
| Oil & Grease | 15.000 mg/l |
| Phenols | 0.007 mg/l |
| Total Phosphorus | 1.100 mg/l |
| Total Copper | 0.022 mg/l |
| Total Lead | 0.039 mg/l |
| Total Silver | 0.013 mg/l |
| Total Zinc | 0.130 mg/l |

6.8.2. July 8, 1994

The second sample was taken at the Eighth Street outfall on July 8, 1994. All parameter values that were measured above detectable limits are shown in Table 6.6. The complete results are provided in Appendix G.

6.8.3. August 5, 1994

The third sample was taken at the Eighth Street outfall on August 5, 1994. All parameter values that were measured above detectable limits are shown in Table 6.7. The complete set of results of the analysis is provided in Appendix G.

Table 6.6 Priority Pollutant Loadings for Eighth Street (7/8/94)

| Parameter | Results (mg/l) |
|---|---|
| Cyanide | 0.004 mg/l |
| Nitrogen Ammonia | 5.400 mg/l |
| Oil & Grease | 26.00 mg/l |
| Phenols | 0.008 mg/l |
| Total Phosphorus | 2.600 mg/l |
| Total Cadmium | 0.003 mg/l |
| Total Chromium | 0.015 mg/l |
| Total Copper | 0.130 mg/l |
| Total Lead | 0.110 mg/l |
| Total Silver | 0.004 mg/l |
| Total Zinc | 0.220 mg/l |
| Bis-Phthalate | 0.003 mg/l |

Table 6.7 Priority Loadings for Eighth Street (8/5/94)

| Parameter | Results (mg/l) |
|---|---|
| Oil & Grease | 3.4 mg/l |
| Total Phosphorus | 0.17 mg/l |
| Toluene | 0.006 mg/l |

# VII. CORRELATION ANALYSES

Correlation analysis can provide an indication of the interdependence between two parameters. A strong correlation between parameters may imply similar sources or other related factors that deserve further examination. However, if a weak correlation, or no correlation is found where a strong one is expected, this requires investigation as well. It could mean that some previously ignored variable has significant impact on the water system and must be taken into consideration.

## 7.1. Rainfall/Fecal Coliform Relationships

To assess the impact of rainfall on fecal coliform loadings, a scattergram of rainfall volume and average fecal coliform counts was developed for all wet weather stream flow samples. The resulting relationship is shown in Figure 7.1. As can be seen from the figure, no explicit relationship was identified between the antecedent 24-hour rainfall and the resulting average fecal coliform loadings.

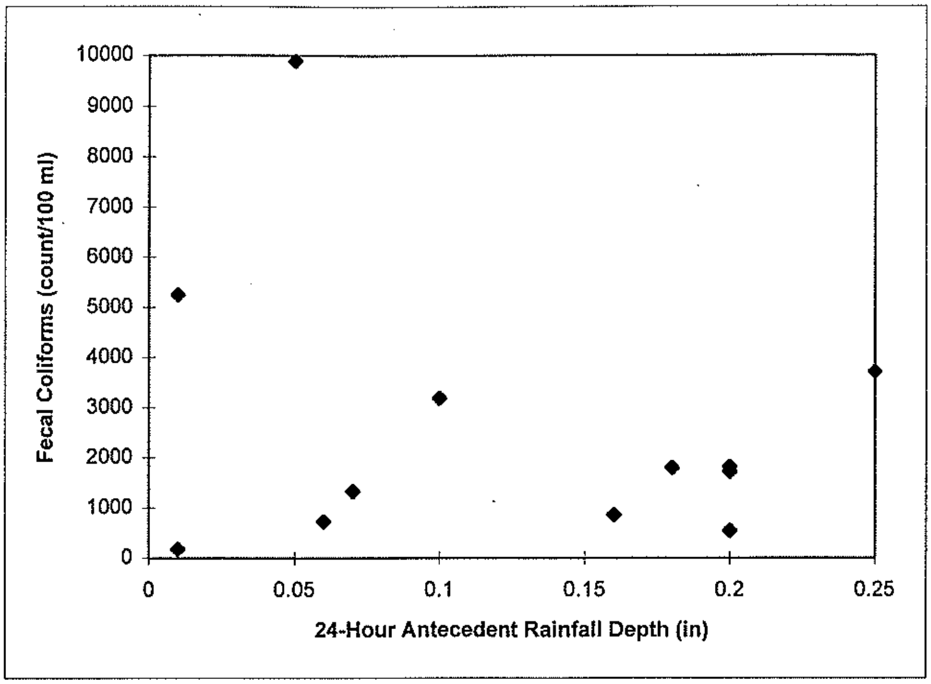


Figure 7.1 Scattergram of Rainfall Volume and Average Fecal Coliform Loadings

## 7.2. Flow/Fecal Coliform Relationships

To assess the impact of river flowrate on fecal concentrations loadings, scattergrams of average daily streamflow volume and average fecal coliform concentrations were developed for both dry weather and wet weather stream flow samples. The resulting relationships are shown in Figures 7.2 and 7.3. As can be seen from Figure 7.3, average fecal coliform concentrations do seem to increase with increasing streamflow, however, an explicit relationship is not readily observed. Conversely, no relationship is observed for the dry weather events. However, it does appear that the largest fecal coliform loadings are normally associated with dry weather events (and lower streamflows). This may be indicative of secondary pollutant sources, or the occurrence of dry weather discharges. In any event, it does appear that the most significant fecal contamination is associated with lower streamflow values.

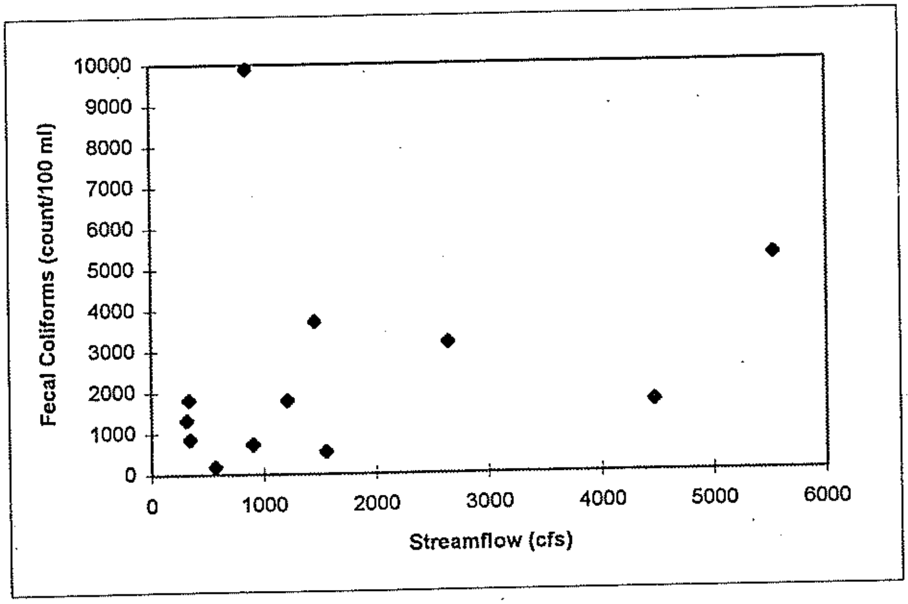


Figure 7.2 Scattergram of River Flow and Average Fecal Loadings for Wet Events

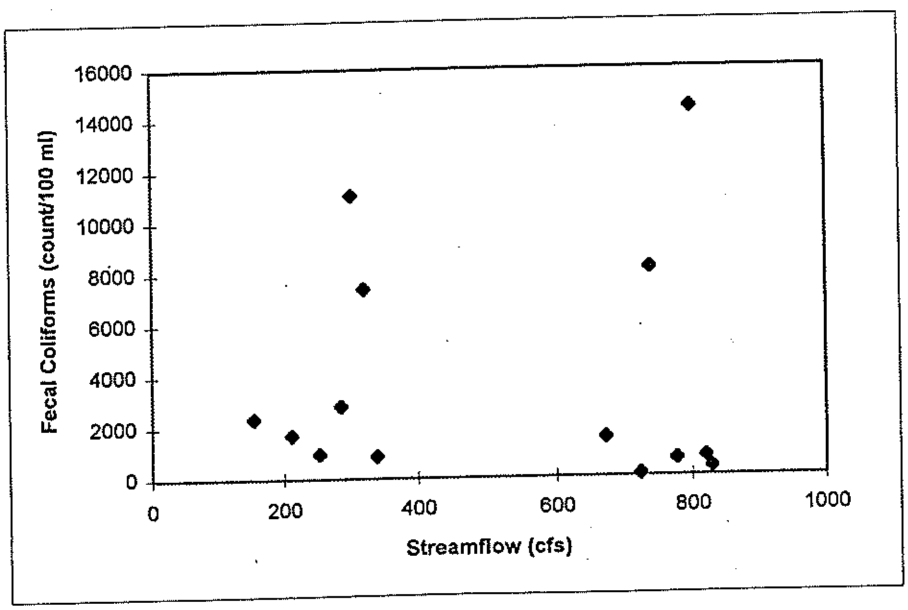


Figure 7.3 Scattergram of River Flow and Average Fecal Loadings for Dry Events

7.3. Flow/DO Relationships

The dissolved oxygen is normally directly related to the flowrate. This is because high flow has turbulent mixing that entrains air. Scattergrams of dissolved oxygen for both dry and wet weather events are provided in Figures 7.4 and 7.5. While the dissolved oxygen levels tended to increase with increasing streamflow values for the dry events, the dissolved oxygen for the wet events remained fairly constant around 7-8 mg/l.

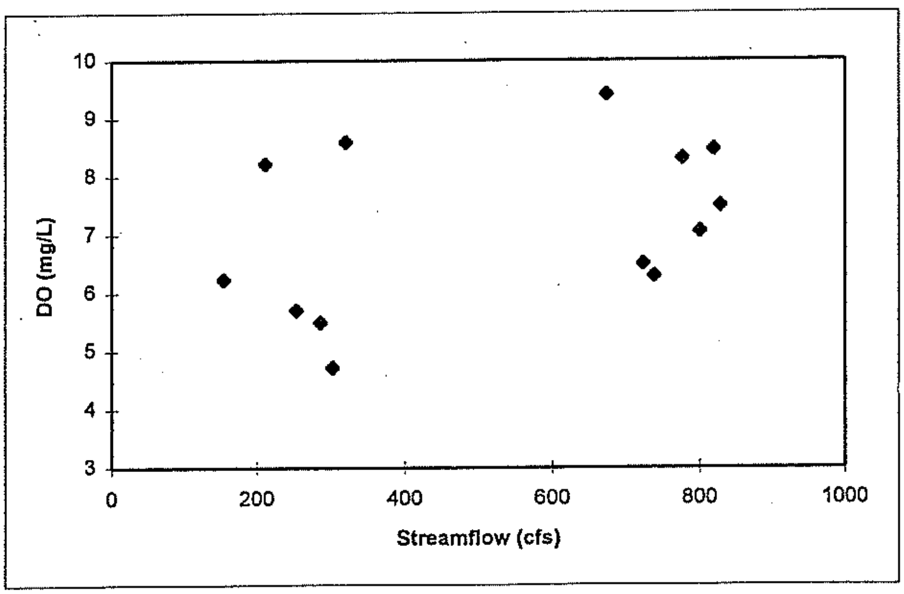


Figure 7.4 Scattergram of River Discharge and Dissolved Oxygen for Dry Weather Events

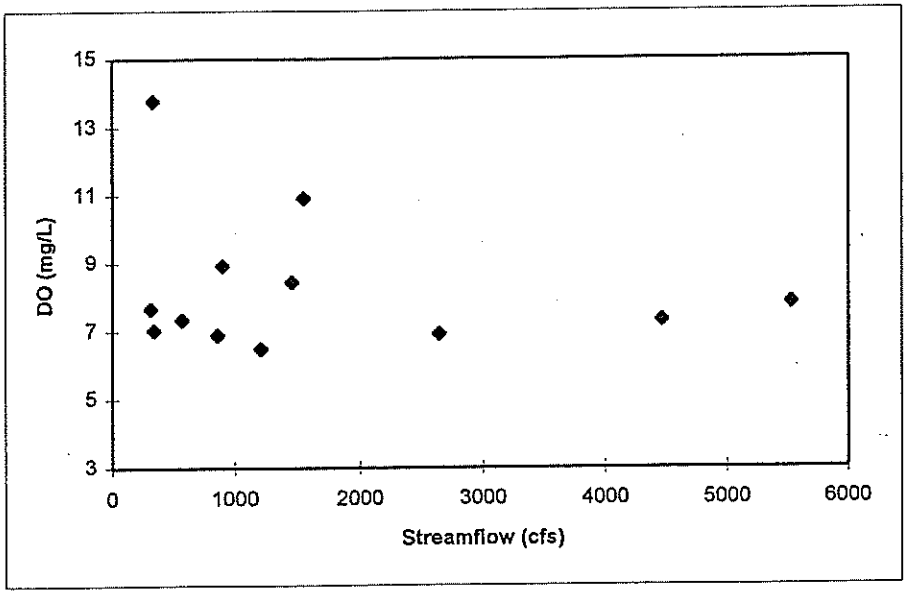


Figure 7.5 Scattergram of River Discharge and Dissolved Oxygen for Wet Weather Events

## 7.4. TSS/VSS Relationship

VSS represents the organic portion of TSS. Throughout the Licking River study the proportion of VSS to TSS tended to increase downstream with the majority of TSS being organic in nature. This indicates that the pollution has a consistent composition that is primarily organic. Domestic sewage discharges would fit this description. Scattergrams of VSS vs TSS for both dry and wet weather events are shown in Figures 7.6 and 7.7. Because of the limited number of TSS and VSS samples that were collected during 1994, any definitive relationship between the two parameters is difficult to establish. From the limited amount of data, it does appear that the ratio of TSS to VSS is around 3:1 for wet events and around 5:1 for dry events.

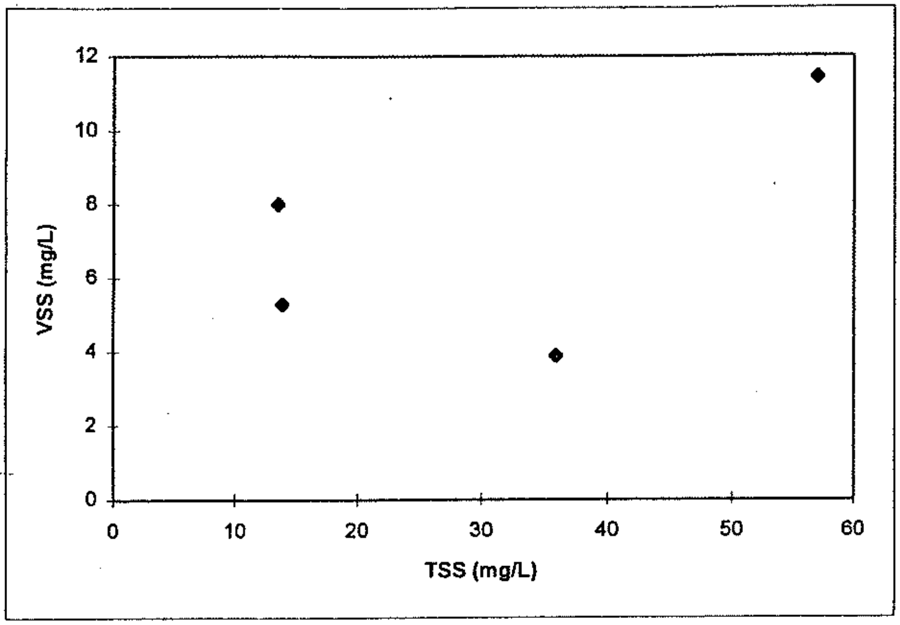


Figure 7.6 Scattergram of TSS vs VSS for Dry Weather Events

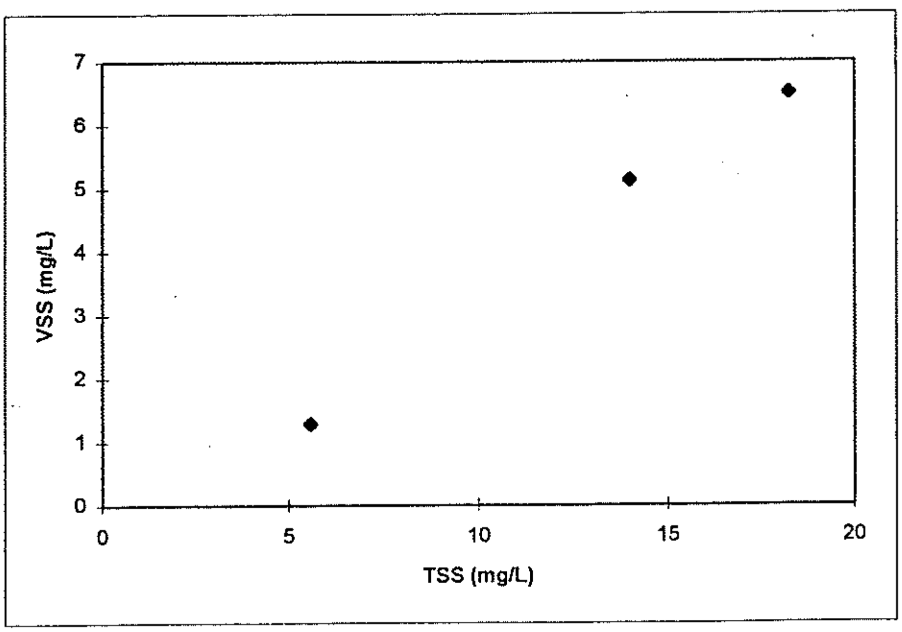


Figure 7.7 Scattergram of TSS vs VSS for Wet Weather Events

7.5. FC/FS Relationship

The FC/FS relationship is a useful one to study because the ratio of FC to FS is a good indicator of whether the pollutant source is from human or animal waste. A FC:FS ratio greater than four indicates that the source of bacteria is from human waste, while a FC:FS ratio less than one indicates that the origin is from animal waste. Scattergrams of FC vs FS for both dry weather and wet weather events are provided in Figures 7.8 and 7.9. As can be seen from the figures, the FC:FS ratio for dry events is approximately 2:1 while the ratio for wet events is approximately 3:1 thus indicating that the fecal contamination during wet events is more likely from domestic sewage. Such a result would be expected if the source of this contamination is from CSOs.

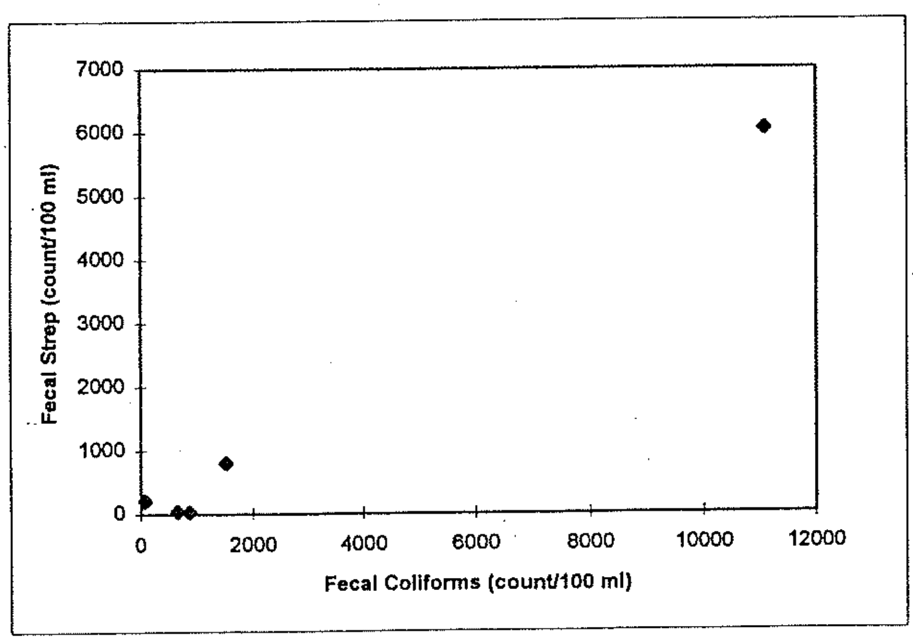


Figure 7.8 Scattergram of FC vs FS for Dry Weather Events

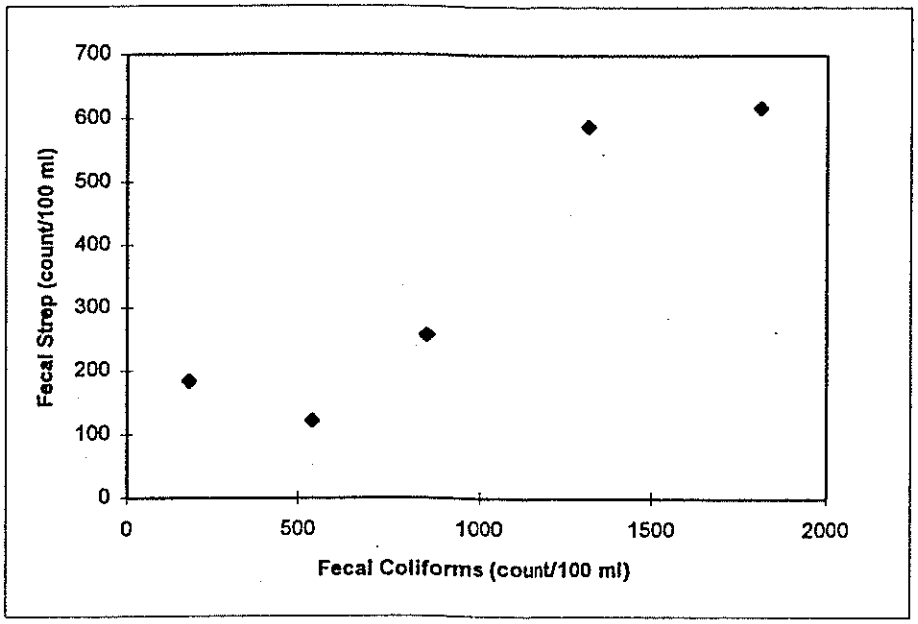


Figure 7.9 Scattergram of FC vs FS for Wet Weather Events

7.6. Data Interpretation

The correlations listed above can assist in data interpretation and predictions of water system response. Care must be taken, however, when evaluating data because failure to consider all variables involved can lead to incorrect conclusions. Such variables include masking effects of one parameter on another and differential flow within the system. Masking can be described as one parameter acting on another in such a manner that false conclusion can be drawn from the data. Examples of masking are:

- Various chemical constituents may inhibit microorganism growth. This will yield a low five day BOD test result, compared to the result if the chemical constituents were not present.

- Photosynthesis of aquatic plants can produce elevated DO levels, which would indicate a healthy water system. At night, those DO levels could drop significantly and cause fish kills.

- High suspended solids concentrations can inhibit plant growth by preventing the penetration of sunlight. This could mask the presence of high nutrient concentrations.

Differential flow within the stream has a strong influence on pollutant transport and residence time. Predictions of system response can be completely wrong if a bad assumption regarding flow in the system is employed. The Licking River, for example, experiences significant backwater effects as a result of high water levels on the Ohio River. These vary significantly with runoff.

## 7.7. Summary

To correctly characterize the health of a water system, all variables acting on the system should be studied. Placing disproportionate weight on one parameter or another can lead to incorrect conclusions. There are numerous interrelationships that can occur at any point in time. Because of this, it is important to become very familiar with the water system over time. This is the only means of identifying trends and characterizing the system's health.

# VIII. SUMMARY AND CONCLUSIONS

The objective of this study was to quantify the impact of combined sewer overflows on the Licking River. This was accomplished by instrumenting and sampling a combined sewer discharge pipe along with eight separate stream locations.

The combined sewer discharge samples were taken from the Eighth Street overflow pipe that conveys combined sewage from Covington, Kentucky. This pipe was chosen for sampling because of its size and accessibility. The eight different stream sampling sites were chosen at various places along the Licking River starting just south of the confluence of Banklick Creek and continuing north to the confluence with the Ohio River.

This report contains the results of two separate sampling efforts for the periods of 5/5/93-8/26/93 and 6/7/94-8/21/94. During the summer of 1993, samples were collected for 17 baseline events while during the summer of 1994, samples were collected for 10 baseline events, 4 sequential events and 4 CSO events. A total of 266 separate stream samples and 7 separate CSO samples were collected. In each case, the sample was analyzed for one or more of the following parameters: 1) Dissolved Oxygen (mg/l), 2) Conductivity (ms/cm), 3) Temperature (degrees Celsius), 4) pH, 5) Fecal Coliform (colonies/100 ml), 6) Fecal Strep (colonies/100 ml), 7) Biochemical Oxygen Demand - BOD(5) (mg/l), 8) Total Suspended Solids - TSS (mg/l), and 9) Volatile Suspended Solids - VSS (mg/l). In addition, one priority pollutant sample was collected from the Eighth Street outfall during 1993, while two additional priority pollutant samples were collected from the Eighth Street outfall during 1994.

Measured discharges from the Eighth Street outfall contained BOD, TSS, and fecal concentrations well above the average monthly maximum limits for municipal discharges. BOD concentrations ranged from a minimum of 10 mg/l to a maximum of 68 mg/l. TSS concentrations ranged from a minimum of 33 mg/l to a maximum of 342 mg/l. Finally, fecal coliform contamination levels varied from a minimum of 212,000 colonies/100 ml to a maximum of 3 million colonies/100 ml. Priority pollutant scans of the discharges from the Eighth Street outfall failed to identify any significant levels of priority pollutants, although trace amounts of cyanide, heavy metals, bis-phthalate, and toluene were detected.

The results of this study indicate that the Licking River was significantly impacted by fecal contamination during both the summer of 1993 and 1994. In general, the level of contamination increased from the confluence of Banklick Creek to the confluence of the Ohio River indicating the presence of significant sources of biological contamination. The aggregate average fecal coliform level for 1993 was 3400 c/100 ml, while the average aggregate level for 1994 was 1942 c/100 ml. Correspondingly, the average fecal strep level for 1994 was 887 c/100 ml. In general, the ratio of fecal coliform to fecal strep populations increased from Banklick Creek to the Ohio River, thus indicating that the increase in fecal contamination was most likely from domestic sewage sources such as combined sewer overflows. During 1993, a maximum fecal coliform count of 40,000 c/100 ml was observed, while during 1994 a maximum fecal coliform count of 26,000 c/100 ml was observed.

Although significant bacteriological contamination has been identified in both Banklick Creek and Three Mile Creek, it does not appear that either creek is having a significant impact on the counts of the Licking River. Indeed, the largest percentage increase in these counts appears to occur between Three Mile Creek and the Ohio River.

While significant fecal contamination was identified within the Licking River study area, observed biochemical oxygen demand (i.e., BOD) levels were much lower. Average aggregate BOD levels were observed to be 2.0 mg/l with an absolute maximum of only 6.0 mg/l. Correspondingly, the observed dissolved oxygen levels generally remained well above the minimum level of 5 mg/l. The average aggregate DO levels were observed to be 7.2 mg/l for 1993 and 8.4 mg/l for 1994. In only one event in 1994 and two events in 1993 did the dissolved oxygen levels drop below 5 mg/l.

In summary, although it would appear that the Licking River continues to experience significant bacteriological contamination, the impacts on dissolved oxygen appear to be minimal. While the results from 1993 show a significant drop in dissolved oxygen between Three Mile Creek and the 4th Street Bridge, the average results for 1994 are less dramatic. In addition, the various fecal contamination sources do not appear to be generating either significant BOD loadings or solid loadings within the actual river. These results appear to be consistent with other similar studies on the impacts of CSO discharges on rivers and streams and may provide insights on the appropriate technology for use in mitigating the resulting effects.

While it may not be concluded conclusively, it would appear that the source of the biological contamination is from domestic sewage sources. This hypothesis is supported by the ratio of fecal coliform to fecal strep and the ratio of volatile suspended solids to total suspended solids. The most likely source of such contamination would be from the numerous CSOs that are located along the Licking River between the confluence of Banklick Creek and the confluence with the Ohio River. Attempts to segregate the impacts of dry weather events from wet weather events proved generally unsuccessful. However, it does appear that the highest level of bacteriological pollution occurs during periods of low streamflow. Attempts at more specific relationships were somewhat hampered by the spatial variability of rainfall in the study area and the occurrence of dry weather CSO discharges.

## REFERENCES


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2. Gupta, R. S., (1989) *Hydrology and Hydraulic Systems*, Prentice Hall, Englewood Cliffs, New Jersey.

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4. Ormsbee, L., Gruzesky, G, Jain, A., Reddy, A. and McPherson, D., (1994) *CSO Impact Assessment for Banklick Creek,* Department of Civil Engineering, University of Kentucky, Lexington, Kentucky 40506-0281.

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# APPENDIX A

Table A.1 Stream Water Quality Parameters on May 05, 1993

| ID | TIME | Diss Oxy | Fecal Coliform | Temp | Cond | pH |
|---|---|---|---|---|---|---|
| 1 | 1234 | 7.56 | 400 | 21.4 | .32 | 7.70 |
| 2 | 1225 | 7.90 | 2800 | 21.8 | .32 | 7.70 |
| 3 | 1219 | 8.80 | 6000 | 22.4 | .33 | 7.90 |
| 4 | 1217 | 8.66 | 7000 | 22.0 | .33 | 7.94 |
| 5 | 1215 | 8.38 | 8000 | 21.7 | .33 | 7.88 |
| 6 | 1102 | 7.11 | 5200 | 21.2 | .34 | 7.64 |
| 7 | 1052 | 7.03 | 6900 | 21.3 | .35 | 7.62 |
| 8 | 1045 | 7.15 | 5700 | 21.3 | .35 | 7.67 |

Table A.2 Stream Water Quality Parameters on May 21, 1993

| ID | TIME | Diss Oxy | Fecal Coliform | Temp | Cond | pH |
|---|---|---|---|---|---|---|
| 1 | --- | --- | 170 | --- | --- | --- |
| 2 | 1155 | 8.90 | 100 | 19.4 | 0.38 | 7.73 |
| 3 | 1135 | 8.80 | 1700 | 19.2 | 0.39 | 7.70 |
| 4 | 1122 | 8.70 | 1800 | 19.0 | 0.40 | 7.91 |
| 5 | 1112 | 8.54 | 2300 | 19.0 | 0.40 | 8.27 |
| 6 | 1102 | 7.78 | 2700 | 18.9 | 0.38 | 8.03 |
| 7 | 1055 | 7.73 | 17000 | 19.1 | 0.74 | 8.23 |
| 8 | 1040 | 8.70 | 3900 | 19.5 | 0.36 | 7.70 |

Table A.3 Stream Water Quality Parameters on May 25, 1993

| ID | TIME | Diss Oxy | Fecal Coliform | Temp | Cond | pH |
|---|---|---|---|---|---|---|
| 1 | 1045 | 9.14 | 30 | 19.9 | 0.28 | --- |
| 2 | 1035 | 9.20 | 40 | 19.9 | 0.28 | --- |
| 3 | 1025 | 8.75 | 600 | 19.2 | 0.29 | --- |
| 4 | 1022 | 8.92 | 500 | 19.2 | 0.29 | --- |
| 5 | 1017 | 8.80 | 400 | 19.2 | 0.29 | --- |
| 6 | 1005 | 8.73 | 1200 | 19.1 | 0.29 | --- |
| 7 | 955 | 8.85 | 1400 | 18.8 | 0.30 | --- |
| 8 | 940 | 9.08 | 1600 | 19.7 | 0.31 | --- |

Table A.4 Stream Water Quality Parameters on May 27, 1993

| ID | TIME | Diss Oxy | Fecal Coliform | Temp | Cond | pH |
|---|---|---|---|---|---|---|
| 1 | 1125 | 8.65 | 10 | 20.9 | 0.30 | 7.50 |
| 2 | 1107 | 8.36 | 20 | 20.9 | 0.30 | 7.53 |
| 3 | 1100 | 8.55 | 40 | 20.7 | 0.29 | --- |
| 4 | 1050 | 8.18 | 60 | 20.6 | 0.29 | 7.44 |
| 5 | 1045 | 8.28 | 90 | 20.6 | 0.29 | 7.56 |
| 6 | 1032 | 8.27 | 3200 | 20.9 | 0.29 | 7.30 |
| 7 | 1024 | 8.55 | 1200 | 20.8 | 0.29 | 7.44 |
| 8 | 1020 | 8.95 | 1300 | 20.5 | 0.32 | 7.56 |

Table A.5 Stream Water Quality Parameters on June 10, 1993

| ID | TIME | Diss Oxy | Fecal Coliform | Temp | Cond | pH |
|---|---|---|---|---|---|---|
| 1 | 1137 | 7.20 | 600 | 19.0 | --- | 7.40 |
| 2 | 1111 | 7.40 | 2000 | 19.3 | 0.20 | 7.28 |
| 3 | 1104 | 7.50 | 2400 | 19.3 | 0.20 | 7.10 |
| 4 | 1059 | 7.35 | 900 | 19.3 | 0.20 | 7.26 |
| 5 | 1050 | 7.37 | 1000 | 19.2 | 0.19 | 7.22 |
| 6 | 1034 | 7.15 | 900 | 19.5 | 0.19 | 7.29 |
| 7 | 1024 | 7.08 | 3400 | 19.8 | 0.19 | 7.24 |
| 8 | 1013 | 7.43 | 2500 | 19.7 | 0.19 | 8.05 |

Table A.6 Stream Water Quality Parameters on June 16, 1993

| ID | TIME | Diss Oxy | Fecal Coliform | Temp | Cond | pH |
|---|---|---|---|---|---|---|
| 1 | 1227 | 5.70 | 25000 | 20.5 | --- | 7.40 |
| 2 | 1203 | 5.60 | 19000 | 20.5 | --- | 7.25 |
| 3 | 1155 | --- | 16600 | --- | --- | 7.20 |
| 4 | 1153 | 5.90 | 16600 | 20.5 | --- | 7.27 |
| 5 | 1108 | 5.60 | 3300 | 21.0 | --- | 7.46 |
| 6 | 1054 | 5.60 | 9600 | 20.5 | --- | 7.48 |
| 7 | 1042 | 5.50 | 30000 | 20.5 | --- | 7.51 |
| 8 | 1035 | 5.50 | 7300 | 21.0 | --- | 7.67 |

Table A.7 Stream Water Quality Parameters on June 24, 1993

| ID | TIME | Diss Oxy | Fecal Coliform | Temp | Cond | pH |
|---|---|---|---|---|---|---|
| 1 | 1013 | 7.43 | 2500 | 19.7 | 0.19 | 8.05 |
| 2 | 1034 | 7.15 | 900 | 19.5 | 0.19 | 7.29 |
| 3 | 1050 | 7.37 | 1000 | 19.2 | 0.19 | 7.22 |
| 4 | 1059 | 7.35 | 900 | 19.3 | 0.20 | 7.26 |
| 5 | 1104 | 7.50 | 2400 | 19.3 | 0.20 | 7.10 |
| 6 | 1111 | 7.40 | 2000 | 19.3 | 0.20 | 7.28 |
| 7 | 1120 | 5.10 | 105000 | 21.8 | 0.58 | 7.50 |
| 8 | 1137 | 7.20 | 600 | 19.0 | --- | 7.40 |

Table A.8 Stream Water Quality Parameters on June 28, 1993

| ID | TIME | Diss Oxy | Fecal Coliform | Temp | Cond | pH |
|---|---|---|---|---|---|---|
| 1 | 1110 | 6.91 | --- | 27.6 | 0.28 | 7.70 |
| 2 | 1056 | 6.88 | 310 | 27.6 | 0.28 | 7.75 |
| 3 | 1052 | 6.72 | 1000 | 27.0 | 0.28 | 7.60 |
| 4 | 1044 | 6.70 | 800 | 27.1 | 0.28 | 7.61 |
| 5 | 1045 | 6.36 | 530 | 26.8 | 0.28 | 7.58 |
| 6 | 1025 | 5.72 | 1700 | 26.6 | 0.29 | 7.45 |
| 7 | 1010 | 5.60 | 4400 | 26.4 | 0.29 | 7.47 |
| 8 | 1002 | 7.00 | 3800 | 26.8 | 0.43 | 7.54 |

Table A.9 Stream Water Quality Parameters on June 30, 1993

| ID | TIME | Diss Oxy | Fecal Coliform | Temp | Cond | pH |
|---|---|---|---|---|---|---|
| 1 | 1050 | 6.80 | --- | 24.8 | --- | 7.90 |
| 2 | 1031 | 6.53 | 700 | 25.6 | 0.29 | 7.83 |
| 3 | 1025 | 6.70 | 1200 | 25.7 | 0.29 | 7.90 |
| 4 | 1024 | 6.90 | 32000 | 25.7 | 0.29 | 7.87 |
| 5 | 1018 | 6.90 | 500 | 25.7 | 0.29 | 7.91 |
| 6 | 952 | 7.15 | 6000 | 26.5 | 0.30 | 8.04 |
| 7 | 947 | --- | 10400 | 26.5 | 0.30 | 7.97 |
| 8 | 942 | 7.25 | 18400 | 26.5 | 0.30 | 8.02 |

Table A.10 Stream Water Quality Parameters on July 08, 1993

| ID | TIME | Diss Oxy | Fecal Coliform | Temp | Cond | pH |
|---|---|---|---|---|---|---|
| 1 | 1125 | 6.90 | 190 | 30.1 | 0.34 | 7.80 |
| 2 | 1105 | 6.68 | 700 | 30.1 | 0.34 | 7.78 |
| 3 | 1059 | 6.55 | 1800 | 29.7 | 0.34 | 7.70 |
| 4 | 1055 | 6.01 | 1300 | 30.0 | 0.34 | 7.69 |
| 5 | 1050 | 6.50 | 1800 | 29.5 | 0.34 | 7.75 |
| 6 | 1032 | 6.06 | 9200 | 29.8 | 0.31 | 7.68 |
| 7 | 1025 | 5.85 | 10200 | 29.4 | 0.32 | 7.69 |
| 8 | 1020 | 5.79 | 40000 | 29.4 | 0.32 | 7.66 |

Table A.11 Stream Water Quality Parameters on July 23, 1993

| ID | TIME | Diss Oxy | Fecal Coliform | Temp | Cond | pH |
|---|---|---|---|---|---|---|
| 1 | 1100 | 5.40 | 20 | 28.8 | 0.28 | 7.60 |
| 2 | 1043 | 5.85 | 20 | 28.6 | 0.29 | 7.73 |
| 3 | 1036 | 5.76 | 120 | 28.3 | 0.30 | 7.70 |
| 4 | 1034 | 5.80 | 130 | 28.3 | 0.29 | 7.64 |
| 5 | 1030 | 5.80 | 50 | 27.9 | 0.30 | 7.62 |
| 6 | 1015 | 4.49 | 6000 | 25.1 | 0.30 | 7.51 |
| 7 | 1000 | 3.58 | 2400 | 27.9 | 0.31 | 7.40 |
| 8 | 957 | 7.30 | 14000 | 29.0 | 0.41 | 7.65 |

Table A.12 Stream Water Quality Parameters on July 27, 1993

| ID | TIME | Diss Oxy | Fecal Coliform | Temp | Cond | pH |
|---|---|---|---|---|---|---|
| 1 | 1140 | 5.00 | 29 | 19.9 | 0.32 | 7.50 |
| 2 | 1120 | 5.13 | 30 | 29.8 | 0.31 | 7.50 |
| 3 | 1123 | 5.78 | 70 | 29.6 | 0.32 | 7.50 |
| 4 | 1107 | 6.90 | 190 | 30.4 | 0.30 | 7.76 |
| 5 | 1051 | 5.47 | 500 | 29.6 | 0.31 | 7.48 |
| 6 | 1028 | 4.49 | 3400 | 29.4 | 0.30 | 7.27 |
| 7 | 1020 | 8.10 | 4700 | 29.9 | 0.46 | 7.85 |
| 8 | 1010 | 9.00 | 10000 | 30.2 | 0.47 | 8.04 |

Table A.13 Stream Water Quality Parameters on July 29, 1993

| ID | TIME | Diss Oxy | Fecal Coliform | Temp | Cond | pH |
|---|---|---|---|---|---|---|
| 1 | 1140 | 5.00 | 520 | 29.2 | 0.32 | 7.50 |
| 2 | 1126 | 6.90 | 70 | 30.0 | 0.32 | 7.79 |
| 3 | 1123 | 5.78 | 270 | 29.6 | 0.32 | 7.50 |
| 4 | 1120 | 5.50 | 160 | 29.7 | 0.31 | 7.50 |
| 5 | 1115 | 5.22 | 940 | 29.6 | 0.31 | 7.38 |
| 6 | 1106 | 4.26 | 5100 | 30.0 | 0.34 | 7.37 |
| 7 | 1102 | 5.76 | 300 | 28.0 | 0.42 | 7.47 |
| 8 | 1100 | 7.20 | 400 | 30.1 | 0.46 | 7.45 |

Table A.14 Stream Water Quality Parameters on August 20, 1993

| ID | TIME | Diss Oxy | Fecal Coliform | Temp | Cond | pH |
|---|---|---|---|---|---|---|
| 1 | 1040 | 7.00 | 2200 | --- | --- | --- |
| 2 | 1032 | 7.00 | 2000 | --- | --- | --- |
| 3 | 1029 | 6.90 | 600 | --- | --- | --- |
| 4 | 1026 | 7.00 | 1500 | --- | --- | --- |
| 5 | 1021 | 6.90 | 1100 | --- | --- | --- |
| 6 | 1012 | 6.70 | 4300 | --- | --- | --- |
| 7 | 1006 | 6.70 | 7600 | --- | --- | --- |
| 8 | 1003 | 7.10 | 6100 | --- | --- | --- |

Table A.15 Stream Water Quality Parameters on August 23, 1993

| ID | TIME | Diss Oxy | Fecal Coliform | Temp | Cond | pH |
|---|---|---|---|---|---|---|
| 1 | 1140 | 7.38 | 60 | 23.3 | 0.20 | --- |
| 2 | 1127 | 7.50 | 140 | 23.9 | 0.20 | --- |
| 3 | 1122 | 7.54 | 150 | 23.5 | 0.20 | --- |
| 4 | 1120 | 7.50 | 100 | 23.5 | 0.21 | --- |
| 5 | 1115 | 7.60 | 140 | 23.8 | 0.21 | --- |
| 6 | 1107 | 7.67 | 1100 | 24.0 | 0.21 | --- |
| 7 | 1057 | 7.30 | 500 | 28.1 | 0.48 | --- |
| 8 | 1050 | 7.56 | 280 | 28.6 | 0.50 | --- |

Table A.16 Stream Water Quality Parameters on August 26, 1993

| ID | TIME | Diss Oxy | Fecal Coliform | Temp | Cond | pH |
|---|---|---|---|---|---|---|
| 1 | 1123 | 8.80 | 10 | 27.3 | 0.21 | 8.40 |
| 2 | 1102 | 8.80 | 7000 | 27.0 | 0.22 | 8.36 |
| 3 | 1058 | 9.19 | 13900 | 27.1 | 0.22 | 8.40 |
| 4 | 1055 | 9.05 | 13000 | 26.7 | 0.22 | 8.44 |
| 5 | 1045 | 10.70 | 13700 | 26.7 | 0.22 | 8.78 |
| 6 | 1030 | 8.10 | 3900 | 29.1 | 0.49 | 8.40 |
| 7 | 1028 | 7.10 | 4400 | 29.2 | 0.49 | 7.90 |
| 8 | 1025 | 7.00 | 3300 | 29.5 | 0.50 | 7.87 |

Table A.17 Stream Water Quality Parameters on August 31, 1993

| ID | TIME | Diss Oxy | Fecal Coliform | Temp | Cond | pH |
|---|---|---|---|---|---|---|
| 1 | 1045 | 8.30 | 90 | 28.5 | 0.24 | 8.30 |
| 2 | 1020 | 8.10 | 90 | 28.4 | 0.24 | 8.28 |
| 3 | 1016 | 8.80 | 260 | 28.4 | 0.24 | 8.40 |
| 4 | 1015 | 9.13 | 290 | 28.4 | 0.24 | 8.47 |
| 5 | 1010 | 9.42 | 2800 | 28.5 | 0.23 | 8.59 |
| 6 | 1008 | 7.43 | 6300 | 29.6 | 0.47 | 7.99 |
| 7 | 1005 | 7.00 | 2200 | 29.7 | 0.52 | 7.89 |
| 8 | 1000 | 7.63 | 1600 | 30.1 | 0.54 | 8.00 |

# APPENDIX B

Figure B.1 Dissolved Oxygen May 05, 1993

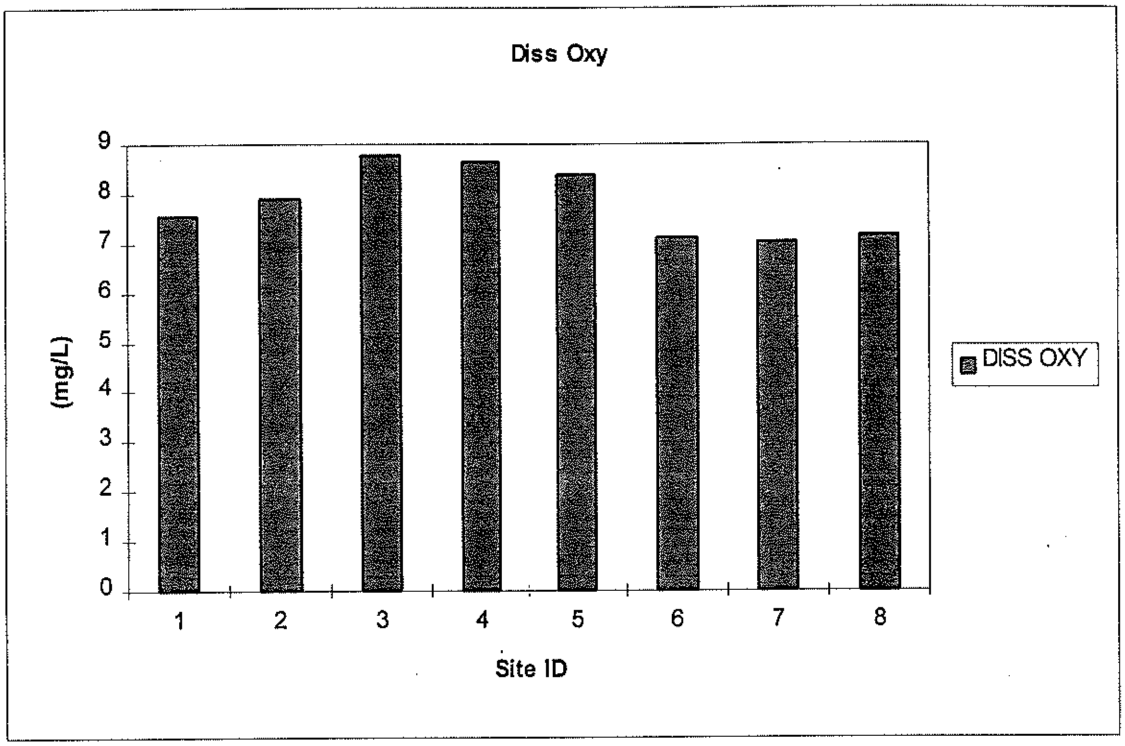



Figure B.2 Fecal Coliform May 05, 1993

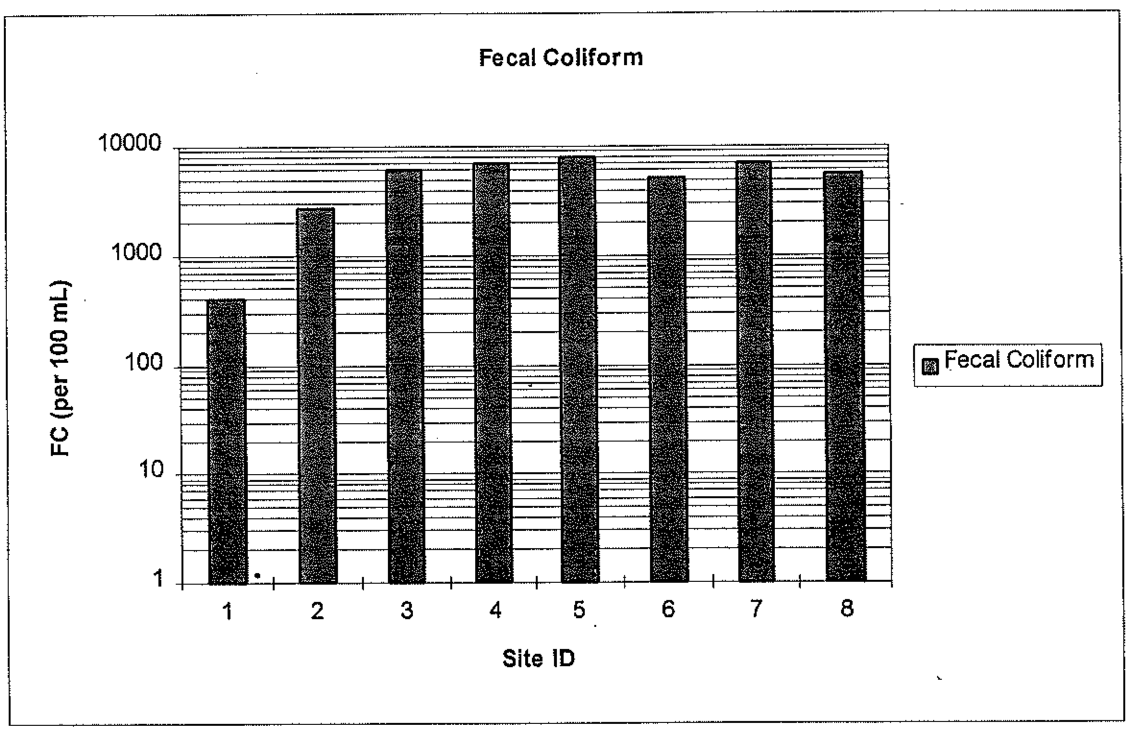


Figure B.3 Dissolved Oxygen May 21, 1993

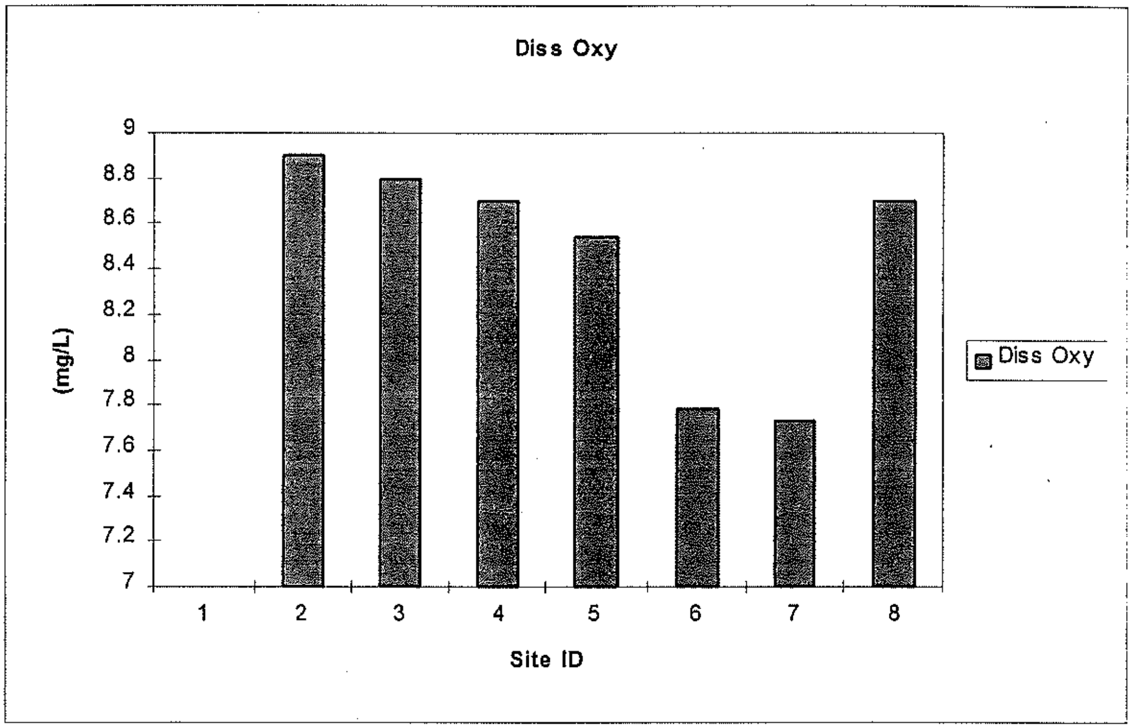



Figure B.4 Fecal Coliform May 21, 1993

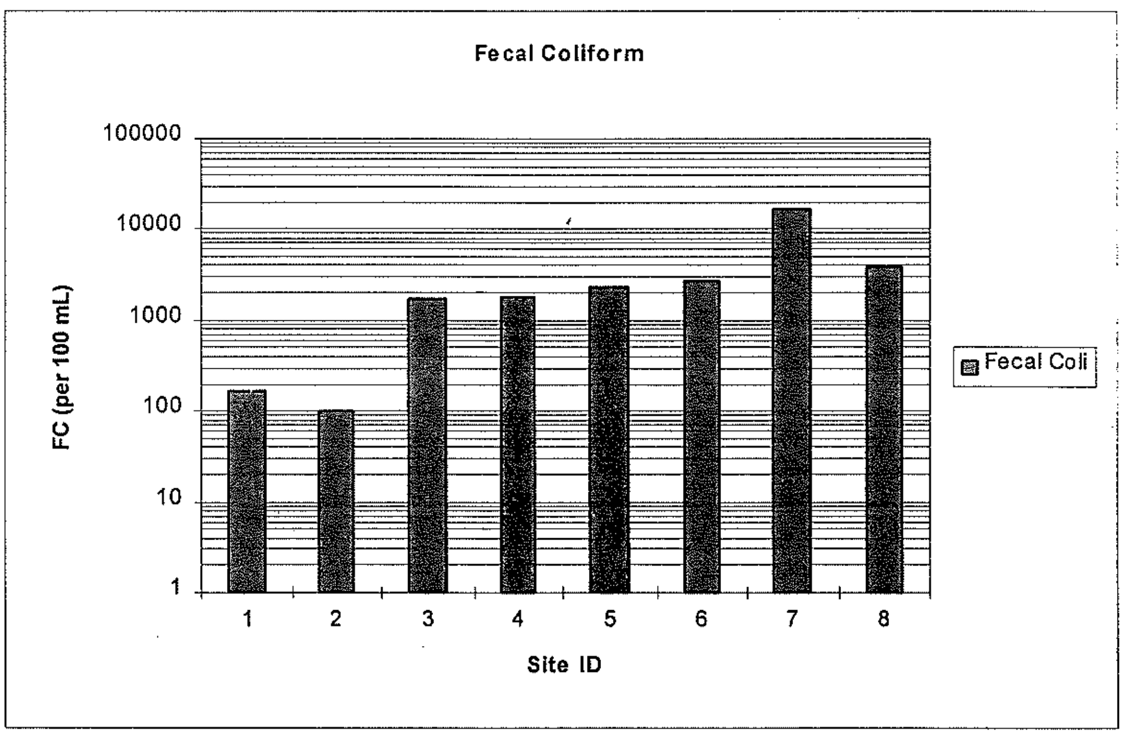


Figure B.5 Dissolved Oxygen May 25, 1993

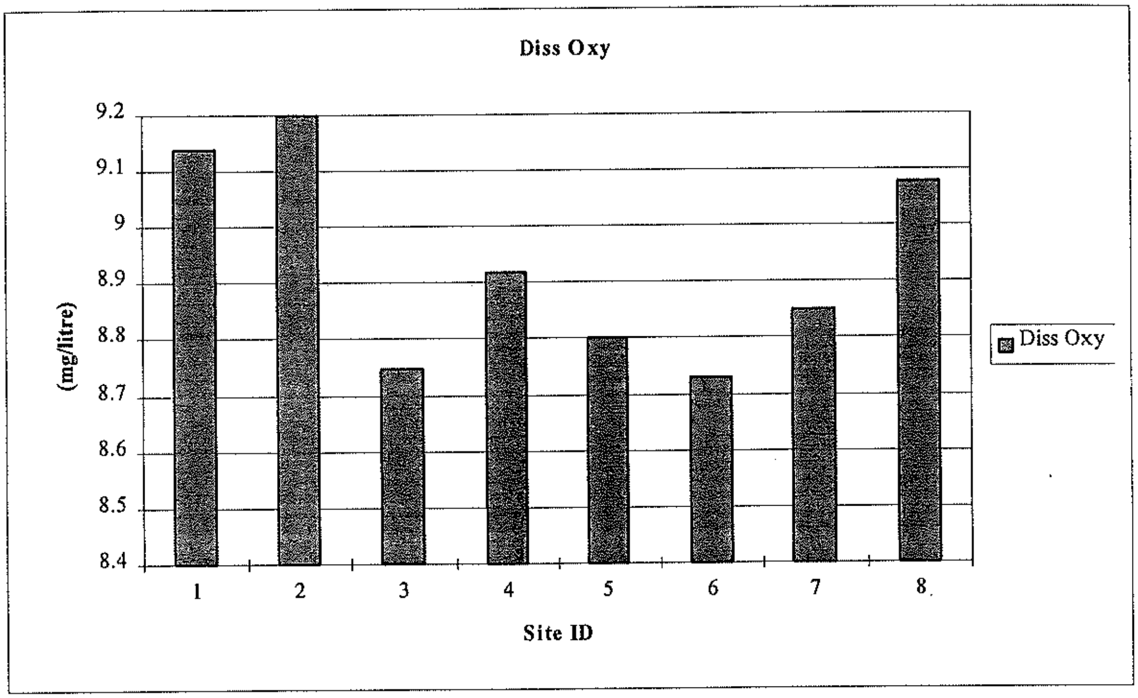



Figure B.6 Fecal Coliform May 25, 1993

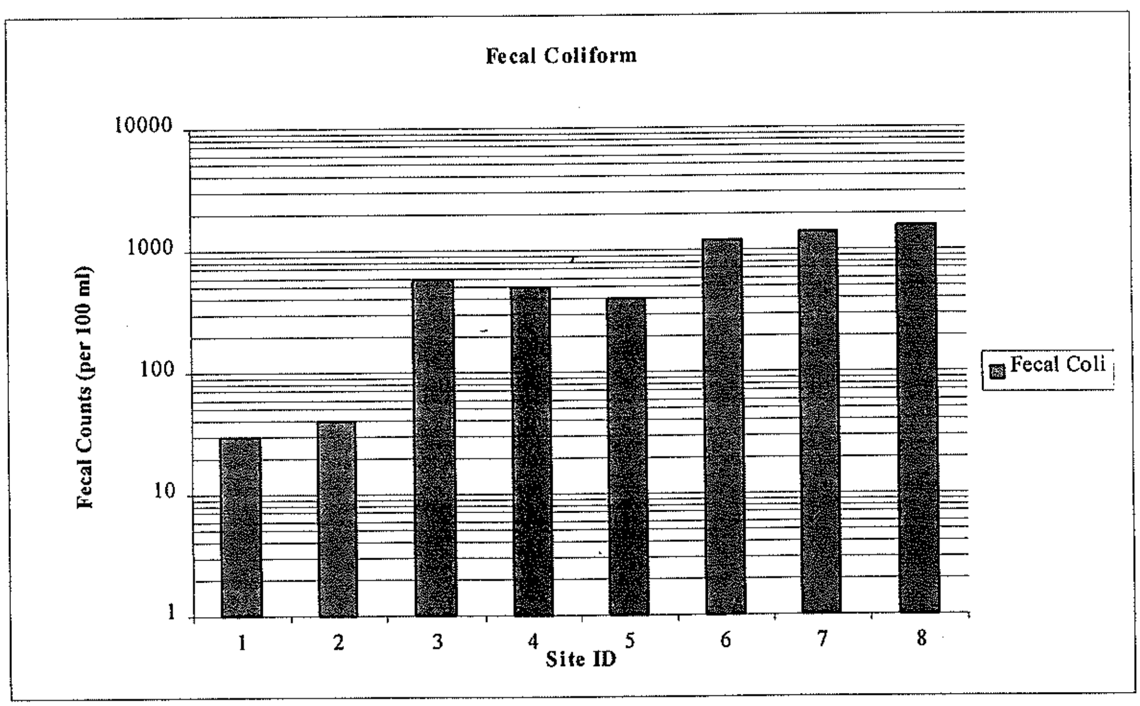


Figure B.7 Dissolved Oxygen May 27, 1993

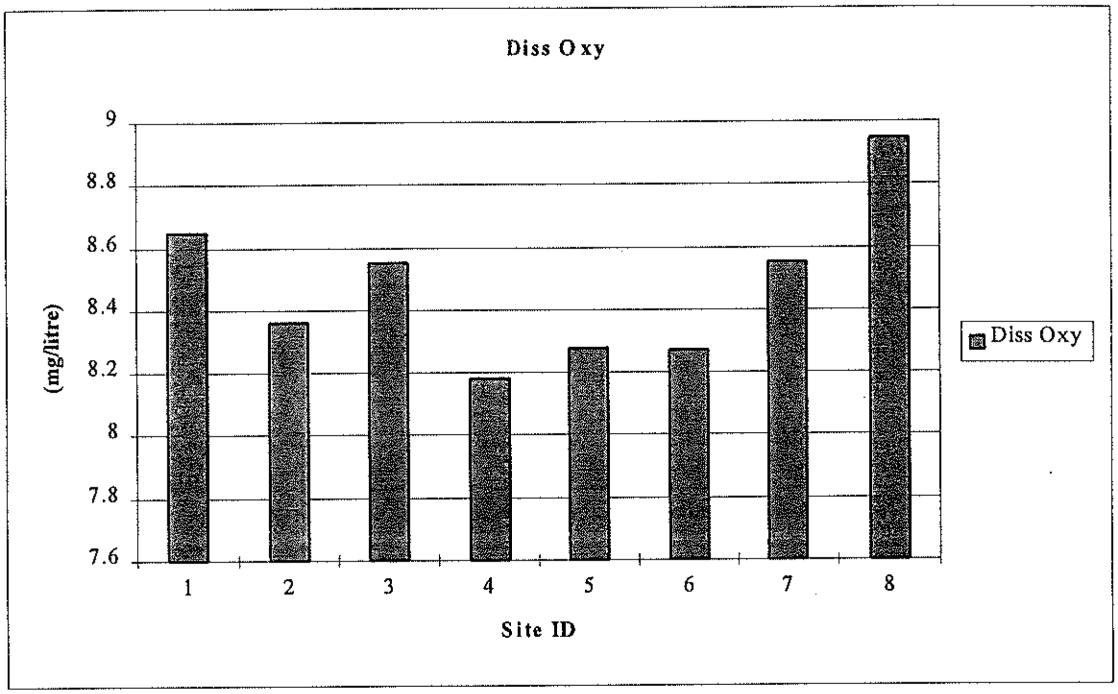



Figure B.8 Fecal Coliform May 27, 1993

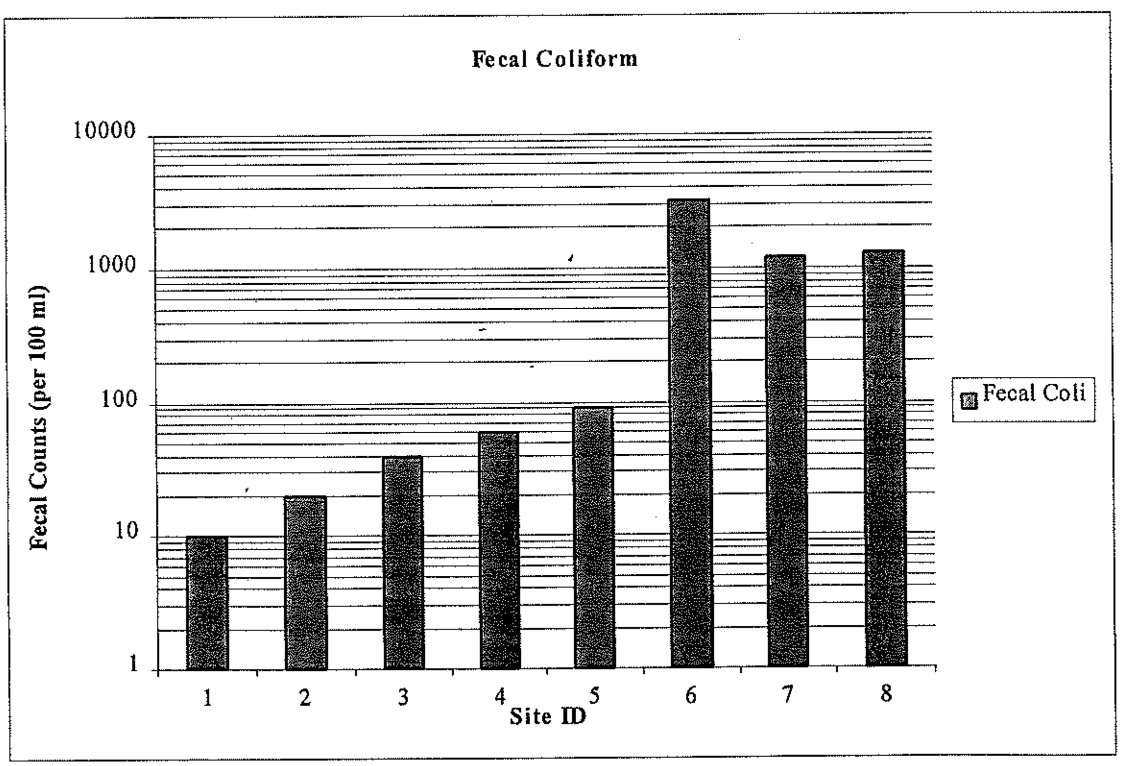


Figure B.9 Dissolved Oxygen June 10, 1993

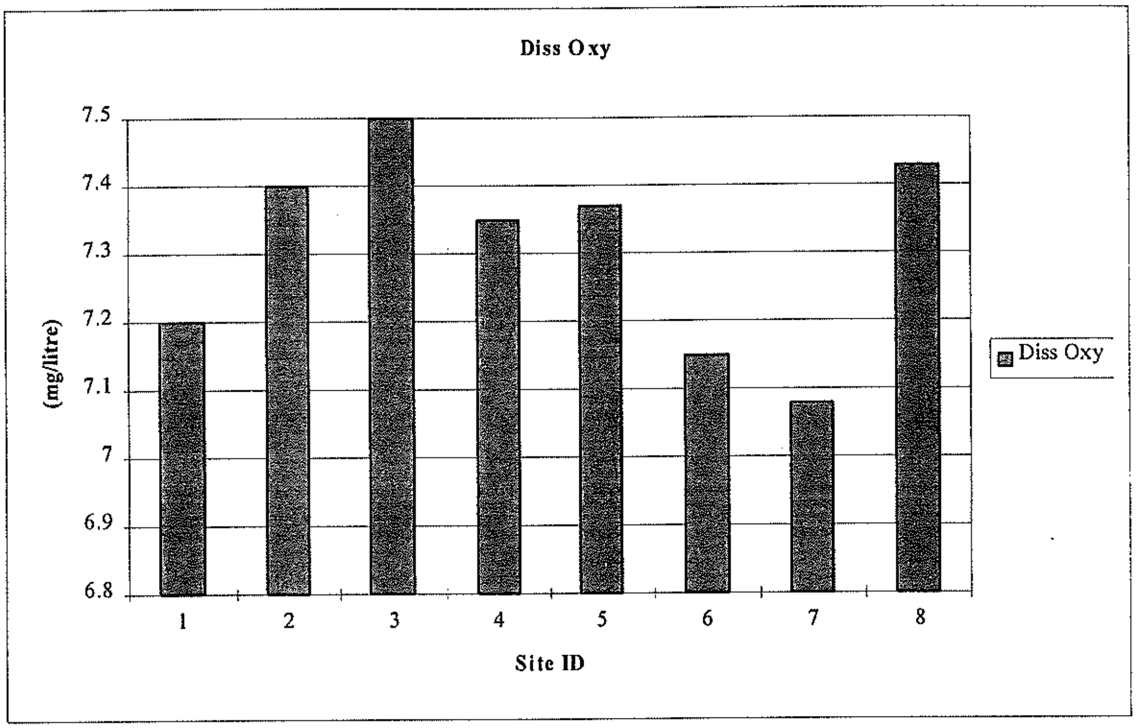



Figure B.10 Fecal Coliform June 10, 1993

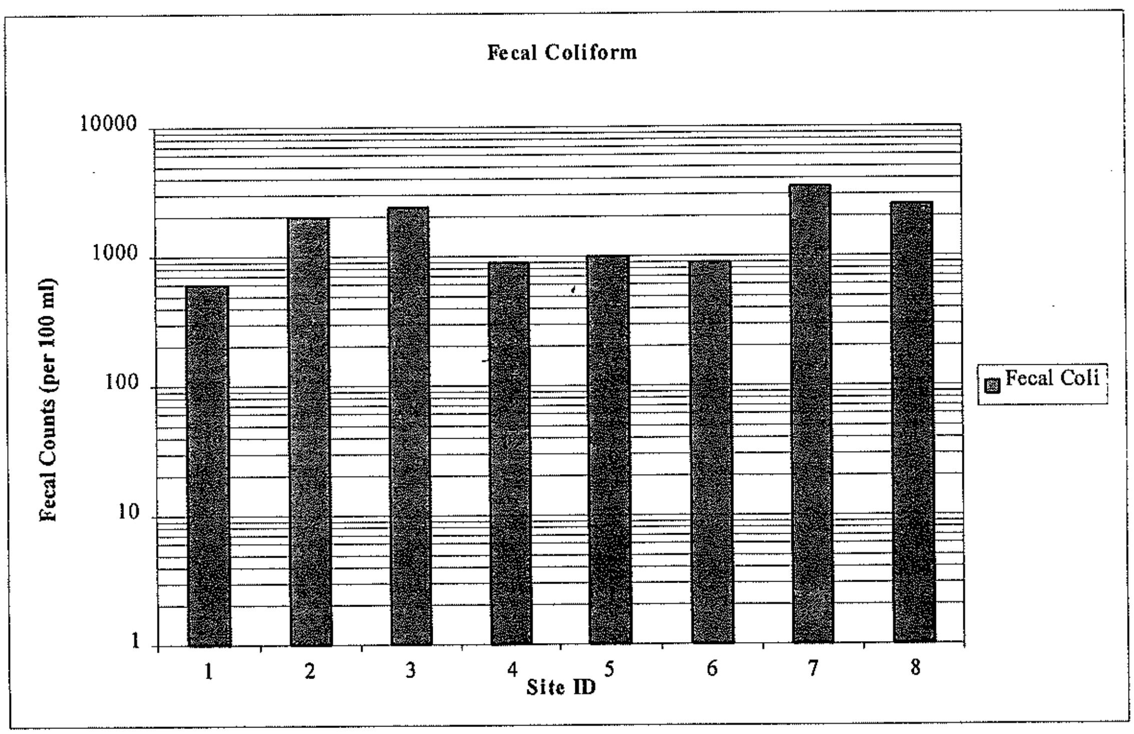


Figure B.11 Dissolved Oxygen June 16, 1993

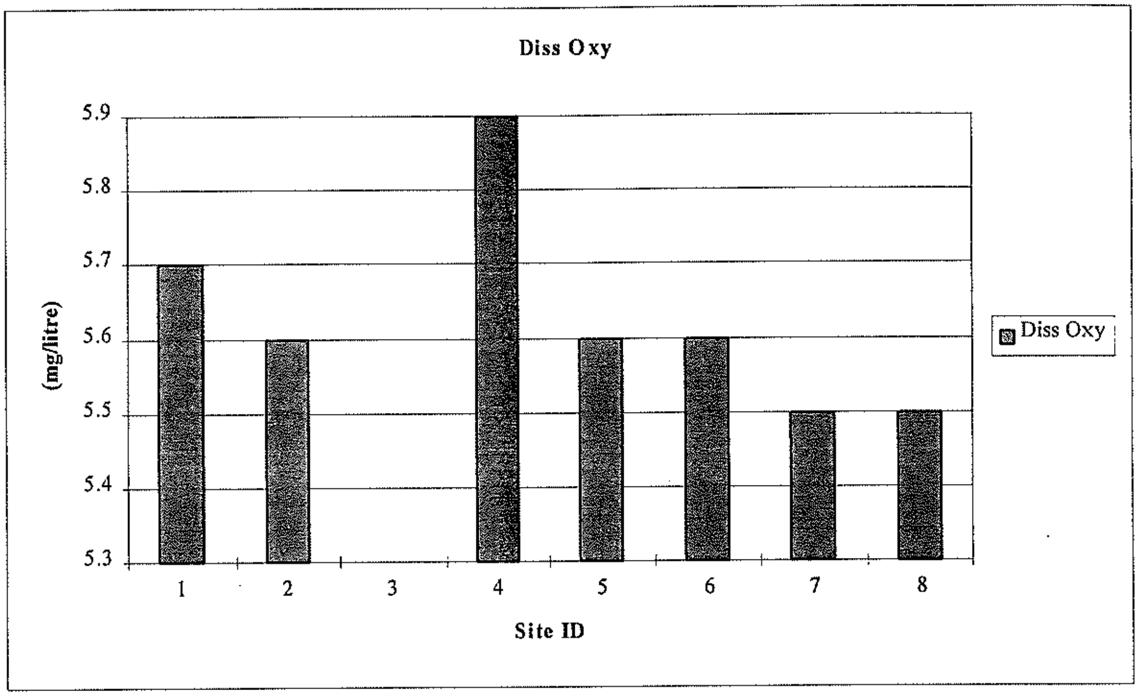



Figure B.12 Fecal Coliform June 16, 1993

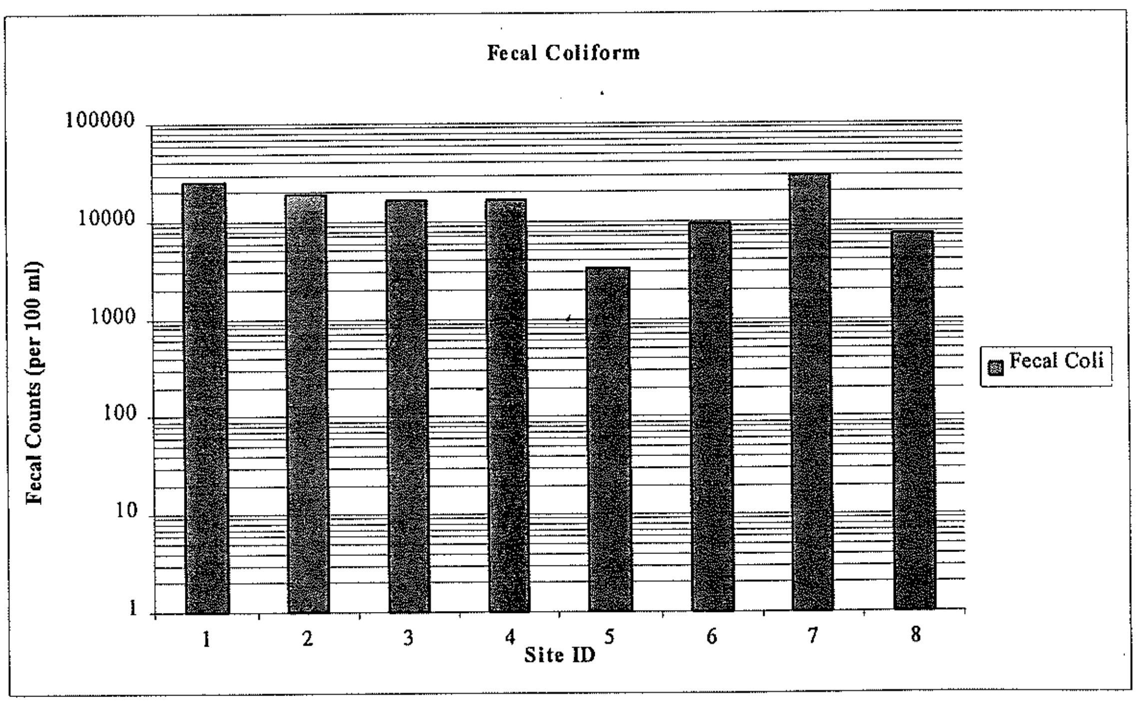


Figure B.13 Dissolved Oxygen June 24, 1993

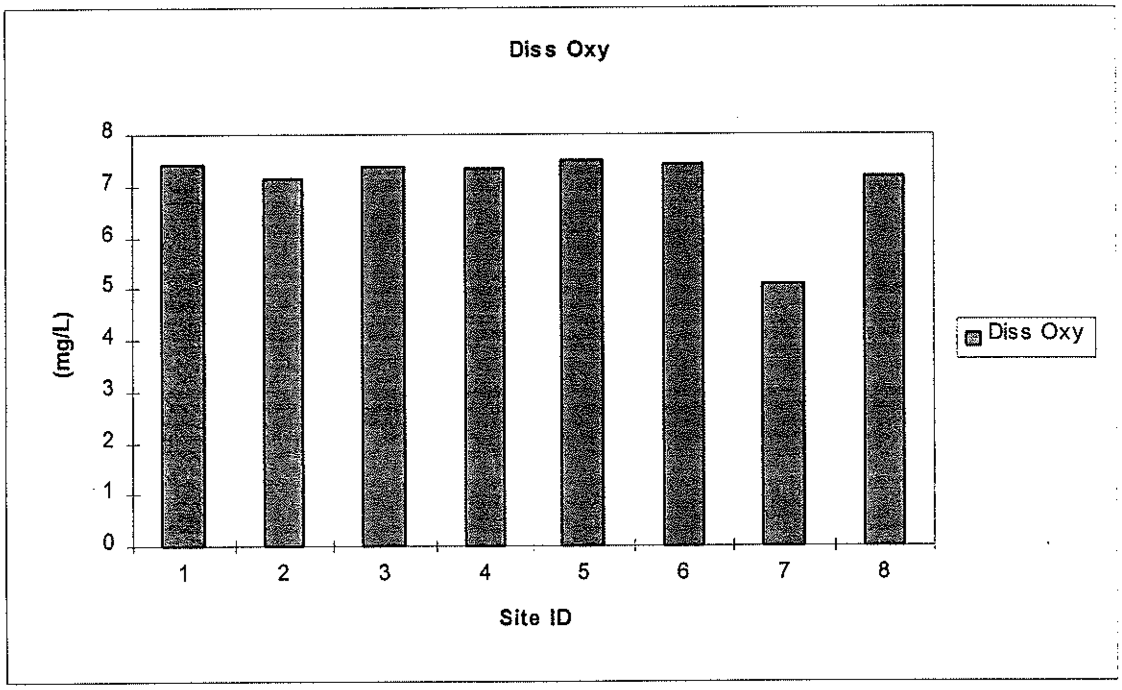



Figure B.14 Fecal Coliform June 24, 1993

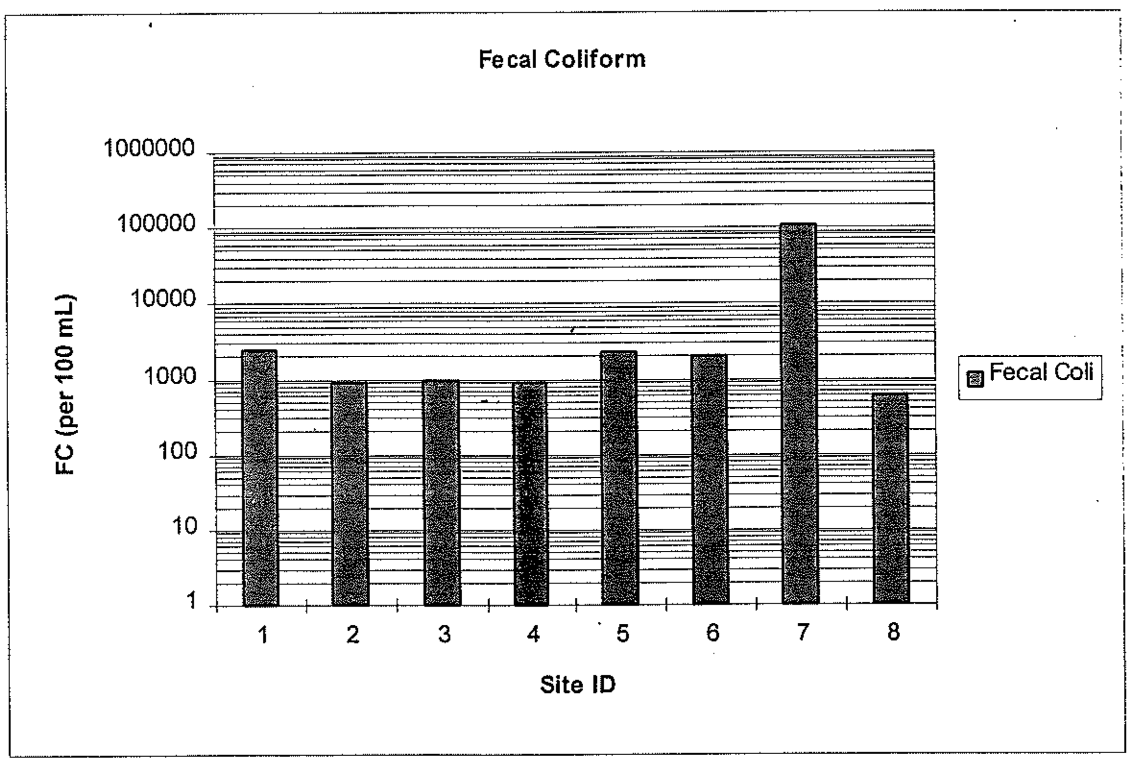


Figure B.15 Dissolved Oxygen June 28, 1993

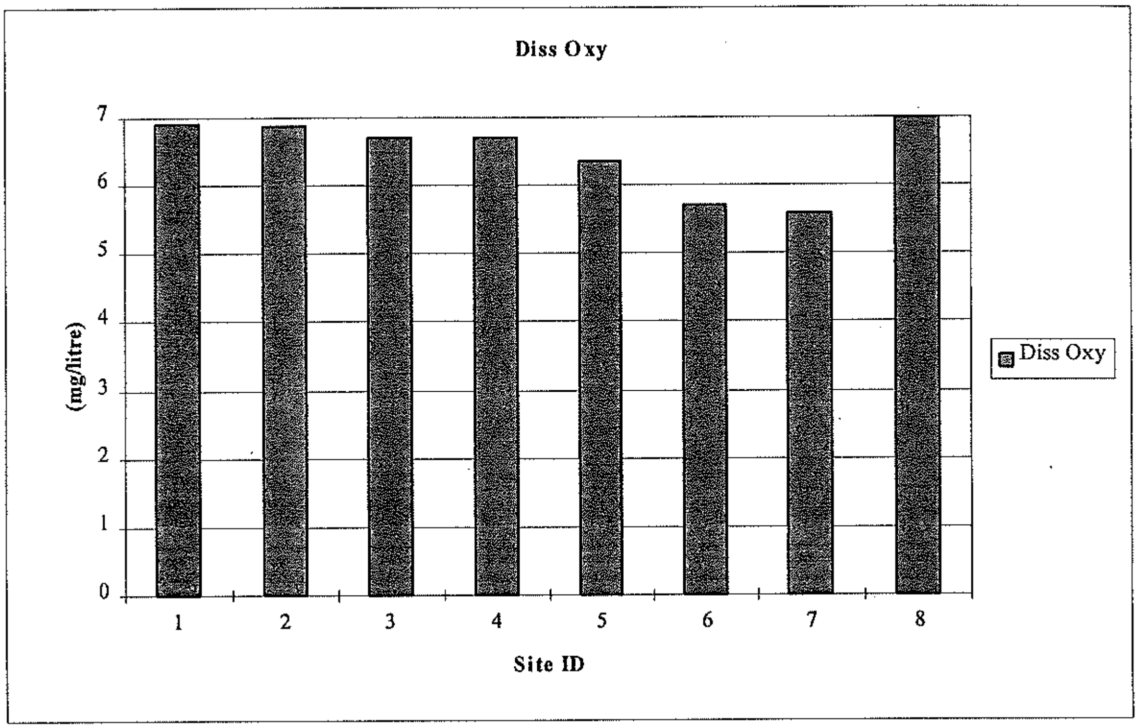



Figure B.16 Fecal Coliform June 28, 1993

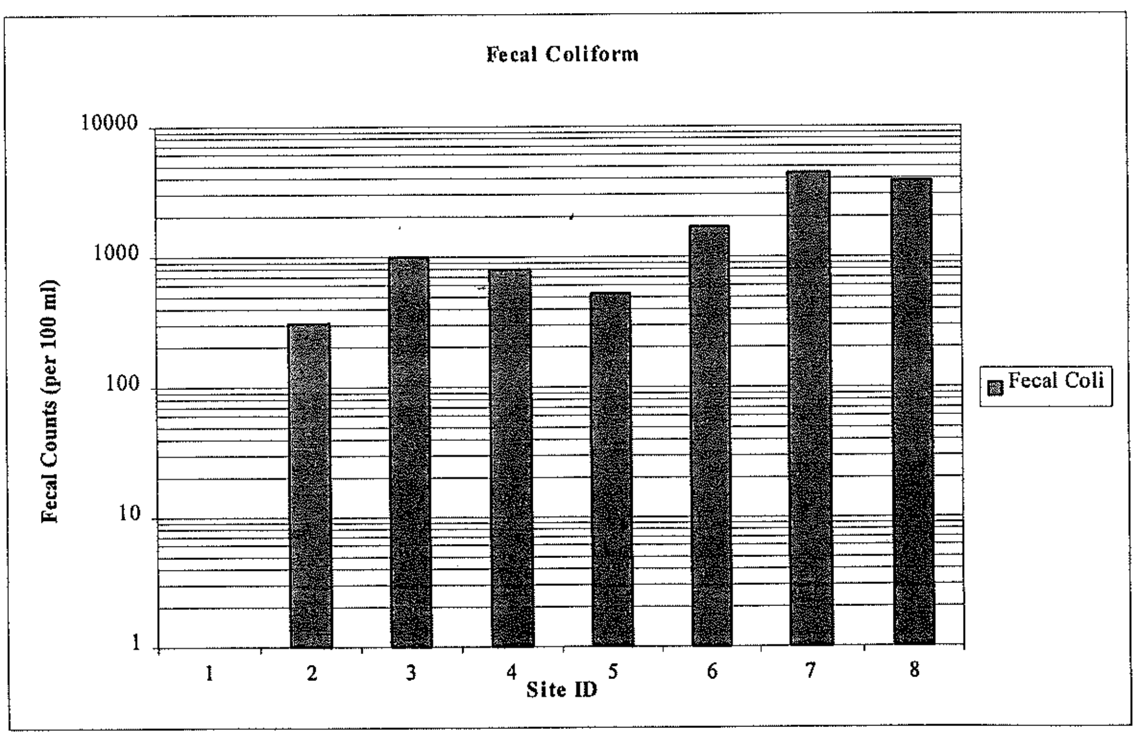


Figure B.17 Dissolved Oxygen June 30, 1993

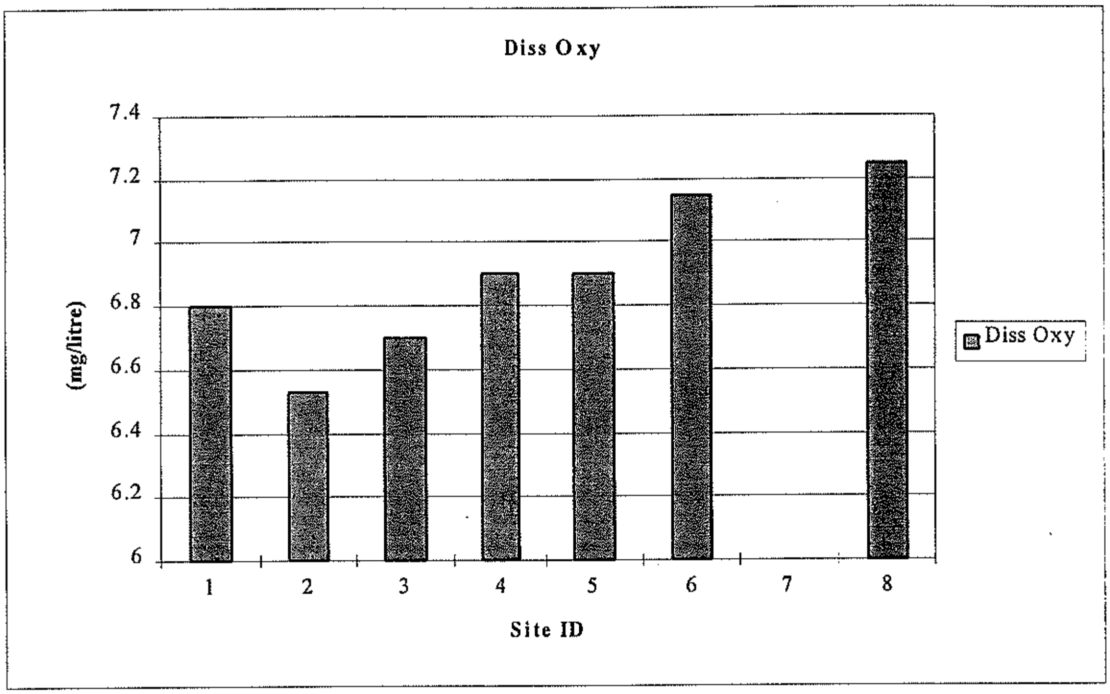



Figure B.18 Fecal Coliform June 30, 1993

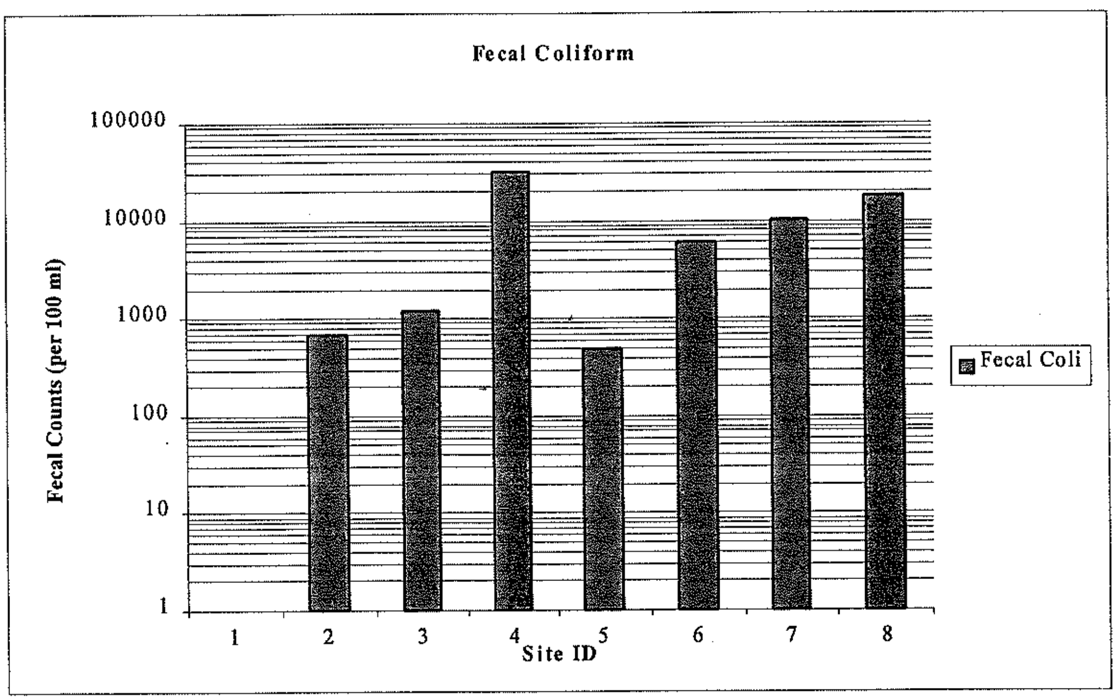


Figure B.19 Dissolved Oxygen July 08, 1993

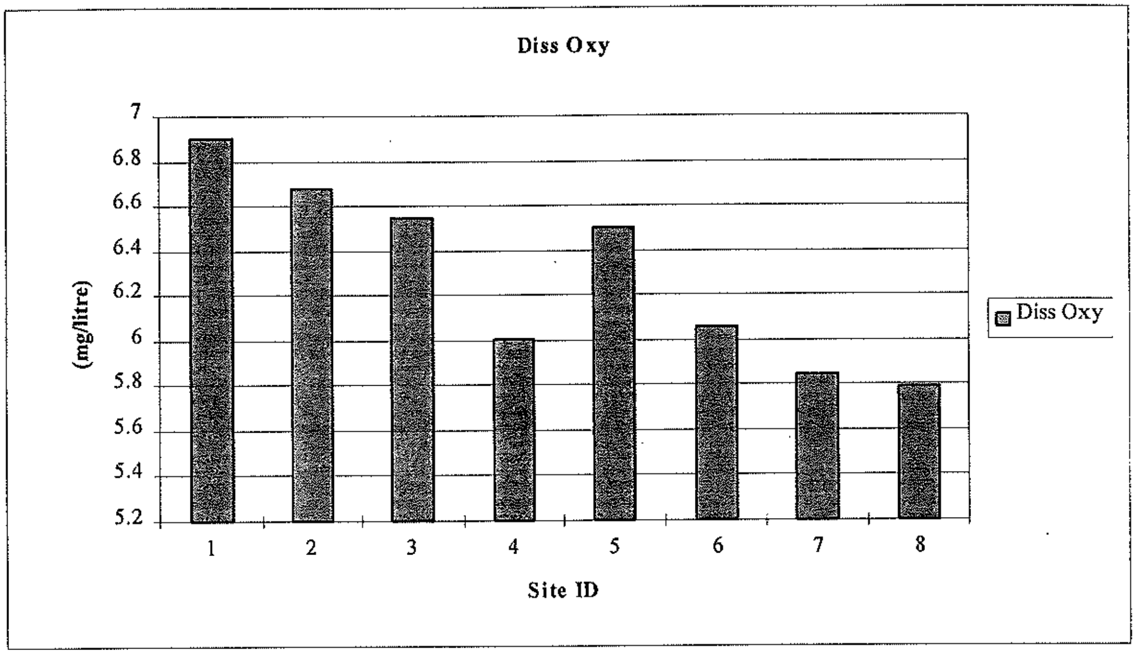



Figure B.20 Fecal Coliform July 08, 1993

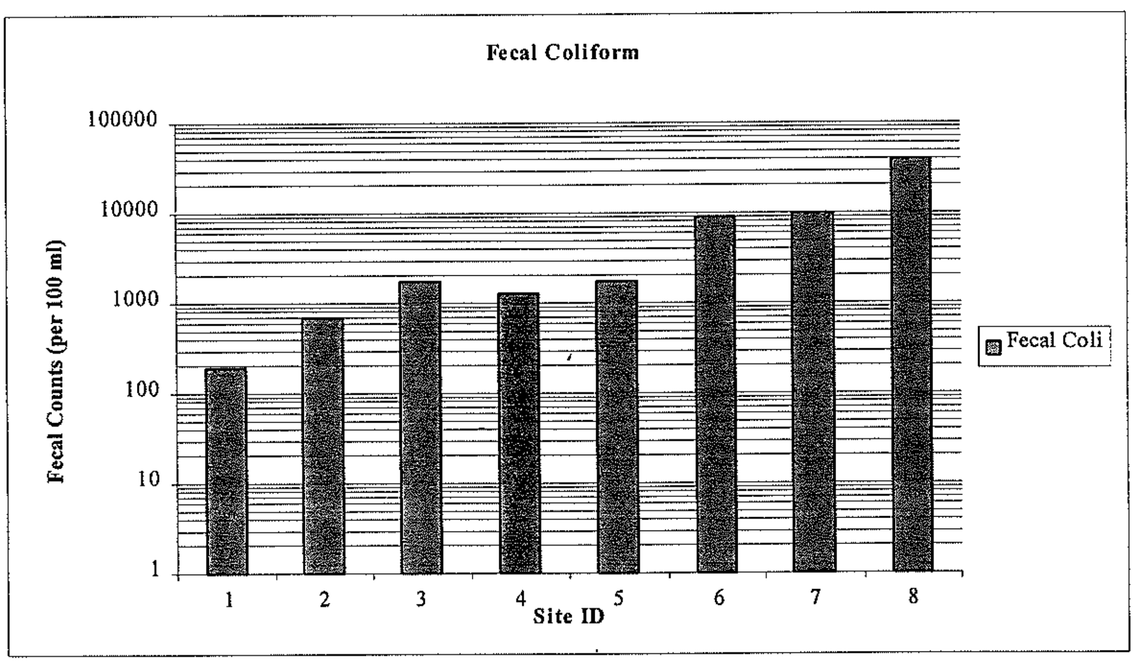


Figure B.21 Dissolved Oxygen July 23, 1993

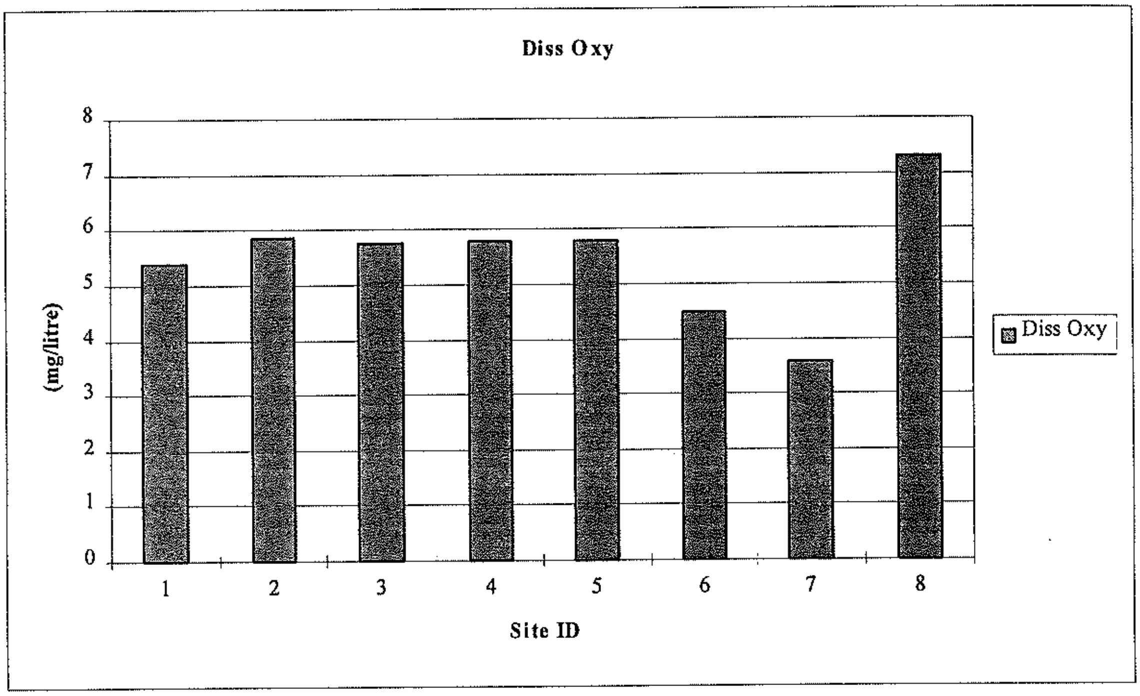



Figure B.22 Fecal Coliform July 23, 1993

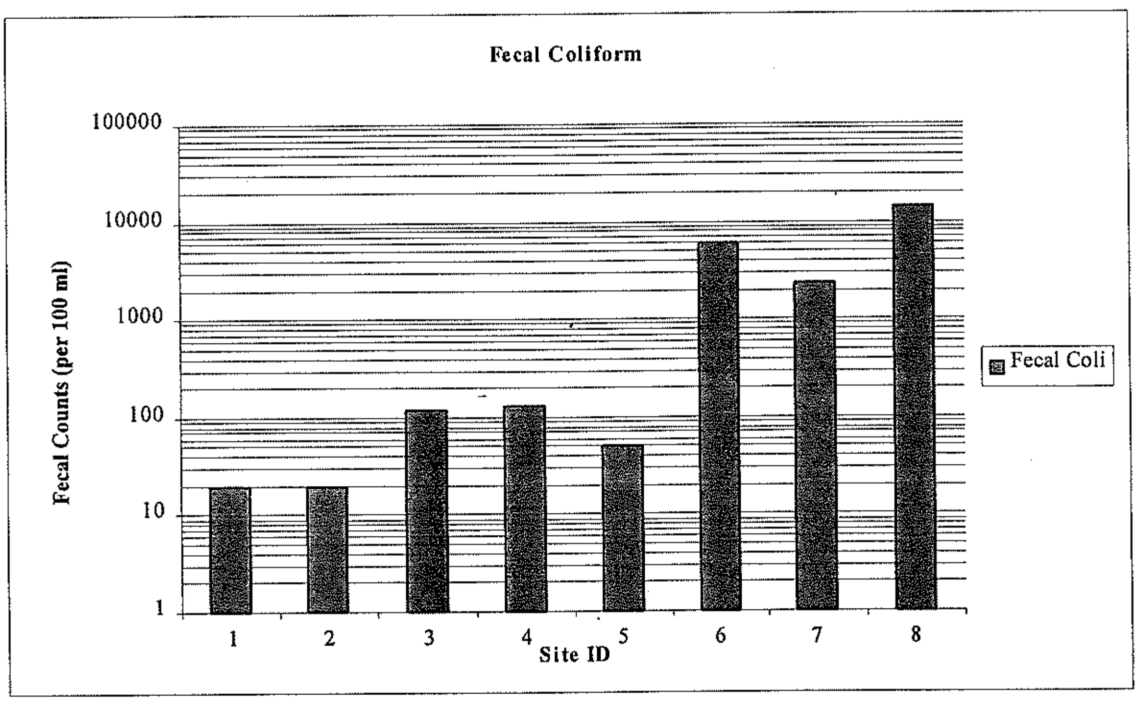


Figure B.23 Dissolved Oxygen July 27, 1993

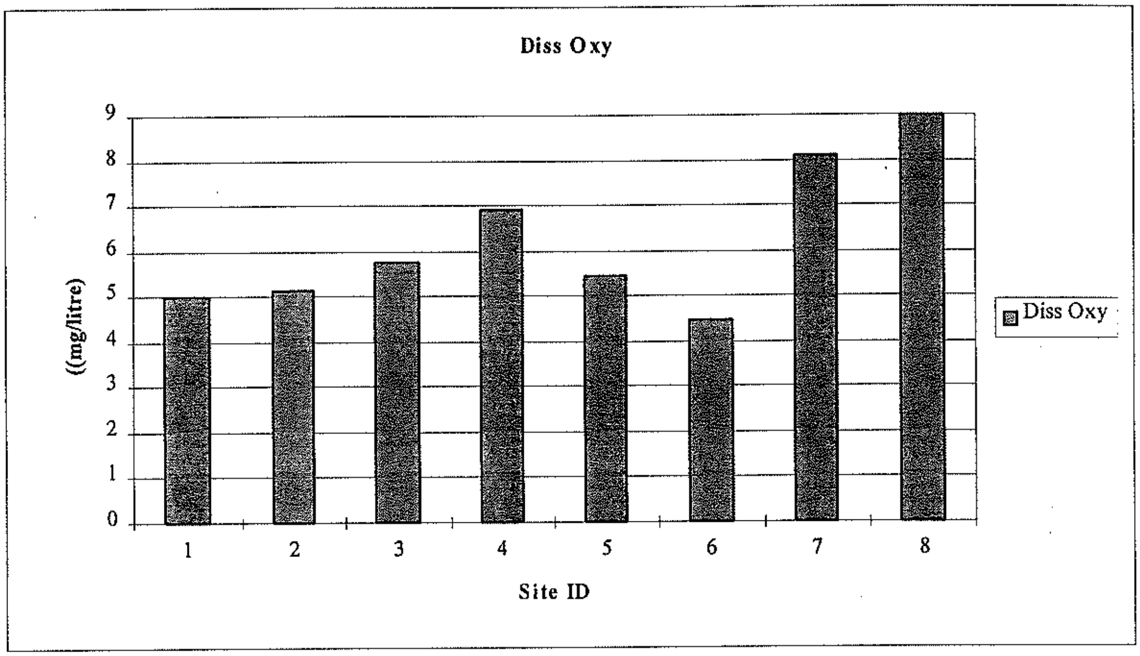



Figure B.24 Fecal Coliform July 27, 1993

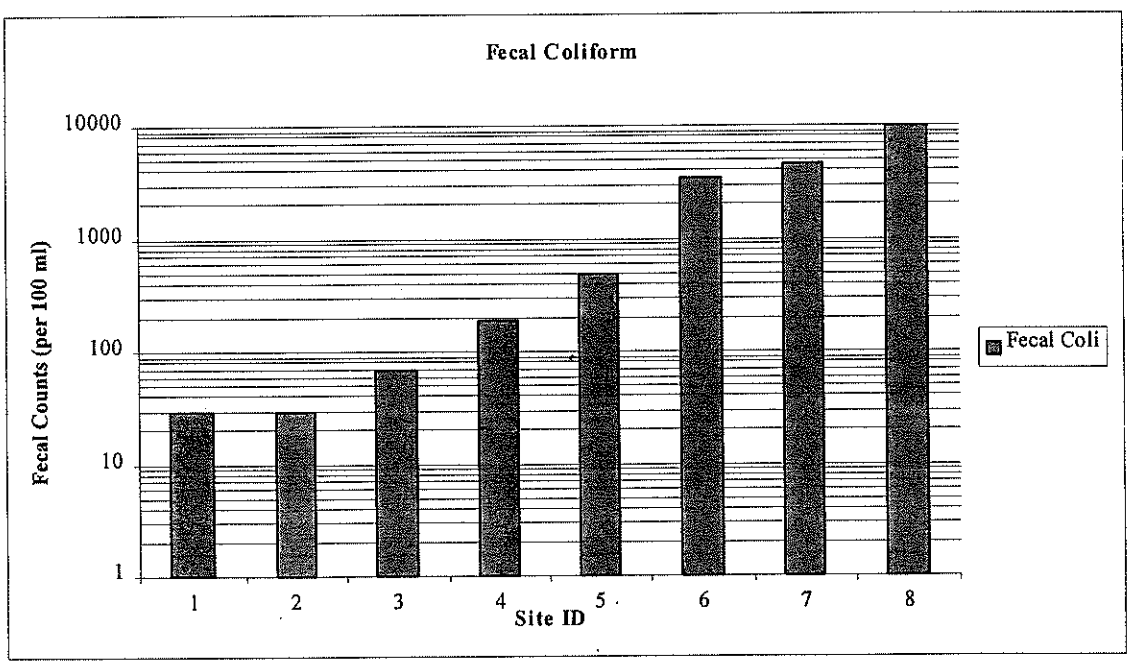


Figure B.25 Dissolved Oxygen July 29, 1993

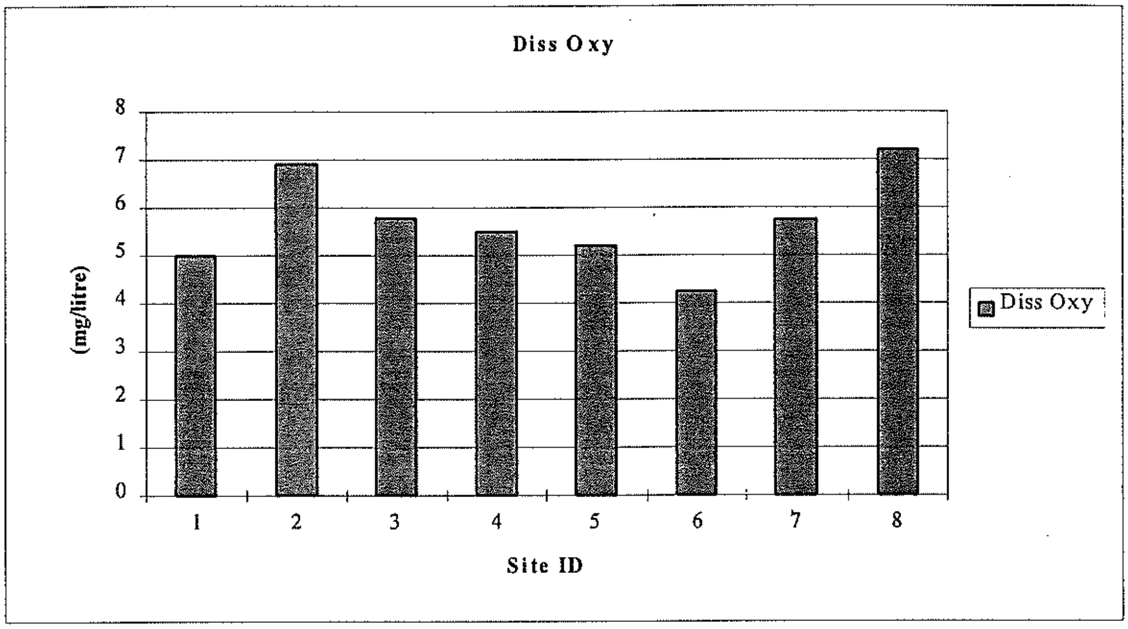



Figure B.26 Fecal Coliform July 29, 1993

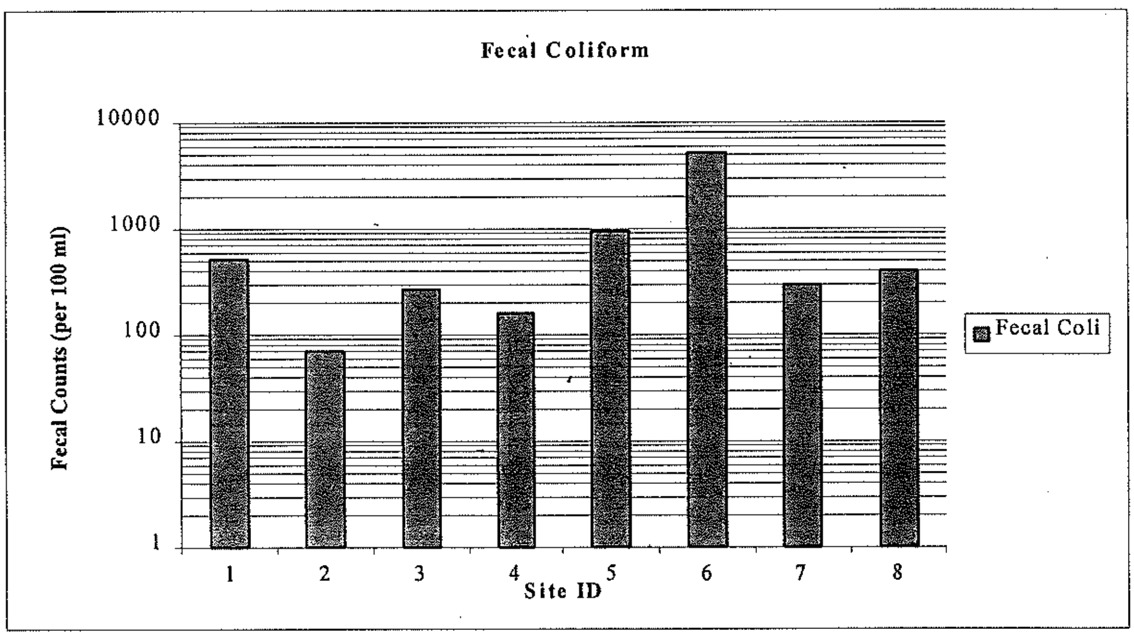


Figure B.27 Dissolved Oxygen August 20, 1993

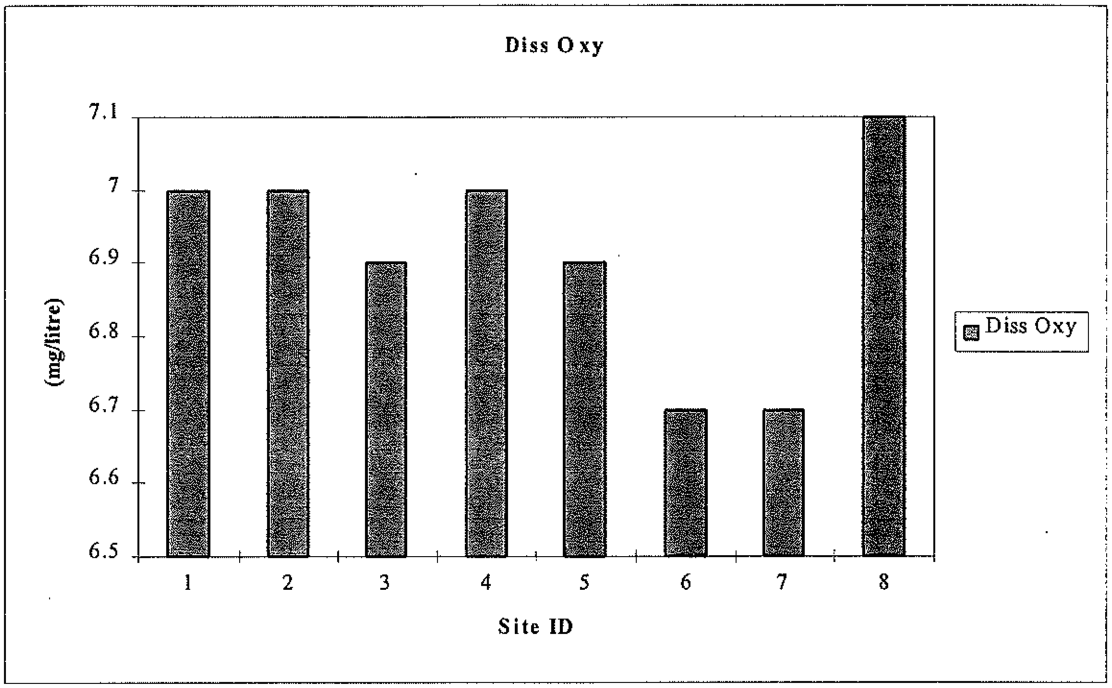



Figure B.28 Fecal Coliform August 20, 1993

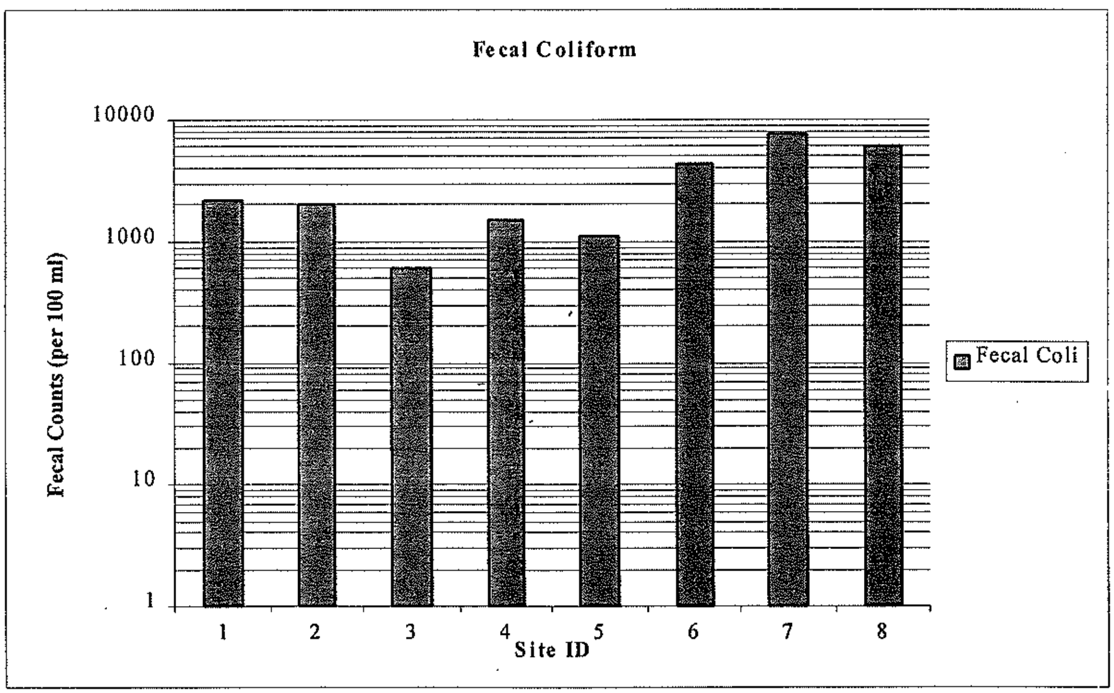


Figure B.29 Dissolved Oxygen August 23, 1993

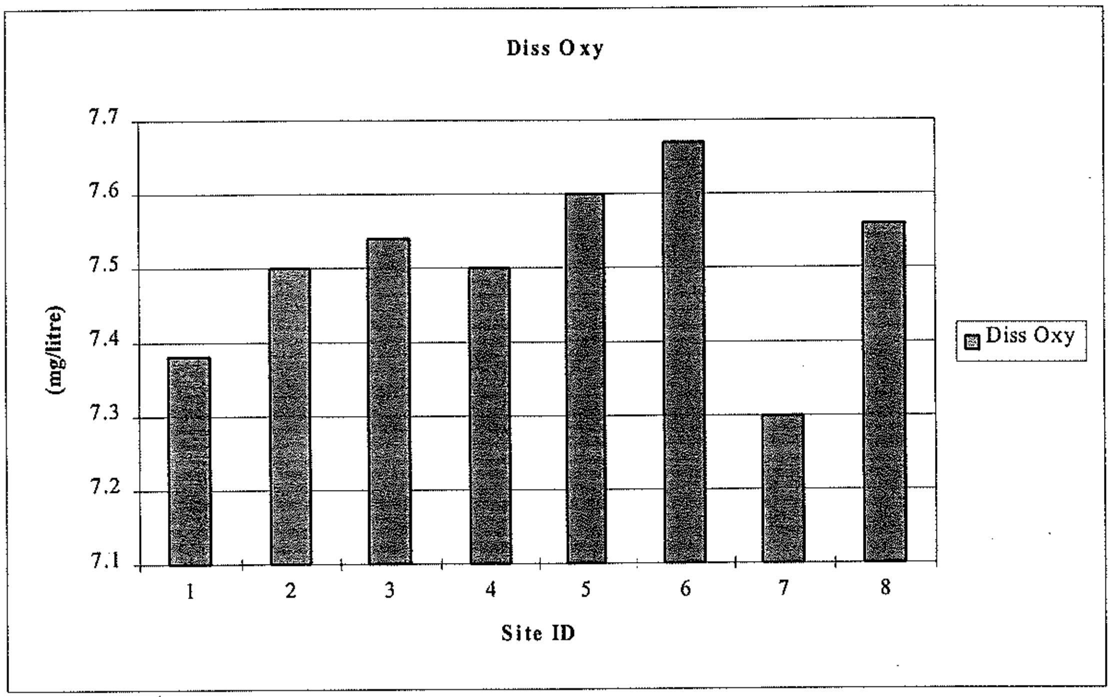



Figure B.30 Fecal Coliform August 23, 1993

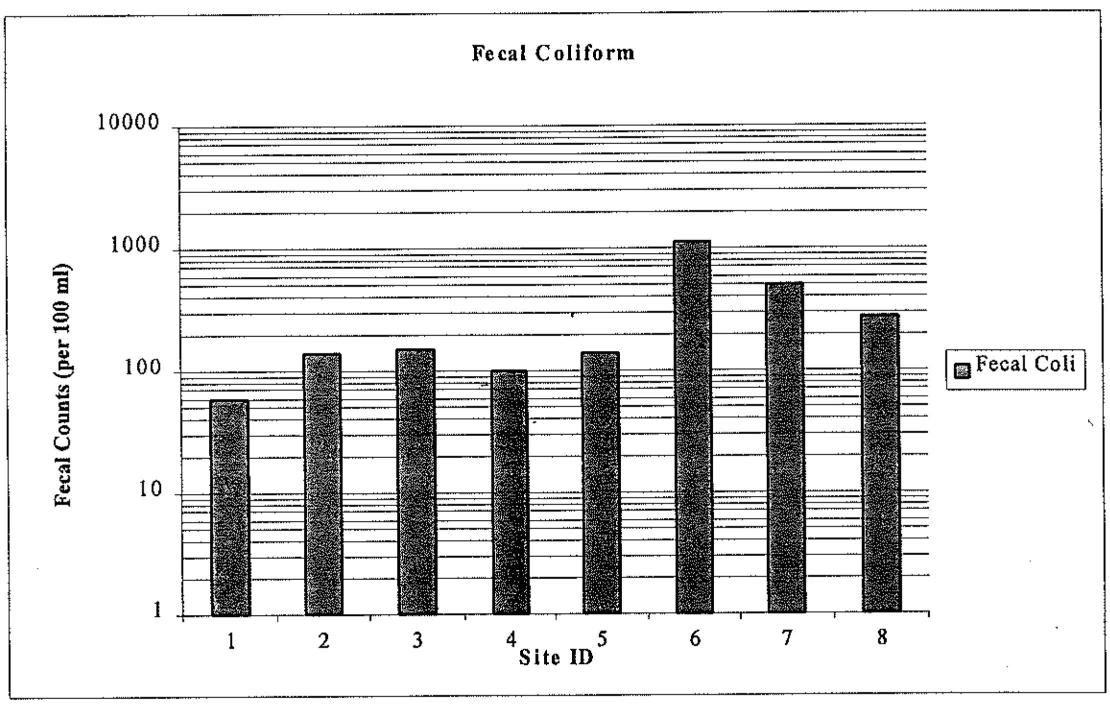


Figure B.31 Dissolved Oxygen August 26, 1993

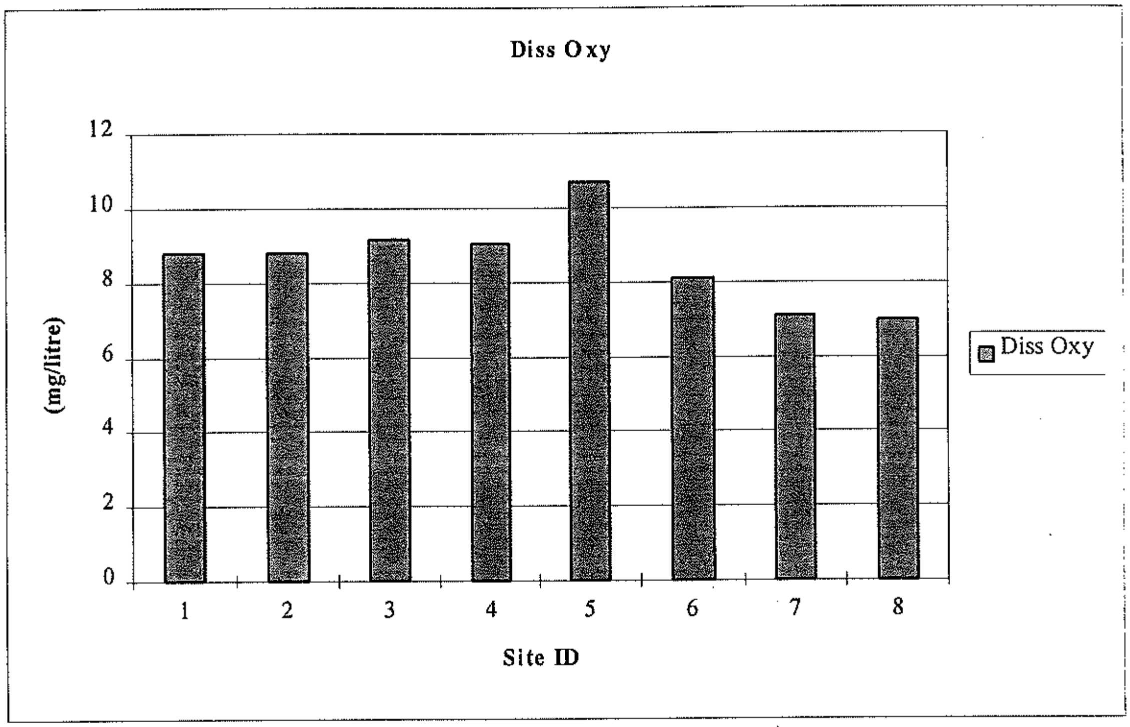



Figure B.32 Fecal Coliform August 26, 1993

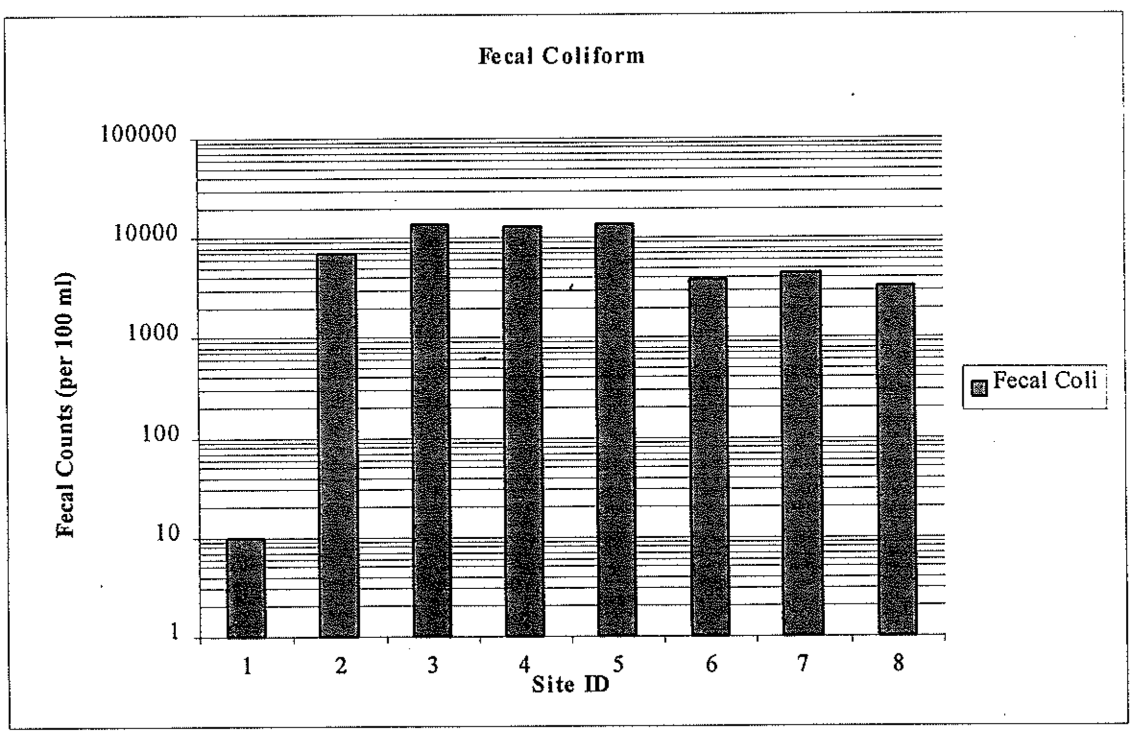


Figure B.33 Dissolved Oxygen August 31, 1993

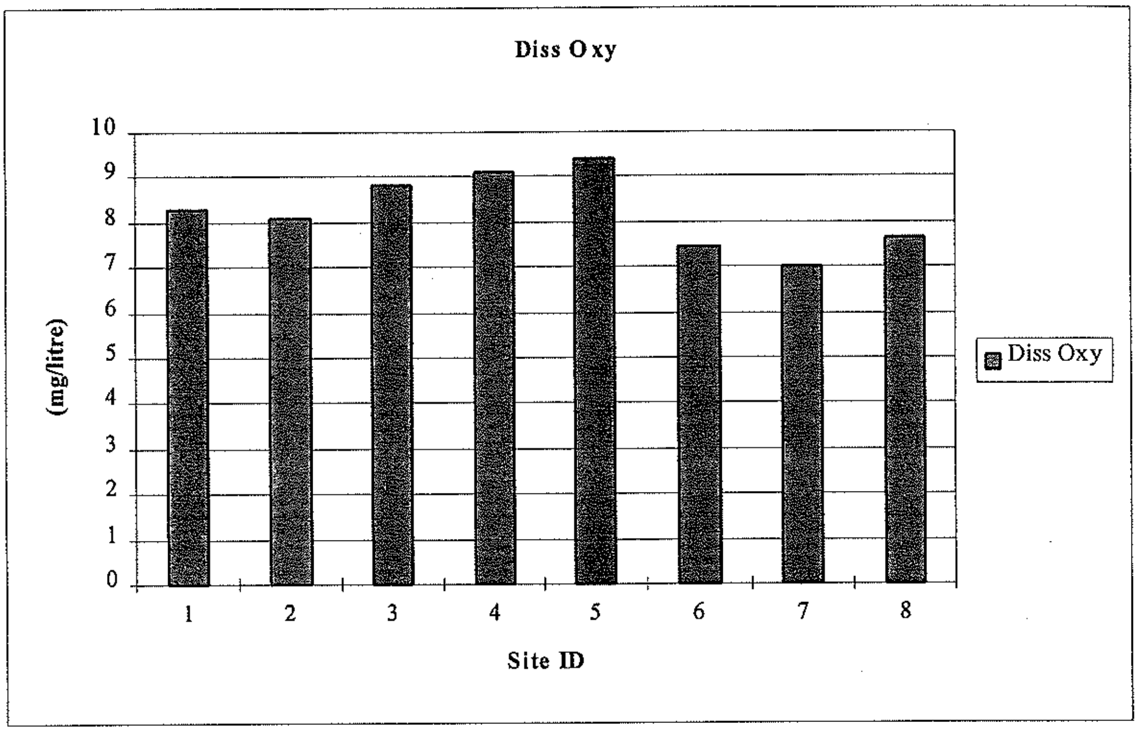
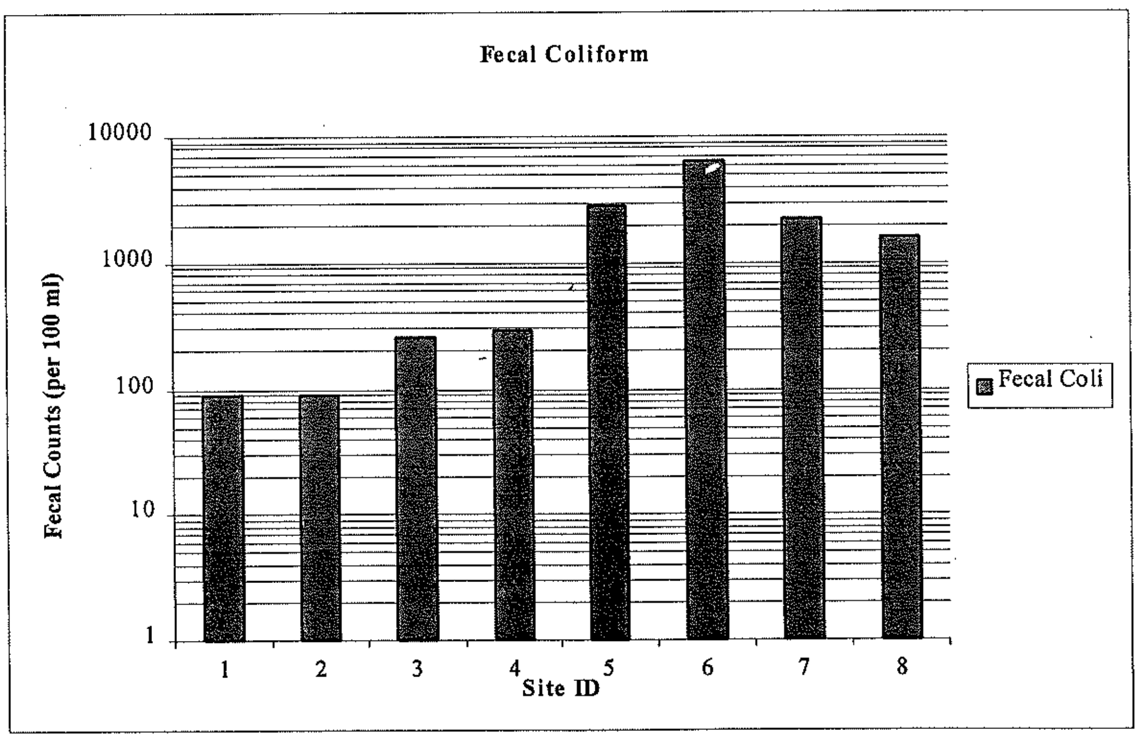



Figure B.34 Fecal Coliform August 31, 1993



# APPENDIX C

Table C.1 Stream Water Quality Parameters on June 07, 1994

| ID | Diss Oxy | BOD | Fecal Coliform | Fecal Strep | TSS | VSS | TMP | COND |
|---|---|---|---|---|---|---|---|---|
| 1 | 12.30 | 1 | 20 | 60 | --- | --- | 26 | 301 |
| 2 | 12.10 | 1 | 560 | 540 | --- | --- | 25 | 301 |
| 3 | 13.00 | --- | 8600 | 240 | --- | --- | 25 | 305 |
| 4 | 13.40 | 1 | 1600 | 520 | --- | --- | 24 | 304 |
| 5 | 15.50 | 3 | 1400 | 1200 | --- | --- | 24 | 290 |
| 6 | 14.70 | 1 | --- | --- | --- | --- | 24 | 286 |
| 7 | 15.10 | 6 | 480 | 400 | --- | --- | 24 | 287 |
| 8 | 14.10 | 3 | 3000 | 1360 | --- | --- | 24 | 288 |

Table C.2 Stream Water Quality Parameters on June 09, 1994

| ID | Diss Oxy | BOD | Fecal Coliform | Fecal Strep | TSS | VSS | TMP | COND |
|---|---|---|---|---|---|---|---|---|
| 1 | --- | 1 | 0 | 4 | 11 | 3 | --- | ---- |
| 2 | --- | 1 | 60 | 10 | 16 | 3 | --- | --- |
| 3 | --- | 1 | 0 | 4 | 13 | 5 | --- | --- |
| 4 | --- | 2 | 0 | 0 | 7 | 3 | --- | --- |
| 5 | --- | 2 | 2000 | 24 | 12 | 2 | --- | --- |
| 6 | --- | 2 | --- | --- | 18 | 4 | --- | --- |
| 7 | --- | 2 | 0 | 48 | 14 | 39 | --- | --- |
| 8 | --- | 2 | 4000 | 100 | 17 | 5 | --- | --- |

Table C.3 Stream Water Quality Parameters on June 14, 1994

| ID | Diss Oxy | BOD | Fecal Coliform | Fecal Strep | TSS | VSS | TMP | COND |
|---|---|---|---|---|---|---|---|---|
| 1 | 8.24 | 1 | 48 | 4 | --- | --- | 27 | 358 |
| 2 | 8.47 | 1 | 100 | 8 | --- | --- | 26 | 352 |
| 3 | --- | --- | 180 | 44 | --- | --- | --- | --- |
| 4 | 8.60 | 2 | 200 | 46 | --- | --- | 26 | 365 |
| 5 | 8.13 | 1 | 3000 | 60 | --- | --- | 26 | 363 |
| 6 | 8.14 | 1 | 800 | 96 | --- | --- | 26 | 360 |
| 7 | 8.08 | 2 | 460 | 24 | --- | --- | 27 | 359 |
| 8 | 8.49 | 1 | 380 | 12 | --- | --- | 26 | 357 |

Table C.4 Stream Water Quality Parameters on June 16, 1994

| ID | Diss Oxy | BOD | Fecal Coliform | Fecal Strep | TSS | VSS | TMP | COND |
|---|---|---|---|---|---|---|---|---|
| 1 | 8.06 | --- | 36 | 46 | --- | --- | 27 | 347 |
| 2 | 8.11 | --- | 40 | 32 | --- | --- | 27 | 346 |
| 3 | --- | --- | 100 | 920 | --- | --- | --- | --- |
| 4 | 8.29 | --- | 400 | 180 | --- | --- | 27 | 349 |
| 5 | 6.88 | --- | 140 | 74 | --- | --- | 27 | 363 |
| 6 | 6.73 | --- | 80 | 58 | --- | --- | 27 | 365 |
| 7 | 6.70 | --- | 160 | 70 | --- | --- | 26 | 365 |
| 8 | 6.64 | --- | 480 | 92 | --- | --- | 26 | 367 |

Table C.5 Stream Water Quality Parameters on June 21, 1994

| ID | Diss Oxy | BOD | Fecal Coliform | Fecal Strep | TSS | VSS | TMP | COND |
|---|---|---|---|---|---|---|---|---|
| 1 | 6.16 | 1 | 32 | 28 | 2 | 0 | 31 | 350 |
| 2 | 5.80 | 1 | 20 | 8 | 12 | 0 | 31 | 352 |
| 3 | --- | --- | 34 | 46 | --- | --- | --- | --- |
| 4 | 6.15 | 1 | 120 | 12 | 14 | 0 | 31 | 353 |
| 5 | 7.12 | 2 | 1220 | 240 | 4 | 1 | 30 | 353 |
| 6 | 8.36 | 3 | 900 | 200 | 4 | 3 | 30 | 353 |
| 7 | 7.80 | 5 | 3600 | 960 | 1 | 0 | 30 | 352 |
| 8 | 7.88 | 3 | 940 | 560 | 2 | 5 | 29 | 352 |

Table C.6 Stream Water Quality Parameters on June 27, 1994

| ID | Diss Oxy | BOD | Fecal Coliform | Fecal Strep | TSS | VSS | TMP | COND |
|---|---|---|---|---|---|---|---|---|
| 1 | 5.49 | --- | 200 | 1600 | --- | --- | 26 | 355 |
| 2 | 5.37 | 4 | 240 | 1680 | 41 | 16 | 26 | 356 |
| 3 | 6.34 | 4 | 7000 | 13200 | 97 | 9 | 25 | 369 |
| 4 | 6.16 | 4 | 4800 | 9600 | 81 | 8 | 24 | 369 |
| 5 | 3.72 | 3 | 18000 | 5600 | 53 | 5 | 26 | 353 |
| 6 | 3.60 | 4 | 22000 | 5200 | 43 | 15 | 26 | 354 |
| 7 | 3.66 | 5 | 26000 | 5000 | 48 | 5 | 26 | 351 |
| 8 | 3.45 | --- | 10400 | 6400 | 36 | 22 | 26 | 353 |

Table C.7 Stream Water Quality Parameters on July 02, 1994

| ID | Diss Oxy | BOD | Fecal Coliform | Fecal Strep | TSS | VSS | TMP | COND |
|---|---|---|---|---|---|---|---|---|
| 1 | 9.79 | --- | 40 | 100 | 11 | 7 | 27 | 342 |
| 2 | 9.30 | --- | 2400 | 800 | 19 | 6 | 27 | 348 |
| 3 | 8.64 | --- | 3600 | 620 | 22 | 6 | 27 | 361 |
| 4 | 8.50 | --- | 920 | 620 | 22 | 7 | 27 | 362 |
| 5 | 5.80 | --- | 400 | 100 | 16 | 5 | 27 | 383 |
| 6 | 5.96 | --- | 1200 | 140 | 21 | 5 | 27 | 393 |
| 7 | 5.58 | --- | 1800 | 120 | 16 | 5 | 27 | 394 |
| 8 | 7.84 | --- | 200 | 2200 | 19 | 11 | 27 | 422 |

Table C.8 Stream Water Quality Parameters on July 06, 1994

| ID | Diss Oxy | BOD | Fecal Coliform | Fecal Strep | TSS | VSS | TMP | COND |
|---|---|---|---|---|---|---|---|---|
| 1 | 9.43 | 2 | 150 | 162 | 16 | 7 | 29 | 356 |
| 2 | 10.40 | 3 | 20 | 2 | 3 | 0 | 30 | 358 |
| 3 | 11.30 | 2 | 400 | 200 | 11 | 5 | 30 | 361 |
| 4 | 11.60 | 3 | 40 | 8 | 19 | 7 | 30 | 363 |
| 5 | 10.20 | 4 | 620 | 320 | 14 | 5 | 30 | 373 |
| 6 | 11.20 | 2 | 1000 | 120 | 20 | 6 | 30 | 394 |
| 7 | 11.20 | 3 | 1200 | 100 | 13 | 6 | 30 | 395 |
| 8 | 12.00 | 5 | 900 | 60 | 16 | 5 | 30 | 414 |

Table C.9 Stream Water Quality Parameters on July 14, 1994

| ID | Diss Oxy | BOD | Fecal Coliform | Fecal Strep | TSS | VSS | TMP | COND |
|---|---|---|---|---|---|---|---|---|
| 1 | 7.98 | 3 | 240 | 840 | 23 | 7 | 27 | 359 |
| 2 | 8.31 | 4 | 280 | 360 | 27 | 6 | 28 | 356 |
| 3 | 7.60 | 2 | 1760 | 1240 | 8 | 5 | 29 | 356 |
| 4 | 8.05 | 4 | 1360 | 1200 | 20 | 6 | 29 | 356 |
| 5 | 11.70 | 3 | 5600 | 620 | 8 | 5 | 29 | 400 |
| 6 | 10.60 | 3 | 1420 | 100 | 10 | 4 | 29 | 410 |
| 7 | 10.70 | 3 | 80 | 120 | 1 | 0 | 29 | 411 |
| 8 | 10.40 | 2 | 1360 | 1880 | --- | --- | 29 | 416 |

Table C.10 Stream Water Quality Parameters on July 28, 1994

| ID | Diss Oxy | BOD | Fecal Coliform | Fecal Strep | TSS | VSS | TMP | COND |
|---|---|---|---|---|---|---|---|---|
| 1 | 6.77 | 1 | 8 | 52 | 26 | 3 | 26 | 238 |
| 2 | 6.80 | 1 | 6 | 42 | 26 | 3 | 26 | 240 |
| 3 | 6.50 | 2 | 30 | 44 | 28 | 3 | 26 | 246 |
| 4 | 6.40 | 2 | 6 | 27 | 33 | 4 | 26 | 247 |
| 5 | 6.12 | 1 | 10 | 400 | 44 | 5 | 25 | 260 |
| 6 | 6.25 | 1 | 40 | 200 | 38 | 4 | 25 | 262 |
| 7 | 6.06 | 2 | 420 | 320 | 45 | 4 | 25 | 261 |
| 8 | 7.11 | 3 | 80 | 560 | 47 | 5 | 26 | 310 |

# APPENDIX D

Figure D.1 BOD and Dissolved Oxygen June 07, 1994

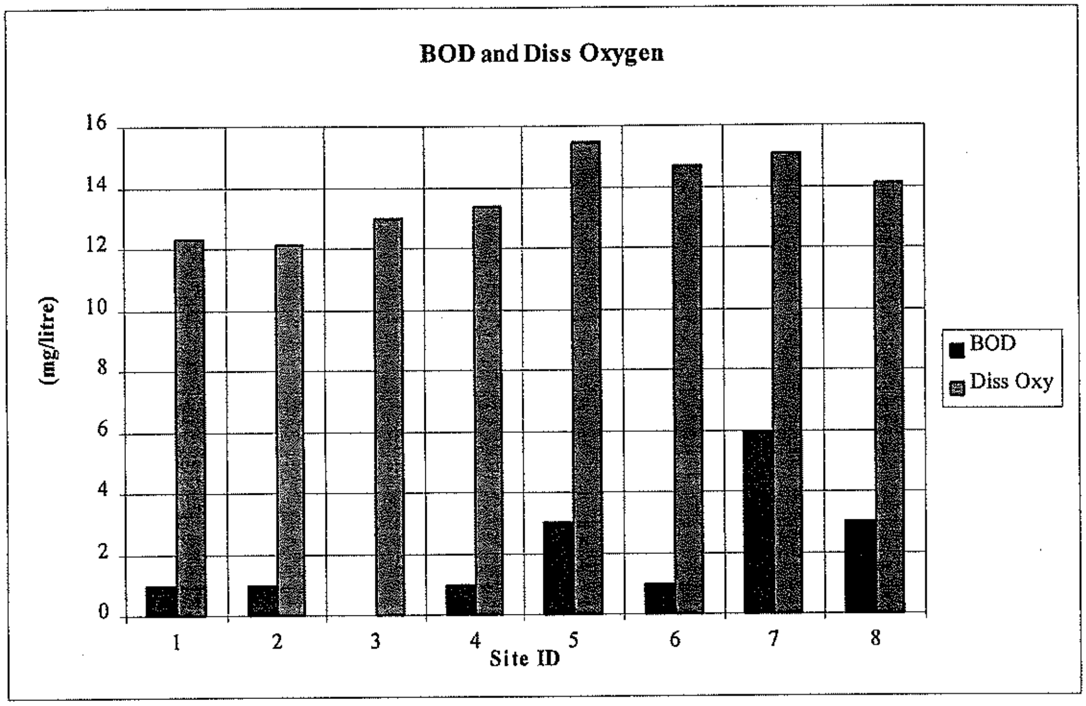



Figure D.2 Fecal Coliform and Fecal Strep June 07, 1994

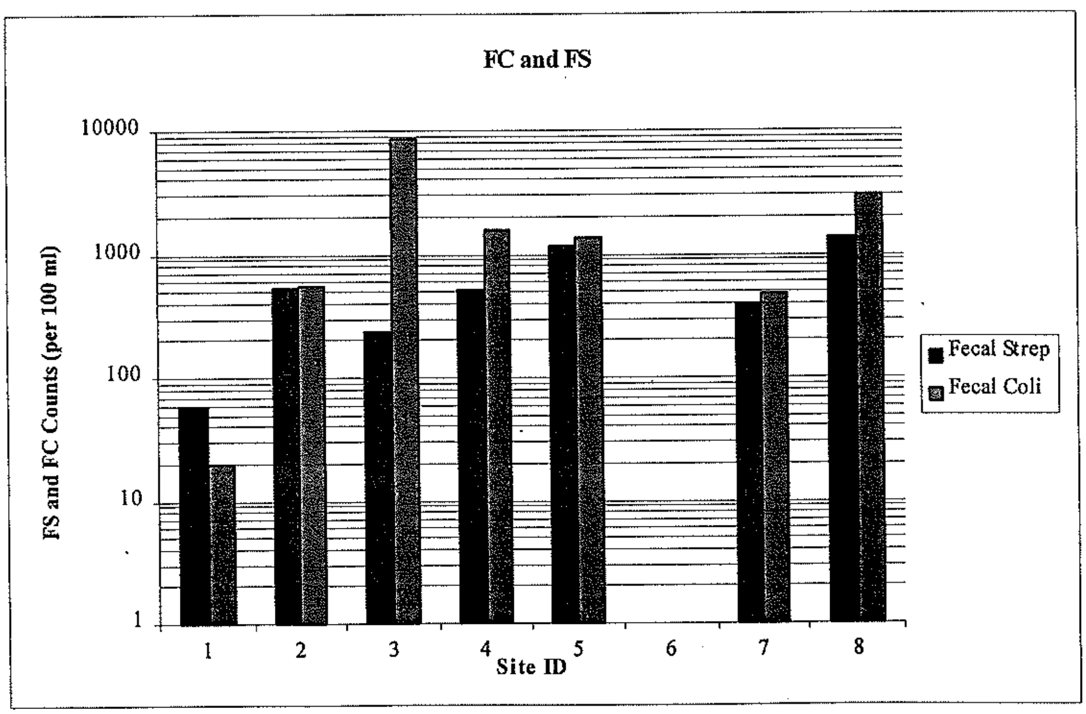


Figure D.3 BOD June 09, 1994

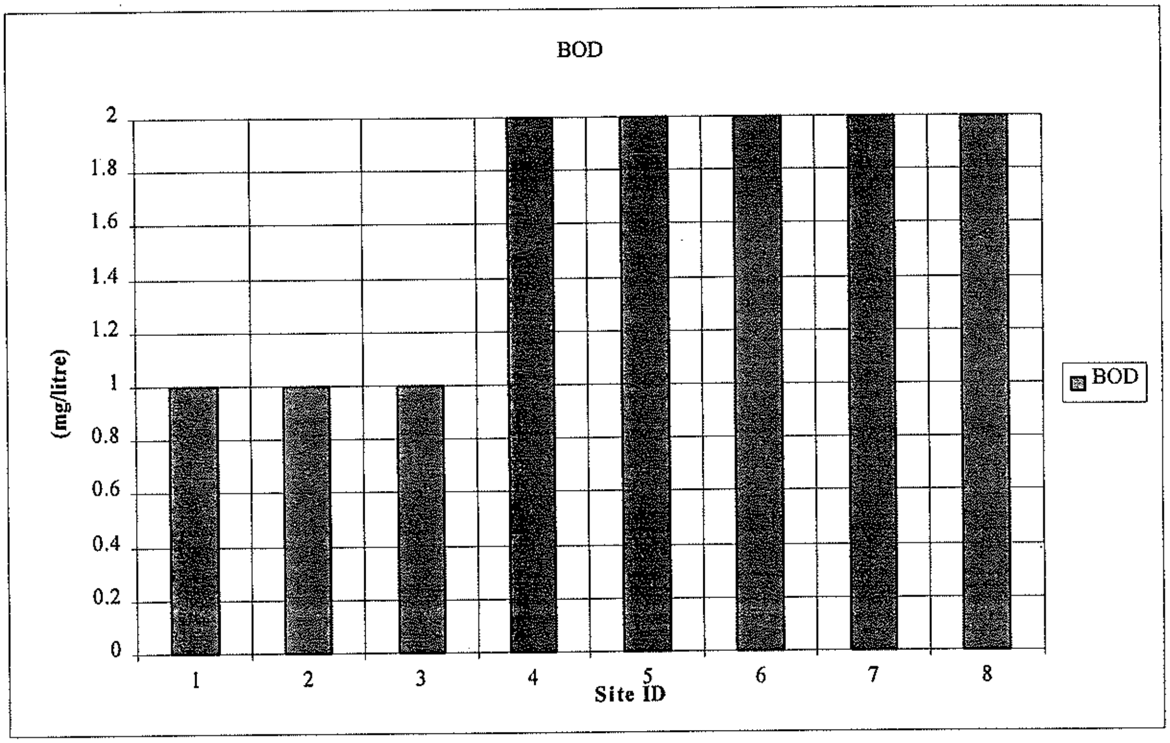



Figure D.4 Fecal Coliform and Fecal Strep June 09, 1994

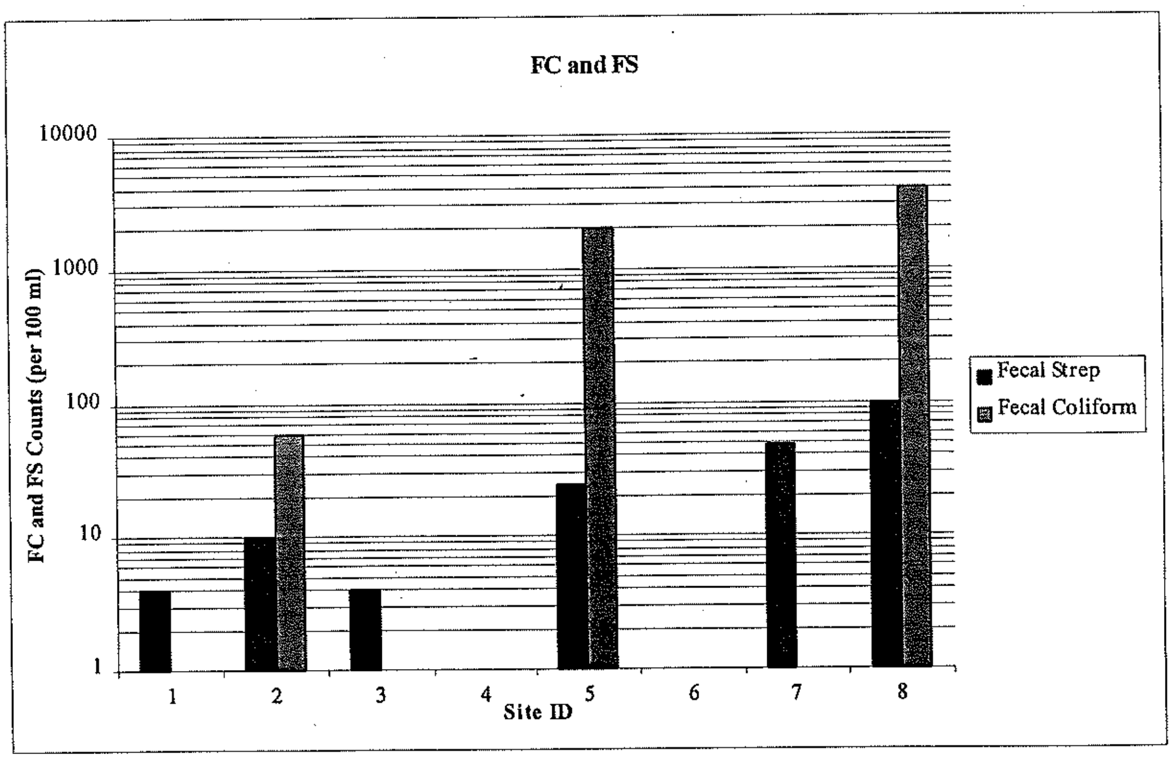


Figure D.5 Total and Volatile Suspended Solids June 09, 1994

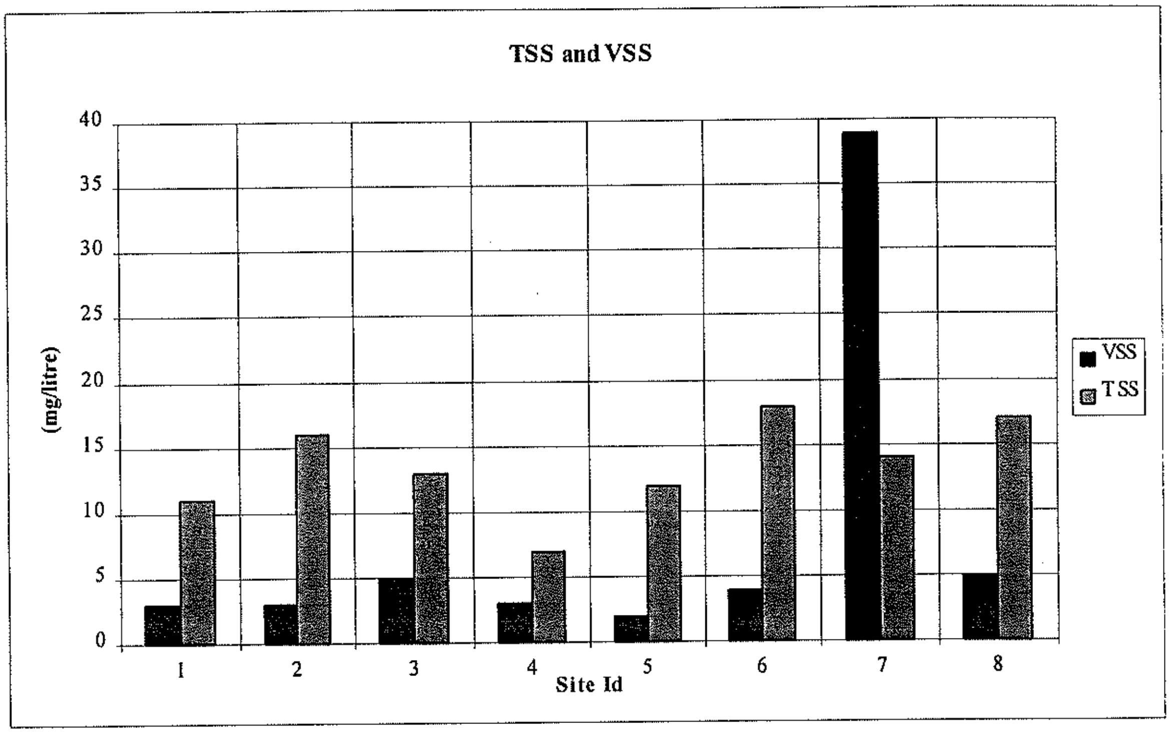


Figure D.6 BOD and Dissolved Oxygen June 14, 1995

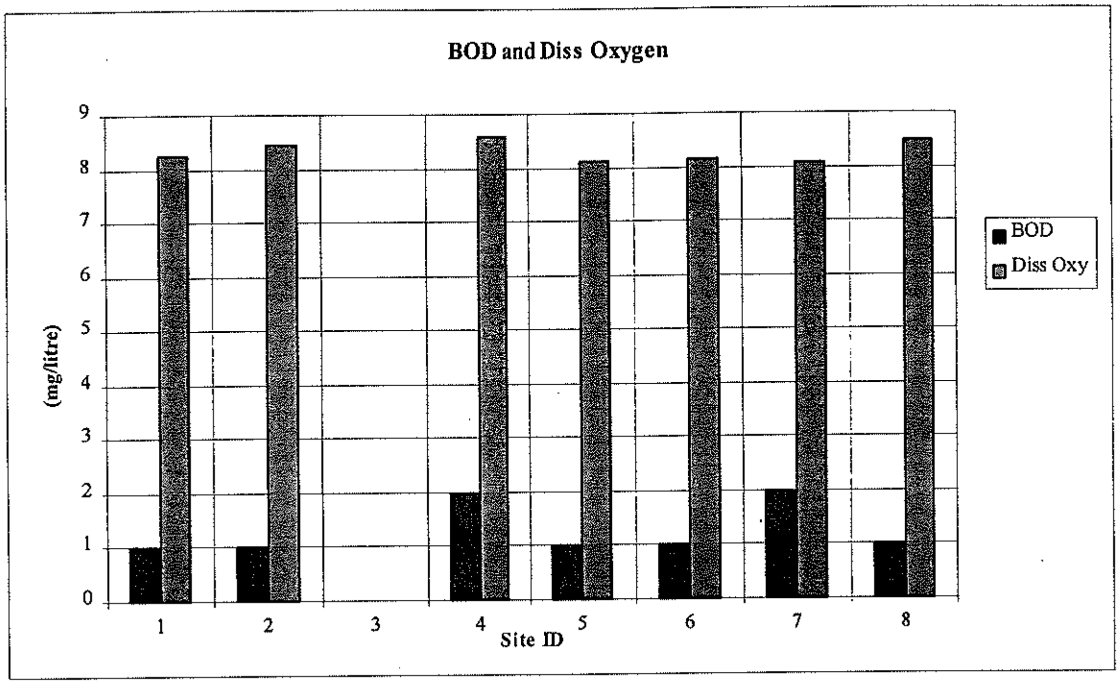



Figure D.7 Fecal Coliform and Fecal Strep June 14, 1995

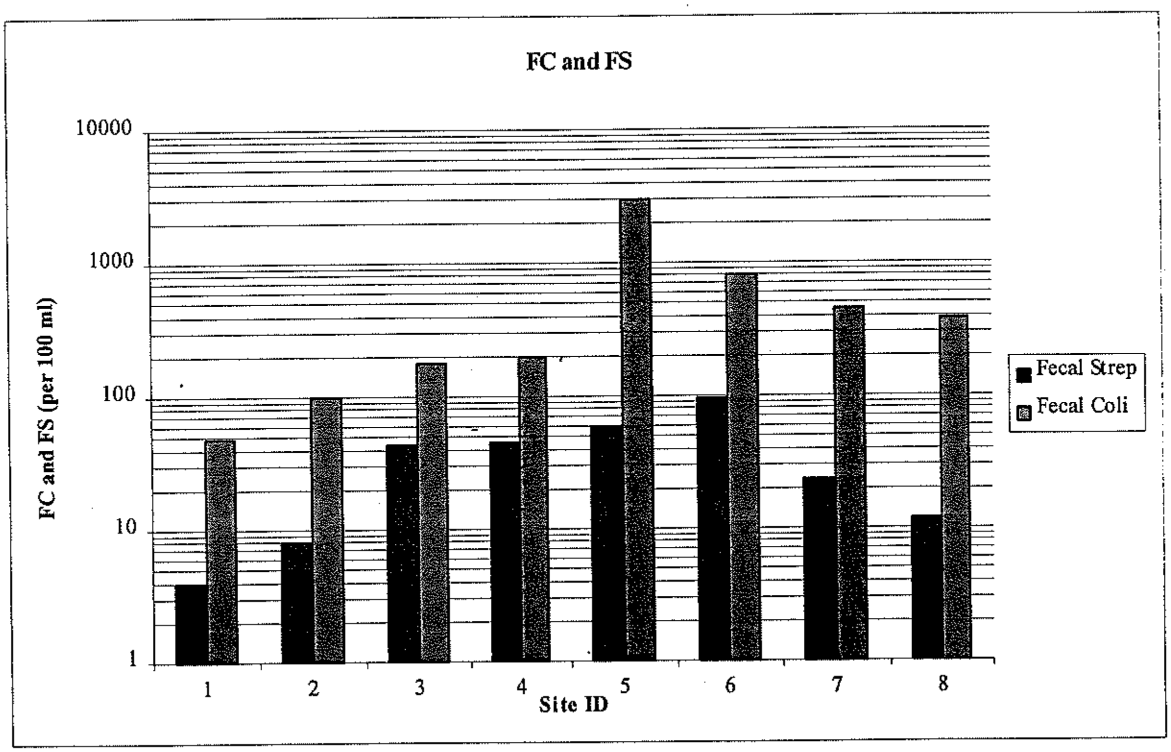


Figure D.8 Dissolved Oxygen June 16, 1994

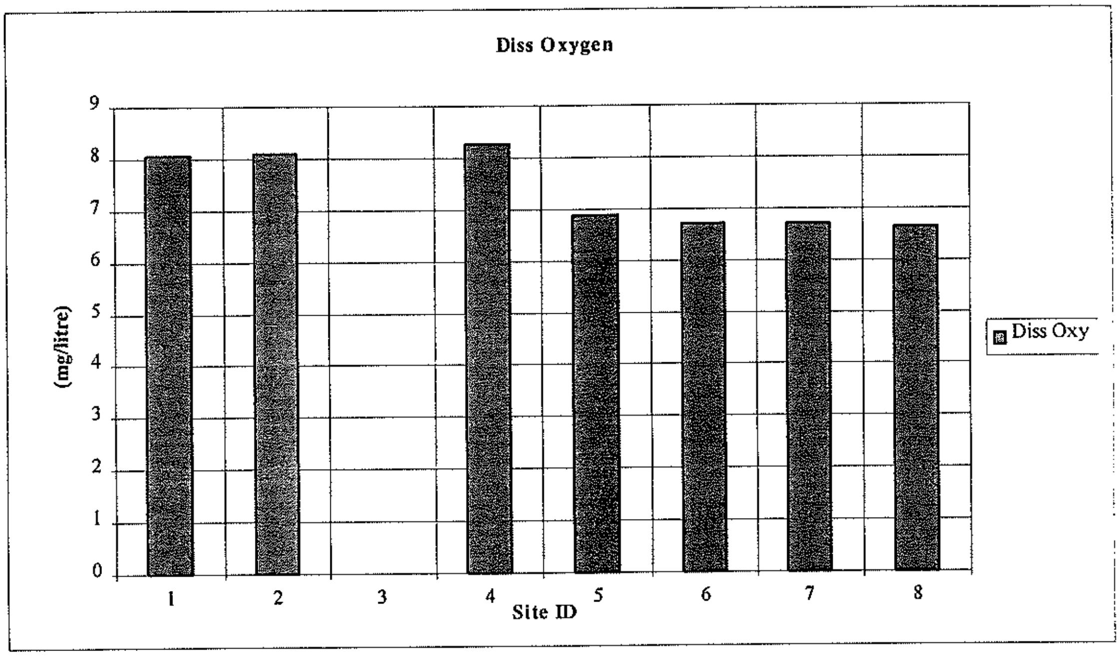



Figure D.9 Fecal Coliform and Fecal Strep June 16, 1994

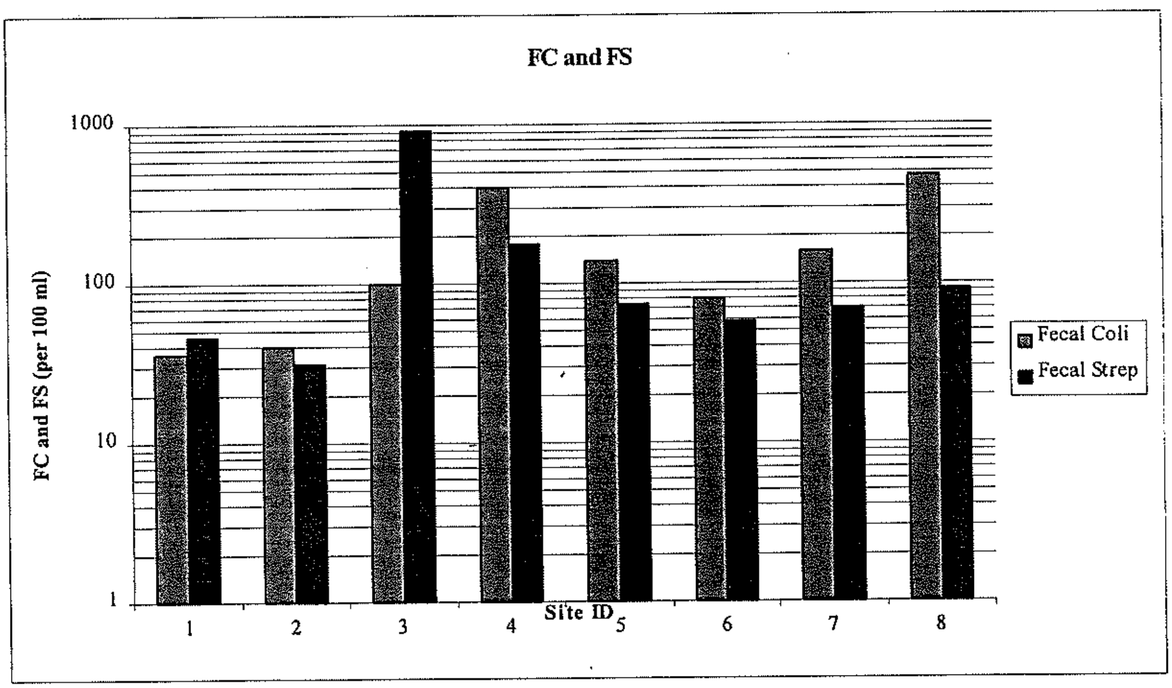


Figure D.10 BOD and Dissolved Oxygen June 21, 1994

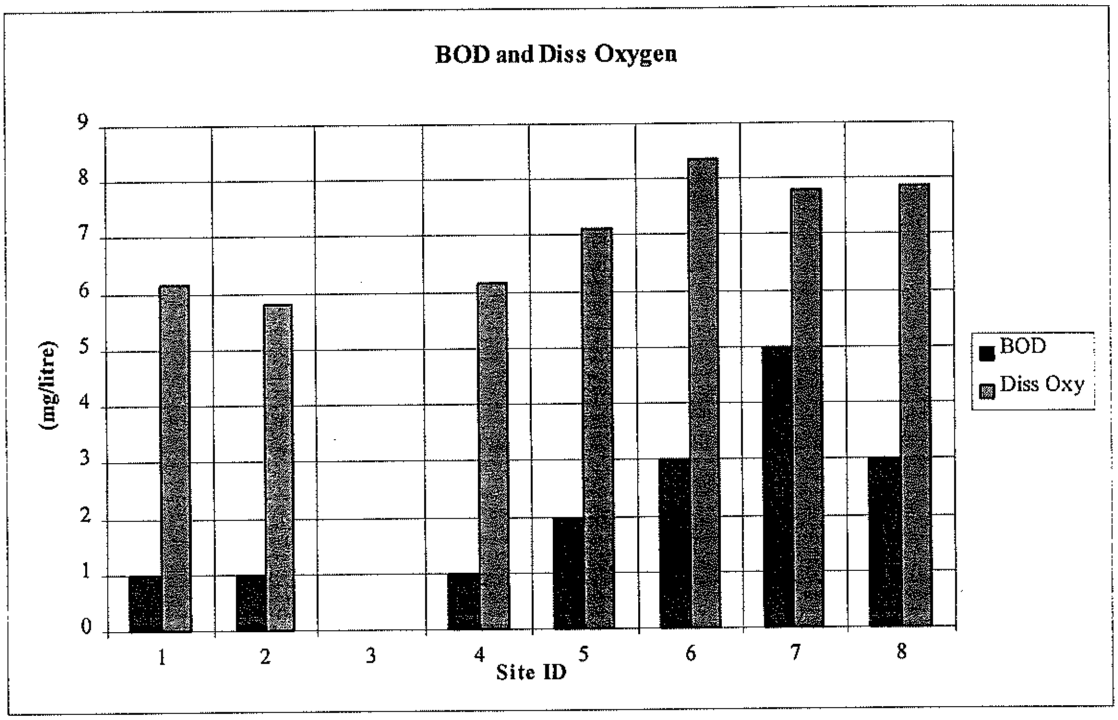



Figure D.11 Fecal Coliform and Fecal Strep June 21, 1994

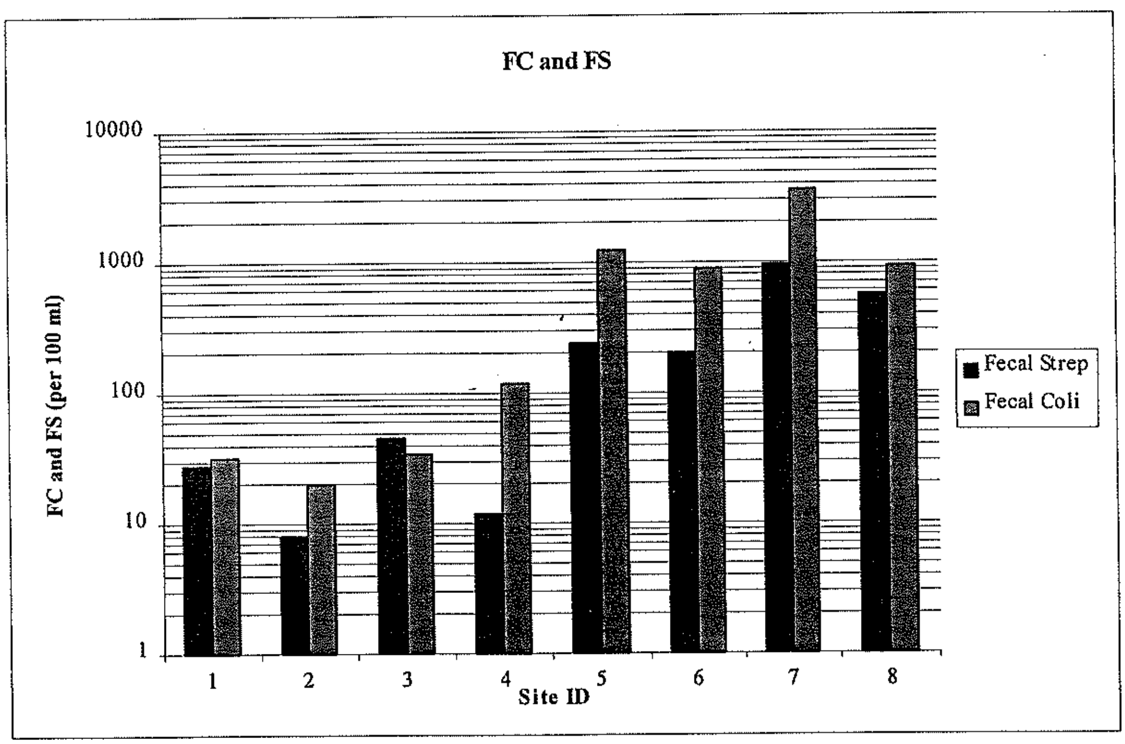


Figure D.12 Total and Volatile Suspended Solids June 21, 1994

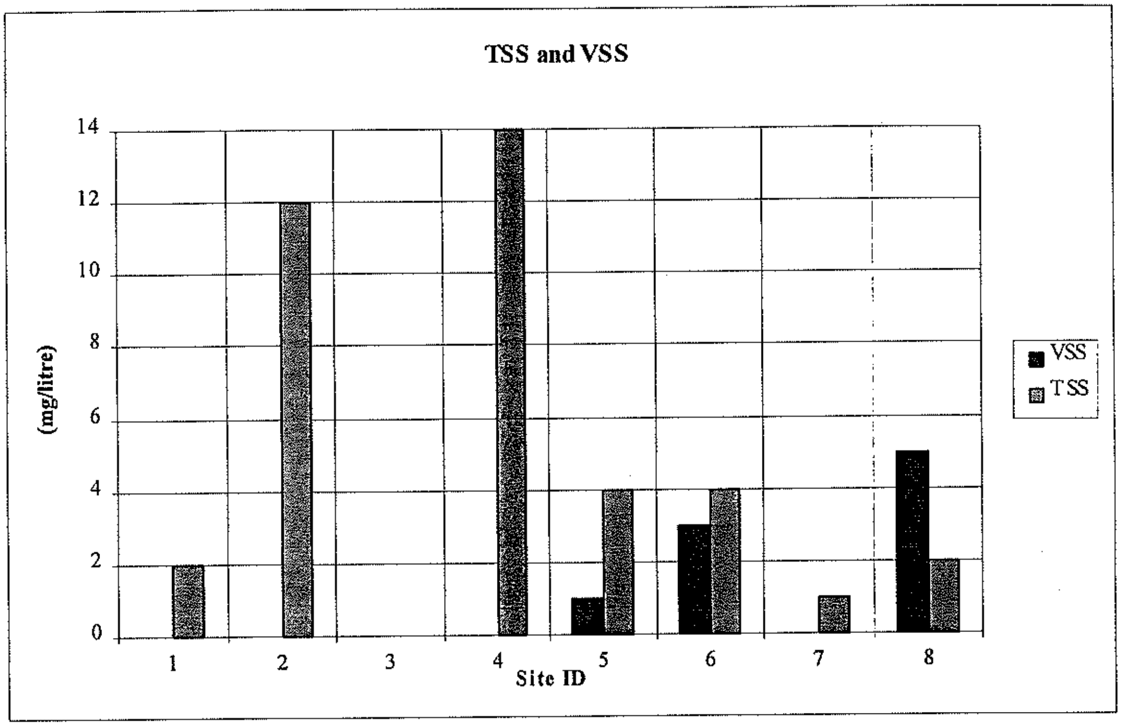


Figure D.13 BOD and Dissolved Oxygen June 27, 1994

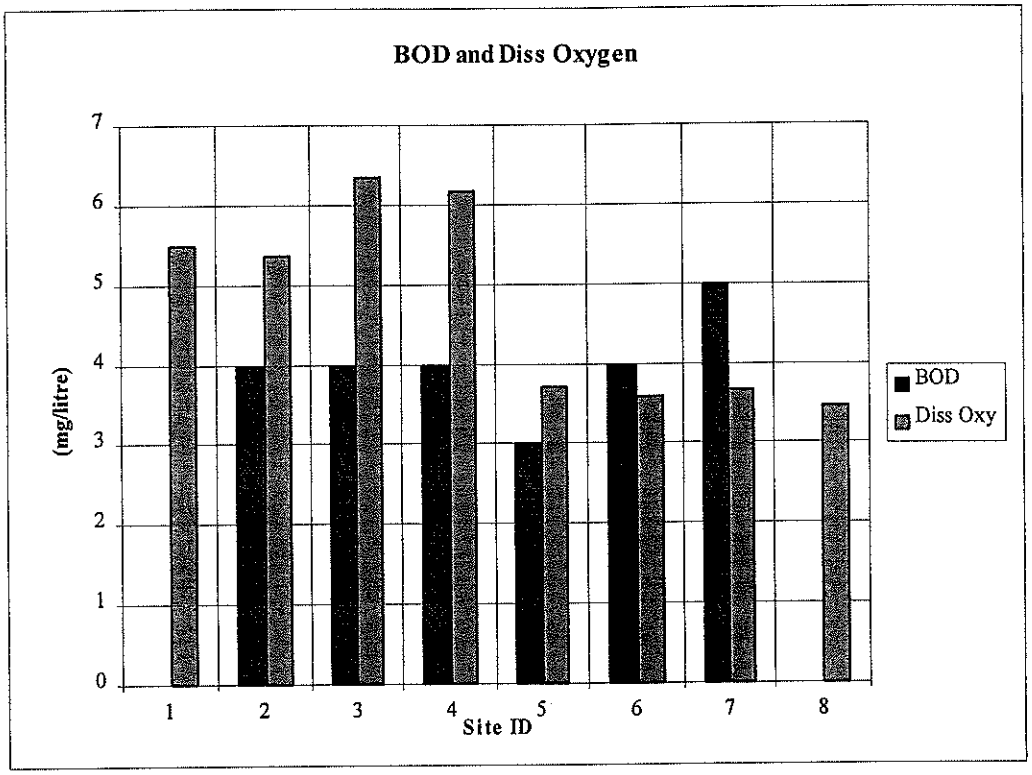



Figure D.14 Fecal Coliform and Fecal Strep June 27, 1994

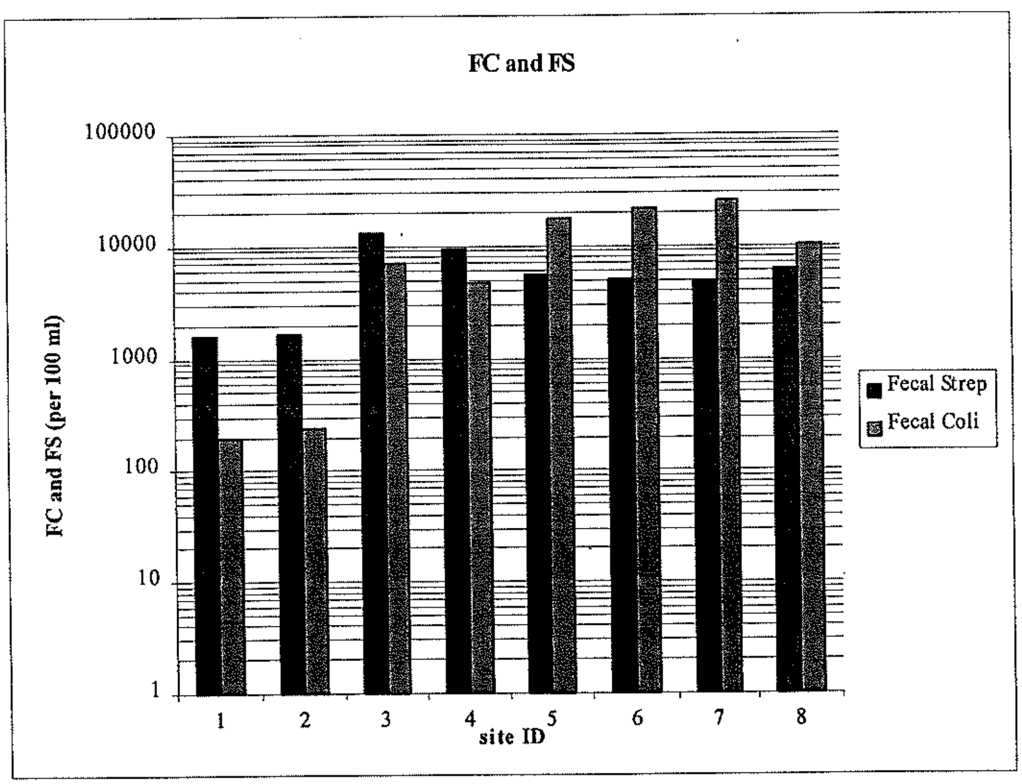


Figure D.15 Total and Volatile Suspended Solids June 27, 1994

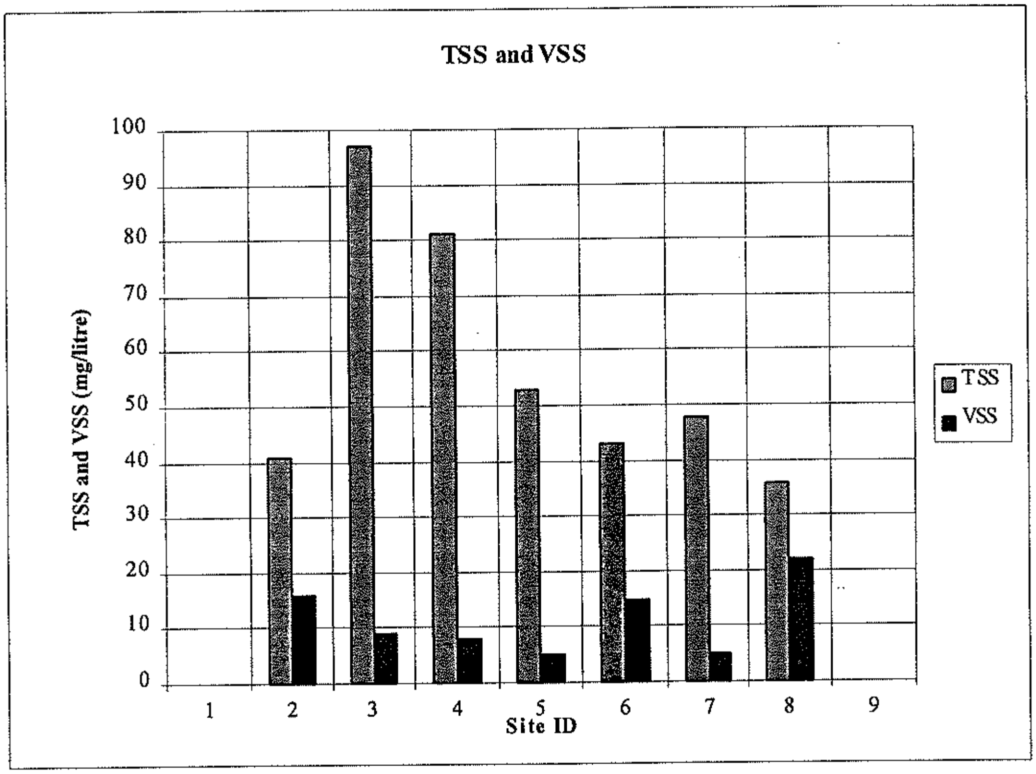


Figure D.16 Dissolved Oxygen July 02, 1994

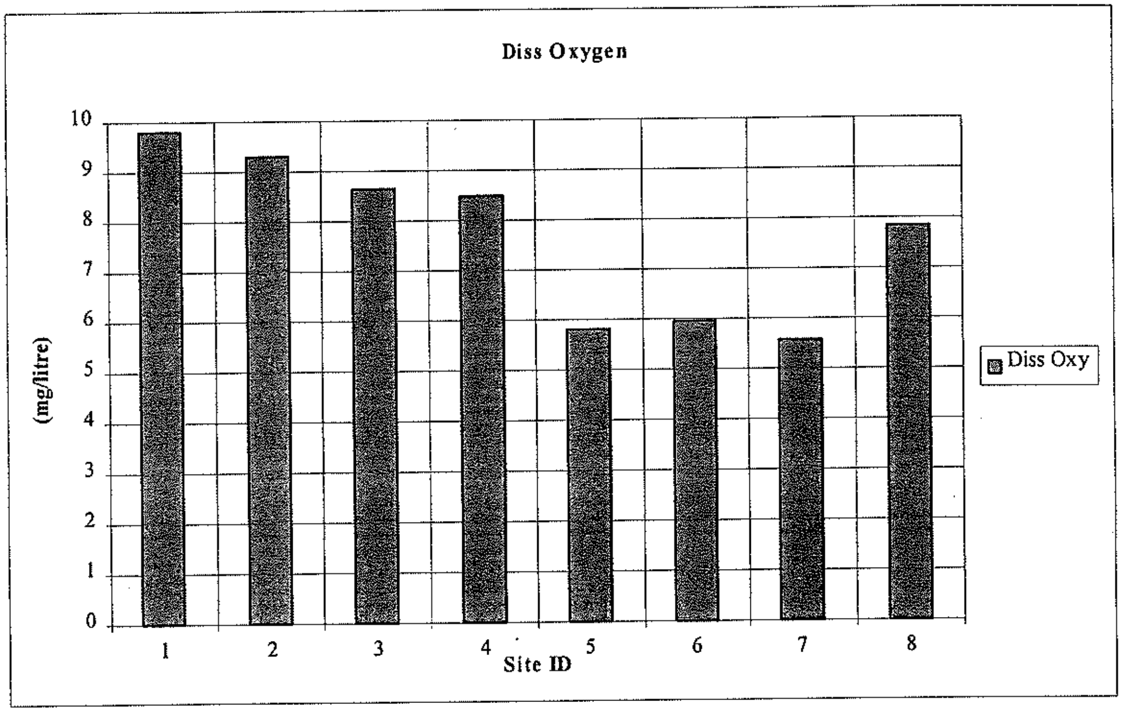



Figure D.17 Fecal Coliform and Fecal Strep July 02, 1994

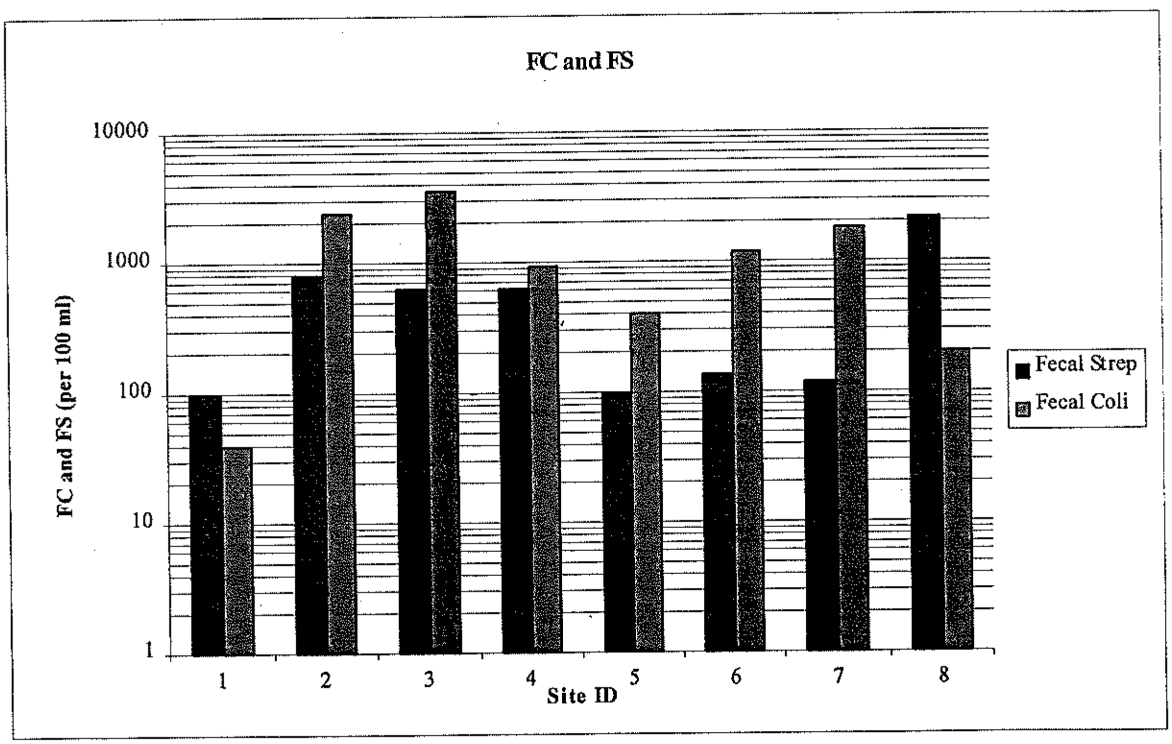


Figure D.18 Total and Volatile Suspended Solids July 02, 1994

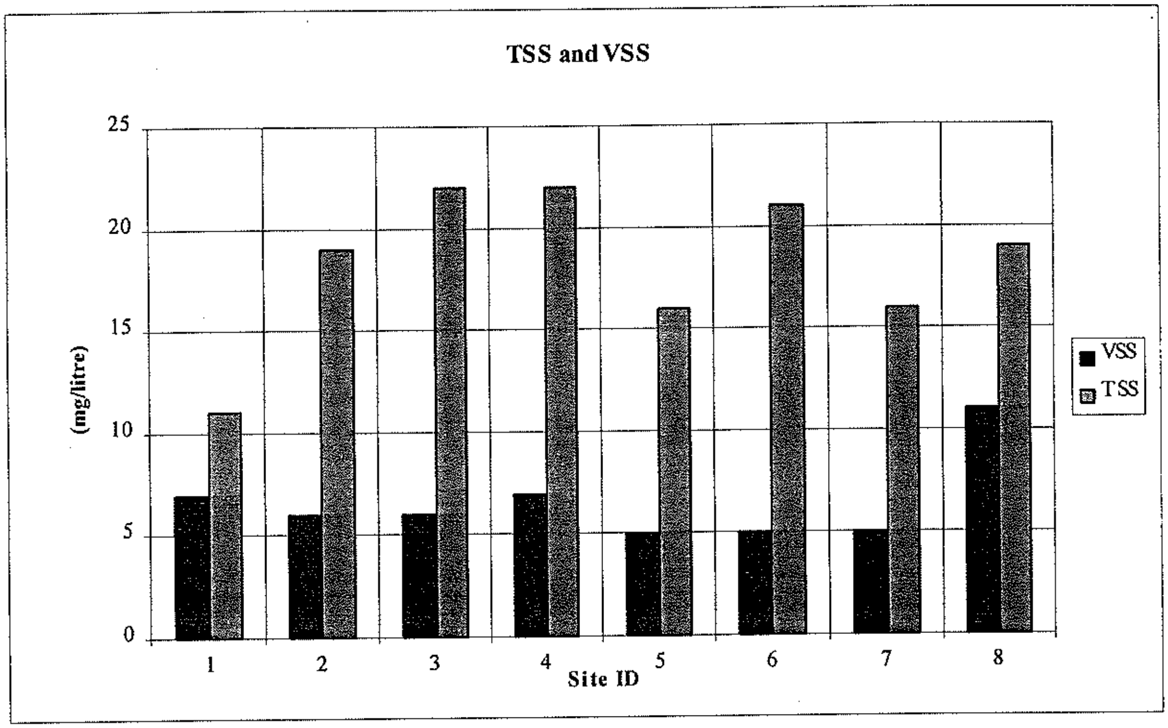


Figure D.19 BOD and Dissolved Oxygen July 06, 1994

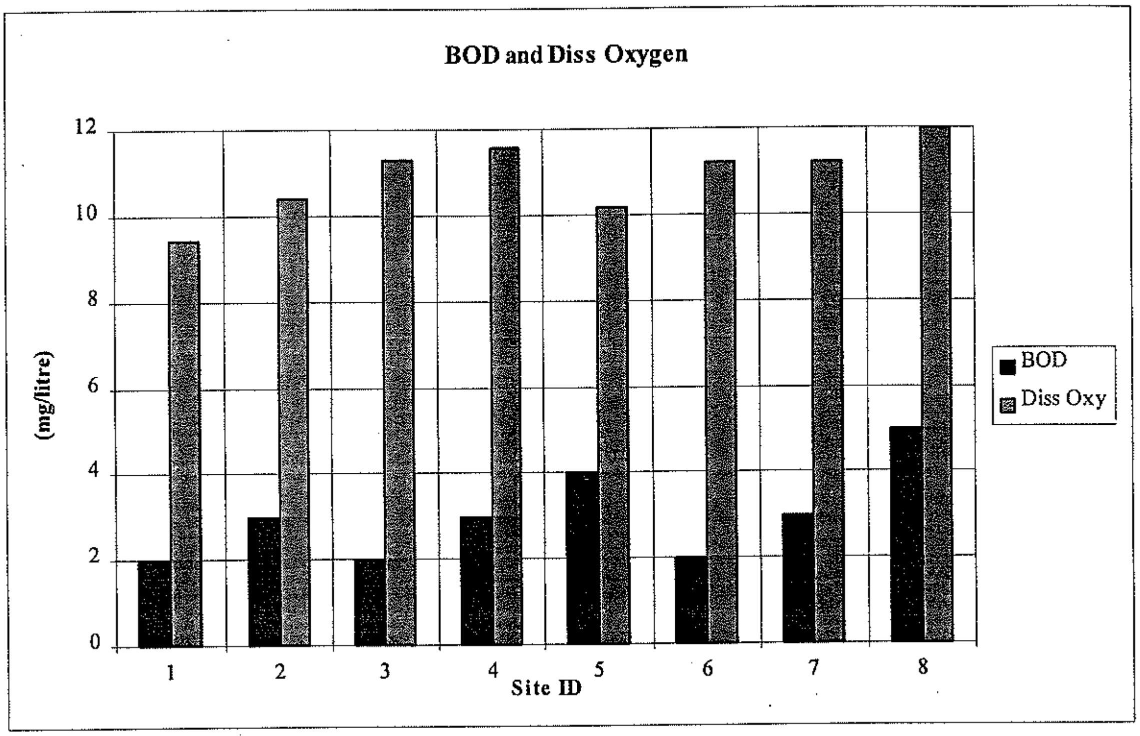



Figure D.20 Fecal Coliform and Fecal Strep July 06, 1994

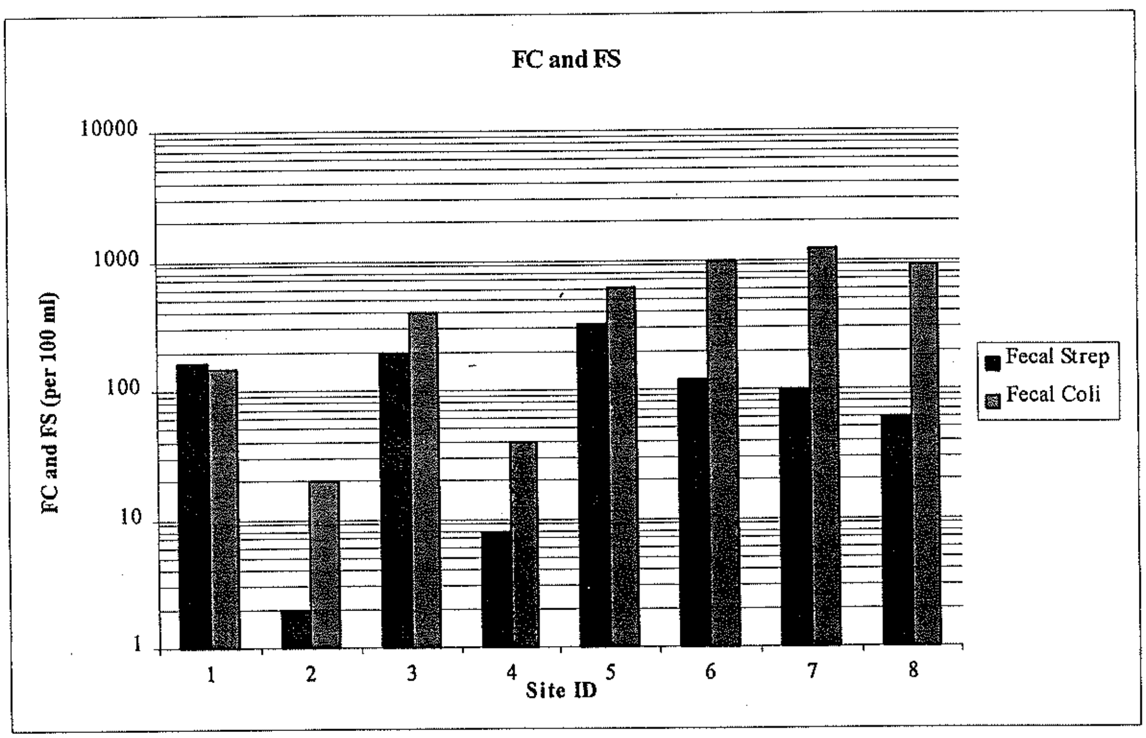


Figure D.21 Total and Volatile Suspended Solids July 06, 1994

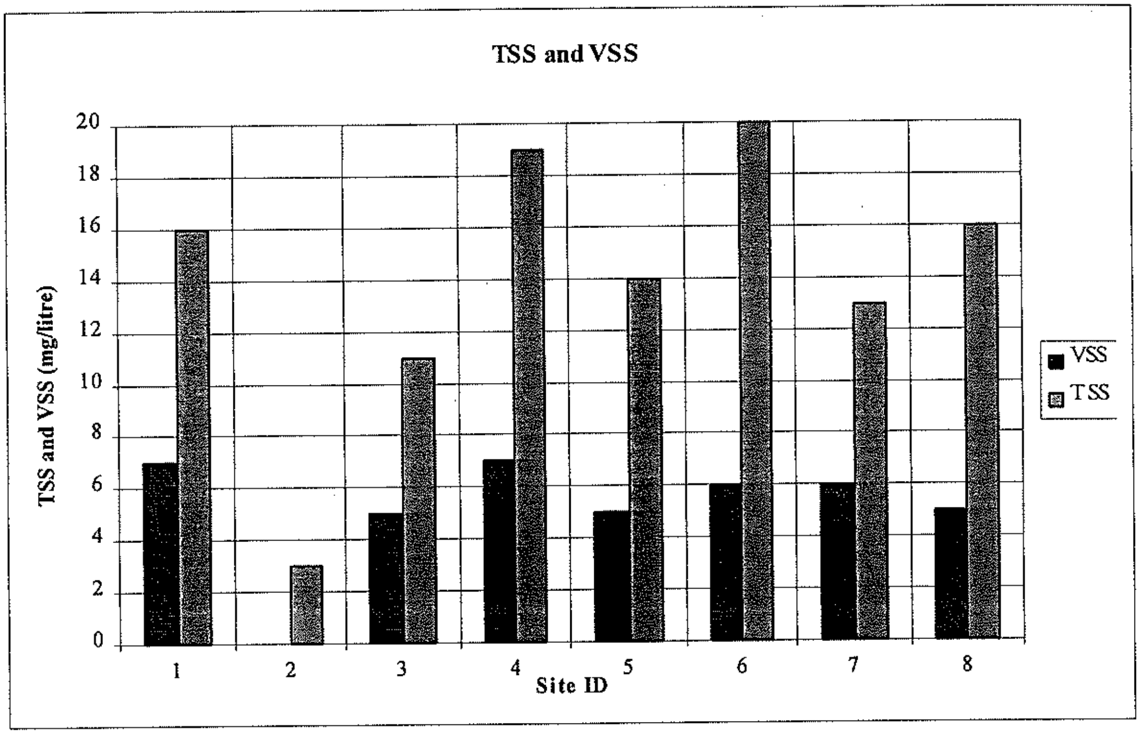


Figure D.22 BOD and Dissolved Oxygen July 14, 1994

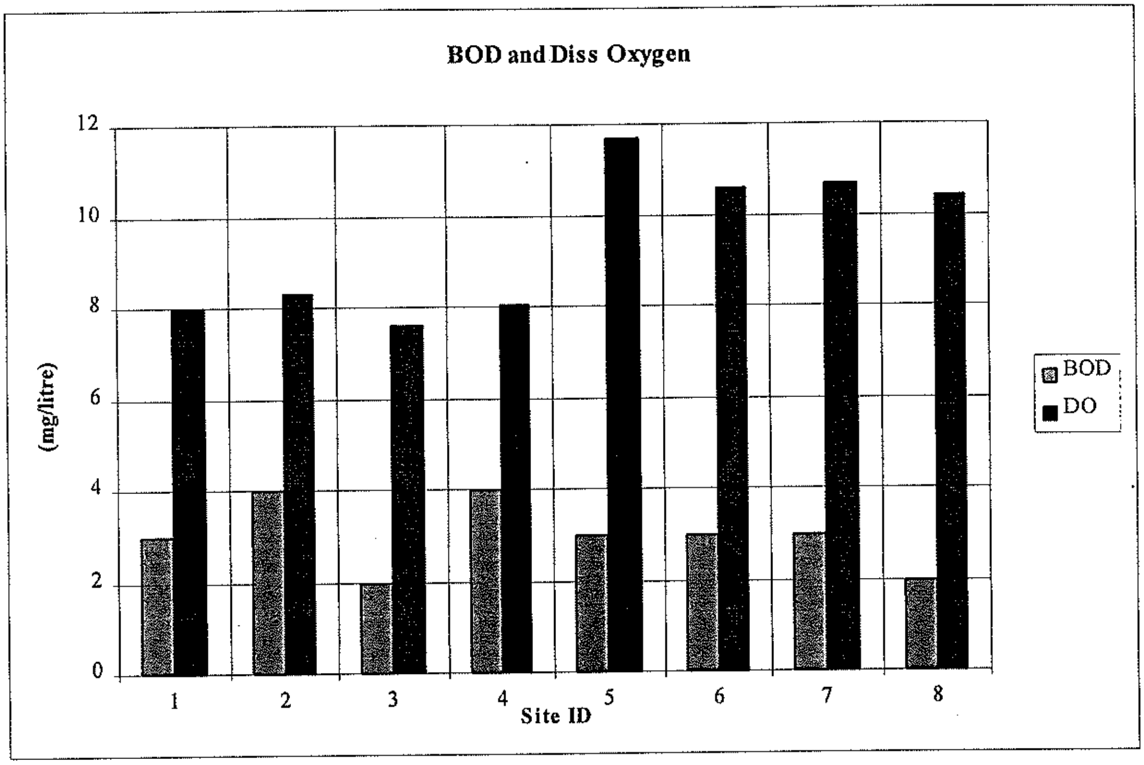



Figure D.23 Fecal Coliform and Fecal Strep July 14, 1994

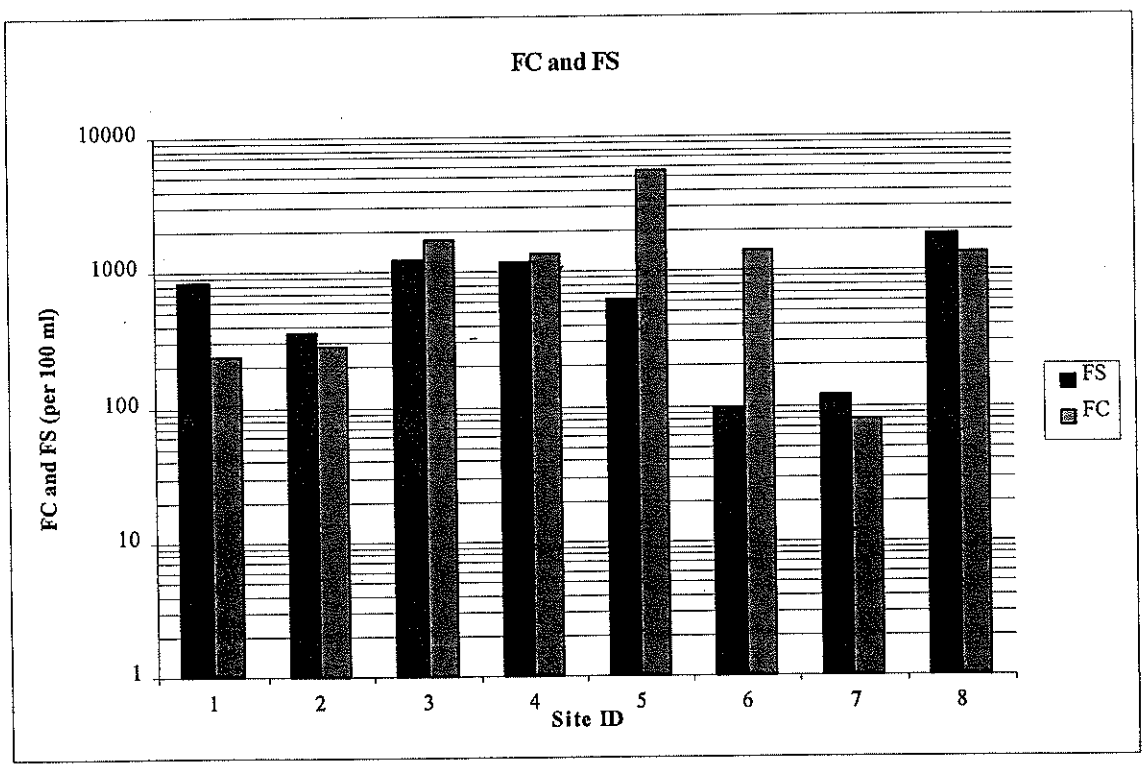


Figure D.24 Total and Volatile Suspended Solids July 14, 1994

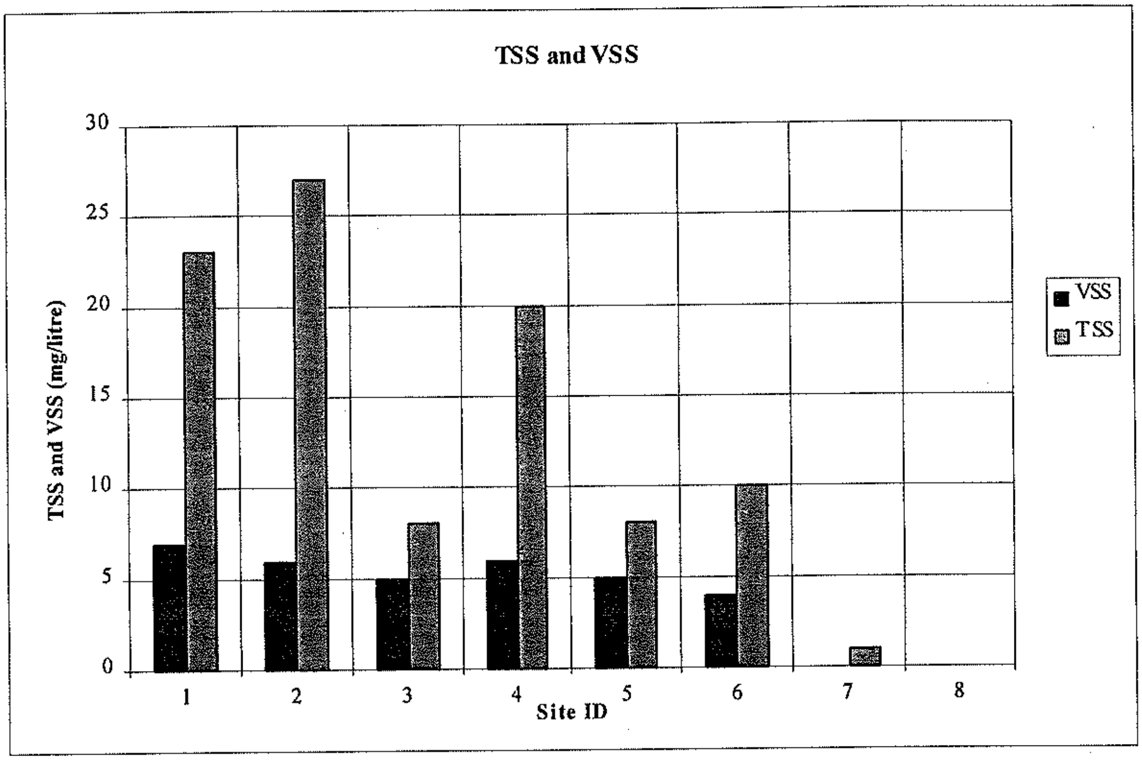


Figure D.25 BOD and Dissolved Oxygen July 28, 1994

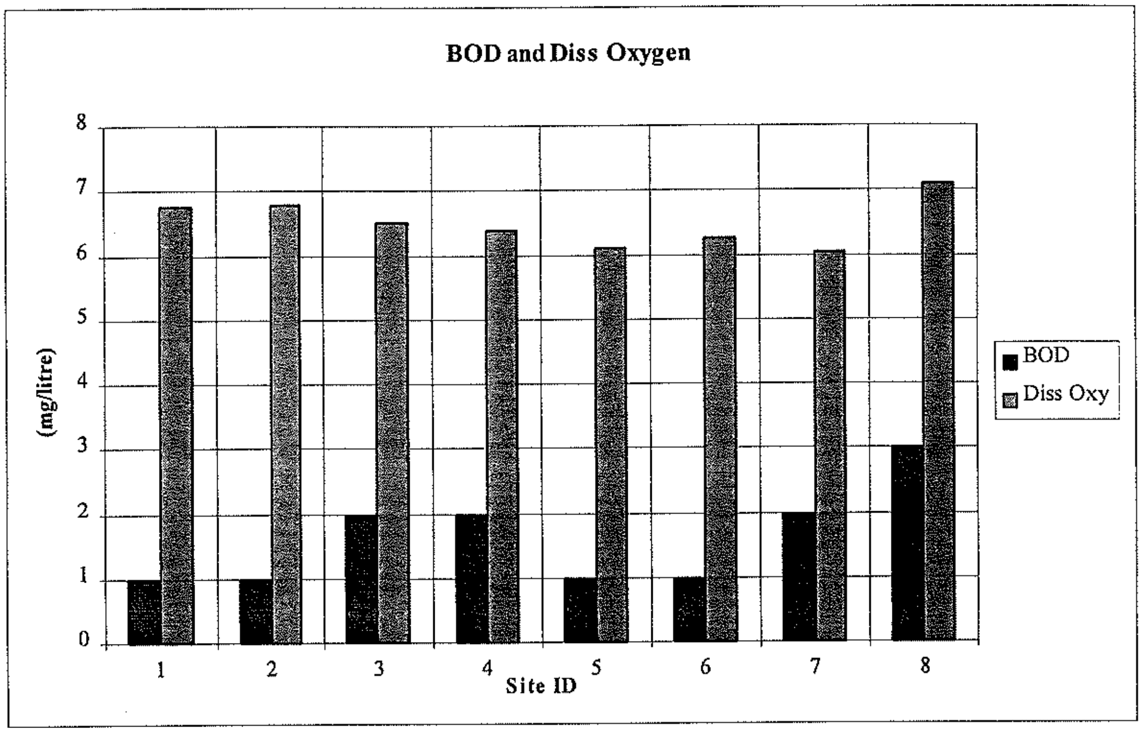



Figure D.26 Fecal Coliform and Fecal Strep July 28, 1994

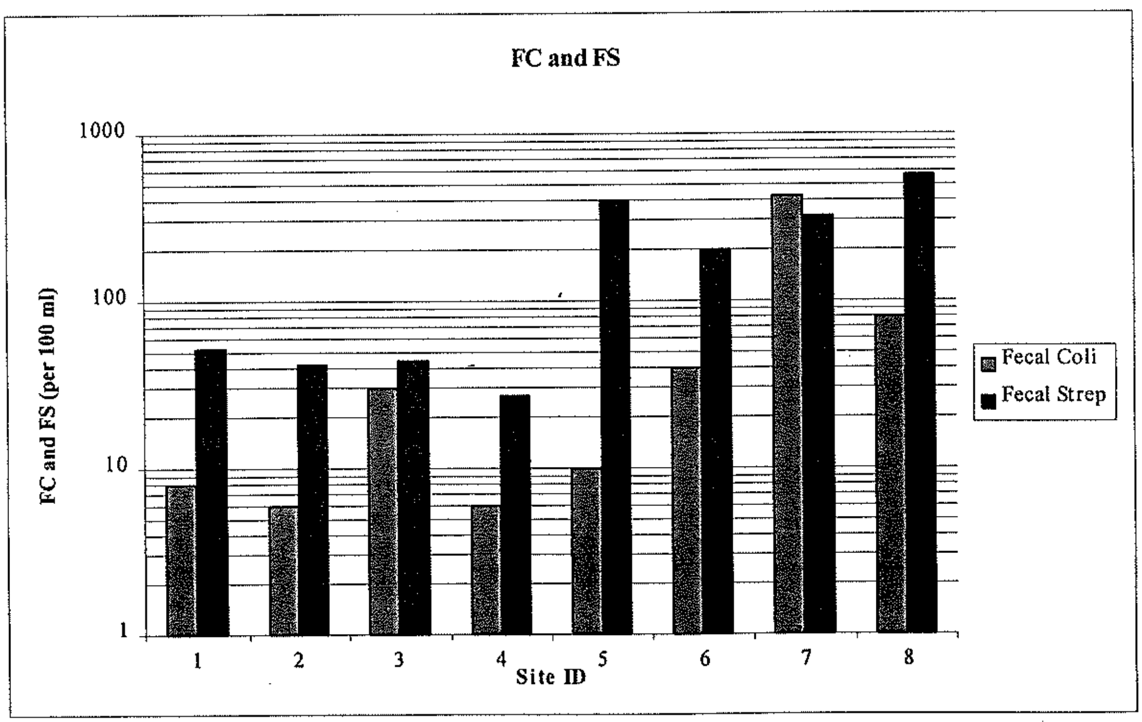
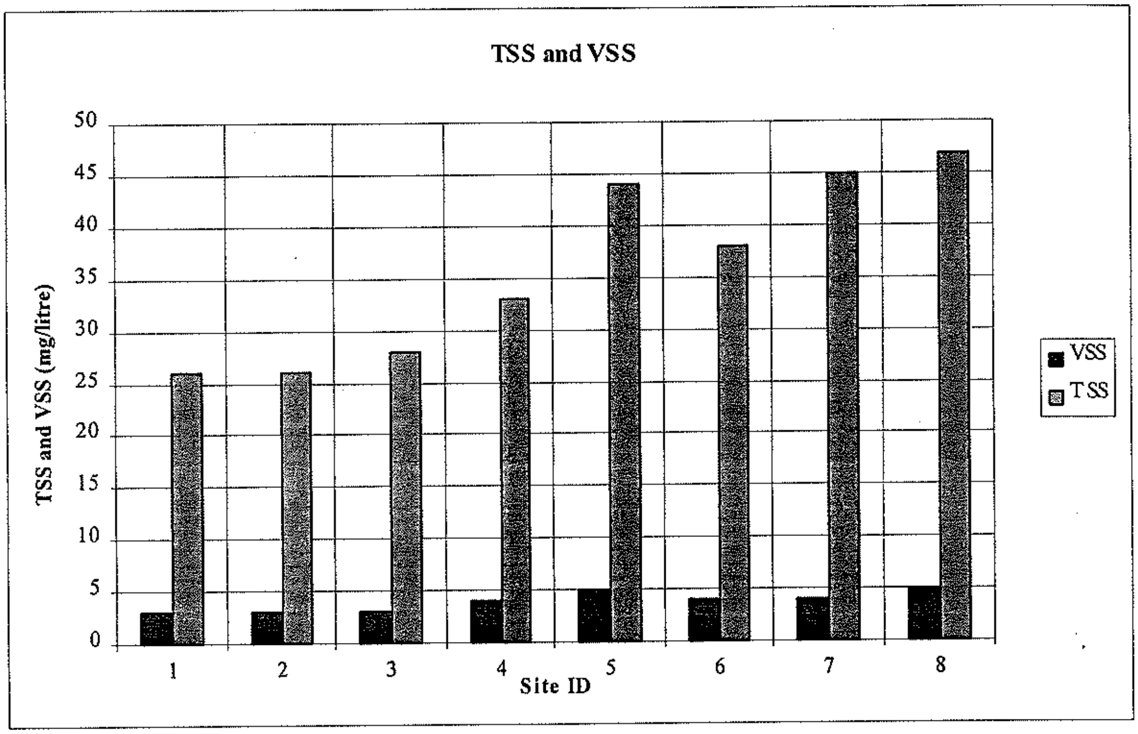


Figure D.27 Total and Volatile Suspended Solids July 28, 1994



# APPENDIX E

Table E.1 Stream Water Quality Parameters on August 19, 1994

| ID | TIME | DO | BOD | FC | FS | TSS | VSS | TMP | COND |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 1828 | 15.00 | 7 | 180 | 80 | 1 | 5 | 27 | 311 |
| 2 | 1823 | 15.00 | 8 | 20 | 20 | 12 | 5 | 27 | 311 |
| 3 | 1816 | 12.80 | 5 | 140 | 74 | 6 | 5 | 27 | 336 |
| 4 | 1812 | 11.80 | 5 | 72 | 42 | 12 | 4 | 27 | 341 |
| 5 | 1803 | 9.73 | 2 | 0 | 70 | 16 | 4 | 27 | 402 |
| 6 | 1758 | 9.96 | 7 | 20 | 66 | 15 | 3 | 27 | 404 |
| 7 | 1754 | 9.10 | 5 | 0 | 64 | 16 | 1 | 27 | 404 |
| 8 | 1751 | 9.33 | 3 | 0 | 80 | 14 | 3 | 27 | 405 |

Table E.2 Stream Water Quality Parameters on August 20, 1994

| ID | TIME | DO | BOD | FC | FS | TSS | VSS | TMP | COND |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 1635 | 13.50 | 9 | 40 | 120 | 21 | 6 | 26 | 316 |
| 2 | 1640 | 12.50 | 6 | 0 | 60 | 22 | 2 | 26 | 317 |
| 3 | 1645 | 12.00 | 5 | 0 | 200 | 11 | 0 | 27 | 358 |
| 4 | 1648 | 10.70 | 5 | 0 | 160 | 15 | 2 | 27 | 369 |
| 5 | 1652 | 9.18 | 3 | 100 | 100 | 20 | 1 | 27 | 400 |
| 6 | 1700 | 9.30 | 8 | 80 | 80 | 18 | 2 | 27 | 399 |
| 7 | 1702 | 9.16 | 5 | 0 | 172 | 11 | 1 | 27 | 399 |
| 8 | 1707 | 8.72 | 2 | 0 | 80 | 14 | 1 | 27 | 396 |

Table E.3 Stream Water Quality Parameters on August 21, 1994 - 2:00 pm

| ID | TIME | DO | BOD | FC | FS | TSS | VSS | TMP | COND |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 1325 | 10.60 | 5 | 64 | 18 | 9 | 4 | 25 | 308 |
| 2 | 1330 | 9.60 | 4 | 2 | 48 | 13 | 4 | 25 | 308 |
| 3 | 1335 | 9.99 | 4 | 8 | 20 | 13 | 6 | 26 | 321 |
| 4 | 1339 | 9.44 | 6 | 160 | 42 | 15 | 5 | 26 | 322 |
| 5 | 1347 | 8.10 | 5 | 1120 | 240 | 18 | 5 | 26 | 387 |
| 6 | 1351 | 8.40 | 4 | 106 | 400 | 20 | 5 | 26 | 389 |
| 7 | 1354 | 8.00 | 4 | 60 | 520 | 14 | 4 | 26 | 390 |
| 8 | 1357 | 7.80 | 3 | 1480 | 680 | 13 | 3 | 26 | 394 |

Table E.4 Stream Water Quality Parameters on August 21, 1994 - 6:00 pm

| ID | TIME | DO | BOD | FC | FS | TSS | VSS | TMP | COND |
|---|---|---|---|---|---|---|---|---|---|
| 1 | 1757 | 11.80 | 5 | 0 | 52 | 13 | 5 | 26 | 298 |
| 2 | 1754 | 12.10 | 5 | 0 | 80 | 13 | 5 | 26 | 297 |
| 3 | 1747 | 11.50 | 5 | 0 | 30 | 16 | 4 | 26 | 316 |
| 4 | 1744 | 11.20 | 5 | 0 | 86 | 14 | 4 | 26 | 318 |
| 5 | 1737 | 10.10 | 5 | 60 | 66 | 17 | 4 | 27 | 379 |
| 6 | 1733 | 9.55 | 3 | 2 | 60 | 8 | 5 | 26 | 385 |
| 7 | 1727 | 9.63 | 5 | 18 | 84 | 14 | 4 | 27 | 387 |
| 8 | 1724 | 10.50 | 5 | 166 | 40 | 13 | 4 | 27 | 389 |

# APPENDIX F

Figure F.1 Dissolved Oxygen

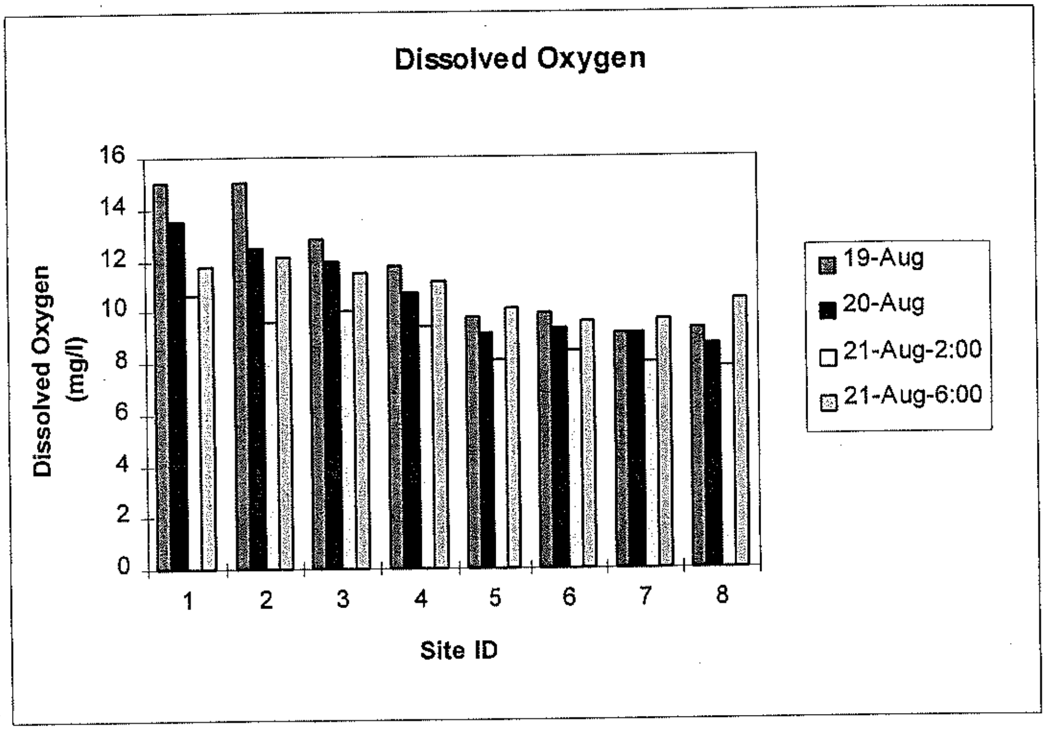



Figure F.2 Biochemical Oxygen Demand

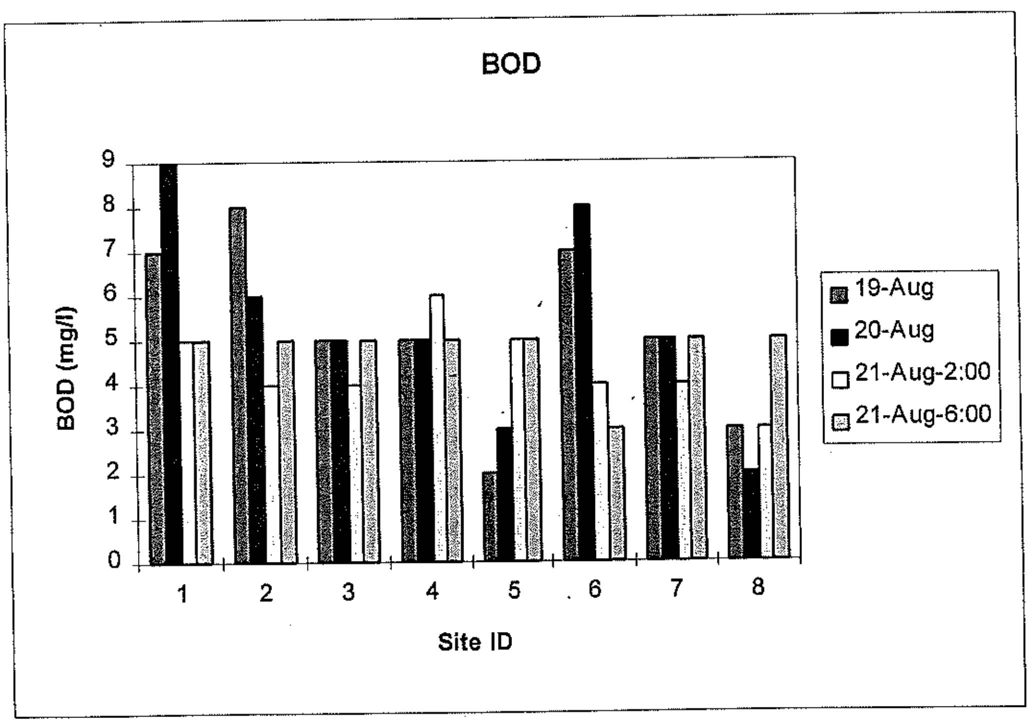


Figure F.5 Volatile Suspended Solids

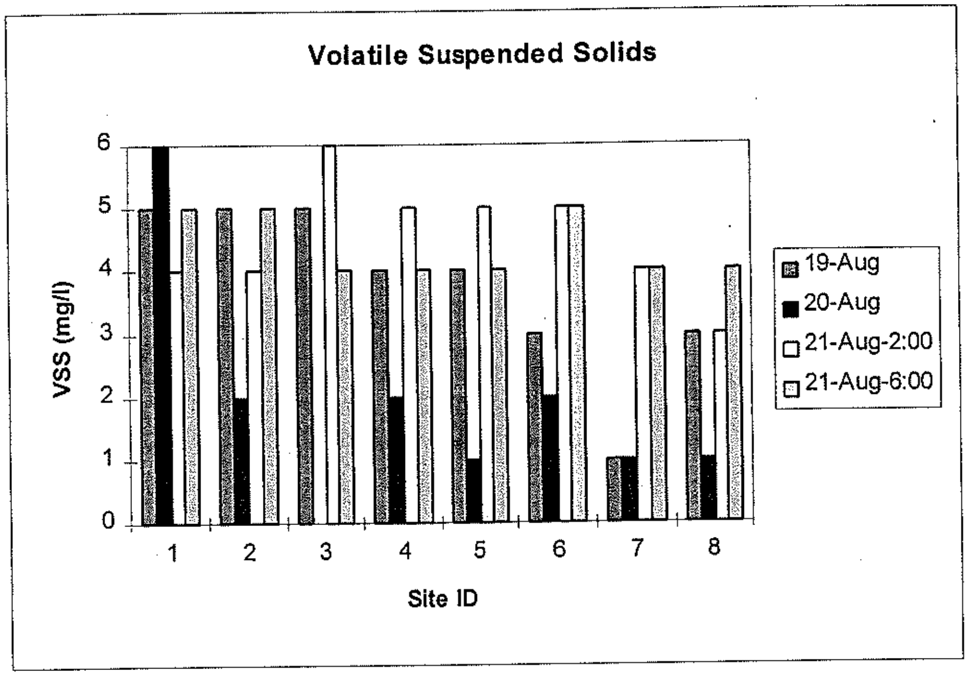



Figure F.6 Total Suspended Solids

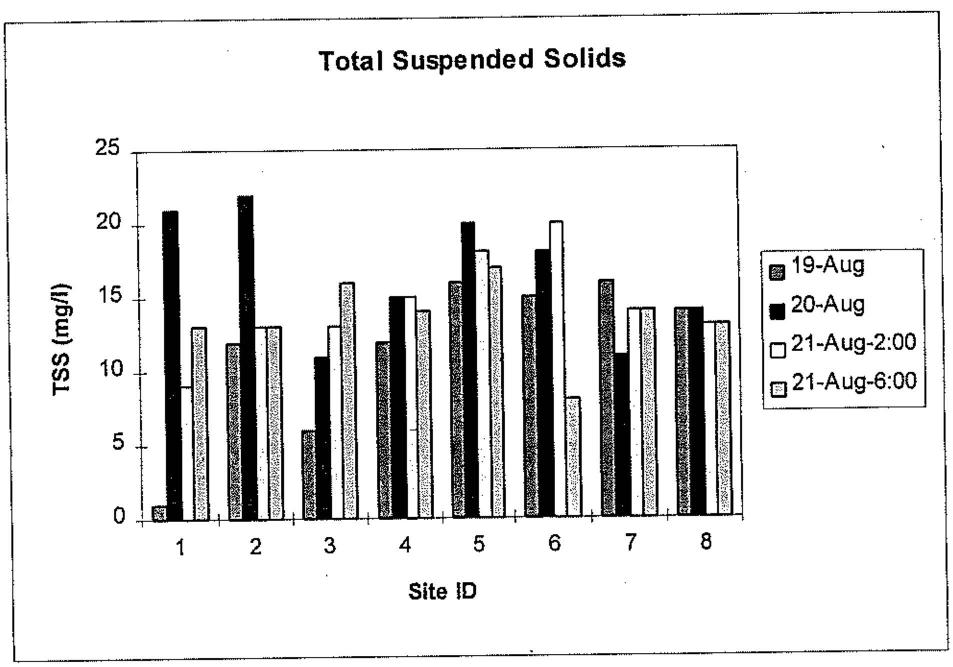


Figure F.3 Fecal Coliform

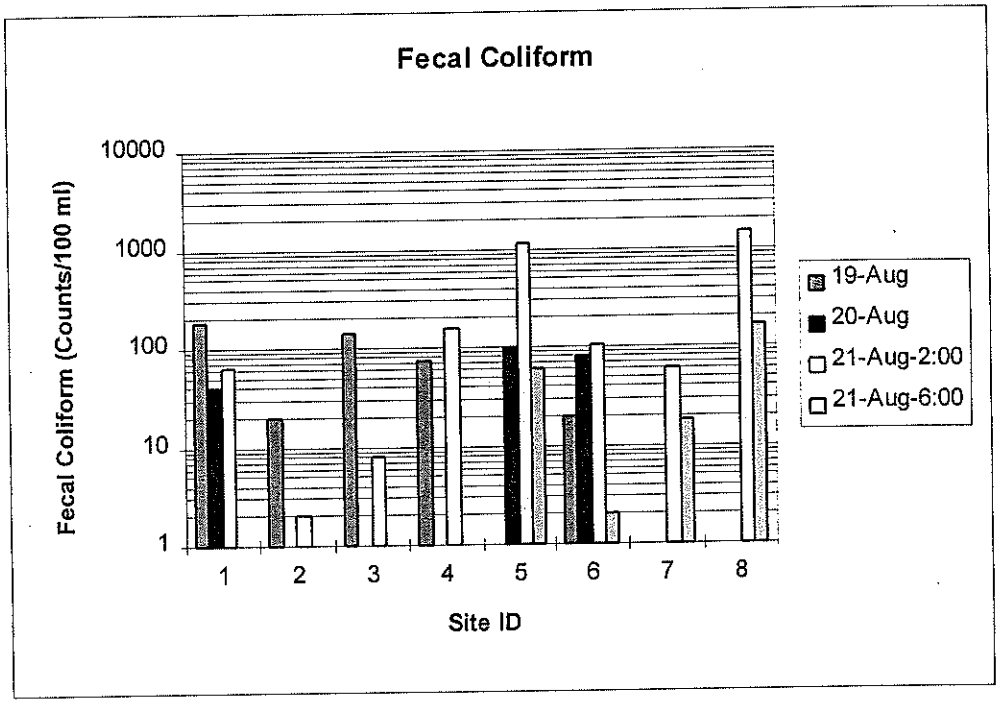
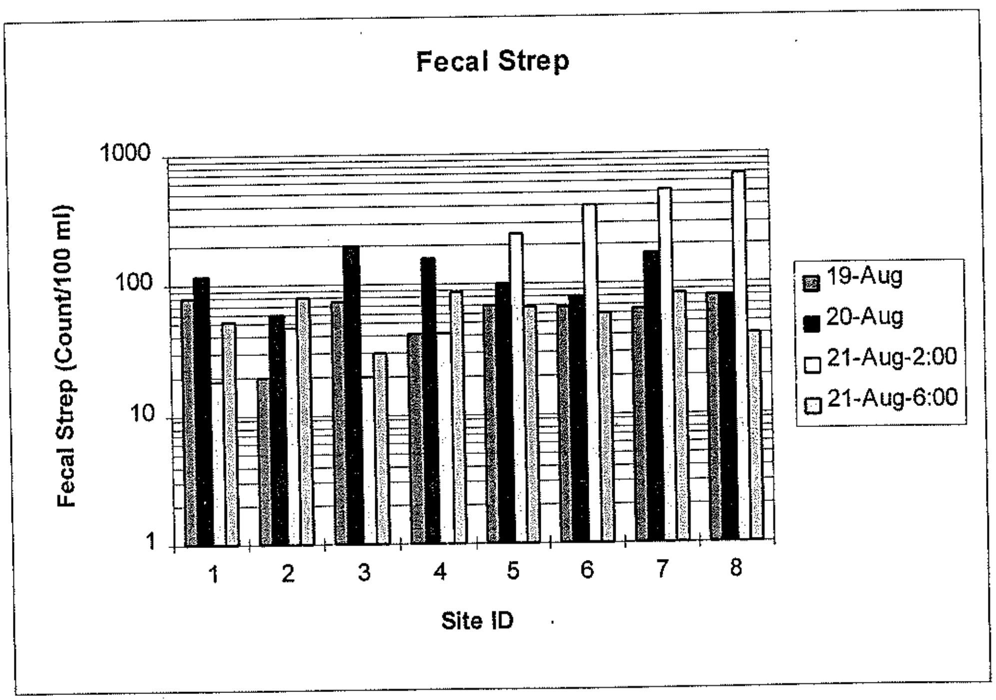



Figure F.4 Fecal Strep



# APPENDIX G

# COMMONWEALTH TECHNOLOGY, INC.

*Laboratory Results*

ACCT#: CUNICE

CTI LAB NO: 93111400

ATTN: Dr. Lindell Ormsbee
TO: University of Kentucky-CE
Dept. of Civil Engineering
242 Anderson Hall
Lexington KY 40506

DATE: June 29, 1993

P. O. NO: 675573

SAMPLE ID: Combined Sewer Overflow
SOURCE OF SAMPLE: -
SAMPLE MATRIX: Wastewater

DATE OF COLLECTION: 06/09/93
COLLECTION TIME: 12:30P
COLLECTED BY: Client
DATE RECEIVED: 06/09/93

NOTE: Chain Of Custody Record Attached/ * Best Detection Limit Possible Due To Sample Matrix Interferences./** Surrogate Did Not Meet EPA Requirements Due To Sample Matrix Interferences.

REPORT OF ANALYTICAL RESULTS

| CTI LAB NO./ ANALYTICAL TEST | | RESULTS | UNITS | DETECT LIMIT | SAMP TYPE | METHOD | ANALYSIS DATE | ANALYSIS BY |
|---|---|---|---|---|---|---|---|---|
| 93111400 | | | | | | | | |
| GENERAL PARAMETERS | | | | | | | | |
| Cyanide, Total | | 0.004 | mg/L | 0.002 | Grab | EPA335.3 | 06/16/93 | MLC |
| Nitrogen, Ammonia | | 1.5 | mg/L | 0.04 | Grab | EPA350.1 | 06/15/93 | CMB |
| Oil & Grease, Total/GRAV | | 15 | mg/L | 7 | Grab | EPA413.1 | 06/24/93 | MLC |
| Phenols | | 0.007 | mg/L | 0.006 | Grab | EPA420.2 | 06/15/93 | MLC |
| Phosphorus, Total | | 1.1 | mg/L as P | 0.01 | Grab | EPA365.4 | 06/16/93 | SCL |
| METALS | | | | | | | | |
| Total Antimony (Furnace) | < | 0.005 | mg/L | 0.005 | Grab | EPA204.2/4.1.3 | 06/21/93 | MEC |
| Total Arsenic (Furnace) | < | 0.005 | mg/L | 0.005 | Grab | EPA206.2/4.1.3 | 06/18/93 | RTV |
| Total Beryllium (Furnace) | < | 0.0005 | mg/L | 0.0005 | Grab | EPA210.2 | 06/24/93 | RTV |
| Total Cadmium (Furnace) | < | 0.002 | mg/L | 0.002 | Grab | EPA213.2/4.1.3 | 06/17/93 | MEC |
| Total Chromium (Furnace) | < | 0.002 | mg/L | 0.002 | Grab | EPA218.2/4.1.3 | 06/18/93 | VDA |
| Total Copper (Furnace) | | 0.022 | mg/L | 0.002 | Grab | EPA220.2/4.1.3 | 06/18/93 | VDA |
| Total Lead (Furnace) | | 0.039 | mg/L | 0.005 | Grab | EPA239.2/4.1.3 | 06/22/93 | MEC |
| Total Mercury (Cold Vapor) | < | 0.0005 | mg/L | 0.0005 | Grab | EPA245.1 | 06/15/93 | VDA/RTV |
| Total Nickel (ICP) | < | 0.02 | mg/L | 0.02 | Grab | EPA200.7/9.3 | 06/15/93 | MEC |
| Total Selenium (Furnace) | < | 0.005 | mg/L | 0.005 | Grab | EPA270.2/4.1.3 | 06/16/93 | VDA |
| Total Silver (Furnace) | | 0.0133 | mg/L | 0.0002 | Grab | EPA272.2/4.1.3 | 06/14/93 | VDA |
| Total Thallium (Furnace) | < | 0.005 | mg/L | 0.005 | Grab | EPA279.2/4.1.3 | 06/17/93 | RTV |
| Total Zinc (ICP) | | 0.13 | mg/L | 0.02 | Grab | EPA200.7/9.3 | 06/15/93 | VDA |
| ORGANIC - PESTICIDES/HERBICIDES | | | | | | | | |
| Herbicides Sample Preparation | | N/A | N/A | N/A | Grab | SW8150 | 06/10/93 | DLJ |
| Herbicide, 2,4,5-TP Silvex* | < | 0.005 | mg/L | 0.005 | Grab | SW8150 | 06/24/93 | LMO |
| Herbicide, 2,4,5-T* | < | 0.005 | mg/L | 0.005 | Grab | SW8150 | 06/24/93 | LMO |
| Herbicide, 2,4-D* | < | 0.005 | mg/L | 0.005 | Grab | SW8150 | 06/24/93 | LMO |
| Herbicide, Dalapon* | < | 0.015 | mg/L | 0.015 | Grab | SW8150 | 06/24/93 | LMO |
| Herbicide, Dicamba* | < | 0.025 | mg/L | 0.025 | Grab | SW8150 | 06/24/93 | LMO |
| Herbicide, Dinoseb* | < | 0.015 | mg/L | 0.015 | Grab | SW8150 | 06/24/93 | LMO |
| ORGANIC - PESTICIDES/PCB'S | | | | | | | | |

2520 Regency Road
Lexington, Kentucky 40503-2921



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REPORT OF ANALYTICAL RESULTS

| CTI LAB NO./ ANALYTICAL TEST | | RESULTS | UNITS | DETECT LIMIT | SAMP TYPE | METHOD | ANALYSIS DATE | BY |
|---|---|---|---|---|---|---|---|---|
| 4,4-DDD | < | 0.001 | mg/L | 0.001 | Grab | EPA608 | 06/24/93 | LMO |
| 93111400 | | | | | | | | |
| ORGANIC - PESTICIDES/PCB'S | | | | | | | | |
| 4,4-DDE | < | 0.001 | mg/L | 0.001 | Grab | EPA608 | 06/24/93 | LMO |
| 4,4-DDT | < | 0.001 | mg/L | 0.001 | Grab | EPA608 | 06/24/93 | LMO |
| Aldrin | < | 0.001 | mg/L | 0.001 | Grab | EPA608 | 06/24/93 | LMO |
| Alpha-BHC | < | 0.001 | mg/L | 0.001 | Grab | EPA608 | 06/24/93 | LMO |
| Arochlor-1016 | < | 0.001 | mg/L | 0.001 | Grab | EPA608 | 06/17/93 | KRH |
| Arochlor-1221 | < | 0.001 | mg/L | 0.001 | Grab | EPA608 | 06/17/93 | KRH |
| Arochlor-1232 | < | 0.001 | mg/L | 0.001 | Grab | EPA608 | 06/17/93 | KRH |
| Arochlor-1242 | < | 0.001 | mg/L | 0.001 | Grab | EPA608 | 06/17/93 | KRH |
| Arochlor-1248 | < | 0.001 | mg/L | 0.001 | Grab | EPA608 | 06/17/93 | KRH |
| Arochlor-1254 | < | 0.001 | mg/L | 0.001 | Grab | EPA608 | 06/17/93 | KRH |
| Arochlor-1260 | < | 0.001 | mg/L | 0.001 | Grab | EPA608 | 06/17/93 | KRH |
| Beta-BHC | < | 0.001 | mg/L | 0.001 | Grab | EPA608 | 06/24/93 | LMO |
| Chlordane | < | 0.002 | mg/L | 0.002 | Grab | EPA608 | 06/24/93 | LMO |
| Delta-BHC | < | 0.001 | mg/L | 0.001 | Grab | EPA608 | 06/24/93 | LMO |
| Dieldrin | < | 0.001 | mg/L | 0.001 | Grab | EPA608 | 06/24/93 | LMO |
| Endosulfan I | < | 0.001 | mg/L | 0.001 | Grab | EPA608 | 06/24/93 | LMO |
| Endosulfan II | < | 0.001 | mg/L | 0.001 | Grab | EPA608 | 06/24/93 | LMO |
| Endosulfan Sulfate | < | 0.001 | mg/L | 0.001 | Grab | EPA608 | 06/24/93 | LMO |
| Endrin | < | 0.0005 | mg/L | 0.0005 | Grab | EPA608 | 06/24/93 | LMO |
| Endrin Aldehyde | < | 0.001 | mg/L | 0.001 | Grab | EPA608 | 06/24/93 | LMO |
| Gamma-BHC | < | 0.001 | mg/L | 0.001 | Grab | EPA608 | 06/24/93 | LMO |
| Heptachlor | < | 0.001 | mg/L | 0.001 | Grab | EPA608 | 06/24/93 | LMO |
| Heptachlor Epoxide | < | 0.001 | mg/L | 0.001 | Grab | EPA608 | 06/24/93 | LMO |
| Methoxychlor | < | 0.001 | mg/L | 0.001 | Grab | EPA608 | 06/24/93 | LMO |
| Pesticides/PCBs Sample Preparation | | N/A | N/A | N/A | Grab | EPA608 | 06/16/93 | TCR/KRH |
| Toxaphene | < | 0.007 | mg/L | 0.007 | Grab | EPA608 | 06/24/93 | LMO |
| ORGANIC - SEMIVOLATILES | | | | | | | | |
| 1,2,4-Trichlorobenzene | < | 0.005 | mg/L | 0.005 | Grab | EPA625 | 06/14/93 | MTM |
| 1,2-Dichlorobenzene | < | 0.005 | mg/L | 0.005 | Grab | EPA625 | 06/14/93 | MTM |
| 1,3-Dichlorobenzene | < | 0.005 | mg/L | 0.005 | Grab | EPA625 | 06/14/93 | MTM |
| 1,4-Dichlorobenzene | < | 0.005 | mg/L | 0.005 | Grab | EPA625 | 06/14/93 | MTM |
| 2,4,6-Trichlorophenol | < | 0.005 | mg/L | 0.005 | Grab | EPA625 | 06/14/93 | MTM |
| 2,4-Dichlorophenol | < | 0.005 | mg/L | 0.005 | Grab | EPA625 | 06/14/93 | MTM |
| 2,4-Dimethylphenol | < | 0.005 | mg/L | 0.005 | Grab | EPA625 | 06/14/93 | MTM |
| 2,4-Dinitrophenol | < | 0.025 | mg/L | 0.025 | Grab | EPA625 | 06/14/93 | MTM |
| 2,4-Dinitrotoluene | < | 0.005 | mg/L | 0.005 | Grab | EPA625 | 06/14/93 | MTM |
| 2,6-Dinitrotoluene | < | 0.005 | mg/L | 0.005 | Grab | EPA625 | 06/14/93 | MTM |
| 2-Chloronaphthalene | < | 0.005 | mg/L | 0.005 | Grab | EPA625 | 06/14/93 | MTM |
| 2-Chlorophenol | < | 0.005 | mg/L | 0.005 | Grab | EPA625 | 06/14/93 | MTM |
| 2-Methyl-4,6-Dinitrophenol | < | 0.025 | mg/L | 0.025 | Grab | EPA625 | 06/14/93 | MTM |
| 2-Nitrophenol | < | 0.005 | mg/L | 0.005 | Grab | EPA625 | 06/14/93 | MTM |
| 3,3'-Dichlorobenzidine | < | 0.005 | mg/L | 0.005 | Grab | EPA625 | 06/14/93 | MTM |
| 4-Bromophenyl-Phenylether | < | 0.005 | mg/L | 0.005 | Grab | EPA625 | 06/14/93 | MTM |
| 4-Chlorophenyl-Phenylether | < | 0.005 | mg/L | 0.005 | Grab | EPA625 | 06/14/93 | MTM |
| 4-Chloro-3-Methylphenol | < | 0.005 | mg/L | 0.005 | Grab | EPA625 | 06/14/93 | MTM |
| 4-Nitrophenol | < | 0.005 | mg/L | 0.005 | Grab | EPA625 | 06/14/93 | MTM |

# COMMONWEALTH TECHNOLOGY, INC.

*Laboratory Results*

REPORT OF ANALYTICAL RESULTS

| CTI LAB NO./ ANALYTICAL TEST | | RESULTS | UNITS | DETECT LIMIT | SAMP TYPE | METHOD | ANALYSIS DATE | BY |
|---|---|---|---|---|---|---|---|---|
| 93111400 | | | | | | | | |
| ORGANIC - SEMIVOLATILES | | | | | | | | |
| Acenaphthene | < | 0.005 | mg/L | 0.005 | Grab | EPA625 | 06/14/93 | MTM |
| Acenaphthylene | < | 0.005 | mg/L | 0.005 | Grab | EPA625 | 06/14/93 | MTM |
| Anthracene | < | 0.005 | mg/L | 0.005 | Grab | EPA625 | 06/14/93 | MTM |
| Benzo(a)Anthracene | < | 0.005 | mg/L | 0.005 | Grab | EPA625 | 06/14/93 | MTM |
| Benzo(a)Pyrene | < | 0.005 | mg/L | 0.005 | Grab | EPA625 | 06/14/93 | MTM |
| Benzo(b)Fluoranthene | < | 0.005 | mg/L | 0.005 | Grab | EPA625 | 06/14/93 | MTM |
| Benzo(g,h,i)Perylene | < | 0.005 | mg/L | 0.005 | Grab | EPA625 | 06/14/93 | MTM |
| Benzo(k)Fluoranthene | < | 0.005 | mg/L | 0.005 | Grab | EPA625 | 06/14/93 | MTM |
| Bis(2-chloroethoxy)methane | < | 0.005 | mg/L | 0.005 | Grab | EPA625 | 06/14/93 | MTM |
| Bis(2-Chloroethyl)Ether | < | 0.005 | mg/L | 0.005 | Grab | EPA625 | 06/14/93 | MTM |
| Bis(2-Chloroisopropyl)Ether | < | 0.005 | mg/L | 0.005 | Grab | EPA625 | 06/14/93 | MTM |
| Bis(2-Ethylhexyl)Phthalate | < | 0.020 | mg/L | 0.02 | Grab | EPA625 | 06/14/93 | MTM |
| Butylbenzylphthalate | < | 0.005 | mg/L | 0.005 | Grab | EPA625 | 06/14/93 | MTM |
| Chrysene | < | 0.005 | mg/L | 0.005 | Grab | EPA625 | 06/14/93 | MTM |
| Dibenzo(a,h)Anthracene | < | 0.005 | mg/L | 0.005 | Grab | EPA625 | 06/14/93 | MTM |
| Diethylphthalate | < | 0.005 | mg/L | 0.005 | Grab | EPA625 | 06/14/93 | MTM |
| Dimethylphthalate | < | 0.005 | mg/L | 0.005 | Grab | EPA625 | 06/14/93 | MTM |
| Di-n-Butylphthalate | < | 0.005 | mg/L | 0.005 | Grab | EPA625 | 06/14/93 | MTM |
| Di-n-Octylphthalate | < | 0.005 | mg/L | 0.005 | Grab | EPA625 | 06/14/93 | MTM |
| Fluoranthene | < | 0.005 | mg/L | 0.005 | Grab | EPA625 | 06/14/93 | MTM |
| Fluorene | < | 0.005 | mg/L | 0.005 | Grab | EPA625 | 06/14/93 | MTM |
| GC/MS Method 625 Sample Preparation | | N/A | N/A | N/A | Grab | EPA625 | 06/09/93 | JLH |
| Hexachlorobenzene | < | 0.005 | mg/L | 0.005 | Grab | EPA625 | 06/14/93 | MTM |
| Hexachlorobutadiene | < | 0.005 | mg/L | 0.005 | Grab | EPA625 | 06/14/93 | MTM |
| Hexachloroethane | < | 0.005 | mg/L | 0.005 | Grab | EPA625 | 06/14/93 | MTM |
| Ideno(1,2,3-cd)Pyrene | < | 0.005 | mg/L | 0.005 | Grab | EPA625 | 06/14/93 | MTM |
| Isophorone | < | 0.005 | mg/L | 0.005 | Grab | EPA625 | 06/14/93 | MTM |
| Naphthalene | < | 0.005 | mg/L | 0.005 | Grab | EPA625 | 06/14/93 | MTM |
| Nitrobenzene | < | 0.005 | mg/L | 0.005 | Grab | EPA625 | 06/14/93 | MTM |
| N-Nitrosodiphenylamine | < | 0.005 | mg/L | 0.005 | Grab | EPA625 | 06/14/93 | MTM |
| N-Nitroso-Di-n-Propylamine | < | 0.005 | mg/L | 0.005 | Grab | EPA625 | 06/14/93 | MTM |
| Pentachlorophenol | < | 0.005 | mg/L | 0.005 | Grab | EPA625 | 06/14/93 | MTM |
| Phenanthrene | < | 0.005 | mg/L | 0.005 | Grab | EPA625 | 06/14/93 | MTM |
| Phenol | < | 0.005 | mg/L | 0.005 | Grab | EPA625 | 06/14/93 | MTM |
| Pyrene | < | 0.005 | mg/L | 0.005 | Grab | EPA625 | 06/14/93 | MTM |
| SURROGATE: 2,4,6-Tribromophenol | | 59 | % Recovery | 1 | N/A | Limits: 10-123% | 06/14/93 | MTM |
| SURROGATE: 2-Fluorobiphenyl | | 55 | % Recovery | 1 | N/A | Limits: 43-116% | 06/14/93 | MTM |
| SURROGATE: 2-Fluorophenol | | 22 | % Recovery | 1 | N/A | Limits: 21-100% | 06/14/93 | MTM |
| SURROGATE: Nitrobenzene-d5** | | 32 | % Recovery | 1 | N/A | Limits: 35-114% | 06/14/93 | MTM |
| SURROGATE: Phenol-d6 | | 20 | % Recovery | 1 | N/A | Limits: 10- 94% | 06/14/93 | MTM |
| SURROGATE: Terphenyl-d14 | | 88 | % Recovery | 1 | N/A | Limits: 33-141% | 06/14/93 | MTM |
| ORGANIC - VOLATILES | | | | | | | | |
| 1,1,1-Trichloroethane | < | 0.005 | mg/L | 0.005 | Grab | EPA624 | 06/15/93 | DHM |
| 1,1,2,2-Tetrachloroethane | < | 0.005 | mg/L | 0.005 | Grab | EPA624 | 06/15/93 | DHM |
| 1,1,2-Trichloroethane | < | 0.005 | mg/L | 0.005 | Grab | EPA624 | 06/15/93 | DHM |
| 1,1-Dichloroethane | < | 0.005 | mg/L | 0.005 | Grab | EPA624 | 06/15/93 | DHM |
| 1,1-Dichloroethene | < | 0.005 | mg/L | 0.005 | Grab | EPA624 | 06/15/93 | DHM |

REPORT OF ANALYTICAL RESULTS

| CTI LAB NO./ ANALYTICAL TEST | | RESULTS | UNITS | DETECT LIMIT | SAMP TYPE | METHOD | ANALYSIS DATE | BY |
|---|---|---|---|---|---|---|---|---|
| 93111400 | | | | | | | | |
| ORGANIC - VOLATILES | | | | | | | | |
| 1,2-Dichlorobenzene | < | 0.005 | mg/L | 0.005 | Grab | EPA624 | 06/15/93 | DHM |
| 1,2-Dichloroethane | < | 0.005 | mg/L | 0.005 | Grab | EPA624 | 06/15/93 | DHM |
| 1,2-Dichloropropane | < | 0.005 | mg/L | 0.005 | Grab | EPA624 | 06/15/93 | DHM |
| 1,3-Dichlorobenzene | < | 0.005 | mg/L | 0.005 | Grab | EPA624 | 06/15/93 | DHM |
| 1,4-Dichlorobenzene | < | 0.005 | mg/L | 0.005 | Grab | EPA624 | 06/15/93 | DHM |
| 2-Chloroethyl vinyl ether | < | 0.005 | mg/L | 0.005 | Grab | EPA624 | 06/15/93 | DHM |
| Benzene | < | 0.005 | mg/L | 0.005 | Grab | EPA624 | 06/15/93 | DHM |
| Bromodichloromethane | < | 0.005 | mg/L | 0.005 | Grab | EPA624 | 06/15/93 | DHM |
| Bromoform | < | 0.005 | mg/L | 0.005 | Grab | EPA624 | 06/15/93 | DHM |
| Bromomethane | < | 0.020 | mg/L | 0.02 | Grab | EPA624 | 06/15/93 | DHM |
| Carbon Tetrachloride | < | 0.005 | mg/L | 0.005 | Grab | EPA624 | 06/15/93 | DHM |
| Chlorobenzene | < | 0.005 | mg/L | 0.005 | Grab | EPA624 | 06/15/93 | DHM |
| Chloroethane | < | 0.020 | mg/L | 0.02 | Grab | EPA624 | 06/15/93 | DHM |
| Chloroform | < | 0.005 | mg/L | 0.005 | Grab | EPA624 | 06/15/93 | DHM |
| Chloromethane | < | 0.010 | mg/L | 0.01 | Grab | EPA624 | 06/15/93 | DHM |
| cis-1,3-Dichloropropene | < | 0.005 | mg/L | 0.005 | Grab | EPA624 | 06/15/93 | DHM |
| Dibromochloromethane | < | 0.005 | mg/L | 0.005 | Grab | EPA624 | 06/15/93 | DHM |
| Ethylbenzene | < | 0.005 | mg/L | 0.005 | Grab | EPA624 | 06/15/93 | DHM |
| Methylene Chloride | < | 0.010 | mg/L | 0.01 | Grab | EPA624 | 06/15/93 | DHM |
| Tetrachloroethene | < | 0.005 | mg/L | 0.005 | Grab | EPA624 | 06/15/93 | DHM |
| Toluene | < | 0.005 | mg/L | 0.005 | Grab | EPA624 | 06/15/93 | DHM |
| trans-1,2-Dichlorethene | < | 0.005 | mg/L | 0.005 | Grab | EPA624 | 06/15/93 | DHM |
| trans-1,3-Dichloropropene | < | 0.005 | mg/L | 0.005 | Grab | EPA624 | 06/15/93 | DHM |
| Trichloroethene | < | 0.005 | mg/L | 0.005 | Grab | EPA624 | 06/15/93 | DHM |
| Trichlorofluoromethane | < | 0.010 | mg/L | 0.01 | Grab | EPA624 | 06/15/93 | DHM |
| Vinyl Chloride | < | 0.010 | mg/L | 0.01 | Grab | EPA624 | 06/15/93 | DHM |
| SURROGATE: 4-Bromofluorobenzene | | 96 | % Recovery | 1 | N/A | EPA624 | 06/15/93 | DHM |
| SURROGATE: d4-1,2-Dichloroethane | | 104 | % Recovery | 1 | N/A | EPA624 | 06/15/93 | DHM |
| SURROGATE: d8-Toluene | | 96 | % Recovery | 1 | N/A | EPA624 | 06/15/93 | DHM |

# COMMONWEALTH TECHNOLOGY, INC.

ACCT#: CUNICE

CTI LAB NO: 94114460

ATTN: Dr. Lindell Ormsbee
TO: University of Kentucky-CE
Dept. of Civil Engineering
242 Anderson Hall
Lexington KY 40506

DATE: September 1, 1994

P. O. NO: N/A

SAMPLE ID: Eighth Street CSO
SOURCE OF SAMPLE: -
SAMPLE MATRIX: Wastewater

DATE OF COLLECTION: 07/08/94
COLLECTION TIME: 5:00P
COLLECTED BY: Client
DATE RECEIVED: 07/11/94

NOTE: Chain Of Custody Record Attached

REPORT OF ANALYTICAL RESULTS

| CTI LAB NO./ ANALYTICAL TEST | | RESULTS | UNITS | DETECT LIMIT | SAMP TYPE | METHOD | ANALYSIS DATE | BY |
|---|---|---|---|---|---|---|---|---|
| 94114460 | | | | | | | | |
| GENERAL PARAMETERS | | | | | | | | |
| Cyanide, Total | | 0.004 | mg/L | 0.002 | Grab | EPA335.3 | 07/22/94 | JSG |
| Nitrogen, Ammonia | | 5.4 | mg/L | 0.02 | Grab | EPA350.1 | 07/27/94 | CMB |
| Oil & Grease, Total/GRAV | | 26 | mg/L | 5 | Grab | EPA413.1 | 07/21/94 | MJV |
| Phenols | | 0.008 | mg/L | 0.006 | Grab | EPA420.2 | 07/13/94 | JSG |
| Phosphorus, Total | | 2.6 | mg/L as P | 0.01 | Grab | EPA365.2 | 07/13/94 | SCL |
| METALS | | | | | | | | |
| Total Antimony (Furnace) | < | 0.005 | mg/L | 0.005 | Grab | EPA204.2/4.1.3 | 07/21/94 | MEC |
| Total Arsenic (Furnace) | < | 0.005 | mg/L | 0.005 | Grab | EPA206.2/4.1.3 | 07/14/94 | GLM |
| Total Beryllium (Furnace) | < | 0.001 | mg/L | 0.001 | Grab | EPA210.2 | 07/27/94 | GLM |
| Total Cadmium (Furnace) | | 0.0026 | mg/L | 0.0002 | Grab | EPA213.2/4.1.3 | 07/20/94 | GLM |
| Total Chromium (Furnace) | | 0.015 | mg/L | 0.002 | Grab | EPA218.2/4.1.3 | 07/22/94 | MEC |
| Total Copper (Furnace) | | 0.13 | mg/L | 0.002 | Grab | EPA220.2/4.1.3 | 07/22/94 | MEC |
| Total Lead (Furnace) | | 0.11 | mg/L | 0.005 | Grab | EPA239.2/4.1.3 | 07/15/94 | SCL |
| Total Mercury (Cold Vapor) | < | 0.0005 | mg/L | 0.0005 | Grab | EPA245.1 | 07/20/94 | MEC |
| Total Nickel (ICP) | < | 0.02 | mg/L | 0.02 | Grab | EPA200.7/9.3 | 07/13/94 | DJM |
| Total Selenium (Furnace) | < | 0.005 | mg/L | 0.005 | Grab | EPA270.2/4.1.3 | 07/15/94 | GLM |
| Total Silver (Furnace) | | 0.0040 | mg/L | 0.0002 | Grab | EPA272.2/4.1.3 | 07/25/94 | GLM |
| Total Thallium (Furnace) | < | 0.005 | mg/L | 0.005 | Grab | EPA279.2/4.1.3 | 07/21/94 | MEC |
| Total Zinc (ICP) | | 0.22 | mg/L | 0.02 | Grab | EPA200.7/9.3 | 07/13/94 | DJM |
| ORGANIC - PESTICIDES/HERBICIDES | | | | | | | | |
| Herbicides Sample Preparation | | N/A | N/A | N/A | Grab | SW8150 | 07/14/94 | SC |
| Herbicide, 2,4,5-T | < | 0.001 | mg/L | 0.001 | Grab | SW8150 | 08/14/94 | XSQ |
| Herbicide, 2,4,5-TP Silvex | < | 0.001 | mg/L | 0.001 | Grab | SW8150 | 08/14/94 | XSQ |
| Herbicide, 2,4-D | < | 0.001 | mg/L | 0.001 | Grab | SW8150 | 08/14/94 | XSQ |
| Herbicide, Dalapon | < | 0.005 | mg/L | 0.005 | Grab | SW8150 | 08/14/94 | XSQ |
| Herbicide, Dicamba | < | 0.005 | mg/L | 0.005 | Grab | SW8150 | 08/14/94 | XSQ |
| Herbicide, Dinoseb | < | 0.005 | mg/L | 0.005 | Grab | SW8150 | 08/14/94 | XSQ |
| ORGANIC - PESTICIDES/PCB'S | | | | | | | | |

# COMMONWEALTH TECHNOLOGY, INC.

REPORT OF ANALYTICAL RESULTS

| CTI LAB NO./ ANALYTICAL TEST | | RESULTS | UNITS | DETECT LIMIT | SAMP TYPE | METHOD | ANALYSIS DATE | BY |
|---|---|---|---|---|---|---|---|---|
| 4,4-DDD | < | 0.001 | mg/L | 0.001 | Grab | EPA608 | 07/15/94 | XSQ |
| 94114460 | | | | | | | | |
| ORGANIC - PESTICIDES/PCB'S | | | | | | | | |
| 4,4-DDE | < | 0.001 | mg/L | 0.001 | Grab | EPA608 | 07/15/94 | XSQ |
| 4,4-DDT | < | 0.001 | mg/L | 0.001 | Grab | EPA608 | 07/15/94 | XSQ |
| Aldrin | < | 0.001 | mg/L | 0.001 | Grab | EPA608 | 07/15/94 | XSQ |
| Alpha-BHC | < | 0.001 | mg/L | 0.001 | Grab | EPA608 | 07/15/94 | XSQ |
| Arochlor-1016 | < | 0.001 | mg/L | 0.001 | Grab | EPA608 | 07/15/94 | XSQ |
| Arochlor-1221 | < | 0.001 | mg/L | 0.001 | Grab | EPA608 | 07/15/94 | XSQ |
| Arochlor-1232 | < | 0.001 | mg/L | 0.001 | Grab | EPA608 | 07/15/94 | XSQ |
| Arochlor-1242 | < | 0.001 | mg/L | 0.001 | Grab | EPA608 | 07/15/94 | XSQ |
| Arochlor-1248 | < | 0.001 | mg/L | 0.001 | Grab | EPA608 | 07/15/94 | XSQ |
| Arochlor-1254 | < | 0.001 | mg/L | 0.001 | Grab | EPA608 | 07/15/94 | XSQ |
| Arochlor-1260 | < | 0.001 | mg/L | 0.001 | Grab | EPA608 | 07/15/94 | XSQ |
| Beta-BHC | < | 0.001 | mg/L | 0.001 | Grab | EPA608 | 07/15/94 | XSQ |
| Chlordane | < | 0.001 | mg/L | 0.001 | Grab | EPA608 | 07/15/94 | XSQ |
| Delta-BHC | < | 0.001 | mg/L | 0.001 | Grab | EPA608 | 07/15/94 | XSQ |
| Dieldrin | < | 0.001 | mg/L | 0.001 | Grab | EPA608 | 07/15/94 | XSQ |
| Endosulfan I | < | 0.001 | mg/L | 0.001 | Grab | EPA608 | 07/15/94 | XSQ |
| Endosulfan II | < | 0.001 | mg/L | 0.001 | Grab | EPA608 | 07/15/94 | XSQ |
| Endosulfan Sulfate | < | 0.001 | mg/L | 0.001 | Grab | EPA608 | 07/15/94 | XSQ |
| Endrin | < | 0.0001 | mg/L | 0.0001 | Grab | EPA608 | 07/15/94 | XSQ |
| Endrin Aldehyde | < | 0.001 | mg/L | 0.001 | Grab | EPA608 | 07/15/94 | XSQ |
| Gamma-BHC | < | 0.001 | mg/L | 0.001 | Grab | EPA608 | 07/15/94 | XSQ |
| Heptachlor | < | 0.001 | mg/L | 0.001 | Grab | EPA608 | 07/15/94 | XSQ |
| Heptachlor Epoxide | < | 0.001 | mg/L | 0.001 | Grab | EPA608 | 07/15/94 | XSQ |
| Methoxychlor | < | 0.001 | mg/L | 0.001 | Grab | EPA608 | 07/15/94 | XSQ |
| Pesticides/PCBs Sample Preparation | | N/A | N/A | N/A | Grab | EPA608 | 07/14/94 | SC |
| Toxaphene | < | 0.001 | mg/L | 0.001 | Grab | EPA608 | 07/15/94 | XSQ |
| ORGANIC - SEMIVOLATILES | | | | | | | | |
| 1,2,4-Trichlorobenzene | < | 0.0005 | mg/L | 0.0005 | Grab | EPA625 | 08/20/94 | JG |
| 1,2-Dichlorobenzene | < | 0.0005 | mg/L | 0.0005 | Grab | EPA625 | 08/20/94 | JG |
| 1,3-Dichlorobenzene | < | 0.0005 | mg/L | 0.0005 | Grab | EPA625 | 08/20/94 | JG |
| 1,4-Dichlorobenzene | < | 0.0005 | mg/L | 0.0005 | Grab | EPA625 | 08/20/94 | JG |
| 2,4,6-Trichlorophenol | < | 0.0005 | mg/L | 0.0005 | Grab | EPA625 | 08/20/94 | JG |
| 2,4-Dichlorophenol | < | 0.0005 | mg/L | 0.0005 | Grab | EPA625 | 08/20/94 | JG |
| 2,4-Dimethylphenol | < | 0.0005 | mg/L | 0.0005 | Grab | EPA625 | 08/20/94 | JG |
| 2,4-Dinitrophenol | < | 0.0025 | mg/L | 0.0025 | Grab | EPA625 | 08/20/94 | JG |
| 2,4-Dinitrotoluene | < | 0.0005 | mg/L | 0.0005 | Grab | EPA625 | 08/20/94 | JG |
| 2,6-Dinitrotoluene | < | 0.0005 | mg/L | 0.0005 | Grab | EPA625 | 08/20/94 | JG |
| 2-Chloronaphthalene | < | 0.0005 | mg/L | 0.0005 | Grab | EPA625 | 08/20/94 | JG |
| 2-Chlorophenol | < | 0.0005 | mg/L | 0.0005 | Grab | EPA625 | 08/20/94 | JG |
| 2-Methyl-4,6-Dinitrophenol | < | 0.0025 | mg/L | 0.0025 | Grab | EPA625 | 08/20/94 | JG |
| 2-Nitrophenol | < | 0.0005 | mg/L | 0.0005 | Grab | EPA625 | 08/20/94 | JG |
| 3,3'-Dichlorobenzidine | < | 0.0005 | mg/L | 0.0005 | Grab | EPA625 | 08/20/94 | JG |
| 4-Bromophenyl-Phenylether | < | 0.0005 | mg/L | 0.0005 | Grab | EPA625 | 08/20/94 | JG |
| 4-Chlorophenyl-Phenylether | < | 0.0005 | mg/L | 0.0005 | Grab | EPA625 | 08/20/94 | JG |
| 4-Chloro-3-Methylphenol | < | 0.0005 | mg/L | 0.0005 | Grab | EPA625 | 08/20/94 | JG |
| 4-Nitrophenol | < | 0.0005 | mg/L | 0.0005 | Grab | EPA625 | 08/20/94 | JG |



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# COMMONWEALTH TECHNOLOGY, INC.

REPORT OF ANALYTICAL RESULTS

| CTI LAB NO./ ANALYTICAL TEST | | RESULTS | UNITS | DETECT LIMIT | SAMP TYPE | METHOD | ANALYSIS DATE | BY |
|---|---|---|---|---|---|---|---|---|
| 94114460 | | | | | | | | |
| ORGANIC - SEMIVOLATILES | | | | | | | | |
| Acenaphthene | < | 0.0005 | mg/L | 0.0005 | Grab | EPA625 | 08/20/94 | JG |
| Acenaphthylene | < | 0.0005 | mg/L | 0.0005 | Grab | EPA625 | 08/20/94 | JG |
| Anthracene | < | 0.0005 | mg/L | 0.0005 | Grab | EPA625 | 08/20/94 | JG |
| Benzo(a)Anthracene | < | 0.0005 | mg/L | 0.0005 | Grab | EPA625 | 08/20/94 | JG |
| Benzo(a)Pyrene | < | 0.0005 | mg/L | 0.0005 | Grab | EPA625 | 08/20/94 | JG |
| Benzo(b)Fluoranthene | < | 0.0005 | mg/L | 0.0005 | Grab | EPA625 | 08/20/94 | JG |
| Benzo(g,h,i)Perylene | < | 0.0005 | mg/L | 0.0005 | Grab | EPA625 | 08/20/94 | JG |
| Benzo(k)Fluoranthene | < | 0.0005 | mg/L | 0.0005 | Grab | EPA625 | 08/20/94 | JG |
| Bis(2-chloroethoxy)methane | < | 0.0005 | mg/L | 0.0005 | Grab | EPA625 | 08/20/94 | JG |
| Bis(2-Chloroethyl)Ether | < | 0.0005 | mg/L | 0.0005 | Grab | EPA625 | 08/20/94 | JG |
| Bis(2-Chloroisopropyl)Ether | < | 0.0005 | mg/L | 0.0005 | Grab | EPA625 | 08/20/94 | JG |
| Bis(2-Ethylhexyl)Phthalate | | 0.003 | mg/L | 0.002 | Grab | EPA625 | 08/20/94 | JG |
| Butylbenzylphthalate | < | 0.0005 | mg/L | 0.0005 | Grab | EPA625 | 08/20/94 | JG |
| Chrysene | < | 0.0005 | mg/L | 0.0005 | Grab | EPA625 | 08/20/94 | JG |
| Dibenzo(a,h)Anthracene | < | 0.0005 | mg/L | 0.0005 | Grab | EPA625 | 08/20/94 | JG |
| Diethylphthalate | | 0.0020 | mg/L | 0.0005 | Grab | EPA625 | 08/20/94 | JG |
| Dimethylphthalate | < | 0.0005 | mg/L | 0.0005 | Grab | EPA625 | 08/20/94 | JG |
| Di-n-Butylphthalate | < | 0.0005 | mg/L | 0.0005 | Grab | EPA625 | 08/20/94 | JG |
| Di-n-Octylphthalate | < | 0.0005 | mg/L | 0.0005 | Grab | EPA625 | 08/20/94 | JG |
| Fluoranthene | < | 0.0005 | mg/L | 0.0005 | Grab | EPA625 | 08/20/94 | JG |
| Fluorene | < | 0.0005 | mg/L | 0.0005 | Grab | EPA625 | 08/20/94 | JG |
| GC/MS Method 625 Sample Preparation | | N/A | N/A | N/A | Grab | EPA625 | 07/13/94 | SC |
| Hexachlorobenzene | < | 0.0005 | mg/L | 0.0005 | Grab | EPA625 | 08/20/94 | JG |
| Hexachlorobutadiene | < | 0.0005 | mg/L | 0.0005 | Grab | EPA625 | 08/20/94 | JG |
| Hexachloroethane | < | 0.0005 | mg/L | 0.0005 | Grab | EPA625 | 08/20/94 | JG |
| Ideno(1,2,3-cd)Pyrene | < | 0.0005 | mg/L | 0.0005 | Grab | EPA625 | 08/20/94 | JG |
| Isophorone | < | 0.0005 | mg/L | 0.0005 | Grab | EPA625 | 08/20/94 | JG |
| Naphthalene | < | 0.0005 | mg/L | 0.0005 | Grab | EPA625 | 08/20/94 | JG |
| Nitrobenzene | < | 0.0005 | mg/L | 0.0005 | Grab | EPA625 | 08/20/94 | JG |
| N-Nitrosodiphenylamine | < | 0.0005 | mg/L | 0.0005 | Grab | EPA625 | 08/20/94 | JG |
| N-Nitroso-Di-n-Propylamine | < | 0.0005 | mg/L | 0.0005 | Grab | EPA625 | 08/20/94 | JG |
| Pentachlorophenol | < | 0.0005 | mg/L | 0.0005 | Grab | EPA625 | 08/20/94 | JG |
| Phenanthrene | < | 0.0005 | mg/L | 0.0005 | Grab | EPA625 | 08/20/94 | JG |
| Phenol | < | 0.0005 | mg/L | 0.0005 | Grab | EPA625 | 08/20/94 | JG |
| Pyrene | < | 0.0005 | mg/L | 0.0005 | Grab | EPA625 | 08/20/94 | JG |
| SURROGATE: 2,4,6-Tribromophenol | | 110 | % Recovery | 1 | N/A | Limits: 10-123% | 08/20/94 | JG |
| SURROGATE: 2-Fluorobiphenyl | | 58 | % Recovery | 1 | N/A | Limits: 43-116% | 08/20/94 | JG |
| SURROGATE: 2-Fluorophenol | | 27 | % Recovery | 1 | N/A | Limits: 21-100% | 08/20/94 | JG |
| SURROGATE: Nitrobenzene-d5 | | 54 | % Recovery | 1 | N/A | Limits: 35-114% | 08/20/94 | JG |
| SURROGATE: Phenol-d6 | | 39 | % Recovery | 1 | N/A | Limits: 10- 94% | 08/20/94 | JG |
| SURROGATE: Terphenyl-d14 | | 50 | % Recovery | 1 | N/A | Limits: 33-141% | 08/20/94 | JG |
| ORGANIC - VOLATILES | | | | | | | | |
| 1,1,1-Trichloroethane | < | 0.005 | mg/L | 0.005 | Grab | EPA624 | 07/12/94 | DHM |
| 1,1,2,2-Tetrachloroethane | < | 0.005 | mg/L | 0.005 | Grab | EPA624 | 07/12/94 | DHM |
| 1,1,2-Trichloroethane | < | 0.005 | mg/L | 0.005 | Grab | EPA624 | 07/12/94 | DHM |
| 1,1-Dichloroethane | < | 0.005 | mg/L | 0.005 | Grab | EPA624 | 07/12/94 | DHM |
| 1,1-Dichloroethene | < | 0.005 | mg/L | 0.005 | Grab | EPA624 | 07/12/94 | DHM |



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# COMMONWEALTH TECHNOLOGY, INC.

REPORT OF ANALYTICAL RESULTS

| CTI LAB NO./ ANALYTICAL TEST | RESULTS | UNITS | DETECT LIMIT | SAMP TYPE | METHOD | ANALYSIS DATE | ANALYSIS BY |
|---|---|---|---|---|---|---|---|
| 94114460 | | | | | | | |
| ORGANIC - VOLATILES | | | | | | | |
| 1,2-Dichlorobenzene | < 0.005 | mg/L | 0.005 | Grab | EPA624 | 07/12/94 | DHM |
| 1,2-Dichloroethane | < 0.005 | mg/L | 0.005 | Grab | EPA624 | 07/12/94 | DHM |
| 1,2-Dichloropropane | < 0.005 | mg/L | 0.005 | Grab | EPA624 | 07/12/94 | DHM |
| 1,3-Dichlorobenzene | < 0.005 | mg/L | 0.005 | Grab | EPA624 | 07/12/94 | DHM |
| 1,4-Dichlorobenzene | < 0.005 | mg/L | 0.005 | Grab | EPA624 | 07/12/94 | DHM |
| 2-Chloroethyl vinyl ether | < 0.005 | mg/L | 0.005 | Grab | EPA624 | 07/12/94 | DHM |
| Benzene | < 0.005 | mg/L | 0.005 | Grab | EPA624 | 07/12/94 | DHM |
| Bromodichloromethane | < 0.005 | mg/L | 0.005 | Grab | EPA624 | 07/12/94 | DHM |
| Bromoform | < 0.005 | mg/L | 0.005 | Grab | EPA624 | 07/12/94 | DHM |
| Bromomethane | < 0.020 | mg/L | 0.02 | Grab | EPA624 | 07/12/94 | DHM |
| Carbon Tetrachloride | < 0.005 | mg/L | 0.005 | Grab | EPA624 | 07/12/94 | DHM |
| Chlorobenzene | < 0.005 | mg/L | 0.005 | Grab | EPA624 | 07/12/94 | DHM |
| Chloroethane | < 0.020 | mg/L | 0.02 | Grab | EPA624 | 07/12/94 | DHM |
| Chloroform | < 0.005 | mg/L | 0.005 | Grab | EPA624 | 07/12/94 | DHM |
| Chloromethane | < 0.010 | mg/L | 0.01 | Grab | EPA624 | 07/12/94 | DHM |
| cis-1,3-Dichloropropene | < 0.005 | mg/L | 0.005 | Grab | EPA624 | 07/12/94 | DHM |
| Dibromochloromethane | < 0.005 | mg/L | 0.005 | Grab | EPA624 | 07/12/94 | DHM |
| Ethylbenzene | < 0.005 | mg/L | 0.005 | Grab | EPA624 | 07/12/94 | DHM |
| Methylene Chloride | < 0.010 | mg/L | 0.01 | Grab | EPA624 | 07/12/94 | DHM |
| Tetrachloroethene | < 0.005 | mg/L | 0.005 | Grab | EPA624 | 07/12/94 | DHM |
| Toluene | < 0.005 | mg/L | 0.005 | Grab | EPA624 | 07/12/94 | DHM |
| trans-1,2-Dichlorethene | < 0.005 | mg/L | 0.005 | Grab | EPA624 | 07/12/94 | DHM |
| trans-1,3-Dichloropropene | < 0.005 | mg/L | 0.005 | Grab | EPA624 | 07/12/94 | DHM |
| Trichloroethene | < 0.005 | mg/L | 0.005 | Grab | EPA624 | 07/12/94 | DHM |
| Trichlorofluoromethane | < 0.010 | mg/L | 0.01 | Grab | EPA624 | 07/12/94 | DHM |
| Vinyl Chloride | < 0.010 | mg/L | 0.01 | Grab | EPA624 | 07/12/94 | DHM |
| SURROGATE: 4-Bromofluorobenzene | 108 | % Recovery | 1 | N/A | EPA624 | 07/12/94 | DHM |
| SURROGATE: d4-1,2-Dichloroethane | 90 | % Recovery | 1 | N/A | EPA624 | 07/12/94 | DHM |
| SURROGATE: dB-Toluene | 96 | % Recovery | 1 | N/A | EPA624 | 07/12/94 | DHM |



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# COMMONWEALTH TECHNOLOGY, INC.

ACCT#: CUNICE

CTI LAB NO: 94118191

ATTN: Dr. Lindell Ormsbee
TO: University of Kentucky-CE
Dept. of Civil Engineering
242 Anderson Hall
Lexington KY 40506

DATE: September 2, 1994

P. O. NO: N/A

SAMPLE ID: Stream Sample
SOURCE OF SAMPLE: -
SAMPLE MATRIX: Wastewater

DATE OF COLLECTION: 08/05/94
COLLECTION TIME: 2:30P
COLLECTED BY: Client
DATE RECEIVED: 08/05/94

NOTE: Chain Of Custody Record Attached

## REPORT OF ANALYTICAL RESULTS

| CTI LAB NO./ ANALYTICAL TEST | | RESULTS | UNITS | DETECT LIMIT | SAMP TYPE | METHOD | ANALYSIS DATE | ANALYSIS BY |
|---|---|---|---|---|---|---|---|---|
| 94118191 | | | | | | | | |
| GENERAL PARAMETERS | | | | | | | | |
| Cyanide, Total | < | 0.002 | mg/L | 0.002 | Grab | EPA335.3 | 08/16/94 | MJV |
| Nitrogen, Ammonia | < | 0.02 | mg/L | 0.02 | Grab | EPA350.1 | 08/09/94 | KAH |
| Oil & Grease, Total/IR | | 3.4 | mg/L | 0.3 | Grab | EPA413.2 | 08/24/94 | WLS |
| Phenols | < | 0.006 | mg/L | 0.006 | Grab | EPA420.2 | 08/15/94 | MJV |
| Phosphorus, Total | | 0.17 | mg/L as P | 0.01 | Grab | EPA365.2 | 08/30/94 | SCL |
| METALS | | | | | | | | |
| Total Antimony (ICP) | < | 0.1 | mg/L | 0.1 | Grab | EPA200.7/9.3 | 08/09/94 | GLM |
| Total Arsenic (Furnace) | < | 0.005 | mg/L | 0.005 | Grab | EPA206.2/4.1.3 | 08/14/94 | MEC |
| Total Beryllium (ICP) | < | 0.005 | mg/L | 0.005 | Grab | EPA200.7/9.3 | 08/09/94 | GLM |
| Total Cadmium (ICP) | < | 0.005 | mg/L | 0.005 | Grab | EPA200.7/9.3 | 08/09/94 | GLM |
| Total Chromium (ICP) | < | 0.01 | mg/L | 0.01 | Grab | EPA200.7/9.3 | 08/09/94 | GLM |
| Total Copper (ICP) | < | 0.01 | mg/L | 0.01 | Grab | EPA200.7/9.3 | 08/09/94 | GLM |
| Total Lead (ICP * Furnace) | < | 0.005 | mg/L | 0.005 | Grab | EPA200.7/239.2 | 08/19/94 | DJM/MEC |
| Total Mercury (Cold Vapor) | < | 0.0005 | mg/L | 0.0005 | Grab | EPA245.1 | 08/21/94 | MEC |
| Total Nickel (ICP) | < | 0.02 | mg/L | 0.02 | Grab | EPA200.7/9.3 | 08/09/94 | GLM |
| Total Selenium (Furnace) | < | 0.005 | mg/L | 0.005 | Grab | EPA270.2/4.1.3 | 08/10/94 | GLM |
| Total Silver (ICP) | < | 0.01 | mg/L | 0.01 | Grab | EPA200.7/9.3 | 08/09/94 | GLM |
| Total Thallium (ICP) | < | 0.5 | mg/L | 0.5 | Grab | EPA200.7/9.3 | 08/09/94 | GLM |
| Total Zinc (ICP) | < | 0.02 | mg/L | 0.02 | Grab | EPA200.7/9.3 | 08/09/94 | GLM |
| ORGANIC - PESTICIDES/HERBICIDES | | | | | | | | |
| Herbicides Sample Preparation | | N/A | N/A | N/A | Grab | SW8150 | 08/08/94 | SC/JZ |
| Herbicide, 2,4,5-TP Silvex | < | 0.001 | mg/L | 0.001 | Grab | SW8150 | 08/14/94 | XSQ |
| Herbicide, 2,4-D | < | 0.001 | mg/L | 0.001 | Grab | SW8150 | 08/14/94 | XSQ |
| ORGANIC - PESTICIDES/PCB'S | | | | | | | | |
| 4,4-DDD | < | 0.001 | mg/L | 0.001 | Grab | EPA608 | 08/18/94 | XSQ |
| 4,4-DDE | < | 0.001 | mg/L | 0.001 | Grab | EPA608 | 08/18/94 | XSQ |
| 4,4-DDT | < | 0.001 | mg/L | 0.001 | Grab | EPA608 | 08/18/94 | XSQ |
| Aldrin | < | 0.001 | mg/L | 0.001 | Grab | EPA608 | 08/18/94 | XSQ |

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REPORT OF ANALYTICAL RESULTS

| CTI LAB NO./ ANALYTICAL TEST | | RESULTS | UNITS | DETECT LIMIT | SAMP TYPE | METHOD | ANALYSIS DATE | BY |
|---|---|---|---|---|---|---|---|---|
| 94118191 | | | | | | | | |
| ORGANIC - PESTICIDES/PCB'S | | | | | | | | |
| Alpha-BHC | < | 0.001 | mg/L | 0.001 | Grab | EPA608 | 08/18/94 | XSQ |
| Aroclor-1016 | < | 0.001 | mg/L | 0.001 | Grab | EPA608 | 08/18/94 | XSQ |
| Aroclor-1221 | < | 0.001 | mg/L | 0.001 | Grab | EPA608 | 08/18/94 | XSQ |
| Aroclor-1232 | < | 0.001 | mg/L | 0.001 | Grab | EPA608 | 08/18/94 | XSQ |
| Aroclor-1242 | < | 0.001 | mg/L | 0.001 | Grab | EPA608 | 08/18/94 | XSQ |
| Aroclor-1248 | < | 0.001 | mg/L | 0.001 | Grab | EPA608 | 08/18/94 | XSQ |
| Aroclor-1254 | < | 0.001 | mg/L | 0.001 | Grab | EPA608 | 08/18/94 | XSQ |
| Aroclor-1260 | < | 0.001 | mg/L | 0.001 | Grab | EPA608 | 08/18/94 | XSQ |
| Beta-BHC | < | 0.001 | mg/L | 0.001 | Grab | EPA608 | 08/18/94 | XSQ |
| Chlordane | < | 0.001 | mg/L | 0.001 | Grab | EPA608 | 08/18/94 | XSQ |
| Delta-BHC | < | 0.001 | mg/L | 0.001 | Grab | EPA608 | 08/18/94 | XSQ |
| Dieldrin | < | 0.001 | mg/L | 0.001 | Grab | EPA608 | 08/18/94 | XSQ |
| Endosulfan I | < | 0.001 | mg/L | 0.001 | Grab | EPA608 | 08/18/94 | XSQ |
| Endosulfan II | < | 0.001 | mg/L | 0.001 | Grab | EPA608 | 08/18/94 | XSQ |
| Endosulfan Sulfate | < | 0.001 | mg/L | 0.001 | Grab | EPA608 | 08/18/94 | XSQ |
| Endrin | < | 0.0001 | mg/L | 0.0001 | Grab | EPA608 | 08/18/94 | XSQ |
| Endrin Aldehyde | < | 0.001 | mg/L | 0.001 | Grab | EPA608 | 08/18/94 | XSQ |
| Gamma-BHC | < | 0.001 | mg/L | 0.001 | Grab | EPA608 | 08/18/94 | XSQ |
| Heptachlor | < | 0.001 | mg/L | 0.001 | Grab | EPA608 | 08/18/94 | XSQ |
| Heptachlor Epoxide | < | 0.001 | mg/L | 0.001 | Grab | EPA608 | 08/18/94 | XSQ |
| Methoxychlor | < | 0.001 | mg/L | 0.001 | Grab | EPA608 | 08/18/94 | XSQ |
| Pesticides/PCBs Sample Preparation | | N/A | N/A | N/A | Grab | EPA608 | 08/10/94 | SC/JZ |
| Toxaphene | < | 0.003 | mg/L | 0.003 | Grab | EPA608 | 08/18/94 | XSQ |
| ORGANIC - SEMIVOLATILES | | | | | | | | |
| 1,2,4-Trichlorobenzene | < | 0.0005 | mg/L | 0.0005 | Grab | EPA625 | 08/20/94 | JG |
| 1,2-Dichlorobenzene | < | 0.0005 | mg/L | 0.0005 | Grab | EPA625 | 08/20/94 | JG |
| 1,3-Dichlorobenzene | < | 0.0005 | mg/L | 0.0005 | Grab | EPA625 | 08/20/94 | JG |
| 1,4-Dichlorobenzene | < | 0.0005 | mg/L | 0.0005 | Grab | EPA625 | 08/20/94 | JG |
| 2,4,6-Trichlorophenol | < | 0.0005 | mg/L | 0.0005 | Grab | EPA625 | 08/20/94 | JG |
| 2,4-Dichlorophenol | < | 0.0005 | mg/L | 0.0005 | Grab | EPA625 | 08/20/94 | JG |
| 2,4-Dimethylphenol | < | 0.0005 | mg/L | 0.0005 | Grab | EPA625 | 08/20/94 | JG |
| 2,4-Dinitrophenol | < | 0.0025 | mg/L | 0.0025 | Grab | EPA625 | 08/20/94 | JG |
| 2,4-Dinitrotoluene | < | 0.0005 | mg/L | 0.0005 | Grab | EPA625 | 08/20/94 | JG |
| 2,6-Dinitrotoluene | < | 0.0005 | mg/L | 0.0005 | Grab | EPA625 | 08/20/94 | JG |
| 2-Chloronaphthalene | < | 0.0005 | mg/L | 0.0005 | Grab | EPA625 | 08/20/94 | JG |
| 2-Chlorophenol | < | 0.0005 | mg/L | 0.0005 | Grab | EPA625 | 08/20/94 | JG |
| 2-Methyl-4,6-Dinitrophenol | < | 0.0025 | mg/L | 0.0025 | Grab | EPA625 | 08/20/94 | JG |
| 2-Nitrophenol | < | 0.0005 | mg/L | 0.0005 | Grab | EPA625 | 08/20/94 | JG |
| 3,3'-Dichlorobenzidine | < | 0.0005 | mg/L | 0.0005 | Grab | EPA625 | 08/20/94 | JG |
| 4-Bromophenyl-Phenylether | < | 0.0005 | mg/L | 0.0005 | Grab | EPA625 | 08/20/94 | JG |
| 4-Chlorophenyl-Phenylether | < | 0.0005 | mg/L | 0.0005 | Grab | EPA625 | 08/20/94 | JG |
| 4-Chloro-3-Methylphenol | < | 0.0005 | mg/L | 0.0005 | Grab | EPA625 | 08/20/94 | JG |
| 4-Nitrophenol | < | 0.0005 | mg/L | 0.0005 | Grab | EPA625 | 08/20/94 | JG |
| Acenaphthene | < | 0.0005 | mg/L | 0.0005 | Grab | EPA625 | 08/20/94 | JG |
| Acenaphthylene | < | 0.0005 | mg/L | 0.0005 | Grab | EPA625 | 08/20/94 | JG |
| Anthracene | < | 0.0005 | mg/L | 0.0005 | Grab | EPA625 | 08/20/94 | JG |
| Benzo(a)Anthracene | < | 0.0005 | mg/L | 0.0005 | Grab | EPA625 | 08/20/94 | JG |

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COMMONWEALTH TECHNOLOGY, INC.

REPORT OF ANALYTICAL RESULTS

| CTI LAB NO./ ANALYTICAL TEST | | RESULTS | UNITS | DETECT LIMIT | SAMP TYPE METHOD | ANALYSIS DATE | BY |
|---|---|---|---|---|---|---|---|
| 94118191 | | | | | | | |
| ORGANIC - SEMIVOLATILES | | | | | | | |
| Benzo(a)Pyrene | < | 0.0005 | mg/L | 0.0005 | Grab EPA625 | 08/20/94 | JG |
| Benzo(b)Fluoranthene | < | 0.0005 | mg/L | 0.0005 | Grab EPA625 | 08/20/94 | JG |
| Benzo(g,h,i)Perylene | < | 0.0005 | mg/L | 0.0005 | Grab EPA625 | 08/20/94 | JG |
| Benzo(k)Fluoranthene | < | 0.0005 | mg/L | 0.0005 | Grab EPA625 | 08/20/94 | JG |
| Bis(2-chloroethoxy)methane | < | 0.0005 | mg/L | 0.0005 | Grab EPA625 | 08/20/94 | JG |
| Bis(2-Chloroethyl)Ether | < | 0.0005 | mg/L | 0.0005 | Grab EPA625 | 08/20/94 | JG |
| Bis(2-Chloroisopropyl)Ether | < | 0.0005 | mg/L | 0.0005 | Grab EPA625 | 08/20/94 | JG |
| Bis(2-Ethylhexyl)Phthalate | < | 0.002 | mg/L | 0.002 | Grab EPA625 | 08/20/94 | JG |
| Butylbenzylphthalate | < | 0.0005 | mg/L | 0.0005 | Grab EPA625 | 08/20/94 | JG |
| Chrysene | < | 0.0005 | mg/L | 0.0005 | Grab EPA625 | 08/20/94 | JG |
| Dibenzo(a,h)Anthracene | < | 0.0005 | mg/L | 0.0005 | Grab EPA625 | 08/20/94 | JG |
| Diethylphthalate | < | 0.0005 | mg/L | 0.0005 | Grab EPA625 | 08/20/94 | JG |
| Dimethylphthalate | < | 0.0005 | mg/L | 0.0005 | Grab EPA625 | 08/20/94 | JG |
| Di-n-Butylphthalate | < | 0.0005 | mg/L | 0.0005 | Grab EPA625 | 08/20/94 | JG |
| Di-n-Octylphthalate | < | 0.0005 | mg/L | 0.0005 | Grab EPA625 | 08/20/94 | JG |
| Fluoranthene | < | 0.0005 | mg/L | 0.0005 | Grab EPA625 | 08/20/94 | JG |
| Fluorene | < | 0.0005 | mg/L | 0.0005 | Grab EPA625 | 08/20/94 | JG |
| GC/MS Method 625 Sample Preparation | | N/A | N/A | N/A | Grab EPA625 | 08/11/94 | SC/JZ |
| Hexachlorobenzene | < | 0.0005 | mg/L | 0.0005 | Grab EPA625 | 08/20/94 | JG |
| Hexachlorobutadiene | < | 0.0005 | mg/L | 0.0005 | Grab EPA625 | 08/20/94 | JG |
| Hexachloroethane | < | 0.0005 | mg/L | 0.0005 | Grab EPA625 | 08/20/94 | JG |
| Ideno(1,2,3-cd)Pyrene | < | 0.0005 | mg/L | 0.0005 | Grab EPA625 | 08/20/94 | JG |
| Isophorone | < | 0.0005 | mg/L | 0.0005 | Grab EPA625 | 08/20/94 | JG |
| Naphthalene | < | 0.0005 | mg/L | 0.0005 | Grab EPA625 | 08/20/94 | JG |
| Nitrobenzene | < | 0.0005 | mg/L | 0.0005 | Grab EPA625 | 08/20/94 | JG |
| N-Nitrosodiphenylamine | < | 0.0005 | mg/L | 0.0005 | Grab EPA625 | 08/20/94 | JG |
| N-Nitroso-Di-n-Propylamine | < | 0.0005 | mg/L | 0.0005 | Grab EPA625 | 08/20/94 | JG |
| Pentachlorophenol | < | 0.0005 | mg/L | 0.0005 | Grab EPA625 | 08/20/94 | JG |
| Phenanthrene | < | 0.0005 | mg/L | 0.0005 | Grab EPA625 | 08/20/94 | JG |
| Phenol | < | 0.0005 | mg/L | 0.0005 | Grab EPA625 | 08/20/94 | JG |
| Pyrene | < | 0.0005 | mg/L | 0.0005 | Grab EPA625 | 08/20/94 | JG |
| SURROGATE: 2,4,6-Tribromophenol | | 14 | % Recovery | 1 | N/A Limits: 10-123% | 08/20/94 | JG |
| SURROGATE: 2-Fluorobiphenyl | | 60 | % Recovery | 1 | N/A Limits: 43-116% | 08/20/94 | JG |
| SURROGATE: 2-Fluorophenol | | 137 | % Recovery | 1 | N/A Limits: 21-100% | 08/20/94 | JG |
| SURROGATE: Nitrobenzene-d5 | | 98 | % Recovery | 1 | N/A Limits: 35-114% | 08/20/94 | JG |
| SURROGATE: Phenol-d6 | | 155 | % Recovery | 1 | N/A Limits: 10- 94% | 08/20/94 | JG |
| SURROGATE: Terphenyl-d14 | | 75 | % Recovery | 1 | N/A Limits: 33-141% | 08/20/94 | JG |
| ORGANIC - VOLATILES | | | | | | | |
| 1,1,1-Trichloroethane | < | 0.005 | mg/L | 0.005 | Grab EPA624 | 08/10/94 | DHM |
| 1,1,2,2-Tetrachloroethane | < | 0.005 | mg/L | 0.005 | Grab EPA624 | 08/10/94 | DHM |
| 1,1,2-Trichloroethane | < | 0.005 | mg/L | 0.005 | Grab EPA624 | 08/10/94 | DHM |
| 1,1-Dichloroethane | < | 0.005 | mg/L | 0.005 | Grab EPA624 | 08/10/94 | DHM |
| 1,1-Dichloroethene | < | 0.005 | mg/L | 0.005 | Grab EPA624 | 08/10/94 | DHM |
| 1,2-Dichlorobenzene | < | 0.005 | mg/L | 0.005 | Grab EPA624 | 08/10/94 | DHM |
| 1,2-Dichloroethane | < | 0.005 | mg/L | 0.005 | Grab EPA624 | 08/10/94 | DHM |
| 1,2-Dichloropropane | < | 0.005 | mg/L | 0.005 | Grab EPA624 | 08/10/94 | DHM |
| 1,3-Dichlorobenzene | < | 0.005 | mg/L | 0.005 | Grab EPA624 | 08/10/94 | DHM |

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REPORT OF ANALYTICAL RESULTS

| CTI LAB NO./ ANALYTICAL TEST | | RESULTS | UNITS | DETECT LIMIT | SAMP TYPE | METHOD | ANALYSIS DATE | BY |
|---|---|---|---|---|---|---|---|---|
| 94118191 | | | | | | | | |
| ORGANIC - VOLATILES | | | | | | | | |
| 1,4-Dichlorobenzene | < | 0.005 | mg/L | 0.005 | Grab | EPA624 | 08/10/94 | DHM |
| 2-Chloroethyl vinyl ether | < | 0.005 | mg/L | 0.005 | Grab | EPA624 | 08/10/94 | DHM |
| Benzene | < | 0.005 | mg/L | 0.005 | Grab | EPA624 | 08/10/94 | DHM |
| Bromodichloromethane | < | 0.005 | mg/L | 0.005 | Grab | EPA624 | 08/10/94 | DHM |
| Bromoform | < | 0.005 | mg/L | 0.005 | Grab | EPA624 | 08/10/94 | DHM |
| Bromomethane | < | 0.020 | mg/L | 0.02 | Grab | EPA624 | 08/10/94 | DHM |
| Carbon Tetrachloride | < | 0.005 | mg/L | 0.005 | Grab | EPA624 | 08/10/94 | DHM |
| Chlorobenzene | < | 0.005 | mg/L | 0.005 | Grab | EPA624 | 08/10/94 | DHM |
| Chloroethane | < | 0.020 | mg/L | 0.02 | Grab | EPA624 | 08/10/94 | DHM |
| Chloroform | < | 0.005 | mg/L | 0.005 | Grab | EPA624 | 08/10/94 | DHM |
| Chloromethane | < | 0.010 | mg/L | 0.01 | Grab | EPA624 | 08/10/94 | DHM |
| cis-1,3-Dichloropropene | < | 0.005 | mg/L | 0.005 | Grab | EPA624 | 08/10/94 | DHM |
| Dibromochloromethane | < | 0.005 | mg/L | 0.005 | Grab | EPA624 | 08/10/94 | DHM |
| Ethylbenzene | < | 0.005 | mg/L | 0.005 | Grab | EPA624 | 08/10/94 | DHM |
| Methylene Chloride | < | 0.010 | mg/L | 0.01 | Grab | EPA624 | 08/10/94 | DHM |
| Tetrachloroethene | < | 0.005 | mg/L | 0.005 | Grab | EPA624 | 08/10/94 | DHM |
| Toluene | | 0.006 | mg/L | 0.005 | Grab | EPA624 | 08/10/94 | DHM |
| trans-1,2-Dichlorethene | < | 0.005 | mg/L | 0.005 | Grab | EPA624 | 08/10/94 | DHM |
| trans-1,3-Dichloropropene | < | 0.005 | mg/L | 0.005 | Grab | EPA624 | 08/10/94 | DHM |
| Trichloroethene | < | 0.005 | mg/L | 0.005 | Grab | EPA624 | 08/10/94 | DHM |
| Trichlorofluoromethane | < | 0.010 | mg/L | 0.01 | Grab | EPA624 | 08/10/94 | DHM |
| Vinyl Chloride | < | 0.010 | mg/L | 0.01 | Grab | EPA624 | 08/10/94 | DHM |
| SURROGATE: 4-Bromofluorobenzene | | 98 | % Recovery | 1 | N/A | EPA624 | 08/10/94 | DHM |
| SURROGATE: d4-1,2-Dichloroethane | | 104 | % Recovery | 1 | N/A | EPA624 | 08/10/94 | DHM |
| SURROGATE: d8-Toluene | | 100 | % Recovery | 1 | N/A | EPA624 | 08/10/94 | DHM |

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