Trends in Water Quality of Ambient Monitoring Stations of the Coosa and Tallapoosa Watersheds: Aquatic Macroinvertebrate Bioassessments, 1980-1995

Ecological Studies Section - Field Operations Division
Alabama Department of Environmental Management

Trends in Water Quality of Ambient Monitoring Stations
Coosa and Tallapoosa Watersheds:
Aquatic Macroinvertebrate Bioassessments
1980-1995

Alabama Dept. of Environmental Management
Ecological Studies Section, Field Operations Division
March, 1996

ABSTRACT

The macroinvertebrate data that has been collected at the eleven ambient monitoring stations located on the Coosa and Tallapoosa waterheds since 1980 was reviewed in order to assess trends in water quality. Biotic index scores and measurements of taxa richness were used to analyze trends in water quality at the four stations that had macroinvertebrate data dating back to 1980: CL-1, CO-1 (Coosa basin), and SO-1, and S-1 (Tallapoosa basin). The results of the macroinvertebrate bioassessments of one station, SO-1, suggest improved water quality. Improved water quality was indicated by:

- Decreased biotic index scores;
- Increased total, chironomidae and EPT taxa richness;
- Increased dissolved oxygen concentrations; and
- Decreased concentrations of some nutrients.

The results of macroinvertebrate assessments conducted at CO-1 within the Coosa watershed, and S-1, within the Tallapoosa watershed, indicated decreased water quality. Decreased water quality was indicated by increased biotic index scores and decreased taxa richness.

The results of biotic index scores, taxa richness, and chemical data were not in accordance at CL-1. The biotic index scores indicated slightly decreased water quality, while taxa richness and analysis of total phosphorus concentrations indicated improved water quality. Therefore, no assessment of trends in water quality was made.

Review of the data indicated that ambient water quality is impaired by multiple stresses at several of the ambient monitoring stations. Most ambient monitoring stations were established to monitor trends in water quality below point sources of pollution (ADEM 1994a). It is suggested that biological assessments could more effectively assess trends in water quality at ambient monitoring stations if:

- the relationship between bioassessment methodologies is established;
- an upstream control and ecoregional reference site are used to establish baseline data and to separate impacts from point and nonpoint sources; and
- chemical/ physical data is used in conjunction with biological data.

It is also suggested that the sampling frequency of chemical data could be decreased and retain its current level of effectiveness in assessing trends in water quality.

Table of Contents

List of Tables

List of Figures

INTRODUCTION

Since 1974, as part of the EPA's national water quality monitoring program, the Alabama Department of Environmental Management (ADEM) has established ninety-three fixed ambient monitoring stations located on seven of the state's major drainage basins. During this period, under the Clean Water Act of 1977, the EPA emphasized programs addressing the chemical contamination of the nation's waters (National Research Council 1992). Therefore, most of the ambient monitoring stations were established to monitor trends in water quality below point sources of pollution (ADEM 1994a). More recently, the EPA has shifted its focus from problem-specific point source monitoring programs to assessment of ecological condition of large scale systems that receive multiple pollution impacts (National Research Council 1992).

In order to address these issues, the Department is scheduled to adopt a watershed protection approach, effective in 1997. This will enable the Department to 1) improve the basic knowledge of each watershed as well as the cumulative impacts within the watershed; 2) provide a framework for more centralized data management; and 3) provide consistent and integrated decision making for water resource issues.

At present, the Department conducts biological assessments at thirty-six freshwater ambient monitoring stations. Since 1993, these bioassessments have been conducted on a triennial rotation by basin (ADEM 1993). This sampling schedule has facilitated efficient use of limited financial and personnel resources and improved monitoring coverage within river basins. However, it is necessary that the biological and chemical data generated from each station be reviewed to evaluate and improve the assessment process.

During 1995, macroinvertebrate bioassessments were conducted at the eight ambient monitoring stations located within the Coosa River watershed, as well as two of the three stations located within the Tallapoosa River watershed. The third station, S-1, was sampled in 1994 for another study and the results included in this report. The purpose of this report is twofold: 1) to review the macroinvertebrate data that has been collected at the ambient monitoring stations located in these watersheds since 1980 in order to assess trends in water quality at each station; and, 2) to review the assessment process so that improvements can be incorporated into future assessments.

METHODOLOGY

Study Stations

Bioassessments are conducted on ambient trend monitoring stations on a three year rotation cycle by basin (ADEM 1993). During 1995, macroinvertebrate bioassessments were conducted at all ambient monitoring stations located within the Coosa and Tallapoosa basins. Locations and descriptions of these sites are presented in Tables 1A (Coosa watershed stations) and 1B (Tallapoosa watershed stations).

Sample Collection

All macroinvertebrate samples from ambient monitoring stations were collected using either artificial substrate samplers (Hester-Dendy Multiplates) or an instream multihabitat bioassessment protocol. Both methodologies are described in the ADEM Standard Operating Procedures and Quality Control Assurance Manual (SOP), Vol. II (1992).

Metrics

In order to accurately assess water quality, macroinvertebrate data is analyzed using metrics.. Guidelines for interpreting these metrics are provided in Table 2A. Taxa richness and the biotic index metric were chosen for trend analysis in this report. Although trends in water quality could be assessed using any of these metrics, taxa richness and the biotic index are easy to understand and have been shown to be reliable and effective (Lenat 1988, Lenat 1993, unpubl. data). Assessments of "improving" or "declining" water quality are assigned only if both metrics support the assessment. Trend analyses based on additional metrics can be found in ADEM (1994b). Explanations of taxa richness and the biotic index metric are given below.

Taxa Richness: Taxa richness is divided into three separate metrics: total taxa richness, EPT taxa richness, and chironomidae taxa richness. Measurements of taxa richness can differ between different collection methods (Beiser 1991, ADEM 1995a). Therefore, taxa richness is only used in the comparison of data collected by the same method.

TOTAL TAXA RICHNESS: Total taxa richness is the number of different kinds of organisms (genera) collected during a sampling event. Although low levels of nutrient enrichment can increase taxa richness (Welch 1992), taxa richness generally increases with increasing water quality (Weber 1973). This metric may also differ somewhat with sampling effort and experience of the investigators (Lenat 1993, unpubl. data).

EPT TAXA RICHNESS: This is the portion of taxa richness that includes three pollution-intolerant groups--Ephemeroptera (E), Plecoptera (P), and Trichoptera (T). The EPT taxa richness generally increases with increasing water quality, although there are some EPT taxa that thrive in slightly enriched waters (Lenat 1994). This metric has been proven to be consistent between investigators and sampling dates (Lenat 1993, unpubl. data).

CHIRONOMIDAE TAXA RICHNESS: The chironomidae taxa are generally a pollution-tolerant group. However, an increase in the Chironomidae taxa richness does not necessarily indicate decreased water quality. Environmental stress would be indicated if this group dominated a sample in percentage of the total taxa richness.

Biotic Index: The biotic index ranges from 0 to 10 (Hilsenhoff 1987). The larger the number, the poorer the water quality. The tolerance values used in this report were developed by North Carolina (Lenat 1994) and summarizes the overall pollution tolerance of the benthic macroinvertebrate community with a single value. This metric has been shown to be comparable between sampling methods (Beiser 1991, ADEM 1995a) and is therefore used in this report to compare data collected by two different sampling methods.

Trend Analysis

1. Macroinvertrate Community Composition

The primary objective of this report is to assess the trends in water quality at the ambient monitoring stations located within the Coosa and Tallapoosa basins. Several improvements in organism identification and sampling methodology over the past two decades make this task more difficult. From 1974-1980, organism identifications were made to the taxonomic level of order or family. Since that time, macroinvertebrates have been identified to genus. Although methods have been developed by the Department to make comparisons between these levels of identification, to do so makes detection of changes in water quality much more difficult (ADEM 1994b). Therefore, the trend analyses presented within this report are based upon data that has been collected since 1980. Analysis of trends in water quality of the ambient monitoring stations that include the data collected 1974-1980 was reported by the Department in Water Quality Trends of Selected Ambient Monitoring Stations in Alabama Utilizing Aquatic Macroinvertebrate Assessments (1994b).

Another problem in analyzing long term trends in water quality arises from changes in sampling methodology. Until 1989 and 1992, biological monitoring was conducted utilizing quantitative, artificial substrate samplers (Hester-Dendy Multiplate samplers) in wadeable and nonwadeable stations, respectively. In 1990, a Multihabitat Assessment protocol was adopted by the ADEM for use in wadeable streams (ADEM 1992). These methods have been shown to result in differences in taxonomic richness (Beiser 1991, ADEM 1995a). The biotic index, however, has been shown to be comparable between these methods (Beiser 1991, ADEM 1995). Therefore, the Multihabitat data was only compared with previous years using biotic index scores.

Although a similar Multihabitat protocol was adopted for use in nonwadeable streams in 1993, macroinvertebrates were collected using both the Hester-Dendy samplers and the multihabitat protocol in 1995. The Hester-Dendy data was used for trend analysis in this report.

Another difficulty in analyzing long term trend data results from differences in sampling dates between years. Although most samples were collected between July and August, some were collected as early as June and as late as November. Macroinvertebrate communities can change with the season, affecting metric results (Lenat 1988). In order to minimize variablity in assessment due to differences in collection date, the period with the most sampling dates was chosen for analysis. The period of analysis was chosen independently for each station.

2. Monthly Nutrient and Chemical Samples

Water samples, collected monthly at the Coosa and Tallapoosa ambient monitoring stations, are analyzed for nutrient content, metal content, and chemical parameters. These data, which are entered into the Department's STORET database monthly, have been checked for accuracy by Field Operations Personnel. The monthly data collected at these stations were retrieved from STORET in order to 1) examine the impact on water quality of remedial actions required by the state; and 2) assess the effect of these improvements on the macroinvertebrate community. Average annual concentrations of selected nutrients and chemical parameters were also calculated to reflect trends based upon monthly and quarterly sampling regimes.

RESULTS

Coosa Watershed Stations

At present, macroinvertebrates are collected at eight ambient monitoring stations located on four waterbodies within the Coosa River watershed (Chattooga River, Tallasahatchee Creek, Choccolocco Creek, and the Coosa River). Four of these stations have been monitored since 1974 (ADEM 1994b). Except CT-2 and CO-3, which monitor the water quality of interstate waterbodies, each of these stations was established to monitor the impact of point source discharges on water quality (Table 1A). The locations of these stations are presented in Table 1. The results of all macroinvertebrate assessments conducted at these stations since 1980 are presented in Table 2B. Trends in water quality are assessed for CL-1 and CO-2, the two Coosa River stations that have macroinvertebrate assessments dating from 1980.

Choccolocco Creek Station: CL-1

Station CL-1 was established in 1974 to monitor the effect of municipal and industrial discharges from the Anniston area on the water quality of Choccolocco Creek (Table 1A). The ten macroinvertebrate assessments conducted at this station since 1980 were collected using Hester-Dendy multiplate samplers (Table 2A). Six of these assessments were collected during summer months, between late June and August, and were used to assess trends in water quality.

Of the four stations analyzed for trends in water quality, CL-1 is the only station in which the results of the taxa richness and the biotic index metrics were not in accordance. The EPT taxa richness has increased significantly since 1980 (fig 1). Chironomidae and total taxa richness have also increased (fig. 1). Biotic index scores, however, have not indicated any significant change in water quality, but have increased slightly, contradicting taxa richness results (fig. 2).

During 1986 -1988, the Anniston wastewater treatment facility was upgraded to eliminate bypasses and hydraulic overloading of effluent (ADEM 1989). Analysis of monthly total phosphorus data collected by the Department suggests that average annual

Table. 1A. Ambient monitoring stations located within the Coosa River basin.

Station	Waterbody	Ecoregion[a]	Water Use Classification[b]	Problem Monitored	Assessment	Location
CT-2	Chattooga R.	67	F&W	Interstate waterway	N/A	T8S, R11E, s27; near Co. Rd. 140 at AL/GA stateline (Cherokee Co.)
CO-3	Coosa R.	67	S/F&W	Interstate waterway	N/A	T10S, R11E, s2; Weiss Reservoir (Coosa River) at AL/GA stateline (Cherokee Co.)
CO-1	Coosa R.	67	F&W	paper plant	N/A	T12S, R6E, s33; AL Hwy77 Bridge in Southside (Etowah Co.)
CO-2	Coosa R.	67	F&W	paper plant	Declining	T20S, R3E, s18 (R.M. 400.7); Hwy 231 bridge near Childersburg (Talladega Co.)
TH-1	Tallasahatchee Cr.	67	F&W	textile and municipal plant	N/A	T20S, R4E,s30; bridge east of Childersburg (Talladega).
CL-2	Choccolocco Cr.	67	F&W	municipal and industrial discharges	N/A	T17S, R7E, s4 (R.M. 15.6); near Coldwater, AL (Talladega Co.)
CL-3	Choccolocco Cr.	67	F&W	municipal and industrial discharges	N/A	T17S, R6E, s15; Talladega Co. Rd. 399 (Talladega Co.)
CL-1	Choccolocco Cr.	67	F&W	municipal and industrial discharges	No Change	T17S, R5E, s15 (R.M. 8.2); Alabama 79 Bridge north of Talladega (Talladega Co.)

a. Ecoregion 67: Central Appalachian Ridges and Valleys
b. Water Use Classifications: F&W: Fish and Wildlife

Table 2A. Interpretation of metrics used to analyze macroinvertebrate data.

Structure Metrics	**Range**	**Interpretation**
Taxa Richness	Total number of distinct taxa.	Generally increases with increasing water quality.
EPT Index	Total number of generally pollution-sensitive insect orders: Ephemeroptera, Plecoptera, and Trichoptera.	Generally increases with increasing water quality.
Chironomidae Taxa Richness	Total number of distinct Chironomidae taxa.	Generally decreases with increasing water quality
Community Balance Metrics	**Range**	**Interpretation**
Biotic Index	0-10	Generally decreases with increasing water quality.
% Contribution Dominant Taxon	0-100%	Generally decreases with increasing water quality.
Quantitative Community Balance Metrics*	**Range**	**Interpretation**
Diversity Index	0-4	Values between 3-4 indicate little stress; values >1 indicate severely impacted waters
Equitability	0-1	Values >0.5 indicate mild or no stress; <0.5 indicates an impact

* Quantitative community balance metrics are only for use with Hester-Dendy multiplate samplers.

Table 2B. Results of aquatic macroinvertebrate data collected at the Coosa River ambient monitoring stations. The wadeable stations, CT-2 and TH-1 were collected using the multihabitat method. All other data was collected using Hester-Dendy samplers.

Waterbody	Station Number	Collection Date	Ecoregion Number	H.A.*	Taxa Richness	EPT * Index	Chiron.* Taxa Richness	Biotic Index	% Contrib. Dominant Taxon	Diversity Index[a]	Equitability Index[a]
Chattooga R.[RBP]	CT-2	7/21/91	67	103	58	16	16	6.2	20	---	---
		7/26/95	67	88	40	12	13	5.8	34	---	---
Tallasahatchee Cr.[RBP]	TH-1	7/17/91	67	109	36	11	6	5.3	21	---	---
		7/6/95	67	97	35	9	9	5.3	29	---	---
Choccolocco Cr.	CL-2	9/26/84	67	---	17	4	8	7.0	26	3.1	0.70
		7/25/95	67	54	30	8	13	6.4	23	3.7	0.60
	CL-3	7/25/95	67	103	29	10	10	5.1	23	3.61	0.61
	CL-1	6/30/80	67	---	5	1	0	4.2	48	0.72	0.38
		6/23/82	67	---	12	4	1	5.2	35	2.56	0.67
		9/26/84	67	---	17	5	6	5.3	38	2.84	0.59
		7/2/85	67	---	22	6	8	7.3	29	3.09	0.55
		7/23/86	67	---	16	6	5	5.5	76	1.41	0.21
		9/30/87	67	---	21	4	8	7.4	33	3.21	0.63
		8/25/88	67	---	36	7	10	6.0	38	3.55	0.47
		11/30/89	67	---	22	7	9	5.3	21	3.60	0.80
		7/27/90	67	---	21	7	8	5.8	34	3.07	0.57
		7/25/95	67	88	31	11	10	5.8	40	3.36	0.47
Coosa R.	CO-3	7/26/95	67	102	11	1	9	8.6	65	1.81	0.41
	CO-1	7/26/95	67	76	11	1	8	8.3	41	2.19	0.55
	CO-2	6/30/80	67	---	9	3	3	7.1	53	2.07	0.62
		7/21/83	67	---	17	2	6	5.5	39	2.8	0.57
		7/23/86	67	---	11	2	5	8.1	33	2.41	0.66
		8/25/88	67	---	20	4	7	8.1	31	3.06	0.59
		11/30/89	67	---	24	5	13	7.5	17	4.04	1.01
		7/27/90	67	---	12	2	8	7.8	33	2.23	0.52
		8/28/91	67	---	13	5	7	8.1	35	2.46	0.58
		7/27/95	67	110	12	3	9	8.0	45	2.43	0.61

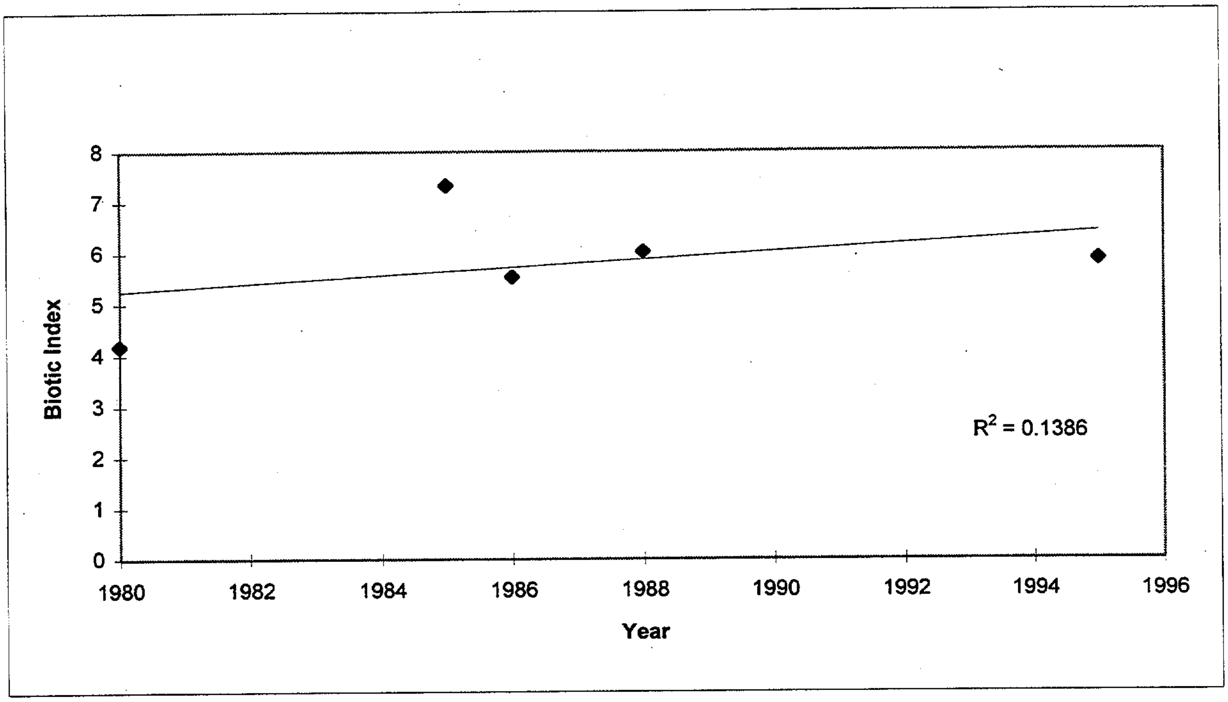

Fig 1. Biotic index scores of macroinvertebrate samples collected at CL-1,1980-1995.

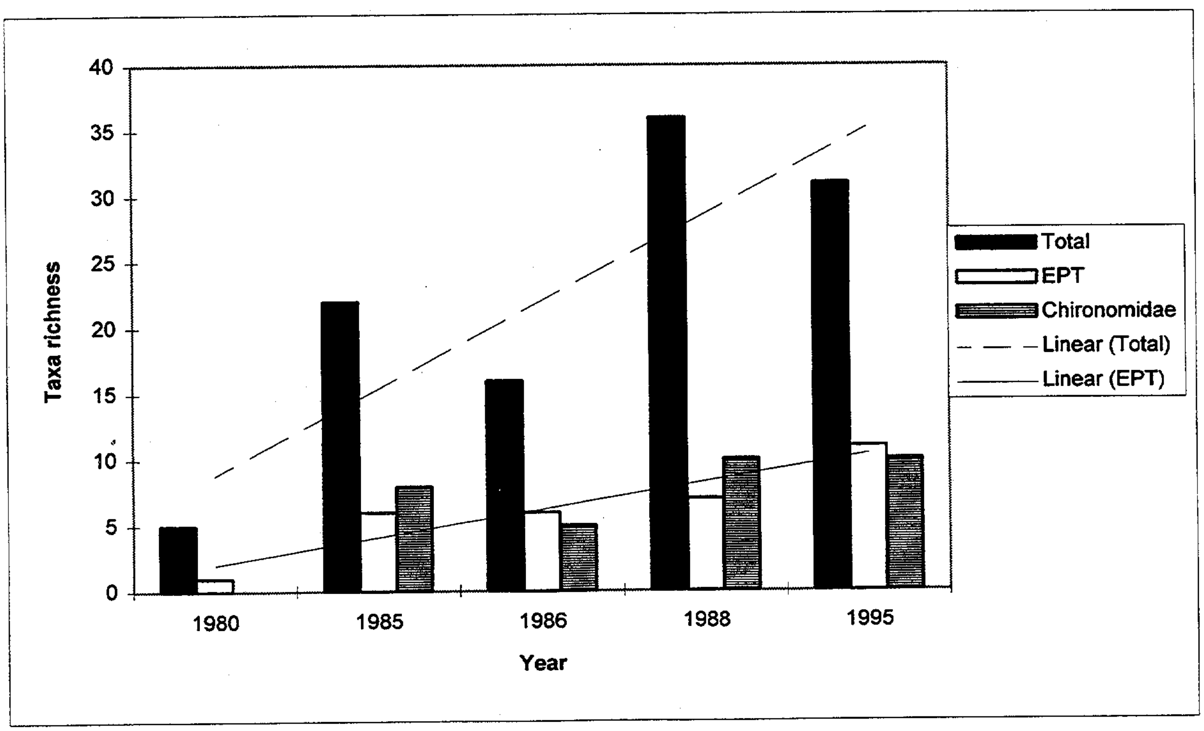

Fig. 2. Trends in taxa richness at CL-1. EPT taxa richness has increased significantly since 1980 (R^2=0.81). Total taxa richness (R^2=0.51) and chironomidae taxa richness (R^2=0.59) have also increased.

concentrations of total phosphorus have decreased dramatically since 1984 (fig. 3). It is difficult to evaluate the concentrations of other nutrients due to missing data and very high detection limits. Decreases in organic and inorganic nutrients have been shown to improve water quality and increase taxa richness (Weber 1973, Struve et al. 1991). Despite the obvious decreases in nutrient enrichments, equitability values measured at CL-1, CL-2, and CL-3 were between 0 and 0.5, indicative of stream communities exposed to slight to moderate organic enrichment (Weber, 1973).

Stations CL-3 and CL-2 were established in 1990 and 1983, respectively. Station CL-2 was established in order to monitor the effects of industrial and municipal effluents (Table 1A). Assessments of water quality at these stations will provide additional information pertaining to the response of macroinvertebrate communities to multiple stresses in streams of the Central Appalachian Ridges and Valleys Ecoregion (Ecoregion 67).

In 1993 and 1994, the Department conducted a study of the Choccolocco Creek watershed in response to public concern. The objective of the study was to ascertain the levels of polychlorinated biphenyls (PCB's) and mercury in both sediment (availability) and fish tissue (contamination) samples, assess the safety of these levels, and to locate the source of these pollutants (ADEM 1994c). Mercury and PCB's have been detected in sediment samples and fish tissue samples collected from the confluence of Choccolocco and Snow Creek to the Choccolocco embayment area of the Coosa River (ADEM 1994c). Consequently, a "no consumption" advisory was issued by the Alabama Department of Public Health for all fish caught within this stretch of Choccolocco Creek (ADEM 1994). The ambient monitoring stations established at CL-2, CL-3, and CL-1 are located within the impacted section of Choccolocco Creek.

Water samples have been analyzed quarterly for mercury since these stations were established. Mercury has never been detected in these samples at detection limits of 1 ug/L (1974-1992) or 0.5 ug/L (1992-present) (ADEM data retrieved from STORET, October, 1995). It may therefore be more effective to monitor mercury and PCB levels by collecting sediment samples annually at CL-2, CL-3, and CL-1.

The stretch of Choccolocco Creek containing the trend stations is also physically impacted by nonpoint source sedimentation (Reference). Remedial action was taken in order to decrease the rate of sedimentation (Cooner pers comm). Results of analysis of total suspended solids at this station has not changed since 1980, however (fig. 4).

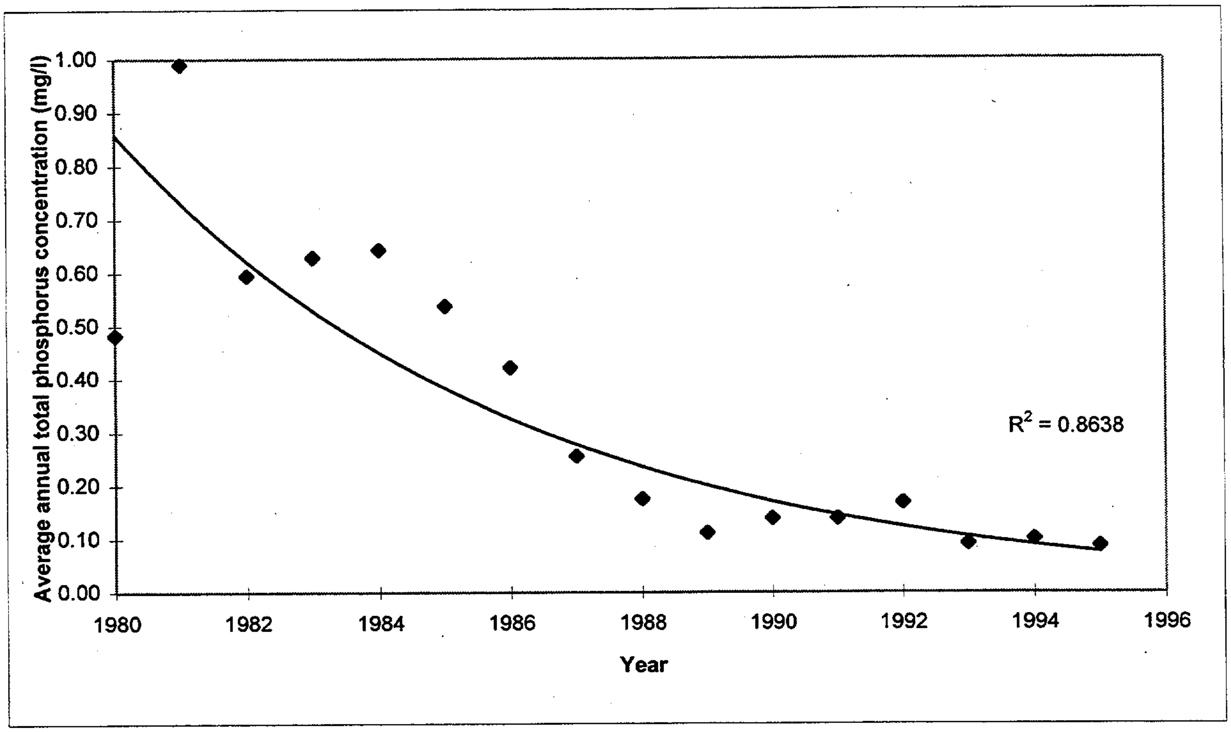

Fig. 3a. Trend in average annual total phosphorus concentration of water samples collected monthly at CL-1 since January, 1980. (Averages calculated from retrieved ADEM STORET data).

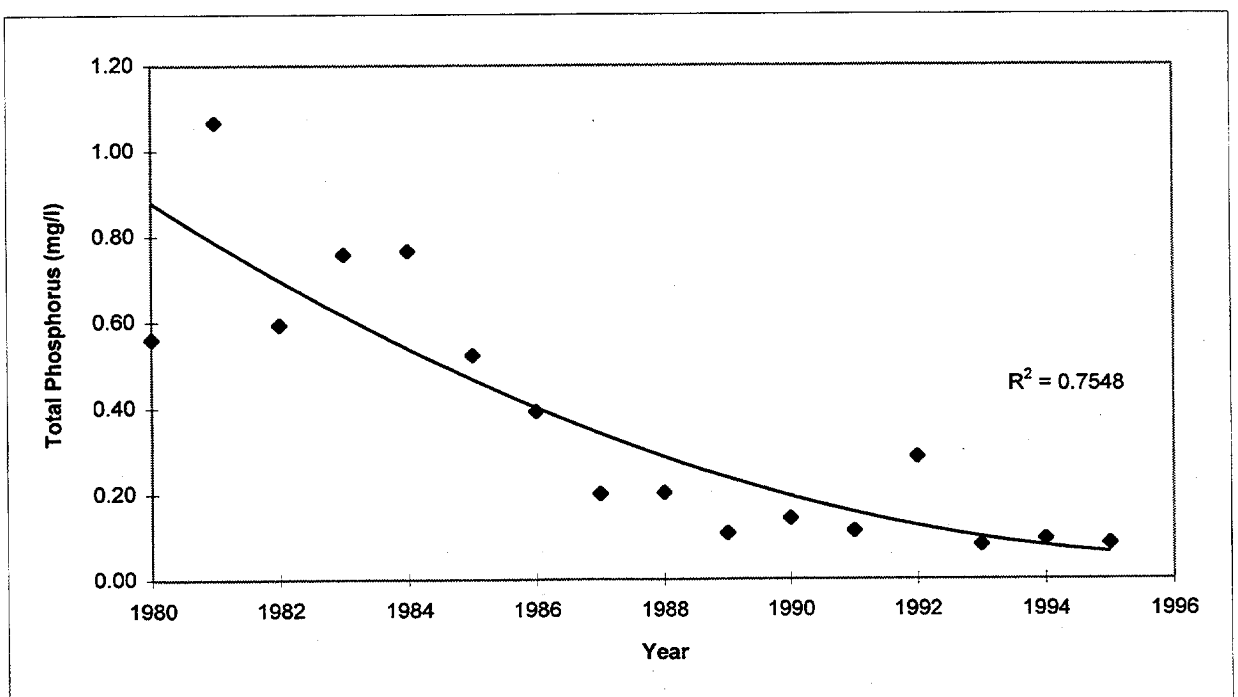

Fig. 3b. Trend in average annual total phosphorus concentration of water samples collected quarterly at CL-1 since January, 1980. Quarterly values based upon January, April, July, and October samples.

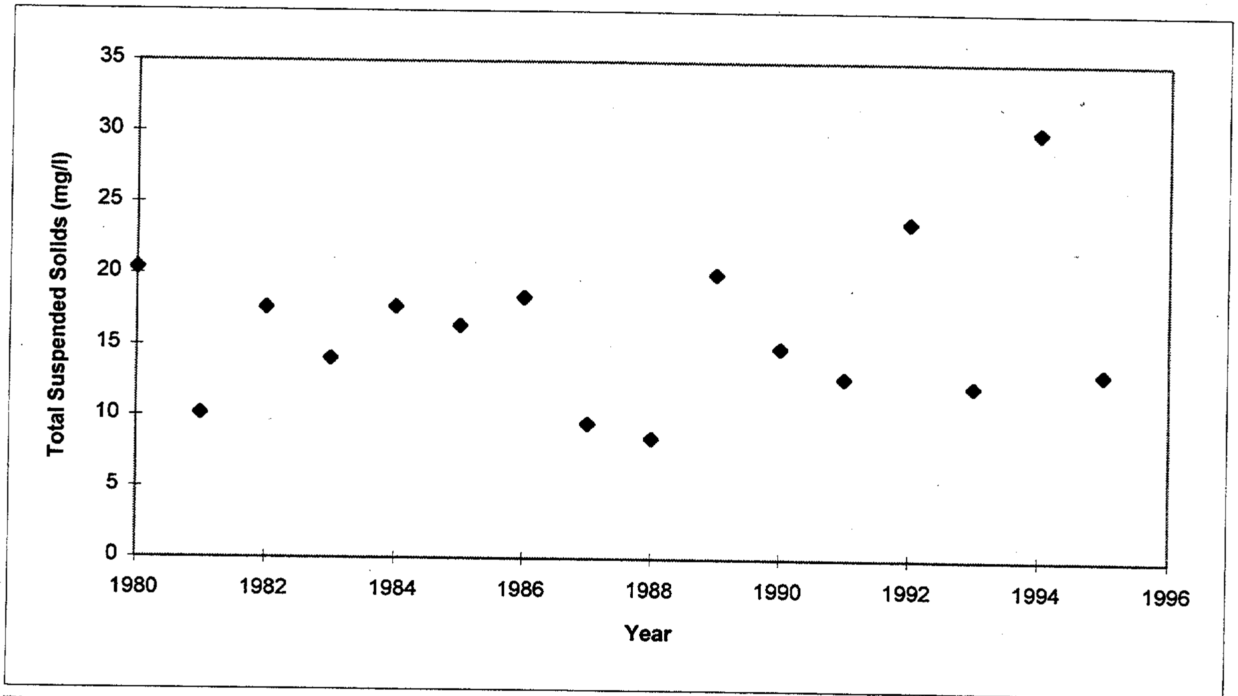

Fig. 4. Average annual total suspended solids measured in water samples collected at CL-1, 1980-1995. This parameter was graphed to evaluate the impact of the Stream Improvement Project undertaken to decrease sedimentation and runoff into the stream. There has been no change in total suspended solids since 1980. (Averages calculated from corrected retrieved STORET data)

The response of the macroinvertebrate community to perturbations can vary depending upon synergistic effects of multiple stresses (Welch 1992). The macroinvertebrate community of Huntsville Spring Branch (HSB) (Madison Co.) was studied by Auburn University in 1985 and 1989 before and after an upgrade to a sewage treatment plant discharging into the creek (Struve et al. 1991). In addition to impacts to the community due to the nutrient enrichment from the sewage treatment plant, the area is impacted by extremely high concentrations of the pesticide DDT, ranging up to >2,700 ppm. Struve et al. (1991) found that nutrient enrichment had a greater impact on benthic communities than did the DDT. An upgrade of the plant in 1987 resulted in increased total taxa richness and EPT taxa richness at the stations most affected by nutrient enrichment (Struve et al. 1991).

Auburn collected macroinvertebrates at HSB using both dredge samples and Hester-Dendy Multiplate samplers (MPS). They found that macroinvertebrate groups sensitive to DDT, such as mayflies and caddisflies, were common on plate samplers at all stations but were rarely collected from sediments with high DDT (Struve et al. 1991). It should also be noted that impacts to the macroinvertebrate community due to the presence of DDT are subtle at concentrations that are dangerous to humans and easily detected in fish and sediments.

Coosa River Station: CO-2

Station CO-2 was established in 1974 to monitor the effect of paper plant effluents on the water quality of the Coosa River (Table 1A). The eight macroinvertebrate assessments conducted at this station since 1980 were collected using Hester-Dendy Multiplate samplers. Results of these assessments are presented in Table 2B. Seven of the eight assessments were collected during summer months, between late June and August, and were used to assess trends in water quality.

Analysis of macroinvertebrate assessments indicate a decrease in water quality since 1980. The biotic index scores appear to be increasing, suggesting a shift in the macroinvertebrate community to more pollution-tolerant organisms (fig. 4). Total taxa richness and EPT taxa richness have remained relatively constant since 1980 (fig. 5). Chironomidae taxa richness, however, has increased and has dominated the macroinvertebrate community since 1990 (fig. 5). Although an increase in the number of chironomid taxa does not necessarily indicate a decrease in water quality, a macroinvertebrate community dominated by this group does indicate environmental stress.

Macroinvertebrate biological assessments were not conducted at CO-3 or CO-1 prior to 1995. Metric results of the 1995 assessments are located in Table 2A. Station CO-3 and CO-1 are nonflowing stations located on the Coosa River (Table 1A). Water quality at station CO-3, located within Weiss Reservoir, has been monitored as part of the Department's Reservoir Water Quality Monitoring Program since 1990 (ADEM 1994d). The Reservoir Water Quality Monitoring Program has also monitored water quality at station CO-1, located within Neely-Henry Reservoir, since 1990.

Lakes assessment data collected at these stations have indicated Neely-Henry Reservoir to be characterized by frequent dissolved oxygen violations of the ADEM Water Quality Criteria. Both Neely-Henry and Weiss Reservoirs to be characterized by a high trophic status caused by nutrient enrichment and indicating degraded water quality (ADEM 1994d). Because the Coosa watershed is naturally productive, nutrient inputs must be regulated to prevent an increase in the trophic state of Weiss Reservoir and Neely-Henry Reservoir from eutrophic to hypereutrophic conditions, characterized by a general deterioration of water quality that degrades biological communities and increases the likelihood of fish kills (ADEM 1994d).

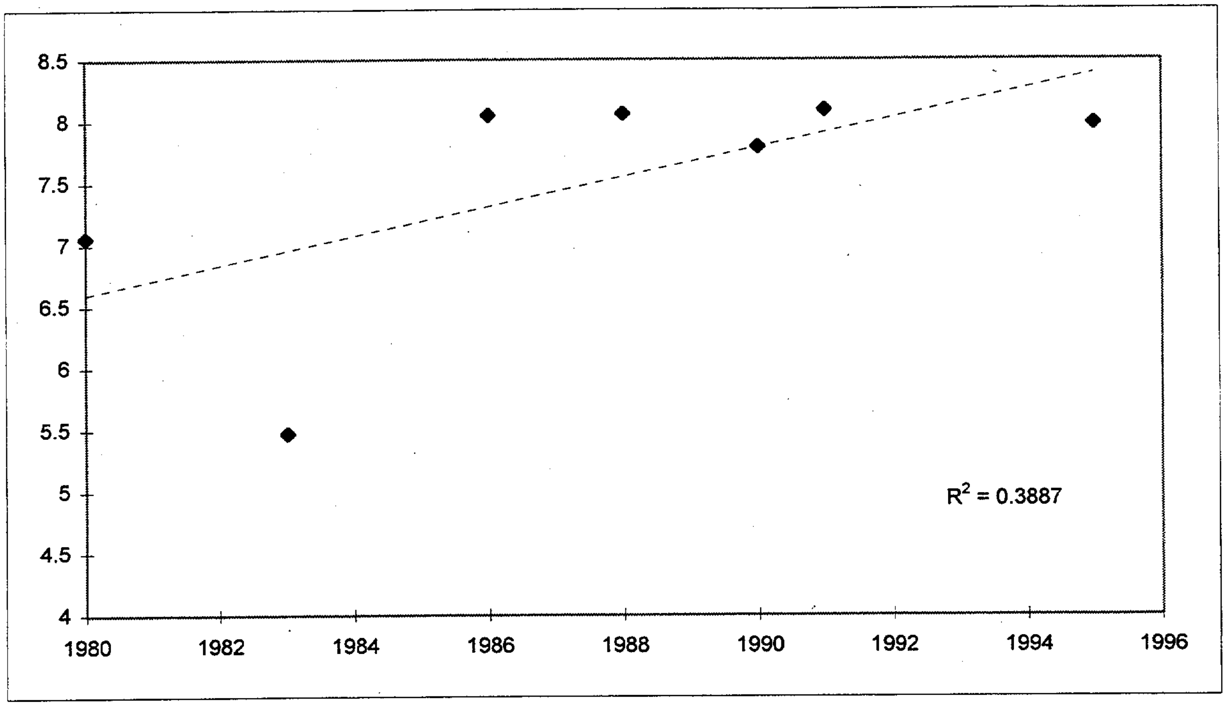

Fig 5. Biotic index scores of macroinvertebrates collected at CO-2 using Hester-Dendy Multiplate samplers, 1980-1995.

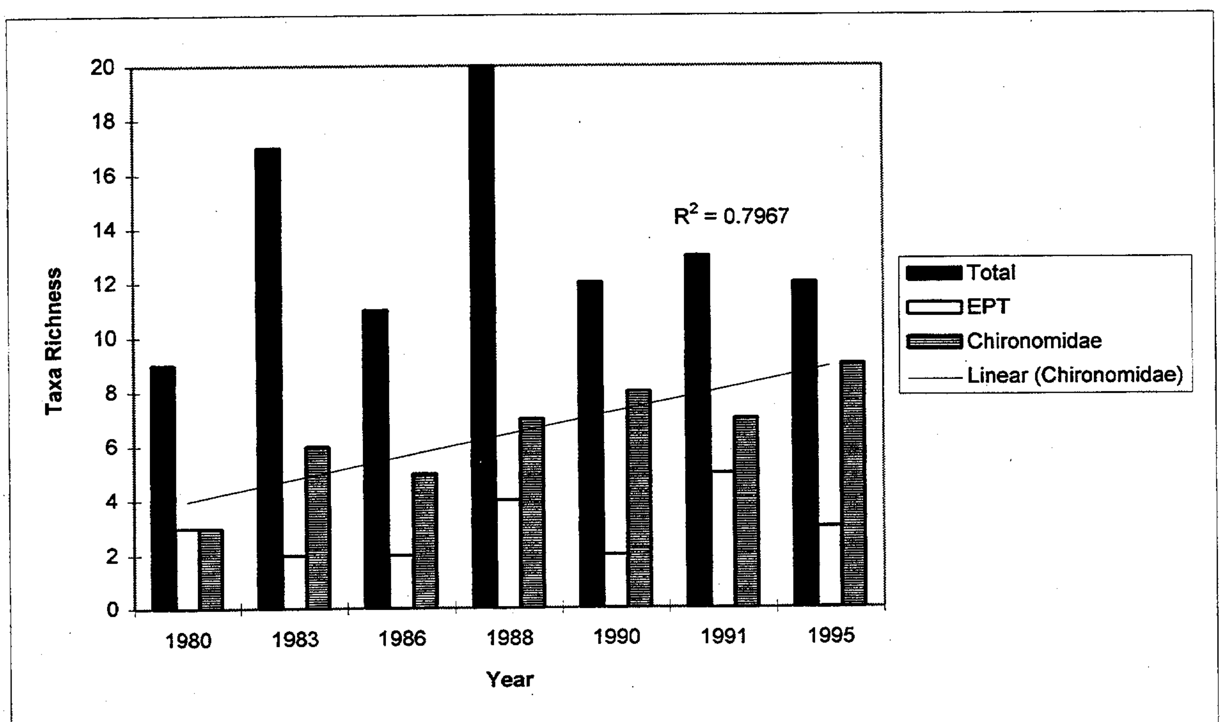

Fig 6. Taxa richness of macroinvertebrates collected at CO-2, 1980-1995 using Hester-Dendy Multiplate samplers. Chironomidae taxa richness has increased significantly since 1980.

Tallapoosa Watershed Stations

At present, macroinvertebrates are collected at three ambient monitoring stations located on three different water bodies (Sougahatchee Creek, Sugar Creek, and Tallapoosa River) (Table 1B). The results of macroinvertebrate assessments conducted at these stations since 1980 are located in Table 2B. Stations SO-1 and S-1 have been monitored since 1974 to assess the impacts of discharges from textile and municipal plants (Table 1B). Station TA-2 was established in 1990 to monitor the water quality of the Tallapoosa River as it enters Alabama from Georgia. Trends in water quality were not analyzed because only three years of macroinvertebrate data have been collected at this station (Table 2B).

Sougahatchee Creek: SO-1

Station SO-1 was established in 1974 to monitor the impact of discharges from a municipal WWTP and a textile plant on water quality (ADEM 1994). Since 1980, ten macroinvertebrate samples have been collected at this station (Table 2B). Five of these assessments, collected using Hester-Dendy plate samplers between late July and September, were used to assess trends in water quality. Three assessments were not used in the analysis because they were collected in June (1980, 1982, and 1985) (Table 2B). Assessments conducted in 1990 and 1995 were not used because they were collected using the RBP-Multihabitat method. Results of all assessments are located in Table 2B.

Macroinvertebrates collected between 1984 and 1989 indicate a substantial improvement in the water quality of Sougahatchee Creek at this station. Biotic index scores have been decreasing, indicating a shift toward a more pollution-intolerant community and an improvement in water quality (fig.7). EPT taxa, a pollution-intolerant group in general and absent from the early macroinvertebrate collections, were collected in 1988 and 1989 (fig. 8). Total taxa richness and chironomidae taxa richness have increased steadily (fig. 8). Data collected since 1989 is difficult to assess because of the change in collection methodology (Table 2B). Results of the biotic index, however, suggest continued improvement in water quality (fig. 7).

The Opelika WWTP was upgraded in 1986 to provide secondary treatment of wastewater (ADEM, 1988). The monthly data collected at SO-1 was retrieved from

Table. 1B. Ambient monitoring stations located within the Tallapoosa River basin.

Station	Waterbody	Ecoregion[a]	Water Use Classification[b]	Problem Monitored	Assessment	Location
TA-2	Tallapoosa R.	65D		Interstate waterway	N/A	T15S, R12E, s. 11 (R.M. 213.4);Bridge @ i mi. downstream of GA stateline near Muscadine (Cleburne Co.)
SO-1	Sougahatchee Cr.	65D	A&I	municipal discharge; textile plant	Improving	T19S, R4E, s. 4 (R.M. 1.9); Co. Rd. 35 bridge north of Auburn (Lee Co.)
S-1	Sugar Cr.	68A	A&I	municipal discharge; textile plant	Declining	T22N, R21E, s. 3 (R.M.2.8); AL 63 bridge south of Alexander City (Tallapoosa Co.)

a. Ecoregion 65D: Piedmont
68A: Southwestern Appalachians

b. Water Use Classifications: A&I: Agricultural and Industrial Water Supply
F&W: Fish and Wildlife

Table 2A. Interpretation of metrics used to analyze macroinvertebrate data.

Structure Metrics	**Range**	**Interpretation**
Taxa Richness	Total number of distinct taxa.	Generally increases with increasing water quality.
EPT Index	Total number of generally pollution-sensitive insect orders: Ephemeroptera, Plecoptera, and Trichoptera.	Generally increases with increasing water quality.
Chironomidae Taxa Richness	Total number of distinct Chironomidae taxa.	Generally decreases with increasing water quality
Community Balance Metrics	**Range**	**Interpretation**
Biotic Index	0-10	Generally decreases with increasing water quality.
% Contribution Dominant Taxon	0-100%	Generally decreases with increasing water quality.
Quantitative Community Balance Metrics*	**Range**	**Interpretation**
Diversity Index	0-4	Values between 3-4 indicate little stress; values >1 indicate severely impacted waters
Equitability	0-1	Values >0.5 indicate mild or no stress; <0.5 indicates an impact

* Quantitative community balance metrics are only for use with Hester-Dendy multiplate samplers.

Table 2C. Results of aquatic macroinvertebrate data collected at the Tallapoosa River ambient monitoring stations. Hester-Dendy samplers were used at S-1 and SO-1 through 1989. Since 1990, all samples have been collected using the RBP-Multihabitat method. The 1994 results of SUG-1, an upstream control of S-1, and OAK-1, a reference site of both S-1 and SUG-1, are presented along with the Sugar Creek data.

Waterbody	Station Number	Collection Date	Ecoregion Number	H.A.*	Taxa Richness	EPT* Index	Chiron.* Taxa Richness	Biotic Index	% Contrib. Dominant Taxon	Diversity Index[a]	Equitability Index[a]
Sugar Cr.	S-1	8/7/84	68A	---	11	0	9	7.3	21	3.09	1.09
		6/18/85	68A	---	8	0	4	8.5	78	1.25	0.36
		7/22/86	68A	---	10	1	6	8.1	24	2.92	1.06
		8/26/88	68A	---	6	0	3	9.5	86	0.89	0.36
		9/21/89	68A	---	8	0	5	9.8	86	0.85	0.26
		6/12/90	68A	70	21	2	8	8.7	40	---	---
		8/17/94	68A	73	15	0	7	7.6	30	---	---
	SUG-1	8/17/94	68A	69	33	2	10	6.7	28	---	---
Oakachoy Cr.	OAK-1	8/17/94	68A	104	70	23	15	5.0	14	---	---
Sougahatchee Cr.	SO-1	6/27/80	65D	---	4	0	3	8.9	90	0.48	0.40
		6/23/82	65D	---	3	0	1	2.4	50	1.41	1.10
		8/8/84	65D	---	13	0	4	8.5	46	2.29	0.51
		6/18/85	65D	---	7	0	4	9.6	61	1.17	0.39
		7/22/86	65D	---	15	0	6	9.4	77	1.4	0.22
		9/30/87	65D	---	22	0	8	8.2	40	2.74	0.42
		8/26/88	65D	---	19	1	8	8.2	26	3.41	0.80
		9/21/89	65D	---	37	4	14	6.4	30	3.88	0.58
		6/12/90	65D	104	26	3	9	5.9	32.0	---	---
		7/20/95	65D	120	30	3	10	6.6	37	---	---
Tallapoosa[RBP]	TA-2	9/9/90	65D	96	31	14	5	4.5	21	---	---
		9/18/91	65D	89	31	13	6	6.0	64	---	---
		7/6/95	65D	76	35	17	5	4.4	20	---	---

H.A.* = Habitat Assessment

EPT*=Ephemeroptera, Plecoptera, Trichoptera

a. Diversity index and Equitability are metrics for quantitative sampling, and are therefore only calculated for Hester-Dendy samples.

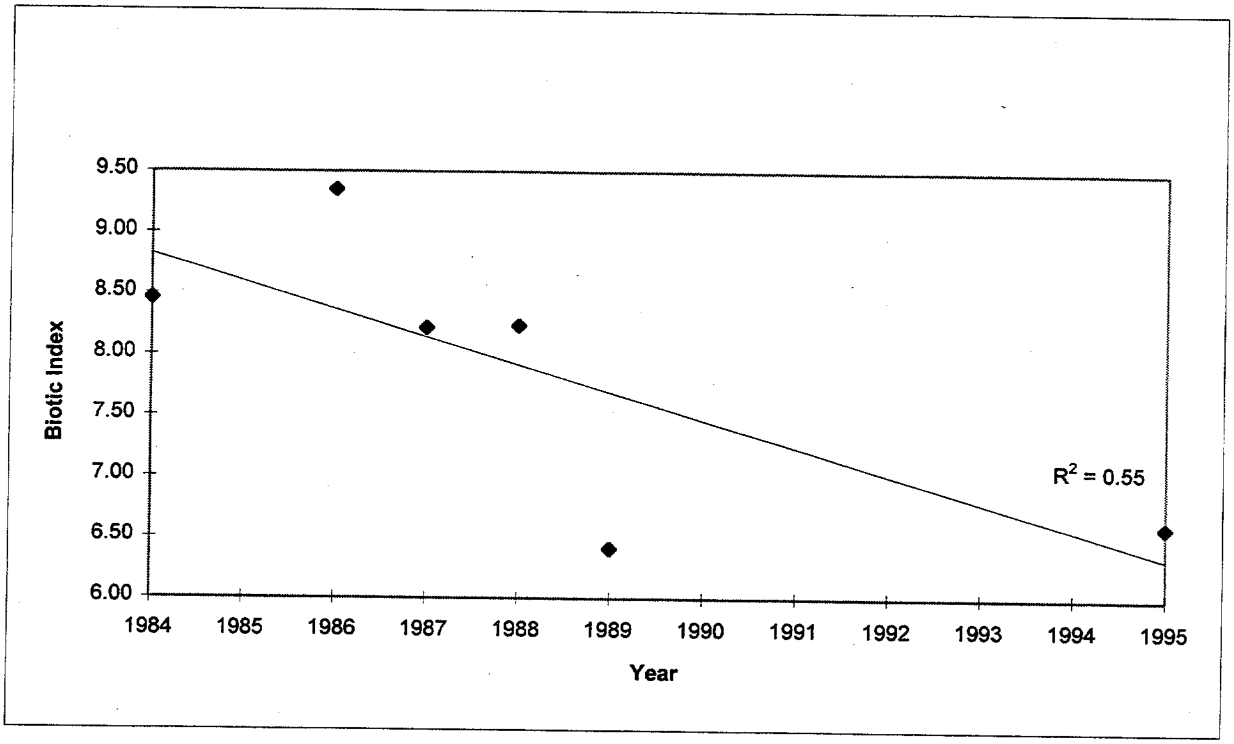

Fig. 7. Biotic index scores of SO-1 appear to have decreased since 1984. The 1995 data was collected using the Multihabitat protocol. All samples used in this analysis were collected during July-early September. Three data sets collected during June were not included in analysis.

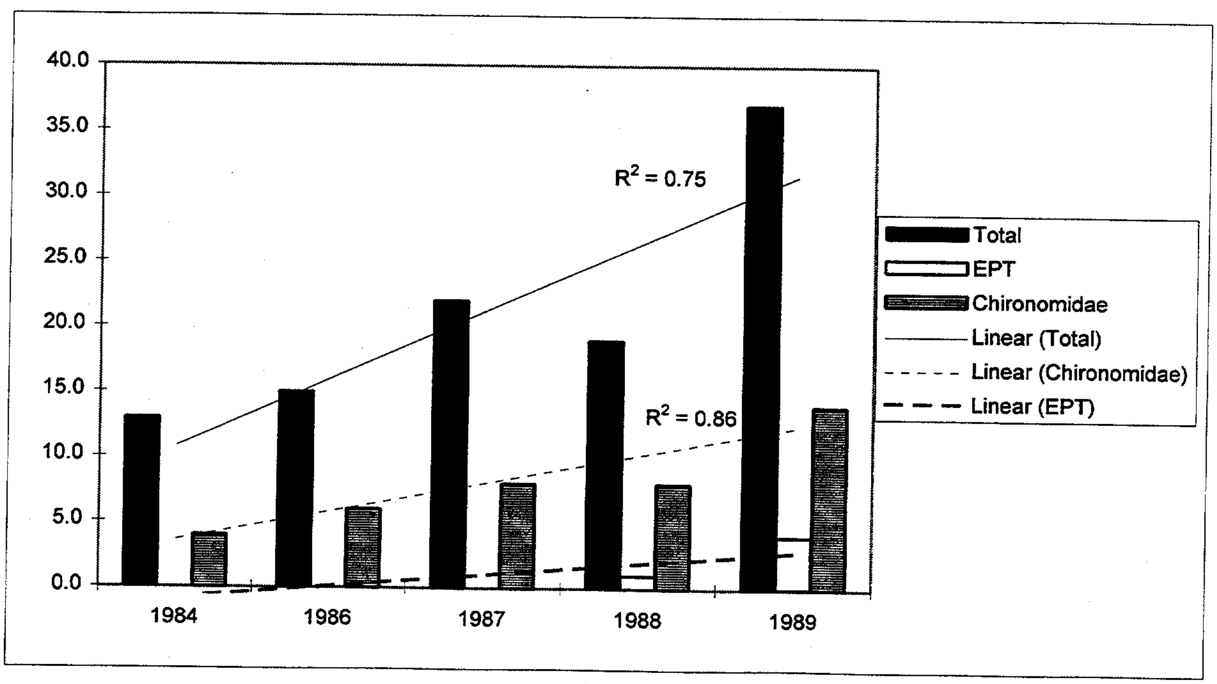

Fig. 8. Total taxa richness and EPT taxa richness have increased significantly at SO-1 since 1984. EPT taxa richness has also increased (R^2=0.68). These samples were collected between July and early September. Three data sets collected during June were not included in this analysis.

STORET to evaluate trends in concentrations of nutrients and chemicals that degrade water quality and impact macroinvertebrate communties. Although the maximum dissolved oxygen concentrations have not changed, the minimum dissolved oxygen concentration has increased steadily since 1986 (fig. 9). BOD and total phosphorus concentrations have also decreased (figs. 10 and 11). Nitrate appears to have increased since 1986 (fig. 12).

Despite the improvement in water quality, comparison of SO-1 to an ecoregional reference station indicates an impacted macroinvertebrate community at this station in 1995 (ADEM 1996). Data collected from the Sougahatchee Creek embayment of Yates Reservoir through the Reservoir Water Quality Monitoring Program indicate hypereutrophic conditions in an embayment to a reservoir that is otherwise mesotrophic (ADEM 1996). Water chemistry data measured during the 1990-1991 and 1994-1995 sampling seasons indicate dissolved oxygen concentrations below 5 mg/l at a depth of five feet, constituting a violation of the ADEM Water Quality Criteria (ADEM 1990). An in-depth study of Sougahatchee Creek from upstream of the WWTP to the embayment at Yates Reservoir may be needed to ascertain what stress or stressors are causing the impact and what remedial actions need to be taken.

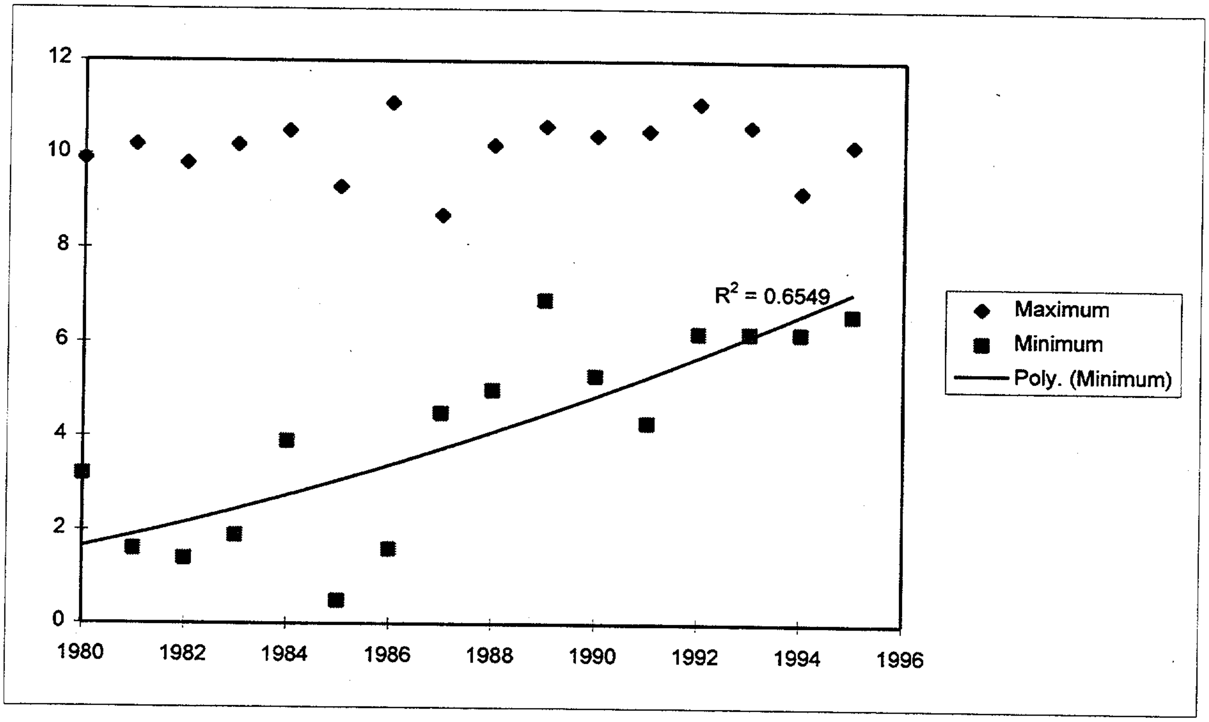

Fig. 9. Maximum and minimum dissolved oxygen concentrations measured at SO-1, 1980-1995. Value calculated from data collected monthly.

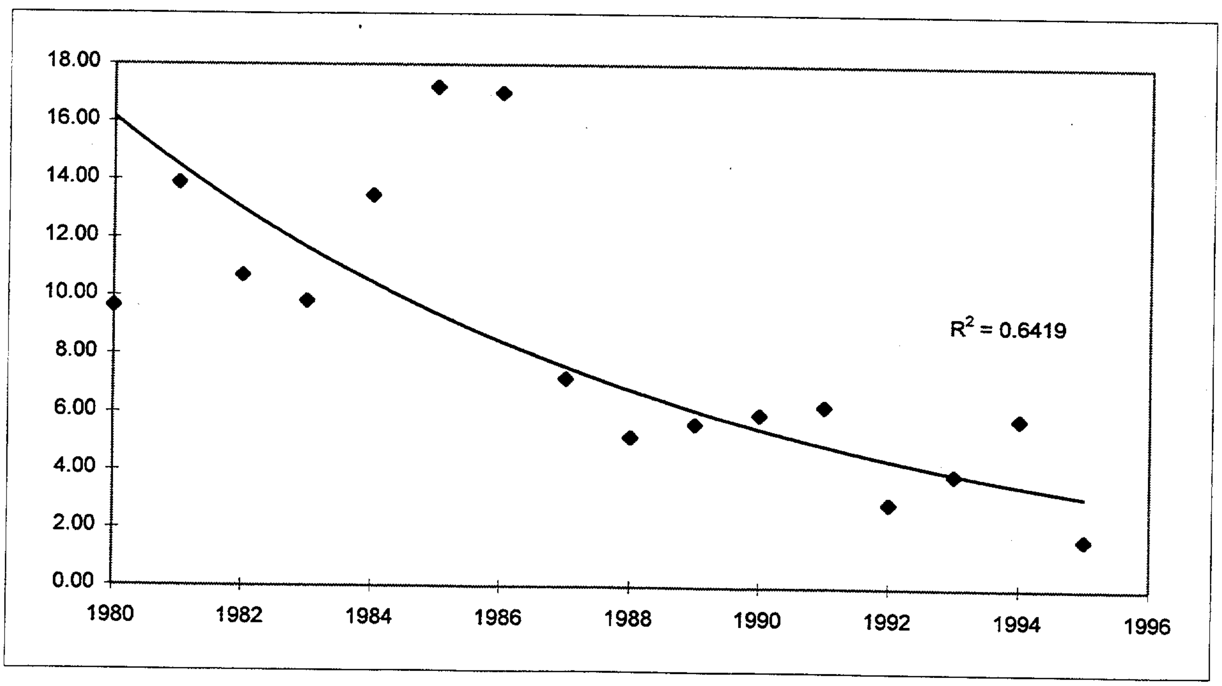

Fig. 10. BOD concentrations of water samples collected at SO-1, 1980-1995. Average annual values calculated from monthly data.

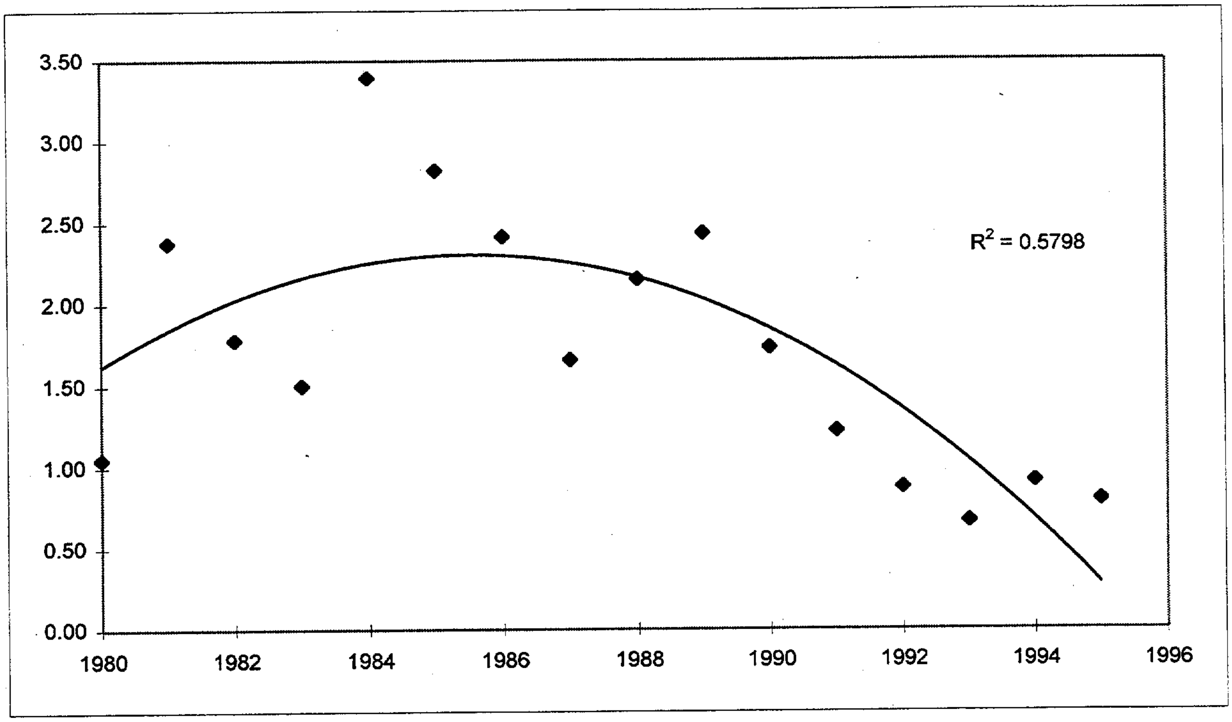

Fig. 11. Phosphorus concentrations of water samples collected at SO-1. Annual values are calculated average of monthly values.

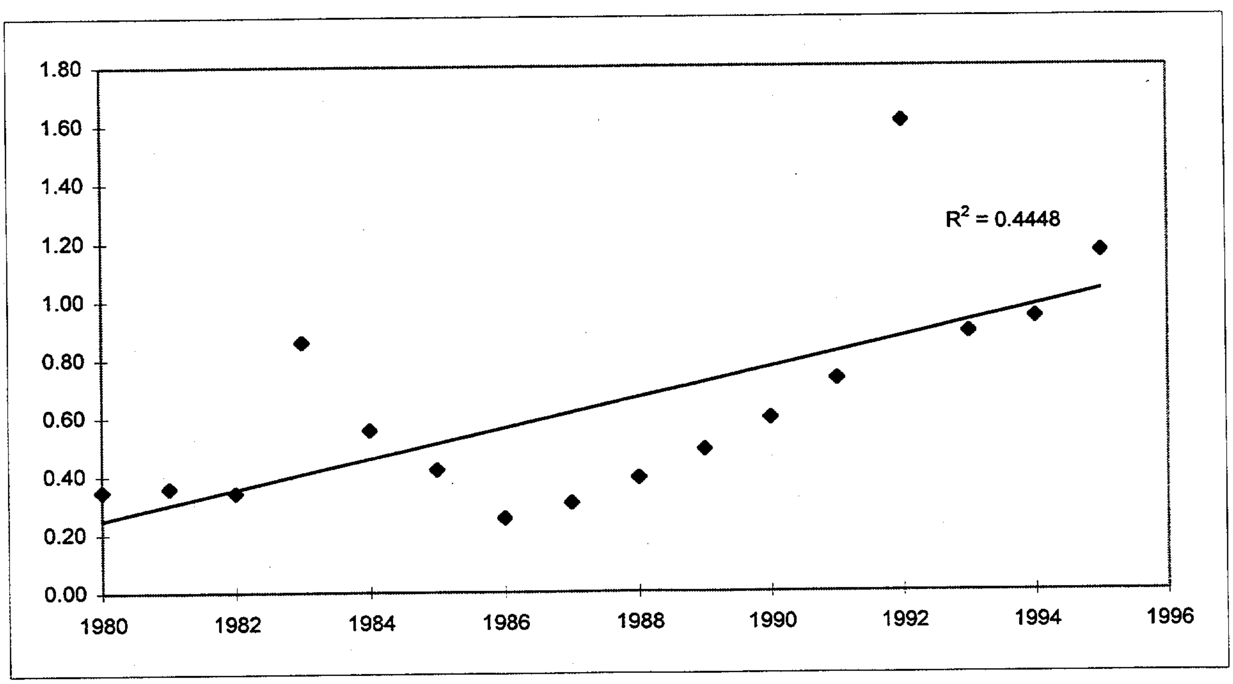

Fig. 12. Nitrate concentrations of water samples collected at SO-1, 1980-1995. Average annual value based upon monthly values.

Sugar Creek: S-1

Seven macroinvertebrate assessments have been conducted at station S-1 since 1984. The first macroinvertebrate assessment was conducted in 1984 (Table 2B). The five assessments conducted between 1984 and 1989 were collected using Hester-Dendy Multiplate samplers and used to assess trends in water quality. Assessments conducted in 1990 and 1994 were not used because they were collected using the RBP-Multihabitat method. Results of all assessments are located in Table 2B.

Analysis of the macroinvertebrate assessments conducted between 1984 and 1989 strongly indicate a deterioration in water quality at this station. The biotic index scores have steadily increased, signifying a shift toward a more pollution-tolerant community and a decrease in water quality (fig. 13). Total taxa richness and Chironomidae taxa richness have decreased (fig. 14). It is also significant that only one EPT taxa was collected from 1984-1989 (fig. 14).

The assessments conducted at this site in 1990 and 1994 cannot be compared to previous assessments because of changes in collection methodologies. However, the 1994 macroinvertebrate assessment was collected in conjunction with both a control station upstream of S-1 (SUG-1) and a physically similar ecoregional reference site located on a relatively unimpacted watershed (OAK-1). Although it cannot be put into a historical context, the 1994 metric results can be compared to SUG-1 and OAK-1 to assess the relative condition of S-1.

Water quality at S-1 is more degraded than its upstream control, SUG-1. Biotic index scores did not differ between the two stations (fig. 15), but total taxa richness and chironomidae taxa richness were lower at S-1 (fig. 15). The pollution-intolerant EPT group were not present at S-1, also indicating decreased water quality at the trend station (fig. 15).

Analysis of water samples collected at S-1 and SUG-1 indicated S-1 to be characterized by higher water temperatures, higher levels of total organic carbon, total dissolved carbon, and total suspended solids (ADEM 1995b). Station S-1 was also characterized by high copper and chloride concentration within the water column. Any one of these conditions would cause a decrease in taxa richness (Weber 1973).

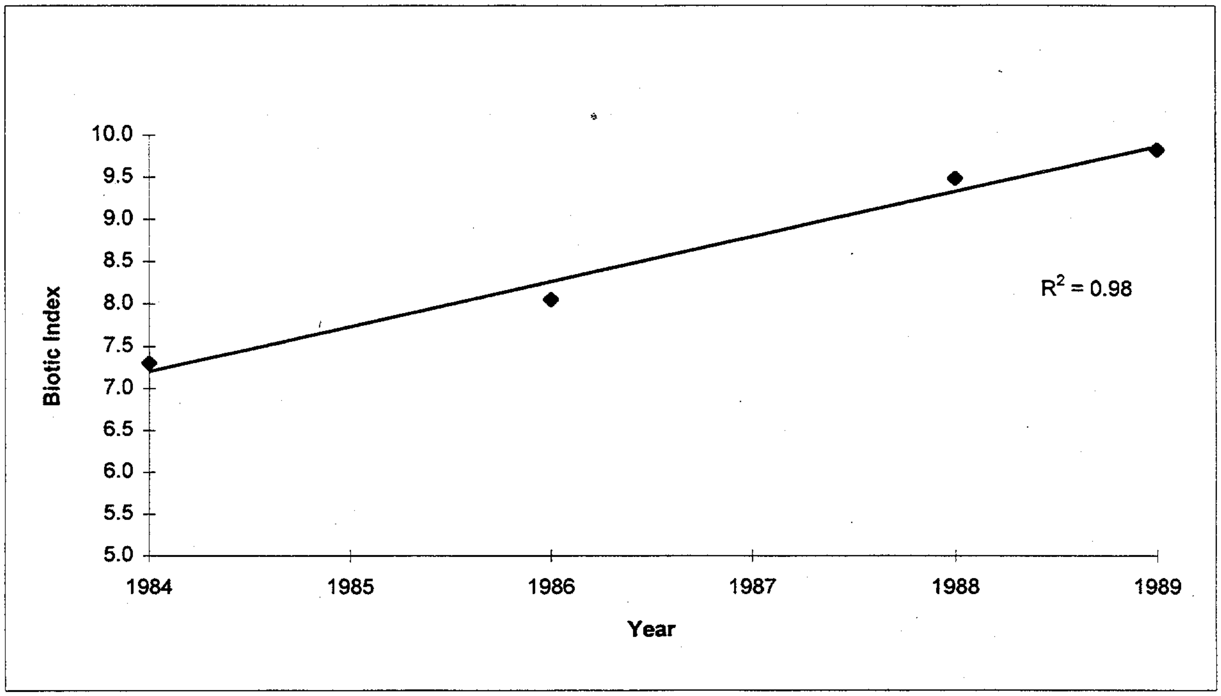

Fig. 13. Biotic index scores of macroinvertebrate samples collected at S-1since 1984.

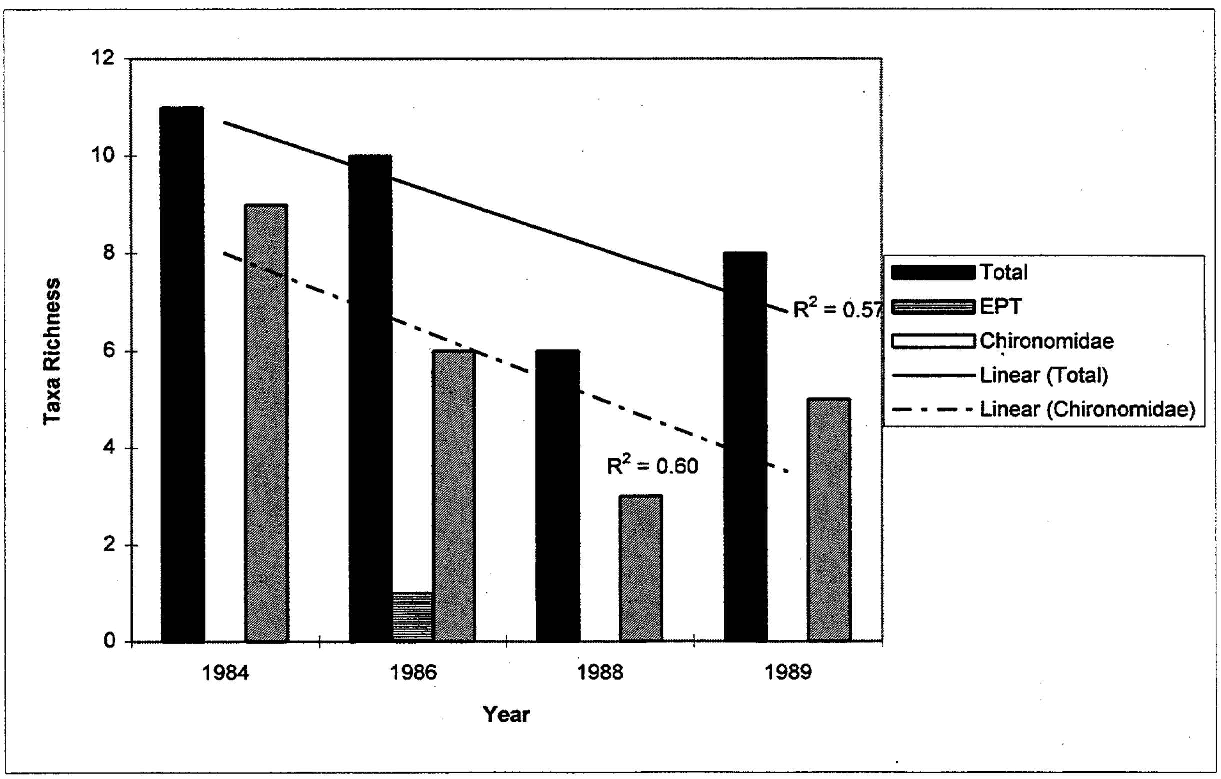

Fig. 14. Total taxa richness and chironomidae taxa richness have both decreased since 1984. One EPT taxa was found in 1986.

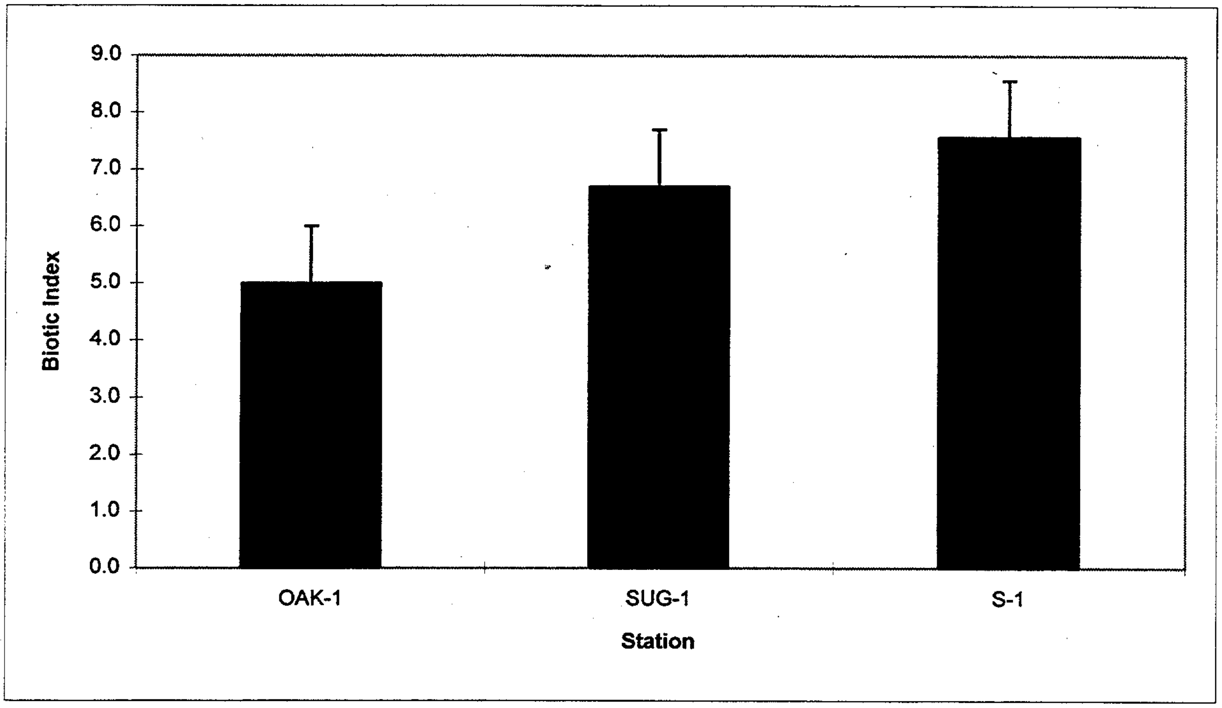

Fig. 15. Comparison of biotic index scores obtained at S-1, an ambient monitoring station, and an upstream control (SUG-1) and a reference station (OAK-1) during August, 1994.

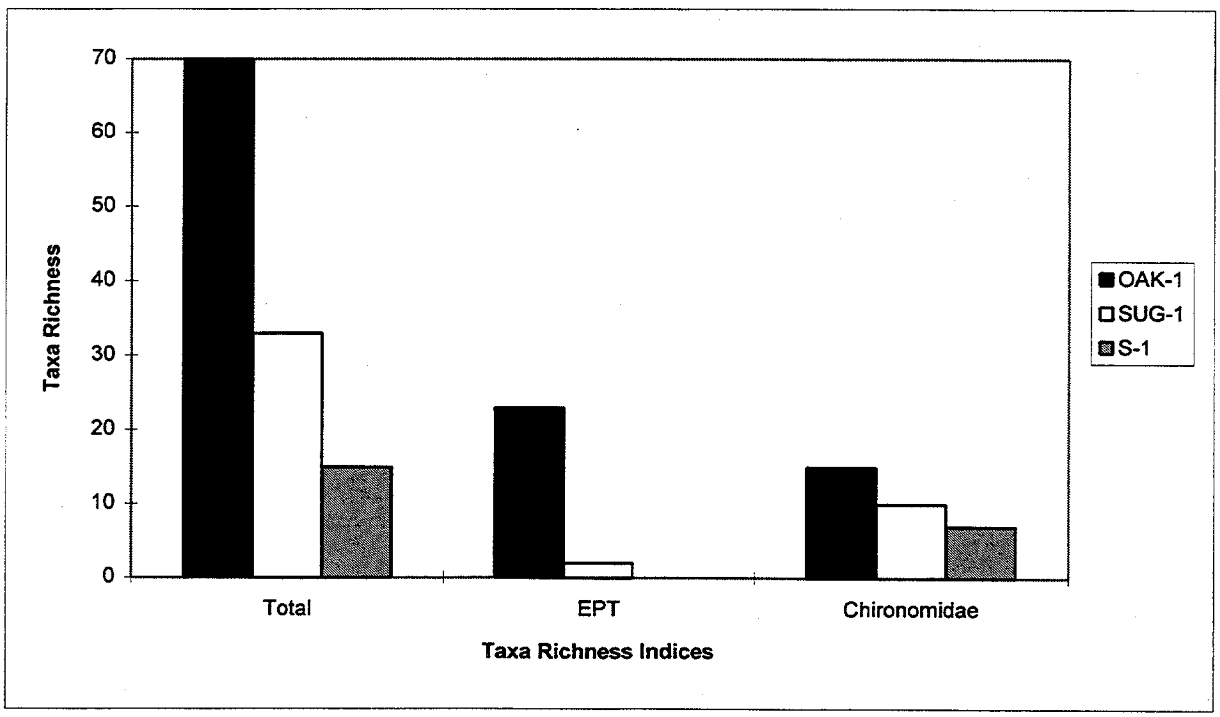

Fig. 16. Comparison of taxa richness results obtained at S-1 with SUG-1, an upstream control and OAK-1, a reference site during August, 1994. Note that data is presented by taxa richness category in order to compare results obtained at each station.

Comparison of both S-1 and SUG-1 to the reference station, OAK-1, illustrates an important point. Both Sugar Creek stations were affected by environmental impacts. The biotic index scores of both S-1 and SUG-1 were higher than at OAK-1, indicating more pollution-tolerant macroinvertebrate communities at the Sugar Creek stations. Total taxa richness and EPT taxa richness were reduced at both S-1 and SUG-1 (fig. 16).

The impacts evident at the upstream station, SUG-1, suggest that the impact to the macroinvertebrate community at S-1 is the result of synergistic effects of multiple impacts and not entirely due to the point sources of effluent actually being monitored. Barium and antimony were detected in water samples from both stations (ADEM 1995b). Comparison of the habitat assessment score of each station (Table 2B) suggest that nonpoint source pollutants are at least degrading the habitat quality of both S-1 and SUG-1.

Although most ambient monitoring stations were established to monitor point sources of pollution, many are probably impacted by nonpoint sources as well. It is more difficult to discern multiple impacts without an adequate upstream control and reference station for comparison.

Conclusions

The macroinvertebrate data that has been collected at the ambient monitoring stations located in the Coosa and Tallapoosa watersheds since 1980 was reviewed in order to assess trends in water quality at each station. Four stations had macroinvertebrate assessments dating back to 1980: CL-1, CO-1, SO-1, and S-1. The results of the macroinvertebrate bioassessments of one station, SO-1, located on Sougahatchee Creek (Tallapoosa basin), suggest improved water quality. Improved water quality at this station was indicated by:

- Decreased biotic index scores (fig. 7); and
- Increased total, chironomidae and EPT taxa richness (fig. 8);
- Increased dissolved oxygen concentrations (fig. 9); and
- Decreased concentrations of some nutrients (figs. 10 and 11).

The results of macroinvertebrate assessments conducted at CO-1, located on the Coosa River, and S-1, located on Sugar Creek within the Tallapoosa watershed, indicated decreased water quality. Decreased water quality was indicated by:

- Increased biotic index scores (figs. 5 and 13); and
- Decreased taxa richness (figs. 6 and 14).

No assessment of trends in water quality at CL-1 could be made because the results of metrics analysis and chemical data collected were not in accordance. The biotic index scores indicated slightly decreased water quality (fig. 1), while taxa richness (fig. 2) and analysis of phosphorus concentrations (fig. 3a) indicated improved water quality. The contradicting metric results suggest multiple impacts to the macroinvertebrate community.

The ambient monitoring program was established to address the chemical contamination of the nation's waters (National Research Council 1992). The results of the macroinvertebrate bioassessments reviewed within this report suggest that macroinvertebrates have been successful in monitoring trends in water quality below point sources of pollution. However, review of this data has suggested some areas in which the ambient monitoring program could be updated to address some of the state's current monitoring and budget needs, while continuing to assess trends in water quality.

Biological Assessments

Review of macroinvertebrate data conducted by the Department since 1980 indicate many of these stations to be impacted by multiple stresses from both point and nonpoint sources. The use of a multihabitat assessment protocols in wadeable and nonwadeable streams will enable the Department to address certain nonpoint source effects by incorporating an assessment of habitat quality into the assessment protocol (Plafkin et al. 1989). Sampling all available habitats may detect impacts for which specific monitoring is not being conducted (Plafkin et al. 1989). In order to assess trends in water quality, however, it is necessary to evaluate the relationship between assessments conducted between 1980-1990 using Hester-Dendy multiplate samplers and assessments conducted more recently using the RBP-Multihabitat Protocol in both wadeable and nonwadeable streams. Trend analysis based on all available data will increase the accuracy and strength of the assessments.

The response of the macroinvertebrate community to perturbations can vary depending upon: 1) synergistic effects of multiple stresses; 2) indirect effects such as changes in available habitat and resources; and, 3) the ecoregion in which the station is located (Weber 1973). These stations should therefore be assessed in conjunction with an upstream control and an ecoregional reference station in order to:

1) quantify nutrient enrichments from point source discharges;

2) establish baseline data from least impacted reference stations; and,

3) determine the extent of nonpoint source impacts.

This will enable the Department to more fully identify the extent of point and nonpoint source problems.

The ambient monitoring program will be modified to compliment the Department's watershed protection approach. At that time, the monitoring programs currently conducted by the Department could be coordinated in order to facilitate efficient use of limited financial and personnel resources and improve monitoring coverage within river basins. The most successful and cost-effective studies conducted by the Department were multi-dimensional studies, such as the Sugar Creek study (ADEM 1995b) and the Choccolocco Creek watershed study (ADEM 1994c).

Collection of Nutrient and Chemical Samples

Chemical data should also be reviewed for the most efficient sampling schedule. Several states have analyzed the trends of key parameters resulting from monthly, bimonthly, and quarterly sampling regimes. The general trend of total phosphorus concentration did not differ between monthly or quarterly samples at CL-1 (figs. 3a and 3b). This example suggests that the current sampling frequency could be decreased. The trends of key parameters resulting from monthly, bimonthly, and quarterly sampling regimes are currently being analyzed by the Department at a limited number of ambient monitoring stations. Once an optimal sampling regime is established, chemical parameters and nutrient content should be sampled at the upstream control and reference site stations, along with study stations.

The Department also collects water samples to detect concentrations of metals in the water column. Review of monthly ambient monitoring data indicate that metals, such as mercury, have never been detected at CL-1. Mercury has been detected at this station in both fish tissue samples and sediment samples. These results suggest that it may be more effective to collect fish tissue and sediment samples along with ambient monitoring biological data rather than collecting monthly water samples for metals analysis. In addition, collecting sediment samples once annually is approximately one third the cost of collecting water samples for metals analysis with the current sampling schedule (Appendix A).

Literature Cited

Alabama Department of Environmental Mangement. 1988. Water quality demonstration study: Sougahatchee Creek, Opelika, Alabama. Alabama Department of Environmental Management, Montgomery, Alabama, 6 pp.

Alabama Department of Environmental Management. 1989. Water quality demonstration study: Choccolocco Creek, Anniston, Alabama. Alabama Department of Environmental Management, Montgomery, Alabama, 7 pp.

Alabama Department of Environmental Management. 1990. Water quality criteria. Water Quality Program -Water Division. Chapter 335-6-10. 41 pp.

Alabama Department of Environmental Management. 1992. Field Operations Division Standard Operating Procedures and Quality Conrol Assurance Manual, Volume II, Montgomery, Alabama.

Alabama Department of Environmental Management. 1993. Proposal for biological sampling of ambient water quality monitoring stations (Freshwater). Alabama Department of Environmental Management, Montgomery, Alabama, 4 pp.

Alabama Department of Environmental Management. 1994a. Water Quality Report to Congress for Calendar Years 1992 and 1993. Alabama Department of Environmental Management, Montgomery, Alabama.

Alabama Department of Environmental Management. 1994b. Water quality trends of selected ambient monitoring stations in Alabama utilizing aquatic macroinvertebrate assessments: 1974-1992. Alabama Department of Environmental Management, Montgomery, Alabama, 113 pp.

Alabama Department of Environmental Management. 1994c. Study Report: Choccolocco Creek watershed fish tissue analysis and sediment analyses. Alabama Department of Environmental Management, Montgomery, Alabama. 14 pp.

Alabama Department of Environmental Management. 1994d. Reservoir water quality and fish tissue monitoring program report: 1992-1993. Alabama Department Environmental Mangement, Montgomery, Alabama, 113 pp.

Alabama Department of Environmental Management. 1995a. Nonwadeable stream bioassessment methodologies: Comparison of Hester-Dendy artificial substrate samplers and RBP-Multihabitat protocol. Alabama Department of Environmental Management, Montgomery, Alabama, 14 pp.

Alabama Deparment of Environmental Mangement. 1995b. Sugar Creek water quality demonstration report: Phase 1. Alabama Department of Environmental Management, Montgomery, Alabama, 58 pp.

Alabama Department of Environmental Management. 1996. Reservoir water quality and fish tissue monitoring program report: 1994-1995. Alabama Department Environmental Mangement, Montgomery, Alabama. In press.

Beiser, M. 1991. A comparison of rapid bioassessment and artificial substrate methods--Implications for Mississippi's ambient monitoring program. Poster Presentation. North American Benthological Society Annual Meeting, Sante Fe, New Mexico.

Hilsenhoff, W. L. 1987. An improved biotic index of organic stream pollution. Great Lakes Entomologist 20:31-39.

Lenat, D. 1988. Water quality assessment of streams using a qualitative collection method for benthic macroinvertebrates. Journal of North American Benthological Society 7:222-223.

Lenat, D. 1993. Method testing: joint bioassessment of four North Carolina streams. Departmental Memorandum, North Carolina Department of Environment, Health, and Natural Resources, 25 pp.

Lenat, D. 1994. Development of a Hilsenhoff-type biotic index for North Carolina, with tolerance values for southeastern stream macroinvertebrates. Departmental Memorandum, North Carolina Department of Environment, Health, and Natural Resources, 9 pp.

National Research Council (U. S.). 1992. Restoration of aquatic ecosystems: science, technology, and public policy. National Academy Press, Washington D.C. pp 44-47.

Plafkin, J. L., M. T. Barbour, K. D. Porter, S. K. Gross, and R. M. Hughes. 1989. Rapid bioassessment protocols for use in streams and rivers: benthic macroinvertebrates and fish. Report No. 444/4-89-001. Office of Water, U.S. EPA, Washington D.C.

Struve, M. R., E. C. Webber, and D. R. Bayne. 1991. Macroinvertebrate communities following remedial action in Huntsville Spring Branch and Indian Creek, Madison County, Alabama, 1990-1991. Auburn University, Auburn, Alabama, 70 pp.

Weber, C. I. 1973. Biological monitoring of its aquatic ecosystems: Environmental Protection Agency. In: Biological methods for the assessment of water quality. ASTM STP 528. American Society for Testing and Materials, Philadelphia, PA, pp. 46-60.

Welch, E. B. 1992. Ecological effects of wastewater: applied limnological and pollutant effects, 2nd ed. Chapman and Hall, New York, New York, 425 pp.

Appendix A

Cost Estimate of Metals Analysis:

Comparison of Water and Sediment Samples

Calculating the Cost for Metal Analysis of Water Samples

Study: *Ambient Monitoring Metals Analysis*

Lab: *Montgomery*

WTU Cost *1.28*

Parameter	*W.T.U*	*# samples*	*cost of analysis*
Aluminum (Al)	14		0.00
Antimony (Sb)	12		0.00
Arsenic (As)	15	4	76.80
Barium (Ba)	14		0.00
Beryllium (Be)	14		0.00
Cadmium (Cd)	12	4	61.44
Cerium (Ce)	15		0.00
Cyanide (Cn)	60		0.00
Cobalt (Co)	12		0.00
Chromium (Cr)	12	4	61.44
Copper (Cu)	12	4	61.44
Hexavalent Chromium (Cr+6)	14		0.00
Iron (Fe)	12	4	61.44
Lead (Pb)	15	4	76.80
Mercury (Hg)	15	4	76.80
Manganese (Mn)	12	4	61.44
Nickel (Ni)	12		0.00
Selenium (Se)	15		0.00
Silver (Ag)	12		0.00
Titanium (Ti)	12		0.00
Tin (Sn)	12		0.00
Thallium (Tl)	12		0.00
Vanadium (V)	15		0.00
Zinc (Zn)	12	4	61.44
			0.00
			0.00
			0.00
			0.00
		Subtotal **$**	***599.04***

Calculating the Cost for Metal Analysis of Sediment Samples

Study: *Ambient Monitoring Metals Analysis*

Lab: *Montgomery*

WTU Cost *1.28*

Parameter	*W.T.U*	*# samples*	*cost of analysis*
Aluminum (Al)	14		0.00
Antimony (Sb)	19		0.00
Arsenic (As)	22	1	28.16
Barium (Ba)	21		0.00
Beryllium (Be)	21		0.00
Cadmium (Cd)	19	1	24.32
Cerium (Ce)	15		0.00
Cyanide (Cn)	110		0.00
Cobalt (Co)	19		0.00
Chromium (Cr)	19	1	24.32
Copper (Cu)	19	1	24.32
Hexavalent Chromium (Cr+6)	30		0.00
Iron (Fe)	19	1	24.32
Lead (Pb)	15	1	19.20
Mercury (Hg)	25	1	32.00
Manganese (Mn)	12	1	15.36
Nickel (Ni)	19		0.00
Selenium (Se)	22		0.00
Silver (Ag)	19		0.00
Titanium (Ti)	12		0.00
Tin (Sn)	12		0.00
Thallium (Tl)	12		0.00
Vanadium (V)	15		0.00
Zinc (Zn)	19	1	24.32
			0.00
			0.00
			0.00
			0.00
		Subtotal *$*	***216.32***