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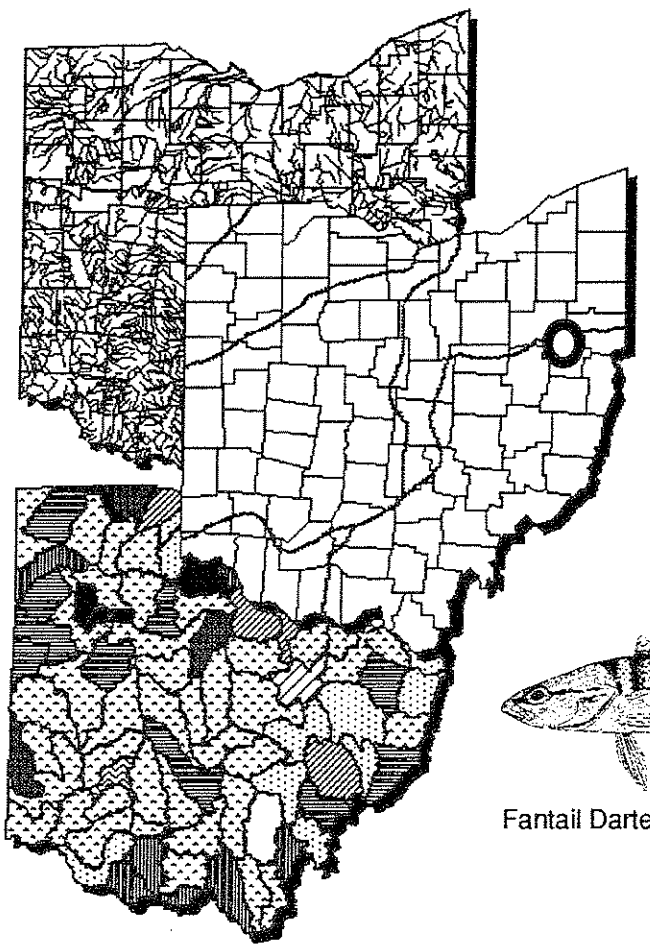
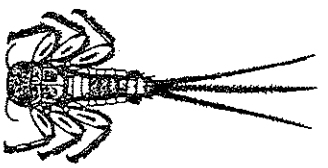
State of Ohio
Environmental Protection Agency

Ecological Assessment
Division of Surface Water

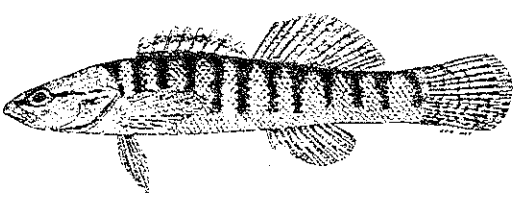
Biological and Water Quality Study of Sandy Creek and Still Fork Sandy Creek

Columbiana, Carroll, and Stark Counties, Ohio





Mayfly *(Stenonema)*



Fantail Darter *(Etheostoma flabellare)*

April 1, 1995

P.O. Box 1049, 1800 WaterMark Dr., Columbus, Ohio 43266-0149

State of Ohio Environmental Protection Agency

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George V. Voinovich
Governor

Monday, May 15, 1995

To Recipients of Sandy Creek Water Quality Report:

Following completion and distribution of the "Biological and Water Quality Study of Sandy Creek and Still Fork" report, an error was discovered by Mr. Dave Hadvinski of PCC Airfoil in the description of the groundwater treatment discharge. Please insert the attached errata sheet in your copy of the report. I apologize for any misunderstanding or inconvenience.

Sincerely,

Jack Freda

Jack Freda, Sandy Creek Report Editor
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Errata Sheet for
"Biological and Water Quality Study of Sandy Creek and Still Fork Sandy Creek
Columbiana, Carroll, and Stark Counties, Ohio"

1) Throughout the report, PCC Airfoil (formerly TRW-Minerva) is erroneously described as operating a groundwater remediation pump and treatment system at RM 30.8. The treatment system and a cell of contaminated soil at the property continues to be owned and operated by TRW-Minerva. Report references to a "PCC Airfoil discharge" should be changed to "TRW-Minerva".

Biological and Water Quality Study of Upper Sandy Creek and Still Fork Sandy Creek

Stark, Carroll and Columbiana Counties, Ohio

1994

Ohio EPA Technical Report EAS/1994-5-4

prepared by

State of Ohio Environmental Protection Agency
Division of Surface Water
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Acknowledgements

The following Ohio EPA staff are acknowledged for their significant contribution to this report.

Study Area Description - Rich McClay
Pollutant Loadings - David Stroud
Ambient Chemical Quality - David Stroud
Biological Assessment:
Macroinvertebrate Community - Jack Freda
Fish Community - Charles Boucher, David Altfater
Data Management - Dennis Mishne
TSD Coordinator - Jack Freda
Reviewer(s) - Chris Yoder

This evaluation and report would not have been possible without the additional assistance of the study team, many full and part time staff in the field, and the chemistry analyses provided by the Ohio EPA Division of Environmental Services.

NOTICE TO USERS

Ohio EPA adopted biological criteria into the Ohio Water Quality Standards regulations (Ohio Administrative Code Chapter 3745-1) regulations in February 1990 (Effective May 1990). These criteria consist of numeric values for the Index of Biotic Integrity (IBI) and Modified Index of Well-Being (MIwb), both of which are based on fish, and for the Invertebrate Community Index (ICI), which is based on macroinvertebrates. Criteria for each index are specified for each of Ohio's five ecoregions, and are further organized by organism group, index, site type, and aquatic life use designation. These criteria, along with the chemical and whole effluent toxicity evaluation methods, figure prominently in the assessment of Ohio's surface water resources.

Several documents support the adoption of the biological criteria by outlining the rationale for using biological information, the specific methods by which the biocriteria were derived and calculated, the field methods by which sampling must be conducted, and the process for evaluating results. These documents are:

Ohio Environmental Protection Agency. 1987a. Biological criteria for the protection of aquatic life: Volume I. The role of biological data in water quality assessment. Division of Water Quality Monitoring & Assessment, Surface Water Section, Columbus, Ohio.

Ohio Environmental Protection Agency. 1987b. Biological criteria for the protection of aquatic life: Volume II. Users manual for biological field assessment of Ohio surface waters. Division of Water Quality Monitoring & Assessment, Surface Water Section, Columbus, Ohio.

Ohio Environmental Protection Agency. 1989a. Addendum to biological criteria for the protection of aquatic life: Volume II. Users manual for biological field assessment of Ohio surface waters. Division of Water Quality Planning & Assessment, Ecological Assessment Section, Columbus, Ohio.

Ohio Environmental Protection Agency. 1989b. Biological criteria for the protection of aquatic life: Volume III. Standardized biological field sampling and laboratory methods for assessing fish and macroinvertebrate communities. Division of Water Quality Planning & Assessment, Ecological Assessment Section, Columbus, Ohio.

Ohio Environmental Protection Agency. 1990. The use of biological criteria in the Ohio EPA surface water monitoring and assessment program. Division of Water Quality Planning & Assessment, Ecological Assessment Section, Columbus, Ohio.

Rankin, E.T. 1989. The qualitative habitat evaluation index (QHEI): rationale, methods, and application. Division of Water Quality Planning & Assessment, Ecological Assessment Section, Columbus, Ohio.

These documents and this document can be obtained by writing to:

Ohio EPA - DSW
Water Quality Monitoring and Assessment Section
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Biological and Water Quality Survey of Upper Sandy Creek and Still Fork Sandy Creek (Stark, Carroll, and Columbiana Counties, Ohio)

Ohio Environmental Protection Agency
Division of Surface Water
P.O. Box 163669
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Introduction

The upper Sandy Creek study area included the Sandy Creek mainstem from river mile (RM) 33.0 to RM 25.1 and Still Fork Sandy Creek from RMs 5.7 to 0.5.

Specific objectives of this evaluation were to:

1) monitor and assess chemical/physical water quality and biological communities to learn the magnitude and extent of impacts from point and nonpoint pollution sources and habitat alteration,

2) evaluate impacts from municipal and industrial discharges on their respective receiving streams,

3) determine the attainment status of current aquatic life use designations and other beneficial uses and recommend changes in uses where appropriate, and

4) compile baseline data for future monitoring comparisons.

The findings of this evaluation may factor into regulatory actions taken by Ohio EPA (*e.g.*, National Pollution Elimination Discharge System [NPDES] permits, Director's Orders), the Ohio Water Quality Standards (Ohio Administrative Code Chapter 3745-1). The findings may eventually be incorporated into the State Water Quality Management Plans, the Ohio Nonpoint Source Assessment, and the biennial Water Resource Inventory (305[b]) Report.

Summary

Sandy Creek and Still Fork Sandy Creek
The 1993 survey of the upper Sandy Creek watershed included an eight-mile segment of Sandy Creek upstream and downstream from the Village of Minerva (RMs 33.1-25.1) and the lower 5.7 miles of Still Fork Sandy Creek. Aquatic life use attainment status and biocriteria scores for all sampling locations are presented in Table 1.

Sampling results showed that poorly treated organic wastes from the Minerva wastewater treatment plant (WWTP) had a significant impact on biological and chemical water quality conditions in Sandy Creek. All biological indices declined to the poor range at a station 0.7 miles downstream from the WWTP (RM 28.3-2) and were in substantial non-attainment of the WWH criteria. A

large fish kill was also observed at the site on August 27 by Ohio EPA personnel. Dissolved oxygen (D.O.) levels below two mg/l were recorded four days earlier at the same location.

During the summer, sharp increases were also noted in several nutrient parameters downstream from the WWTP including ammonia-N, total kjeldahl nitrogen (TKN: *i.e.,* ammonia plus organic nitrogen), phosphorus and five-day carbonaceous biochemical oxygen demand ($cBOD_5$). A fecal coliform exceedence of the secondary contact recreation criterion was also noted downstream from the discharge. Further downstream at RM 25.2-25.1, biological communities reflected partial attainment of the WWH use (fair-good range). Recovery of both the biological communities and water chemistry was considered incomplete at the most downstream station.

Biological community health upstream from the WWTP (RM 33.1-29.4) ranged from good to exceptional and all stations fully attained the designated Warmwater Habitat (WWH) biocriteria (Table 1). Chemical sampling also indicated no water quality standards exceedences upstream from the discharge.

The Minerva WWTP has been recommended for enforcement action by the Ohio EPA Northeast District Office. These measures were taken due to a history of NPDES permit violations over the past five years. Problems with treatment include poor plant design, plant overloading, and inadequate pretreatment from a local dairy that is a major contributor of influent nutrient loadings. Demonstrable impacts to both the stream biota and chemistry in 1993 clearly implicate the WWTP as the major source of stream degradation in the upper reaches of Sandy Creek. Impairment in Sandy Creek extended for a minimum of four miles downstream from the WWTP.

Impacts associated with the Minerva WWTP discharge appeared primarily related to excessive organic enrichment. However, the severity of the impacts (*i.e.*, poor fish and macroinvertebrate communities) and an observed fish kill suggested water quality conditions occasionally reached lethal levels. Fish sampling also revealed a high incidence of anomalies and deformities, an indication of chronic, sublethal stresses. In Ohio EPAs experience, these anomalies are often the result of exposure to toxic substances combined with marginal D.O. levels.

Anomalies downstream from the WWTP also included an elevated incidence of internal skeletal deformities. Several studies have suggested a correlation between skeletal deformities and pollution, including contamination from heavy metals and pesticides The physical condition of Sandy Creek fish suggests an additional stress downstream from the Minerva WWTP, beyond domestic sewage. Several sources of heavy metals were identified in this report (e.g., Minerva WWTP, Masco Tech) and fish tissue sampling revealed an increased body burden of pesticides downstream from TRW-Minerva (aka, PCC Airfoil). However, based on the 1993 sampling results, toxics contamination in the upper Sandy Creek watershed was not considered a serious problem, particularly when compared to impacts from gross organic enrichment. Some anomalies (particularly skeletal), may have been an artifact of past water quality problems.

The 1993 survey detected several lesser sources of impact in the upper Sandy Creek watershed. In Still Fork Sandy Creek, unrestricted livestock access and historical channel modifications at RM 5.7 resulted in habitat degradation and fair quality fish and macroinvertebrate communities. The Masco Tech (formerly Burns Cold Forge) discharge at RM 0.6 may have contributed to sediment metals contamination in the dam pool at RM 0.5 and further downstream in Sandy Creek. Biological communities immediately downstream from Masco Tech were in PARTIAL attainment

of WWH criteria. However, evaluation of the discharge was confounded by the impounded conditions.

In the Village of Minerva, fish community sampling, water chemistry, and sediment results showed no detectable impacts downstream from the PCC Airfoil groundwater treatment system discharge. Whole body fish tissue sampling revealed an increase in detectable quantities of priority organic compounds. The concentrations were well below FDA action limits but did demonstrate bioaccumulation of organics in the fish. Macroinvertebrates declined sharply downstream from the groundwater discharge but still achieved the WWH criterion. Occasional septic and organic (i.e., chemical) odors were noted in slack water sediments suggesting potential sources of impact. However, a specific reason for the decline in the ICI remained unknown.

Evaluated Point Sources

Minerva WWTP (Sandy Creek: RM 29.0)
Biological communities declined from the good range upstream from the Minerva WWTP (FULL attainment of the WWH aquatic life use) to the poor range 0.7 miles downstream (**NON**-attainment). Impacts appeared *primarily* related to gross organic enrichment, although the severity of impact coupled with an observed fish kill suggested periodically lethal conditions downstream from the discharge. Biological impacts were characterized by sharp increases in the predominance of tolerant species, the almost complete elimination of pollution sensitive fish and macroinvertebrates, and a sharp increase in fish anomalies downstream from the discharge. Fish anomalies included a high incidence of internal skeletal deformities that suggested a source of additional stress besides domestic sewage. Some fish anomalies, particularly the skeletal deformities, may have reflected past water quality problems.

Before the fish kill, dissolved oxygen (D.O.) levels were recorded below minimum WWH and Limited Resource Water (LRW) criteria downstream from the WWTP. Sharp increases in most nutrient parameters were also noted during the summer sampling period. Since 1989 WWTP loadings of $cBOD_5$, ammonia, and total suspended solids (TSS) have been increasing steadily while discharge flows have remained relatively stable during the same period.

Further downstream at RM 25.1, biological community indices reflected PARTIAL attainment. Macroinvertebrates improved to the good range but very high densities of a filter-feeding midge taxon suggested continued enrichment. Fish communities improved to a fair condition but community health remained below WWH expectations.

The Minerva WWTP has been recommended for enforcement action following a history of NPDES permit violations over the past five years. Most violations were for $cBOD_5$, total suspended solids and fecal coliform bacteria. Problems with treatment include poor plant design, plant overloading and inadequate pretreatment from a local dairy that is a major contributor of influent nutrient loadings. Demonstrable impacts to both the stream biota and water chemistry in 1993 clearly implicate the WWTP as the major source of stream degradation in the upper reaches of Sandy Creek.

PCC Airfoil - (formerly TRW-Minerva) (Sandy Creek: RM 30.8)
Biological communities were in FULL attainment of WWH criteria both upstream and immediately downstream from the PCC Airfoil treated groundwater discharge. No detectable impacts were observed in chemistry, sediment or fish community sampling. Fish tissue sampling did reveal an

increase in detectable quantities of some pesticides but the concentrations were well below FDA action limits. The invertebrate community index (ICI) score was in the good range (34), but declined when compared to the exceptional value found upstream (50). Septic and organic (*i.e.*, chemical) odors were noted in some slack water sediments, indications of possible pollution sources upstream. However, specific causes of the decline in the ICI were unknown. Overall, impacts associated with the PCC Airfoil discharge appeared small.

Masco Tech (formerly Burns Cold Forge) (Still Fork Sandy Creek: RM 0.6)
Masco Tech discharges to an impounded section of Still Fork Sandy Creek near the confluence with Sandy Creek. Sediments immediately downstream from the discharge had highly elevated concentrations of chromium, zinc, and lead. Biological communities were in PARTIAL attainment of the WWH biocriteria immediately downstream from the discharge. Due to the overriding impoundment influences in this section, potential biological impacts associated with the discharge could not be detected.

Conclusions

- Minerva WWTP effluent had a significant impact on water chemistry in Sandy Creek. Nutrient concentrations in particular showed significant increases downstream from the WWTP that corresponded with elevated concentrations in the final effluent. There were also significant declines in mean D.O. concentrations and violations were detected downstream from the WWTP. Effluent D.O. concentrations near zero were often recorded during the survey.

- Ambient grab water chemical samples were collected during low flows and thus tend to reflect the greatest influence of point source dischargers. Heavy metals concentrations were generally at or below detection limits. Increased concentrations of total suspended solids and metals associated with nonpoint sources would likely be found under higher flow conditions.

- Minerva WWTP loadings of $cBOD_5$, ammonia-N, and suspended solids have been increasing steadily in recent years.

- Recent monthly operating report (MOR) information from Minerva shows a consistent pattern of NPDES permit violations, primarily for discharges of $cBOD_5$, suspended solids, and fecal coliform bacteria. Violations occurred sporadically in 1991 and 1992 but were noted for each month from November 1992 to October 1993.

- The PCC Airfoil discharge did not appear to influence chemical water quality in Sandy Creek. No PCB isomers were detected in sediment samples collected immediately downstream from the discharge (RM 30.7).

- Highly elevated levels of zinc were detected in Still Fork Sandy Creek sediments at RM 0.5, immediately downstream from Masco Tech. Slight increases in zinc were also noted in Sandy Creek downstream from both Still Fork Sandy Creek and the Minerva WWTP, another known discharger of zinc.

- Masco Tech has had a chronic pattern of NPDES permit violations for metals (primarily zinc) since 1992 when monitoring of metals was required in their NPDES permit. Violations occurred in each MOR submitted from June 1992 to November 1993.

- Physical habitat conditions in Sandy Creek were considered good to excellent throughout the mainstem study area. Habitat was not considered a negative influence on stream faunas in Sandy Creek.

- Fish and macroinvertebrate index scores in Sandy Creek achieved the WWH biocriteria upstream from the Minerva WWTP (good to exceptional ranges) and declined to the poor range (NON attainment) 0.7 miles downstream from the WWTP. Community compositions downstream from the WWTP showed severe impacts from excessive loadings of organic or oxygen demanding wastes. The poor quality of biological communities and a fish kill at RM 28.3 suggests water quality conditions periodically reached lethal levels during the summer of 1993.

- Impacts to both the fish and macroinvertebrate communities were characterized by sharp increases in the predominance of tolerant taxa and a reduction or elimination of pollution sensitive species. Additionally, a punctuated increase in the mean incidence of physical deformities and lesions (*i.e.*, DELT anomalies) were observed in the fish community.

- The high percentage of DELT anomalies at RM 28.3 also included a much higher incidence of internal, skeletal deformities (8.3 % of total fish). Several studies have suggested a correlation between elevated skeletal deformities and increased heavy metals contamination (Bengtsson 1974, Bengtsson et. al. 1975, Reash and Berra, 1989). Pesticides were considered a probable source of skeletal deformities in crappies in an Illinois lake (Baumann and Hamilton 1984). The deformities observed downstream from the Minerva WWTP suggested a source of additional stress, beyond domestic sewage. It was uncertain if the deformities reflected current conditions or were artifacts of past water quality problems.

- Sandy Creek was visibly degraded downstream from the WWTP; the stream bottom was covered with a layer of sewage solids, the water often had a blackish-grey tint, and strong septic and ammonia odors were detected.

- Incomplete recovery in both the water chemistry and biological communities was noted at RM 25.2-25.1, four miles downstream from the Minerva WWTP.

- In the upper reaches of Still Fork Sandy Creek, fish and macroinvertebrate community health was in the fair range and index scores reflected non-attainment of the designated WWH aquatic life use. Observed degradation resulted primarily from unrestricted livestock access to the stream and extensively modified channel conditions. Within the open pasture, the stream bottom was almost entirely composed of soft muck and silt. Banks were denuded and collapsing and large amounts of manure were observed next to the channel. The fish sampling site immediately downstream from the pasture had more stable banks and an intact riparian border. However, siltation was extensive and had the section of stream been historically channelized.

- Potential impacts on biological communities downstream from Masco Tech could not be separated from the influence of impounded habitat conditions in the lower reaches of Still Fork Sandy Creek.

Recommendations

- Given the severity of impacts observed during the 1993 survey, planned improvements at the Minerva WWTP should be constructed as soon as possible.

- Additional investigation of pollutant sources in Minerva should be conducted given the very high number of internal skeletal deformities in fish downstream from the WWTP. These deformities suggested a source of additional stress beyond the influence of domestic sewage.

- High levels of zinc in sediments downstream from Masco Tech coupled with a chronic pattern of NPDES permit violations for zinc and other metals suggest the need for additional treatment or improvements in current treatment at this facility.

Status of Aquatic Life Uses

- The current **Warmwater Habitat** aquatic life use designations for Sandy Creek and Still Fork Sandy Creek should be maintained. Sandy Creek had consistently good habitat quality at all stations (mean QHEI=75.2) and displayed FULL attainment of the WWH use at several sampling locations. Habitats in Still Fork Sandy Creek were negatively influenced by past channelization activity and unrestricted livestock access at RM 5.7 and a low-head dam impoundment in the lower reaches (station RM 0.5). Biological communities were in **NON** and PARTIAL attainment of WWH at the two sites, respectively. Despite marginal biological and physical habitat quality, the WWH use was considered appropriate because 1) Still Fork Sandy Creek is not under scheduled channel maintenance as a petition ditch, 2) impacts from agricultural nonpoint sources (e.g., unrestricted livestock access) can be remediated and therefore, are not considered irreversible influences, and, 3) impoundment effects were fairly localized and, in themselves, are not considered justification for a change in use designation.

Status of Non-Aquatic Life Uses

- One fecal coliform exceedence of the secondary contact recreation criterion (*i.e.*, 5,000 colonies/100 ml) was detected in Sandy Creek downstream from the Minerva WWTP. The WWTP also recorded six NPDES permit violations for fecal coliform between May and October 1993. Results showed that, with the current effluent quality, the potential exists for violations of the bacteriological criterion and non-attainment of the designated Primary Contact Recreation (PCR) use downstream from the WWTP.

Future Monitoring Needs

- The upper reaches of Sandy Creek should be resurveyed after an adequate recovery period, following completion of the proposed Minerva WWTP improvements.

- Because of the apparent incomplete recovery observed during the 1993 survey, future monitoring should extend further downstream to fully document recovery patterns, evaluate the town of Malvern, and continue to monitor trends between Nimishillen Creek and the mouth.

- Future monitoring should expand the evaluation of nonpoint source pollution in previously unmonitored stream segments in the Sandy Creek watershed.

Table 1. Aquatic life use attainment status for the designated Warmwater Habitat (WWH) aquatic life use of Sandy Creek and Still Fork Sandy Creek based on data collected from June to October 1993. Attainment status is based on biocriteria for the Erie-Ontario Lake Plain (EOLP) ecoregion of Ohio for Sandy Creek and the Western Allegheny Plateau (WAP) ecoregion for Still Fork Sandy Creek (OAC Chapter 3745-1-07, Table 7-17).

RIVER MILE Fish/Invert.	IBI	Modified Iwb	ICI	QHEI[a]	Attainment Status[c]	Comment
Sandy Creek						
		Erie Ontario Lake Plain-WWH Use Designation				
33.1[w] /33.1	44	7.6[ns]	50	66.5	FULL	Upstream Minerva
30.3[w] /30.4	46	9.5	34	70.5	FULL	Downstream PCC Airfoil
29.4[w] /29.6	39	8.4	36	77.0	FULL	Upstream Still Fork & Minerva WWTP
28.2[w] /28.3	23*	5.5*	10*	83.0	**NON**	Dst. Minerva WWTP
25.2[w] /25.1	33*	7.0*	40	78.5	PARTIAL	@ Oneida
Still Fork Sandy Creek						
		Western Allegheny Plateau-WWH Use Designation				
5.7[w] /5.7	37*	7.1*	30*	29.5	**NON**	Livestock impacts, channelized
0.5[b] /0.5	39[ns]	7.9*	Fair*[c]	40.0	PARTIAL	Impounded; Dst Masco Tech

Ecoregion Biocriteria: Erie Ontario Lake Plain (EOLP)

INDEX - Site Type	WWH	EWH	MWH[d]
IBI - Wading	38	50	24
Mod. Iwb - Wading	7.9	9.4	6.2
IBI - Boat	40	48	24/30
Mod. Iwb - Boat	8.7	9.6	5.8/6.6
ICI	34	46	22

Ecoregion Biocriteria: Western Allegheny Plateau (WAP)

INDEX - Site Type	WWH	EWH	MWH[c]
IBI - Wading	44	50	24
Mod. Iwb - Wading	8.4	9.4	6.2
IBI - Boat	40	48	24/30
Mod. Iwb - Boat	8.6	9.6	5.8/6.6
ICI	36	46	22

* - significant departure from ecoregional biocriteria; poor and very poor results are underlined.
ns - nonsignificant departure from ecoregional biocriteria (4 IBI or ICI units; 0.5 Mod. Iwb units).
a - Qualitative Habitat Evaluation Index (QHEI) values based on the new version (Rankin 1989).
b - Boat sampling method.
w - Wading sampling method.
c- Narrative evaluation for macroinvertebrates used in leu of ICI due to impounded habitat conditions.
d - Modified Warmwater Habitat for channel modified areas and / impounded habitats.

Study Area

Sandy Creek and its tributaries drain a 503 square mile watershed in northeast Ohio (ODNR 1954). From its headwaters in Columbiana County, Sandy Creek flows in a southwesterly direction through Stark, Carroll, and Tuscarawas counties before joining the Tuscarawas River at the southern edge of Stark County. The northern Sandy Creek watershed is in Ohio's glaciated region, while the southern half is in the unglaciated region.

The 1993 study area consists of the upper portion of Sandy Creek located between river miles 31 and 25, and the lower 6 miles of Still Fork Sandy Creek (Figure 1). This is a tri-county area including north central Carroll County, southeast Stark County, and southwest Columbiana County. Towns in the study area include Minerva and the smaller communities of Oneida, Pekin, and Bayard. Major tributaries of Sandy Creek include Hugle Run, Still Fork Sandy Creek, Muddy Fork, and Middle Branch. Table 2 lists the general characteristics of streams in the study area.

The Sandy Creek watershed is physically split between two ecoregions. The northern half and headwaters portion of the watershed is in the Erie-Ontario Lake Plain (EOLP) ecoregion while the southern half is in the Western Allegheny Plateau (WAP) ecoregion. Although all of the 1993 survey monitoring sites are physically in the WAP ecoregion, the ecoregional characteristics of the sites on Sandy Creek appear more strongly associated with the glacial outwash and physiological conditions typical of the EOLP. Since the characteristics of the parent ecoregion tend to be exported into the next ecoregion, the entire study area was deemed to be most representative of the EOLP. A detailed evaluation of the ecoregion characteristics confirmed attributes were characteristic of the EOLP ecoregion.

Coal mining and oil and gas production are the primary types of nonpoint source (NPS) pollution in the Sandy Creek watershed. Other types of NPS pollution known or suspected in the basin include on-site septic systems and livestock production (Ohio EPA 1990b).

Table 2. Stream characteristics and significant identified pollution sources in the Sandy Creek study area (ODNR 1954 and Ohio EPA 1992).

Stream Name	Length (Miles)	Average Gradient (Ft./Mile)	Drainage Area (Sq. Miles)	Nonpoint Source Pollution Categories	Point Sources Evaluated
Sandy Creek	41.3	10.0	503.1	Coal Mining Oil & Gas Production On-site Septic Systems	PCC Airfoil (aka, TRW-Minerva) Minerva WWTP
Still Fork Sandy Creek	16.1	9.5	71.0	In Place Pollutants	Masco Tech (aka, Burns Cold Forge)

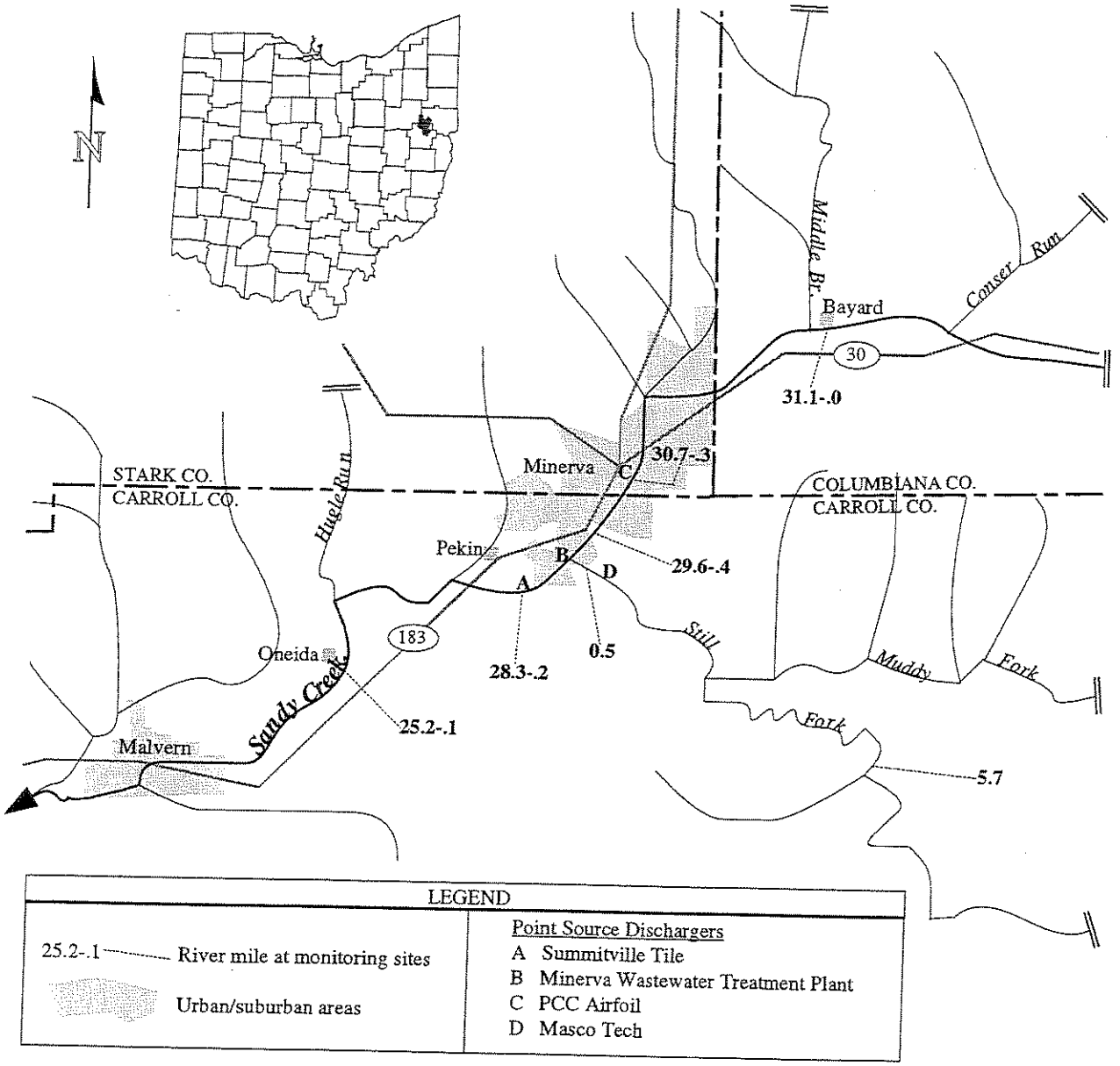

Figure 1. The upper Sandy Creek study area showing principal streams and tributaries, population centers, pollution sources and stream sampling locations, 1993.

Methods

All chemical, physical, and biological field, laboratory, data processing, and data analysis methods and procedures follow those specified in the Manual of Ohio EPA Surveillance Methods and Quality Assurance Practices (Ohio Environmental Protection Agency 1989c) and Biological Criteria for the Protection of Aquatic Life, Volumes II-III (Ohio Environmental Protection Agency 1987, 1989b, 1989a), and The Qualitative Habitat Evaluation Index (QHEI): Rationale, Methods, and Application (Rankin 1989) for aquatic habitat assessment.

Attainment/non-attainment of aquatic life uses is determined by using biological criteria codified in Ohio Administrative Code (OAC) Chapter 3745-1-07, Table 7-17. The biological community performance measures used include the Index of Biotic Integrity (IBI) and the Modified Index of Well-being (MIwb), both of which are based on fish community characteristics, and the Invertebrate Community Index (ICI) which is based on macroinvertebrate community characteristics. The IBI and ICI are multi-metric indices patterned after an original IBI described by Karr (1981) and Fausch *et al.* (1984). The MIwb is a measure of fish community abundance and diversity using numbers and weights information; it is a modification of the original Index of Well-Being applied to fish community information from the Wabash River (Gammon 1976, Gammon *et al.* 1981).

Performance expectations for the basic aquatic life uses (Warmwater Habitat [WWH], Exceptional Warmwater Habitat [EWH], and Modified Warmwater Habitat [MWH]) were developed using the regional reference site approach (Hughes *et al.* 1986; Omernik 1988). This fits the practical definition of biological integrity as the biological performance of the natural habitats within a region (Karr and Dudley 1981). Attainment of an aquatic life use is **FULL** if all three indices (or those available) meet the applicable criteria, **PARTIAL** if at least one index does not attain and performance does not fall below the fair category, and **NON** if all indices either fail to attain or any index shows poor or very poor performance.

Physical habitat was evaluated using the Qualitative Habitat Evaluation Index (QHEI) developed by the Ohio EPA for streams and rivers in Ohio (Rankin 1989). Various attributes of the available habitat are scored based on their overall importance to the establishment of viable, diverse aquatic faunas. Evaluations of type and quality of substrate, amount of instream cover, channel morphology, extent of riparian canopy, pool and riffle development and quality, and stream gradient are among the metrics used to determine the QHEI score. Scores generally range from 20 to 100. The QHEI is used to evaluate the characteristics of a stream segment, not just the characteristics of a single sampling site. As such, individual sites may have much poorer physical habitat due to a localized disturbance yet still support aquatic communities closely resembling those sampled at adjacent sites with better habitat, provided water quality conditions are similar. QHEI scores from hundreds of segments around the state have shown that values higher than 60 are generally conducive to the establishment of warmwater faunas while those scores over 75-80 often typify habitat conditions that could support exceptional faunas.

Macroinvertebrate communities from Sandy Creek and Still Fork Sandy Creek were sampled using modified Hester/Dendy multiple-plate artificial substrates supplemented with a qualitative assessment of macroinvertebrates (taxa list) from the available natural substrates at each sampling location.

Fish were sampled two or three times using pulsed DC electrofishing gear using the wading method (100-250 meter zones) at free flowing stations and the boat method (500 meter zones) in

the impoundment on Still Fork Sandy Creek. All chemical/physical and biological sampling locations are listed in Table 3.

An Area of Degradation Value (ADV; Rankin and Yoder 1992) was calculated for the study area based on the longitudinal performance of the biological communities. The ADV portrays the length or "extent" of degradation to aquatic communities and is simply the distance that the biological index (IBI, MIwb, and ICI) departs from the stream criterion or the upstream level of performance (Figure 2). The magnitude of impact refers to the vertical departure of each index below the criterion. The total ADV is the area beneath the ecoregional criterion when the results for each index are plotted against river mile. This is also expressed as ADV/mile to normalize comparisons between segments and other areas.

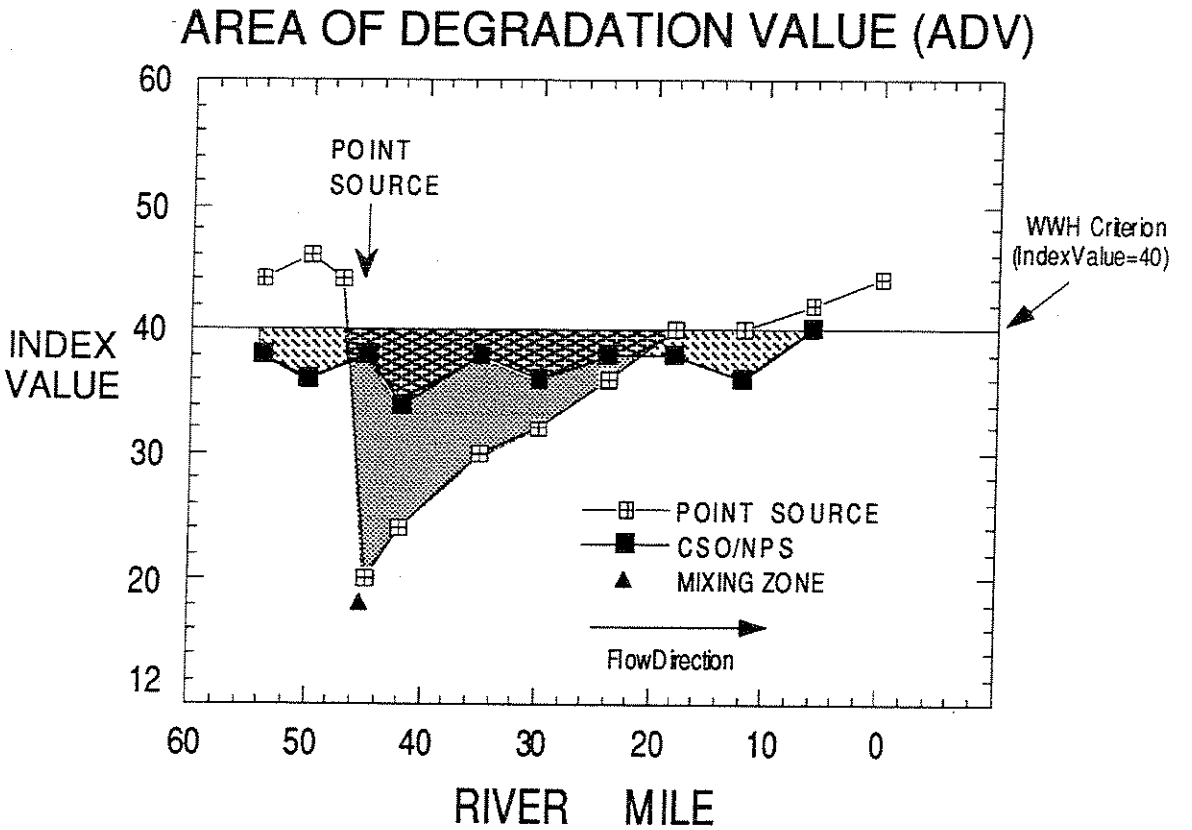

Figure 2. Graphic illustration of the Area of Degradation Value (ADV) based on the ecoregion biocriterion (WWH in this example). The index value trend line indicated by the unfilled boxes and solid shading (area of departure) represents a typical response to a point source impact (mixing zone appears as a solid triangle); the filled boxes and dashed shading (area of departure) represent a typical response to a nonpoint source or combined sewer overflow impact. The blended shading represents the over-lapping impact of the point and nonpoint sources.

Table 3. Sampling locations (effluent sample - E, water chemistry - C, sediment - S, benthic macroinvertebrates - B, fish - F, fish tissue - FT) in the Sandy Creek study area, 1993.

Stream/ River Mile	Type of Sampling	Latitude/Longitude	Landmark	USGS 7.5 min. Quad
Sandy Creek				
33.1	F,B,FT	40°44'56''/81°04'01"	Upstream Sandy Creek Road	Minerva
33.0	C,S	40°44'56"/81°04'07"	Sandy Creek Road @ Bayard	Minerva
30.7	C,S	40°44'06"/81°06'01"	@ Minerva Park	Minerva
30.4	B	40°43'20"/81°05'56"	Dst Minerva Park	Minerva
30.3	F,FT	40°43'50"/81°05'26"	Dst Minerva Park	Minerva
29.6	B	40°43'20"/81°06'23"	NYC RR trestle	Minerva
29.5	C,S	40°43'20"/81°06'22"	NYC RR trestle	Minerva
29.4	F	40°43'16"/81°06'26"	NYC RR trestle	Minerva
29.06	E	40°43'01"/81°06'38"	Minerva WWTP effluent	Minerva
28.3	B	40°42'45"/81°07'06"	@ Pekin	Minerva
28.2	C,S,F	40°42'45"/81°07'08"	@ Pekin	Minerva
25.2	F	40°42'02"/81°08'59"	Blade Road ust Oneida	Malvern
25.1	C,S,B	40°42'01"/81°09'02"	Blade Road ust Oneida	Malvern
Still Fork Sandy Creek				
5.7	C,S,F,B	40°40'48"/81°03'12"	Twp.Rd. 246	Minerva
0.5	C,S,F,B	40°42'47"/81°06'07"	Arrow Road	Minerva

Results and Discussion

Pollutant Loadings: 1983- 1993

A summary of municipal and industrial point source discharge locations and effluent characteristics in the 1993 Sandy Creek survey area is provided in Table 4. A summary of NPDES permit violations for the discharges is listed in Table 5. None of the entities are considered "major discharges" (i.e., process wastewater discharge volumes are less than one MGD) and none are on the Ohio EPA significant non-compliance list. However, enforcement actions are underway for the Minerva WWTP, Masco Tech, and the Minerva Dairy.

Minerva WWTP

The Village of Minerva operates a 0.93 million gallons per day (mgd) design flow extended aeration plant that discharges to Sandy Creek at RM 29.06. Discharge flows have been averaging 0.63 mgd since the current plant came on line in early 1988. The previous plant was an activated sludge/trickling filter type and was abandoned in 1988. Current treatment processes include screening, extended aeration, settling, and chlorination. Sludge from the WWTP is land applied. A large organic load from the Minerva Dairy has resulted in operational problems and many NPDES permit limit excursions over the last few years (Table 5). Parameters that have contributed to violations include dissolved oxygen, suspended solids, $cBOD_5$, and fecal coliform bacteria. A major design flaw at the plant can be found in the settling tanks. The tanks are square but the sludge collection mechanisms are circular. Sludge builds up in the corners and eventually tops the weirs. Also, due to the high organic loads there is insufficient detention time in the aeration system. Minerva has been required to submit corrective action plans for an upgrade and improvements. A consultant study showed that the Minerva Dairy was contributing 7.9% of the flow, 23.4% of the BOD load, 15.6% of the TSS, 12% of the TKN, 99.7% of the phosphorus, 8.6% of the ammonia-N, and 16.2% of the oil and grease to the Minerva WWTP. The consultant has developed a General Plan for the facility. The plan calls for replacement of existing aeration equipment, new secondary clarifiers, scum handling facilities and blowers, conversion of the current clarifiers to sludge holding tanks, and an update of the laboratory equipment. The estimated cost of the project is $828,850. Meanwhile, the Minerva Dairy is hauling a portion of their waste to a different WWTP for treatment. Enforcement action has been recommended by the Ohio EPA Northeast District Office for the NPDES violations.

Historical loading trends for ammonia-N, $cBOD_5$, suspended solids, oil and grease, and phosphorus from the Minerva WWTP are depicted in Figure 3. Most loadings of $cBOD_5$, ammonia, and suspended solids dropped after 1988 but have been increasing steadily in recent years. The increases, particularly for TSS and $cBOD_5$, are due to the Minerva Dairy discharge *and* deficiencies in treatment and operations at the Minerva WWTP.

Masco Tech *(formerly Burns Cold Forge)*

Masco Tech is a manufacturer of warm and cold formed shafts and pinions. The facility has two outfalls that discharge to Still Fork Sandy Creek at RM 0.56. The 001 discharge includes process wastewater, boiler blowdown, non-contact cooling water, and stormwater. The average discharge is 160,000 gallons per day (gpd). NPDES limited parameters at outfall 001 include TSS, oil and grease, ammonia, cadmium, copper, iron, lead, nickel, zinc, carbon tetrachloride, total toxic organics, and flow. Many NPDES permit limit excursions have been documented in recent years for heavy metals, particularly zinc (Table 5). Process wastewater originates at the zinc phosphate coating and cleaning lines. The wastewater undergoes alkaline precipitation, clarification, and pH adjustment before being discharged. Sludge is filter pressed and then taken to a solid waste landfill

for disposal. Zinc and nickel are the main parameters of concern. The discharge from outfall 002 is non-contaminated stormwater runoff.

Figure 4 depicts mean annual effluent flow and loading trends for suspended solids, oil and grease, and dissolved iron from 1983 to 1993. Loadings have been steadily declining in recent years.

PCC Airfoil *(formerly TRW-Minerva)*
PCC Airfoil operates a groundwater remediation pump and treatment system that came on line in early 1987 and discharges at RM 30.8. Groundwater contaminated with low levels of volatile organic compounds (VOCs) is pumped from eight recovery wells at a rate of 1200 gallons per minute (gpm) to a packed column air stripping system. Contaminants of concern include 1,1-dichloroethane, t-1,2 dichloroethene, trichloroethene, and vinyl chloride. Monthly sampling for eight specific VOCs and total volatile organics are required by the NPDES permit. A few permit violations have been documented (Table 5). Figure 5 depicts mean annual flow and loading trends for total volatile organics from the PCC Airfoil treatment system from 1987 to 1993.

The PCC Airfoil facility was also the subject of a large surface and groundwater PCB clean up, completed in 1987. A PCB disposal facility is located on the property. Sediment sampling in 1993 detected no PCB isomers at RM 30.7, immediately downstream from the discharge. However, septic and organic chemical odors were noted in some slack-water sediments at RM 30.4 by Ohio EPA personnel during macroinvertebrate sampling.

Summitville Tile Company
Summitville Tile is a manufacturer of ceramic floor brick and tile. The facility has six NPDES permitted outfalls. Outfall 006 discharges 10,200 gpd of non-contact cooling water while the remaining five are designated as non-contaminated stormwater outfalls only. No glazing is done at this facility. Only a very limited amount of discharge information was available from the facility and was not included in this report.

Table 4. Characteristics of point source wastewater dischargers to Sandy Creek and Still Fork Sandy Creek.

Entity	County	Permit #	Stream	RM	Discharge Type	Flow (MGD)
Public/Semi-public Dischargers						
Minerva WWTP	Carroll	3PC00023	Sandy Creek	29.06	S	0.70
Industrial Dischargers						
PCC Airfoil	Columbiana	3ID00060	Sandy Creek	30.80	CGW	1.73
Summitville Tile	Carroll	3IN00178	Sandy Creek	≈ 28.00	SW, NC	NA
Masco Tech	Carroll	3IN00142	Still Fork Sandy Creek	0.56	P	0.16

NC = Non-Contact Cooling Water
S = Sanitary Wastewater
SW = Stormwater
P = Process Wastewater
CGW = Contaminated Groundwater

Table 5. A summary of NPDES permit violations for municipal and industrial dischargers in the Sandy Creek study area, 1991-1993.

Entity	Outfall	Month	Violation
Sandy Creek			
PCC Airfoil (formerly TRW-Minerva)	001	3-93	1,2 dichloroethene, total volatile organics (TVO), monitoring
		5-93	tetrachloroethylene, monitoring
		8-93	TVO, dichloroethene
		9-93	TVO, dichloroethene
Minerva WWTP	001	4-91	total suspended solids (TSS)
		7-91	total residual chlorine
		8-91	total residual chlorine
		12-91	cBOD, TSS
		1-92	$cBOD_5$, TSS
		2-92	$cBOD_5$, TSS
		11-92	$cBOD_5$, TSS
		12-92	$cBOD_5$, TSS
		1-93	TSS
		2-93	$cBOD_5$, TSS
		3-93	$cBOD_5$, TSS
		4-93	$cBOD_5$, TSS
		5-93	$cBOD_5$, TSS, fecal coliform
		6-93	$cBOD_5$, TSS, fecal coliform
		7-93	$cBOD_5$, TSS, fecal coliform
		8-93	$cBOD_5$, TSS, fecal coliform
		9-93	TSS, fecal coliform
		10-93	fecal coliform
Still Fork Sandy Creek			
Masco Tech* (formerly Burns Cold Forge)	001	6-92	total (T) zinc
		7-92	T-copper, T-zinc
		8-92	T-zinc
		9-92	T-nickel, T-zinc
		10-92	T-zinc
		11-92	T-copper, T-zinc
		12-92	T-zinc
		1-93	T-zinc
		2-93	T-zinc
		3-93	T-zinc
		4-93	T-zinc
		5-93	T-zinc
		6-93	T-zinc
		7-93	T-copper, T-zinc
		8-93	T-zinc
		9-93	T-zinc
		10-93	T-copper, T-zinc, oil+grease
		11-93	TSS, T-copper, T-nickel, T-zinc, oil+grease

* Data for Masco Tech are incomplete; the company did not submit reports for several months in 1992 and did not have metals monitoring in their previous permit.

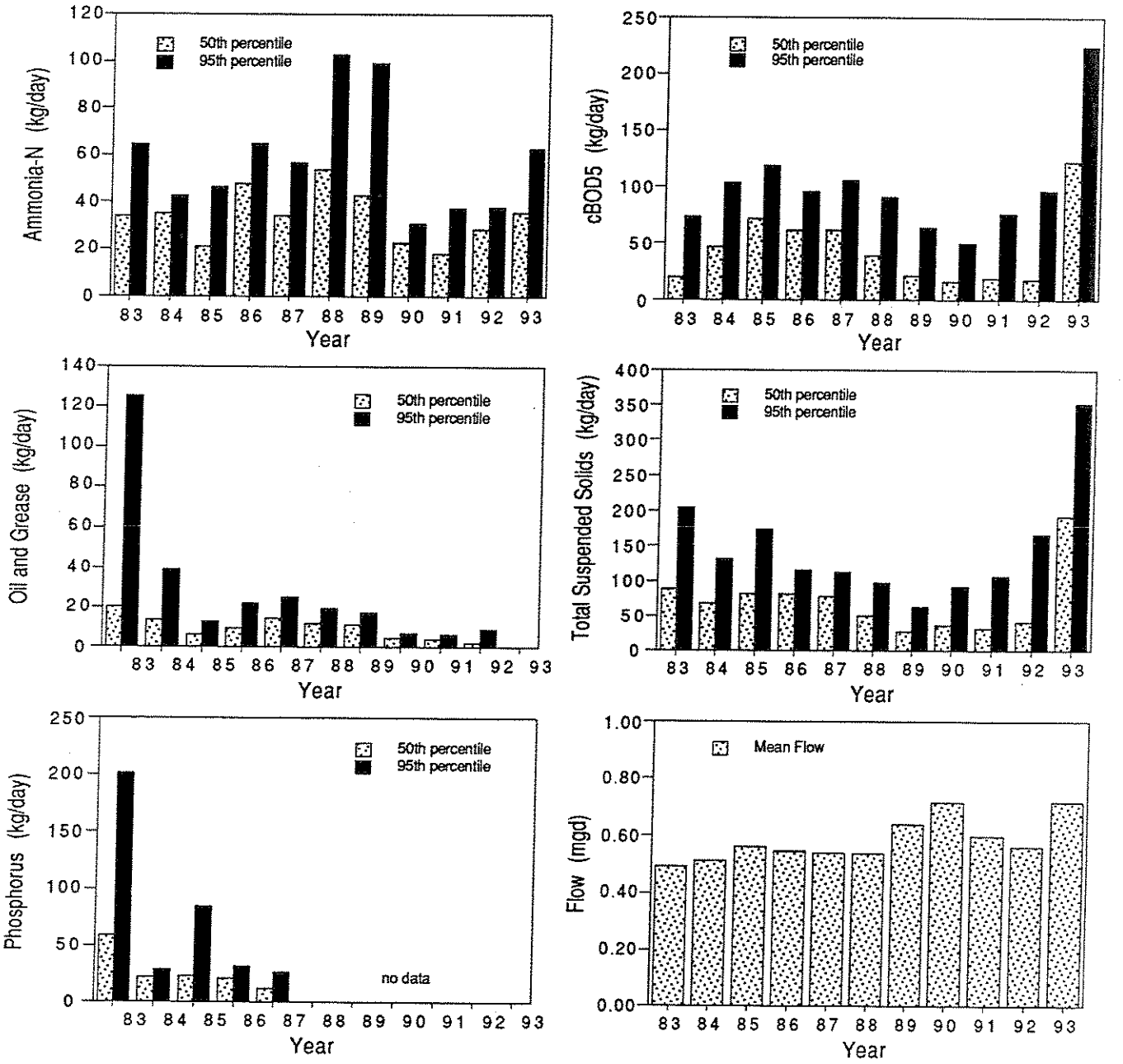

Figure 3. Annual loadings (kg/day) of ammonia-N, carbonaceous biochemical oxygen demand ($cBOD_5$), oil and grease, total suspended solids, phosphorus, and mean annual effluent flow (mgd) from the Minerva WWTP, 1983-93.

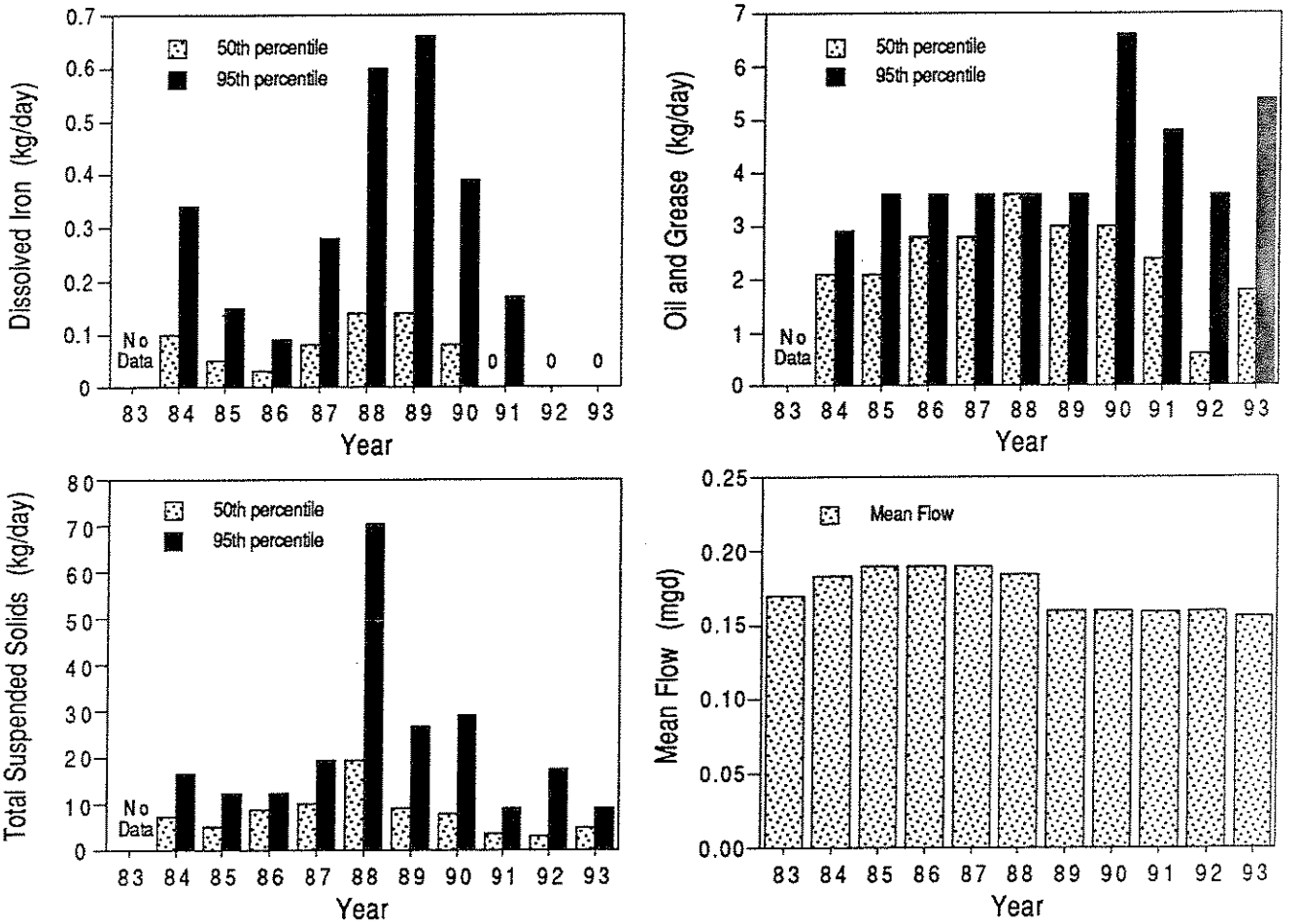

Figure 4. Annual loadings (kg/day) of dissolved iron, oil and grease, total suspended solids, and mean annual effluent flow (mgd) from Masco Tech (formerly Burns Cold Forge), 1983-93.

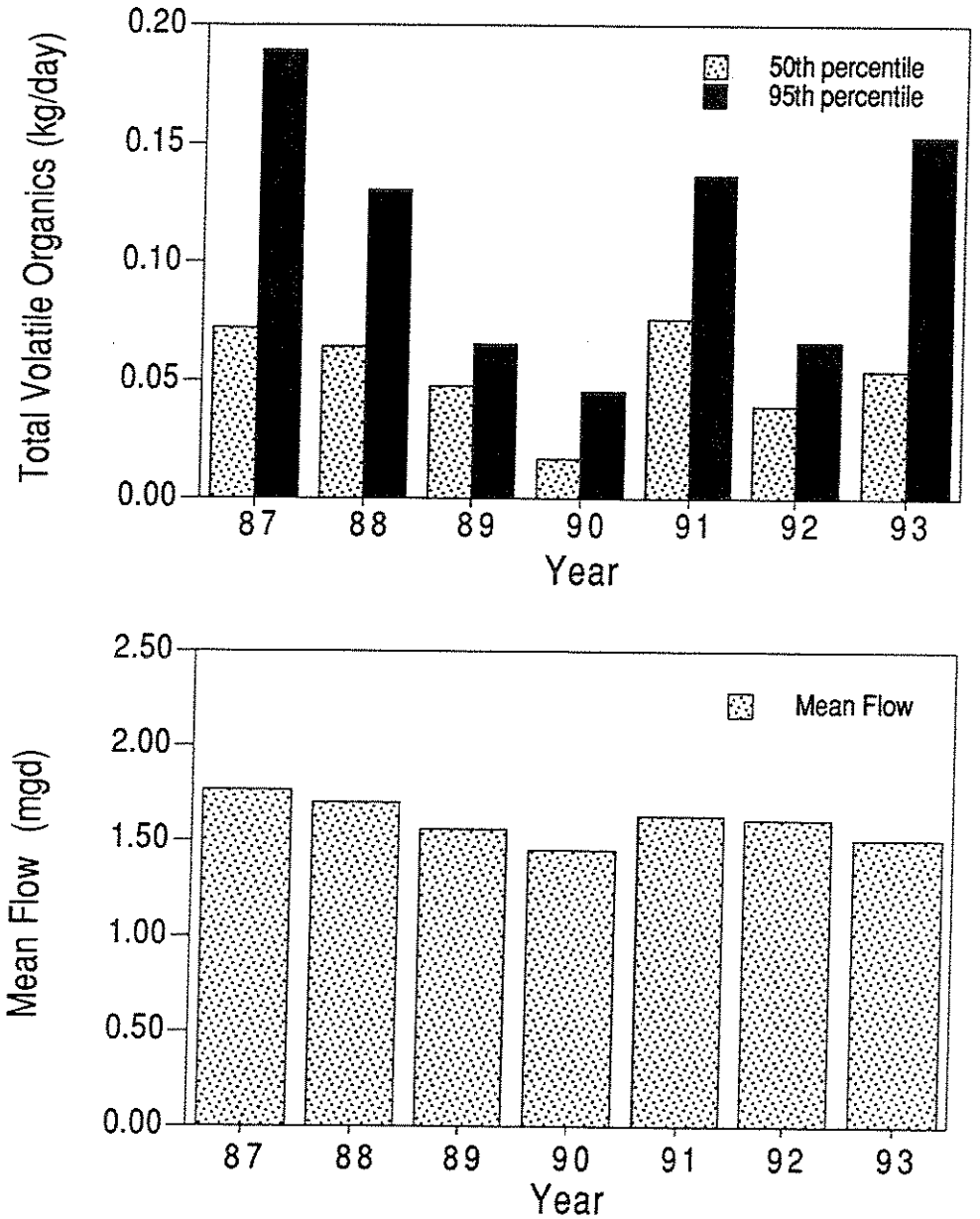

Figure 5. Annual loadings (kg/day) of total volatile organics (TVOs) and mean annual effluent flow (mgd) from PCC Airfoil (formerly TRW-Minerva), 1987-93.

Wild Animal Kills

Lists of wild animal kills are also indications of possible impacts due to pollutant loadings (Table 6). A review was conducted of kills in the upper Sandy Creek basin (Columbiana, Carroll and Stark Counties, Ohio) as reported by the Ohio EPA Division of Emergency and Remedial Response and Ohio Department of Natural Resources (ODNR) Division of Wildlife Pollution Investigative Reports. Results from 1980 through 1993 show:

- Ohio EPA and Ohio DNR pollution investigation reports list seven incidents from 1981-93 where a total of 56,967 fish or wild animals were killed within the upper Sandy Creek basin.

Table 6. List of fish and wild animal kills recorded by Ohio DNR and/or Ohio EPA in upper Sandy Creek and Still Fork Sandy Creek (Columbiana, Carroll and Stark Counties, Ohio), 1980 - 1991.

Date	Waterbody	Material	County	Number of Fish (Animals) Killed
8/27/93	Sandy Creek	sewage (OEPA fish crew obs.)	Carroll	>100
10/15/89	Sandy Creek	alkaline wastes	Columbiana	11,065
5/25/88	Sandy Creek	anhydrous ammonia	Stark	7,540
7/17/83	Still Fork Sandy Creek	acidic water	Carroll	36,287
5/21/82	Sandy Creek	sewage	Carroll	101
8/11/81	Sandy Creek	unknown	Carroll	234
7/29/81	Sandy Creek	coal washer waste	Columbiana	1,630

Chemical Water Quality

Sandy Creek and Still Fork Sandy Creek

- Water quality sampling was conducted on five dates in July and August 1993 (Appendix Table 1). Stream flows during collections were generally near or well below monthly mean discharges based on flow information from the United States Geological Survey (USGS) gage at Waynesburg.

- Violations of the dissolved oxygen minimum criteria for WWH and Limited Resource Water (LRW) were recorded downstream from the Minerva WWTP at RM 28.2 (3.6 and 1.3 mg/l, respectively) (Figure 6, Table 7). An exceedence of the Secondary Contact Recreation criterion for fecal coliform bacteria was also documented at this site (42,000 colonies/100 ml. water). No other violations of Water Quality Standards criteria were noted during this survey.

- Phosphorus concentrations increased significantly downstream from the Minerva WWTP (Figure 7). Effluent concentrations for phosphorus averaged 5.38 mg/l in effluent grab samples and 0.47 mg/l downstream in Sandy Creek (RM 28.2). In contrast, mean phosphorus concentrations of less than 0.1 mg/l were found upstream from the WWTP in Sandy Creek and the lower reaches of Still Fork Sandy Creek.

- Ammonia-N and total kjeldahl nitrogen (TKN: *i.e.,* ammonia plus organic nitrogen) concentrations increased significantly down-stream from the Minerva WWTP (Figure 7). Ammonia-N concentrations averaged 13.1 mg/l and TKN concentrations averaged 20.7 mg/l in effluent grab samples during the survey.

- Dissolved oxygen (D.O.) concentrations declined downstream from the Minerva WWTP (Figure 7). Mean D.O. concentrations approached the WWH criterion at the sample station downstream from the Minerva WWTP. Effluent D.O. concentrations were often near zero in chemical grabs collected during the survey. D.O. concentrations in the rest of the survey area were well within expected ranges.

- Total zinc concentrations increased slightly in Still Fork Sandy Creek downstream from Masco Tech, and in Sandy Creek downstream from the Village of Minerva and the Minerva WWTP (Figure 7). Twenty-five percent of stream samples had zinc concentrations above detection limits with the highest average concentration found in Still Fork Sandy Creek at RM 0.5 (19 ug/l). Zinc concentrations from the Minerva WWTP averaged 204.8 ug/l in effluent grabs. The zinc increases in Sandy Creek downstream from Minerva were primarily attributed to the Masco Tech and Minerva WWTP discharges. However, all in-stream concentrations were well below Water Quality Standards criteria.

- Lead concentrations were below detection limits in nine of 10 samples from Still Fork Sandy Creek. In Sandy Creek, slight increases in lead were detected downstream from Minerva and well downstream from the Minerva WWTP (Figure 7). Lead concentrations averaged 25 ug/l in effluent grabs from the Minerva WWTP. Like zinc, all in-stream lead concentrations were well below Water Quality Standards criteria.

- Copper, nickel, chromium, and cadmium results were all below lab detection limits. Arsenic concentrations were below detection limits in Sandy Creek while several sample results were just above detection limits in Still Fork Sandy Creek.

Table 7. Exceedences of Ohio EPA Warmwater Habitat criteria (OAC Chapter 3745-1) for chemical/physical parameters measured in grab samples taken from the Sandy Creek study area, 1993 (units are in # of colonies/100 ml water for fecal coliform, and mg/l for all other parameters).

Stream	River Mile	Parameter (value)
Sandy Creek	28.2	fecal coliform bacteria (42,000)◊◊ dissolved oxygen (3.6)‡, (1.3)‡‡

‡ indicates a violation of the WWH minimum D.O. criterion (4 mg/l).
‡‡ indicates a violation of LRW minimum D.O. criterion (2 mg/l).
◊◊ indicates an exceedence of the maximum Secondary Contact Recreation criterion (set as 5000 colonies/100 ml water).

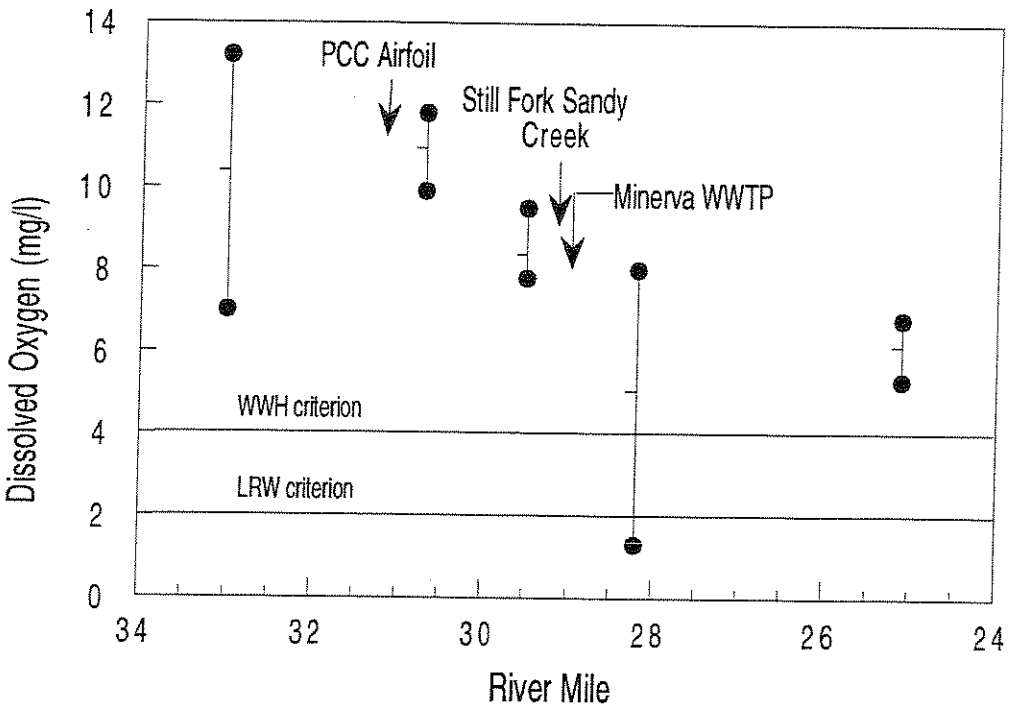

Figure 6. Mean, minimum, and maximum dissolved oxygen (D.O.) concentrations from chemical grab samples (n=5) in Sandy Creek, 1993.

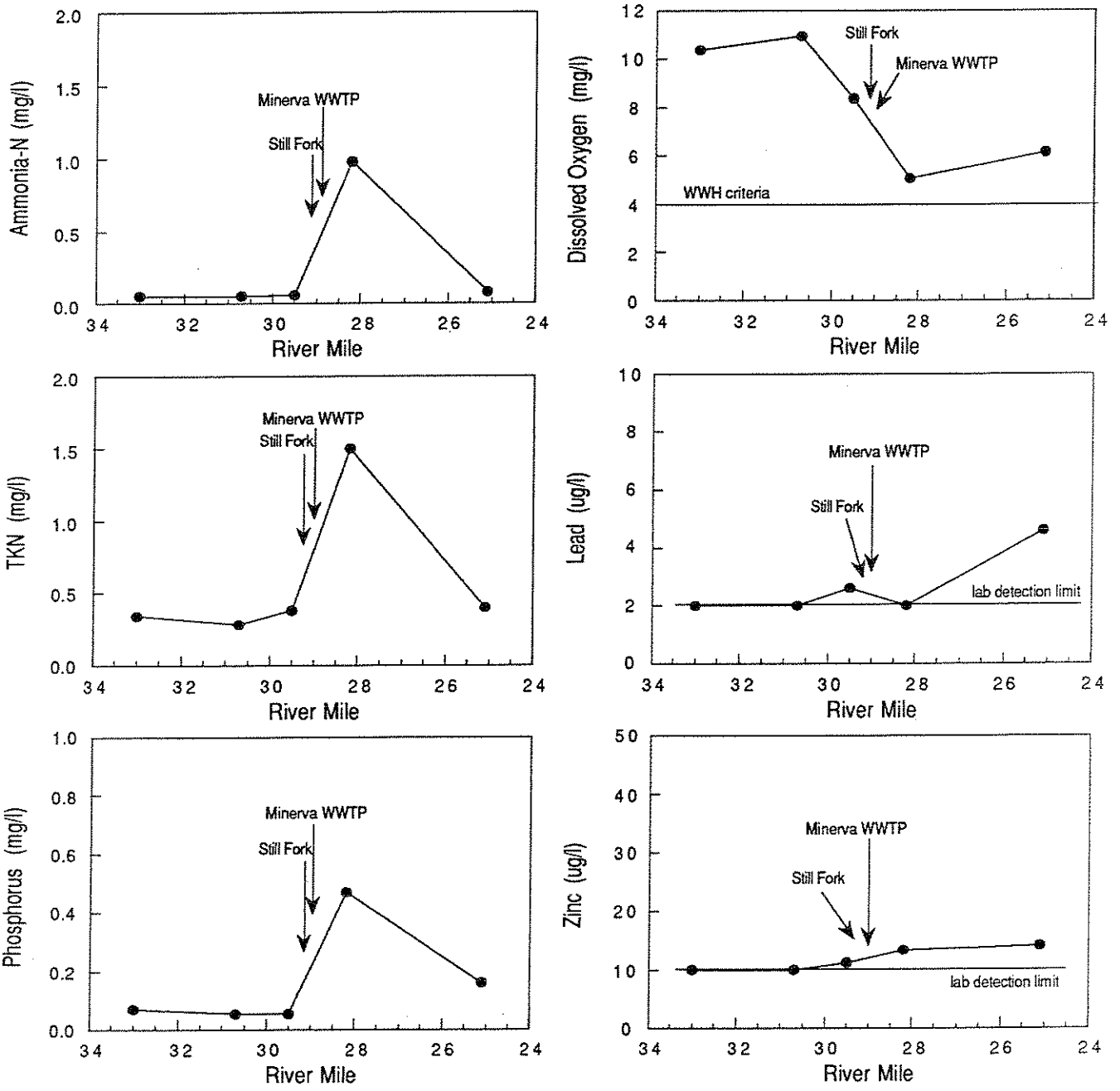

Figure 7. Longitudinal trend of mean ammonia-N, dissolved oxygen, TKN (ammonia plus organic nitrogen), lead, phosphorus, and zinc concentrations in Sandy Creek, 1993.

Sediment Chemistry

- Sediment metals were collected at each of the seven chemical sampling locations in Sandy Creek and Still Fork Sandy Creek (Table 8). Concentrations were evaluated using the classification system of Kelly and Hite (1984); this system addresses relative concentrations but does not directly assess biological toxicity. Sediment organics (PCBs only) were collected at RMs 33.0 and 30.7, upstream and immediately downstream from the PCC Airfoil facility.

Metals

- Extremely elevated levels of arsenic found in Sandy Creek upstream from Minerva at RM 33.0. Potential sources include natural background levels from surrounding geological features, coal mining, and possible historical herbicide/pesticide use. Chromium, lead, iron and zinc levels were also elevated at RM 33.0. Since there are no known point source discharges in this section, resource extraction was considered the most likely source.

- In Still Fork Sandy Creek, levels of chromium, iron and zinc were elevated at RM 5.7 and highly elevated at RM 0.5, immediately downstream from the Masco Tech discharge. Lead levels were also highly elevated within the dam impoundment at RM 0.5.

- Highly elevated levels of iron and zinc were found at RM 28.2 in Sandy Creek downstream from both the Minerva WWTP and the confluence of Still Fork Sandy Creek.

Organics

- No PCBs or pesticides were detected in two samples collected upstream and downstream from the PCC Airfoil facility.

Table 8. Concentrations of heavy metals in sediments in the Sandy Creek study area collected on September 21, 1993. All parameter concentrations were ranked based on a stream sediment classification system described by Kelly and Hite (1984). All values are in milligram per kilogram (mg/kg).

River Mile	As	Cd	Cr	Cu	Fe	Pb	Ni	Zn
Sandy Creek								
33.0	**28.7[e]**	0.55[b]	26.8[c]	18.3[a]	28,800[c]	40.8[c]	37.1	163[c]
> PCC Airfoil								
30.7	16.1[c]	0.44[a]	20.5[b]	17.2[a]	31,100[c]	50.1[c]	52.3	121[c]
29.5	8.4[b]	0.35[a]	10.2[a]	6.8[a]	19,900[b]	27.6[a]	16.0	81[b]
> Still Fork Sandy Creek								
> Minerva WWTP								
28.2	7.1[a]	1.20[c]	18.4[b]	29.8[a]	**32,300[d]**	50.2[c]	42.4	**215[d]**
25.1	5.1[a]	0.13[a]	3.7[a]	6.2[a]	16,600[a]	18.7[a]	9.7	55[a]
Still Fork Sandy Creek								
5.7	6.8[a]	0.415[a]	28.7[c]	15.1[a]	31,300[c]	32.8[b]	35.6	109[c]
0.5	16.4[c]	0.94[b]	**49.3[d]**	37.6[a]	**35,600[d]**	**68.8[d]**	44.1	**227[d]**

[a]Non-elevated; [b]Slightly elevated; [c]Elevated; [d]**Highly elevated**; [e]**Extremely elevated**

> Denotes the entry of significant point source discharges or tributaries between stations.

Note: The Kelly and Hite classification system addresses relative concentrations but does not directly assess toxicity.

Fish Tissue

Fish tissue samples were collected from Sandy Creek at two fish community sampling stations during 1993. Whole body composite samples of common white suckers were collected from RM 33.0, (upstream from Minerva) and at RM 30.7, immediately downstream from the PCC Airfoil discharge at RM 30.8. Samples were analyzed for mercury, cadmium, lead, priority pollutant pesticides (residues and metabolites), and seven polychlorinated biphenyl (PCB) mixtures (Table 9). Contaminant levels in whole body samples are expected to be higher than in comparable, fillet-only or skin-on fillets since they include the entire fish body and internal organs. These inedible portions of the fish often have a high fat content that tends to concentrate organics. Therefore, whole body results are primarily used as a screening tool to initially detect the presence or absence of contaminants.

Mercury, cadmium and lead were found above detection limits at each site. However, concentrations of mercury were well below the U.S. Food and Drug Administration (USFDA) action limit of one (1) mg/kg (mercury is the only metal in fish tissue currently rated for consumption by USFDA). Most pesticide residues and metabolites were absent or below detection limits at each site. However, the number of detected pesticide compounds did increase from two at RM 33.0 to seven at RM 30.7. All concentrations of pesticide compound currently rated by USFDA (dieldrin, mirex and DDT metabolites) were well below USFDA action levels. Detectable concentrations of PCB mixtures (PCB 1254 and 1260) were highest downstream from the PCC Airfoil discharge. However, these values were also well below the 2 mg/k USFDA action limit for PCBs. Despite the low levels of contamination, sampling results did show that bioaccumulation of organics has occurred in Sandy Creek fish communities and concentrations tended to increase downstream from PCC Airfoil.

Table 9. Summary of contaminant levels in fish tissue samples collected from Sandy Creek upstream from the Village of Minerva (RM 33.0) and downstream from PCC Airfoil (RM 30.7) during 1993. All results are reported in mg/kg (NA - not analyzed, ND - below detection levels).

Stream Parameter	RM 33.0 5-white sucker (whole body)	RM 30.7 4-white sucker (whole body)
Sandy Creek		
Mercury	0.03620	0.03520
Cadmium	< 0.00586	0.00611
Lead	< 0.05860	< 0.06110
Aldrin	ND	ND
a-BHC	ND	ND
b-BHC	ND	ND
d-BHC	ND	ND
y-BHC	ND	ND
4,4'-DDD	0.00265	0.00640
4,4'-DDE	0.00740	0.01545
4,4'-DDT	ND	0.00969
Dieldrin	ND	0.00340
Endosulfane I	ND	ND
Endosulfane II	ND	ND
Endosulfane Sulfate	ND	ND
Endrin	ND	ND
Endrin Aldehyde	ND	0.00350
Heptachlor	ND	ND
Heptachlor Epoxide	ND	ND
Methoxychlor	ND	0.00280
Mirex	ND	0.01806
Hexachlorobenzene	ND	ND
Chlordane	ND	ND
Toxaphene	NA	NA
PCB-1016	ND	ND
PCB-1221	ND	ND
PCB-1232	ND	ND
PCB-1242	ND	ND
PCB-1248	ND	ND
PCB-1254	ND	0.37930
PCB-1260	0.02672	0.05653

Physical Habitat for Aquatic Life

- Sandy Creek within the study area (RMs 33.1-25.2) consisted of predominantly natural habitats including pool, run and riffle areas. Cobble, gravel, and sands were the predominant substrate types with lesser amounts of silt, boulders, and artificial riprap. Qualitative Habitat Evaluation Index (QHEI) scores for Sandy Creek ranged from 66.5 at RM 33.1 (Sandy Creek Rd.) to 83.0 at RM 28.2 (next to Summitville Tile Co.) with a mean QHEI value of 75.2 (Table 10). A mean QHEI score greater than 60.0 suggests habitat conditions are of sufficient quality to support and maintain a community of aquatic organisms consistent with the WWH aquatic life use designation (Rankin 1989). In all but one sampling location (RM 30.3), WWH attributes outnumbered Modified Warmwater (MWH) attributes; no high influence MWH attributes were observed. Moderate to extensive substrate embeddedness in pool and riffle areas was considered the only potentially limiting aspect of physical habitat.

- Still Fork Sandy Creek habitat conditions were evaluated at two locations (RMs 5.7 and 0.5). Habitats at both sampling locations had undergone modification. Station RM 0.5 was impounded by a low-head dam and RM 5.7 was historically channelized. Siltation was extensive at RM 5.7 and the channel immediately upstream was severely degraded by unrestricted livestock access. QHEI scores of 29.5 and 40.0 were recorded at RMs 5.7 and 0.5, respectively, and reflected the poor habitat conditions. Both sites were predominated by silt substrates, riffles were absent, and channel development was considered poor. The total number of MWH attributes was considerably higher than the total WWH attributes at both locations. Still Fork Sandy Creek is not under a ditch maintenance schedule.

Table 10. Qualitative Habitat Evaluation Index (QHEI) matrix showing Modified Warmwater (MWH) and Warmwater habitat (WWH) characteristics for the Sandy Creek study area, August - October 1993.

Key QHEI Components

River Mile	QHEI	Gradient (ft/mile)	WWH Attributes: No Channelization or Recovered	Boulder/Cobble/Gravel Substrates	Silt Free Substrates	Good/Excellent Development	Moderate/High Sinuosity	Extensive/Moderate Cover	Fast Current/ Eddies	Low/Normal Embeddedness	Max Depth > 40 cm	Low/No Riffle Embeddedness	Total WWH Attributes	MWH Attributes, High Influence: Channelized or No Recovery	Silt/Muck Substrates	Low Sinuosity	Sparse/No Cover	Max Depth < 40 cm (WD,HW)	Total H.I. MWH Attributes	MWH Attributes, Moderate Influence: Recovering Channel	Heavy/Moderate Silt Cover	Sand Substrates (Boat)	Hardpan Substrate Origin	Fair/Poor Development	Low/No Sinuosity	Only 1-2 Cover Types	Intermittent & Poor Pools	No Fast Current	High/Moderate Embeddedness	Ext./Moderate Riffle Embed.	No Riffle	Total M.I. MWH Attributes	MWH H.I./WWH Ratio	MWH M.I./WWH Ratio
(17-450) – Sandy Creek																																		
Year: 93																																		
33.1	66.5	6.9	■	■		■	■	■	■		■		7						0		▲			▲				▲	▲	▲		5	.13	.75
30.3	70.5	8.3		■		■		■		■	■		6						0	▲				▲	▲			▲		▲		5	.14	.86
29.4	77.0	9.0	■	■		■	■	■	■		■		7						0		▲			▲				▲	▲	▲		5	.13	.75
28.2	83.0	9.0	■	■		■	■	■	■		■		7						0		▲			▲					▲	▲		4	.13	.63
25.2	78.5	7.6	■	■		■	■	■	■	■	■		9						0						▲					▲		2	.10	.30
(17-470) – Still Fork Sandy Creek																																		
Year: 93																																		
5.7	29.5	1.4					■				■		2	●	●		●		3		▲			▲	▲			▲	▲		▲	6	1.33	3.33
.5	40.0	.1	■					■			■		3		●				1		▲			▲	▲			▲	▲		▲	6	.50	2.00

Biological Assessment: Macroinvertebrate Community

Sandy Creek

- Artificial substrate samples were collected at five Sandy Creek stations from RMs 33.1 to 25.1 (Table 11; Figure 8). Narrative evaluations ranged from exceptional at RM 33.1 (ICI = 50) to poor at RM 28.3 (ICI = 10). All other Sandy Creek stations were in the good range and met or exceeded the WWH criterion. Lists of macroinvertebrate taxa and ICI metric scores from each site in the upper Sandy Creek study area can be found in Appendix Tables 4 and 5.

- ICI scores declined from the exceptional range at RM 33.1 (ICI=50) upstream from Minerva to the lower good range at RM 30.4 (ICI=34) downstream from the PCC Airfoil discharge. Changes in the community were characterized by increases in the predominance of some nutrient and toxic tolerant taxa and sharp reductions in the predominance of caddisflies, particularly the purse-net caddisfly genus *Hydroptila*. This caddisfly numbered over 1,000 individuals per square foot upstream from Minerva but was absent at RM 30.4 and additional sites downstream. The absence of this taxon was unusual given that other pollution sensitive mayflies and caddisflies continued to be well represented on the artificial substrates (nine taxa) and natural substrates (12 taxa). Occasional patches of odiferous sediment with both septic and organic (chemical) odors were noted at RM 30.4 in slack water areas, suggesting a potential source of impact. However, the drop in the ICI may have also been related to other, unknown factors. These may include temperature variability downstream from the treated groundwater discharge or compositional changes in the algal community, a primary food source of *Hydroptila* larvae (Wiggins 1984). Despite the changes in the macroinvertebrate community, collections from RM 30.4 remained quite diverse. Impacts downstream from the PCC Airfoil discharge were not considered severe.

- Station RM 29.6 was located immediately upstream from the Minerva WWTP and the confluence with Still Fork Sandy Creek. The ICI of 36 was in the good range and similar to collections upstream at RM 30.4. While occasional patches of septic sediments were still observed, communities remained quite diverse and included good numbers of pollution sensitive varieties.

- Downstream from the Minerva WWTP macroinvertebrate sampling at RM 28.3 showed severe impacts from organic wastes. The stream had a strong odor of ammonia and sewage and the stream bottom was covered with a layer of sewage solids. The ICI of 10 was in the poor range with seven of the ten ICI metrics receiving a zero on the 0-6 scoring scale. Pollution tolerant taxa accounted for over 50% of the organisms on the artificial substrates. Conversely, pollution sensitive mayflies, caddisflies and tanytarsini midges in both artificial and natural substrate samples were virtually eliminated (Figure 8).

- Macroinvertebrates improved to the good range (ICI=40) at RM 25.1, an additional 3.2 miles downstream. Community densities increased sharply to 8,740 organisms per square foot on the artificial substrates (Figure 8). A single group of tanytarsini midges, *Rheotanytarsus exiguus* group, accounted for over 78% of the total organisms. This midge is considered quite sensitive to toxic impacts but is often prolific in areas of strong current and high levels of suspended solids (Simpson & Bode 1981). On the natural substrates, mayfly, stonefly, and caddisfly (EPT) taxa increased to nine but did not equal the EPT diversity collected upstream from Minerva and the Minerva WWTP. While substantial improvement was noted at RM 25.1, the macroinvertebrates suggested enriched conditions and recovery was considered incomplete.

Still Fork Sandy Creek

- Still Fork Sandy Creek communities were affected by degraded habitat conditions and unrestricted livestock access at RM 5.7. The ICI of 30 was in the fair range with low numbers of mayflies and caddisflies collected from both artificial and natural substrates. The natural substrates at RM 5.7 were almost entirely composed of soft muck and silt. Stream banks were denuded and collapsing and large amounts of manure were observed along the banks and stream margins.

- Station RM 0.5 was located within a low-head dam impoundment built near the mouth of Still Fork Sandy Creek. Artificial substrates were retrieved from an area with no noticeable current and natural substrates were primarily thick deposits of soft muck. The ICI of 18 was well below ecoregional expectations for warmwater habitats but, currently, macroinvertebrate criteria have not been developed to specifically evaluate impoundments. The macroinvertebrate community was considered fair based primarily on the predominance of pollution and silt tolerant taxa and the low number of EPT taxa (three) from the natural substrates. The Masco Tech discharge was located immediately upstream from the site but any potential impacts associated with the discharge could not be separated from the impoundment influences.

Table 11. Summary of macroinvertebrate data collected from artificial substrates (quantitative sampling) and natural substrates (qualitative sampling) in the Sandy Creek study area, July -September 1993.

Stream River Mile	Relative Density	Quant. Taxa	Qual. Taxa	Qual. EPT[a]	ICI	Narrative Evaluation
			Quantitative Evaluation			
			Erie-Ontario Lake Plain - WWH Use designation (Existing)			
Sandy Creek						
33.1	1943	49	61	13	50	Exceptional
30.4	749	40	54	12	34	Good
29.6	568	41	60	13	36	Good
28.3	2275	26	34	1	10*	Poor
25.1	8740	32	54	9	40	Good
			Western Allegheny Plateau - WWH Use designation (Existing)			
Still Fork Sandy Creek						
5.7	576	46	48	5	30*	Fair
0.5 (impounded)	454	28	30	3	18*	Fair

Ecoregion Biocriteria: Erie Ontario Lake Plain -(EOLP)

INDEX	WWH	EWH	MWH[b]
ICI	34	48	22

Ecoregion Biocriteria: Western Allegheny Plateau -(WAP)

INDEX	WWH	EWH	MWH[b]
ICI	36	48	22

* Significant departure from ecoregional biocriteria (>4 ICI units); poor and very poor results are underlined.

a EPT= total Ephemeroptera (mayflies), Plectoptera (stoneflies) and Tricoptera (caddisflies).

b Modified Warmwater Habitat for channel modified areas.

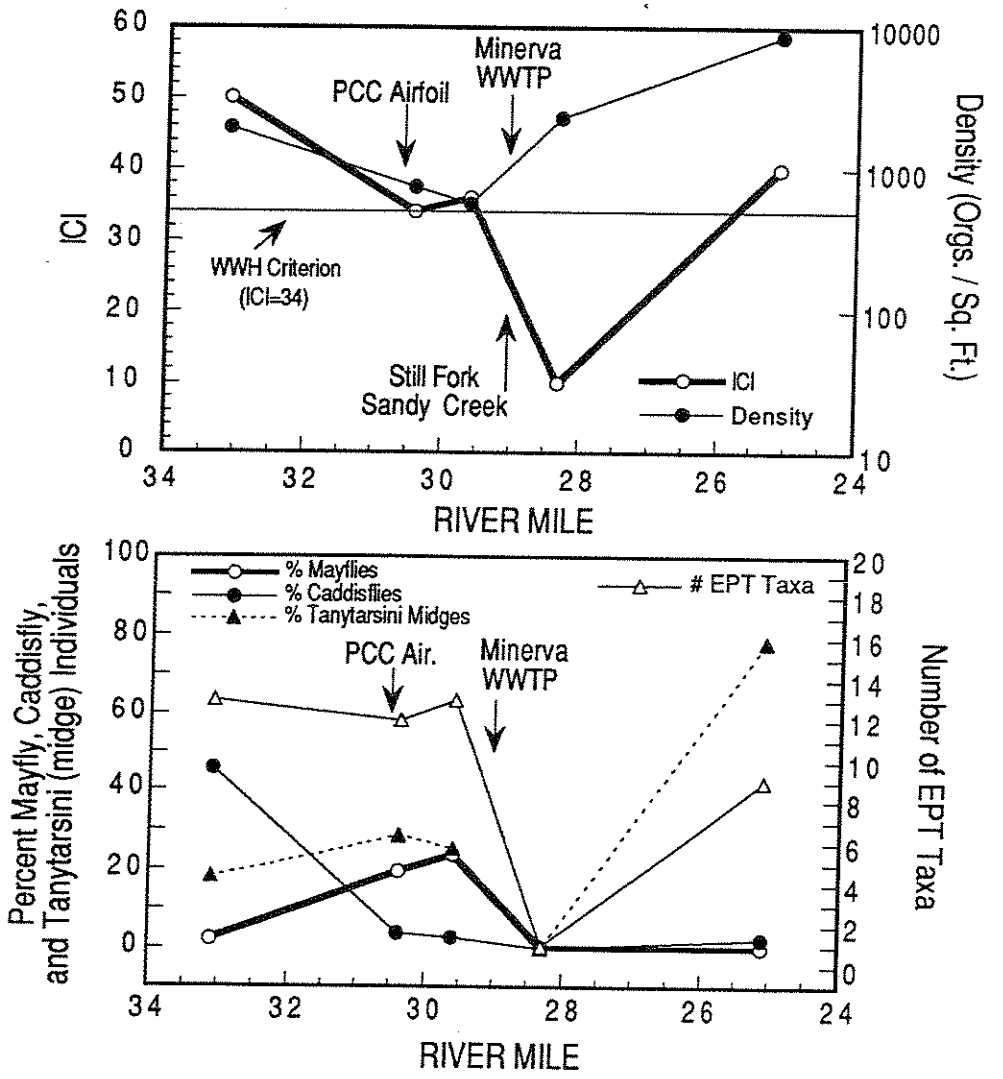

Figure 8. Longitudinal trend of the Invertebrate Community Index (ICI) and organism density [upper plot]; percentages of mayflies, caddisflies, tanytarsini midges and Qualitative EPT taxa richness (i.e., the number of mayfly, caddisfly and stonefly taxa from the natural substrates) [lower plot] at macroinvertebrate sampling stations in Sandy Creek, 1993.

Biological Assessment: Fish Community

A total of 6,648 fish representing 37 species and two hybrids was collected from Sandy Creek and a total of 1,014 fish consisting of 22 species and one hybrid was collected from Still Fork Sandy Creek between August and October 1993. The sampling effort included a cumulative electrofished distance of 3.54 km at seven locations (Table 12, Figure 9). Lists of relative numbers, species collected per location and IBI metric scores are presented in Appendix Tables 2 and 3.

Sandy Creek

- The upstream sampling site at RM 33.1 yielded a fish community in the good range with an IBI of 44 and a MIwb of 7.6 (Table 12, Figure 9). Both index scores exceeded the WWH criterion. Pollution sensitive fish species collected at RM 33.1 included hornyhead chub, bigeye chub, rosyface shiner and mimic shiner.

- Sampling downstream (RM 30.3) from the PCC Airfoil groundwater treatment discharge revealed a fish community in the very good to exceptional range with IBI and MIwb scores of 46 and 9.5, respectively. Pollution sensitive species such as river chub, hornyhead chub, rosyface shiner and banded darter were abundant. The fish community fully achieved the WWH biocriteria.

- Fish were sampled at RM 29.4 immediately upstream from the Minerva WWTP. The community was diverse (28 species) and functionally well organized. Both the MIwb and IBI scores (8.4 and 39, respectively) achieved the WWH biocriteria.

- The fish community at RM 28.2 was located 0.8 miles downstream from the Minerva WWTP and exhibited substantial biological degradation. The IBI (23) and MIwb (5.5) scores reflected poor community condition and violated the WWH biocriteria. Pollution tolerant species predominated (75%, numerically) along with a complete absence of pollution intolerant fishes. Conversely, six intolerant species were collected at upstream sampling locations.

- A fish kill occurred at RM 28.2 on August 27, 1993 with at least 100 dead fish reported by Ohio EPA personnel. However, this is likely a low estimate since the Aug. 27 investigation was cursory and only included the 200 meter fish sampling reach. It was likely that the kill extended upstream and downstream. Large amounts of black sludge were observed in pooled areas and strong septic odors were detected. Within the area of the fish kill, living fish were observed to be lethargic and maintained a position near the water surface, a characteristic of D.O. stress. These conditions along with the degraded fish community suggest that organic enrichment and dissolved oxygen deficits resulted in biological impairment.

- Darters and sculpins (moderately intolerant species) were also absent from Sandy Creek at RM 28.2 (Figure 9). In contrast, these species were found at all other sampling locations with relative abundance (No./0.3 km) ranging from 22-177 per site.

- The fish community reflected some improvement at RM 25.2, 3.8 miles downstream from the Minerva WWTP. The IBI (33) and MIwb (7.0) scores reflected fair quality. Fish community index scores were below ecoregional expectations but recovery appeared well underway.

- The physical condition of fish in Sandy Creek and Still Fork Sandy Creek was monitored at each fish sampling site by recording the incidence of gross deformities, fin erosion, lesions/ulcers and tumors (DELT) external anomalies. Biosurvey results collected by Ohio EPA

from throughout Ohio show that a high frequency of DELT anomalies is a consistent indicator of pollution stress. Anomalies are usually caused by multiple sublethal stresses as the result of degraded water and sediment quality (*i.e.*, often a combination of toxic impacts combined with marginal D.O. concentrations). The highest percent occurrence of DELT anomalies (15.7%) was recorded at RM 28.2, located 0.8 miles downstream from the Minerva WWTP. DELT anomalies at other sampling sites ranged from between 0.25% and 1.5%. The high percentage of anomalies downstream from the Minerva WWTP clearly reflected pollutional stress on the fish community.

- DELT anomalies at RM 28.3 included a high incidence of internal, skeletal deformities (8.3 % of total fish). In contrast, skeletal deformities averaged 0.9% in Sandy Creek upstream from the Minerva WWTP and were not detected in Still Fork Sandy Creek downstream from Masco Tech at RM 0.5. Several studies have suggested a correlation between elevated skeletal deformities and increased heavy metals contamination (Bengtsson 1974, Bengtsson et. al. 1975, Reash and Berra, 1989). Pesticides were considered a probable source of skeletal deformities in crappies in an Illinois lake (Baumann and Hamilton 1984). The high percentage of both external anomalies and internal skeletal deformities downstream from the Minerva WWTP suggests an additional source of stress on the fish community. However, since most deformities were observed in mature fish, these anomalies may have been an artifact of past water quality problems.

Still Fork Sandy Creek

- Fish communities in Still Fork Sandy Creek were influenced by poor instream habitat conditions. The IBI and MIwb scores reflected fair to marginally good conditions at RMs 5.7 and 0.5, respectively. The impounded conditions at RM 0.5 contributed to the low number of sucker species observed. Sampling results from RM 5.7 revealed an absence of species sensitive to habitat modification and chemical pollution. This site had been historically channelized and was located immediately downstream from an open livestock pasture. Overall, fish community indices for Still Fork Sandy Creek did not achieve the WWH biocriteria at RM 5.7 but partially achieved them at RM 0.5.

Table 12. Fish community indices based on pulsed D.C. electrofishing samples at seven locations sampled by Ohio EPA in the Sandy Creek study area from August to October 1993. Sites were sampled using boat or wading methods. Relative number and weight are per 1.0 km for boat sites and 0.3 km for wading sites.

Stream River Mile	Mean Number of Species	Mean Cumulative Species	Mean Rel. No.	Mean Rel. Wt.	QHEI	Modified Index of Well-Being	Index of Biotic Integrity	Evaluation[a]
Erie-Ontario Lake Plain - WWH Use Designation (Existing)								
Sandy Creek								
33.1[w]	23.0	28	1463	26.93	66.5	7.6[ns]	44	Good
30.3[w]	22.0	25	1516	54.37	70.5	9.5	46	V.G.-Exceptional
29.4[w]	23.5	28	938	46.08	77.0	8.4	39	Good
28.2[w]	13.0	15	494	52.90	83.0	5.5*	23*	Poor
25.2[w]	20.5	22	385	28.55	78.5	7.0*	33*	Fair
Western Allegheny Plateau - WWH Use Designation (Existing)								
Still Fork Sandy Creek								
5.7[w]	17.0	20	297	24.55	29.5	7.1*	37*	Fair
0.5[b]	12.5	13	618	46.56	40.0	7.9*	39[ns]	Fair-Marg. Good

Ecoregion Biocriteria: Erie-Ontario Lake Plain (EOLP)

INDEX - Site Type	WWH	EWH	MWH[c]
IBI - Wading	38	50	24
Mod. Iwb - Wading	7.9	9.4	6.2

Ecoregion Biocriteria: Western Allegheney Plateau (WAP)

INDEX - Site Type	WWH	EWH	MWH[c]
IBI - Wading	44	50	24
Mod. Iwb - Wading	8.4	9.4	6.2
IBI - Boat	40	48	24/30
Mod. Iwb - Boat	8.6	9.6	5.8/6.6

* Significant departure from applicable biological criterion (>4 IBI units or >0.5 Iwb units); underlined values are in the poor and very poor range.
ns Nonsignificant departure from biocriterion (≤4 IBI units or ≤ 0.5 MIwb units)
a Narrative evaluation is based on both MIwb and IBI scores.
b Boat sampling method.
c Modified Warmwater Habitat for channel modified areas and / impounded habitats.
w Wading sampling method.

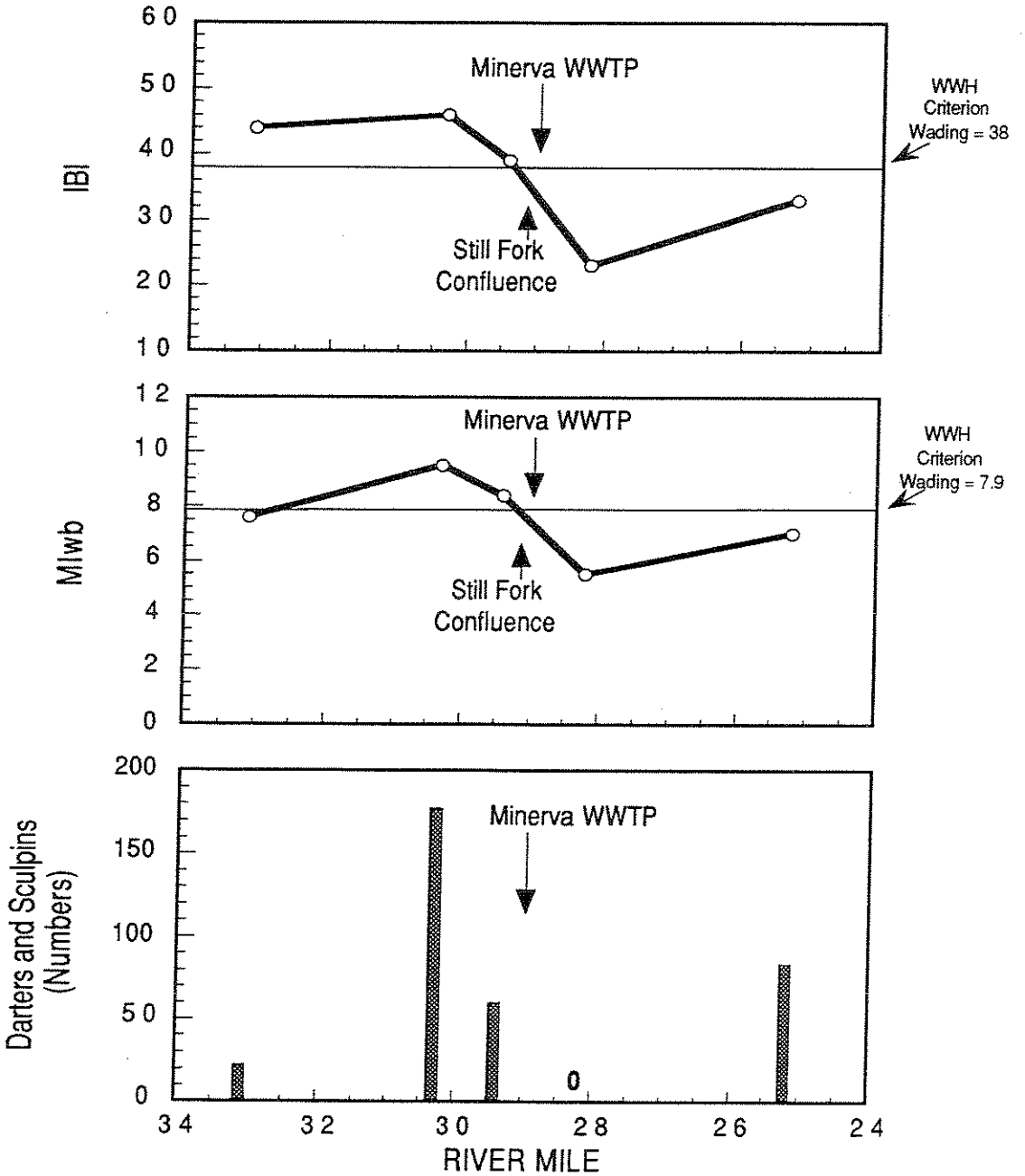

Figure 9. Longitudinal trend of the Index of Biotic Integrity (IBI), Modified Index of Well-Being, and relative abundance (No./0.3 km) of darters and sculpins (moderately sensitive to pollution) at stations in the Sandy Creek study area, 1993.

Area of Degradation (ADV) Statistics

- Area of Degradation Values (ADV) for the 1993 sampling effort provides a measure of the degradation portrayed by the IBI, MIwb, and ICI from ecoregional expectations for the Sandy Creek study area (Table 13). This information will provide the basis for future trend analysis of Sandy Creek in the Minerva area.

- The elevated ADV/mile for each index from Sandy Creek was mostly associated with point source impacts from the Minerva WWTP. In particular, the recording of poor/ very poor ADVs corresponded with the poor fish and macroinvertebrate communities found downstream from the WWTP.

- Slightly elevated ADVs/ mile for Still Fork Sandy Creek did not suggest severe biological degradation (biological index scores did not fall below the fair range). ADVs primarily reflected habitat alteration associated with the low-head dam impoundment, channelization and NPS influences from unrestricted livestock access.

Table 13. Area of Degradation (ADV) statistics for the Sandy Creek study area, 1993 (calculated using ecoregional criteria as the background community performance).

	Biological Index Scores				ADV Statistics			Attainment Status (miles)			
Stream Index	Upper RM	Lower RM	Mini mum	Maxi mum	ADV	**ADV/ Mile**	Poor/VP ADV	FULL	PARTIAL	**NON**	Poor/VP
Sandy Creek											
IBI			23	46	227	**28.4**	30.0				
MIwb	33.1	25.1	5.5	9.5	215	**26.9**	0.1	3.9	1.5	**2.7**	1.7
ICI			10	50	313	**39.1**	3.0				
Still Fork Sandy Creek											
IBI			37	39	104	**20.0**	0.0				
MIwb	5.7	0.5	7.1	7.9	105	**20.2**	0.0	0.0	0.4	**4.9**	0.0
ICI*			30	30	12	**2.3**	0.0				

* macroinvertebrate data from dam pool site was excluded from analysis.

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Appendix Tables

Appendix Table 1. Chemical/physical sampling results from the Sandy Creek study area during July-September 1993.

	River Mile	Date	Arsenic	Cadmium	Calcium	Chromium	Copper	Lead	Magnisium
0	Sandy Creek	7/1/1993	2.00	0.200	53	30.0	10.0	2.0	12.0
1	@ Bayard	7/21/1993	2.00	0.200	60	30.0	10.0	2.0	14.0
2	RM 33.0	7/26/1993	2.00		55	30.0	10.0	2.0	13.0
3		8/5/1993	2.00	0.200	62	30.0	10.0	2.0	14.0
4		8/23/1993	2.00	0.200	56	30.0	10.0	2.0	14.0
5	Sandy Cr. @	7/1/1993	2.00	0.200	60	30.0	10.0	2.0	13.0
6	Minerva Park	7/21/1993	2.00	0.200	65	30.0	10.0	2.0	14.0
7	RM 30.7	7/26/1993	2.00		60	30.0	10.0	2.0	13.0
8		8/5/1993	2.00	0.200	68	30.0	10.0	2.0	14.0
9		8/23/1993	2.00	0.200	56	30.0	10.0	2.0	14.0
10	Sandy Creek	7/1/1993	2.00	0.200	62	30.0	10.0	4.0	14.0
11	@ RR	7/21/1993	2.00	0.0200	65	30.0	10.0	3.0	14.0
12	RM 29.5	7/26/1993	2.00		66	30.0	10.0	2.0	14.0
13		8/5/1993	2.00	0.200	72	30.0	10.0	2.0	15.0
14		8/23/1993	2.00	0.200	67	30.0	10.0	2.0	16.0
15	Sandy Creek	7/1/1993	2.00	0.200	44	30.0	10.0	2.0	11.0
16	@ Pekin	7/21/1993	2.00	0.200	49	30.0	10.0	2.0	12.0
17	RM 28.2	7/26/1993	2.00		53	30.0	10.0	2.0	12.0
18		8/5/1993	2.00	0.200	56	30.0	10.0	2.0	13.0
19		8/23/1993	2.00	0.200	55	30.0	10.0	2.0	13.0
20	Sandy Creek	7/1/1993	2.00	0.200	54	30.0	10.0	2.0	13.0
21	@ Blade Rd.	7/21/1993	2.00	0.200	56	30.0	10.0	2.0	13.0
22	RM 25.1	7/26/1993	2.00		63	30.0	10.0	2.0	14.0
23		8/5/1993	2.00	0.200	66	30.0	10.0	15	14.0
24		8/23/1993	2.00	0.200	66	30.0	10.0	2.0	15.0
25	Still Fork	7/1/1993	2.00	0.200	21	30.0	10.0	2.0	8.00
26	@ Arrow Rd.	7/21/1993	3.00	0.200	26	30.0	10.0	2.0	10.0
27	RM 0.5	7/26/1993	3.00		25	30.0	10.0	2.0	9.00
28		8/5/1993	3.00	0.0200	29	30.0	10.0	2.0	10.0
29		8/23/1993	2.00	0.200	30	30.0	10.0	2.0	10.0
30	Still Fork	7/1/1993	2.00	0.200	21	30.0	10.0	2.0	8.00
31	@ TWP RD 246	7/21/1993	2.00	0.200	23	30.0	10.0	2.0	9.00
32	RM 5.7	7/26/1993	3.00		24	30.0	10.0	2.0	9.00
33		8/5/1993	3.00	0.200	27	30.0	10.0	3.0	10.0
34		8/23/1993	2.00	0.200	25	30.0	10.0	2.0	10.0

Appendix Table 1. (continued).

	Site	Date	Nickel	Zinc	Hardness
0	Sandy Creek	7/1/1993	40.0	10.0	182
1	@ Bayard	7/21/1993	40.0	10.0	207
2	RM 33.0	7/26/1993	40.0	10.0	191
3		8/5/1993	40.0	10.0	212
4		8/23/1993	40.0	10.0	197
5	Sandy Cr. @	7/1/1993	40.0	10.0	203
6	Minerva Park	7/21/1993	40.0	10.0	220
7	RM 30.7	7/26/1993	40.0	10.0	203
8		8/5/1993	40.0	10.0	227
9		8/23/1993	40.0	10.0	187
10	Sandy Creek	7/1/1993	40.0	10.0	212
11	@ RR	7/21/1993	40.0	16.0	220
12	RM 29.5	7/26/1993	40.0	10.0	222
13		8/5/1993	40.0	10.0	242
14		8/23/1993	40.0	10.0	233
15	Sandy Creek	7/1/1993	40.0	10.0	155
16	@ Pekin	7/21/1993	40.0	10.0	172
17	RM 28.2	7/26/1993	40.0	18.0	182
18		8/5/1993	40.0	10.0	193
19		8/23/1993	40.0	19.0	191
20	Sandy Creek	7/1/1993	40.0	10.0	188
21	@ Blade Rd.	7/21/1993	40.0	10.0	193
22	RM 25.1	7/26/1993	40.0	31.0	215
23		8/5/1993	40.0	10.0	222
24		8/23/1993	40.0	10.0	227
25	Still Fork	7/1/1993	40.0	14.0	85.0
26	@ Arrow Rd.	7/21/1993	40.0	10.0	106
27	RM 0.5	7/26/1993	40.0	10.0	99.0
28		8/5/1993	40.0	38.0	114
29		8/23/1993	40.0	22.0	116
30	Still Fork	7/1/1993	40.0	10.0	85.0
31	@ TWP RD 246	7/21/1993	40.0	10.0	94.0
32	RM 5.7	7/26/1993	40.0	12.0	97.0
33		8/5/1993	40.0	10.0	109
34		8/23/1993	40.0	11.0	104

Appendix Table 1. (continued).

	site	date	time	cond	DO	pH	Temp	COD	Nitrate	Nitrite	NH3
0	Sandy Creek	7/1/1993	1130	415	13.2	8.5	19.0	15	1.16	0.0200	0.0500
1	@ Bayard	7/21/1993	1000	395	7.00	7.7	20.5	12	0.520	0.0200	0.0500
2	RM 33.0	7/26/1993	1115	462	9.40	7.8	26.0	10	0.390	0.0200	0.0500
3		8/5/1993	1130	385	10.4	8.4	20.0	10	0.520	0.0200	0.0500
4		8/23/1993	1155	495	10.8	8.2	21.7	17	0.270	0.0200	0.0500
5	Sandy Cr. @	7/1/1993	1110	290	11.0	8.4	17.0	11	0.970	0.0200	0.0500
6	Minerva Park	7/21/1993	1015	436	9.90	8.1	19.5	15	0.340	0.0200	0.0500
7	RM 30.7	7/26/1993	1130	504	11.1	8.1	21.5	10	0.210	0.0200	0.0500
8		8/5/1993	1120	420	11.0	8.4	19.2	10	0.330	0.0200	0.0500
9		8/23/1993	1245	490	11.8	8.0	21.5	17	0.560	0.0200	0.0500
10	Sandy Creek	7/1/1993	1045	480	9.50	8.0	17.8	16	0.940	0.0200	0.0500
11	@ RR	7/21/1993	1250	467	8.70	8.2	20.1	14	0.240	0.0200	0.0700
12	RM 29.5	7/26/1993	1055	510	7.80	7.6	21.0	10	0.210	0.0200	0.0500
13		8/5/1993	958.0	470	7.80	8.1	16.5	10	0.300	0.0200	0.0500
14		8/23/1993	1045	535	8.10	7.7	18.2	14	0.310	0.0200	0.0900
15	Sandy Creek	7/1/1993	955.0	420	6.20	7.6	18.5	16	1.03	0.0300	0.380
16	@ Pekin	7/21/1993	1211	469	6.20	7.7	22.0	16	0.400	0.0300	0.650
17	RM 28.2	7/26/1993	1010	510	8.00	7.2	21.0	26	0.250	0.0400	1.04
18		8/5/1993	920.0	490	3.60	7.7	18.0	11	0.230	0.0400	0.880
19		8/23/1993	1000	624	1.30	7.4	18.1	18	0.100	0.0300	1.98
20	Sandy Creek	7/1/1993	950.0	460	6.50	7.5	18.0	18	0.930	0.0600	0.100
21	@ Blade Rd.	7/21/1993	1150	457	6.80	7.3	21.0	13	0.530	0.0700	0.120
22	RM 25.1	7/26/1993	945.0	525	5.30	7.3	20.2	13	0.570	0.110	0.0800
23		8/5/1993	900.0	460	5.50	7.7	17.2	10	0.540	0.100	0.0800
24		8/23/1993	945.0	577	6.70	7.7	17.5	12	0.770	0.0800	0.0500
25	Still Fork	7/1/1993	1145	235	6.30	6.3	20.0	18	1.41	0.0400	0.0500
26	@ Arrow Rd.	7/21/1993	1045	311	8.40	7.8	24.0	13	0.530	0.0200	0.0700
27	RM 0.5	7/26/1993	1215	285	9.10	8.2	26.5	10	0.320	0.0200	0.0500
28		8/5/1993	1015	270	6.00	7.6	22.0	14	0.470	0.0500	0.110
29		8/23/1993	1105	340	6.40	7.4	22.4	14	0.330	0.0300	0.0700
30	Still Fork	7/1/1993	1215	185	6.50	6.7	19.0	19	0.990	0.0300	0.0600
31	@ TWP RD 246	7/21/1993	1110	228	5.40	7.0	22.0	18	0.480	0.0300	0.120
32	RM 5.7	7/26/1993	1250	260	5.80	7.2	24.0	14	0.380	0.0200	0.0500
33		8/5/1993	1040	220	5.00	7.6	19.0	12	0.300	0.0300	0.0800
34		8/23/1993	1125	295	8.20	7.2	21.0	18	0.140	0.0200	0.0600

Appendix Table 1. (continued).

	R	Q	TKN	Phos	TDS	TSS	sulfate
0	Sandy Creek	7/1/1993	0.20	0.0500	268	5.0	
1	@ Bayard	7/21/1993	0.60	0.0600	320	12	64.0
2	RM 33.0	7/26/1993	0.40	0.0500	288	23	52.0
3		8/5/1993	0.20	0.0800	288	17	58.0
4		8/23/1993	0.30	0.110	291	14	57.0
5	Sandy Cr. @	7/1/1993	0.30	0.0600	300	5.0	
6	Minerva Park	7/21/1993	0.30	0.0500	334	10	66.0
7	RM 30.7	7/26/1993	0.20	0.0500	312	7.0	60.0
8		8/5/1993	0.20	0.0600	308	5.0	70.0
9		8/23/1993	0.40	0.0500	296	7.0	63.0
10	Sandy Creek	7/1/1993	0.30	0.0500	310	5.0	
11	@ RR	7/21/1993	0.40	0.0600	336	27	66.0
12	RM 29.5	7/26/1993	0.40	0.0500	322	9.0	59.0
13		8/5/1993	0.40	0.0600	320	7.0	67.0
14		8/23/1993	0.40	0.0500	340	5.0	80.0
15	Sandy Creek	7/1/1993	0.70	0.820	270	5.0	
16	@ Pekin	7/21/1993	1.4	0.470	314	9.0	70.0
17	RM 28.2	7/26/1993	1.7	0.300	292	6.0	63.0
18		8/5/1993	1.5	0.300	346	8.0	92.0
19		8/23/1993	2.3	0.450	378	5.0	107
20	Sandy Creek	7/1/1993	0.40	0.150	304	5.0	
21	@ Blade Rd.	7/21/1993	0.40	0.140	344	5.0	76.0
22	RM 25.1	7/26/1993	0.50	0.160	330	5.0	75.0
23		8/5/1993	0.40	0.190	360	5.0	100
24		8/23/1993	0.30	0.160	386	5.0	103
25	Still Fork	7/1/1993	0.30	0.130	160	9.0	
26	@ Arrow Rd.	7/21/1993	0.50	0.0500	178	11	32.0
27	RM 0.5	7/26/1993	0.60	0.0500	152	5.0	30.0
28		8/5/1993	0.70	0.140	184	11	39.0
29		8/23/1993	0.50	0.120	174	9.0	41.0
30	Still Fork	7/1/1993	0.40	0.160	157	15	
31	@ TWP RD 246	7/21/1993	0.60	0.180	164	52	20.0
32	RM 5.7	7/26/1993	0.60	0.100	148	33	20.0
33		8/5/1993	0.50	0.0900	164	36	20.0
34		8/23/1993	0.30	0.0500	158	42	24.0

Appendix Table 2 Summary of relative numbers of fish and species collected at each sampling location (by river code and river mile) in the Sandy Creek Study area. Stream codes are as follows: Sandy Creek - 17450; Still Fork Sandy Creek - 17470. Note: The total relative number for Still Fork RM 0.5 was per 1.0 km; all other stations were numbers per 0.3 km.

Species	Stream Code:	17450	17450	17450	17450	17450
	Year:	93	93	93	93	93
	River Mile:	25.2	28.2	29.4	30.3	33.1
CENTRAL MUDMINNOW		-	-	-	-	0.8
GRASS PICKEREL		-	-	-	-	0.8
NORTHERN HOG SUCKER		18.6	1.5	92.8	132.8	3.8
WHITE SUCKER		74.4	237.0	136.4	156.0	99.0
SPOTTED SUCKER		-	-	-	-	-
COMMON CARP		6.0	3.8	15.7	-	1.5
GOLDEN SHINER		-	2.3	-	0.8	0.8
HORNYHEAD CHUB		1.8	-	2.7	74.3	19.5
RIVER CHUB		-	-	11.6	129.0	-
BIGEYE CHUB		-	-	-	-	2.3
BLACKNOSE DACE		9.0	-	-	-	-
CREEK CHUB		20.4	30.8	45.7	21.8	41.3
ROSYFACE SHINER		-	-	30.7	96.0	9.0
STRIPED SHINER		1.8	40.5	222.3	332.3	819.8
COMMON SHINER		-	6.0	1.4	18.0	10.5
SPOTFIN SHINER		-	-	-	0.8	-
SAND SHINER		-	-	0.7	12.0	26.3
MIMIC SHINER		-	-	-	-	6.0
SILVERJAW MINNOW		-	0.8	13.0	-	24.8
BLUNTNOSE MINNOW		22.2	22.5	38.9	36.8	325.5
CENTRAL STONEROLLER		101.4	30.8	171.2	244.5	6.8
COMMON SH X STR. SH.		-	3.8	8.9	18.0	-
YELLOW BULLHEAD		18.6	42.0	4.1	4.5	21.0
BROWN BULLHEAD		-	-	-	-	-
TROUT-PERCH		-	-	0.7	-	-
WHITE CRAPPIE		-	-	-	-	-
BLACK CRAPPIE		-	-	-	-	-
ROCK BASS		3.0	12.8	25.2	42.8	3.0
SMALLMOUTH BASS		-	-	2.7	4.5	0.8
LARGEMOUTH BASS		6.0	10.5	6.8	9.0	9.0
WARMOUTH SF		4.2	-	-	-	-
GREEN SUNFISH		3.0	46.5	45.0	4.5	3.0
BLUEGILL SUNFISH		10.2	2.3	0.7	0.8	6.8
REDEAR SUNFISH		0.6	-	-	0.8	-
PUMPKINSEED SUNFISH		-	-	0.7	-	-
GREEN SF X BLUEGILL		-	0.8	-	-	-
LOGPERCH		1.8	-	0.7	0.8	-
JOHNNY DARTER		9.0	-	0.7	-	3.0
GREENSIDE DARTER		6.0	-	30.7	67.5	10.5
BANDED DARTER		10.2	-	15.0	21.8	-
RAINBOW DARTER		6.6	-	5.5	21.0	6.8
FANTAIL DARTER		-	-	1.4	-	0.8
MOTTLED SCULPIN		49.8	-	6.1	66.0	0.8
Total Relative Number		384.6	494.2	937.7	1516.5	1463.2
Total Number of Species		22	15	28	25	28
Total Number of Hybrids		0	2	1	1	
Distance Sampled		.50	.40	.44	.40	.40
Number of Passes		2	2	2	2	2

Appendix Table 2 (continued).

Species	Stream Code:	17470	17470			
	Year:	93	93			
	River Mile:	.5	5.7			
CENTRAL MUDMINNOW		-	-	-	-	-
GRASS PICKEREL		2.0	18.0	-	-	-
NORTHERN HOG SUCKER		-	-	-	-	-
WHITE SUCKER		28.0	50.3	-	-	-
SPOTTED SUCKER		18.0	12.0	-	-	-
COMMON CARP		8.0	-	-	-	-
GOLDEN SHINER		36.0	60.0	-	-	-
HORNYHEAD CHUB		-	-	-	-	-
RIVER CHUB		-	-	-	-	-
BIGEYE CHUB		-	-	-	-	-
BLACKNOSE DACE		-	-	-	-	-
CREEK CHUB		-	-	-	-	-
ROSYFACE SHINER		-	-	-	-	-
STRIPED SHINER		-	0.8	-	-	-
COMMON SHINER		-	-	-	-	-
SPOTFIN SHINER		-	16.5	-	-	-
SAND SHINER		-	-	-	-	-
MIMIC SHINER		-	-	-	-	-
SILVERJAW MINNOW		-	-	-	-	-
BLUNTNOSE MINNOW		-	15.8	-	-	-
CENTRAL STONEROLLER		-	-	-	-	-
COMMON SH X STR. SH.		-	-	-	-	-
YELLOW BULLHEAD		2.0	23.3	-	-	-
BROWN BULLHEAD		-	1.5	-	-	-
TROUT-PERCH		-	2.3	-	-	-
WHITE CRAPPIE		18.0	7.5	-	-	-
BLACK CRAPPIE		11.0	-	-	-	-
ROCK BASS		-	2.3	-	-	-
SMALLMOUTH BASS		-	-	-	-	-
LARGEMOUTH BASS		57.0	18.8	-	-	-
WARMOUTH SF		27.0	2.3	-	-	-
GREEN SUNFISH		27.0	3.8	-	-	-
BLUEGILL SUNFISH		320.0	49.5	-	-	-
REDEAR SUNFISH		-	-	-	-	-
PUMPKINSEED SUNFISH		62.0	7.5	-	-	-
GREEN SF X BLUEGILL		2.0	-	-	-	-
LOGPERCH		-	-	-	-	-
JOHNNY DARTER		-	3.0	-	-	-
GREENSIDE DARTER		-	1.5	-	-	-
BANDED DARTER		-	-	-	-	-
RAINBOW DARTER		-	-	-	-	-
FANTAIL DARTER		-	0.8	-	-	-
MOTTLED SCULPIN		-	-	-	-	-
Total Relative Number		618.0	297.0			
Total Number of Species		13	20			
Total Number of Hybrids		1				
Distance Sampled		1.00	.40			
Number of Passes		2	2			

Appendix Table 3. Index of Biotic Integrity (IBI) and Modified Index of Well-Being (MIwb) scores by sampling date from the upper Sandy Creek study area, 1993.

River Mile	Type	Date	Drainage area (sq mi)	Number of: Total species	Sunfish species	Sucker species	Intolerant species	Darter species	Percent of Individuals: Simple Lithophils	Tolerant fishes	Omni-vores	Top carnivores	Insect-ivores	DELT anomalies	Rel.No. minus tolerants /(0.3km)	Modified IBI	Iwb
Sandy Creek - (17450)																	
Year: 93																	
33.10	D	10/06/93	38	20(5)	2(3)	2(3)	3(3)	4(3)	68(5)	34(3)	30(3)	0.5(1)	66(5)	0.5(3)	1212(5)	42	7.3
33.10	D	08/25/93	38	25(5)	3(3)	2(3)	4(5)	3(3)	62(5)	33(3)	27(3)	1.6(3)	68(5)	0.0(5)	729(3)	46	8.0
30.30	D	10/06/93	62	19(3)	2(3)	2(3)	4(3)	3(3)	62(5)	17(5)	16(5)	4.2(3)	71(5)	1.3(1)	1026(5)	44	9.4
30.30	D	08/25/93	62	24(5)	3(3)	2(3)	4(3)	4(3)	51(5)	13(5)	11(5)	3.3(3)	62(5)	0.4(3)	1559(5)	48	9.7
29.40	D	10/06/93	133	23(5)	3(3)	2(1)	4(3)	4(3)	63(5)	33(3)	23(3)	2.9(3)	59(5)	0.9(3)	502(3)	40	7.7
29.40	D	08/27/93	133	22(3)	3(3)	2(1)	4(3)	5(3)	53(5)	29(3)	18(5)	4.3(3)	49(3)	2.1(1)	802(5)	38	9.0
28.20	D	10/06/93	135	12(3)	2(3)	2(1)	0(1)	0(1)	64(5)	81(1)	58(1)	4.9(3)	25(1)	26.1(1)	141(1)	22	5.0
28.20	D	08/27/93	135	12(3)	3(3)	1(1)	0(1)	0(1)	39(5)	69(1)	40(1)	4.2(3)	44(3)	5.3(1)	78(1)	24	5.9
25.20	D	10/07/93	162	18(3)	4(5)	2(1)	1(1)	5(3)	29(3)	29(3)	19(3)	6.1(5)	52(3)	0.0(5)	169(1)	36	6.7
25.20	D	08/27/93	162	20(3)	4(5)	2(1)	2(1)	5(3)	35(3)	45(1)	30(3)	2.3(3)	29(3)	2.0(1)	293(3)	30	7.4
Still Fork - (17470)																	
Year: 93																	
5.70	D	10/06/93	50	17(3)	5(5)	2(3)	0(1)	1(1)	21(3)	58(1)	22(3)	12.9(5)	65(5)	0.0(5)	161(1)	36	7.2
5.70	D	08/31/93	50	17(3)	6(5)	2(3)	0(1)	3(3)	23(3)	41(3)	22(3)	15.6(5)	62(5)	1.2(3)	125(1)	38	7.1

na - Qualitative data, Modified Iwb not applicable.
▲ - IBI is low-end adjusted.
● - One or more species excluded from IBI calculation.

Appendix Table 3. (continued).

River Mile	Type	Date	Drainage area (sq mi)	Number of: Total species	Sunfish species	Sucker species	Intolerant species	Percent of Individuals: Rnd-bodied suckers	Simple Lithophils	Tolerant fishes	Omni-vores	Top carnivores	Insect-ivores	DELT anomalies	Rel.No. minus tolerants /(1.0 km)	Modified IBI	Iwb
Still Fork - (17-470)																	
Year: 93																	
.50	A	10/05/93	70	11 (3)	6 (5)	2 (1)	0 (1)	2 (1)	8 (1)	9 (5)	7 (5)	15 (5)	78 (5)	0.0 (5)	384 (3)	40	7.2
.50	A	08/31/93	70	12 (3)	6 (5)	2 (1)	0 (1)	3 (1)	7 (1)	20 (3)	5 (5)	14 (5)	81 (5)	0.5 (3)	650 (5)	38	8.7

▲ - IBI is low end adjusted.

Appendix Table 4. ICI metric scores from the upper Sandy Creek study area, 1993.

River Mile	Drainage Area (sq mi)	Number of: Total Taxa	Mayfly Taxa	Caddisfly Taxa	Dipteran Taxa	Percent: Mayflies	Caddis-flies	Tany-tarsini	Other Dipt/NI	Tolerant Taxa	Qual. EPT	Eco-region	ICI
SANDY CREEK — 17-450													
Year: 93													
33.10	38.6	49(6)	7(4)	8(6)	20(6)	2.1(2)	45.8(6)	18.1(4)	32.0(4)	1.2(6)	13(6)	3	50
30.40	62.0	40(6)	7(4)	2(4)	18(4)	19.6(4)	3.7(2)	28.5(4)	46.1(2)	25.5(0)	12(4)	3	34
29.60	63.0	41(6)	6(4)	7(6)	18(4)	23.8(4)	2.6(2)	25.3(4)	46.4(2)	25.0(0)	13(4)	3	36
28.30	135.0	26(4)	1(0)	0(0)	14(4)	0.1(2)	0.0(0)	0.0(0)	99.8(0)	53.2(0)	1(0)	3	10
25.10	162.0	32(4)	4(2)	6(6)	12(4)	0.1(2)	2.4(2)	78.2(6)	19.3(6)	2.1(6)	9(2)	3	40
STILL FK. SANDY CR. — 17-470													
Year: 93													
5.70	74.0	46(6)	3(2)	2(4)	29(6)	9.7(2)	1.5(2)	18.6(4)	68.8(0)	13.5(2)	5(2)	4	30
.50	70.0	28(4)	1(0)	4(6)	14(4)	1.0(2)	0.4(2)	0.0(0)	95.3(0)	33.5(0)	3(0)	4	18

Ohio EPA Water Quality Monitoring and Assessment Section
Macroinvertebrate Collection

Collection Date: 08/18/93 River Code: 17-450 River: Sandy Creek RM: 33.10

Taxa Code	Taxa	Quan/Qual
01320	*Hydra sp*	32
01801	*Turbellaria*	1221 +
03600	*Oligochaeta*	44 +
04964	*Mooreobdella microstoma*	0 +
06201	*Hyalella azteca*	39 +
06700	*Crangonyx sp*	31 +
08260	*Orconectes (Crokerinus) sanbornii sanbornii*	0 +
08601	*Hydracarina*	204
11130	*Baetis intercalaris*	12 +
12200	*Isonychia sp*	1
13400	*Stenacron sp*	60 +
13540	*Stenonema mediopunctatum*	16 +
13561	*Stenonema pulchellum*	62 +
13570	*Stenonema terminatum*	2 +
17200	*Caenis sp*	44
18600	*Ephemera sp*	0 +
21200	*Calopteryx sp*	10 +
22001	*Coenagrionidae*	0 +
24900	*Gomphus sp*	0 +
45100	*Palmacorixa sp*	0 +
52200	*Cheumatopsyche sp*	261 +
52430	*Hydropsyche (Ceratopsyche) morosa group*	22 +
52530	*Hydropsyche (H.) depravata group*	7
53800	*Hydroptila sp*	4087 +
57400	*Neophylax sp*	0 +
57900	*Pycnopsyche sp*	1 +
58505	*Helicopsyche borealis*	51 +
59400	*Nectopsyche sp*	1
59500	*Oecetis sp*	24 +
60300	*Dineutus sp*	0 +
60900	*Peltodytes sp*	0 +
63900	*Laccophilus sp*	0 +
65800	*Berosus sp*	6 +
67700	*Paracymus sp*	0 +
67800	*Tropisternus sp*	0 +
68025	*Ectopria nervosa*	0 +
68702	*Dubiraphia bivittata*	0 +
68708	*Dubiraphia vittata group*	26 +
68901	*Macronychus glabratus*	29
69400	*Stenelmis sp*	124 +
71100	*Hexatoma sp*	0 +
71700	*Pilaria sp*	0 +
71900	*Tipula sp*	1
74501	*Ceratopogonidae*	0 +
77355	*Clinotanypus pinguis*	0 +
77500	*Conchapelopia sp*	35
77750	*Hayesomyia senata or Thienemannimyia norena*	35
77800	*Helopelopia sp*	377 +
78401	*Natarsia species A (sensu Roback, 1978)*	0 +
78600	*Pentaneura inconspicua*	208
78650	*Procladius sp*	0 +
80410	*Cricotopus (C.) sp*	35
80430	*Cricotopus (C.) tremulus group*	0 +
82730	*Chironomus (C.) decorus group*	0 +
82820	*Cryptochironomus sp*	0 +
82880	*Cryptotendipes sp*	0 +
83002	*Dicrotendipes modestus*	0 +
83003	*Dicrotendipes fumidus*	0 +
83040	*Dicrotendipes neomodestus*	104 +
83820	*Microtendipes "caelum" (sensu Simpson & Bode, 1980)*	69
84300	*Phaenopsectra obediens group*	35 +
84450	*Polypedilum (P.) convictum*	207 +
84460	*Polypedilum (P.) fallax group*	69
85230	*Cladotanytarsus mancus group*	0 +
85500	*Paratanytarsus sp*	35 +
85615	*Rheotanytarsus distinctissimus group*	173
85625	*Rheotanytarsus exiguus group*	726 +
85800	*Tanytarsus sp*	138 +
85802	*Tanytarsus curticornis group*	35
85814	*Tanytarsus glabrescens group*	311
85840	*Tanytarsus guerlus group*	346 +
86100	*Chrysops sp*	0 +
87501	*Empididae*	158 +
89501	*Ephydridae*	4
93200	*Hydrobiidae*	196 +
95100	*Physella sp*	1 +
96900	*Ferrissia sp*	1
98200	*Pisidium sp*	0 +
98600	*Sphaerium sp*	0 +

Ohio EPA Water Quality Monitoring and Assessment Section
Macroinvertebrate Collection

Collection Date: 08/18/93 River Code: 17-450 River: Sandy Creek RM: 33.10

Taxa Code	Taxa	Quan/Qual	Taxa Code	Taxa	Quan/Qual
99220	*Alasmidonta viridis*	0 +			

No. Quantitative Taxa: 49 Total Taxa: 80
No. Qualitative Taxa: 61 ICI: **50**

Ohio EPA Water Quality Monitoring and Assessment Section
Macroinvertebrate Collection

Collection Date: 08/18/93 River Code: 17-450 River: Sandy Creek RM: 30.40

Taxa Code	Taxa	Quan/Qual
01801	*Turbellaria*	21 +
03360	*Plumatella sp*	0 +
03600	*Oligochaeta*	466 +
06201	*Hyalella azteca*	12 +
06700	*Crangonyx sp*	18 +
08260	*Orconectes (Crokerinus) sanbornii sanbornii*	1 +
08601	*Hydracarina*	20 +
11120	*Baetis flavistriga*	4
12200	*Isonychia sp*	3 +
13400	*Stenacron sp*	319 +
13540	*Stenonema mediopunctatum*	92 +
13561	*Stenonema pulchellum*	169 +
16700	*Tricorythodes sp*	1
17200	*Caenis sp*	145 +
18600	*Ephemera sp*	0 +
22001	*Coenagrionidae*	0 +
42700	*Belostoma sp*	0 +
44501	*Corixidae*	0 +
52200	*Cheumatopsyche sp*	110 +
52430	*Hydropsyche (Ceratopsyche) morosa group*	30 +
57400	*Neophylax sp*	0 +
57900	*Pycnopsyche sp*	0 +
58505	*Helicopsyche borealis*	0 +
59310	*Mystacides sepulchralis*	0 +
63300	*Hydroporus sp*	0 +
63900	*Laccophilus sp*	0 +
65800	*Berosus sp*	0 +
67800	*Tropisternus sp*	0 +
68025	*Ectopria nervosa*	0 +
68075	*Psephenus herricki*	0 +
68130	*Helichus sp*	0 +
68601	*Ancyronyx variegata*	1
68708	*Dubiraphia vittata group*	6 +
68901	*Macronychus glabratus*	59
69400	*Stenelmis sp*	12 +
74501	*Ceratopogonidae*	12
77750	*Hayesomyia senata or Thienemannimyia norena*	60
77800	*Helopelopia sp*	60 +
78401	*Natarsia species A (sensu Roback, 1978)*	0 +
80310	*Cardiocladius obscurus*	0 +
80410	*Cricotopus (C.) sp*	242 +
80420	*Cricotopus (C.) bicinctus*	40 +
80440	*Cricotopus (C.) trifascia group*	0 +
80570	*Doncricotopus prob. bicaudatus*	20 +
81231	*Nanocladius (N.) crassicornus or N. (N.) rectinervus*	20
81240	*Nanocladius (N.) distinctus*	60 +
81825	*Rheocricotopus (Psilocricotopus) robacki*	40
82730	*Chironomus (C.) decorus group*	0 +
82820	*Cryptochironomus sp*	0 +
83040	*Dicrotendipes neomodestus*	40
84300	*Phaenopsectra obediens group*	20 +
84315	*Phaenopsectra flavipes*	0 +
84450	*Polypedilum (P.) convictum*	81
84460	*Polypedilum (P.) fallax group*	101
85263	*Cladotanytarsus vanderwulpi group Type 3*	0 +
85500	*Paratanytarsus sp*	0 +
85615	*Rheotanytarsus distinctissimus group*	20
85625	*Rheotanytarsus exiguus group*	765 +
85814	*Tanytarsus glabrescens group*	121
85840	*Tanytarsus guerlus group*	161 +
87501	*Empididae*	101 +
93200	*Hydrobiidae*	4 +
94201	*Lymnaeidae*	0 +
95100	*Physella sp*	38 +
96900	*Ferrissia sp*	249 +
98200	*Pisidium sp*	0 +
98600	*Sphaerium sp*	0 +

No. Quantitative Taxa: 40 Total Taxa: 67
No. Qualitative Taxa: 54 ICI: 34

Ohio EPA Water Quality Monitoring and Assessment Section
Macroinvertebrate Collection

Collection Date: 08/19/93 River Code: 17-450 River: Sandy Creek RM: 29.60

Taxa Code	Taxa	Quan/Qual
00401	*Spongillidae*	0 +
01801	*Turbellaria*	0 +
03600	*Oligochaeta*	64 +
04685	*Placobdella ornata*	0 +
04964	*Mooreobdella microstoma*	0 +
06201	*Hyalella azteca*	0 +
06700	*Crangonyx sp*	126 +
08260	*Orconectes (Crokerinus) sanbornii sanbornii*	0 +
08601	*Hydracarina*	8 +
12200	*Isonychia sp*	1 +
13400	*Stenacron sp*	521 +
13540	*Stenonema mediopunctatum*	30 +
13561	*Stenonema pulchellum*	64 +
13570	*Stenonema terminatum*	2
17200	*Caenis sp*	57 +
18600	*Ephemera sp*	0 +
21300	*Hetaerina sp*	0 +
22001	*Coenagrionidae*	0 +
22300	*Argia sp*	0 +
23909	*Boyeria vinosa*	0 +
47600	*Sialis sp*	0 +
51001	*Polycentropodidae*	4
51600	*Polycentropus sp*	2 +
52200	*Cheumatopsyche sp*	58 +
52430	*Hydropsyche (Ceratopsyche) morosa group*	1 +
52530	*Hydropsyche (H.) depravata group*	4 +
57400	*Neophylax sp*	0 +
57900	*Pycnopsyche sp*	1 +
58505	*Helicopsyche borealis*	0 +
59310	*Mystacides sepulchralis*	4
60300	*Dineutus sp*	0 +
65800	*Berosus sp*	0 +
68075	*Psephenus herricki*	0 +
68130	*Helichus sp*	0 +
68601	*Ancyronyx variegata*	2
68708	*Dubiraphia vittata group*	41 +
68901	*Macronychus glabratus*	3
69400	*Stenelmis sp*	9 +
71900	*Tipula sp*	0 +
74100	*Simulium sp*	0 +
77500	*Conchapelopia sp*	133 +
77750	*Hayesomyia senata or Thienemannimyia norena*	67
77800	*Helopelopia sp*	100 +
78401	*Natarsia species A (sensu Roback, 1978)*	0 +
78650	*Procladius sp*	15 +
80310	*Cardiocladius obscurus*	0 +
80410	*Cricotopus (C.) sp*	15
80420	*Cricotopus (C.) bicinctus*	0 +
81240	*Nanocladius (N.) distinctus*	30
81825	*Rheocricotopus (Psilocricotopus) robacki*	0 +
82730	*Chironomus (C.) decorus group*	0 +
83002	*Dicrotendipes modestus*	0 +
83040	*Dicrotendipes neomodestus*	45
83051	*Dicrotendipes simpsoni*	0 +
84210	*Paratendipes albimanus or P. duplicatus*	15 +
84300	*Phaenopsectra obediens group*	15 +
84315	*Phaenopsectra flavipes*	0 +
84450	*Polypedilum (P.) convictum*	0 +
84460	*Polypedilum (P.) fallax group*	375
84470	*Polypedilum (P.) illinoense*	0 +
84540	*Polypedilum (Tripodura) scalaenum group*	30 +
84888	*Xenochironomus xenolabis*	0 +
85230	*Cladotanytarsus mancus group*	0 +
85500	*Paratanytarsus sp*	15
85615	*Rheotanytarsus distinctissimus group*	15
85625	*Rheotanytarsus exiguus group*	375 +
85800	*Tanytarsus sp*	0 +
85802	*Tanytarsus curticornis group*	30
85814	*Tanytarsus glabrescens group*	165
85840	*Tanytarsus guerlus group*	120 +
87501	*Empididae*	25 +
93200	*Hydrobiidae*	0 +
95100	*Physella sp*	4
95501	*Planorbidae*	12
96900	*Ferrissia sp*	238 +
98600	*Sphaerium sp*	0 +

Ohio EPA Water Quality Monitoring and Assessment Section
Macroinvertebrate Collection

Collection Date: / / River Code: River: RM: .00

Taxa Code	Taxa	Quan/Qual	Taxa Code	Taxa	Quan/Qual

No. Quantitative Taxa:	41	Total Taxa:	76
No. Qualitative Taxa:	60	ICI:	**36**

Ohio EPA Water Quality Monitoring and Assessment Section
Macroinvertebrate Collection

Collection Date: 08/19/93 River Code: 17-450 River: Sandy Creek RM: 28.30

Taxa Code	Taxa	Quan/Qual
01801	*Turbellaria*	10 +
03600	*Oligochaeta*	992 +
04935	*Erpobdella punctata punctata*	2 +
04964	*Mooreobdella microstoma*	4 +
06700	*Crangonyx sp*	12 +
08601	*Hydracarina*	0 +
13400	*Stenacron sp*	0 +
17200	*Caenis sp*	1
21200	*Calopteryx sp*	9
22001	*Coenagrionidae*	0 +
22300	*Argia sp*	0 +
23909	*Boyeria vinosa*	0 +
45400	*Trichocorixa sp*	0 +
47600	*Sialis sp*	1 +
67800	*Tropisternus sp*	0 +
68901	*Macronychus glabratus*	8
69400	*Stenelmis sp*	4 +
74100	*Simulium sp*	888 +
77120	*Ablabesmyia mallochi*	0 +
77500	*Conchapelopia sp*	1195 +
77750	*Hayesomyia senata or Thienemannimyia norena*	527
77800	*Helopelopia sp*	120 +
78401	*Natarsia species A (sensu Roback, 1978)*	0 +
80420	*Cricotopus (C.) bicinctus*	876 +
80430	*Cricotopus (C.) tremulus group*	0 +
81240	*Nanocladius (N.) distinctus*	966 +
82730	*Chironomus (C.) decorus group*	351 +
82770	*Chironomus (C.) riparius group*	0 +
83051	*Dicrotendipes simpsoni*	527 +
83158	*Endochironomus nigricans*	0 +
83300	*Glyptotendipes (Phytotendipes) sp*	0 +
84300	*Phaenopsectra obediens group*	878 +
84315	*Phaenopsectra flavipes*	176
84450	*Polypedilum (P.) convictum*	1404 +
84460	*Polypedilum (P.) fallax group*	1229 +
84470	*Polypedilum (P.) illinoense*	1053 +
84540	*Polypedilum (Tripodura) scalaenum group*	88
95100	*Physella sp*	1 +
96120	*Menetus (Micromenetus) dilatatus*	0 +
96900	*Ferrissia sp*	51 +

Taxa Code	Taxa	Quan/Qual

No. Quantitative Taxa: 26 Total Taxa: 40
No. Qualitative Taxa: 34 ICI: 10

Ohio EPA Water Quality Monitoring and Assessment Section
Macroinvertebrate Collection

Collection Date: 08/19/93 River Code: 17-450 River: Sandy Creek RM: 25.10

Taxa Code	Taxa	Quan/Qual
01320	*Hydra sp*	8
01801	*Turbellaria*	1 +
03600	*Oligochaeta*	704 +
06201	*Hyalella azteca*	1 +
06700	*Crangonyx sp*	19 +
08260	*Orconectes (Crokerinus) sanbornii sanbornii*	0 +
08601	*Hydracarina*	766 +
11130	*Baetis intercalaris*	0 +
13400	*Stenacron sp*	1 +
13540	*Stenonema mediopunctatum*	2
16700	*Tricorythodes sp*	1
17200	*Caenis sp*	1
18600	*Ephemera sp*	0 +
21200	*Calopteryx sp*	0 +
22001	*Coenagrionidae*	0 +
22300	*Argia sp*	0 +
23909	*Boyeria vinosa*	0 +
45400	*Trichocorixa sp*	0 +
47600	*Sialis sp*	0 +
52200	*Cheumatopsyche sp*	82 +
52430	*Hydropsyche (Ceratopsyche) morosa group*	717 +
52530	*Hydropsyche (H.) depravata group*	162 +
52540	*Hydropsyche (H.) dicantha*	46 +
53800	*Hydroptila sp*	3 +
57900	*Pycnopsyche sp*	0 +
59500	*Oecetis sp*	64
60300	*Dineutus sp*	2 +
67800	*Tropisternus sp*	0 +
68601	*Ancyronyx variegata*	16 +
68708	*Dubiraphia vittata group*	0 +
68901	*Macronychus glabratus*	0 +
69400	*Stenelmis sp*	0 +
70600	*Antocha sp*	1
74100	*Simulium sp*	0 +
77120	*Ablabesmyia mallochi*	0 +
77500	*Conchapelopia sp*	735 +
77750	*Hayesomyia senata or Thienemannimyia norena*	1102 +
77800	*Helopelopia sp*	367 +
78401	*Natarsia species A (sensu Roback, 1978)*	0 +
80310	*Cardiocladius obscurus*	0 +
80410	*Cricotopus (C.) sp*	0 +
80420	*Cricotopus (C.) bicinctus*	0 +
80430	*Cricotopus (C.) tremulus group*	367
81650	*Parametriocnemus sp*	0 +
81825	*Rheocricotopus (Psilocricotopus) robacki*	1102 +
82730	*Chironomus (C.) decorus group*	0 +
82820	*Cryptochironomus sp*	0 +
83040	*Dicrotendipes neomodestus*	735 +
83820	*Microtendipes "caelum" (sensu Simpson & Bode, 1980)*	0 +
84210	*Paratendipes albimanus or P. duplicatus*	0 +
84300	*Phaenopsectra obediens group*	0 +
84450	*Polypedilum (P.) convictum*	2204 +
84460	*Polypedilum (P.) fallax group*	0 +
84470	*Polypedilum (P.) illinoense*	0 +
84540	*Polypedilum (Tripodura) scalaenum group*	0 +
85500	*Paratanytarsus sp*	735
85625	*Rheotanytarsus exiguus group*	33055 +
85800	*Tanytarsus sp*	0 +
85814	*Tanytarsus glabrescens group*	367
85840	*Tanytarsus guerlus group*	0 +
87501	*Empididae*	123 +
95100	*Physella sp*	17 +
96900	*Ferrissia sp*	193 +

No. Quantitative Taxa: 32 Total Taxa: 63
No. Qualitative Taxa: 54 ICI: 40

Ohio EPA Water Quality Monitoring and Assessment Section
Macroinvertebrate Collection

Collection Date: 08/18/93 River Code: 17-470 River: Still Fork RM: 5.70

Taxa Code	Taxa	Quan/Qual
01801	*Turbellaria*	255 +
03600	*Oligochaeta*	40 +
04666	*Helobdella triserialis*	0 +
04685	*Placobdella ornata*	0 +
04964	*Mooreobdella microstoma*	0 +
06201	*Hyalella azteca*	154 +
08260	*Orconectes (Crokerinus) sanbornii sanbornii*	1 +
08601	*Hydracarina*	12 +
11120	*Baetis flavistriga*	1
11130	*Baetis intercalaris*	26
11200	*Callibaetis sp*	0 +
13400	*Stenacron sp*	253 +
21200	*Calopteryx sp*	0 +
22001	*Coenagrionidae*	0 +
22300	*Argia sp*	17
23600	*Aeshna sp*	0 +
23905	*Boyeria grafiana*	0 +
23909	*Boyeria vinosa*	5 +
42700	*Belostoma sp*	0 +
45100	*Palmacorixa sp*	0 +
45400	*Trichocorixa sp*	0 +
45900	*Notonecta sp*	0 +
47600	*Sialis sp*	6 +
52200	*Cheumatopsyche sp*	42 +
53800	*Hydroptila sp*	2
57900	*Pycnopsyche sp*	0 +
59500	*Oecetis sp*	0 +
60900	*Peltodytes sp*	0 +
63300	*Hydroporus sp*	0 +
65800	*Berosus sp*	0 +
66500	*Enochrus sp*	0 +
67750	*Sperchopsis tesselatus*	0 +
67800	*Tropisternus sp*	0 +
68601	*Ancyronyx variegata*	0 +
68708	*Dubiraphia vittata group*	1 +
68901	*Macronychus glabratus*	12
74501	*Ceratopogonidae*	8
77120	*Ablabesmyia mallochi*	41
77470	*Coelotanypus sp*	0 +
77750	*Hayesomyia senata or Thienemannimyia norena*	103
77800	*Helopelopia sp*	21
78350	*Meropelopia sp*	21
78401	*Natarsia species A (sensu Roback, 1978)*	0 +
78600	*Pentaneura inconspicua*	21 +
78650	*Procladius sp*	0 +
80370	*Corynoneura lobata*	144
80420	*Cricotopus (C.) bicinctus*	205
80430	*Cricotopus (C.) tremulus group*	21
82121	*Thienemanniella n.sp 3*	21
82141	*Thienemanniella xena*	21
82820	*Cryptochironomus sp*	41
82880	*Cryptotendipes sp*	0 +
83002	*Dicrotendipes modestus*	41
83003	*Dicrotendipes fumidus*	82
83040	*Dicrotendipes neomodestus*	82 +
83820	*Microtendipes "caelum" (sensu Simpson & Bode, 1980)*	123
84300	*Phaenopsectra obediens group*	0 +
84450	*Polypedilum (P.) convictum*	103 +
84460	*Polypedilum (P.) fallax group*	103
84470	*Polypedilum (P.) illinoense*	41
84540	*Polypedilum (Tripodura) scalaenum group*	164 +
84700	*Stenochironomus sp*	21
84790	*Tribelos fuscicorne*	41
84800	*Tribelos jucundum*	41 +
85500	*Paratanytarsus sp*	62 +
85615	*Rheotanytarsus distinctissimus group*	41 +
85625	*Rheotanytarsus exiguus group*	267 +
85800	*Tanytarsus sp*	21
85814	*Tanytarsus glabrescens group*	103 +
85840	*Tanytarsus guerlus group*	41
93200	*Hydrobiidae*	8
95100	*Physella sp*	1 +
98200	*Pisidium sp*	0 +
98600	*Sphaerium sp*	0 +

No. Quantitative Taxa: 46 Total Taxa: 74
No. Qualitative Taxa: 48 ICI: 30

04/07/95

Ohio EPA Water Quality Monitoring and Assessment Section
Macroinvertebrate Collection

Collection Date: 08/19/93 River Code: 17-470 River: Still Fork RM: .50

Taxa Code	Taxa	Quan/Qual
01801	*Turbellaria*	4
03600	*Oligochaeta*	366
04664	*Helobdella stagnalis*	0 +
04960	*Mooreobdella sp*	1
06201	*Hyalella azteca*	270 +
11200	*Callibaetis sp*	0 +
17200	*Caenis sp*	23 +
22001	*Coenagrionidae*	53 +
22300	*Argia sp*	4
27610	*Epitheca (Tetragoneuria) cynosura*	0 +
43300	*Ranatra sp*	0 +
43570	*Neoplea sp*	0 +
45100	*Palmacorixa sp*	0 +
47600	*Sialis sp*	0 +
51206	*Cyrnellus fraternus*	2
51600	*Polycentropus sp*	1
54200	*Orthotrichia sp*	4
59530	*Oecetis eddlestoni*	1 +
60900	*Peltodytes sp*	0 +
65800	*Berosus sp*	2
68702	*Dubiraphia bivittata*	0 +
68708	*Dubiraphia vittata group*	17 +
72700	*Anopheles sp*	0 +
74501	*Ceratopogonidae*	25 +
77120	*Ablabesmyia mallochi*	0 +
77130	*Ablabesmyia rhamphe group*	123 +
77355	*Clinotanypus pinguis*	0 +
78130	*Labrundinia neopilosella*	23
78600	*Pentaneura inconspicua*	23
78650	*Procladius sp*	0 +
80410	*Cricotopus (C.) sp*	23
81231	*Nanocladius (N.) crassicornus or N. (N.) rectinervus*	23
82820	*Cryptochironomus sp*	0 +
83002	*Dicrotendipes modestus*	0 +
83050	*Dicrotendipes lucifer*	224 +
83051	*Dicrotendipes simpsoni*	393 +
83158	*Endochironomus nigricans*	46 +
83300	*Glyptotendipes (Phytotendipes) sp*	389 +
84315	*Phaenopsectra flavipes*	23
84460	*Polypedilum (P.) fallax group*	0 +
84470	*Polypedilum (P.) illinoense*	0 +
84520	*Polypedilum (Tripodura) halterale group*	23
84540	*Polypedilum (Tripodura) scalaenum group*	0 +
84790	*Tribelos fuscicorne*	46
84960	*Pseudochironomus sp*	137
95100	*Physella sp*	1 +

No. Quantitative Taxa: 28 Total Taxa: 46
No. Qualitative Taxa: 30 ICI: 18

04/07/95