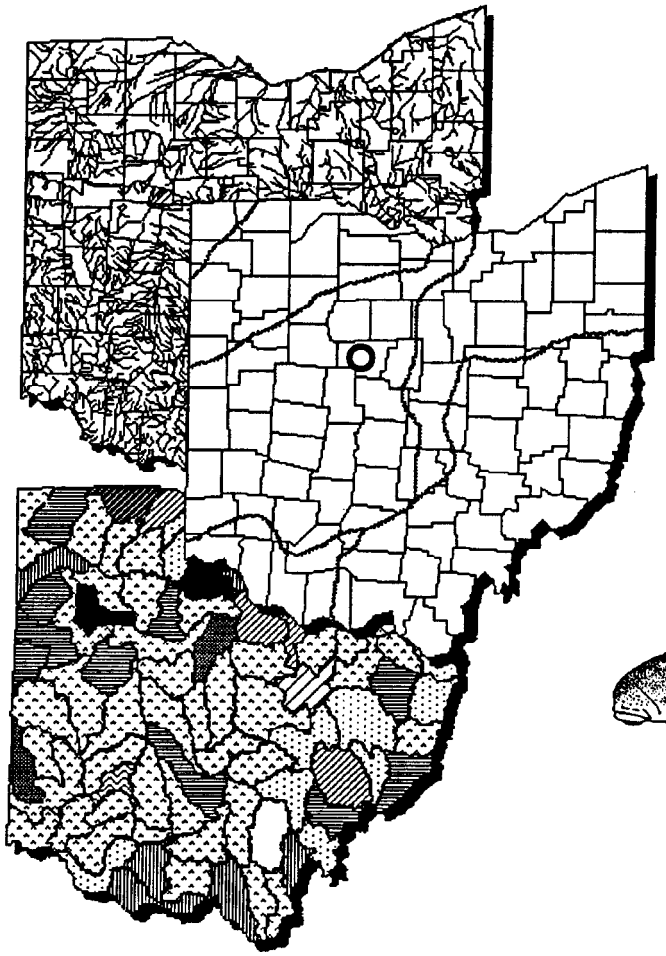
State of Ohio
Environmental Protection Agency

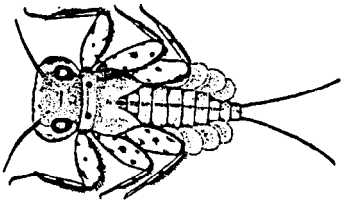
Ecological Assessment Section
Division of Surface Water

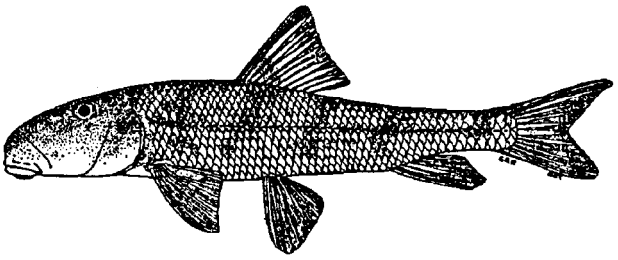
Biological, Sediment and Water Quality Study of the Little Scioto River, Marion, Ohio

Marion County, Ohio



$C_{20}H_{12}$
Benzo(a)pyrene





April 8, 1994

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

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prepared by

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TSD Coordinator - David Altfater
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Biological, Sediment and Water Quality Study of the Little Scioto River (Marion County, Ohio)

Ohio Environmental Protection Agency
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1685 Westbelt Drive
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INTRODUCTION

The Little Scioto River study area included the lower nine miles of the Little Scioto River, the lower two miles of Rockswale Ditch, the lower half mile of North Rockswale Ditch, one location on Columbia Ditch, and the Scioto River upstream (RM 179.6) to downstream (RM 171.9) from the confluence with the Little Scioto River.

Specific objectives of this evaluation were to:

1) determine the longitudinal extent of polycyclic aromatic hydrocarbons (PAHs), heavy metals, and other potential contaminants in the sediments of the Little Scioto River, North Rockswale, Scioto River, Rockswale Ditch and Columbia Ditch;

2) evaluate the presence of pentachlorophenol and dibenzofuran in the sediments of the Little Scioto River, Scioto River, North Rockswale Ditch, Rockswale Ditch and Columbia Ditch;

3) determine and measure adverse impacts on biological condition and water quality in the Little Scioto River;

4) identify the relative significance of combined sewer overflows, Marion landfill, Marion wastewater treatment plant (WWTP), and sediment contaminants on the impairment of the Little Scioto River biological communities;

5) determine the potential accumulation of contaminants in river sediments and fish tissue;

6) determine the attainment status of current aquatic life use designations for the Little Scioto River; and,

7) follow-up to conditions documented in the 1987 Ohio EPA survey (Ohio EPA 1988).

The findings of this evaluation may factor into regulatory actions taken by Ohio EPA (e.g. NPDES permits, Director's Orders), the Ohio Water Quality Standards (OAC 3745-l), and eventually be incorporated into the State Water Quality Management Plans, the Ohio Nonpoint Source Assessment, and the biennial Ohio Water Resource Inventory (305[b] report).

SUMMARY/CONCLUSIONS

From August,1992 to February, 1993, Ohio EPA's Division of Surface Water (DSW) staff, at the request of the Division of Emergency and Remedial Response (DERR), conducted biological

community, fish tissue, biomarker, sediment and surface water sampling of the Little Scioto River in the vicinity of Marion, Ohio. Sediment sampling was also conducted in North Rockswale Ditch, Rockswale Ditch, Columbia Ditch and the Scioto River. The results of these sampling events are summarized below.

- Seventeen polycyclic aromatic hydrocarbons (PAHs) were identified and quantified in sediment in the Little Scioto River study area. In addition, 25 tentatively identified compounds (TIC) of PAHs were documented in the Little Scioto River sediments tested at four locations. PAHs which were detected ranged between 0.33 mg/kg and 221mg/kg, with the highest concentrations occurring between RM 6.5 and RM 4.4 in the Little Scioto River and in the lower 0.1 mile of North Rockswale Ditch. PAH sediment contamination extends from RM 7.0 to the mouth of the Little Scioto River, in the Scioto River for at least one mile downstream from the Little Scioto River, in the lower 0.1 mile of North Rockswale Ditch and in the upper reach of Rockswale Ditch (RM 2.1).

- Five of the PAH compounds identified in sediments in the Little Scioto River study area have been identified as possible human carcinogens: benzo(a)anthracene, benzo(b)fluoranthene, benzo(a)pyrene, chrysene and dibenzo(a,h)anthracene. Four PAH compounds (phenanthrene, fluoranthene, benzo(a)pyrene, and benzo(a)anthracene) were within the range of sediment values associated with areas with widespread occurrences of tumors in fish.

- In the segment of the Little Scioto River (RM 6.5 - 4.4) with sediments highly contaminated with PAHs, the greatest concentrations were found at the 18-24" (46 - 61cm) depth, in comparison to the l-8" (2.5 - 2Ocm) depth. Sampling results suggest that PAH contaminants extend deeper than two feet (61cm) below the sediment surface.

- Benzo(a)pyrene, a known mammalian carcinogen with a high carcinogenic potency, has been documented in the past at high concentrations in Little Scioto River sediments between RM 6.6 and RM 5.8 (Ohio EPA 1988, 1992a). The 1992 results documented that highly elevated levels of benzo(a)pyrene were also observed as far downstream as RM 4.4 (7.2 mg/kg at the less than 20cm depth and 33 mg/kg at the 46 - 61 cm depth), and near the mouth of North Rockswale Ditch (9.2 mg/kg at the 30 - 46cm depth and 29.7 mg/kg at the less than 15cm depth).

- Twenty-three metals and cyanide were measured in sediment from sampling locations in the Little Scioto River study area. Generally, the highest metal concentrations occurred in the Little Scioto River from between RMs 6.5 and 2.7, in North Rockswale Ditch near the mouth, and in the entire Rockswale Ditch. This segment of the Little Scioto River receives discharges of wastewater from the Marion WWTP, combined sewer overflows, Marion landfill leachate and industrial discharges. North Rockswale Ditch receives combined sewer overflows and Rockswale Ditch receives wastewater from the Whirlpool Marion Company and storm sewer discharges.

- Chromium, lead, mercury and zinc were recorded at extremely elevated levels in river sediments based on a sediment classification scheme by Kelly and Hite (1984). In particular, mercury was measured in North Rockswale Ditch at 4.27 mg/kg (RM 0.04) and zinc was measured in Rockswale Ditch at 4580 mg/kg (RM 2.1).

- DDT metabolites (4,4'-DDE and 4,4'-DDD) were measured at highly elevated levels between RMs 6.5 and 5.8 in Little Scioto River sediments. One dieldrin sample at RM 6.5 was

considered extremely elevated compared to background conditions. Overall, the highest concentrations of pesticides in sediment occurred in the Little Scioto River at RM 6.5. Two volatile organic compounds, ethylbenzene (4.1 mg/kg) and total xylenes (4.4 mg/kg) were recorded at elevated levels in the sediment from the Little Scioto River at RM 4.4.

- All PCB parameters measured in the study area were reported as not detected above lab quantitation limits.

- Overall sediment quality suggests highly contaminated conditions between RMs 6.5 and 3.0. A significant increase in total PAHs, chromium, lead, zinc, mercury and cadmium in stream sediments occurs in the Little Scioto River downstream from the confluence with North Rockswale Ditch (RM 6.6), and remains relatively high to RM 3.0. This area is influenced by combined sewer overflows to North Rockswale Ditch, a stream bottom which is heavily saturated with a black material with a creosote odor, effluent discharges from the Marion WWTP, and landfill leachate. Significantly elevated levels of zinc were noted in Rockswale Ditch downstream from the Whirlpool Marion effluent discharge (a permitted discharge of zinc). Elevated levels of PAHs, chromium, lead, zinc and mercury were documented in the lower section of North Rockswale Ditch.

- Surface water chemical quality suggests that substantial loadings of ammonia-N and oxygen demanding wastes from the Marion sewage collection and treatment system are discharged into the Little Scioto River. Increased surface water ammonia-N concentrations and a substantial reduction in dissolved oxygen (D.O. violations occurred at RM 2.67) were observed downstream from the Marion WWTP. Although the Marion WWTP is an advanced nitrification plant, significant loadings of ammonia-N and BOD5 are discharged into the Little Scioto River via the plant influent bypass. It is estimated that during 1992, over 30% of the known wastewater load to the river was comprised of untreated influent bypasses. This does not include additional loadings from the CSO at Holland Rd.

- The instream physical habitat of the Little Scioto River from RM 9.0 to 0.0 was channelized in the early 1900's, these modifications continue to prevail and result in poor conditions for supporting viable warmwater biological communities. QHEI scores in this segment ranged between 38.5 and 42.5, well below the score of 76 recorded in the upstream unmodified area and typifying conditions associated with the designated Modified Warmwater Habitat (MWH) use.

- Below the surface layer of sediments, the bottom and banks of the Little Scioto River between RMs 6.6 and 4.4 were observed to be heavily saturated with a black material with a creosote odor. Disturbance of the bottom sediments released an oily substance which created an extensive oil sheen on the surface of the water.

- Fish and macroinvertebrate communities in the Little Scioto River between RM 7.9 and 0.3 were in the fair to poor range and did not attain the Modified Warmwater Habitat ecoregional biocriteria. The most severe degradation occurred between RMs 6.5 and 2.1, where communities were in the poor to very poor range. Clearly, part of the decline in the biological communities between RMs 7.9 and 0.3 was attributable to the poor instream physical habitat; however, the severity of the biological degradation was also indicative of toxic sediment and water quality conditions particularly where departure from even the MWH criteria were observed.

- The physical condition of fish was monitored at each sampling site by recording the incidence of gross external DELT (deformities, fin erosions, lesions/ulcers and tumors) anomalies. Biosurvey results collected by Ohio EPA from throughout the state show that a high frequency of DELT anomalies is an accurate indication of pollution stress usually caused by multiple sublethal stresses as the result of degraded water quality *(i.e.,* often a combination of toxic impacts combined with marginal D.O. concentrations). Within Ohio, there also appears to be a positive relationship between sites containing chemically contaminated sediments (e.g., metals, PAHs) and high percent occurrence of DELT anomalies (Yoder 1991). At RM 7.9, DELT anomalies occurred in 1.6% of the fish population. A substantial increase in anomalies occurred from RM 6.5 to RM 0.3, with values ranging between 9.9% and 22.3%. These results in combination with poor and very poor IBI and MIwb scores indicates a complex toxic impact. This area has elevated sediment concentrations of PAHs, cadmium, chromium, lead, mercury and zinc, as well as, elevated surface water concentrations of ammonia-N and nitrite-N and reduced D.O. values.

- A significant improvement in IBI and MIwb scores was observed in the Little Scioto River (RMs 6.5 - 0.0) between 1987 and 1992. However, the scores were still within the poor to very poor range and did not meet the MWH biocriteria. ICI scores likewise improved, but these too failed to meet the MWH biocriteria.

- Fish tissue samples were collected from the Little Scioto River at three locations and from the Scioto River at two locations by the Ohio EPA during 1992. Whole body composite and individual fish representing three species were analyzed for pesticides, PCBs, metals, semivolatile compounds and percent lipid. Most parameters measured were reported as 'not detected'. One white sucker sample from the Little Scioto River at RM 6.5 had an elevated lead level of 8 1.4 mg/kg.

- White sucker and common carp were collected from Little Scioto River biological sampling sites to conduct biochemical analyses of liver, blood plasma, and bile samples. The analyses measured bile metabolites, ethoxyresorufin-0-deetbylase (EROD) activity, and total hepatic glutathione (GSH). All three analyses were used to determine exposure to xenobiotics. Common carp and white sucker results from the Little Scioto River had EROD activity and GSH levels at RM 9.2 and RM 7.9 within the nominal range for these markers compared to data from Ohio reference streams. These two locations are upstream from areas with bottom sediments contaminated with PAH compounds. Levels of EROD and GSH for both species were highly elevated at RM 6.5 and RM 5.7, and white sucker results remained high from RMs 4.4 to 0.3. The common carp and white sucker EROD and GSH data demonstrate a physiological response from exposure to PAHs. Elevated levels of bile metabolites were also detected at all Little Scioto River sites between RMs 6.5 and 0.3, with the highest concentrations of fluorescent metabolites occurring at RM 5.7, 4.4 and 2.7. The bile metabolite data further substantiates that white sucker and common carp have been exposed to polycyclic aromatic hydrocarbons.

- The pattern of bile metabolites, EROD, and glutathione compared with IBI scores and DELT anomalies suggests that the reduced biological community performance at RM 7.9 is due to instream habitat alteration. The further decline in IBI and increases in DELT anomalies between RMs 6.5 and 0.3, along with biomarker results, suggest that at least part of the biological impairment is associated with the presence and exposure of fish to PAHs.

RECOMMENDATIONS

Status of Aquatic Life Uses

Prior to the present study, aquatic life use designations of the upper Little Scioto River (upstream from RM 9.0) and lower Little Scioto River (RM 9.0 to mouth) were Warmwater Habitat (WWH) and Modified Warmwater Habitat (MWH) (OAC 3745-l), respectively. The following recommendations are made based on the 1992 survey results.

- The current Warmwater Habitat aquatic life use designation is appropriate for the upper Little Scioto River. One sampling station (at RM 9.2) within the upper Little Scioto River clearly had physical habitat conditions which could support a warmwater biological community (QHEI = 76).

- The existing Modified Warmwater Habitat designation for the lower Little Scioto River should remain. This area of the Little Scioto River (RM 9.0 - 0.0) was extensively modified in the early 1900's and the 8O+ year old channelization reflects the long term nature and slow recovery potential in this low gradient stream. QHEI scores in the lower Little Scioto River ranged between 38.5 and 42.5, well below the 60 minimum which generally reflects the low end score conducive to the support of WWH communities.

Other

- The significant loading of bypassed sewage at the Marion WWTP should be reduced substantially. Presently, the bypassed loadings of BOD5, ammonia-N, and total nonfilterable residue comprised 50%, 32%, and 59% of all point source discharges to the Little Scioto River.

- Significant contamination of bottom sediments was observed between RMs 6.5 and 4.4 in the Little Scioto River. The removal of PAH contaminated sediments needs to be explored as well as the potential of in-place bioremediation. Along with the potential removal of contaminated sediments, the feasibility of restoring the modified channel to more natural conditions should be considered as part of a total restoration project.

Table 1. Aquatic life use attainment status for the Little Scioto River based on data collected during August - October, 1992. Also included are results and status based on a 1987 Ohio EPA biosurvey. Attainment status is based on biocriteria for the Eastern Corn Belt Plains ecoregion of Ohio (OAC 3745-1-07, Table 7-17).

River Mile Fish/Invert.	IBI	Modified Iwb	ICI	QHEI[a]	Attainment Status	Comments
Eastern Corn Belt Plain - WWH use Designation (Upstream from RM 9.0)						
Eastern Corn Belt Plain - MWH use Designation (RM 9.0 to mouth)						
1992						
Little Scioto River						
9.2/ 9.2	33*	7.2*	38	76.0	PARTIAL	Upstream Marion-natural
7.9/ 7.9	23*	5.3*	16*	42.5	NON	Upstream Marion-channelized
6.5/ 6.5	19*	4.8*	8*	38.5	NON	Dst. CSO - Holland Rd., PAH contamination
5.7 5.7	19*	5.2*	6*	40.0	NON	Dst. Marion WWTP, PAH contamination
4.4/ 4.4	18*	4.1*	10*	39.0	NON	PAH contamination
2.7/ 2.1	19*	4.1*	18*	42.0	NON	Dst. Rockswale Ditch
0.3/ 0.4	25	5.0*	18*	38.5	PARTIAL	At mouth
1987						
Little Scioto River						
9.2/ 9.2	33*	7.9[ns]	40	74	PARTIAL	Upstream Marion
6.6/ -	24	4.2*	-	30	PARTIAL	Upst. N. Rockswale Ditch
6.5/ 6.5	14*	3.6*	22	38	NON	Dst. CSO-Holland Rd., PAH contamination
6.0/ 5.8	14*	3.7*	8*	40	NON	Dst. Marion WWTP, PAH contamination
3.1/ 3.2	12*	0.8*	8*	36	NON	Upst. Rockswale Ditch
2.7/ 2.7	13*	1.9*	4*	41	NON	Dst. Rockswale Ditch
0.1/ 0.4	14*	3.6*	6*	43	NON	At mouth

Ecoregion Biocriteria: Eastern Corn Belt Plains (ECBP)

INDEX - Site Type	WWH	MWH[b]
IBI - Wading	40	24
IBI - Boat	42	24
Mod. Iwb - Wading	8.3	6.2
Mod. Iwb - Boat	8.5	5.8
ICI	36	22

* - Significant departure from ecoregion biocriteria; poor and very poor results are underlined.

ns - Nonsignificant departure from WWH ecoregion biocriteria (4 IBI or ICI units; 0.5 Iwb units).

a - All Qualitative Habitat Evaluation Index (QHEI) values are based on the most recent version (Rankin 1989).

b- Modified Warmwater Habitat for channel modified areas.

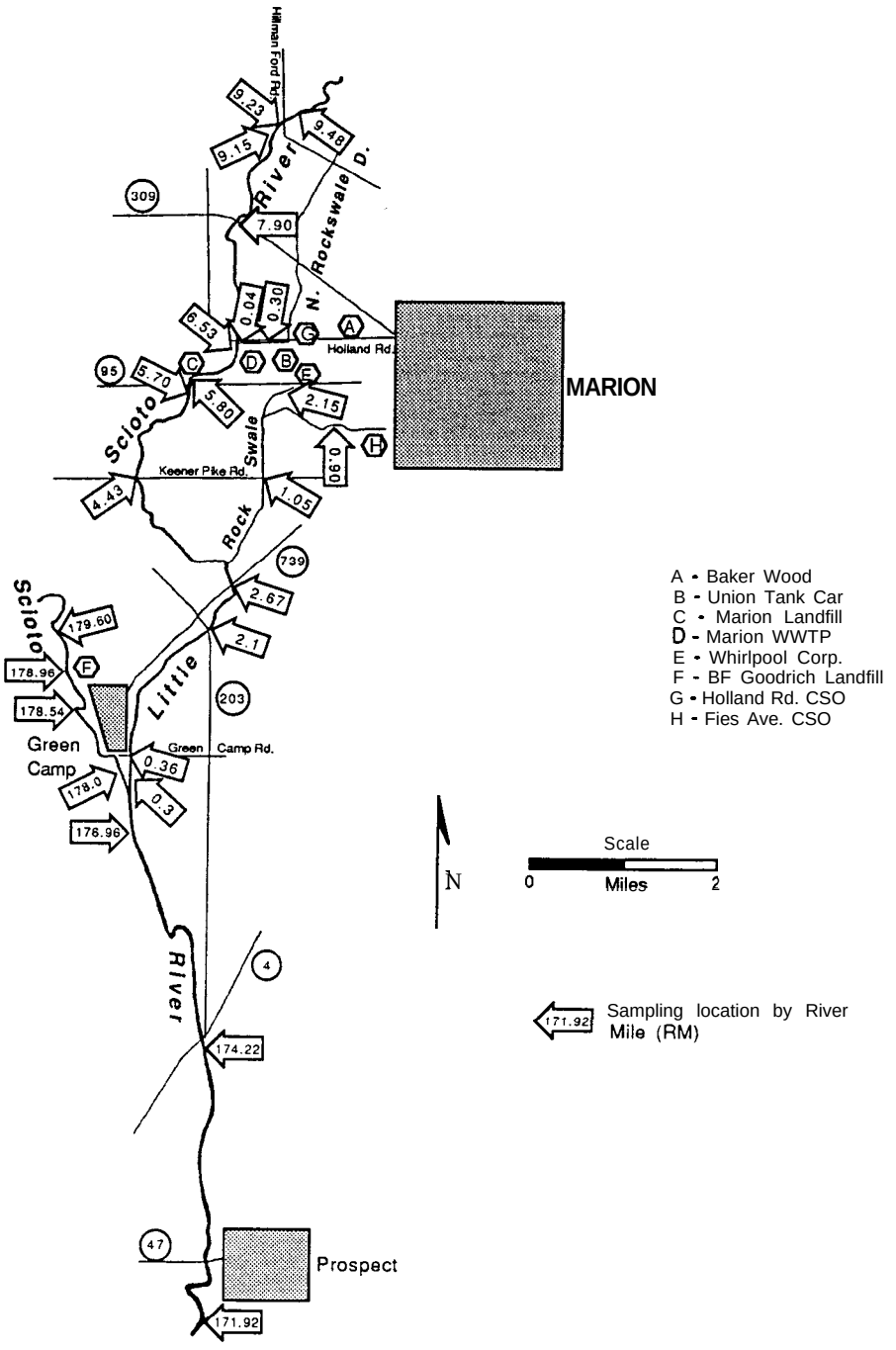

Figure 1. Map of the Little Scioto River study area showing principal streams, landmarks, potential pollution sources and sampling locations.

METHODS

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

Attainment/non-attainment of aquatic life uses was determined by using biological criteria codified in Ohio Administrative Code (OAC) 3745-l-07, Table 7-17. The biological community performance measures that were used included 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 weight 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; Omemik 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 was FULL if all three indices (or those available) meet the applicable criteria, PARTIAL if at least one of the indexes did not attain and performance did not fall below the fair category, and NON if all indices either failed to attain or any index indicated 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 were 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 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 indicated that values higher than 60 were generally conducive to the establishment of warmwater faunas while those which scored in excess of 75-80 often typify habitat conditions which have the ability to support exceptional faunas.

During this survey, macroinvertebrates were sampled using modified Hester/Dendy multiple-plate artificial substrate samplers supplemented with a qualitative assessment of the available natural substrates. Qualitative macroinvertebrate sampling consists of an inventory of species with no attempt to quantify the populations and a measure of EPT (Ephemeroptera -mayfly, Plecoptera - stonefly, and Trichoptera - caddisfly) taxa richness - an indication of the prevalence of pollution sensitive organisms.

Fish were sampled 2-3 times using pulsed DC electrofishing gear using either the wading or boat methods. Whole body fish were collected in October, 1992 for tissue analysis. Fish tissue sampling procedures are detailed in the Manual of Ohio EPA Surveillance Methods and Quality Assurance Practices (Ohio Environmental Protection Agency 1989a). Fine grained sediment samples were collected in the upper 6 inches of bottom material at each location (and one - two foot depth at selected locations) using decontaminated stainless steel scoops or teflon core samplers (decontamination followed the procedures outlined in FSOP 10.01, DERR Sampling Guidance, Vol III, Ohio EPA 1992b). Collected sediment was placed into clear glass jars with teflon lined lids, placed on ice (to maintain 4oC) and shipped to an Ohio EPA contract lab. Surface water samples were collected directly into appropriate containers, preserved and delivered to the Ohio EPA lab. Dissolved oxygen was monitored continuously over a three-day period in the Little Scioto River using Datasonde monitors. All surface water, sediment, fish tissue, biomarker and biological sampling locations are listed in Table 2.

White sucker and common carp were collected for biomarker processing during normal community assessment sampling . Fish were kept in a floating livewell until biomarker tissue samples could be taken. Fish were anesthetized in MS222 and length and weight measured. Fish health/ condition was assessed using procedures in Goede (1988). Blood was drawn from the caudal vein through a 21 gauge needle into heparin treated 3 ml blood drawing tubes. Whole blood was centrifuged on-site and the plasma removed (flash frozen at -lOO°C in a liquid nitrogen dry shipper). The liver was excised, wrapped in aluminum foil and frozen in a liquid nitrogen dry shipper. Bile was removed, placed in amber microcentrifuge tubes and frozen in a liquid nitrogen dry shipper. Sections of liver and spleen were excised from each fish and placed in buffered formalin for histological evaluation. Tissue samples were transported to the Environmental Monitoring Systems Laboratory, U.S. EPA in Cincinnati for laboratory analysis. Specific biomarker analyses included ethoxyresorufin-0-deethylase (EROD), total hepatic glutathione, blood urea nitrogen, plasma levels of pseudocholinesterase and bile metabolites. Each bile sample was diluted with distilled/deionized water and measured by fixed fluorescence at four excitation/emission wavelength pairs according to Lin et al. (in preparation). Although more than one compound is known to fluoresce under these conditions, some compounds give a greater response. The metabolites are referred to by one of their most sensitive respondents: pyrenol-type at 340/380 nm, benzo(a)pyrenol-type at 380/430 nm, phenanthrol-type at 256/380 nm and naphthol-type at 290/335 nm. Microsomes for measuring EROD and cytosol for glutathione were prepared from liver tissue. Microsomes were prepared according to Lin et al.(1989) and the cytosolic supematant resulting from the high speed centrifugation was reserved for glutathione measurement. EROD activity was measured fluorometrically according to Pohl and Fouts (1980) and modified Lin *et al.* (1989). Glutathione was measured according to Akerboum and Sies (1981) and adapted for use with an automated chemistry analyzer.

An Area of Degradation Value (ADV; Rankin and Yoder 1991) 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.

Table 2. Sampling locations (sediment - S, biomarker - B, fish - F, macroinvertebrate - M, surface water - W, fish tissue - T, datasonde dissolved oxygen - D) in the Little Scioto River study area, 1992.

Stream/ River Mile	Type of Sampling	Latitude/ Longitude	Landmark	USGS 7.5 min. Quad. Map
Little Scioto River				
9.48	S	40 37 42/83 10 09	Upst. RR bridge	Morral, OH
9.23	F,B,T,M,W	40 37 38/83 10 21	Hillman-Ford Rd.	Morral, OH
9.15	D	40 37 33/83 10 29	Dst. Hillman-Ford Rd.	Morral, OH
7.90	S,B,F,M,W,D	403640/83 11 02	State Route 309	Marion West, OH
6.53	S,B,F,M,W,T	403532/83 1102	Holland Rd. (Dst. N. Rockswale D.)	Marion West, OH
5.80	S,W,D	40 3.5 12/83 11 35	Upst. State Route 95	Marion West, OH
5.7	B,F,M	40 35 07/83 11 36	Dst. State Route 95	Marion West, OH
4.43	S,B,F,M,W,D	40 34 18/83 12 14	Keener Pike Rd.	Marion West, OH
2.67	S,F,T,B,W,D	40 33 17/83 11 08	State Route 739	Marion West, OH
2.1	M	40 32 51/83 11 22	State Route 203	Marion West, OH
0.36	S,WW,D	4031 39/83 1220	Owens Greencamp Rd.	Marion West, OH
0.3	F,B	40 31 33/83 12 20	Dst. Owens Greencamp Rd.	Marion West, OH
Scioto River				
179.60	S	40 32 49/83 13 13	Upst. BF Goodrich landfill	Marion West, OH
178.96	S	40 32 20/83 13 01	Adj. BF Goodrich landfill	Marion West, OH
178.54	S	40 32 07/83 12 58	Dst. BF Goodrich landfill	Marion West, OH
178.0	T	40 31 41/83 1242	Greencamp (Upst. L. Scioto R.)	Marion West, OH
176.96	TS	40 31 03/83 12 18	Dst. Little Scioto River	Marion West, OH
174.22	S	40 29 00/83 11 27	State Route 4	Prospect, OH
171.92	S	40 26 27/83 11 31	Upst. Prospect dam	Prospect, OH
Rockswale Ditch				
2.15	S	40 35 07/83 10 23	Dst. RR/ State Route 95	Marion West, OH
1.05	S	40 34 17/83 10 49	Keener Pike Rd.	Marion West, OH
North Rockswale Ditch				
0.30	S	40 35 33/83 10 41	Adj. Holland Rd.	Marion West, OH
0.04	S	40 35 33/83 10 59	Near mouth	Marion West, OH
Columbia Ditch				
0.90	S	40 34 45/ 83 09 49	Campbell Rd.	Marion West, OH

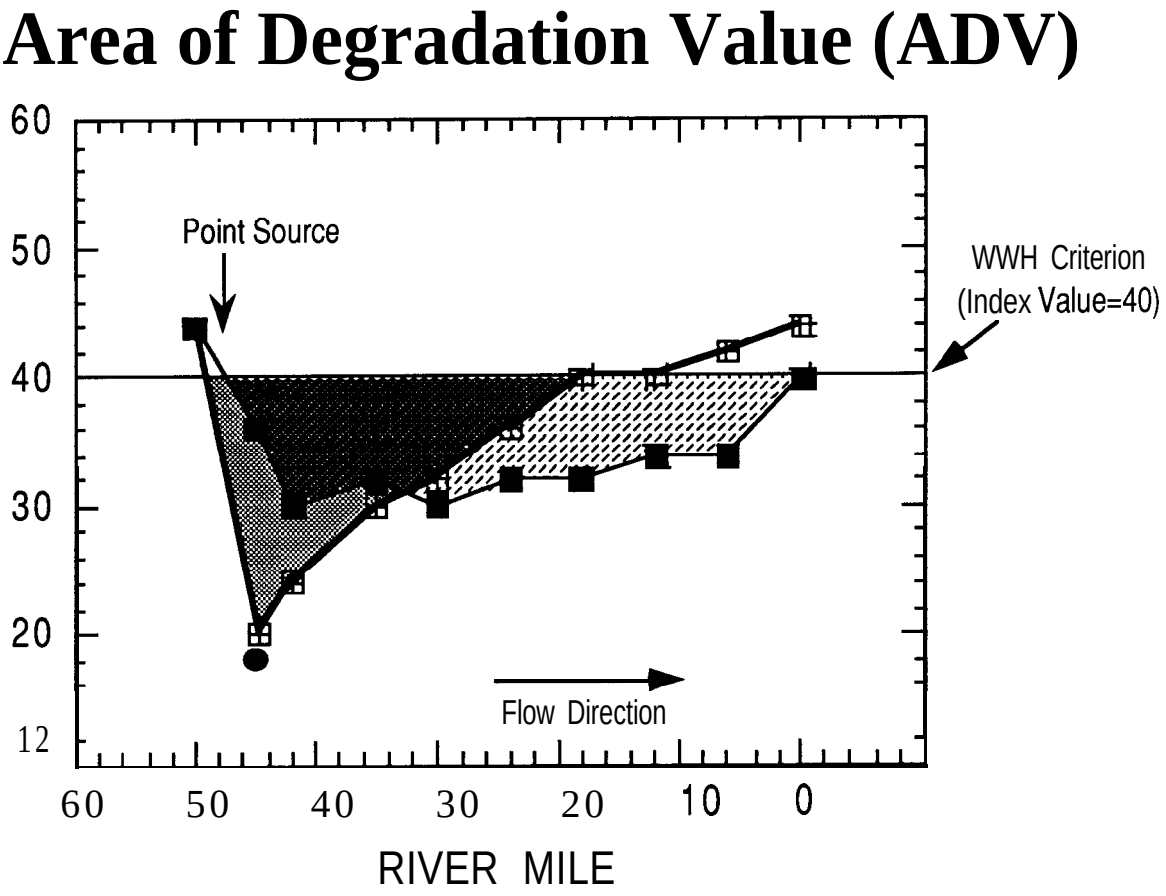

Figure 2. Graphic illustration of the Area of Degradation Value (ADV) based on the ecoregion biocriterion (WWH in this example). The index value trend line indicated by the unfilled boxes and solid shading (area of departure) represents a typical response to a point source impact; the filled boxes and dashed shading (area of departure) represent a typical response to a nonpoint source impact.

RESULTS AND DISCUSSION

Sediment Chemistry

Sediment samples were collected at seven locations in the Little Scioto River, six locations in the Scioto River, two locations in North Rockswale Ditch, two locations in Rockswale Ditch and one location in Columbia Ditch. All sampling locations are indicated by river mile (RM) in Figure 1 and Table 2. Eight of the stations included samples collected at the l-8" depth and samples collected at the 18-24" depth. Each sample was analyzed for volatile organic compounds, semivolatile organic compounds, pesticides, PCBs, and target analyte list compounds (metals and cyanide); specific chemical parameters are listed in appendix A- 1.

- Seventeen polycyclic aromatic hydrocarbons (PAH) were identified and quantified (Table 3) in sediment in the Little Scioto River study area. In addition, 25 tentatively identified compounds (TIC) of PAHs were documented in the Little Scioto River sediments tested at four locations. PAHs which were quantified ranged between 0.33 mg/kg and 221mg/kg, with the highest concentrations occurring between RM 6.5 and RM 4.4 in the Little Scioto River and in the lower 0.1 mile of North Rockswale Ditch.

- Five of the PAH compounds identified in sediments in the Little Scioto River study area have been identified as possible human carcinogens: benzo(a)anthracene, benzo(b)fluoranthene, benzo(a)pyrene, chrysene and dibenzo(a,h)anthracene.

- Four PAH compounds from the Little Scioto River (phenanthrene, fluoranthene, benzo(a)pyrene, and benzo(a)anthracene) were within the range of sediment values associated with areas of epizootics of neoplasia in fish (P. Baumann, pers. comm.).

- PAH sediment contamination extends from RM 7.0 to the mouth of the Little Scioto River (Table 4), in the Scioto River for at least one mile downstream from the Little Scioto River, in the lower 0.1 mile of North Rockswale Ditch and in the upper reach of Rockswale Ditch (RM 2.1).

- In the segment of the Little Scioto River (RM 6.5 - 4.4) highly contaminated with PAHs, the highest concentrations were found at the 18-24" (46-61cm) depth, in comparison to the l-8" (2.52Ocm) depth. Sampling results suggest that PAH contaminants extend deeper than two feet (61cm) below the sediment surface.

- Benzo(a)pyrene, a known mammalian carcinogen with a high carcinogenic potency, has been documented in the past at high concentrations in the Little Scioto River between RM 6.6 and RM 5.8 The 1992 results documented that highly elevated levels of benzo(a)pyrene were also observed as far downstream as RM 4.4 (7.2 mg/kg and 33 mg/kg), and near the mouth of North Rockswale Ditch (9.2 mg/kg and 29.7 mg/kg).

- Twenty-three metals and cyanide were measured in sediment from sampling locations in the Little Scioto River study area. Sixteen of these parameters are presented in Table 5. Generally, the highest metal concentrations occurred in the Little Scioto River between RMs 6.5 and 2.7, in North Rockswale Ditch near the mouth, and in the entirety of Rockswale Ditch. This segment of the Little Scioto River receives discharges of wastewater from the Marion WWTP, combined sewer overflows, Marion landfill leachate and industrial discharges. North Rockswale Ditch receives combined sewer overflows and Rockswale Ditch receives wastewater from the Whirlpool Marion Company and storm sewer discharges.

- Using sediment evaluation criteria developed by Kelly and Hite (1984), the following chemicals and areas are considered highly elevated to extremely elevated above background conditions:

  Cadmium - Little Scioto River from RMs 5.8 to 4.4
  Chromium - Little Scioto River from RMs 6.5 to 0.4, North Rockswale Ditch at RM 0.04, and Rockswale Ditch at RMs 2.1 and 1.0
  Lead - Little Scioto River from RMs 6.5 to 2.7, North Rockswale Ditch at RM 0.3 and 0.04, Rockswale Ditch at RMs 2.1 and 1 .O and Columbia Ditch at RM 0.9
  Mercury - Little Scioto River from RMs 6.5 to 2.7, North Rockswale Ditch at RM 0.04, Rockswale Ditch at RMs 2.1 and 1.0 and Columbia Ditch at RM 0.9
  Zinc - Little Scioto River from RMs 6.5 to 2.7, North Rockswale Ditch at RM 0.3 and 0.04, Rockswale Ditch at RMs 2.1 and 1.0 and Columbia Ditch at RM 0.9

- Several metal concentrations were recorded at extremely elevated levels. Mercury was measured in North Rockswale Ditch at 4.27 mg/kg (RM 0.04) and zinc was measured in Rockswale Ditch at 4580 mg/kg (RM 2.1).

- Twenty-one pesticides were analyzed for in sediment samples from the Little Scioto River study area. Six pesticides were detected (Table 6), with DDT metabolites (4,4'-DDE and 4,4'-DDD) measured at highly elevated levels between RMs 6.5 and 5.8 in the Little Scioto River. One dieldrin sample at RM 6.5 was considered extremely elevated compared to background conditions using evaluation criteria in Kelly and Hite (1984). The highest concentrations of pesticides in sediment occurred in the Little Scioto River at RM 6.5.

- Fourteen volatile organic compounds were detected in sediment samples collected in the Little Scioto River study area. The parameters with the highest concentrations are listed in Table 7. Of particular concern were elevated concentrations of ethylbenzene (4.1 mgkg) and total xylenes (4.4 mg/kg) recorded in the Little Scioto River at RM 4.4. The next highest levels of ethylbenzene (0.34 mg/kg) and total xylenes (0.55 mg/kg) were documented in the sediment of North Rockswale Ditch near the mouth.

- All PCB parameters measured in the study area were reported as not detected above lab quantitation limits.

- Overall sediment quality within the Little Scioto River study area is depicted in Table 4. A significant increase in total PAHs, chromium, lead, zinc, mercury and cadmium in stream sediments occurs in the Little Scioto River downstream from the confluence with North Rockswale Ditch (RM 6.6) and remains relatively high to RM 3.0. This area is influenced by combined sewer overflows in North Rockswale Ditch, a stream bottom which is heavily saturated with a black material with a creosote odor, effluent discharges from the Marion WWTP, and landfill leachate. Significantly elevated levels of zinc were noted in Rockswale Ditch downstream found the Whirlpool Marion effluent discharge (a permitted discharger of zinc). Elevated levels of PAHs, chromium, lead, zinc and mercury were documented in the lower North Rockswale Ditch.

Table 3. PAH contaminant levels in sediment collected from the Little Scioto River study area during 1992 and 1993. ND = not detected above limit of practical quantitation. Levels of practical quantitation varied among sampling locations. NA = not analyzed. TIC = tentatively identified compounds. J = estimated value (below quantitation limit).

	PAHs - mg/kg (ppm) dry weight								
Stream River Mile (Location)	Acenaphthene	Anthracene	Benzo(a)anthracene	Benzo(b)fluoranthene	Benzo(k)fluoranthene	Benzo(ghi)perylene	Benzo(a)pyrene	Chrysene	Dibenzo(a,h)anthracene
Littl Scioto River									
9.48 "(l-8" depth)	ND	ND	ND	ND	ND	ND	ND	ND	ND
7.90 (8-l 2" depth)	ND	ND	ND	ND	ND	ND	ND	ND	ND
6.53 (1-6" depth)	ND	ND	8.2J	18.1	9.9J	49.5	14.8J	16.5	ND
(18-24" depth)	ND	ND	26.4J	118.8	82.5	82.5	125	69.3	33
(Duplicate of 18-24"depth)	ND	ND	20J	52.8	42.9	39.6	59.4	46.9	ND
5.80 (l-6" depth)	5	27.1	16.5	16.8	12.87	11.2	15.8	20.8	4.6
(18-24" depth)	ND	52.8	26.4J	42.9	33	33	46.2	56.1	ND
4.43 (l-8" depth)	4.3	7.9	6.9	6.9	4.6	4.9	7.2	9.9	ND
(18-24" depth)	57.7	66	39.6	37.9	23.1	19.8	33	52.8	ND
2.67 (l-6" depth)	ND	ND	2J	1.6J	ND	ND	ND	1.6J	ND
(18-24" depth)	ND	ND	ND	ND	ND	ND	ND	ND	ND
0.36 (l-6" depth)	ND	3.3	15.8	13.8	10.5	6.9	11.5	ND	3.3
(18-24" depth)	3.3	ND	ND	ND	ND	ND	ND	ND	ND
North Rockswale Ditch									
0.30 (l-6" depth)	ND	ND	1.6J	ND	ND	ND	ND	1.6J	ND
0.04 (l-6" depth)	14.8J	33	24.7	31.3	23.1	16.5	29.7	31.3	ND
(12-18"depth)	10.2	14.2	10.9	9.4	7.6	5.6	9.2	10.9	ND
Rockswale Ditch									
2.15 (l-10" depth)	1.35	3.05	8.65	10.3	3.66	4.33	8.0	9.32	1.0J
1.05 (2-6" depth)	ND	ND	ND	0.5J	ND	0.5J	ND	0.5J	ND
(18-24" depth)	ND	ND	0.33J	0.46J	ND	0.33J	0.33J	0.4J	ND
Columbia Ditch									
0.90 (2-6" depth)	ND	ND	ND	0.83J	ND	ND	0.5J	0.67J	ND
(Duplicate)	ND	ND	0.67J	ND	ND	ND	0.67J	1.0J	ND
Scioto River									
179.60 (2-6" depth)	ND	ND	ND	ND	ND	ND	ND	ND	ND
178.96 (6-12" depth)	ND	ND	ND	ND	ND	ND	ND	ND	ND
178.54 (6-12" depth)	ND	ND	ND	ND	ND	ND	ND	ND	ND
176.96 (2-6" depth)	0.8	3.6	1.8	1.86	0.53J	0.67	1.27	2.0	ND
(18-24" depth)	1.33J	1.65	ND	1.17J	0.5J	1.0J	0.83	1.5J	1.33J
174.22 (6-12" depth)	ND	ND	ND	ND	ND	ND	ND	ND	ND
171.92 (l-6" depth)	ND	ND	ND	ND	ND	ND	ND	ND	ND

Table 3. Continued.

Stream River Mile (Location)	PAHs - mg/kg (ppm) dry weight								
	Dibenzo fllran	Fluor anthene	Fluorene	Indeno (1,2,3cd) PYene	2-Methyl naphth alene	Naphth alene	Phenan threne	Pyrene	TIC PAHs
Little Scioto River									
9.48 (l-8" depth)	ND	***ND***	***ND***	***ND***	***ND***	***ND***	***ND***	***ND***	NA
7.90 (8-12" depth)	ND	***ND***	***ND***	***ND***	***ND***	***ND***	***ND***	***ND***	NA
6.53 (l-6" depth)	ND	8.2J	***ND***	13.2J	***ND***	***ND***	***ND***	***ND***	NA
(18-24" depth)	ND	19.8J	***ND***	119	***ND***	***ND***	***ND***	***ND***	217.8
(Duplicate of 18-24"depth)	ND	26.4J	***ND***	56	***ND***	***ND***	***ND***	16.5J	4.6J
5.80 (l-6" depth)	4.0	37.6	7.0	14.5	***ND***	4.6	24.1	23.8	NA
(18-24" depth)	ND	56.1	ND	42.9	***ND***	ND	19.8J	39.6	6.9J
4.43 (l-8" depth)	2.6J	13.5	4.0	6.6	2.0J	ND	12.9	10.2	NA
(18-24" depth)	34.6	125	62.7	26.4	23.1	9.9J	221	90.7	243.7
2.67 (l-6" depth)	ND	ND	ND	ND	ND	ND	ND	ND	NA
(18-24" depth)	ND	ND	ND	ND	ND	ND	ND	ND	NA
0.36 (l-6" depth)	ND	22.4	ND	10.5	ND	ND	2.6J	17.5	NA
(18-24" depth)	ND	ND	1.6J	ND	ND	ND	ND	ND	NA
North Rockswale Ditch									
0.30 (l-6" depth)	ND	3.0J	ND	ND	ND	ND	2.0J	2.3J	NA
0.04 (l-6" depth)	11.5J	69.3	ND	24.7	8.2J	ND	52.8	51.1	NA
(12-18" depth)	8.6	29.4	12.5	7.9	5.3	3.0J	46.5	23.4	61.8
Rockswale Ditch									
2.15 (I-10" depth)	0.83J	19.65	1.665	5.66	ND	ND	13	17.65	NA
1.05 (2-6" depth)	ND	0.83J	ND	ND	ND	ND	0.5J	0.83J	NA
(18-24" depth)	ND	0.86	ND	0.4J	ND	ND	0.46J	0.6J	NA
Columbia Ditch									
0.90 (2-6" depth)	ND	1.5J	ND	ND	ND	ND	0.83J	1.33J	NA
(Duplicate)	ND	1.83	ND	ND	ND	ND	l.OJ	1.6J	NA
Scioto River									
179.60 (2-6" depth)	ND	ND	ND	ND	ND	ND	ND	ND	NA
178.96 (6-12" depth)	ND	ND	ND	ND	ND	ND	ND	ND	NA
178.54 (6-12" depth)	ND	ND	ND	ND	ND	ND	ND	ND	NA
176.96 (2-6" depth)	0.4J	5.26	1.2	0.73	ND	ND	5.2	4.6	NA
(18-24" depth)	0.5J	5.33	1.65	l.OJ	ND	ND	6.16	4.0	NA
174.22 (6-12" depth)	ND	ND	ND	ND	ND	ND	ND	ND	NA
171.92 (1-6" depth)	ND	ND	ND	ND	ND	ND	ND	ND	NA

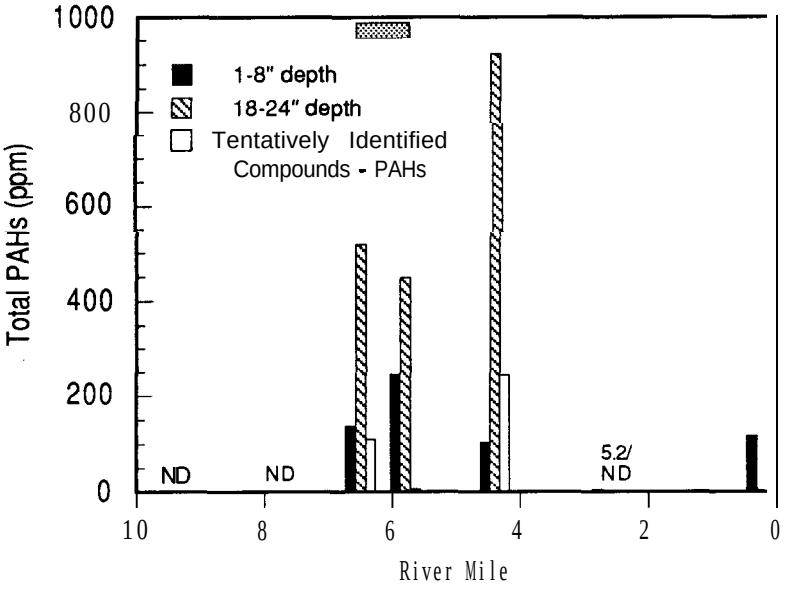

Figure 3. Summary of sediment PAH levels in the Little Scioto River during 1992. The shaded bar at top represents an area which encompasses the North Rockswale Ditch discharge, Union Tank Car Co., Marion WWTP effluent discharge, combined sewer overflows, and the Marion City landfill. Baker Wood Preserving Co. (abandoned) is located 0.5 miles east of North Rockswale Ditch.

Table 4. Summary of median PAH and metal concentrations (minimum and maximum in parentheses) in sediment from the Little Scioto River study area. Samples were collected by Ohio EPA in 1988, 1991, 1992 and 1993. ND - not detected.

	SEDIMENT (mg/kg)					
Stream Segment	**Total PAHs**	**Total Chromium**	**Total Lead**	**Total Zinc**	**Total Mercury**	**Total Cadmium**
Little Scioto River						
RM 9.5-7.2 (Background)	ND (ND)	7.1 (5.8/13.6)	ND (<10/19.1)	54.8 (30.6/79.0)	<O.10 (<O. 10)	<l.O (<l.O)
RM 7.2-6.6 (Dst. Waterworks)	105	13.2	25.5	NA	<O.10	<1.0
RM 6.6-3.0 (Dst. N. Rockswale D., CSOs, Marion WWTP, Marion Landfill, Union Tank Car, Creosote Contamination)	448.8 (104/3235)	117.4 (39.2/415)	105 (59.5/175.5)	174 (141/226)	0.37 (0.16/0.79)	1.8 (<1.0/10.5)
RM 3.0-0.0 (Dst. Rockswale Ditch)	5.2 (ND/ l18.1)	48.6 (5.32/134)	84.4 (16.1/160)	181 (43/760)	ND (<0.10/0.29)	1.0 (<1.0/4.39)
North Rockswale Ditch						
RM 1.4-0.6 (Background)	ND (ND)	6.3 (5.4/7.2)	13.3 (12.4/14.2)	NA	<O.10 (<O. 10)	<l.O (<l.O)
RM 0.6-0.0 (CSO, Union Tank Car)	117.3 (10.5/422)	95.1 (23.0/259)	154.2 (75.8/223)	198 (180/238)	0.3 (<0.10/4.27)	ND (<1.0/2.10)
Rockswale Ditch						
RM 2.2-0.0 (Dst Industrial Discharges)	4.17 (3.66/108.0)	127 (113/258)	166 (129/601)	800 (640/4580)	0.20 (0.20/0.23)	1.2 (<1.0/1.44)
Columbia Ditch						
RM 1.0-0.0 (Dst. CSOs)	6.25	27.9	101.5	223	0.17	<l.0
Scioto River						
RM 180-177.3 (Background)	ND (ND)	13.5 (8.5/14.2)	13.3 (10.9/15.1)	69.8 (46.2/70.0)	<O.lO (<O. 10)	<l.O (<l.O)
RM 177.3-176 (Dst. Little Scioto R.)	27.95 (17.54/29.92)	29.5 (13.1/32.2)	35.4 (22.4/53)	97.4 (70.2/187)	<O.lO (<O. 10)	<l.O (<1.0/1.43)
RM 176-171.9 (Prospect Impoundment)	ND (ND)	7.66 (7.30/8.02)	ND (<10/13.6)	47.9 (36.7/59.2)	ND (<0.10/O. 13)	<l.O (<l.O)

Table 5. Metal and cyanide contaminant levels in sediment collected from the Little Scioto River study area, 1992 and 1993. Sediment evaluations were based upon criteria in Kelly and Hite (1984). Evaluations with two letters (e.g. a and b) indicates that the reported less than value could be either non-elevated or slightly elevated.

Stream River Mile (Location)	METALS/ CYANIDE - mg/kg (ppm) dry weight								
	Cyanide	Arsenic	Barium	Cadmium	Chromium	Cobalt	Copper	Lead	Mercury
Little Scioto River									
9.48 (1-8" depth)	<l.O	<10.0 a,b	47.6	<l.0 a,b	7.34 a	3.02	7.44 a	12.1 a	<0.10 a,b
7.90 (8-12" depth)	<l.O	12.4 c	79.8	<l.O a,b	13.6 a	7.30	17.2 a	19.1 a	<0.10 a,b
6.53 (l-6" depth)	<l.O	<10.0 a,b	77.8	<l.O a,b	208e	3.00	79.0 c	***172e***	***0.33e***
(18-24" depth)	<l.O	10.3 b	76.2	<l.O a,b	92.8e	3.18	71.6 c	147e	0.42e
(Duplicate of 18-24"depth)	<l.O	<10.0 a,b	81.4	1.04 c	142e	3.68	66.8 c	173e	0.39e
5.80 (l-6" depth)	<l.O	13.8 c	85.6	<l.O a,b	60.9e	5.62	56.0 b	84.6d	0.24d
(18-24" depth)	<l.O	14.5 c	104	3.52d	73.8e	4.60	79.8 c	105e	0.46e
4.43 (l-8" depth)	<l.O	11.3 c	139	10.5d	302e	3.36	76.8 c	93.4d	0.79e
(18-24" depth)	<l.O	10.4 b	117	5.64d	179e	5.80	88.4 c	76.4d	0.48e
2.67 (l-6" depth)	<l.O	<10.0 a,b	91.0	1.0 c	71.2e	5.46	42.4 b	108e	0.12 c
(18-24" depth)	<l.O	13.2 c	91.0	<l.O a,b	13.0 a	6.10	73.2 c	84.4d	0.29d
0.36 (l-6" depth)	<l.O	<IO.0 a,b	60.0	1.56 c	48.6d	5.34	24.5 a	38.0 c	<O.lO a,b
(18-24" depth)	<l.O	<10.0 a,b	20.2	<l.0 a,b	5.32 a	4.62	10.1 a	16.1 a	<O.lO a,b
North Rockswale Ditch									
0.30 (1-6" depth)	<l.O	<10.0 a,b	53.4	<l.0 a,b	23.0 c	4.04	64.1 c	75.8d	<O.lO a,b
0.04 (l-6" depth)	<l.O	<10.0 a,b	109	<l.0 a,b	155e	6.14	59.2 b	211e	4.27e
(12-18"depth)	3.5	10.2 b	90.2	2.10	259e	3.84	66.5 c	223e	0.49 e
Rockswale Ditch									
2.15 (l-10" depth)	<l.O	<10.0 a,b	90.7	1.44 c	238e	3.26	91.4 c	601e	0.23d
1.05 (2-6" depth)	<l.O	10.9 b	95.4	<I.0 a,b	127e	6.34	51.7 b	163e	0.20d
(18-24" depth)	<l.O	<10.0 a,b	120	1.20 c	116e	8.74	63.0c	166e	0.20d
Columbia Ditch									
0.90 (2-6" depth)	<l.O	<10.0 a,b	67.3	<l.O a,b	27.2 c	3.92	56.0 b	103e	0.19d
(Duplicate)	<l.O	<10.0 a,b	65.2	<l.0 a,b	28.6 c	3.80	55.0 b	1OOe	0.15c
Scioto River									
179.60 (2-6" depth)	<l.O	10.2 b	39.0	<l.O a,b	8.5 a	5.92	14.4 a	10.9 a	<0.10 a,b
178.96 (6-12" depth)	<l.O	10.0 b	65.7	<l.O a,b	14.2 a	7.40	18.1 a	15.1 a	<0.10 a,b
178.54 (6-12" depth)	<l.O	<10.0 a,b	62.9	<l.0 a,b	13.5 a	6.14	17.6 a	13.3 a	<O.lO a,b
176.96 (2-6" depth)	<l.O	11.1 c	60.8	<l.0 a,b	32.2 c	5.92	28.7 a	35.4 b	<0.10 a,b
(18-24" depth)	<l.O	10.0 b	63.3	<l.0 a,b	13.1 a	6.68	22.6 a	22.4 a	<0.10 a,b
174.22 (6-12" depth)	<l.O	<10.0 a,b	36.2	<l.O a,b	8.02 a	5.80	19.4 a	13.6 a	0.13 c
171.92 (l-6" depth)	<l.O	<10.0 a,b	49.1	<l.0 a,b	7.30 a	3.72	15.3 a	< lO.O a	<O.lO a,b

Table 5. Continued.

Stream River Mile (Location)	METALS/ CYANIDE - mg/kg (ppm) dry weight						
	Manganese	Nickel	Selenium	Silver	Vanadium	Zinc	Thallium
Little Scioto River							
9.48 (1-8" depth)	96.6 a	9.36	<lO.O	<2.0	9.92	30.6 a	<lO.O
7.90 (8-12" depth)	143 a	22.6	<lO.O	<2.0	23.0	79.0 a	<lO.O
6.53 (l-6" depth)	133 a	12.6	<lO.O	<2.0	12.1	**173** d	<lO.O
(18-24" depth)	123 a	14.4	<lO.O	<2.0	9.96	136c	<lO.O
(Duplicate of 18-24"depth)	131 a	13.9	<lO.O	<2.0	10.5	**178** d	<lO.O
5.80 (l-6" depth)	188 a	20.9	<lO.O	<2.0	15.3	141 c	<lO.O
(18-24" depth)	164a	34.5	<IO.0	<2.0	16.1	**174 d**	<lO.O
4.43 (l-8" depth)	118	46.3	<lO.O	5.12	13.4	226 **d**	<lO.O
(18-24" depth)	156 a	55.2	<IO.0	<2.0	19.3	188 **d**	<lO.O
2.67 (l-6" depth)	266 a	35.2	<lO.O	<2.0	20.2	408 e	< 10.0
(18-24" depth)	120 a	18.8	<lO.O	<2.0	18.0	**181 d**	<lO.O
0.36 (l-6" depth)	147 a	34.3	<lO.O	<2.0	9.96	96.8 b	<lO.O
(18-24" depth)	109 a	10.6	<lO.O	<2.0	8.20	43.0 a	< 10.0
North Rockswale Ditch							
0.30 (l-6" depth)	131 a	17.1	<lO.O	<2.0	12.3	**180 d**	< 10.0
0.04 (l-6" depth)	171 a	21.4	<lO.O	<2.0	15.1	**198 d**	<lO.O
(12-18"depth)	137 a	15.5	<lO.O	<2.0	12.8	238 **d**	<lO.O
Rockswale Ditch							
2.15 (l-10" depth)	195 a	116	<lO.O	<2.0	5.18	4580 e	<lO.O
1.05 (2-6" depth)	275 a	78.9	<IO.0	<2.0	11.6	640 e	< 10.0
(18-24" depth)	221 a	26.1	<lO.O	<2.0	14.7	651 e	<lO.O
Columbia Ditch							
0.90 (2-6" depth)	202 a	15.5	<lO.O	<2.0	9.62	195 **d**	<lO.O
(Duplicate)	193 a	16.2	<IO.0	<2.0	9.94	**251 d**	<IO.0
Scioto River							
179.60 (2-6" depth)	154 a	16.0	<lO.O	<2.0	12.1	46.2 a	<lO.O
178.96 (6- 12" depth)	253 a	22.4	<lO.O	<2.0	21.2	70.0 a	<lO.O
178.54 (6-12" depth)	200 a	17.8	<lO.O	<2.0	19.2	69.8 a	<lO.O
176.96 (2-6" depth)	208 a	20.0	<lO.O	<2.0	14.7	97.4 b	<lO.O
(18-24" depth)	203 a	18.5	<lO.O	<2.0	17.2	70.2 a	<lO.O
174.22 (6-12" depth)	149 a	13.5	<lO.O	<2.0	11.4	59.2 a	< 10.0
171.92 (l-6" depth)	109 a	12.9	<lO.O	<2.0	10.9	36.7 a	<lO.O

a - non elevated; b - slightly elevated; c - elevated; d - highly elevated; e - extreme.
Arsenic: a <8.0, b >8.0, c > 11; Cadmium: a <0.5, b >0.5, c >1.0; Mercury: a <0.07, b >0.07, c >O.lO.

Table 6. Pesticide contaminant levels in sediment collected from the Little Scioto River study area, 1992 and 1993. Sediment evaluations were based upon criteria in Kelly and Hite (1984). Evaluations of DDT were based on the sum of the metabolites DDD and DDE. ND - not detected.

	PESTICIDES - ug/kg (ppb) dry weight					
Stream River Mile (Location)	Aldrin	4,4'-DDD	Endrin Ketone	Methoxychlor	4,4'-DDE	Dieldrin
Little Scioto River						
9.48 (l-8" depth)	ND	ND	ND	ND	ND	ND
7.90 (8-12" depth)	ND	ND	ND	ND	ND	ND
6.53 (l-6" depth)	57J	170 d	120J	300J	ND	ND
(18-24" depth)	ND	ND	ND	370J	ND	ND
(Duplicate of 18-24"depth)	47J	ND	130J	440J	47J d	47J e
5.80 (l-6" depth)	23	28 d	54	150	13J d	ND
(18-24" depth)	ND	ND	ND	ND	ND	ND
4.43 (l-8" depth)	ND	ND	ND	ND	ND	ND
(18-24" depth)	15	ND	ND	ND	ND	ND
2.67 (l-6" depth)	ND	ND	ND	ND	ND	ND
(18-24" depth)	ND	ND	ND	ND	ND	ND
0.36 (l-6" depth)	ND	ND	ND	ND	ND	ND
(18-24" depth)	ND	ND	ND	ND	ND	ND
North Rockswale Ditch						
0.30 (l-6" depth)	ND	ND	ND	ND	ND	ND
0.04 (l-6" depth)	ND	ND	ND	ND	ND	ND
(12-18" depth)	ND	ND	ND	ND	ND	ND
Rockswale Ditch						
2.15 (l-10" depth)	15	30 c	ND	ND	ND	3J a
1.05 (2-6" depth)	ND	ND	ND	ND	ND	ND
(18-24" depth)	ND	ND	ND	ND	ND	ND
Columbia Ditch						
0.90 (2-6" depth)	ND	ND	ND	ND	ND	ND
(Duplicate)	ND	ND	ND	ND	ND	ND
Scioto River						
179.60 (2-6" depth)	ND	ND	ND	ND	ND	ND
178.96 (6-12" depth)	ND	ND	ND	ND	ND	ND
178.54 (6-12" depth)	ND	ND	ND	ND	ND	ND
176.96 (2-6" depth)	ND	ND	ND	ND	ND	ND
(18-24" depth)	ND	ND	ND	ND	ND	ND
174.22 (6-12" depth)	ND	ND	ND	ND	ND	ND
171.92 (l-6" depth)	ND	ND	ND	ND	ND	ND

a - non elevated, b - slightly elevated; c - elevated; d - highly elevated; e - extreme.
J - estimated value (below quantitation limit).

Table 7. Select volatile organic compound concentrations in sediment collected from the Little Scioto River study area, 1992 and 1993. ND - not detected

Streaq River Mile (Location)	VOLATILE ORGANICS - mg/kg (ppm) dry weight					
	Acetone	Ethylbenzene	Toluene	Total Xylenes	Tetrachloroethene	Benzene
Little Scioto River						
9.48 (l-8" depth)	0.021J	ND	ND	ND	ND	ND
7.90 (8-12" depth)	0.015J	ND	ND	ND	ND	ND
6.53 (l-6" depth)	0.037J	ND	ND	ND	0.002J	ND
(18-24" depth)	0.150	0.037	0.023	0.110	0.012	0.004J
(Duplicate of 18-24"depth)	0.090	0.150	0.037	0.310	0.030	0.006
5.80 (l-6" depth)	0.024J	0.004J	0.005	ND	0.008	ND
(18-24" depth)	0.072	ND	ND	ND	ND	ND
4.43 (l-8" depth)	O.lOOJ	0.260	ND	0.235	ND	ND
(18-24"depth)	ND	4.1	ND	4.4	ND	ND
2.67 (l-6" depth)	0.035J	ND	ND	ND	ND	ND
(18-24" depth)	0.047J	ND	ND	ND	ND	ND
0.36 (l-6" depth)	0.02OJ	ND	ND	ND	ND	ND
(18-24" depth)	0.032J	ND	ND	ND	ND	ND
North Rockswale Ditch						
0.30 (l-6" depth)	0.037J	ND	ND	ND	ND	ND
0.04 (l-6" depth)	0.250	0.340	0.055	0.550	ND	0.025
(12-18" depth)	0.15OJ	0.075	0.060	0.210	ND	0.020J
Rockswale Ditch						
2.15 (l-10" depth)	0.120	ND	ND	0.016	0.010	ND
1.05 (2-6" depth)	0.050	ND	ND	ND	ND	ND
(18-24" depth)	0.035J	ND	ND	ND	ND	ND
Columbia Ditch						
0.90 (2-6" depth)	0.047J	ND	0.014	ND	ND	ND
(Duplicate)	0.034J	ND	0.014	ND	ND	ND
Scioto River						
179.60 (2-6" depth)	0.023J	ND	ND	ND	ND	ND
178.96 (6-12" depth)	ND	ND	ND	ND	ND	ND
178.54 (6-12" depth)	0.047J	ND	ND	ND	ND	ND
176.96 (2-6" depth)	0.03 1J	ND	ND	ND	ND	ND
(18-24" depth)	0.065	ND	ND	ND	ND	ND
174.22 (6-12" depth)	0.047J	ND	ND	ND	ND	ND
171.92 (l-6" depth)	0.17OJ	ND	ND	ND	ND	ND

J - estimated value (below quantitation limit).

Pollutant Loadings 1977-1992

- Marion operates an advanced nitrification wastewater treatment plant (OEPA permit number 2PDOOOll) with an average design flow of 10.5 million gallons per day (MGD). The final effluent from the plant enters the Little Scioto River at RM 6.42. The city implements an approved industrial pretreatment program, with one categorical industrial user (metal finisher) and eight non-categorical users. The collection system contains approximately 50% combined sewers, with three combined sewer overflows (CSOs). These overflows are permitted to discharge during wet weather periods and have monitoring requirements. One CSO is located on North Rockswale Ditch at RM 0.6 (Holland Rd.) and one is located on Columbia Ditch at RM 1.2 (Fies Ave.). The plant also has an influent bypass. Current summer 30-day average permit limits for ammonia-N and CBOD5 are 1.0 mg/l (40 kg/day) and 10 mg/l (398 kg/day), respectively.

- 1977 - 1992 loading trends of three pollutants discharged to the Little Scioto River from the Marion WWTP 001 effluent (mean annual kg/day) are shown in Figure 4. No clear trends are evident in the loadings of total nonfilterable residue and BOD5 from the Marion WWTP between 1977 and 1992. Ammonia-N values were generally low, with 50th percentile loadings values below 10 kg/day between 1977 and 1991. The highest ammonia-N loading occurred during 1992, with a 50th percentile value of 12.6 kg/day.

- The Whirlpool Marion Co. manufactures laundry dryers and microwave ovens. Industrial waste from the plant process consists of alkaline cleaners, zinc phosphate, iron precipitates and chromium. The wastewater treatment process consists of flow equalization, oil & grease separation, chemical coagulation and clarification for removal of phosphates, chromium and zinc. The 001 outfall consists of process and noncontact cooling water; the 002 outfall consists of untreated stormwater runoff. An average of 0.357 MGD of treated wastewater (Ohio EPA # 2lCOOOO9) is discharged to Rockswale Ditch at RM 2.2

- 1977 - 1992 loading trends of three pollutants discharged to Rockswale Ditch from the Whirlpool-Marion 001 effluent (mean annual kg/day) are shown in Figure 5. Total nonfilterable residue has shown an increase in loadings over the 1977 to 1992 time period; however, overall loadings of total nonfilterable residue into Rockswale Ditch is substantially lower than the Marion 001 discharge. No clear trends were apparent in the BOD5 or zinc loadings over the 1977 to 1992 period. The second lowest yearly loading of zinc from the Whirlpool-Marion effluent occurred during 1992.

- Parker Hannifan Corp. (Stratoflex/ B.F. Goodrich) discharges sanitary wastewater (outfal1 001) into the Little Scioto River at RM 1 .OO. The wastewater plant (Ohio EPA permit number 2lROOOOO) has an average design flow of 0.015 MGD, substantially less than the Marion WWTP and Whirlpool-Marion facility. Between 1977 and 1992, total nonfilterable residue loadings were all less than 0.3 kg/day (50th percentile) and 1.6 kg/day (95th percentile), and BOD5 loadings were less than 0.2 kg/day (50th percentile) and 3.0 kg/day (95th percentile). Loadings of BOD5 and total nonfilterable residue from the Parker Hannifan Corp. comprised less than one percent of the total load into the Little Scioto River.

- An evaluation of Marion WWTP influent bypass data during 1992 revealed a significant contribution of ammonia-N, BOD5 and total nonfilterable residue loadings into the Little

Scioto River. Mean 1992 influent bypass loadings of ammonia-N (30 kg/day), BOD5 (158 kg/day) and total nonfilterable residue (133 kg/day) comprised 50%, 32%, and 59%, respectively, of the total known load to the Little Scioto River during 1992 (this does not include potential loadings from the CSO at Holland Rd.).

· List of spills are also an indication of possible impacts due to pollutant loadings. A. listing of spills to the Little Scioto River and Rockswale Ditch is detailed in Table 8. Primary pollutants reported in spills included dyes (6), oil (4), paint/ paint waste (3) and diesel fuel (2). Leading sources of spills were Quaker Oats, Whirlpool-Marion and Eaton Company. While the frequency of reported spills appears to be low, the types of substances can pose a substantial risk of adverse ecological impacts.

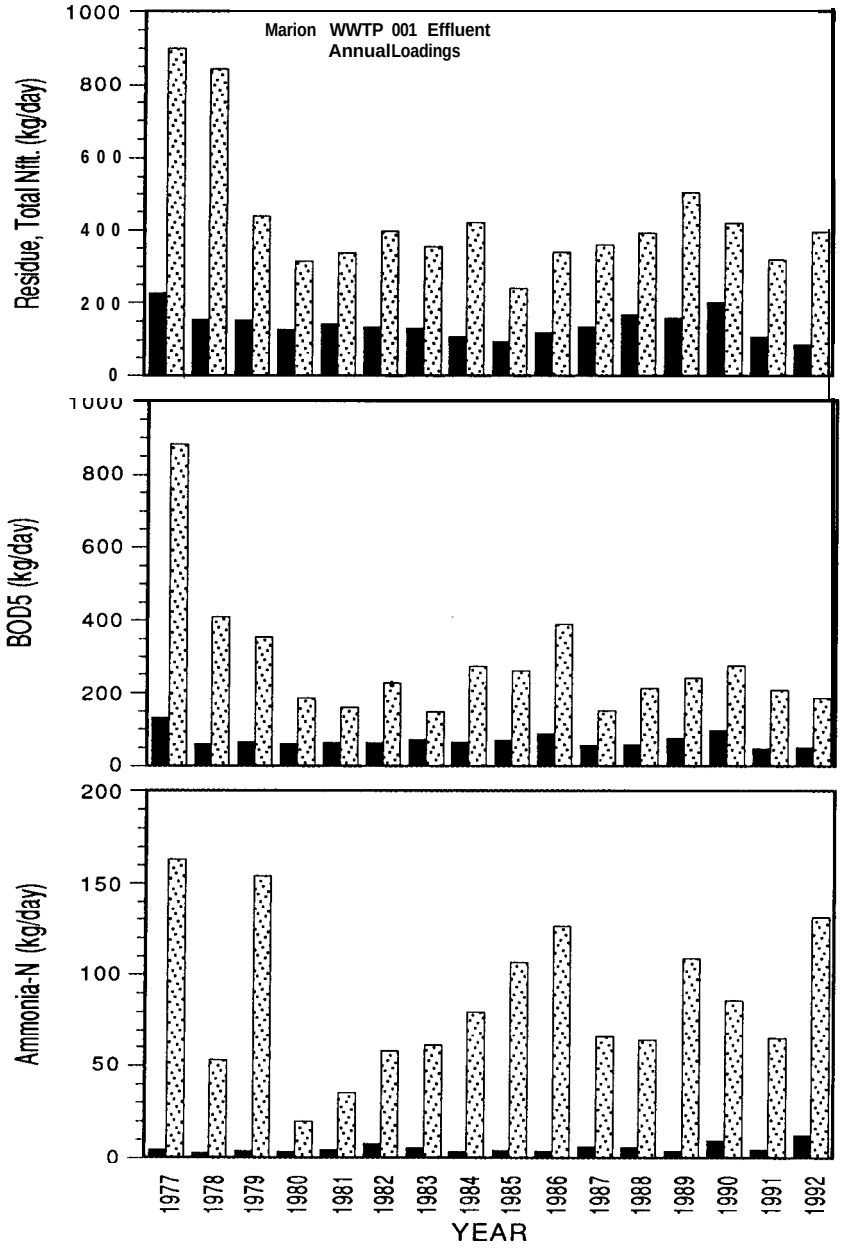

Figure 4. Loadings (kg/day) of total nonfilterable residue, biochemical oxygen demand (BOD5) and ammonia-nitrogen from the Marion WWTP 001 effluent to the Little Scioto River from 1977 to 1992. 50th percentile is a solid bar, 95th percentile is a dotted bar.

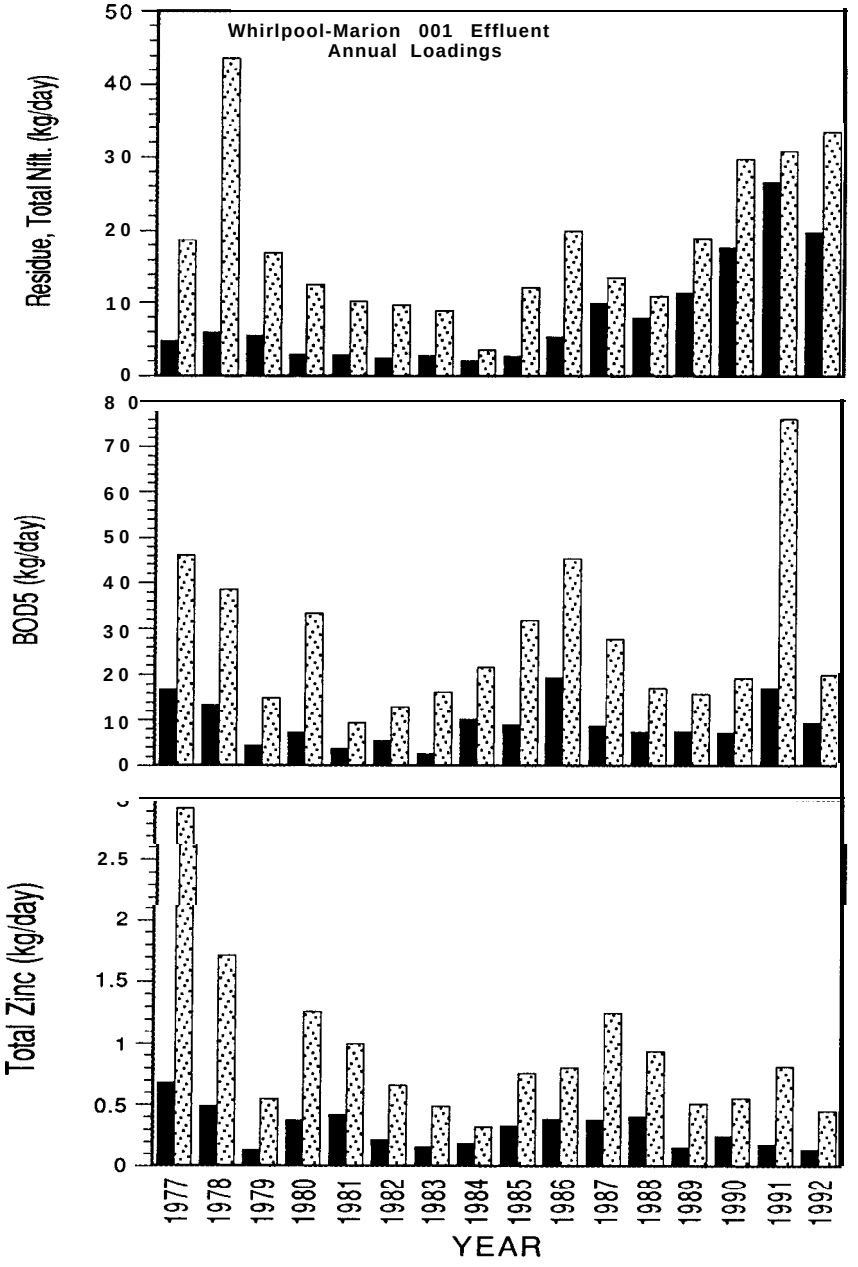

Figure 5. Loadings (kg/day) of total nonfilterable residue, biochemical oxygen demand (BOD5) and total zinc from the Whirlpool-Marion 001 effluent to Rockswale Ditch from 1977 to 1992. 50th percentile values are solid bars, 95th percentile values are dotted bars.

Table 8. Summary of pollutant discharges (spills) to the Little Scioto River and Rockswale Ditch reported to the Ohio EPA Division of Emergency and Remedial Response from January 1982 - December 1992.

Date	Material	Entity	Amount
Little Scioto River			
08MAR82	mercury	Marion	unknown
26JUL83	red food dye	Quaker Oats Co.	unknown
OCT83	red dye	Quaker Oats Co.	unknown
050CT84	wastewater	Union Tank Car Co.	214,000 gal.
FEB85	sewage sludge	Marion WWTP	unknown
MAY85	fluorescent dye	Marion Power	unknown
13JUN86	red dye	Quaker Oats Co.	unknown
22JAN87	red dye #40	Quaker Oats Co.	unknown
17DEC87	red dye #40	Quaker Oats Co.	200 gal.
16AUG89	diesel fuel	Marion Power	250 gal.
23FEB90	garbage	Marion	unknown
Rockswale Ditch			
18APR84	Oil	Eaton/ Whirlpool	unknown
22MAY85	diesel fuel	Signal Delivery	1,000 gal.
29JUN85	cutting oil	Whirlpool	unknown
OlMAY86	resisto coat #39	Marion Precision	70 gal.
23DEC86	soluble oil	Eaton Co.	150 gal.
24JUL87	paint waste	Whirlpool Corp.	100 gal.
07AUG87	soluble oil	Eaton Co.	100 gal.
17FEB88	xylene	Whirlpool Co.	4,000 gal.
20FEB88	paint	Whirlpool Co.	50 gal.
lOJUL90	paint	Whirlpool Co.	unknown

Surface Water Chemical Quality

Surface water samples were collected in the Little Scioto River on September 28, 1992. Results are presented in Table 9.

- Notable increases in nutrient concentrations were observed in the Little Scioto River downstream from the Marion WWTP 001 effluent discharge. Total phosphorus measured upstream from the Marion WWTP ranged between 0.06 mg/l and 0.09 mg/l; downstream values ranged between 1.34 mg/l and 2.17 mg/l. Increases in BOD5 (2.3 mg/l upstream, 4.7 mg/l downstream) and nitrate-nitrite (0.81 mg/l upstream, 8.07 mg/l downstream) were also observed downstream from the Marion WWTP discharge.

- A substantial increase in ammonia-N in the Little Scioto River occurred downstream from the Marion WWTP. Sample results upstream from Marion ranged between <0.05 mg/l and 0.2 mg/l; downstream values ranged between 0.58 mg/l and 2.10 mg/l. Nitrite-N concentrations were elevated downstream from the Marion WWTP, with values ranging between 0.34 mg/l and 0.65 mg/l (upstream values ranged between 0.02 mg/l and 0.05 mg/l).

- Results for arsenic, cadmium, chromium, copper, lead , nickel and zinc were low at all sampling locations, with most values reported as below lab detection limits. None of these parameters exceeded Ohio Water Quality Criteria.

- Continuous dissolved oxygen data was collected at six locations in the Little Scioto River during October 6-8, 1992 (Figure 6). The Ohio Water Quality Standards for the WWH aquatic life use apply to the Little Scioto River upstream from the channelized section (upstream from RM 9.0). Modified Warmwater Habitat criteria apply to the channelized section of the Little Scioto River (RM 9.0 to 0.0). Violations of the WWH dissolved oxygen WQS were not detected at RM 9.2. A distinct decline in dissolved oxygen did occur downstream from RM 9.2 (within the MWH designated area). Part of the decline was attributed to low instream flow conditions, along with the virtual absence of riffles (areas of stream reaeration). However, a further decline in dissolved oxygen (D.O.) levels occurred downstream from the Marion WWTP at RM 2.67, where violations of the MWH 24-hour average D.O. criteria of 4.0 mg/l were documented (Figure 6). Over 75% of the D.O. measurements taken at RM 2.67 were below 4.0 mg/l. Likely causes for the decline in dissolved oxygen include excessive loadings from the Marion WWTP bypasses, and sediment oxygen demand from the oil contaminated sediments.

Table 9. Surface water chemical sampling results from the Little Scioto River collected on September 28, 1992.

Parameter	RM 9.23	RM 7.90	RM 6.53	RM 5.80	RM 4.43	RM 2.67	RM 0.36
Arsenic, T (ug/l)	<2	2	<2	<2	<2	2	3
Cadmium, T (ug/l)	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Chromium, T (ug/l)	<30	<30	<30	<30	<30	<30	<30
Copper, T (ug/l)	<10	<10	15	<10	<10	<10	<10
Lead, T (ug/l)	<2	<2	3	3	<2	<2	<2
Nickel, T (ug/l)	<40	<40	<40	<40	<40	<40	<40
Zinc, T (ug/l)	<10	<10	<10	18	12	13	<10
Hardness, T $CaCO_3$ (mg/l)	329	327	389	278	280	306	320
BOD_5 (mg/l)	1.0	1.0	2.3	4.7	4.2	3.5	2.2
Nitrate-Nitrite,N (mg/l)	1.22	1.44	0.81	8.07	6.59	4.47	4.47
Nitrite, N (mg/l)	0.02	0.02	0.05	0.65	0.65	0.51	0.34
Ammonia-N (mg/l)	<0.05	<0.05	0.12	1.16	1.44	2.10	0.58
Phenolics (ug/l)	12	12	12	<10	<10	<10	10
Phosphorus, T (mg/l)	0.06	0.07	0.09	2.17	1.96	1.80	1.34

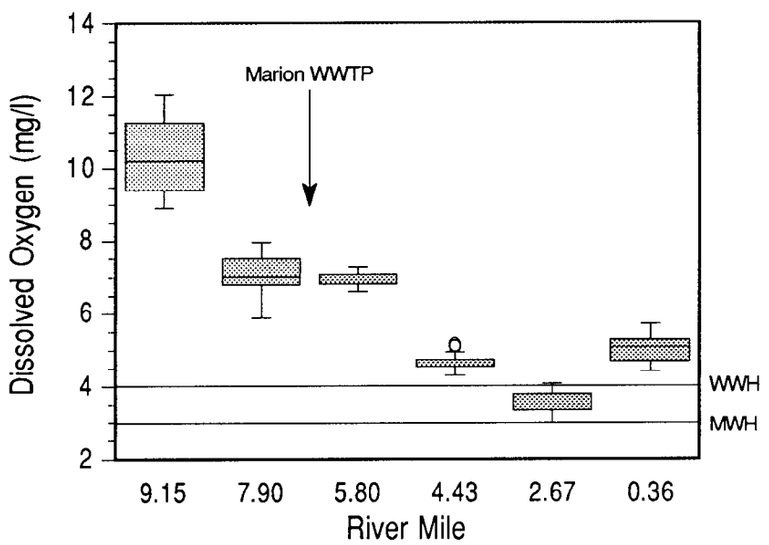

Figure 6. Boxplots of dissolved oxygen data (mg/l) recorded with Datasonde continuous monitors at six locations in the Little Scioto River during October 6-8, 1992. The minimum D.O. criteria for the WWH (4 mg/l) and MWH (3 mg/l) use designations are indicated by horizontal lines. The *24 hour average* D.O. criteria for MWH is 4 mg/l.

Physical Habitat for Aquatic Life

Physical habitat was evaluated in the Little Scioto River at biological sampling locations (RM 9.2 - 0.3). Qualitative Habitat Evaluation Index (QHEI) scores in the Little Scioto River are detailed in Table 10. The Little Scioto River from RM 9.0 to the mouth was extensively modified in the early 1900's.

- Stream morphology in the natural section of the Little Scioto River (RM 9.2) consisted of pool, riffle, and run areas. Bottom substrates were predominated by cobble and sand, with lesser amounts of exposed bedrock, boulders and gravel. The QHEI score at RM 9.2 was 76, reflective of good to very good stream habitat. The total number of WWH attributes was considerably higher than the total of MWH attributes.

- Physical habitat in the Little Scioto River within the lower nine miles consisted of 100 percent pool and glide areas. This section of the Little Scioto River was extensively modified in the early 1900's and the 80+ year old channelization reflects the long term nature and slow recovery potential in this low gradient stream. Bottom substrates were predominated by muck, silt and sand with detritus material (sticks, branches) common. QHEI scores in the lower Little Scioto River ranged between 38.5 and 42.5. The lower section of the Little Scioto River generally had a moderate width of trees along both stream banks, instream cover was sparse to moderate and bottom substrates were extensively embedded. The total number of MWH attributes were considerably higher than the total of WWH attributes.

- Below the surface layer of sediments, the bottom and banks of the Little Scioto River between RM 6.6 and 4.4 were observed to be heavily saturated with a black material with a creosote odor. Disturbance of the bottom sediments released an oily substance which created an extensive oil sheen on the surface of the water.

Table 10. Qualitative Habitat Evaluation Index (QHEI) matrix showing modified and warmwater habitat characteristics for the Little Scioto River, August - October, 1992.

Key QHEI Components			WWH Attributes										MWH Attributes																											
													High Influence										Moderate Influence																			
River Mile	QHEI	Gradient (ft/mile)	No Channelization or Recovered	Boulder/Cobble/Gravel Substrates	Silt Free Substrates	Good/Excellent Substrates	Moderate/High Sinuosity	Extensive/Moderate Cover	Fast Current/ Eddies	Low/Normal Embeddedness	Max Depth > 40 cm	Low/No Riffle Embeddedness	Total WWH Attributes	Channelized or No Recovery	Silt/Muck Substrates	Low Sinuosity	Sparse/No Cover	Max Depth < 40 cm (WD,HW)	Total H.I. MWH Attributes	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
(02-158) – Little Scioto River																																							
Year: 92																																							
9.2	76.0	2.8	■	■	■	■	■	■	■	■	■	■	9						0	▲											1	.10	.20
7.9	42.5	1.5					■				■		2	●	●				2	▲	▲		▲	▲		▲	▲		▲		7	1.00	3.33
6.5	38.5	1.5					■				■		2	●	●				2	▲	▲		▲	▲		▲	▲		▲		7	1.00	3.33
5.7	40.0	1.5					■				■		2	●	●				2	▲	▲		▲	▲		▲	▲		▲		7	1.00	3.33
4.4	39.0	.3					■				■		2	●	●				2	▲	▲		▲	▲		▲	▲		▲		7	1.00	3.33
2.7	42.0	.3					■				■		2	●	●				2	▲	▲		▲	▲		▲	▲		▲		7	1.00	3.33
.3	38.5	.3									■		1	●	●				2	▲	▲		▲	▲		▲	▲		▲		7	1.50	5.00

Macroinvertebrate Community

The macroinvertebrate community was sampled at seven sites in the Little Scioto River during August and September 1992. Results are presented in Table 11.

- The Hillman-Ford Road site (RM 9.2) is a regional reference site. The site performed above the WWH ICI criterion with a score of 38. The benthic macroinvertebrate community was predominated by Ephemeroptera (mayflies) in particular individuals of the genus *Stenucron.*

- The benthic macroinvertebrate community was impaired in the Little Scioto River at river mile 7.9. The ICI score was 16, within the fair range, but failing to perform above the MWH ICI criterion. Overall, the benthic macroinvertebrate community was predominated by Chironomidae (midges); however, high numbers of the mayfly genus *Stenacron* made it the single most predominant taxon. The most noticeable change at this site compared with RM 9.2 was the decreased diversity of mayfly taxa (7 to 2) and caddisfly taxa (4 to 0). This, most likely, is due to the loss of habitat heterogeneity and current velocity in this channelized reach of the river.

- The benthic macroinvertebrate fauna in Little Scioto River from RM 6.5 to RM 0.4 is indicative of highly impaired conditions with ICI scores in the poor range at RMs 6.5,5.7 and 4.4 and in the fair range at RMs 2.1 and 0.4. No sites in the reach attained the MWH ICI criterion. The site at Holland Road (RM 6.5), just downstream from North Rock Swale Ditch, scored an ICI of 8; the site at State Route 95 (RM 5.7), which is downstream from the Marion WWTP outfall and the Marion County dump, scored an ICI of 6. The Keener Road site (RM 4.4) had an ICI score of 10; two Chironomidae taxa and the limpet genus *Ferrissia* comprised 57 percent of the total organisms in the sample. These results reflect predominantly toxic impacts, although poor instream habitat is a contributing factor. The site at State Route 203 (RM 2.1) had an ICI score of 18. The macroinvertebrate community was predominated by blackfly larva (genus *Simulium)* which comprised 56 percent of the total organisms in the sample. The site at the mouth also (RM 0.4) scored an ICI of 18. These lower two sites indicate mitigated water quality impacts both spatially and temporally; however, macroinvertebrate community recovery will be limited by toxic conditions instream along with poor habitat.

Table 11. Summary of macroinvertebrate data collected from artificial substrate samplers (quantitative sampling) and natural substrates (qualitative sampling) in the Little Scioto River, August - September, 1992. Also included are Ohio EPA data collected during 1991, 1987, 1977, 1976, and 1974.

Stream **River Mile**	Density Orgs./ ft^2	Total Taxa	Quant. Taxa	Qual. Taxa	Qual. EPT[a]	ICI	Narrative Evaluation
Little Scioto River							
			WWH Use Designation				
1992							
9.2	293	47	36	24	8	38	Good
1991							
9.0	376	70	52	48	12	34ns	Mar. Good
1987							
9.2	155	51	34	36	10	40	Very Good
1977							
9.2	227	25	23	11	6	34ns	Mar. Good
1976							
9.2	223	25	22	9	5	22*	Fair
1974							
9.2	229	23	12	15	0	2*	Poor
			MWH Use Designation				
1992							
7.9	390	38	30	17	1	16*	Fair
6.5	563	29	18	18	0	8*	Poor
5.7	320	32	18	22	1	6*	Poor
4.4	379	27	20	14	0	10*	Poor
2.1	1048	41	23	29	6	18*	Fair
0.4	230	37	26	22	2	18*	Fair
1991							
2.7	95	42	28	22	1	14*	Fair
1987							
6.5	223	38	25	21	2	22	Fair
5.8	41	26	13	17	1	8*	Poor
3.2	153	28	14	24	4	8*	Poor
2.7	356	28	13	23	2	4*	Poor
0.4	129	24	16	19	1	6*	Poor
1977							
4.4	210	12	11	5	0	2*	Poor
2.1	165	23	18	12	1	4*	Poor
1976							
4.4	593	16	16	5	0	6*	Poor
2.1	104	10	10	4	0	0*	Very Poor
1974							
4.4	76	4	2	3	0	2*	Poor
2.1	1069	7	4	7	0	0*	Very Poor

Ecoregion Biocriteria: Eastern Corn Belt Plains (ECBP)

INDEX	WWH	EWH	MWH[b]
ICI	36	46	22

a EPT = total Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies) taxa.

b Modified Warmwater Habitat for channel modified areas.

ns Nonsignificant departure from ecoregion biocriteria (≤4 ICI units).

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

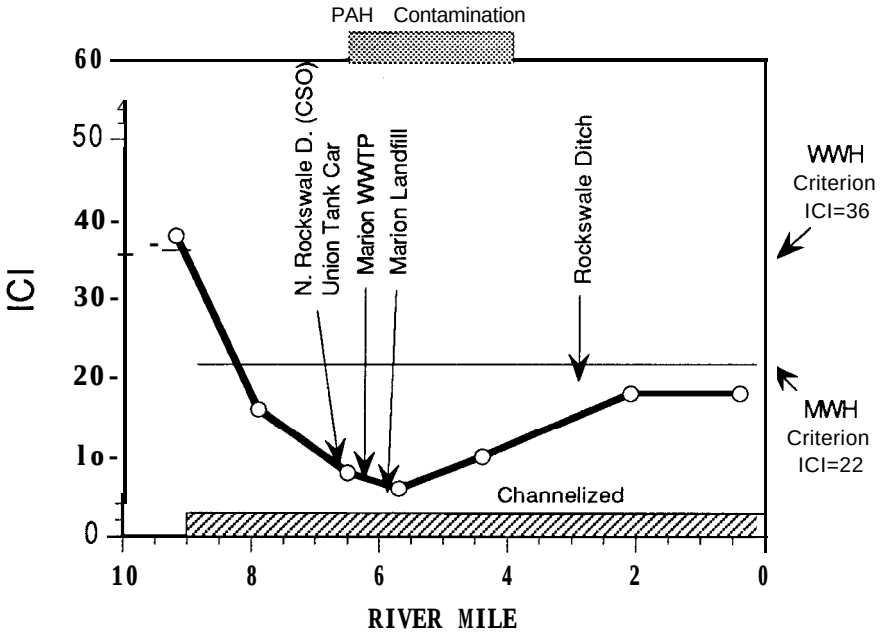

Figure 7. Longitudinal trend of the Invertebrate Community Index (ICI) in the Little Scioto River, 1992.

Fish Community

A total of 3,274 fish representing 36 species and 3 hybrids were collected from the Little Scioto River between August and October, 1992. The sampling effort included a cumulative distance electrofished of 8.90 km at seven locations (Table 2, Figure 1). Relative numbers and species collected per location is presented in Appendix A-3.

- A fish community indicative of fair conditions existed in the Little Scioto River at RM 9.2 (Figure 8, Table 12). A total of 26 species (the highest in the Little Scioto River study area) were collected, including several sensitive species. Bluntnose minnow (comprised >50% of the catch), johnny darter, and greenside darter numerically predominated the catch. IBI and MIwb scores of 33 and 7.2, respectively, were significant departures from the WWH criteria and reflective of fair conditions. Natural habitats appeared capable of supporting a fish community meeting WWH biocriteria. Nonpoint source influences, including an unsewered housing development several miles upstream, may have contributed to the impaired fish community.

- Fish communities in the lower 8 miles of the Little Scioto River were severely degraded. IBI scores ranged between 18 and 25 and MIwb values ranged from 4.1 to 5.3. All of the IBI and MIwb scores in the lower 8 miles of the Little Scioto River were in the poor or very poor range, with all but one value (IBI of 25 at RM 0.3) showing significant departures from the MWH ecoregion biocriteria. White sucker, common carp, green sunfish, highly tolerant species, and orangespotted sunfish numerically predominated the catch. Within this reach of the Little Scioto River, channel modifications have resulted in poor quality physical habitats. Within the lower 8 miles, the most upstream site (RM 7.9 - outside of the PAH contamination area) and the most downstream site (RM 0.3) had the highest IBI and MIwb scores. The site at RM 0.3 showed some improvement due to being the furthest downstream from the pollutant sources and adjacent to a higher quality stream (Scioto River) which could supply a source of reinvading fish.

- The physical condition of fish was monitored at each sampling site by recording the incidence of gross DELT (deformities, fin erosions, lesions/ulcers and tumors) external anomalies. Biosurvey results collected by Ohio EPA from throughout the state show a high frequency of DELT anomalies to be an accurate indication of pollution stress usually caused by multiple sublethal stresses as the result of degraded water quality *(i.e.,* often a combination of toxic impacts combined with marginal D.O. concentrations). Within Ohio, there also appears to be a positive relationship between sites containing chemically contaminated sediments (e.g., metals, PAHs) and very high percent occurrence of DELT anomalies in combination with very low IBI and MIwb scores (Yoder 1991). At RM 7.9, DELT anomalies occurred in 1.6% of the fish population. A substantial increase in anomalies occurred from RM 6.5 to RM 0.3, with values ranging between 9.9% and 22.3%. This area has elevated sediment concentrations of PAHs, cadmium, chromium, lead, mercury and zinc, as well as, elevated surface water concentrations of ammonia-N and nitrite-N and reduced D.O. values.

- There appeared to be several influences contributing to the non-attainment of the IBI and MIwb biocriteria at RM 7.9. Stagnant water conditions can occur at RM 7.9, caused by low stream gradient, stream water removal by a water treatment plant at RM 7.1 and an impoundment at RM 7.1. In addition, several raw septic tank leachate outfalls were observed discharging in the lower section of the fish sampling zone. These conditions can cause excessive organic enrichment. On October 30, 1991 a water sample collected at RM 7.9 had a BOD5 concentration of 19.0 mg/l, suggestive of highly enriched conditions.

Table 12. Fish community indices based on pulsed D.C. electrofishing samples at 7 locations sampled by Ohio EPA in the Little Scioto River during August - October, 1992. Sites were sampled using the wading method (RM 9.2) and the boat method (RM 7.9-0.3). 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	Cumulative Species	Mean Relative Number	Mean Relative Weight	QHEI	Mean Modified Index of Well-Being	Mean Index of Biotic Integrity	Narrative Evaluation[a]
Little Scioto River								
1992								
9.2	22	26	1104	8.6	76.0	7.2*	33*	Fair
7.9	13	19	206	74.9	42.5	5.3*	23*	Poor
6.5	8.3	13	335	38.7	38.5	4.8*	19*	Poor-Very Poor
5.7	10.7	14	174	17.0	40.0	5.2*	19*	Poor
4.4	7.7	12	137	7.2	39.0	4.1*	18*	Poor-Very Poor
2.7	7.7	13	94	6.3	42.0	4.1*	19*	Poor-Very Poor
0.3	9.7	14	75	21.1	38.5	5.0*	25	Poor
1987								
9.2	19.3	26	808	4.0	74.0	7.9[ns]	33*	Marg. Good-Fair
6.5	13.0	13	416	34.2	30.0	4.2*	24	Very Poor-Poor
6.4	10.5	14	757	61.8	38.0	3.6*	14*	Very Poor
6.0	10.0	13	237	29.8	40.0	3.7*	14*	Very Poor
3.1	3.3	6	85	10.7	36.0	0.8*	12*	Very Poor
2.7	6.0	10	237	24.5	40.5	1.9*	13*	Very Poor
0.1	8.7	14	78	46.1	43.0	3.6*	14*	Very Poor

Ecoregion Biocriteria: Eastern Corn Belt Plains (ECBP)

INDEX - Site Type	WWH	MWH[b]
IBI - Wading	40	24
IBI - Boat	42	24
Mod. Iwb - Wading	8.3	6.2
Mod. Iwb - Boat	8.5	5.8

* Significant departure from ecoregion biocriteria; poor and very poor results are underlined.

ns Nonsignificant departure from ecoregion biocriteria (4 IBI or ICI units; 0.5 Iwb units).

a Narrative evaluation is based on both MIwb and IBI scores.

b Modified Warmwater Habitat for channel modified areas.

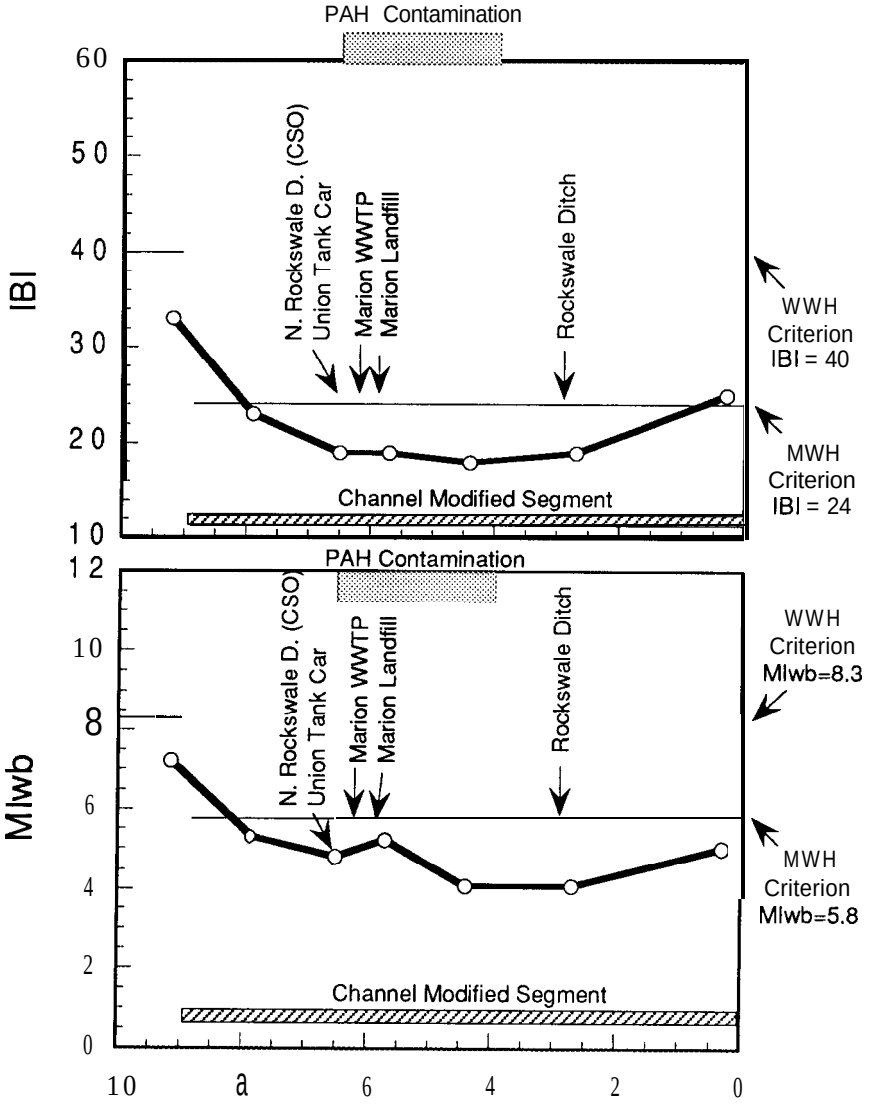

Figure 8. Longitudinal trend of the Index of Biotic Integrity (IBI) and the Modified Index of Well-Being (MIwb) in the Little Scioto River during 1992.

Trend Assessment

Changes in Fish Community Performance: I987 - 1992

- Seven fish locations (RM 9.2 to 0.1) were sampled during 1987 by Ohio EPA in the Little Scioto River. The upstream background site at RM 9.2 was in the fair to marginally good range, with an IBI of 33 and a MIwb of 7.9 (Figure 9). Results at RM 9.2 were in partial attainment of WWH fish biocriteria. During 1987, a significant decline in fish communities occurred from RM 6.6 to 0.1, with fish communities in very poor to poor condition. IBI scores ranged between 12 and 24, and MIwb values varied between 0.8 and 4.2. Part of this decline was attributable to the poor physical habitat instream. The most degraded area of the Little Scioto River occurred immediately downstream from North Rockswale Ditch to the mouth (RM 6.5 to 0.1). Fish community results in the Little Scioto River between RM 6.5 and 0.1 were indicative of toxic conditions instream. A comparison of the 1992 and 1987 Little Scioto River fish data, revealed an improvement during 1992 in the area downstream from North Rockswale Ditch (RM 6.5 to the mouth). However, IBI and MIwb scores were still within the poor to very poor range. Similar results occurred at RM 9.2 between 1992 and 1987 (1992: IBI = 33, MIwb = 7.2; 1987: IBI = 33, MIwb = 7.9), an area upstream from known point sources of pollutants.

- Area of Degradation Values (ADV) for the 1992 and 1987 sampling effort (Table 13) provides a relative measure of performance of the IBI and MIwb. The ADV/ mile of the IBI and MIwb demonstrates the improvement noted between 1987 and 1992. IBI ADV/ mile values improved substantially from 98.3 in 1987 to 39.8 in 1992. Mlwb ADV/ mile scores also showed significant improvement between 1987 and 1992 (142.5 and 63.5, respectively).

Changes in Macroinvertebrate Performance: 1987 - 1992

- The benthic macroinvertebrate communities were sampled at six locations in 1987 by Ohio EPA in the Little Scioto River. The site at Hillman Ford Road (RM 9.2) is a regional reference site and as such was sampled in 1987, 1991 (RM 9.0) and 1992. The site achieved the WWH ICI criterion in 1987 and 1992 (ICI 40 and 38, respectively); in 1991, the score of 34 at RM 9.0 was in the nonsignificant departure range below the criterion. This site has shown continued improvement of the macroinvertebrate community since 1974 when an ICI of 2 was scored.

- The benthic macroinvertebrate fauna in Little Scioto River from RM 6.5 to RM 0.4 is indicative of highly impacted conditions with ICI scores in the poor range at RMs 6.5,5.7 and 4.4 and in the fair range at RMs 2.1 and 0.4. The site at Holland Road (RM 6.5) just downstream from North Rock Swale Ditch declined from an ICI score in 1987 of 22 to an ICI score of 8 in 1992. The site at State Route 95 (RM 5.7) which is downstream from the Marion WWTP outfall and the Marion County dump went from an ICI of 8 in 1987 to an ICI of 6 in 1992. The Keener Road site (RM 4.4) had an ICI score of 10. This site previously had ICI scores of 2 (1974 and 1977) and 6 (1976). A site at State Route 739 (RM 2.7) was sampled in 1987 with an ICI of 4 and in 1991 with an improved ICI of 14. The site at State Route 203 (RM 2.1) had an ICI score of 18; this is an improvement from past years when this site scored ICIs of 0 (1974 and 1976) and 4 (1977). The site at the mouth (RM 0.4) showed some improvement since 1987 when it scored an ICI of 6 with a 1992 score of 18.

The improvement in biological communities in the Little Scioto River downstream from RM 6.5 between 1987 and 1992 appears attributable in part to reductions in metals loadings to the stream.

Table 13. Area of Degradation (ADV) statistics for the Little Scioto River, 1987 and 1992 (calculated using ecoregion criteria as the background community performance).

Stream Index	Biological Index Scores				ADV Statistics			Attainment Status (miles)			
	Upper RM	Lower RM	Mini-mum	Maxi-mum	**ADV**	**Mile ADV**	Poor/VP	PULL	PAR-TIAL	NON	**POOR/** VP
Little Scioto River (1987)											
IBI	9.2	0.1	12	33	895	98.3	644	0.5	1.3	8.0	7.5
MIwb			0.8	7.9	1300	142.5	220				
ICI			4	40	1026	**112.7**	326				
Little Scioto River (1992)											
IBI	9.2	0.3	19	33	354	39.8	198	0.5	0.4	8.9	7.3
MIwb			4.1	7.2	565	63.5	100				
ICI			6	38	784	**88.1**	113				

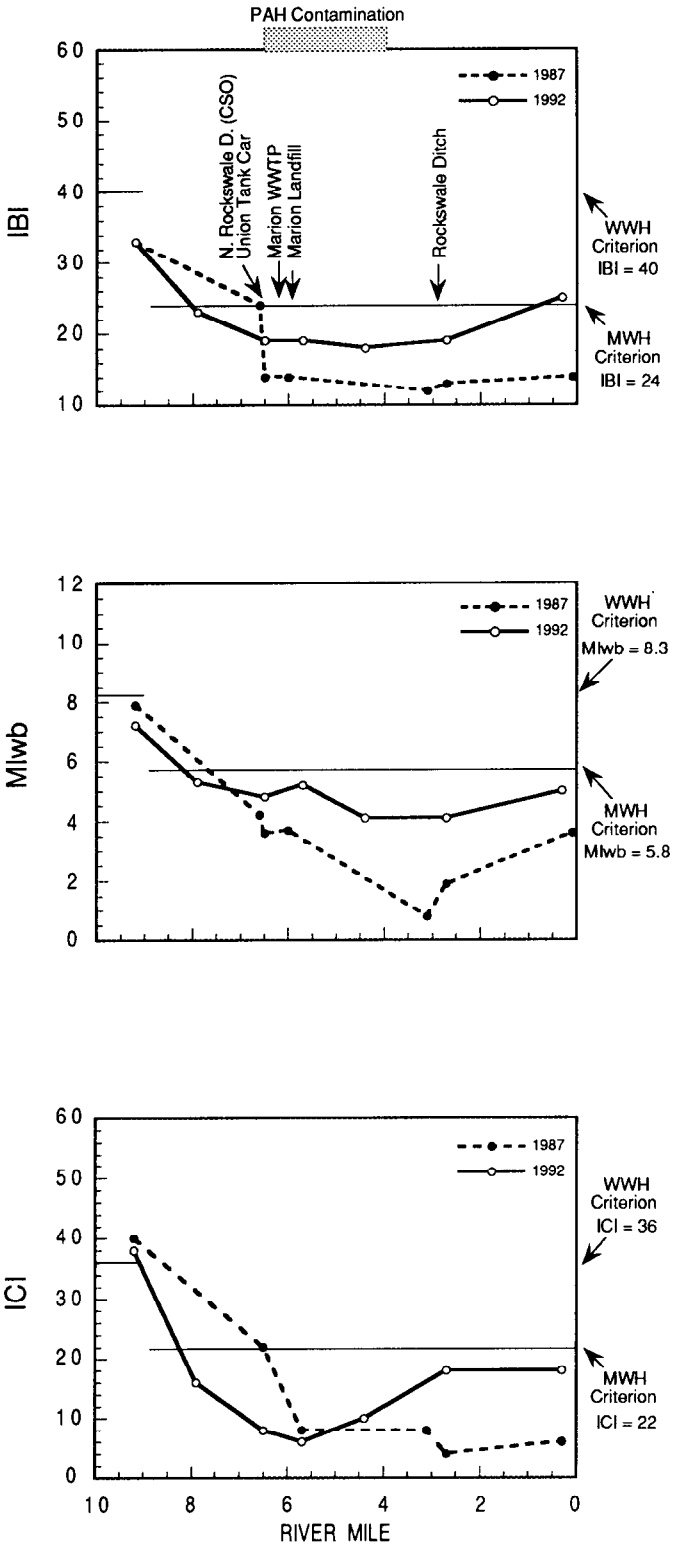

Figure 9. Longitudinal trend of the Modified Index of Well-Being (MIwb), Index of Biotic Integrity (IBI), and Invertebrate Community Index in the Little Scioto River during 1987 and 1992.

Fish Tissue

Fish tissue samples were collected from the Little Scioto River at three locations and the Scioto River at two locations by the Ohio EPA during 1992. Whole body composite and individual fish representing three species were analyzed for pesticides, PCBs, metals, semivolatile compounds and percent lipid (Table 14).

- Seven PCB congeners were tested in 11 fish tissue samples. All values were below lab detection limits. Detection levels for PCBs varied from between 80 ug/kg and 160 ug/kg.

- Nineteen pesticide compounds were tested in 11 fish tissue samples. All values were below lab detection limits. Detection levels for pesticides generally varied from between 8.3 ug/kg and 67 ug/kg.

- Fifty-six semivolatile organic compounds were tested in 11 fish tissue samples. All common carp and white sucker test results (nine samples) were reported as 'not detected'. One northern pike sample in the Scioto River upstream from the Little Scioto River confluence had detectable concentrations of several phthalates and PAHs. Phthalate concentrations ranged from 130 ug/kg to 1,300 ug/kg and PAH concentrations ranged from 160 ug/kg to 170 ug/kg.

- Four metals (barium, arsenic, lead and zinc) were detected in seven fish whole body samples from the 1992 sampling sites. Five other metal parameters (cadmium, chromium, mercury, selenium and silver) tested in whole body fish samples were reported as 'not detected'. Zinc was detected in all fish samples analyzed, with values ranging from 15.8 mg/kg to 92.0 mg/kg. Lead was reported above the lab detection limit of 0.30 mg/kg in two samples; one sample at 0.34 mg/kg and one sample at RM 6.5 which had an elevated level of 81.4 mg/kg (white sucker). Arsenic was detected in one sample (6.5 mg/kg) from the Scioto River at RM 178.0.

Table 14. Summary of chemical levels in fish (whole body) collected in the Little Scioto River and Scioto River during October, 1992.

FISH TISSUE

Stream River Mile	Parameter	Concentration
Little Scioto River		
9.2		
Common carp (3 fish composite)	Semivolatiles	***ND***
	Pesticides/ PCBs	***ND***
	Lipids	4.0 %
Common carp (2 fish composite)	Barium	1.1 mg/kg
	zinc	79.6 mg/kg
	Lipids	1.3 %
6.5		
Common carp (5 fish composite)	Semivolatiles	ND
	Pesticides/ PCBs	ND
	Lipids	3.0 %
Common carp (5 fish composite)	Barium	1.7 mg/kg
	zinc	68.3 mg/kg
	Lipids	2.6 %
White sucker (5 fish composite)	Semivolatiles	ND
	Pesticides/ PCBs	ND
	Lipids	3.6 %
White sucker (5 fish composite)	Barium	2.8 mg/kg
	Lead	81.4 mg/kg
	zinc	17.8 mg/kg
	Lipids	2.0 %
Northern pike (1 fish)	Bis(2-ethylhexy1) phthalate	680J ug/kg
	Pesticides/ PCBs	ND
	zinc	29.6 mg/kg
	Lipids	2.6 %
2.7		
White sucker (1 fish)	Semivolatiles	ND
	Pesticides/ PCBs	ND
	Lipids	0.66 %
White sucker (5 fish composite)	Lead	0.34 mg/kg
	zinc	15.8 mg/kg
	Lipids	2.0 %
White sucker (5 fish composite)	Semivolatiles	ND
	Pesticides/ PCBs	ND
	Lipids	2.0 %

Table 14. Continued.

FISH TISSUE

Stream River Mile	Parameter	Concentration
Scioto River		
178.0		
Common carp (4 fish composite)	Semivolatiles	ND
	Pesticides/ PCBs	ND
	Lipids	5.6 %
Common carp (4 fish composite)	Barium	1.2 mg/kg
	zinc	92.0 mg/kg
	Arsenic	6.5 mg/kg
	Lipids	5.0 %
White sucker (1 fish)	Semivolatiles	ND
	Pesticides/ PCBs	ND
	Lipids	1.0 %
Northern pike (1 fish)	Benzo(b)fluoranthene	160J ug/kg
	Bis(2-ethylhexyl) phthalate	1,300 ug/kg
	Butyl benzyl phthalate	270J ug/kg
	Chrysene	170J ug/kg
	Di-n-butyl phthalate	130J
	Di-n-octyl phthalate	330J
	Pesticides/PCBs	ND
	Lipids	ND
177.0		
Common carp (5 fish composite)	Semivolatiles	ND
	Pesticides/ PCBs	ND
	Lipids	2.3 %
Common carp (3 fish composite)	Barium	1.0 mg/kg
	zinc	57.1 mg/kg
	Lipids	2.6 %
White sucker (1 fish)	Semivolatiles	ND
	Pesticides/ PCBs	ND
	Lipids	2.3 %

J = detected, but below quantitation limit; estimated value.

ND = not detected.

Biomarker Assessment

White sucker and common carp were collected at each fish sampling location (7 sites) during 1992, as well as, two sites during 1991. Samples were collected as part of a study by the United States Environmental Protection Agency, Office of Research and Development (Environmental Monitoring Systems Laboratory) in collaboration with Ohio EPA. The purpose of this joint study was to collect liver, blood, spleen and bile samples from white sucker and common carp for various analyses to detect physiological and biochemical responses to various chemical and environmental exposures. Three indicators reported here are ethoxyresorufin-o-deethylase (EROD) activity, hepatic glutathione (GSH) and bile metabolites. EROD measures a class of metabolic enzymes that are induced by planar xenobiotics such as polycyclic aromatic hydrocarbons and halogenated hydrocarbons. EROD activity is an indicator of the induction of hepatic detoxification systems. A white sucker score below 100 pmol EROD/mg protein and a common carp score below 50 pmol EROD/mg protein are a conservative indication of non-induction. Scores greater than 100 (white sucker) and 50 (common carp) indicate induction and are a measure of the exposure to these contaminants and detoxification activity by fish. Glutathione is the major free thiol in most living cells, and among other processes, participates in the detoxification of xenobiotics. Total hepatic glutathione provides an indication of the available capacity of glutathione to reduce free oxidative moieties and to conjugate metabolites. A depleted state occurs at early stages of exposure and an elevated GSH level is a response to chronic exposure. A white sucker and common carp GSH score below 0.6 ,umol/ L is at reference levels. Bile metabolites were measured to determine exposure to PAH compounds detected in sediment and to determine relative amounts of exposure among different sites.

- Common carp results from seven locations in the Little Scioto River show EROD activity and GSH levels at RM 9.2 and RM 7.9 within the reference range for these markers compared to data from Ohio reference streams (16 sites) evaluated state-wide in 1992 (Figure 10). These two locations are located upstream from areas with bottom sediments contaminated with PAH compounds. Levels of EROD and GSH were highly elevated at RM 6.5 and RM 5.7. EROD activity in common carp declined to within the nominal range at RM 2.7 and RM 0.3. GSH levels continued to be elevated from RM 4.4 to RM 0.3. Both EROD and GSH showed a response consistent with exposure to co-planar aromatic hydrocarbons (PAHs and/or halogenated hydrocarbons) beginning at RM 6.5 and declining in a dose response fashion to RM 0.3.

- White sucker values for EROD and GSH in the Little Scioto River at RM 7.9 were within reference levels (as determined for white sucker from 37 stream sites in Ohio during 1991 and 1992). White sucker were not collected from RM 9.2 during 1992. Levels of EROD activity for white sucker were highly elevated between RM 6.5 and RM 0.3, indicating that xenobiotic stress is present in the lower 6.5 miles of the Little Scioto River. White sucker showed a dose type response for GSH, with an increase at RM 6.5, a significant increase at RM 5.7 and then declining to near normal values at RM 0.3. The white sucker EROD and GSH data demonstrate a physiological response to exposure to PAHs.

- Fluorescent products in bile were measured for all four wavelength pairs at each biological site in the Little Scioto River (Figure 11). Metabolites were 10 times higher in common carp than white sucker and may be attributed to the more efficient conjugation of metabolic intermediates. Higher levels of bile metabolites were detected at all sites between RM 6.5 and 0.3, with the highest concentrations of fluorescent metabolites occurring at RM 5.7,4.4 and 2.7. The bile metabolite data substantiates that white sucker and common carp have been exposed to polycyclic aromatic hydrocarbons.

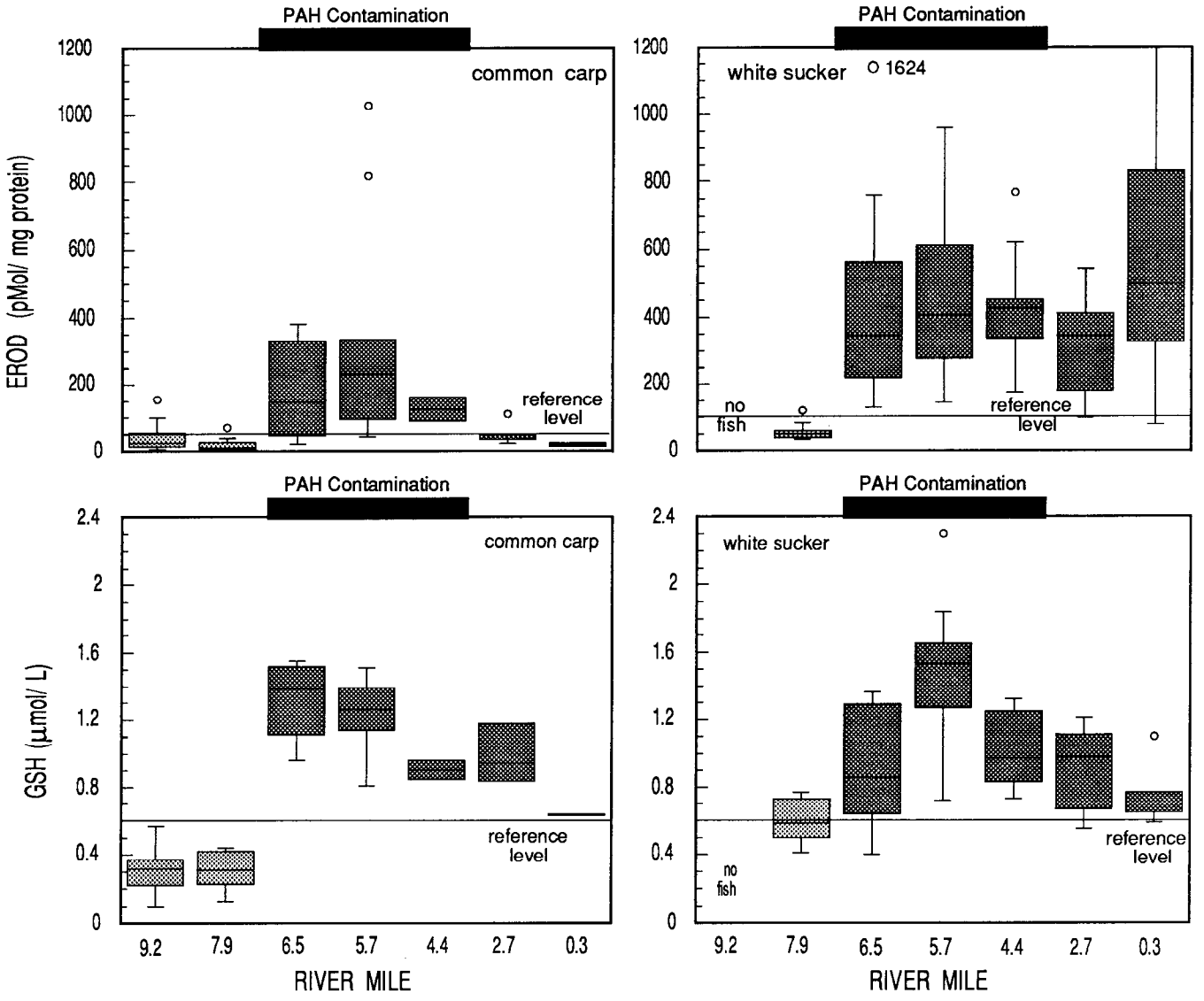

Figure 10. Longitudinal boxplots of EROD (ethoxyresorufin-o-deethylase) and GSH (glutathione) values from common carp and white sucker collected in the Little Scioto River during 1991 (2 sites) and 1992 (7 sites). Reference values are indicated by a horizontal line.

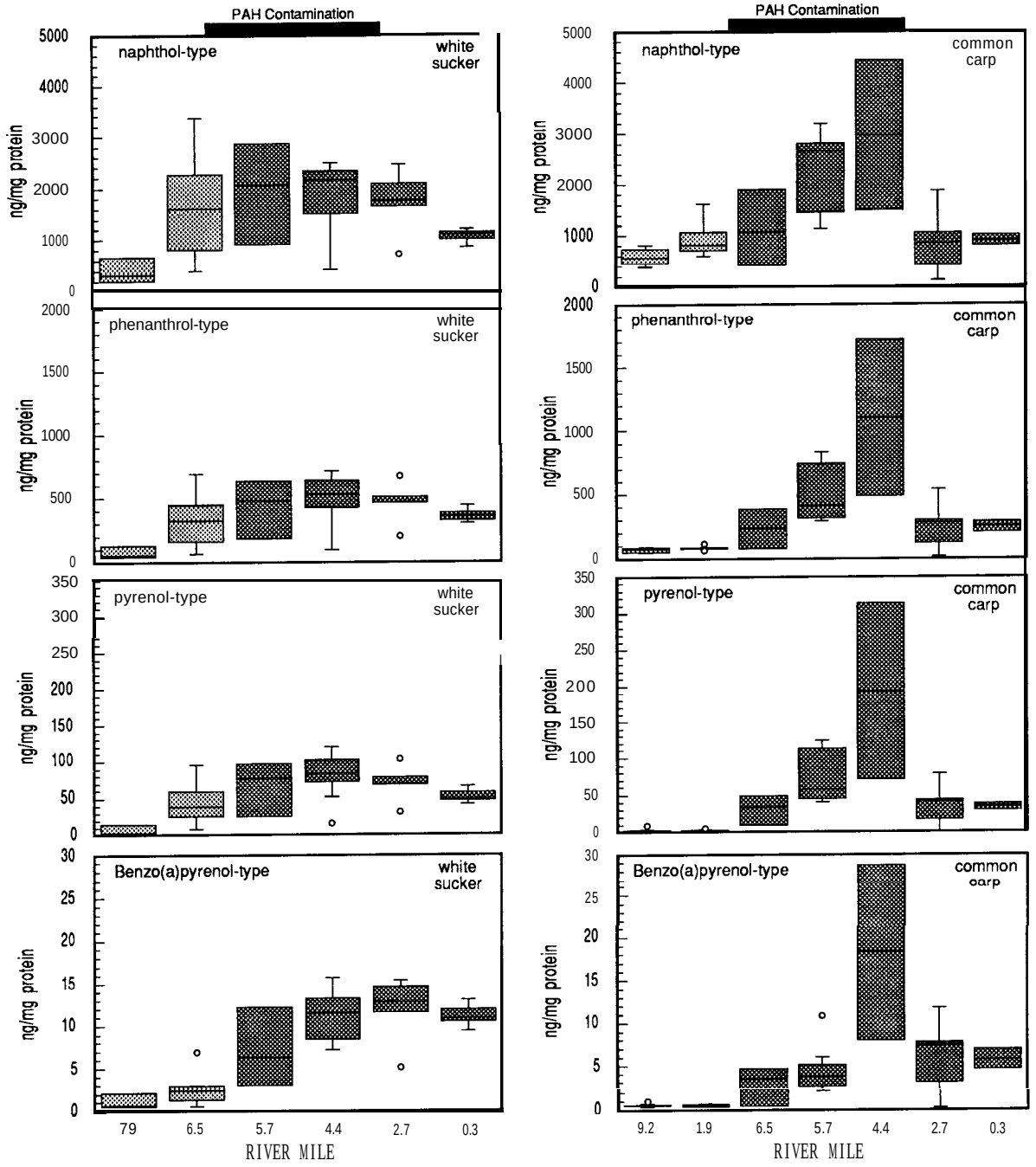

Figure 11. Longitudinal boxplots of bile metabolites in common carp and white sucker from the Little Scioto River, 1992. Bile samples were measured by fixed fluorescence at four excitation/emission wavelengths, and are represented by their most sensitive metabolites (pyrenol-type at 340/380 nm, benzo(a)pyrenol-type at 380/430 nm, phenanthrol-type at 2X/380 nm, and naphthol-type at 290/335 nm).

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APPENDIX TABLES

Table A-l. Semivolatile, volatile, pesticides, PCB's and heavy metal compounds analyzed in Ohio EPA 1992 Little Scioto River sediment, fish tissue and surface water samples. Tentatively identified compounds (TICs) are not listed in this table but can be found on the raw data sheets.

METALS/ CYANIDE (sediment, fish, surface water)

Cyanide **	Cadmium	Iron *	Selenium***
Aluminum *	Calcium **	Lead	Silver***
Antimony *	Magnesium **	Mercury +**	Sodium *
Arsenic	Chromium	Manganese *	Vanadium *
Barium***	Cobalt *	Nickel **	Zinc
Beryllium *	Copper **	Potassium *	Thallium *

SEMIVOLATILE COMPOUNDS (sediment, fish)

Acenaphthene	Benzidine	Hexachlorocyclopentadiene
Acenaphthylene	N-nitrosodimethylamine	Indeno (1,2,3-CD) pyrene
Anthracene	Dibenzo(A,H) anthracene	Isophorone
Benzo (A) anthracene	Dibenzofuran *	2-Methyl-4,6-Dinitrophenol
Benzo(A) pyrene	1,2Dichlorobenzene	2-Methylnaphthalene *
Benzo(B) fluoranthene	1,3-Dichlorobenzene	Naphthalene
Benzo(G,H,I) perylene	1,4-Dichlorobenzene	2-Nitroaniline *
Benzo(K) fluoranthene	3,3'-Dichlorobenzidine	3-Nitroaniline *
Benzoic acid *	2,4-Dichlorophenol	4-Nitroaniline *
Benzyl alcohol *	Diethyl phthalate	Nitrobenzene
Butylbenzyl phthalate	2,4-Dimethylphenol	2-nitrophenol
Bis(2chloroethoxy) methane	Dimethyl phthalate	cl-Nitrophenol
Bis(2cbloroethy1) ether	Di-N-butyl phthalate	N-nitrosodiphenyl amine
Bis(2-chloroisopropyl)ether	2,4-Dinitrophenol	N-Nitroso-N-propylamine
Bis(2-ethylhexyl) phthalate	2,4Dinitrotoluene	Pentachlorophenol
4-Bromophenyl phenyl ether	2,6-Dinitrotoluene	Phenanthrene
4-Chloroaniline *	Di-N-octyl phthalate	Phenol
4-Chloro-3-methyl phenol	Fluoranthene	Pyrene
2Chloronaphthalene	Fluorene	1,2,4-Trichlorobenzene
2-Chlorophenol	Hexachlorobenzene	2.4.5Trichlorophenol *
4-Chlorophenyl phenyl ether	Hexacblorobutadiene	2,4,6-Trichlorophenol
Chrysene	Hexachloroethane	2-Methylphenol*
		4-Methylphenol*

VOLATILECOMPOUNDS (sediment)

Acetone	Chloroethane	I.2-Dichloropropane	Tetrachloroethene
Benzene	2-Chloroethylvinylether	cis-1,3-Dichloropropene	Toluene
Bromodichloromethane	Chloroform	Trans-1,3-dichloropropene	1,1,1-Trichloroethane
Bromoform	Chloromethane	Ethylbenzene	1,1,2-Trichloroethane
Bromomethane	Dibromochloromethane	2-Hexanone	Trichloroetbene
2-Butanone	1,l-Dichloroethane	Methylene chloride	Vinyl acetate
Carbon disulfide	1,2DichIoroethane	4-Methyl-2-pentanone	Vinyl chloride
Carbon tetrachloride	1.1 -Dichloroethene	Styrene	Total Xylenes
Chlorobenzene	Trans-1,2-dichloroethene	cis- 1,2-Dicbloroethene	1,1,2,2-Tetrachloroethane
Trichlorofluoromethane			

* - sediment only.
** - sediment & surface water only.
*** - sediment & fish only.

Table A-l. Continued.

PESTICIDE [sediment. fish)

a-BHC	Aldrin	Heptachlor
bBHC	Dieldrin	Heptachlor epoxide
g-BHC (Lindane)	Endrin	Methoxychlor
d-BHC	Endrin Aldehyde	a-Chlordane
Endosulfan I	Endrin ketone (sediment only)	Toxaphene
Endosulfan II	4,4'-DDT	gChlordane
Endosulfan sulfate	4,4'-DDD	4,4'-DDE

PCBs fsediment. fish)

Arcclor-1016	Aroclor-1232	Aroclor- 1248
Aroclor-1221	Aroclor-1242	Aroclor- 1254
		Aroclor- 1260

OTHER (water)

Phenolics	Nitrate-Nitrite, N
BOD5	Nitrite,N
Ammonia-N	Phosphorus, Total

Other (fish)

Percent lipid

Ohio EPA/DSW Ecological Assessment Section
Macroinvertebrate Collection

Collection Date: 09/23/1992 River Code: 02-158 River: Little Scioto River RM: 9.20

Taxa Code	Taxa	Quant/Qual
01320	*Hydra sp*	12
01801	*Turbellaria*	8 +
03600	*Oligochaeta*	+
06201	*Hyalella azteca*	+
08250	*Orconectes (Procericambarus) rusticus*	+
11020	*Acerpenna pygmaeus*	72
11120	*Baetis flavistriga*	58 +
11130	*Baetis intercalaris*	120 +
12200	*Isonychia sp*	13 +
13000	*Leucrocuta sp*	8
13400	*Stenacron sp*	566 +
17200	*Caenis sp*	24
21200	*Calopteryx sp*	+
21300	*Hetaerina sp*	+
22300	*Argia sp*	+
50315	*Chimarra obscura*	+
52200	*Cheumatopsyche sp*	78 +
52430	*Ceratopsyche morosa group*	17 +
52530	*Hydropsyche depravata group*	1 +
68708	*Dubiraphia vittata group*	2 +
68901	*Macronychus glabratus*	4
69410	*Stenelmis crenata*	2 +
71900	*Tipula sp*	+
74100	*Simulium sp*	+
77120	*Ablabesmyia mallochi*	7
77500	*Conchapelopia sp*	35
77750	*Hayesomyia senata or Thienemannimyia norena*	21
78140	*Labrundinia pilosella*	7
80370	*Corynoneura lobata*	60
80410	*Cricotopus (C.) sp*	7
81240	*Nanocladius (N.) distinctus*	28
81270	*Nanocladius (N.) spiniplenus*	7
81825	*Rheocricotopus (Psilocricotopus) robacki*	14
82121	*Thienemanniella lobapodema*	4
83051	*Dicrotendipes simpsoni*	7
83840	*Microtendipes pedellus group*	98
84460	*Polypedilum (P.) fallax group*	91 +
84470	*Polypedilum (P.) illinoense*	+
84540	*Polypedilum (Tripodura) scalaenum group*	14
84790	*Tribelos fuscicorne*	7
85625	*Rheotanytarsus exiguus group*	7
85720	*Stempellinella n.sp nr. flavidula*	7
85814	*Tanytarsus glabrescens group*	14
85840	*Tanytarsus guerlus group*	21
87501	*Empididae*	19 +
93900	*Elimia sp*	4 +
97601	*Corbicula fluminea*	+

No. Quantitative Taxa: 36 Total Taxa: 47
No. Qualitative Taxa: 24 ICI: **38**
Number of Organisms: 1464 Qual EPT: 8

Ohio EPA/DSW Ecological Assessment Section
Macroinvertebrate Collection

Collection Date: 09/23/1992 River Code: 02-158 River: Little Scioto River RM: 7.90

Taxa Code	Taxa	Quant/Qual		Taxa Code	Taxa	Quant/Qual
01320	*Hydra sp*	16				
01801	*Turbellaria*	16				
03600	*Oligochaeta*	40	+			
06201	*Hyalella azteca*		+			
08250	*Orconectes (Procericambarus) rusticus*		+			
13400	*Stenacron sp*	304	+			
13561	*Stenonema pulchellum*	16				
21604	*Archilestes grandis*	1				
22001	*Coenagrionidae*	1	+			
22300	*Argia sp*	28	+			
45400	*Trichocorixa sp*		+			
47600	*Sialis sp*	20				
68601	*Ancyronyx variegata*		+			
68708	*Dubiraphia vittata group*	16	+			
68901	*Macronychus glabratus*		+			
77120	*Ablabesmyia mallochi*	22				
77750	*Hayesomyia senata or Thienemannimyia norena*	88	+			
78401	*Natarsia species A (sensu Roback, 1978)*	44				
78650	*Procladius sp*	22				
80370	*Corynoneura lobata*	8				
81631	*Parakiefferiella n.sp 1*	66				
82710	*Chironomus (C.) sp*	22				
83040	*Dicrotendipes neomodestus*	242				
83051	*Dicrotendipes simpsoni*	22				
83300	*Glyptotendipes (G.) sp*	22	+			
83840	*Microtendipes pedellus group*	198				
84315	*Phaenopsectra flavipes*		+			
84460	*Polypedilum (P.) fallax group*	176	+			
84540	*Polypedilum (Tripodura) scalaenum group*	176	+			
84700	*Stenochironomus sp*		+			
84790	*Tribelos fuscicorne*	154				
84800	*Tribelos jucundum*	132				
85625	*Rheotanytarsus exiguus group*		+			
85720	*Stempellinella n.sp nr. flavidula*	22				
85814	*Tanytarsus glabrescens group*	22				
85840	*Tanytarsus guerlus group*	22				
95100	*Physella sp*	2				
96900	*Ferrissia sp*	32				

No. Quantitative Taxa: 30 Total Taxa: 38
No. Qualitative Taxa: 17 ICI: **16**
Number of Organisms: 1952 Qual EPT: 1

Ohio EPA/DSW Ecological Assessment Section
Macroinvertebrate Collection

Collection Date: 09/23/1992 River Code: 02-158 River: Little Scioto River RM: 6.50

Taxa Code	Taxa	Quant/Qual		Taxa Code	Taxa	Quant/Qual
03600	*Oligochaeta*	976	+			
04664	*Helobdella stagnalis*		+			
04935	*Erpobdella punctata punctata*	1	+			
05800	*Caecidotea sp*		+			
06700	*Crangonyx sp*		+			
08250	*Orconectes (Procericambarus) rusticus*		+			
13400	*Stenacron sp*	76				
17200	*Caenis sp*	65				
22001	*Coenagrionidae*		+			
22300	*Argia sp*	3				
63900	*Laccophilus sp*		+			
67200	*Hydrochara sp*		+			
67800	*Tropisternus sp*		+			
77500	*Conchapelopia sp*	132				
77750	*Hayesomyia senata or Thienemannimyia norena*	154				
78401	*Natarsia species A (sensu Roback, 1978)*	44				
78700	*Psectrotanypus sp*	22				
80420	*Cricotopus (C.) bicinctus*		+			
81240	*Nanocladius (N.) distinctus*	132				
82730	*Chironomus (C.) decorus group*	176	+			
84460	*Polypedilum (P.) fallax group*	704	+			
84470	*Polypedilum (P.) illinoense*	110	+			
84540	*Polypedilum (Tripodura) scalaenum group*	66				
85500	*Paratanytarsus sp*	44				
85814	*Tanytarsus glabrescens group*	22				
87601	*Dolichopodidae*	8	+			
95100	*Physella sp*		+			
95904	*Gyraulus (G.) deflectus*		+			
96900	*Ferrissia sp*	80	+			

No. Quantitative Taxa: 18 Total Taxa: 29
No. Qualitative Taxa: 18 ICI: **8**
Number of Organisms: 2815 Qual EPT: 0

Ohio EPA/DSW Ecological Assessment Section
Macroinvertebrate Collection

Collection Date: 09/23/1992 River Code: 02-158 River: Little Scioto River RM: 5.70

Taxa Code	Taxa	Quant/Qual		Taxa Code	Taxa	Quant/Qual
01801	*Turbellaria*	4	+			
03600	*Oligochaeta*	8	+			
13400	*Stenacron sp*	12	+			
17200	*Caenis sp*	20				
22001	*Coenagrionidae*		+			
22300	*Argia sp*		+			
45300	*Sigara sp*		+			
60910	*Peltodytes edentulus*		+			
63900	*Laccophilus sp*		+			
65800	*Berosus sp*		+			
67000	*Helophorus sp*		+			
77120	*Ablabesmyia mallochi*	16				
77130	*Ablabesmyia rhamphe group*	16				
77500	*Conchapelopia sp*	160				
77750	*Hayesomyia senata or Thienemannimyia norena*	224	+			
78650	*Procladius sp*		+			
78702	*Psectrotanypus dyari*		+			
80420	*Cricotopus (C.) bicinctus*	128				
81240	*Nanocladius (N.) distinctus*	128	+			
81631	*Parakiefferiella n.sp 1*	16				
82730	*Chironomus (C.) decorus group*	128	+			
82770	*Chironomus (C.) riparius group*		+			
83000	*Dicrotendipes sp*	16				
83040	*Dicrotendipes neomodestus*		+			
83051	*Dicrotendipes simpsoni*		+			
83380	*Goeldichironomus holoprasinus*	16				
84300	*Phaenopsectra obediens group*		+			
84460	*Polypedilum (P.) fallax group*	464				
84470	*Polypedilum (P.) illinoense*	128	+			
84540	*Polypedilum (Tripodura) scalaenum group*	16				
95100	*Physella sp*		+			
96900	*Ferrissia sp*	100	+			

No. Quantitative Taxa: 18 Total Taxa: 32
No. Qualitative Taxa: 22 ICI: **6**
Number of Organisms: 1600 Qual EPT: 1

Ohio EPA/DSW Ecological Assessment Section
Macroinvertebrate Collection

Collection Date: 09/23/1992 River Code: 02-158 River: Little Scioto River RM: 4.40

Taxa Code	Taxa	Quant/Qual		Taxa Code	Taxa	Quant/Qual
03600	*Oligochaeta*	80	+			
13400	*Stenacron sp*	5				
22001	*Coenagrionidae*		+			
22300	*Argia sp*	55	+			
45300	*Sigara sp*		+			
52200	*Cheumatopsyche sp*	1				
63900	*Laccophilus sp*		+			
67000	*Helophorus sp*		+			
71900	*Tipula sp*		+			
74100	*Simulium sp*	13	+			
77120	*Ablabesmyia mallochi*	32				
77750	*Hayesomyia senata or Thienemannimyia norena*	416				
77800	*Helopelopia sp*	80				
78401	*Natarsia species A (sensu Roback, 1978)*	80				
78650	*Procladius sp*		+			
80420	*Cricotopus (C.) bicinctus*	48				
81231	*Nanocladius (N.) crassicornus or N. (N.) "rectinervis"*	112				
81240	*Nanocladius (N.) distinctus*	160				
82710	*Chironomus (C.) sp*		+			
82730	*Chironomus (C.) decorus group*	32	+			
83050	*Dicrotendipes lucifer*	32				
84460	*Polypedilum (P.) fallax group*	336				
84470	*Polypedilum (P.) illinoense*	48	+			
84540	*Polypedilum (Tripodura) scalaenum group*	32				
95100	*Physella sp*	8	+			
96120	*Menetus (Micromenetus) dilatatus*	1				
96900	*Ferrissia sp*	328	+			

No. Quantitative Taxa: 20 Total Taxa: 27
No. Qualitative Taxa: 14 ICI: **10**
Number of Organisms: 1899 Qual EPT: 0

Ohio EPA/DSW Ecological Assessment Section
Macroinvertebrate Collection

Collection Date: 09/23/1992 River Code: 02-158 River: Little Scioto River RM: 2.10

Taxa Code	Taxa	Quant/Qual		Taxa Code	Taxa	Quant/Qual
03600	*Oligochaeta*	24	+			
04666	*Helobdella triserialis*		+			
06201	*Hyalella azteca*		+			
08250	*Orconectes (Procericambarus) rusticus*		+			
08601	*Hydracarina*	1				
11130	*Baetis intercalaris*		+			
12200	*Isonychia sp*		+			
13400	*Stenacron sp*	5	+			
13521	*Stenonema femoratum*		+			
17200	*Caenis sp*	1	+			
21200	*Calopteryx sp*		+			
22001	*Coenagrionidae*		+			
22300	*Argia sp*		+			
45300	*Sigara sp*		+			
45900	*Notonecta sp*		+			
48200	*Chauliodes sp*		+			
52200	*Cheumatopsyche sp*	8	+			
52430	*Ceratopsyche morosa group*	1				
52530	*Hydropsyche depravata group*	5				
63900	*Laccophilus sp*		+			
67000	*Helophorus sp*		+			
68901	*Macronychus glabratus*	1				
69400	*Stenelmis sp*		+			
74100	*Simulium sp*	2960	+			
77120	*Ablabesmyia mallochi*		+			
77500	*Conchapelopia sp*	180	+			
77750	*Hayesomyia senata or Thienemannimyia norena*	108				
80204	*Brillia flavifrons group*	36				
80370	*Corynoneura lobata*	32				
80420	*Cricotopus (C.) bicinctus*	504	+			
81240	*Nanocladius (N.) distinctus*	126				
81825	*Rheocricotopus (Psilocricotopus) robacki*	198				
82141	*Thienemanniella xena*	108				
84460	*Polypedilum (P.) fallax group*	198	+			
84470	*Polypedilum (P.) illinoense*	594	+			
84540	*Polypedilum (Tripodura) scalaenum group*	18				
85615	*Rheotanytarsus distinctissimus group*	18	+			
87501	*Empididae*	12				
95100	*Physella sp*		+			
96900	*Ferrissia sp*	104	+			
98600	*Sphaerium sp*		+			

No. Quantitative Taxa: 23 Total Taxa: 41
No. Qualitative Taxa: 29 ICI: **18**
Number of Organisms: 5242 Qual EPT: 6

Ohio EPA/DSW Ecological Assessment Section
Macroinvertebrate Collection

Collection Date: 09/23/1992 River Code: 02-158 River: Little Scioto River RM: 0.40

Taxa Code	Taxa	Quant/Qual	
01320	*Hydra sp*	2	
05800	*Caecidotea sp*	1	
08200	*Orconectes sp*		+
13400	*Stenacron sp*	30	+
16700	*Tricorythodes sp*	1	
17200	*Caenis sp*	6	
22001	*Coenagrionidae*		+
22300	*Argia sp*	7	
42700	*Belostoma sp*		+
45300	*Sigara sp*		+
48200	*Chauliodes sp*		+
52200	*Cheumatopsyche sp*	1	+
63900	*Laccophilus sp*		+
67800	*Tropisternus sp*		+
69410	*Stenelmis crenata*	1	
71900	*Tipula sp*		+
74100	*Simulium sp*	2	+
74673	*Atrichopogon websteri*	1	
77120	*Ablabesmyia mallochi*	36	
77500	*Conchapelopia sp*	12	
77750	*Hayesomyia senata or Thienemannimyia norena*	96	+
78401	*Natarsia species A (sensu Roback, 1978)*	24	
78650	*Procladius sp*		+
80370	*Corynoneura lobata*	184	
80420	*Cricotopus (C.) bicinctus*	24	+
81240	*Nanocladius (N.) distinctus*	84	+
82141	*Thienemanniella xena*	16	
82710	*Chironomus (C.) sp*	24	+
82820	*Cryptochironomus sp*		+
84460	*Polypedilum (P.) fallax group*	384	+
84470	*Polypedilum (P.) illinoense*	120	+
84540	*Polypedilum (Tripodura) scalaenum group*	24	
84800	*Tribelos jucundum*		+
85500	*Paratanytarsus sp*	12	
85814	*Tanytarsus glabrescens group*	12	
95100	*Physella sp*	1	+
96900	*Ferrissia sp*	46	+

Taxa Code	Taxa	Quant/Qual

No. Quantitative Taxa: 26 Total Taxa: 37
No. Qualitative Taxa: 22 ICI: **18**
Number of Organisms: 1151 Qual EPT: 2

Table A-3. Summary of relative numbers of fish and species collected at each location (by RM) sampled in the Little Scioto River during 1992.

species	Stream Code:	02158	02158	02158	02158	02158
	Year:	92	92	92	92	92
	River Mile:	.3	2.7	4.4	5.7	6.5
GIZZARD SHAD				4.5		
GRASS PICKEREL		0.7	2.0	2.2	1.5	5.2
NORTHERN PIKE		2.2	0.7		1.5	2.2
GOLDEN REDHORSE		13.3	0.7			
NORTHERN HOG SUCKER		0.7				
WHITE SUCKER		6.7	22.7	43.0	39.3	136.3
SPOTTED SUCKER		0.7			1.5	3.1
COMMON CARP		5.9	21.3	44.5	40.8	59.3
GOLDFISH				2.2		
GOLDEN SHINER		-			2.2	7.4
CREEK CHUB		-	0.7	1.5		
REDFIN SHINER			0.7		8.2	1.5
STRIPED SHINER						
SPOTFIN SHINER		0.7				
BLVNTNOSE MINNOW		11.9	4.0	4.5	3.7	3.0
CENTRAL STONEROLLER						
COM. CARP X GOLDFISH			0.7			
YELLOW BULLHEAD		-				-
BLACK BULLHEAD						1.5
BRINDLED MADTOM		-				
TADPOLE MADTOM		-				
BL'KSTRIPE TOPMINNOW		-				
WHITE CRAPPIE		-		0.7	0.7	
BLACK CRAPPIE						0.7
ROCK BASS						
SMALLMOUTH BASS		1.5				
IARGEMOVTH BASS		3.7	0.7	5.2	7.4	3.0
GREEN SUNFISH		5.2	17.3	17.8	35.6	88.2
BLUEGILL SUNFISH			0.7	1.5	1.5	
OR'GESPOTTED SUNFISH		16.3	20.0	9.6	29.6	28.9
LONGEAR SUNFISH		4.5	0.7		1.5	
GREEN SF X HYBRID			0.7			
BLACKSIDE DARTER						
LOGPERCH		-				
JOHNNY DARTER		-				
GREENSIDE DARTER						
BANDED DARTER						
FANTAIL DARTER						
SAVGER X WALLEYE		1.5	0.7			
Total Relative Number		75.5	94.0	137.0	174.8	340.8
Total Number of Species		14	13	12	14	13
Total Number of Hybrids		1	3			
Distance Sampled		1.35	1.50	1.35	1.35	1.35
Number of Passes		3	3	3	3	3

Table A-3. Continued.

Species	Stream Code: 02158 / Year: 92 / River Mile: 1.9	02158 / 92 / 9.2			
GIZZARD SHAD	5.3	4.2			
GRASS PICKEREL	-		-	-	-
NORTHERN PIKE	0.7		-	-	-
GOLDEN REDHORSE	3.3	0.6	-		
NORTHERN HOG SUCKER	-	7.2	-		
WHITE SSJCXER	28.7	3.6	-	-	
SPOTTED SUCKER	5.3		-	-	
COMMON CARP	56.7	8.4		-	
GOLDFISH	-	2.4	-	-	
GOLDEN SHINER	0.7		-	-	
CREEK CHUB	-	25.8	-	-	
REDFIN SHINER	0.7	35.4	-	-	
STRIPED SHINER	-	1.8	-	-	
SPOTFIN SHINER	0.7	2.4	-	-	
BLUNTNOSE MINNOW	4.0	602.4		-	
CENTRAL STONEROLLER	-	43.2	-	-	
COM. CARP X GOLDFISH	-		-	-	
YELLOW BULLHEAD		0.6	-	-	-
BLACK BULLHEAD	-		-	-	
BRINDLED MADTOM		0.6		-	
TADPOLE MADTOM		0.6	-	-	
BL'KSTRIPE TOPMINNOW	0.7				
WHITE CRAPPIE	1.3		-	-	
BLACK CRAPPIE	0.7		-		
ROCK BASS	0.7	17.4	-	-	
SMALLMOUTH BASS			-	-	
LARGEMOUTH BASS	2.1	1.2	-	-	
GREEN SUNFISH	54.7	28.2			
BLUEGILL SUNFISH	3.3				
OR'GESPOTTED SUNFISH	21.3	10.8		-	
LONGEAR SUNFISH	14.7	42.0		-	
GREEN SF X HYBRID				-	
BLACKSIDE DARTER		4.2		-	-
LOGPERCH	-	1.8			
JOHNNY DARTER		114.6			
GREENSIDE DARTER		120.6		-	-
BANDED DARTER		0.6			
FANTAIL DARTER	-	23.4			-
SAUGER X WALLEYE		0.6			-
Total Relative Number	206.1	1104.6			
Total Number of Species	19	26			
Total Number of Hybrids	0	1			
Distance Sampled	1.50	.50			
Number of Passes	3	2			

Table A-4. Raw chemical data for sediment, fish tissue and surface water sampling locations in the Little Scioto River study area, 1992.

(Data is available upon request)