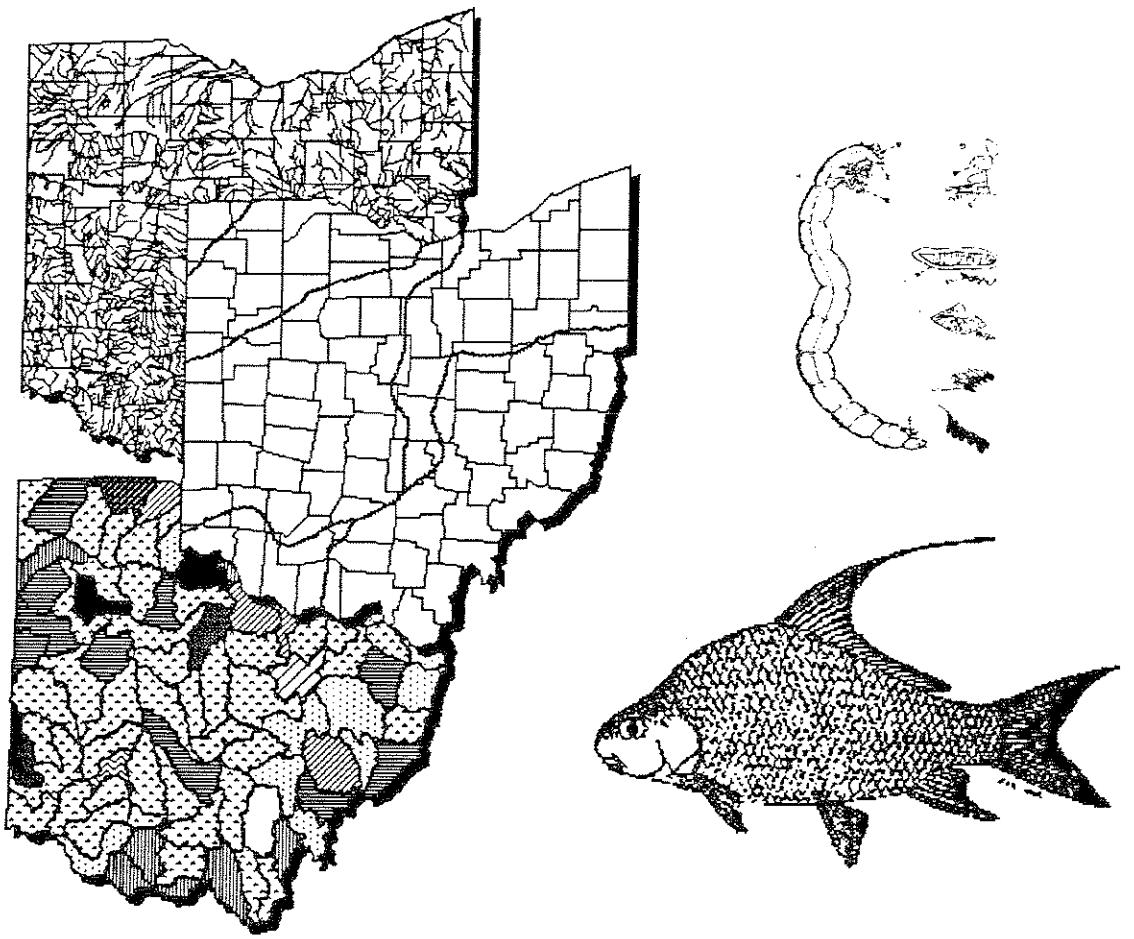
State of Ohio
Environmental Protection Agency

Ecological Assessment Section
Division of Water Quality
Planning & Assessment

Biological and Water Quality Study of the Southeast Ohio River Tributaries

Scioto, Lawrence, Gallia, Jackson, Vinton, Meigs, and Washington Counties (Ohio)



June 27, 1991

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

Biological and Water Quality Study of the Southeast Ohio River Tributaries

Scioto, Lawrence, Gallia, Jackson, Vinton, Meigs, and Washington Counties, Ohio.

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prepared by

Ohio Environmental Protection Agency
Division of Water Quality Planning and Assessment

Ecological Assessment Section
Nonpoint Source Program Management Section
Surface Water Section, Southeast District Office

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

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Study Area Description - Larry Antosch
Ambient Chemical Quality - Marty Kuklis
Sediment - Marty Kuklis
Datasonde Data - Modeling Section
Biological Assessment:
Macroinvertebrates - Mike Bolton
Fish - Randy Sanders
Data Management - Jeff DeShon, Dennis Mishne, and Ed Rankin
Editing - Mike Bolton
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Introduction

Biological and water quality data were collected from 18 streams in the Southeast Ohio River Tributaries study area between June and September, 1990 (Table 1).

Specific objectives of this evaluation were to:

1) Evaluate existing aquatic life use designations.

2) Evaluate biological and water quality impacts to Meadow Run and Little Raccoon Creek from the Jenos and Wellston WWTPs.

3) Evaluate biological and water quality impacts to Kyger Creek from the American Electric Power (AEP) Gavin power plant ash pond on Stingy Run and the Ohio Valley Electric Company (OVEC) Kyger Creek power plant ash pond.

The findings of this evaluation may factor into regulatory actions taken by Ohio EPA (e.g. NPDES permits) and eventually be incorporated into the State water quality management plans and biennial 305(b) report.

Conclusions

* During 1990, biological and water quality sampling was conducted at 29 stations within 18 streams in the Southeast Ohio River Tributaries study area (Table 1). The aquatic life attainment status (at the sites were both organism groups were collected) was FULL at 10 stations, PARTIAL at 10 stations, and NON at 4 stations (Table 10). Using the recommended use designation changes the attainment status would be FULL at 12 stations, PARTIAL at 8 stations, and NON at 4 stations. The primary causes of PARTIAL and NON attainment were mine related sedimentation and water quality impacts and point source pollution (from the Jenos and Wellston WWTPs).

* Little Scioto River, Rocky Fork, Bear Run, Storms Creek, Ice Creek, and the Shade River are currently designated EWH aquatic life use . However, none of these streams demonstrated attainment of the EWH criteria for both organism groups.

* Little Scioto River and Rocky Fork overall had very good biological communities. Rocky Fork sampling yielded the highest number of fish species collected during a single sample and was one of three streams in the study area where seven species of darters were collected. Macroinvertebrate sampling yielded the highest mayfly, caddisfly, and stonefly diversity from natural substrates during this study. Chemically the Little Scioto River

exceeded the 30-day average criterion for lead in two samples (7, 14 µg/l).

* Bear Run had an exceptional headwater fish community including the state threatened species rosyside dace (*Clinostomus funduloides*). Macroinvertebrates were evaluated as good and water chemistry indicated a localized sewage source with slightly depressed D.O. levels and an exceedence of the 30-day average ammonia-N criterion (6.83 mg/l).

* Storms Creek and Ice Creek had good to very good fish communities. A good macroinvertebrate community was found in Storms Creek and an exceptional community was found in Ice Creek. Heavy sand bed loads were attributed as the predominant limiting factor for the biological communities. Surface mining is present in the lower portion of Storms Creek but is essentially absent from the Ice Creek basin.

* Pine Creek and Indian Guyan Creek overall had marginally good to good biological communities. One minor violation of the pH criterion was recorded for each stream along with three exceedences of the minimum 24 hr. average criterion for D.O. in Pine Creek. Both basins have some unreclaimed surface mines in their headwaters (USDA 1985), but no impact was recorded in this survey.

* Buffalo Creek and Caulley Creek generally had very good to exceptional fish communities except for the downstream site on Buffalo Creek which had a marginally good community. The macroinvertebrates sampled in Buffalo Creek under interstitial flow conditions were scarce, but the taxa collected were characteristic of a good community. Both streams became intermittent during the study period which was the most likely cause of the violations of the minimum D.O. criterion. The impacted fish community at the downstream Buffalo Creek site may have been due to contamination from abandoned gas wells.

* Symmes Creek had a marginally good (MIwb) to exceptional (IBI) fish community and an exceptional macroinvertebrate community. Seven darter species were collected including the eastern sand darter which is listed as an Ohio species of special concern. However, lower than expected fish biomass suggests a possible impact from sedimentation.

* Raccoon Creek had very good and exceptional macroinvertebrate communities and a fair fish community in the section currently designated LRW for acid mine drainage. Exceptional macroinvertebrate and fair to good fish communities were found in the section designated WWH. There were no exceedences of WWH water quality criteria at either of the sites sampled. The data support the redesignation of Raccoon Creek to WWH, but the impacted fish communities indicate continued runoff problems from the unreclaimed surface mines in the basin.

* Meadow Run was impacted by acid mine drainage upstream from Jenos WWTP. Biological communities were fair to poor but achieved the interim biological criteria assigned to the LRW use. Downstream from the Jenos WWTP pH values improved to attain the WWH criterion, but ammonia-N and BOD_5 loadings degraded water quality and will prevent this segment from meeting the WWH use.

* Biological communities and water quality were further degraded in Meadow Run by the Wellston WWTP. The macroinvertebrate community was very poor and the fish community was poor downstream from the mixing zone. Thick deposits of sludge blanketed the stream bed and a 45 hour continuous sampling effort recorded an average D.O. value of 0.24 mg/l downstream from the mixing zone.

* Within the Wellston WWTP mixing zone very high levels of ammonia-N (7-10 mg/l) and elevated levels of phosphorus (avg. 2.2 mg/l) and BOD_5 (avg. 18.6 mg/l) were recorded. Biological communities were poor to very poor, but did not indicate acute toxicity other than that associated with severe organic pollution.

* Little Raccoon Creek upstream from Meadow Run had a very good macroinvertebrate community but only a fair fish community. The only exceedences of WWH water quality criteria were for iron. The substandard fish community was attributed to runoff from upstream mining activities. Downstream from Meadow Run the biological communities declined into non-attainment of the WWH biological criteria and two violations of the minimum D.O. criterion along with two elevated ammonia-N levels were recorded. The biological and water quality degradation at the downstream site was attributed to impacts from Meadow Run.

* Kyger Creek was chemically and biologically impaired by the effects of mining in the basin. There was also an additional element of concern with the large load of ammonia-N being added by the two ash pond discharges to the stream. Biological communities improved slightly downstream from Stingy Run, probably due to the increased flow. Contamination of the sediment by arsenic and chromium likely resulted from the coal ash pond discharges.

* Campaign Creek, Leading Creek, the Shade River, and the Little Hocking River generally had fair fish communities and all had exceptional macroinvertebrate communities except Leading Creek which supported a good community. The reason for the difference between the organism groups was not clear. An exceedence of the total dissolved solids (2480 mg/l) 30-day average criterion and elevated sulfates (mean 610 mg/l) in Leading Creek may be due to impacts from a large coal preparation plant or a water treatment plant located upstream from the sampling area. USDA (1985) reported limited mine drainage impacts in the headwaters of Campaign Creek and Leading Creek, but none in the sampling area. The Shade River was reported as impacted by sedimentation in the sampling area

resulting from unreclaimed surface mining in the headwaters. The Little Hocking River does not have any appreciable surface mining within the basin.

Recommendations

Based on the results of this study, the following recommendations are made for the Southeast Ohio River Tributaries study area:

Evaluation of Designated Aquatic Life Uses

1. Redesignate Little Scioto River, Rocky Fork, Bear Run, Storms Creek, Ice Creek, and the Shade River from EWH to WWH due to a failure to demonstrate biological attainment of the EWH aquatic life use criteria for *both* organism groups.

2. Redesignate Raccoon Creek from LRW - acid mine drainage to WWH for the headwaters to Tycoon Lake, due to the biological community demonstrating partial attainment of the WWH criteria and the lack of any obvious acid mine drainage water quality impacts.

3. All other streams and stream segments are correctly designated and should retain their current uses.

4. The following streams and stream segments qualify as State Resource Waters (SRW) as defined in the Ohio water quality standards (OEPA 1990a): (1) Little Scioto River due to the presence of the state endangered amphibian species hellbender (*Cryptobranchus alleganiensis*) and state threatened fish species silver lamprey (*Ichthyomyzon unicuspis*), (2) Rocky Fork due to the presence of high quality biological communities, (3) Bear Run due to the presence of the state threatened fish species rosyside dace (*Clinostomus funduloides*), (4) Pine Creek due to the presence of the state endangered mollusk species little spectaclecase (*Villosa lienosa*), (5) Storms Creek from the headwaters to RM 8.3 because it is located in Wayne National Forest lands including the Lake Vesuvius Recreation Area, (6) Symmes Creek due to presence of high quality biological communities and the state endangered mollusk species little spectaclecase (*Villosa lienosa*), (7) Buffalo Creek and Caulley Creek because they are in Wayne National Forest lands, (8) Leading Creek due to the presence of the state threatened fish species silver lamprey (*Ichthyomyzon unicuspis*).

Future Monitoring Needs

1. Sample Symmes Creek more extensively to evaluate the potential for the EWH use.

2. Raccoon Creek should be resampled to determine if the fish communities show improvement toward achieving the WWH criteria and for trend assessment.

3. A site inspection in Buffalo Creek should be performed upstream from RM 1.7 to ascertain any contamination from abandoned gas wells.

4. Meadow Run should be resampled after completion of the proposed new Wellston WWTP and the Jenos expansion to evaluate any changes to the water quality and biological communities.

5. A review of the Jenos WWTP operation and data reporting procedures should be undertaken to determine if elevated water quality parameters within Meadow Run can be reduced and assure accurate reporting on effluent quality.

Study Area Description

The study area is located in all or parts of the following ten south-central Ohio counties: Scioto, Lawrence, Gallia, Pike, Jackson, Vinton, Meigs, Hocking, Athens and Washington. Principal subbasins in the study area include: Little Hocking River, Shade River, Leading Creek, Champaign Creek, Raccoon Creek, Symmes Creek, Indian Guyan Creek, Pine Creek, Little Scioto River, plus several small direct tributaries to the Ohio River Mainstem. The drainage area of the combined subbasins covers 2,511 square miles (ODNR, 1960; 1985). Table 2 presents the general characteristics of the streams in the study area. The streams generally flow north to south discharging into the Ohio River.

The study area is situated in the Western Allegheny Plateau ecoregion which is a dissected plateau comprised of horizontally bedded sandstone, siltstone, shale and limestone. The steep topography and high erosion potential are the chief land use limitations of the ecoregion. Most of the ecoregion is forested with a large portion being subjected to coal mining activities. Less than one-fifth of the ecoregion is cropland which generally occurs on the valley floors (U.S. EPA, 1988).

Coal mining operations have a major impact on the water quality of streams and rivers in the Western Allegheny Plateau ecoregion. Erosion and sedimentation from open pits, the introduction of toxic compounds, and the direct physical disruption of the stream beds have degraded stream habitat and water quality in many areas. Sludge and seepage from numerous oil and gas wells adds sediment and affects water quality in nearby streams. Crops and livestock production can significantly impact water quality because they occur predominantly in narrow stream valleys. Stream side vegetation often has been removed to expand cropland or pasture, increasing streambank erosion, turbidity and sedimentation (U.S. EPA, 1988; Ohio EPA, 1990b). The identified pollution sources in the study area are presented in Table 2.

Table 1. Sampling locations (effluent sample-E, water chemistry-C, sediment chemistry-S, benthos-B, fish-F) in the Southeast Ohio River Tributaries study area, 1990.

Stream RM	Type of Sampling	Latitude/Longitude	Landmark	USGS 7.5 min. Quad. Map
Little Scioto River (Tributary to the Ohio River)				
18.8	F	38 51 12 / 82 47 23	ust. TR 221	Minford
12.7	C, S, B	38 49 27 / 82 50 52	Wheelers Mill Rd.	Minford
12.6	F	38 49 28 / 82 50 55	dst.Wheelers Mill Rd.	Minford
Rocky Fork (Tributary to the Little Scioto River)				
0.6	C, B, F	38 51 28 / 82 47 49	Glades Run Rd. (TR 222)	Minford
Bear Run (Tributary to the Little Scioto River)				
0.2	C, B, F	38 51 25 / 82 46 06	Burton Rd. (TR 219)	Minford
Pine Creek (Tributary to the Ohio River)				
20.5	F	38 38 20 / 82 44 26	Kellys Mill Rd	Pedro
20.4	C, S, B	38 38 15 / 82 44 27	Kellys Mill Rd.	Pedro
Storms Creek (Tributary to the Ohio River)				
3.3	C, S, B, F	38 32 54 / 82 39 44	ust. CR 21	Ironton
Ice Creek (Tributary to the Ohio River)				
6.1	B	38 31 36 / 82 36 43	ust. private drive	Kitts Hill
2.3	F	38 31 09 / 82 38 18	adj. CR 181	Ironton
2.1	C, S	38 31 05 / 82 38 30	adj. CR 181	Ironton
Symmes Creek (Tributary to the Ohio River)				
11.0	F	38 30 00 / 82 28 33	adj. SR 378	Huntington
10.6	C, S	38 29 42 / 82 28 38	SR 243	Huntington
8.4	B	38 29 07 / 82 27 10	adj. SR 243	Huntington
Buffalo Creek (Tributary to Symmes Creek)				
5.0	F	38 45 06 / 82 33 28	adj. TR 129	Gallia
1.9	C, B	38 44 19 / 82 31 21	TR 154	Sherritts
1.7	F	38 44 06 / 82 31 15	dst. Caulley Creek	Sherritts
Caulley Creek (Tributary to Buffalo Creek)				
0.2	C, F	38 44 21 / 82 31 10	ust. CR 14	Sherritts
Indian Guyan Creek (Tributary to the Ohio River)				
5.8	C, S, F	38 28 42 / 82 23 55	CR 69	Huntington
5.7	B	38 28 41 / 82 23 55	dst. CR 69	Huntington
Raccoon Creek (Tributary to the Ohio River)				
63.0	B	39 07 55 / 82 21 53	adj. CR 28	Vales Mills
40.2	F	38 58 49 / 82 20 24	ust. dam @ Vinton	Vinton
40.1	C, S, B	38 58 34 / 82 20 18	ust. SR 160	Vinton
10.2	C, S, B, F	38 47 02 / 82 16 55	dst. dam @ Northup	Rodney
Little Raccoon Creek (Tributary to Raccoon Creek)				
28.3	B	39 07 29 / 82 30 21	ust. Meadow Run	Wellston
27.9	C, S, F	39 07 26 / 82 30 00	CR 39, ust. Meadow Run	Wellston
24.6	C, S	39 06 01 / 82 29 05	SR 32, dst. Meadow Run	Mulga
24.5	B, F	39 06 00 / 82 29 04	SR 32, dst. Meadow Run	Mulga

Table 1. Cont.

Stream RM	Type of Sampling	Latitude/Longitude	Landmark	USGS 7.5 min. Quad. Map
Meadow Run (Tributary to the Ohio River)				
3.2	B	39 05 44 / 82 32 50	ust. Jenos WWTP	Wellston
3.1	C, S, F	39 05 45 / 82 32 49	ust. Jenos WWTP	Wellston
3.02	E	39 05 45 / 82 32 48	Jenos 002	Wellston
3.00	E	39 05 46 / 82 32 48	Jenos 001	Wellston
2.9	C	39 05 49 / 82 32 48	dst. Jenos	Wellston
1.5	B	39 06 34 / 82 31 35	14th Street	Wellston
1.4	S, F	39 06 32 / 82 31 36	ust. Wellston WWTP	Wellston
1.3	C	39 06 45 / 82 31 29	ust. Wellston WWTP	Wellston
1.2	C, B, F	39 06 46 / 82 31 26	Wellston WWTP mixing zone	Wellston
1.1	S, F	39 06 48 / 82 31 22	dst. mixing zone	Wellston
0.8	B	39 06 56 / 82 30 56	ust. Chaetwood Rd.	Wellston
Campaign Creek (Tributary to the Ohio River)				
5.8	F	38 53 50 / 82 11 10	Porter Rd. @ Bulaville	Addison
5.5	C, B	38 54 00 / 82 10 58	@ Bulaville	Addison
Kyger Creek (Tributary to the Ohio River)				
5.1	B	38 57 49 / 82 07 35	ust. Stingy Run	Addison
4.9	F	38 57 37 / 82 07 48	ust. Stingy Run	Addison
4.8	C	38 57 38 / 82 07 46	TR 17 ust. Stingy Run	Addison
4.6	C, F	38 57 10 / 82 07 34	dst. Stingy Run	Addison
4.4	B	38 57 25 / 82 07 54	dst. Stingy Run	Addison
1.0	C, B, F	38 55 07 / 82 08 12	ust. OVEC ash pond	Addison
0.7	F	38 55 00 / 82 08 11	dst. OVEC ash pond	Addison
0.6	C	38 54 46 / 82 08 10	dst. OVEC ash pond	Addison
0.5	S, B	38 54 44 / 82 08 09	dst. OVEC ash pond	Addison
Leading Creek (Tributary to the Ohio River)				
10.3	C, S, B, F	39 02 22 / 82 09 32	TR 41, ust. Rutland	Rutland
Shade River (Tributary to the Ohio River)				
17.6	F	39 05 06 / 81 55 28	SR 248, @ Chester	Chester
17.0	C, S, B	39 05 14 / 81 55 31	dst SR 248	Chester
Little Hocking River (Tributary to the Ohio River)				
7.6	F	39 17 52 / 81 39 47	ust. backwaters; SR 555	Little Hocking
7.5	C, S, B	39 17 52 / 81 39 49	SR 339	Little Hocking

Table 2. Stream characteristics and identified pollution sources in the Southeast Ohio River Tributaries Study Area

Stream Name	Length (Miles)	Average Fall (Feet/Mile)	Drainage Area (Square Miles)	Identified Nonpoint Source Pollution Categories	Point Sources Evaluated
Little Scioto River	41.3	10.5	232.6	Resource Extraction, In-place Pollutants	-
Rocky Fork	13.9	10.3	68.6	-	-
Bear Run	2.8	39.3	2.60	-	-
Pine Creek	48.0	8.6	184.7	Resource Extraction	-
Storms Creek	15.5	26.8	39.36	-	-
Ice Creek	14.5	27.8	38.62	-	-
Symmes Creek	70.0	3.4	355.7	Resource Extraction	-
Buffalo Creek	7.5	49.1	17.80	-	-
Caulley Creek	3.9	53.4	5.26	In-Place Pollutants	-
Indian Guyan Creek	31.5	11.3	76.5	Agriculture, Resource Extraction	-
Raccoon Creek	109.0	3.8	683.5	Agriculture, Silverculture, Resource Extraction, On-site Wastewater Treatment	-
Little Raccoon Creek	36.5	6.4	157.8	Agriculture, Urban, Resource Extraction On-site Wastewater Treatment	-
Meadow Run	4.6	9.8	10.24	Urban, Resource Extraction, In-place Pollutants	Jenos WWTP, Wellston WWTP
Champaign Creek	19.2	15.2	46.25	Resource Extraction	-
Kyger Creek	11.8	23.3	30.08	Agriculture, Resource Extraction	-
Leading Creek	29.5	8.4	151.08	Agriculture, Resource Extraction	-
Shade River	38.2	7.9	220.6	Agriculture, Resource Extraction	-
Little Hocking River	18.4	19.6	102.86	-	-

Methods

All chemical, physical, and biological field, laboratory, data processing, and data analysis methods and procedures adhere to those specified in the OEPA Manual of Surveillance Methods and Quality Assurance Practices (OEPA 1989a) and Biological Criteria for the Protection of Aquatic Life, Volumes II - III (OEPA 1987a, 1989b, 1989c), and Rankin (1989) for aquatic habitat assessment.

Attainment/non-attainment of aquatic life uses is determined by using the recently developed biological criteria (OEPA 1987a, 1987b, 1989b, 1989c). The biological community performance measures that are used include the Index of Biotic Integrity (IBI) and the Modified Index of Well-Being (MIwb), both of which are based on fish community characteristics, and the Invertebrate Community Index (ICI) which is based on macroinvertebrate community characteristics. Performance expectations for the basic aquatic life uses (Warmwater Habitat (WWH), Exceptional Warmwater Habitat(EWH), and Modified Warmwater Habitat (MWH)) were developed using the regional reference site approach (Hughes et al. 1986; Omernik 1988). This fits the practical definition of biological integrity as the biological performance of the natural habitats within a region (Karr and Dudley 1981).

Attainment of an aquatic life use is FULL if all three indices (or those available) meet the applicable criteria, PARTIAL if one or more attains and at least one does not attain, and NON if all three (or those available) fail to meet the applicable criteria *or* when one or two organism groups indicate poor or very poor performance, even if the other group is attaining the applicable criteria.

During this survey, macroinvertebrates were sampled using modified Hester-Dendy multiplate artificial substrate samplers and qualitative techniques and fish were sampled using wading and boat pulsed D.C. electrofishing methods.

Results and Discussion

Chemical/Physical Assessment

Chemical Water Quality

Each chemical sample site was sampled six times during the 1990 field season. Each sampling effort consisted of field chemistry, metals analysis, nutrients, oxygen demand parameters, mine drainage associated parameters, and total residues. There was only one sampling station allotted for many of the subbasins within the study area. Thus, the data

generated does not necessarily reflect the water quality within the entire subbasin, but generally will give some indication of the water quality in the subbasin. The following general discussion will note criteria violations, exceedences, and elevated levels found in each subbasin. More specific information can be found in the chemical water quality violation and exceedences table (Table 3). As is commonly noted in Ohio streams exceedences of the total iron criterion occurred frequently in most every subbasin. Sediment sampling results for 17 stations in the study area is presented in Table 6.

Little Scioto River (EWH)

* Two minor exceedences (Fe, D.O.) were reported at the site. In addition, two samples exceeded the 30-day average criterion for lead concentrations. No point sources are located in the basin and the sources of contamination are unknown.

Rocky Fork, Storms Creek,Ice Creek (EWH)

* There were no exceedences of the water quality criteria in any of the above named tributaries. Elevated levels of lead and zinc were recorded from the bottom sediment in Storms Creek (Table 6).

Bear Run (EWH)

* The dissolved oxygen criterion was violated in four of the six samples collected. An ammonia-N concentration (6.83 mg/l) exceeded the 30-day average criterion. Elevated nitrite-nitrate levels were recorded on three of the sampling efforts (maximum= 2.4 mg/l). It appears that a localized sewage source may be affecting the sampling site since there are no permitted point sources in the subbasin.

Pine Creek (WWH)

* Two minor exceedences occurred (Fe, pH). The dissolved oxygen levels recorded on three of the visits were below the average criterion for WWH. Chronic criteria for dissolved oxygen are based on a 24 hour period. Since these data were from grab samples this level would have had to occur over a 24 hour period to result in a formal violation. Manganese levels were elevated on three of the samples. Elevated levels of zinc were also recorded from the sediment (Table 6).

Symmes Creek (WWH)

* The only criteria exceeded at this site was iron, which was exceeded on all six of the sampling events. All other parameters were below WWH criteria.

Buffalo Creek (WWH)

* Four exceedences of the iron criterion occurred. There were also three violations of the daily minimum dissolved oxygen criterion. In addition manganese values were elevated (>1 mg/l). These results may have occurred due to the lack of flow in this tributary during the sampling period. Small areas of pooled water were stagnated due to lack of flow and

therefore dissolved oxygen levels declined.

Caulley Creek (WWH)

* Three exceedences of iron criterion were noted. There were also three violations of daily minimum WWH and one LRW criterion for dissolved oxygen during the survey. Again, lack of stream flow appeared to be a critical element. This left small pooled areas that received little reaeration. Associated with these low flow periods were elevated (>1 mg/l) manganese levels on two occasions.

Indian Guyan Creek (WWH)

* A minor pH violation (6.41 S.U.) was the only one noted at this site. Chemically the WWH aquatic life use is being met.

Raccoon Creek (WWH)- RM 10.2; (LRW)- RM 40.0

* There were no exceedences of the WWH chemical criteria at either of the two sites in this basin. The site at RM 40.0 is currently designated as LRW, but is presently meeting all chemical criteria for WWH. A National Ambient Water Quality Monitoring Network (NAWQMN) site, which is located at RM 29.2, further substantiates this conclusion. Refer to the trend analysis for further discussion of chemical results from this site (RM 29.2).

Little Raccoon Creek (WWH)

* Two sites were located on Little Raccoon Creek, one upstream from Meadow Run and the other downstream. Sites were located at these points to determine if there was any impact from Meadow Run. Both of the sites were located in reaches of the mainstem which are designated WWH. The upstream station (RM 27.9) had exceedences only for iron concentrations. However,elevated levels of chromium and zinc, and highly elevated iron levels were recorded from the sediment. The site downstream of Meadow Run (RM 24.6), in addition to five iron exceedences, had two violations of the minimum dissolved oxygen criterion for the WWH use. Elevated levels of manganese on three occasions and elevated levels of ammonia-N on two occasions were also noted. These values show considerable differences in comparison to the upstream station. An elevated level of chromium was recorded from the sediment. This site (RM 24.6) is three miles downstream from the confluence of Meadow Run. Considerably more impact would have been demonstrated in Little Raccoon Creek had sampling been conducted nearer the mouth of Meadow Run.

Meadow Run (LRW- Headwaters to RM 2.1; WWH- RM 2.1 to Mouth)

* RM 3.1 (LRW)- No exceedences of the LRW use designation were noted. This site, which is located upstream from all point source discharges, had elevated levels of several mine drainage parameters (Al, Fe, Mn). These were noted in most of the samples collected. Highly elevated levels of cadmium and iron were also recorded in the sediment.

Datasonde units provided information for a forty five hour period in June (Table 5, Fig. 1). The results showed pH levels to vary from 4.37 to 7.28 (S.U.). Dissolved oxygen levels ranged from 4.52 to 7.46 (mg/l). The large variability shown in the results points to a pollution source as the possible cause since natural conditions do not change this quickly. The Wellston area is underlaid with vast amounts of underground mine shafts and drainage portals. Part of Wellston's water supply is pumped from these mine shafts. Perhaps pumpage for the water supply or flow regimes associated with the upstream mined areas accounts for the variability in water chemistry.

* JENOS (Pillsbury) (LRW)- The two outfalls from the plant discharge to Meadow Run. Outfall 001 (RM 3.0) is the process outfall and 002 (RM 3.02) is a non-contact cooling water discharge. Mean flow for the process outfall has ranged from 1.0 to 1.4 MGD (1.4-2.1 cfs) for the past three years. Significant contributions of oil and grease, BOD_5, and ammonia-N have impacted water quality downstream of the discharges. Several complaints by downstream residents have been investigated concerning spills of oily and greasy substances. Other concerns of nearby residents have been the water quality in the stream and the increased flows from the plant. The plant formerly discharged downstream near the Wellston WWTP, but has since moved the discharges closer to the Jenos treatment facility. The plant is currently undergoing a doubling of capacity for a new product line. Flows from the remaining discharges are not expected to increase due to this upgrade. Review of the monthly operating reports showed large divergences from the data collected during this survey. Laboratory inspections and split sampling with the entity indicates that a laboratory analysis problem exists, or that sampling does not properly represent the true composition of the effluent stream.

* RM 2.9 (LRW)- This site downstream of Jenos shows elevated levels of iron, BOD_5, and ammonia-N. Input from Jenos 001 and 002 outfalls improved pH values that attain the WWH criteria in Meadow Run, but the ammonia-N and BOD_5 loadings degrade water quality and will prevent this segment from attaining WWH.

* RM 1.25 (WWH)- Upstream from the Wellston WWTP there was one violation of the WWH criterion for dissolved oxygen and exceedences of the average criteria for iron and ammonia-N. There were also elevated levels of aluminum, manganese, and BOD_5. There is an increased impact from the Jenos outfall oxygen demand parameters (BOD_5, D.O.) at this site. The aluminum, iron, and manganese are results of the persistence of mine drainage parameters in the headwaters. Elevated levels of arsenic and lead, and highly elevated zinc were recorded from the sediment. Sediment samples taken at this site showed large accumulations of sewage sludge. Field observations further upstream showed sewage sludge to be prevalent in pooled areas as far as RM 1.6. Since this area appeared to be above the backwater of the Wellston WWTP, the deposits must have originated from the Jenos discharges.

* Wellston WWTP 001- This is an antiquated treatment plant with secondary treatment and trickling filters. There is no disinfection of the effluent. Therefore, fecal coliform is highly elevated in the effluent. In general, the plant is poorly operated and the entity self-monitoring program is not representative of the total plant performance. The plant is also hydraulically overloaded. One major factor is the amount of inflow and infiltration into the poorly designed collection system. The collection system is partially combined with storm sewers. There are overflows within manholes to both surface waters and to abandoned underground mine shafts. Standpipes have been driven into the shafts at the bottom of each manhole so that when large flows occur the manhole can bypass into the mine shaft.

* There are other sources of water quality degradation to Meadow Run from the Wellston WWTP in addition to the relatively poor quality of effluent. There are large amounts of sludge and the underdrains of the sludge drying beds discharge directly to the stream in the vicinity of the mixing zone downstream of the effluent.

* Four bioassay tests have been completed on the Wellston WWTP over the past two years. In all tests the effluent has been found to be acutely toxic. *Ceriodaphnia dubia* was more sensitive than the fathead minnow (*Pimephales promelas*). Acute toxicity was not found in the mixing zone and no chronic toxicity tests were undertaken. Total ammonia-N concentrations were mentioned as a likely causative agent.

* The Wellston WWTP has also shown high dioxin levels in the plant sludge resulting from previous industrial discharges. After an intensive investigation it was determined that contaminated solvents used by the Frick-Gallagher company was the source of the dioxin. Frick-Gallagher had ceased use of this solvent several years ago. Contamination of the sewer lines to the WWTP plant is still a concern. The Wellston WWTP is currently starting a program to clean the lines.

* RM 1.20 (WWH)- In the Wellston WWTP mixing zone there were no exceedences of any water quality criteria. Mixing zone criteria are differentiated from the WWH use criteria. The metals associated with mine drainage (Fe, Mn, Al) were elevated on all of the sample events. There were also very high levels of ammonia-N (7-10 mg/l). Phosphorus and BOD_5 levels were also elevated (avg 2.2 and 18.6 mg/l, respectively).

* Sediment samples taken at this site showed the stream bed composition to be very deep (1-2 ft.) depositions of sewage sludge. There also was an abundance of hydrogen sulfide gas being emitted. Elevated levels of arsenic and copper and highly elevated lead and zinc were present in the sediment.

* Impacts from the sludge and poor effluent quality is at its highest at RM 1.1 where Datasonde units revealed an average dissolved oxygen value for the 45 hour sampling period to be 0.24 mg/l (Table 5, Fig. 1). pH values remained stable downstream ranging

from 6.91 to 7.06 (S.U.).

Campaign Creek (WWH)

* One exceedence of the iron criterion was recorded. All other parameters were below WWH criteria.

Kyger Creek (LRW)

* RM 4.9- Samples show the characteristic mine drainage parameter impairments. Elevated levels of aluminum, manganese, and sulfate and low pH values were prevalent. This station is located upstream from Stingy Run. The headwaters of Stingy Run are in the Gavin Electric Generating Station (EGS) ash pond discharge. Flows were very low at this site during some sampling efforts.

* RM 4.6- This site is located downstream from Stingy Run. At the present time the Gavin EGS has a process in which they inject ammonia into the flue gas to reduce the corrosion of the flue gas stack liner. After the electroprecipitator removes the fly ash it is sluiced along with the ammonia to the ash pond where after retention and settling it exits via the outfall to Stingy Run. Ammonia-N levels at this site averaged 2.4 mg/l (minimum 0.67, maximum 4.5 mg/l). The Gavin EGS makes up the total flow of Stingy Run and virtually all of the flow of upper Kyger Creek during dry weather periods. The mean monthly flow of the Gavin EGS discharge for the July-October 1990 sampling period was 16.0 MGD. LRW chemical criteria were not exceeded, but significant loadings of ammonia-N were present because of the discharge.

* RM 1.0- This site which is upstream of the Kyger Creek EGS 005 (ash pond) discharge and several miles downstream from the confluence of Stingy Run, still shows elevated ammonia-N levels. Data from the 1990 field collections had a mean of 1.5 mg/l (minimum 0.13, maximum 3.0 mg/l). Kyger Creek EGS collects ammonia-N data upstream of their ash pond discharge. The data collected in 1989 showed a mean of 7.76 mg/l (minimum 0.8, maximum 24.2 mg/l). The site had several heavy metals that were detected, although not exceeding the LRW criteria. Included with these metals were several mine drainage parameters (Mn, Al, SO_4) and elevated levels of nitrite-nitrate and low pH values.

* Kyger Creek EGS 005 discharge- The plant uses an ammonium hydroxide pH adjustment system in their ash pond. This system is located near the discharge channel which proceeds into Kyger Creek. Data submitted by the plant indicates that in 1989 the 005 discharge had a mean ammonia-N of 6.25 mg/l (minimum 0.3, maximum 10.5 mg/l). Flow for this outfall on the dates OEPA sampled in 1990 were obtained from monthly operating reports and averaged 16.1 MGD for the six collections.

* RM 0.5- This site is downstream from the Kyger Creek EGS ash pond effluent (005). During the sampling events of this past study period the site was free flowing, but the

backwater effect of the Ohio River can affect this site during higher flows. Ammonia-N levels were elevated. The mean value was 2.5 mg/l for the sampling period (minimum 0.7, maximum 4.5 mg/l). The addition of the Kyger Creek EGS 005 effluent adds further to the impacts from the upstream contribution of the Gavin EGS 001 discharge. Again, mine drainage parameters showed elevated levels at this site. In addition, nitrite-nitrate levels were elevated. Elevated levels of copper, highly elevated zinc, and extremely elevated arsenic and chromium were recorded from the bottom sediment. Both arsenic and chromium are present in coal at concentrations of 5-25 and 5-60 µg/g, respectively (Kelley and Hite 1984), and thus are likely entering Kyger Creek from the coal ash discharges .

* The subbasin is chemically impaired by the effects of mining in the basin. There is also an additional element of concern with the large load of ammonia-N being added by the two EGS discharges. The combined flows of the two EGS discharges average 32 MGD during the July - October period with an average of more than 300 Kg/day of ammonia-N being discharged each day.

Leading Creek (WWH)

* Iron exceedences occurred on four of the sampling efforts. Total dissolved solids were exceeded once (2480 mg/l). On three other sampling efforts dissolved solids were elevated. The mean for the study period was 1176 mg/l. Sulfates were also elevated with a mean of 610 mg/l. There are several sources which are responsible for these results. The Columbus Southern Power Company's Meigs Mine #1 and #2 have a large coal preparation plant that has discharges to tributaries a few miles upstream from the sampling site. In addition there is a water treatment plant discharge from the Leading Creek Conservancy District. There are potential impacts from oil and gas wells in the area. Little Leading Creek is affected by mine drainage, but it discharges to the mainstem well downstream from the sampling site near the mouth. There are some previously mined areas upstream of the sampling station, but these impacts are relatively minor.

Shade River (EWH)

* Four exceedences of the iron standard were noted. In addition, aluminum was elevated in two samples. On two of the sampling occasions the stream appeared abnormally turbid for the flow and runoff conditions. Some unknown upstream activity is most likely the cause.

Little Hocking River (WWH)

* Three exceedences of the iron standard occurred. There were also elevated levels of aluminum on three occasions.

Table 3. Exceedences and violations of Ohio EPA Warmwater, Modified Warmwater, Exceptional Warmwater, and Cold Water Habitat water quality criteria (OAC 3745-1) for chemical/physical parameters measured in the Southeast Ohio River Tributaries study area, 1990. (Units are µg/l for metals; S.U. for pH; #/100ml for Fecal Coliform and mg/l for other parameters)

Stream Name	River Mile	Exceedences/Violations: Parameter
Little Scioto River (EWH)	12.6	Fe (1110)*; D.O.(5.7)**; Pb (7, 14)*
Bear Run (EWH)	0.2	D.O. (5.4, 5.0, 4.2, 5.2)**; NH3-N (6.83)*
Pine Creek (WWH)	20.5	Fe (1010)*; pH (6.39)**; D.O.(4.6, 4.9, 4.8)*
Symmes Creek (WWH)	10.6	Fe (1260, 1310, 1270, 1480, 1430, 1070)*
Buffalo Creek (WWH)	2.0	Fe (1210, 1170, 2740, 1450)* D.O. (3.9, 3.4, 2.0)**
Caulley Creek (WWH)	0.2	Fe (1260, 1510, 1290)*; D.O. (3.0, 1.9, 2.5, 2.7)**
Indian Guyan Creek (WWH)	5.8	pH (6.41)**
Little Raccoon Creek (WWH)	27.9 24.6	Fe (1260, 1320, 1060, 1510, 1400)* Fe (1780, 1670, 1510, 2570,2030, 1090)* D.O. (3.4, 3.9)**
Meadow Run (WWH)	1.25	Fe (2280, 2190, 4480, 1460,2430, 1620)* D.O. (3.8)**; NH3-N (4.02, 2.21,6.21, 6.28)*
Campaign Creek (WWH)	5.6	Fe (1150)*
Leading Creek (WWH)	10.3	Fe (1090, 1050, 1070,1330, 1100)*; TDS (2480)*
Shade River (EWH)	17.1	Fe (3600, 1380, 1040, 1720, 2270)*
Little Hocking River (WWH)	7.56	Fe (1500, 1240, 1200, 1600)*

* Indicates an exceedence of outside mixing zone 30-day average (24-hour ave. for D.O.) criterion.
** Indicates a violation of outside mixing zone criterion.
*** Indicates a violation of inside mixing zone criterion.

Table 4. Mean[a], minimum, maximum values for selected parameters in the Southeast Ohio River Tributaries study area, 1990.

Stream River Mile	D.O. (mg/l)	pH field (S.U)	Ammonia-N (mg/l)	Dissolved Solids (mg/l)	Sulfate (mg/l)	Al (µg/l)	Mn (µg/l)
Little Scioto R.	6.6	7.3	0.05	142	35	378	255
12.7	5.7-8.1	6.9-8.0	0.05-0.05	127-172	54-72	200-590	100-310
Rocky Fork	7.5	7.4	0.05	149	34	260	108
0.6	6.1-9.0	7.0-7.9	0.05-0.05	132-184	22-43	200-360	50-145
Bear Run	5.8	7.1	1.2	158	49	200	105
0.2	4.2-8.5	6.8-7.7	0.05-6.8	134-172	34-59	200-200	70-175
Pine Creek	5.5	7.2	0.06	387	184	263	1173
20.3	4.6-7.1	6.4-8.3	0.05-0.06	288-442	125-240	200-370	480-2170
Storms Creek	6.5	7.2	0.052	226	66	278	658
3.3	5.9-7.2	6.7-7.9	0.05-0.06	208-264	55-74	200-540	415-935
Ice Creek	6.8	7.2	0.05	312	109	210	518
2.05	6.0-8.2	6.7-8.0	0.05-0.05	282-386	104-121	200-260	350-820
Symmes Creek	6.4	7.4	0.05	242	89	425	399
10.6	5.2-7.2	6.6-7.9	0.05-0.05	226-269	75-104	230-620	225-630
Buffalo Creek	4.6	7.4	0.052	123	21	213	1315
1.9	2.0-6.2	6.9-7.8	0.05-0.06	102-136	10-30	200-280	260-2900
Caulley Creek	3.7	7.2	0.05	153	32	185	1278
0.2	1.9-6.2	6.7-7.6	0.05-0.05	140-176	17-44	110-200	655-2010
Indian Guyan Cr.	7.8	7.4	0.05	381	177	235	343
5.8	7.0-8.9	6.4-7.8	0.05-0.05	278-474	155-214	200-380	240-560
Raccoon Creek	8.4	7.0	0.052	288	145	257	1182
40.0	7.7-9.6	6.1-7.9	0.05-0.06	256-334	126-167	200-490	660-1650
	7.1	7.5	0.05	284	139	263	822
10.2	5.5-8.6	6.5-8.0	0.05-0.05	230-322	120-165	230-310	505-1050
Little Raccoon Cr.	6.7	6.9	0.08	147	60	412	707
27.9	5.4-8.1	6.8-7.1	0.05-0.12	124-164	54-72	250-530	585-940
	4.8	7.0	0.8	218	76	445	1345
24.6	3.4-7.2	6.9-7.1	0.29-1.37	174-244	73-85	350-630	980-1680

Table 4. Cont.

Stream River Mile	D.O. (mg/l)	pH field (S.U)	Ammonia-N (mg/l)	Dissolved Solids (mg/l)	Sulfate (mg/l)	Al (µg/l)	Mn (µg/l)
Meadow Run	7.1	5.3	0.21	462	234	2983	6758
3.1	5.6-8.7	4.2-7.3	0.05-0.43	276-594	134-288	280-5980	2690-10200
Jenos 002	8.9	7.6	0.05	319	102	200	10
3.02	8.6-9.1	7.3-8.0	0.05-0.05	306-336	94-109	200-200	10-10
Jenos 001	7.8	7.8	6.2	556	100	405	52
3.00	5.5-10.5	7.7-7.9	0.1-11.6	534-574	90-110	270-770	25-80
Meadow Run	7.2	7.9	4.9	450	110	683	630
2.9	4.4-9.7	7.7-8.7	0.05-10.8	348-496	98-119	240-2350	105-1400
	5.7	7.4	3.9	381	90	408	4337
1.25	3.8-7.8	7.2-7.7	0.74-6.3	282-430	69-119	200-1390	2040-5490
	5.4	7.2	8.4	377	93	522	2370
1.19	4.3-7.1	7.0-7.5	2.7-12.6	322-420	80-112	200-930	1630-2850
Campaign Creek	7.7	7.4	0.05	338	138	403	613
5.6	6.0-10.0	6.5-7.9	0.05-0.05	265-400	114-180	200-800	385-960
Kyger Creek	8.1	6.7	0.1	702	413	797	6908
4.9	6.1-9.6	6.0-7.3	0.05-0.19	488-820	272-552	280-1410	4300-8670
	7.5	7.1	2.4	1018	585	608	767
4.6	5.8-9.3	6.8-7.4	0.67-4.5	808-1100	499-678	240-810	340-1420
	6.9	6.7	1.5	1058	594	982	1679
1.0	5.5-9.1	6.1-7.6	0.13-3.0	790-1170	465-673	690-1300	925-2180
	7.4	6.9	2.5	835	473	752	984
0.5	6.4-9.1	6.3-7.2	0.66-3.8	662-888	386-526	640-840	380-2040
Leading Creek	6.9	7.5	0.05	1176	610	408	264
10.3	5.5-8.5	7.4-7.7	0.05-0.05	265-2480	103-1390	200-570	195-320
Shade River	7.7	7.8	0.05	240	67	1012	337
17.1	6.6-8.7	7.0-8.4	0.05-0.05	208-288	57-81	315-2340	240-415
Little Hocking R.	7.8	7.8	0.24	165	42	1002	253
7.6	7.1-8.3	7.5-8.1	0.05-0.8	144-182	36-52	850-1150	205-285

[a] Means calculated using detection limits as the minimum value where reported minimum was less than detection limit.

Table 5. Summary of diurnal D.O. (mg/l) and pH (S.U.) data recorded with Datasonde continuous monitors at seven locations in Meadow Run during June 27-29, 1990.

RM	N[a]	Mean	Min.	Max.	25th %ile	Mean	Min.	Max.	25th %ile
		D.O.				pH			
LRW									
3.1	43	5.31	4.52	7.46	4.76	5.04	4.37	7.28	4.41
2.9	45	3.70	1.57**	7.11	2.14**	7.50	7.44	7.60	7.47
2.15	46	0.83**	0.21**	2.02**	0.28**	6.85	6.73	6.96	6.78
WWH									
1.30	44	4.21**	3.39**	5.64	3.71**	7.24	7.20	7.45	7.21
1.10	45	0.24**	0.10**	2.33**	0.13**	6.97	6.91	7.06	6.94
0.7	11	0.42**	0.04**	0.87**	0.11**	7.11	6.95	7.19	7.09
0.01	46	2.19**	1.10**	3.73**	1.39**	6.47**	6.38**	6.62	6.41**

a number of hourly readings

** Indicates a violation of outside mixing zone criterion.

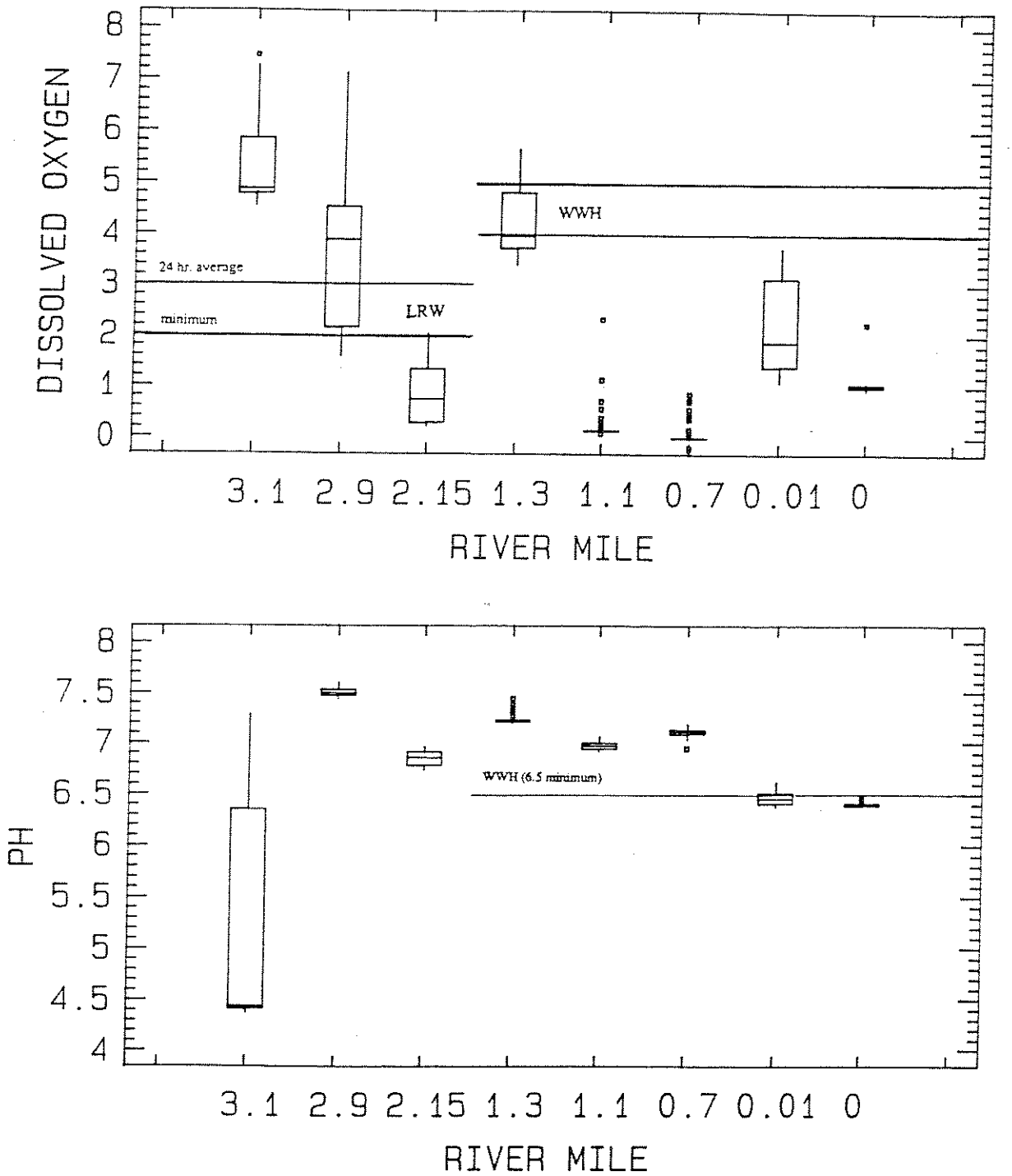


Figure 1. Longitudinal profile of dissolved oxygen (mg/l) and pH (S.U.) collected over a 45 hour period with Datasonde continuous monitors in Meadow Run, June 27-29, 1990. The RM 0.0 data is from the sink hole outflow.

Table 6. Concentrations of heavy metals (µg/g dry weight) in sediments of the Southeast Ohio River Tributaries study area, 1990. All parameter concentrations, excluding aluminum and nickel, were ranked based on a stream sediment classification system described by Kelly and Hite (1984).

Stream name River Mile	Al	As	Cd	Cr	Cu	Fe	Pb	Ni	Zn
Little Scioto River									
12.7	4330	1.62[a]	0.122[a]	5.89[a]	6.45[a]	9060[a]	20.9[a]	7.05	28.8[a]
Pine Creek									
20.3	12700	4.69[a]	0.296[a]	8.67[a]	21.8[a]	17800[a]	15.6[a]	47.0	131[c]
Storms Creek									
3.3	10600	4.98[a]	0.451[a]	11.4[a]	25.9[a]	21200[b]	44.5[c]	29.2	127[c]
Ice Creek									
2.05	9290	3.88[a]	0.345[a]	11.2[a]	23.7[a]	18400[b]	34.0[b]	28.4	95.8[b]
Symmes Creek									
10.6	7070	4.27[a]	0.245[a]	9.23[a]	11.6[a]	14100[a]	28.6[b]	17.4	46.2[a]
Indian Guyan Creek									
5.8	26700	9.01[b]	0.249[a]	22.3[b]	24.0[a]	32100[c]	20.4[a]	31.3	96.5[b]
Raccoon Creek									
40.0	-	3.76[a]	0.235[a]	6.52[a]	9.24[a]	16000[a]	10.4[a]	25.7	71.0[a]
10.2	-	6.82[a]	0.089[a]	14.3[a]	12.3[a]	17200[a]	11.3[a]	17.7	47.1[a]
Little Raccoon Creek									
27.9	-	8.46[b]	0.351[a]	29.2[c]	27.4[a]	47100[d]	30.9[b]	39.3	140[c]
24.6	-	10.6[b]	0.135[a]	26.6[c]	27.8[a]	29000[c]	26.2[a]	26.2	98.5[b]
Meadow Run									
3.1	14800	5.06[a]	4.20[d]	12.4[a]	11.8[a]	36600[d]	12.4[a]	17.5	69.5[a]
1.4	19200	11.2[c]	0.762[b]	15.6[a]	31.8[a]	29000[c]	52.8[c]	36.7	193[d]
1.1	12000	11.0[c]	0.869[b]	17.8[b]	71.0[c]	22700[b]	73.4[d]	25.9	232[d]
Kyger Creek									
0.5	-	41.8[e]	0.719[b]	93.9[e]	82.1[c]	27800[c]	24.1[a]	31.7	178[d]
Leading Creek									
10.3	-	9.08[b]	0.422[a]	15.8[a]	20.4[a]	22100[b]	21.3[a]	43.0	124[c]
Shade River									
17.1	-	-	0.190[a]	14.2[a]	17.8[a]	16100[a]	15.4[a]	18.7	58.5[a]
Little Hocking River									
7.5	-	-	0.093[a]	14.4[a]	14.2[a]	16200[a]	15.3[a]	14.5	43.5[a]

a non-elevated
b slightly elevated
c elevated
d highly elevated
e extremely elevated

Physical Habitat for Aquatic Life

* QHEI scores in the study area ranged from 34 to 81 reflecting exceptional to poor habitat quality. Aquatic habitats in many of the tributaries are predominantly influenced by warmwater habitat attributes with few to no modified habitat attributes (Table 7). Kyger Creek had the greatest number of high influence modified attributes followed by Little Raccoon Creek and Raccoon Creek, a reflection of the sediment bedload and erosion resulting from abandoned surface mine runoff. Three streams: Rocky Fork, Symmes Creek, and Leading Creek; were characterized by having no MWH attributes, a reflection of the high quality habitat of each.

* Sites within the basin were located in a variety of watersheds ranging from small headwaters (Bear Run, 2.6 sq. miles) to large streams (Raccoon Creek, 648 sq. miles).

Table 7. Matrix of QHEI scores and corresponding Warmwater and Modified Warmwater Habitat attributes from the Southeast Ohio River Tributaries study area, 1990.

Warmwater and Modified Warmwater attributes for the Southeast tributaries during 1990.

River Mile	QHEI	Gradient (ft/mile)	WWH Attributes: No Channelization or Recovered	Boulder/Cobble/Gravel Subs trates	Silt Free Substrates	Good/Excellent Development	Mod/High Sinuosity	Extensive/Moderate Cover	Fast Current/ Eddies	Low/Normal Embeddedness	Max Depth >40 cm	Low/No Riffle Embeddedness	Total WWH Attributes	MWH High Influence: Channelized or No Recovery	Silt/Muck Substrates	Low Sinuosity	Sparse/No Cover	Max Depth < 40 cm (WD,HW)	Total (High Influence) MWH Attributes	MWH Moderate Influence: Recovering Channel	Heavy/Mod Silt Cover	Sand Substrates (BT)	Hardpan Origin	Fair/Poor Development	Low/No Sinuosity	Only 1-2 Cover Types	Intermittent & Poor Pools	No Fast Current	High/Mod Embeddedness	Ext/Mod Riffle Embeddedness	No Riffle	Total (Moderate Influence) MWH Attributes	MWH (High)/WWH Attributes	MWH (Mod.)/WWH Attributes
STORMS CREEK																																		
Year: 90																																		
3.3	68.5	5.51	■		■		■	■	■	■	■	■	7						0			▲	▲								2	.13	.38
ICE CREEK																																		
Year: 90																																		
2.3	74.0	7.27	■	■		■	■	■	■	■	■	■	8						0			▲				▲					2	.11	.33
CAMPAIGN CREEK																																		
Year: 90																																		
5.8	72.0	5.09	■		■	■	■	■	■	■	■	■	8						0	▲											1	.11	.22
KYGER CREEK																																		
Year: 90																																		
0.7	61.5	1.50	■		■	■	■		■				6						0			▲								▲	3	.14	.57
1.0	51.5	1.50			■	■	■		■				4	●			●		2			▲								▲	3	.60	1.20
4.6	60.5	5.76				■	■	■	■	■			5						0	▲		▲	▲									3	.17	.67
4.9	34.0	5.76				■		■	■				3	●	●		●		3	▲		▲	▲			▲					▲	5	1.00	2.25
INDIAN GUYAN CREEK																																		
Year: 90																																		
5.8	71.5	6.29	■		■		■	■	■	■	■		7						0			▲	▲				▲					3	.13	.50
LEADING CREEK																																		
Year: 90																																		
10.3	72.0	3.93	■		■	■	■	■	■	■	■		8						0													0	.11	.11
LITTLE SCIOTO RIVER																																		
Year: 90																																		
12.6	78.5	3.05	■	■		■	■	■		■	■	■	8						0								▲					1	.11	.22
18.8	77.0	3.41	■		■		■	■	■	■	■	■	7						0			▲										1	.13	.25
ROCKY FORK LITTLE SCIOTO RIVER																																		
Year: 90																																		
0.6	77.5	4.29	■	■	■	■	■	■	■	■	■	■	10						0													0	.09	.09
BEAR RUN																																		
Year: 90																																		
0.2	70.5	69.00	■	■		■	■	■		■	■	■	8						0			▲					▲					2	.11	.33
PINE CREEK																																		
Year: 90																																		
20.5	74.0	2.90	■	■		■		■	■	■	■		8						0			▲	▲									2	.11	.33

Table 7. Cont.

Warmwater and Modified Warmwater attributes for the Southeast tributaries during 1990.

River Mile	QHEI	Gradient (ft/mile)	WWH Attributes: No Channelization or Recovered	Boulder/Cobble/Gravel Substrates	Silt Free Substrates	Good/Excellent Development	Mod/High Sinuosity	Extensive/Moderate Cover	Fast Current/ Eddies	Low/Normal Embeddedness	Max Depth >40 cm	Low/No Riffle Embeddedness	Total WWH Attributes	MWH Attributes (High Influence): Channelized or No Recovery	Silt/Muck Substrates	Low Sinuosity	Sparse/No Cover or Max Depth < 40 cm (WD,HW)	Total (High Influence) MWH Attributes	MWH Attributes (Moderate Influence): Recovering Channel	Heavy/Mod. Silt Cover	Sand Substrates (BT)	Hardpan Origin	Fair/Poor Development	Low/No Sinuosity	Only 1-2 Cover Types	Intermittent & Poor Pools	No Fast Current	High/Mod. Embeddedness	Ext./Mod. Silt/No Embeddedness	No Riffle	Total (Moderate Influence) MWH Attributes	MWH (High)/WWH Attributes	MWH (Mod.)/WWH Attributes
RACCOON CREEK																																
Year: 90																																
10.0	81.0	1.54	■	■	■	■	■	■	■	■	■	■	8					0				▲								1	.11	.22
40.2	48.5	.10	■		■	■	■		■	■		■	6	●				1	▲		▲				▲				▲	4	.29	.86
LITTLE RACCOON CREEK																																
Year: 90																																
24.5	64.0	2.59	■		■	■	■		■	■	■	■	7	●				1	▲							▲					2	.25	.50
27.9	55.0	2.33	■		■	■	■		■	■		■	6	●				1	▲							▲			▲		3	.29	.71
SHADE RIVER																																
Year: 90																																
17.2	80.0	2.35	■	■	■	■	■	■	■	■	■	■	8					0				▲								1	.11	.22
SYMMES CREEK																																
Year: 90																																
11.0	79.0	1.95	■	■	■	■	■	■	■	■	■	■	10					0													0	.09	.09
BUFFALO CREEK																																
Year: 90																																
2.0	73.5	7.09	■		■	■	■		■	■	■	■	7					0								▲					1	.13	.25
5.0	68.5	9.30	■	■	■	■	■	■	■	■	■	■	9					0								▲					1	.10	.20
CAULLEY CREEK																																
Year: 90																																
0.2	64.5	9.85	■	■	■	■	■	■	■	■	■	■	8					0								▲					1	.11	.22
LITTLE HOCKING RIVER																																
Year: 90																																
7.6	75.5	6.00	■	■	■	■	■	■	■	■	■	■	7					0	▲			▲				▲					3	.13	.50

Biological Assessment

Macroinvertebrates

Macroinvertebrates were sampled at 26 stations within the Southeast Ohio River Tributaries study area during the summer of 1990. Data for these stations are summarized in Table 8.

Little Scioto River

* A very good macroinvertebrate community was found in the Little Scioto River (RM 12.7). The Invertebrate Community Index (ICI) score was 44 which is a nonsignificant departure from the Exceptional Warmwater Habitat (EWH) ICI criterion (46). Mayfly, stonefly, and caddisfly diversity (EPT taxa) at this station was moderate with 16 taxa collected from the artificial and natural substrates combined, including the stonefly *Acroneuria evoluta*. This summer stonefly is generally only collected from high quality warmwater streams. In 1983 an ICI of 38 (good) was recorded at this station.

Rocky Fork

* An exceptional macroinvertebrate community was qualitatively collected from Rocky Fork (RM 0.6). Seventeen mayfly, stonefly, and caddisfly taxa were collected at this station including the stonefly *Acroneuria evoluta*. This was the highest number of EPT taxa collected from natural substrates during this study.

Bear Run

* Thirty six qualitative taxa were collected from Bear Run (RM 0.2) including 9 taxa of mayflies and caddisflies; this number falls in a range generally associated with good water quality.

Pine Creek

* The macroinvertebrate community sampled in Pine Creek (RM 20.4) had an ICI score (40) in the good range. Mayfly and caddisfly diversity was moderate with 11 taxa collected from the artificial and natural substrates. In 1983 an ICI score of 30 (fair) was recorded under nondetectable current conditions. Overall, the macroinvertebrate data supports the existing WWH use designation. The state endangered mollusk little spectaclecase (*Vellosa lienosa*) has been recorded from Pine Creek (Watters, 1988).

Storms Creek

* The macroinvertebrate community sampled in Storms Creek (RM 3.3) had an ICI score (40) in the good range. Sampling of the natural substrates supported the good evaluation despite the relatively low EPT collection of five taxa.

Ice Creek

* The macroinvertebrate community sampled in Ice Creek (RM 6.1) had an ICI score (54) in the exceptional range. Fifteen mayfly, stonefly, and caddisfly taxa were collected from the artificial and natural substrates including the stonefly *Acroneuria evoluta.*

Symmes Creek

* The macroinvertebrate community sampled in Symmes Creek (RM 8.4) had an ICI score (48) in the exceptional range. Nineteen mayfly, stonefly, and caddisfly taxa were collected from the artificial and natural substrates including the stonefly *Acroneuria lycorias.* The state endangered mollusk little spectaclecase (*Vellosa lienosa*) was recorded from the upper part of Symmes Creek (Watters, 1988).

Buffalo Creek

* Thirty seven taxa were collected qualitatively from Buffalo Creek (RM 1.9) under interstitial flow conditions including seven taxa of mayflies and caddisflies. These numbers fall in a range generally associated with good water quality.

Indian Guyan Creek

* The macroinvertebrate community sampled in Indian Guyan Creek (RM 5.7) had an ICI score (40) in the good range. Sixteen taxa of mayflies and caddisflies were collected from the artificial and natural substrates.

Raccoon Creek

* Raccoon Creek is currently designated Limited Resource Water (LRW)-acid mine drainage upstream from Lake Tycoon. The two macroinvertebrate stations located in this section, RMs 63.0 and 40.1, had ICIs scoring in the very good (42) and exceptional (46) range, respectively. Mayfly and caddisfly diversity was relatively low at RM 63.0 with 11 taxa collected and moderate at RM 40.1 with 17 taxa collected from the artificial and natural substrates.

* The macroinvertebrate community sampled at RM 10.2 had an ICI score (46) in the exceptional range. Fourteen mayfly and caddisfly taxa were collected from the artificial and natural substrates.

Little Raccoon Creek

* The macroinvertebrate community sampled in Little Raccoon Creek (RM 28.3) upstream from Meadow Run had an ICI score in the very good (42) range under slow current velocity conditions. The natural substrates at this site were composed primarily of sand and silt. Mayfly and caddisfly diversity was relatively low with 8 taxa collected from the artificial and natural substrates. The community at this site appeared limited by physical habitat characteristics including sedimentation, low gradient, and sluggish current conditions.

* The ICI (24) declined to the fair range at RM 24.5 downstream from Meadow Run. Mayfly and caddisfly diversity was low with 4 taxa collected from the artificial and natural substrates combined. Percent tolerant taxa and other dipteran/non-insects increased substantially compared to the upstream station. Water quality degradation from Meadow Run was the most likely cause of the community degradation at this site.

Meadow Run

* The macroinvertebrate community sampled in Meadow Run (RM 3.2) upstream from the Jenos WWTP had an ICI score (14) in the fair range. The community had low diversity and density and was composed of acidophilic taxa.

* The macroinvertebrate community sampled (RM 1.5) upstream from the Wellston WWTP had an ICI score (20) in the fair range. The diversity and density increased at this site with many pollution tolerant or intermediate taxa of midges present in high numbers. Water quality degradation by the Jenos WWTP was the most likely cause of the community changes at this site.

* Downstream from the Wellston WWTP (RM 1.2) the community was very poor with an ICI score of 0 at RM 0.8. Thick deposits of black sludge were observed within the WWTP mixing zone (RM 1.2) and at RM 0.8. Diversity was extremely low at both stations with only taxa tolerant of severe organic pollution present.

Campaign Creek

* The macroinvertebrate community sampled in Campaign Creek (RM 5.5) had an ICI score (54) in the exceptional range. Mayfly and caddisfly diversity was moderate with 13 taxa collected from the artificial and natural substrates.

Kyger Creek

* The macroinvertebrate community sampled in Kyger Creek (RM 5.1) upstream from Stingy Run had and ICI score (8) in the poor range. Diversity and density were low with mayfly, stonefly, and caddisfly taxa completely lacking. The community was apparently impacted by mining activities in the basin.

* The communities sampled downstream from Stingy Run improved slightly, apparently as the result of increased flow and dilution of the acid mine drainage present at the upstream site. The ICI (24) increased to the fair range at RM 4.4, primarily due to three caddisfly taxa present in moderate densities. No impact was attributed to the AEP Gavin EGS ash pond on Stingy Run.

* The communities upstream (RM 1.0) and downstream (RM 0.5) from the OVEC Kyger Creek EGS ash ponds were similar except the ICI declined downstream from the ash ponds due primarily to an increase in percent tolerant taxa. This decline may be due at least in part

to habitat influences and flow velocity changes brought about by occasional Ohio River inundations of Kyger Creek as far upstream as RM 0.5. No significant impact could be attributed to the OVEC Kyger Creek EGS ash ponds.

Leading Creek

* The macroinvertebrate communities sampled in Leading Creek (RM 10.3) had an ICI score (36) in the good range. Mayfly, stonefly, and caddisfly diversity was low (7) due to the near complete absence of mayflies (only one individual collected on artificial substrates). The stonefly *Acroneuria evoluta* was collected, however.

Shade River

* The macroinvertebrate community sampled in the Shade River (RM 17.0) had an ICI score (48) in the exceptional range. Mayfly, stonefly, and caddisfly diversity was moderate (16 taxa) and included the stonefly *Acroneuria evoluta.*

Little Hocking River

* The macroinvertebrate community sampled in the Little Hocking River (RM 7.5) had an ICI score (48) in the exceptional range. Mayfly, stonefly, and caddisfly diversity was moderate with 13 taxa collected from the artificial and natural substrates including the stonefly *Acroneuria evoluta.*

Table 8. Summary of macroinvertebrate data collected from multiplate artificial substrate samplers (quantitative sampling) and from natural substrates (qualitative sampling) in the Southeast Ohio River Tributaries study area, 1990.

Stream River Mile	Narrative Evaluation	Quantitative Evaluation ICI	No. Quant. Taxa	Density orgs./ft^2	No. Qual. Taxa	Qual. EPT[a]
Little Scioto River (EWH)						
12.7	Very Good	44[ns]	57	770	55	11
Pine Creek (WWH)						
20.4	Good	40	39	880	58	7
Storms Creek (EWH)						
3.3	Good	40*	33	464	28	5
Ice Creek (EWH)						
6.1	Exceptional	54	45	300	41	10
Symmes Creek (WWH)						
8.4	Exceptional	48	45	368	33	10
Indian Guyan Creek (WWH)						
5.7	Good	40	36	245	36	10
Raccoon Creek (LRW-acid mine drainage)						
63.0	Very Good	42	28	518	29	8
40.1	Exceptional	46	37	1378	48	12
Raccoon Creek (WWH)						
10.2	Exceptional	46	28	689	31	10
Little Raccoon Creek (WWH)						
28.3	Very Good	42	43	195	30	6
24.5	Fair	24*	37	205	29	3
Meadow Run (LRW-acid mine drainage)						
3.2	Fair	14	7	97	13	0
Meadow Run (WWH)						
1.5	Fair	20*	33	594	37	3
0.8	Very Poor	0*	3	89	6	0
Campaign Creek (WWH)						
5.5	Exceptional	54	40	438	37	11

Table 8. Cont.

Stream River Mile	Narrative Evaluation	ICI	Quantitative Evaluation: No. Quant. Taxa	Density orgs./ft^2	No. Qual. Taxa	Qual. EPT[a]
Kyger Creek (LRW-acid mine drainage)						
5.1	Poor	8*	16	57	10	0
4.4	Fair	24	19	398	17	4
1.0	Fair	26	22	86	14	3
0.5	Fair	20	14	95	11	3
Leading Creek (WWH)						
10.3	Good	36	37	281	21	4
Shade River (EWH)						
17.0	Exceptional	48	44	234	34	10
Little Hocking River (WWH)						
7.5	Exceptional	48	45	758	49	10

Stream River Mile	Narrative Evaluation[b]	Qualitative Evaluation: No. Qual. Taxa	Qual. EPT[a]	Relative Density	Predominant Organisms
Rocky Fork (EWH)					
0.6	Exceptional	54	17	Moderate	Mayflies, caddisflies
Bear Run (EWH)					
0.2	Good	36	9	Low	Midges, mayflies
Buffalo Creek (WWH)					
1.9	Good	37	7	Low	Midges, caddisflies
Meadow Run (WWH)					
1.2	Very Poor	6	0	High	Oligochaetes

ns Nonsignificant departure from biocriterion (≤ 4 ICI units).

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

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

b Qualitative evaluation based on Ohio WQS narrative definitions of the aquatic life uses is used when quantitative data is not available to calculate the Invertebrate Community Index (ICI) scores.

Fish Communities

Throughout the study area, a total of 66 fish species representing 12 families were collected from 28 sites in 18 tributaries. Families with the highest number of species were minnows (16), suckers (13), sunfish (12), and perch (11). The quality of fish assemblages ranged from exceptional to very poor and appear to be related with to the degree of impact from abandoned coal mines. Fish community data for these stations are summarized in Table 9.

Little Scioto River

* At RM 12.6, fish assemblages were exceptional to very good. Compositionally, dominant species numerically were golden redhorse and longear sunfish and by weight, common carp and golden redhorse. The state threatened species silver lamprey (*Ichthyomyzon unicuspis*) was collected at this site. The state endangered amphibian hellbender (*Cryptobranchus alleganiensis*) and the state listed fish of special interest eastern sand darter (*Ammocrypta pellucida*) have been previously recorded from this stream (D. Rice, ODNR pers. comm.).

* At RM 18.8, upstream from the confluence of Rocky Fork, fish assemblages were considered good to very good. Dominant species numerically were; longear sunfish, fantail darters, and bluntnose minnows, and by weight spotted bass, longear sunfish, yellow bullhead, and northern hog sucker.

Rocky Fork

* Fish assemblages were similar to those nearby in the Little Scioto River and were considered good to very good. Rocky Fork contained the highest number of species collected during a single sample. Central stonerollers, fantail darters, and longear sunfish, were dominant by numbers, while the biomass was predominated by common carp followed by northern hog sucker. This tributary was one of three streams in the study area where seven species of darters, the highest number, were collected including variegate darter (*Etheostoma variatum*), which has not previously been reported for the Little Scioto River watershed (Trautman 1981).

Bear Run

* The fish assemblage in this headwater stream was exceptional and included the state threatened species rosyside dace (*Clinostomus funduloides*), a geographically restricted minnow in Ohio. Numerically the fauna was dominated by creek chubs and central stonerollers.

Pine Creek

* Fish assemblages were considered marginally good to good and were dominated numerically by; banded darter, bluntnose minnows, longear sunfish and fantail darters, and by weight; northern hog suckers, gizzard shad, golden redhorse and longear sunfish. Pine

Creek was one of three streams in the study area where seven species of darters were found. Although past coal mining activities were located in the subbasin there appears to be minimal chemical and physical impact (USDA 1985).

Storms Creek

* Storms Creek, another direct tributary of the Ohio River, supported a very good to good fish assemblage despite a heavy sand bedload. Compositionally, dominant species were by numbers; longear sunfish followed by northern hog sucker and by weight; northern hog sucker, longear sunfish, spotted bass, white sucker,and freshwater drum. This stream supported the healthiest population of least brook lamprey (*Lampetra aepyptera*) in the study area with a relative number of 52 per 0.3 km during August. It is unknown why the fish indices were not fully attaining the EWH criteria. Topographical maps (1972) show no coal mining in the basin upstream from RM 3.3.

Ice Creek

* The fish assemblage at RM 2.3 was similar to Storms creek and was considered very good to good despite a heavy sand bedload. Dominant species numerically consisted of; emerald shiners, sand shiners, bluntnose minnows and silverjaw minnows and by weight; northern hog sucker, largemouth bass, white sucker, and longear sunfish. The number of intolerant species was the only IBI metric which strongly deviated from the expected during both samples. A reduction of in the sand bedload should result in an improved fish assemblage.

Symmes Creek

* Symmes Creek supported a marginally good/exceptional fish assemblage at RM 11.0. The community included pollution sensitive species and was dominated numerically by; banded darters, fantail darters and striped shiners and by weight; northern hog sucker, golden redhorse, gizzard shad, rock bass, and longear sunfish. Seven darter species were collected at the sampling location, including the eastern sand darter (state listed species of special interest) which had not been collected recently despite several attempts. Trautman (1981) shows records for this species in Symmes Creek between 1924 and 1954. Ironically, the stream supported one of the lowest relative weight of fish (2.8 kg/.3 km) in the study area which suggests possible impacts. Possible sources of impact include runoff from unreclaimed surface and underground coal mines (USDA 1985).

Buffalo Creek

* In this Symmes Creek tributary, fish assemblages declined from exceptional quality in the headwaters to good/marginally good in the lower reaches. The decline in quality is believed to be caused by impacts from one or more abandoned gas wells. Except for the abandoned gas wells, the watershed is relatively undisturbed and within the Wayne National Forest. Numerically, dominant species shifted from creek chub, southern redbelly dace and striped shiners in the headwaters to striped shiners, bluntnose minnow

and creek chub at RM 1.7. By weight, dominance shifted from creek chubs and grass pickerel to longear sunfish, spotted bass and creek chubs.

Caulley Creek

* The fish assemblage in this headwater tributary of Buffalo Creek was very good and exceeded the ecoregion IBI criteria for the WWH use. This small stream supported a diverse fish community comprised of 20 species. Numerically, the fauna was dominated by two highly tolerant species; creek chubs and white suckers.

Indian Guyan Creek

* In the lower reach of this Ohio River tributary, fish index scores were in the good range. Dominant species were by numbers; emerald shiners, striped shiners and longear sunfish, and by weight; freshwater drum, golden redhorse, and spotted bass. Some unreclaimed surface coal mines are located in the headwaters.

Raccoon Creek

* Historically, the water quality of Raccoon Creek was severely impacted by coal mining (and possibly point source discharges) within the basin. On 6 May 1972, USGS (1981) reported that Raccoon near Adamsville had minimum pH and dissolved oxygen values of 2.0 and 2.5 mg/l, respectively. Sections of the stream had few or no fish (pers. observation). Given these previous conditions, fish assemblages in Raccoon Creek during the 1990 survey were much better than expected and ranged from fair upstream from the confluence of Little Raccoon Creek, to good/fair in the lower reach. IBI scores were 35 at both locations and values for only one metric, the number of intolerant species, strongly deviated from the expected during both passes. Although not fully recovered, sport fishing was evident at both locations and species assemblages were more characteristic of typical warmwater fish communities.

* Upstream from the confluence of Little Raccoon Creek (RM 40.2), fish were sampled in an impoundment. Dominant species consisted numerically of longear sunfish, bluegill, and spotted suckers and by weight; common carp, spotted sucker, and longear sunfish. A total of 22 species were collected from the site, including three darter species; dusky darter, blackside darter, and johnny darter. The marginal index scores are attributed to continued runoff from upstream underground and surface coal mines.

* Downstream from the confluence of Little Raccoon Creek (RM 10.2), the fish assemblage improved and the MIwb achieved the WWH criteria. Compositionally, the fish community also improved and dominant species consisted numerically of; channel catfish and golden redhorse and by weight; channel catfish and common carp.

Little Raccoon Creek

* USDA (1985) shows Little Raccoon Creek as chemically contaminated and sediment

laden from runoff from unreclaimed underground and surface coal mines. QHEI scores were 55 to 58 and reflect less than optimal physical habitats. Extensive sedimentation, low gradient, and aquatic macrophytes created near wetland type habitats at both sites. Fish assemblages were fair quality both upstream and downstream from Meadow Run.

* Upstream from Meadow Run, Little Raccoon Creek (RM 27.9) was dominated numerically by; bluegill followed by longear sunfish and common carp, and by weight; overwhelmingly common carp. IBI metrics strongly deviating from the expected were; number of sucker species, intolerant species, percent round-bodied suckers, and simple lithophils; this is indicative of severe degradation.

* Downstream from Meadow Run, MIwb and IBI scores declined indicating a water quality impact in Little Raccoon Creek (RM 24.5). Additional IBI metrics which strongly deviating from the expected were; number of total species, intolerant species and relative number (minus tolerants). The relative weight of fish also declined and was only 20 percent of that upstream from Meadow Run. Impacts at this site are attributed to low D.O. and elevated NH_3-N levels in Meadow Run. Compositionally, the fish assemblage was dominated numerically by golden shiner followed by bluegill and common carp, and by weight common carp, spotted sucker, and largemouth bass.

Meadow Run

* Meadow Run supports only poor to fair fish assemblages due to poor water quality from mine runoff upstream from Jenos and excessive pollutant loadings causing low D.O. and high NH_3 concentrations downstream from the Jenos and Wellston WWTPs. Although physically located upstream from the Jenos discharge, results from RM 3.1 were influenced by the Jenos effluent which is backed up by a large pool. The IBI improved slightly at RM 1.4 then declined slightly downstream from the Wellston WWTP.

Campaign Creek

* Fish assemblages at RM 5.8 were only fair quality despite good physical habitat. IBI metrics strongly deviating from the norm were; total species, intolerant species, darter species, simple lithophils, and the number of fish. A possible source of the impact is sand bedload resulting from runoff from unreclaimed strip mine lands. Dominant species included by numbers; creek chubs and longear sunfish and by weight; gizzard shad, spotted bass, flathead catfish, and longear sunfish. The stream supported a lower than expected density and biomass of fish.

Kyger Creek

* Kyger Creek supported very poor to fair/poor quality fish assemblages at four sites. IBI scores were very low with most metric values strongly deviating from regional expectations scores. The degraded condition began upstream from the two power plant ash pond

discharges and is attributed to acidic runoff from unreclaimed surface and underground coal mines within the watershed (USDA 1985). A thick, sand bedload with coal fragments fills most of the stream channel resulting in predominantly shallow, uniform, unstable aquatic habitats. The two power plant discharges add significant flow to Kyger Creek and its Ohio River backwater extended throughout the RM 0.7 sampling zone during July's high flows.

* The two power plant ash pond discharges did not add further to the already degraded conditions observed upstream. Downstream from the two discharges, biological and habitat index scores increased slightly suggesting some positive influence to the stream's fish community. However, MIwb and IBI scores remained below ecoregion criteria and collections were characterized by below expected numbers of species, densities and weight of fish. The species collected downstream from the discharges were more characteristic of the Ohio River than a small tributary due to the augmented flow.

Leading Creek

* In Leading Creek at RM 10.3, the extent of upstream unreclaimed mines declined within the watershed and fish index scores were higher than in adjacent Kyger Creek. The MIwb score was in the good range, but the IBI was indicative of only fair quality. IBI metrics strongly deviating from the ecoregional criteria were; intolerant species and darter species. This below standard value is attributed to upstream mine runoff. A QHEI of 72 at RM 10.3 reflects good habitat quality. The fish community was dominated numerically by; creek chubs and fantail darters, and by weight; freshwater drum, common carp, and golden redhorse. A new drainage basin record was established for river redhorse (state species of special interest) which was not previously recorded (Trautman 1981). The quality of fish assemblages may decline in the lower reaches of Leading Creek with increased mine runoff. The state threatened species silver lamprey was recorded from this steam (D. Rice, ODNR pers. comm.).

Shade River

* The fish assemblage at Chester, OH (RM 17.6) was only marginally good/fair quality despite very good physical habitat. IBI metrics strongly deviating from the ecoregional criteria were; total species, intolerant species, darter species, and number of fish. After several high flow events, extensive sand deposits were evident in the channel suggesting high erosion rates within the watershed. Possible source(s) include runoff from unreclaimed surface mines (USDA 1985) and oil and gas wells. Dominant species consisted numerically of fantail darters and by weight; common carp, northern hog sucker, freshwater drum, and rock bass.

Little Hocking River

* Fish assemblages in the Little Hocking River (RM 7.6) were only in the fair range despite good physical habitats and no coal mining within the watershed. Possible causes of impact include septic contamination from an adjacent subdivision and runoff from numerous

upstream gas and oil wells. Dominant species were numerically; fantail darters followed by creek chubs, and by weight; freshwater drum, yellow bullhead, northern hog sucker, largemouth bass and golden redhorse. IBI metrics strongly deviating from the ecoregional criteria were; total species, intolerant species, simple lithophils, and DELT anomalies.

Table 9. Fish community (MIwb and IBI) and habitat (QHEI) index scores at 28 locations (18 streams) in the Western Allegheny Plateau sampled by OEPA during 1990.

Stream River Mile[a]	Cum. Species	Mean No. of Species	Mean Relative Number	Mean Relative Weight(kg)	MIwb	IBI	QHEI	Narrative Evaluation
Little Scioto River (EWH criteria for MIwb = 9.4w, 9.6b; IBI = 50w, 48b)								
18.8w	24	24.0	388	8.9	8.6*	48ns	77	Good/Very Good
12.6b	33	25.5	405	76.7	9.6	45ns	79	Exceptional/Very Good
Rocky Fork (EWH criteria for MIwb = 9.4w; IBI = 50w)								
0.6w	29	29.0	469	12.8	8.8*	48ns	78	Good/Very Good
Bear Run (EWH criteria for IBI = 50h)								
0.2h	12	12.0	1089	-	-	50	71	Exceptional
Pine Creek (WWH criteria for MIwb = 8.4w; IBI = 44w)								
20.5w	27	22.5	236	5.6	8.0ns	45	74	Marg. Good/Good
Storms Creek (EWH criteria for MIwb = 9.4w; IBI = 50w)								
3.3w	28	23.5	609	17.2	9.1ns	44*	69	Very Good/Good
Ice Creek (EWH criteria for MIwb = 9.4w; IBI = 50w)								
2.3w	31	27.0	539	6.1	8.9ns	43*	74	Very Good/Good
Symmes Creek (WWH criteria for MIwb = 8.4w; IBI = 44w)								
11.0w	26	26.0	254	2.8	8.1ns	50	79	Marg. Good/Exceptional
Buffalo Creek (WWH criteria for MIwb = 8.4w; IBI = 44w, 44h)								
5.0h	19	19.0	1226	-	-	52	69	Exceptional
1.7w	23	23.0	1198	8.3	8.8	40ns	-	Good/Marg. Good
Caulley Creek (WWH criteria for IBI = 44h)								
0.2h	20	19.0	1241	-	-	47	65	Very Good
Indian Guyan Creek (WWH criteria for MIwb = 8.4w; IBI = 44w)								
5.8w	29	24.0	250	12.5	8.6	45	72	Good

Table 9. Cont.

Stream River Mile[a]	Cum. Species	Mean No. of Species	Mean Relative Number	Mean Relative Weight(kg)	MIwb	IBI	QHEI	Narrative Evaluation
Raccoon Creek (LRW; WWH criteria for MIwb = 8.4w; IBI = 44w)								
40.2b	22	16.5	191	18.3	7.5	35	49	Fair
10.2b	24	19.5	221	58.6	8.8	35*	81	Good/Fair
Little Raccoon Cr. (WWH criteria for MIwb = 8.4w; IBI = 44w)								
27.9b	16	14.0	428	100.4	7.1*	34*	55	Fair
24.5b	12	10.5	302	19.6	6.8*	26*	58	Fair
Meadow Run (LRW; WWH criteria for IBI = 44h)								
3.1h	7	7.0	75	-	-	24	-	Poor
1.4h	10	10.0	258	-	-	30*	-	Fair
1.2h	4	4.0	228	-	-	24*	-	Poor
1.1h	8	8.0	335	-	-	26*	-	Fair
Campaign Creek (WWH criteria for MIwb = 8.4w; IBI = 44w)								
5.8w	23	18.0	176	4.5	7.1*	33*	72	Fair
Kyger Creek (LRW)								
4.9w	6	6.0	42	2.3	3.8*	16*	34	Very Poor
4.6w	8	8.0	72	8.1	5.8	24	61	Poor
1.0w	7	7.0	119	4.5	5.2	26	52	Poor
0.7w	10	10.0	194	7.7	6.2	20	62	Fair/Poor
Leading Creek (WWH criteria for MIwb = 8.4w; IBI = 44w)								
10.3w	25	21.0	348	30.1	8.5	34*	72	Good/Fair
Shade River (EWH criteria for MIwb = 9.4w; IBI = 50w)								
17.6w	22	21.0	204	10.0	8.3*	38*	80	Marg. Good/Fair
Little Hocking River (WWH criteria for MIwb = 8.4w; IBI = 44w)								
7.6w	21	19.0	189	8.5	7.7*	34*	76	Fair

a Fish collection method (h=headwater, w=wading, b=boat).

ns Nonsignificant departure from biological criteria (≤ 4 IBI units, ≤ .5 MIwb units).

* Significant departure from biological criteria (> 4 IBI units, > .5 MIwb units).

Table 10. Aquatic life use attainment status for the Southeast Ohio River Tributaries study area during the summer of 1990. Attainment status is based on biocriteria for the Western Allegheny Plateau ecoregion in Ohio.

River Mile Fish[a]/Invert.	IBI	MIwb	ICI[b]	QHEI	Attainment Status[c]	Comment
Little Scioto River (EWH / WWH recommended)						
18.8[W]/ -	48[ns]/48	8.6*/8.6	-	77	(PART./FULL)	Ambient
12.6[B]/12.7	45[ns]/45	9.6/9.6	44[ns]/44	79	FULL/FULL	Regional reference site
Rocky Fork (EWH / WWH recommended)						
0.6[W]/0.6	48[ns]/48	8.8*/8.8	E	78	PART./FULL	Ambient
Bear Run (EWH / WWH rcommended)						
0.2[H]/0.2	50/50	-	G	71	PART./FULL	Ambient
Pine Creek (WWH)						
20.5[W]/20.4	45	8.0[ns]	40	74	FULL	Regional reference site
Storms Creek (EWH / WWH recommended)						
3.3[W]/3.3	44*/44	9.1[ns]/9.1	40*/40	69	PART./FULL	Ambient
Ice Creek (EWH / WWH recommended)						
2.3[W]/6.1	43*/43[ns]	8.9[ns]/8.9	54/54	74	PART./FULL	Ambient
Symmes Creek (WWH)						
11.0[W]/8.4	50	8.1[ns]	48	79	FULL	Ambient
Buffalo Creek (WWH)						
5.0[H]/ -	52	-	-	69	(FULL)	Ambient
1.7[H]/1.9	40[ns]	-	G	-	FULL	Ambient
Caulley Creek (WWH)						
0.2[H]/ -	47	-	-	69	(FULL)	Regional reference site
Indian Guyan Creek (WWH)						
5.8[W]/5.7	45	8.6	40	72	FULL	Ambient
Raccoon Creek (LRW-acid mine drainage / WWH-recommended)						
- /63.0	-	-	42/42	-	(FULL/FULL)	Recovery from mine impact
40.2[B]/40.1	35/35*	7.5/7.5*	46/46	49	FULL/PART.	Recovery from mine impact
Raccoon Creek (WWH)						
10.0[B]/10.2	35*	8.8	46	81	PARTIAL	Ambient

Table 10. Cont.

River Mile Fish[a]/Invert.	IBI	MIwb	ICI[b]	QHEI	Attainment Status[c]	Comment
Little Raccoon Creek (WWH)						
27.9^{B}/28.3	34*	7.1*	42	55	PARTIAL	Ust. Meadow Run
24.5^{B}/24.5	26*	6.8*	24*	58	NON	Dst. Meadow Run
Meadow Run (LRW-acid mine drainage)						
3.1^{H}/3.2	24	-	14	-	FULL	Ust. Jenos WWTP
Meadow Run (WWH)						
1.4^{H}/1.5	30*	-	20*	-	NON	Ust. Wellston WWTP
1.2^{H}/1.2	24*	-	VP	-	N/A	Wellston WWTP mix zone
1.1^{H}/0.8	26*	-	0*	-	NON	Dst. Wellston WWTP
Campaign Creek (WWH)						
5.8^{W}/5.5	34*	6.9*	54	72	PARTIAL	Ambient
Kyger Creek (LRW-acid mine drainage)						
4.9^{W}/5.1	16*	3.8*	8*	34	NON	Ust. Stingy Run, AEP ash pond
4.6^{W}/4.4	24	5.8	24	61	FULL	Dst. Stingy Run, AEP ash pond
1.0^{W}/1.0	26	5.2	26	52	FULL	Ust. OVEC ash pond
0.7^{W}/0.5	20	6.2	20	62	FULL	Dst. OVEC ash pond
Leading Creek (WWH)						
10.3^{W}/10.3	34*	8.5	36	72	PARTIAL	Ambient
Shade River (EWH / WWH rcommended)						
17.2^{W}/17.0	38*/38*	$8.3^{*}/8.3^{ns}$	48/48	80	PART./PART.	Regional reference site
Little Hocking River (WWH)						
7.6^{W}/7.5	34*	7.7*	48	76	PARTIAL	Ambient

ECOREGION BIOCRITERIA: Western Allegheny Plateau

Index - Site Type	WWH	EWH	LRW
IBI	$44^{H\&W}$, 40^{B}	$50^{H\&W}$, 48^{B}	$18^{H\&W}$, 16^{B}
MIwb	8.4^{W}, 8.6^{B}	9.4^{W}, 9.6^{B}	4.5^{W}, 5.0^{B}
ICI	36	46	14

ns Nonsignificant departures from the ecoregion criteria (≤ 4 IBI and ICI units; ≤ 0.5 MIwb units); poor and very poor results are underlined.

* Significant departure from the ecoregion criteria (> 4 IBI and ICI units; > 0.5 MIwb units).

a Fish collection method (H=headwater, W=wading, B=boat).

b Narrative criteria used when only a qualitative sample was taken (VP=very poor, P=poor, G=good, VG=very good, E=exceptional).

c Use attainment status based on one organism group is parenthetically expressed.

Trend Assessment

Chemical Water Quality Trend

* Little historical water quality information is available for most of the basins within the Southeast Ohio River Tributaries study area. Historical information is available for a NAWQMN trend station site on Raccoon Creek and a biological and water quality survey was done on Meadow Run in 1984 (OEPA 1985). Monthly operating report data is also available, but as mentioned in the section on Ambient Water Quality Chemistry, there are several problems with the quality of laboratory work for the two entities on Meadow Run. Another problem in comparing earlier monthly operating data from Jenos is the fact that the outfalls were relocated within the past two years. This relocation separated the non-contact cooling water and the process wastestream into two separate outfalls and placed them nearly two miles upstream of the combined outfall that was studied in the 1984 report.

* The Raccoon Creek NAWQMN site (RM 29.2) has a period of record since 1978. The site is three to four miles downstream of Tycoon Lake. Tycoon Lake is the point at which the Warmwater Habitat use designation begins. pH values at RM 29.2 indicate an increasing trend (Fig. 2). Minimum values reported for 1989 and 1990 are higher than in any other year of record. The maximum and mean values also exhibit increases. No violations of the WWH pH criteria occurred at RM 40.0 (which is located in the LRW segment) during the 1990 survey. Acidic mine drainage has been the primary factor which has been affecting the upper segment. In addition to pH values, total dissolved solids can be used as indicators of mine drainage, often elevated in mine drainage streams. The ambient site (RM 29.2) has shown that the levels of dissolved solids has been well below WWH standards and in the range of non affected streams (200-400 mg/l) (Fig. 2). This further indicates the upstream segment is meeting WWH and is showing no impact at this RM 29.2.

* No trends could be distinguished with the Jenos plant due to the change in plant production and separation and movement of the outfalls. The period of record for the new outfalls is less than two years. In addition the plant has had some difficulty in laboratory analysis due to algal growth in their discharge lagoons and other in-house problems. Therefore no appropriate data comparisons can be made over a sufficient period of time.

* The Wellston WWTP was originally built in 1939. The plant was upgraded with a trickling filter and clarifier in 1957 and 1961. Since that time there have been no changes made at the plant. The plant is scheduled for a major upgrade starting in 1991. Effluent quality over the past five years has been erratic. Total suspended solids loadings the past four years have increased substantially (54.3 kg/day to 75.7 kg/day-50th percentile). BOD_5 levels have been consistent. Ammonia-N, which had been decreasing (14.6 kg/day

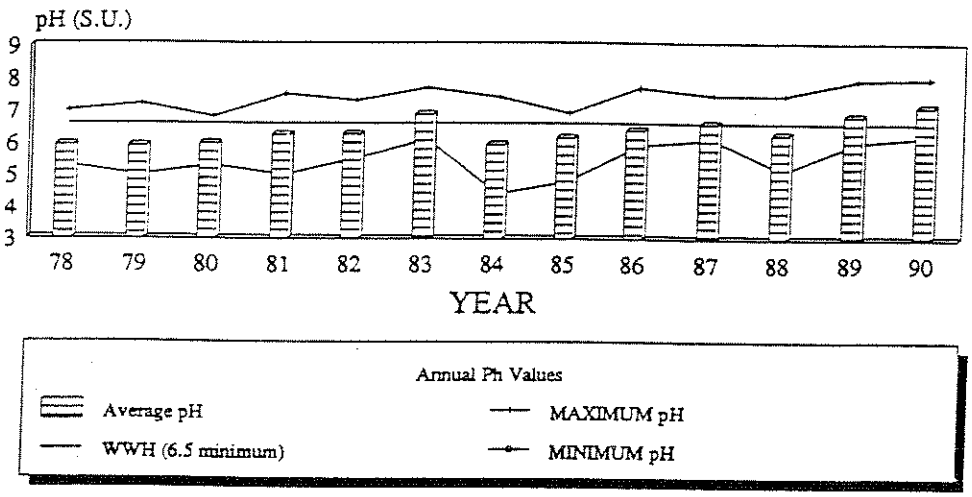
to 2.4 kg/day) for the years 1985 to 1987 abruptly increased in 1988 and has remained at an elevated level (18-19 kg/day) since (Fig. 3). During this period the annual 50th percentile plant flow has also been erratic, thus the loadings have not been entirely controlled by flow.

* Meadow Run was studied in 1984 when the Wellston and Jenos discharge points were located adjacent to each other on opposite banks of the stream. For this reason and the scope of the survey being different, some of the sites from the two surveys do not directly correspond. However, some comparisons are possible. In general the 1984 survey showed that dissolved oxygen levels to be below 1.0 mg/l and BOD_5 levels to range from 18 to 55 mg/l downstream of the WWTP (RM 0.72). Although chemical sampling at RM 0.72 was not done in 1990, Datasonde monitors provided dissolved oxygen results for this site. The 1990 data showed similarly low D.O. concentrations at this site (minimum 0.04 mg/l; maximum 0.87 mg/l).

* pH measured at RM 3.1 has shown an increase since the 1984 survey (Table 11). In 1984, the headwaters of Meadow Run were acidic, but in 1990 pH values were generally higher. Dissolved oxygen, sulfates, iron, and zinc have all shown decreases in 1990. There appears to be less impact from acidic mine drainage since the 1984 study. At RM 1.2 there has been a general improvement of all parameters with the exception of iron which showed a substantial increase since the 1984 survey. Most of the improvements are related to the movement of the Jenos outfall farther upstream. RM 1.2 in the 1984 survey was within the mixing zone of the Jenos and Wellston WWTP discharges. It appears that by separating these outfalls the impact has been reduced at the discharge point and spread through the upper two miles.

Table 11. Comparison of mean values for sites chemically sampled in 1984 and 1990 on Meadow Run.

Parameter	R.M. 3.1		R.M. 1.2	
	1984 Mean	1990 Mean	1984 Mean	1990 Mean
Dissolved Oxygen (mg/l)	8.32	7.05	2.35	5.35
pH (S.U.)	3.6	5.3	7.0	7.2
Sulfates (mg/l)	512	234	-	-
Iron (µg/l)	8294	1065	690	2005
Zinc (µg/l)	296	116	30	34
Ammonia-N (mg/l)	-	-	8.6	8.2
BOD_5 (mg/l)	-	-	39	19



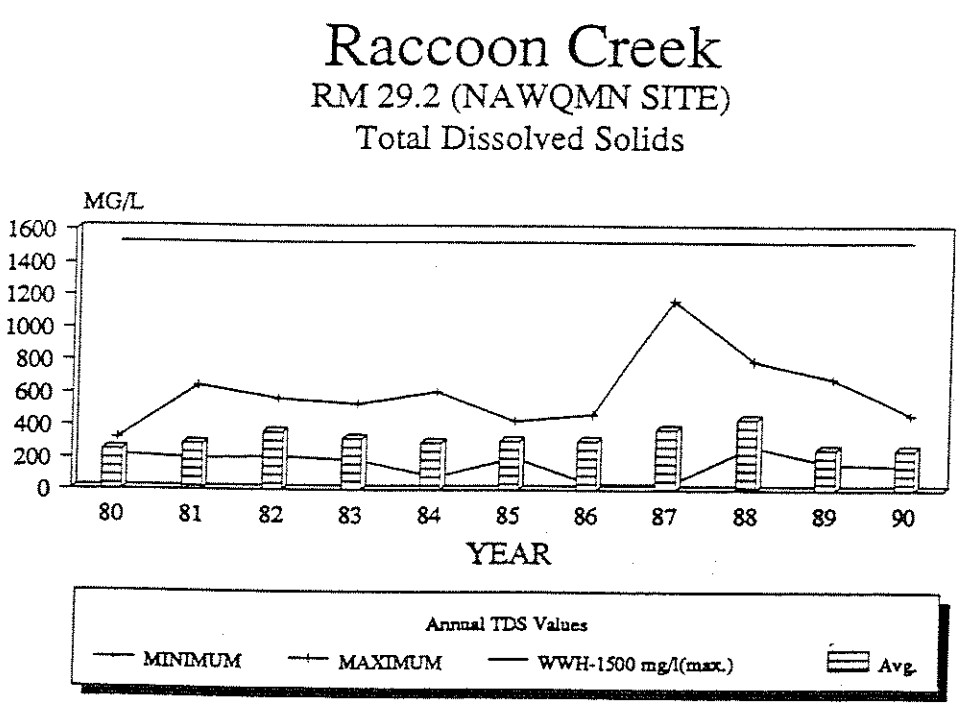
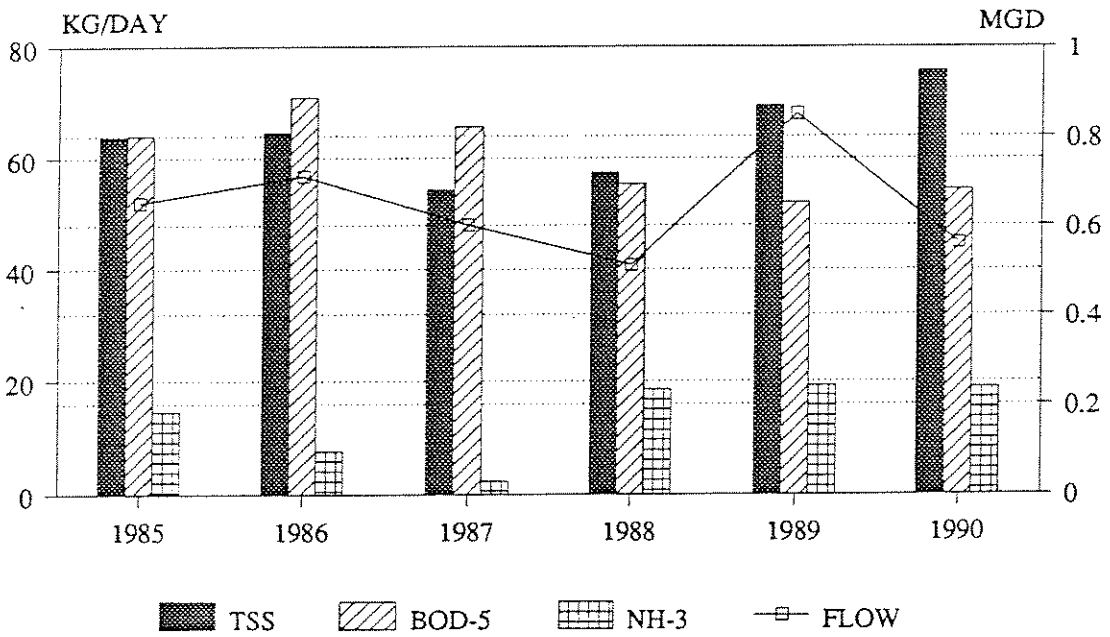


Figure 2. Long term trends for pH (S.U.) and total dissolved solids (mg/l) in Raccoon Creek at RM 29.2 (NAWQMN fixed station monitoring site).

WELLSTON WWTP
001



50th percentile

Figure 3. Trend of 50th percentile loadings of total suspended solids (TSS), BOD_5, and ammonia-N (NH_3-N) for the Wellston WWTP 001 discharge.

Biological Trend

Little Scioto River

* Since 1983, the ICI increased to 44 (very good) from 38 (good), the MIwb remained similar (RM 9.6/9.7) while the IBI decreased to 45 (very good) from 51 (exceptional). The mean number of fish species collected and total relative number also declined. Overall community composition was similar in both years.

* The attainment status was PARTIAL in 1983 and FULL in 1990 (the IBI and ICI were nonsignificant departure from EWH criteria). Using the recommended use designation change from EWH to WWH this site would be FULL attainment in both years.

Pine Creek

* Since 1983 the ICI increased to 40 (good) from 30 (fair) primarily due to more favorable flow conditions in 1990, rather than any changes in water quality. Comparison of the fish sampling results from 1990 to 1983 showed a decline of 0.9 MIwb units but an increase of 4 IBI units. The lower MIwb was due to a considerably lower relative number of fish (236 vs. 1017) and mean number of species (27 vs. 31) which suggests a decline in the overall quality of fish assemblages at this reference site. Impacts may be attributed to non-acidic surface mine runoff.

* The attainment status was PARTIAL in 1983 due to the fair macroinvertebrate community rating and FULL in 1990 despite the decline in the MIwb score.

Caulley Creek

* IBI scores from 1990 and 1984 were similar (47 vs. 49, respectively) and suggests no significant changes during the six year period. The ICI score in 1984 was 16 (fair) due primarily to intermittent stream conditions during the sampling period. The sampler was lost in 1990.

* The attainment status was PARTIAL in 1984 due to the adverse effect of stream intermittence on the macroinvertebrate community.

Raccoon Creek

* The macroinvertebrate communities sampled in Raccoon Creek during 1990 were substantially improved compared to a 1980 sample taken at RM 29.1 which had an ICI score of 6 (poor). This improvement was most likely due to improved water quality (especially related to mitigation of acid mine drainage) in Raccoon Creek since 1980.

Little Raccoon Creek

* The macroinvertebrate communities sampled in Little Raccoon Creek during 1990 (ICI=42 at RM 28.3 and 24 at RM 24.5) were substantially improved compared to 1984

when the ICI scores were 12 (poor) at RM 28.4 and 14 (fair) at RM 24.5. The improvement was attributed to improved acid mine drainage related water quality as well as better flow conditions in 1990.

* 1990 results show fish assemblages in Little Raccoon Creek have not significantly changed upstream from Meadow Run since 1984. During the six year period, the MIwb decreased 0.2 units while the IBI increased 4 units upstream from Meadow Run. Downstream from the tributary, index values were similar decreasing 0.1 and 5 units, respectively.

* The attainment status was NON at both sites in 1984, and PARTIAL upstream from Meadow Run and NON downstream from Meadow Run in 1990. The causes of the NON (1984) and PARTIAL (1990) attainment upstream from Meadow Run were surface mine related sedimentation in both years and acid mine related water quality problems in 1984. Downstream from Meadow Run point source related water quality degradation from Meadow Run combined with mine related sedimentation were the primary causes of the NON attainment in both years.

Meadow Run

* Macroinvertebrate communities sampled in Meadow Run upstream from the Jenos WWTP in 1984 (ICI=2) and 1990 (ICI=14) reflected degradation from acid mine drainage in the upper watershed. Communities sampled downstream from the Wellston WWTP were very poor (ICI=0) in both years; diversity was very low with only tolerant taxa characteristic of severe organic pollution present.

* Although still considerably impacted, 1990 fish sampling results showed considerable improvement since 1984. IBI values at two sites (RM 3.1 and 0.9) increased from 12 to 24 and 26, respectively. The mean number of fish species increased from 0.3 to 7 and 8, respectively.

* The attainment status upstream from the Jenos WWTP, where the use is LRW, was NON in 1984 and FULL in 1990. The slight improvement in the biological community at this site seems to be due to a lessening of acid mine related water quality impacts (Table 11). The attainment status downstream from the Wellston WWTP, where the use is WWH, was NON both years due to continued pollution loadings from the Jenos and Wellston WWTPs.

Kyger Creek

* Macroinvertebrate sampling in Kyger Creek during 1990 and 1982 (qualitative data only) produced similar results. Acid mine drainage and sedimentation were attributed as the pervasive background conditions that caused poor to fair macroinvertebrate community performance in this stream.

Leading Creek

* Macroinvertebrate sampling in Leading Creek (RM 10.3) during 1990 (ICI=36), 1989 (ICI=34), 1988 (ICI=28), and 1987 (ICI=32) produced similar results. The 1988 data was somewhat unusual in that the sample had the highest mayfly, stonefly, and caddisfly diversity (EPT taxa) (15) and the lowest ICI. Other years resulted in ICI scores in the marginally good or good range and EPT counts of 7. The stonefly *Acroneuria evoluta* was collected each year. The difference in the 1988 data was attributed to the early collection date (May 26).

Shade River

* Macroinvertebrate sampling in the Shade River in 1990 (ICI=48 at RM 17.0) and 1984 (ICI=42 at RM 17.6) produced generally similar results. In both years, 16 mayfly, stonefly, and caddisfly taxa were collected from the artificial and natural substrates including the stonefly *Acroneuria evoluta.*

* 1990 results at RM 17.6 show a slight decline in fish community performance since 1984. MIwb and IBI values decreased 0.1 and 5 units, respectively. The mean number of species decreased from 27.3 in 1984 to 21.0 during 1990.

* The attainment status was PARTIAL in both years. Using the recommended use designation change from EWH to WWH the use would be FULL in 1984 and PARTIAL in 1990. A Possible cause of the PARTIAL attainment of the WWH use is non-acidic mine related sedimentation.

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List of Available Appendix Tables

APPENDIX B - MACROINVERTEBRATE DATA

Table B-1. Organisms collected from artificial substrate samplers and from natural substrates in the Southeast Ohio River Tributaries study area, 1990.

Table B-2. Evaluation of the macroinvertebrate community by river mile (RM) for the Southeast Ohio River Tributaries study area, 1990, using the Invertebrate Community Index (ICI) developed for application to Ohio surface waters. Scores of 6, 4, 2, and 0 are assigned to each metric according to whether it: exceeds (6), approximates (4), slightly deviates from (2), or strongly deviates from (0) an ecological grouping expected in a relatively undisturbed stream or river.

Table B-3. Ohio EPA Macroinvertebrate Evaluations Group Site Description Sheets.

APPENDIX C - CHEMICAL DATA

Table C-1. STORET retrieval of chemical data collected in the Southeast Ohio River Tributaries study area, 1990.

APPENDIX F - FISH DATA

Table F-1. Characteristics of electrofishing sampling methods most frequently used by the Ohio EPA to sample fish communities.

Table F-2. Species, relative numbers (#/0.3 km), and relative weights (kg/0.3 km) of fish collected at sampling sites in the Southeast Ohio River Tributaries study area, July - September, 1990.

Table F-3. Evaluation of the fish community by river mile (RM) in the Southeast Ohio River Tributaries study area during July- September, 1990, using the Index of Biotic Integrity (IBI) modified for application to Ohio waters. Scores of 5, 3, or 1 are assigned to each metric according to whether it: approximates (5), slightly deviates from (3), or strongly deviates from (1) an ecological grouping expected in a relatively undisturbed stream. Numbers in parentheses are numbers of species, individuals, or proportion of individuals, as indicated.

Table F-4. The presence of external anomalies observed on fish from sampling locations in the Southeast Ohio River Tributaries study area, July-September, 1990.

Table F-5. Fish species documented in the Southeast Ohio River Tributaries study area as reported in Trautman (1981) and collected by the Ohio EPA during 1990.

Table F-6. Ohio EPA Fish Evaluation Group Site Description Sheets.

Appendix Tables available upon written request by contacting:

Ohio Environmental Protection Agency
Division of Water Quality Planning and Assessment
P.O. Box 1049, 1800 WaterMark Drive
Columbus, Ohio 43266-0149