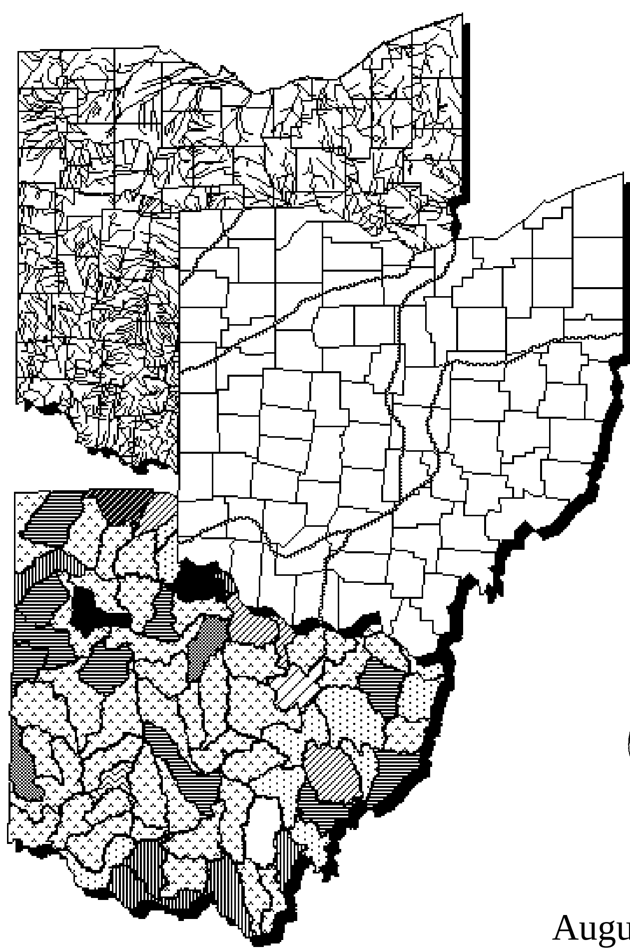
State of Ohio
Environmental Protection Agency

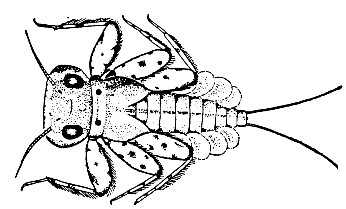
Ecological Assessment Unit
Monitoring and Assessment Section
Division of Surface Water

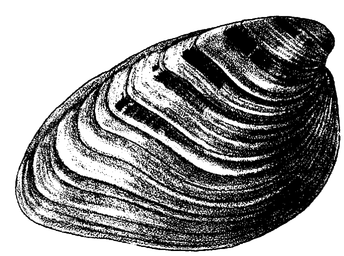
Biological and Sediment Quality Study of the Grand River at the Diamond Shamrock Waste Lagoons Area

Lake County, Ohio

1994







August 31, 1995

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

Biological and Sediment Quality Study of the Grand River in the Vicinity of the Diamond Shamrock Waste Lagoons Area

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Lake County, Ohio

August 30, 1995

OEPA Technical Report MAS/1995-8-11

prepared for

State of Ohio Environmental Protection Agency
Division of Emergency and Remedial Response

prepared by

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ACKNOWLEDGEMENTS

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

Coordinator - Bernie Counts
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Fish Data Analysis - David Altfater
Macroinvertebrate, Sediment, Fish Tissue, Unionid Mussel Tissue, and Surface Water Data Analysis - Bernie Counts
Reviewers - Chris Yoder, Jeff DeShon, and Marc Smith

Support during field collections was provided by Dan Williams (DynCorp), Mike Pettegrew, Bret Henninger, and Shane Farnsworth (college interns).

Biological and Sediment Quality Study of the Grand River in the Vicinity of the Diamond Shamrock Waste Lagoons Area (Lake County, Ohio)

Ohio Environmental Protection Agency
Division of Surface Water
Monitoring and Assessment Section
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1685 Westbelt Drive
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INTRODUCTION

The Grand River study area began upstream from the Diamond Shamrock waste lagoon area (River Mile [RM] 8.66) to near State Route 535 (RM 2.37).

Specific objectives of this evaluation were to:

1) determine and measure adverse impacts on biological condition and sediment quality in the Grand River in the vicinity of the Diamond Shamrock waste lagoons;

2) determine the potential accumulation of contaminants in river sediments, unionid mussel tissue and fish tissue in the vicinity of the Diamond Shamrock waste lagoons;

3) determine the attainment status of current aquatic life use designations for the Grand River within the study area; and

4) follow-up on conditions documented in the 1987 Ohio EPA surveys.

The findings of this evaluation may factor into regulatory actions taken by Ohio EPA (e.g. NPDES permits, Director's Orders, Ohio Water Quality Standards rulemakings [OAC 3745-1]), and eventually be incorporated into the State Water Quality Management Plans, the Ohio Nonpoint Source Assessment, and the biennial Ohio Water Resource Inventory (305[b]) report.

Fish and macroinvertebrate communities were sampled during the summer of 1994 at four locations on the Grand River from RMs 6.6 to 3.1 (Table 1, Figure 2). Sampling was conducted to assess fish and macroinvertebrate communities in the vicinity of the Diamond Shamrock waste lagoons. Fish collections were made at each site between August and October using pulsed DC electrofishing gear, with a sampling distance of 400 - 500 meters. Macroinvertebrate collections were made at each site using modified Hester-Dendy multiple-plate artificial substrate samplers colonized for a six-week period from August 19 - September 29. At the time of sampler retrieval, a qualitative sample of the macroinvertebrate community was collected from all available natural habitats in the near vicinity of the sampling site.

The Grand River is located in the Erie-Ontario Lake Plain (EOLP) ecoregion and is currently designated Exceptional Warmwater Habitat (EWH) upstream from RM 5.5 to RM 30.9 and Warmwater Habitat (WWH) from RM 5.5 to the mouth. The section from RM 4.7 to RM 3.1 was evaluated based on the interim Lake Erie estuary and harbor criteria.

SUMMARY / CONCLUSIONS

From August to October, 1994, Ohio EPA Division of Surface Water staff, at the request of the Division of Emergency and Remedial Response, conducted biological community, unionid mussel tissue, fish tissue, fish biomarker, and sediment sampling on the Grand River in the vicinity of the Diamond Shamrock waste lagoons. The results of these sampling events are summarized below.

- FULL attainment of the EWH use designation (Table 2) was observed at RM 6.6/6.4 with the macroinvertebrate community being assessed based on the qualitative sample. Full attainment of the interim Lake Erie estuary and harbor criteria was observed at RMs 4.6/4.7 and 4.2. PARTIAL attainment of the interim estuary and harbor criteria was observed at RM 3.2/3.1 with the fish indices considered nonsignificant departures from the interim criteria and the macroinvertebrate community index not meeting the interim criterion.

- The Ohio EPA survey of the Grand River in 1987 reported a significant change in water quality in the area of the Diamond Shamrock Co. waste lagoons (Ohio EPA 1987c). Concentrations of total dissolved solids (TDS), calcium, sodium, and chlorides increased downstream from the waste lagoons. An indication that this problem persists is evidenced by conductivity data collected by the Ohio EPA Water Quality Modeling Section in September 1990 (Figure 1). This increase in ionic concentrations could lead to the establishment of a pycnocline, a density gradient similar to a salt wedge in a marine estuary, at the boundary between the higher density river water and the lower density lake water. Pycnoclines can be very stable but move upstream or downstream depending on stream flow and lake levels or seiches, they can be disrupted by mechanical action (e.g. a storm event); such an occurrence may have occurred in the late hours of Sept. 6, 1990 (Figure 1). If a density gradient formed in the vicinity of the Painesville WWTP, it could have the effect of trapping effluent in the vicinity of the outfall. This could create water quality problems, even with the WWTP in compliance with NPDES permit limits, and result in degraded biological communities.

- Fish tissue results documented two samples (a laboratory split duplicate sample of smallmouth buffalo from RM 3.2) with total PCBs of 850 ug/kg and 1050 ug/kg; these would be considered moderately to highly elevated values based on comparison to the Ohio Department of Health PCB consumption guidelines. A smallmouth buffalo from RM 3.2 and a channel catfish from RM 4.2 had elevated levels of chromium compared with the other samples. All other results were below the estimated quantitation limits (EQL) or at low concentrations.

- The unionid mussel tissue results showed low levels of the pesticide 4,4’ DDE, cadmium, chromium, and lead. All other pesticides, PCBs, mercury, and hexavalent chromium were below the EQL.

- Sediment samples were collected at six locations in the Grand River by the Ohio EPA during November 1994. The sample from RM 4.04 yielded levels of arsenic and chromium and the sample from RM 4.06 a level of chromium which exceeded the Lowest Effect Levels (Persaud *et al*. 1993). Hexavalent chromium was detected at four of the nine sample sites with values ranging from 1.83 mg/kg to 5.04 mg/kg.

RECOMMENDATIONS

A comprehensive surface water quality survey should be conducted from approximately RM 6.0 to near the mouth. Sampling should include: TDS, sodium, calcium, chlorides, and metals including hexavalent chromium. A longitudinal and depth profile of the river based on conductivity and temperature readings needs to be completed under a variety of flow conditions and include flow data from USGS gaging station 04212100, wind direction, and lake level.

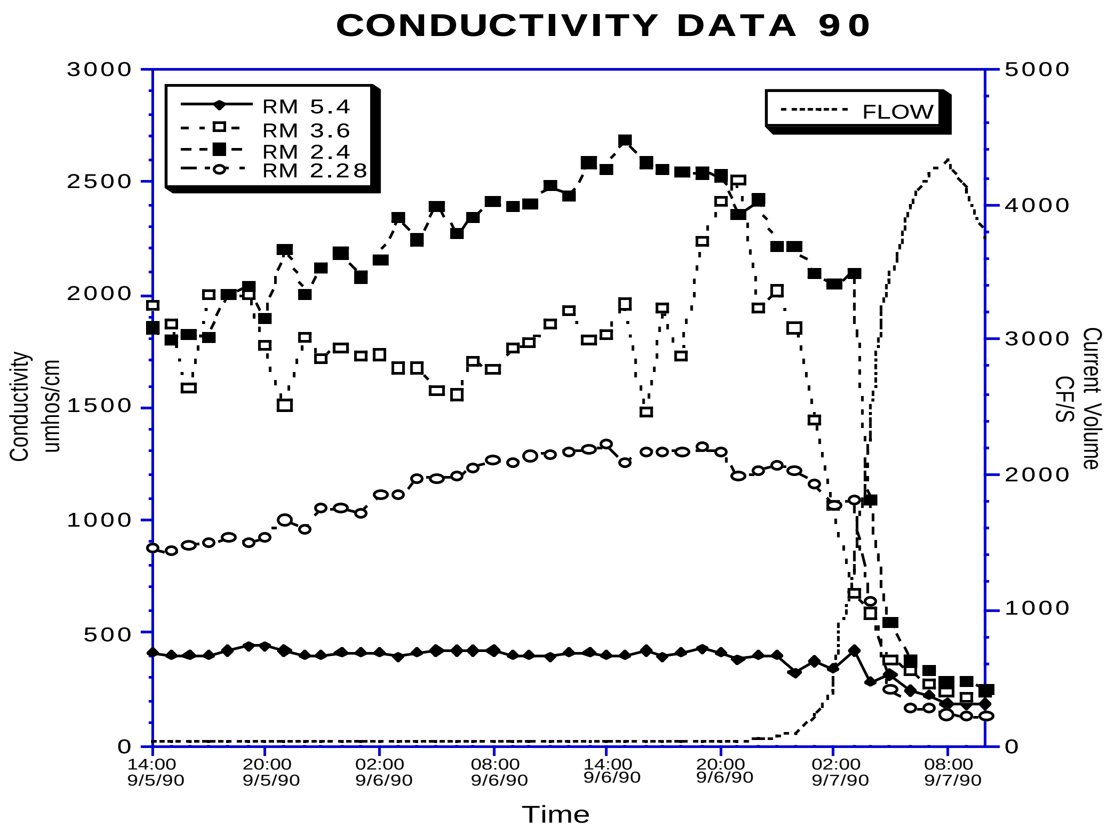

Figure 1. Conductivity (umhos/cm) and flow (cubic feet / second) measurements from the Grand River (RMs 8.6 to 2.28) collected between 2:00 pm September 5, 1990 and 10:00 am September 7, 1990. Conductivity was measured using Datasonde© continuous instream monitors. Flow data (measured at RM 8.45) was supplied by the United States Geological Survey, Water Resources Division, Columbus, Ohio.

Table 1. Sampling locations (sediment - S, macroinvertebrate - M, fish - F, fish tissue - T, biomarkers - B, unionid mussel tissue - U) in the Grand River, 1994.

Stream/ River Mile	Type of Sampling	Latitude	Longitude	Landmark	County	USGS 7.5 min. Quad. Map
Grand River						
8.66	S	41°42’58”	81°13’41”	Upst. N&W Railroad	Lake	Painesville,OH
6.6	F,T	41°43’40”	81°14’12”	E.Main St., Painesville	Lake	Painesville,OH
6.4	M	41°43’51”	81°14’09”	Painesville Recreation Park	Lake	Painesville,OH
4.82	S	41°44’56”	81°14’11”	Adj. SE side Waste Lake 4	Lake	Painesville,OH
4.7	M	41°45’02”	81°14’14”	First boulder riffle	Lake	Perry,OH
4.6	F,T	41°45’07”	81°14’23”	Most upst. estuary location	Lake	Perry,OH
4.45	S	41°45’12”	81°14’23”	Adj. E side of Waste Lake 4	Lake	Perry,OH
4.2	F,M,T	41°45’12”	81°14’41”	Adj. N.side Waste Lake 4	Lake	Perry,OH
4.06	S	41°45’09”	81°14’50”	Adj. former Impounding Basin	Lake	Perry,OH
4.04	S,U	41°45’07”	81°14’50”	Adj. N. side Waste Lake 4	Lake	Perry,OH
3.80	S	41°45’02”	81°15’07”	Adj. NW side Waste Lake 4	Lake	Perry,OH
3.48	S	41°45’00”	81°15’28”	At Hydro Basin	Lake	Mentor,OH
3.2	F,T,B	41°44’48”	81°15’42”	Upst. Painesville WWTP	Lake	Mentor,OH
3.1	M	41°44’44”	81°15’48”	Upst. Painesville WWTP	Lake	Mentor,OH
2.97	S	41°44’37”	81°15’45”	Waste Lake 3, upst. WWTP	Lake	Mentor,OH
2.37	S	41°44’11”	81°15’58”	Upst. State Route 535	Lake	Mentor,OH

Table 2. Aquatic life use attainment status for the Grand River based upon sampling conducted between August and September, 1994. Attainment status is based on biocriteria for the Erie-Ontario Lake Plain ecoregion of Ohio (OAC Chapter 3745-1-07, Table 7-17) and interim Lake Erie estuary and harbor biocriteria under development by Ohio EPA.

RIVER MILE Fish/ Invert.	IBI	MIwb	ICI	QHEI	Attainment Status	Comment
Grand River - 1994						
Erie-Ontario Lake Plain Ecoregion - EWH Use Designation (Existing)						
6.6/ 6.4	54	9.7	VG[c]	77.5	FULL	Macroinvertebrate evaluation based on qual sample
Interim estuary and harbor biocriteria						
4.6/ 4.7	49	8.5	30	62.0	FULL	Transition zone between free flowing and estuary conditions
4.2/ 4.2	41	7.3[ns]	26	54.5	FULL	Adjacent lagoons
3.2/ 3.1	28[ns]	7.1[ns]	16*	53.5	PARTIAL	Upst. Painesville WWTP
Grand River - 1987						
Erie-Ontario Lake Plain Ecoregion - EWH Use Designation (Existing)						
6.1/ 6.2	54	9.4	46	77	FULL	
Interim estuary and harbor biocriteria						
4.4/ 4.3	29[ns]	6.7*	34	64	PARTIAL	
3.0/ 3.0	30[ns]	5.9*	22	52	PARTIAL	

***Ecoregion Biocriteria**: Erie-Ontario Lake Plain (EOLP)*

INDEX	*WWH*	*EWH*	*MWH[b]*	*Interim Estuary*
IBI - Boat	40	48	24	32
MIwb - Boat	8.7	9.6	5.8	7.5
ICI	34	46	22	22

* Significant departure from ecoregion biocriterion (>4 IBI or ICI units or >0.5 MIwb units); poor and very poor results are underlined.

ns Nonsignificant departure from the interim estuary and harbor biocriterion (≤ 4 IBI or ICI units or ≤ 0.5 MIwb units).

b Modified Warmwater Habitat for channel modified areas.

c The narrative evaluation using the qualitative sample (VG = very good) is based on best professional judgment utilizing sample attributes such as taxa richness, EPT taxa richness, and community composition and is used in lieu of the ICI when artificial substrates are lost or deemed not useable.

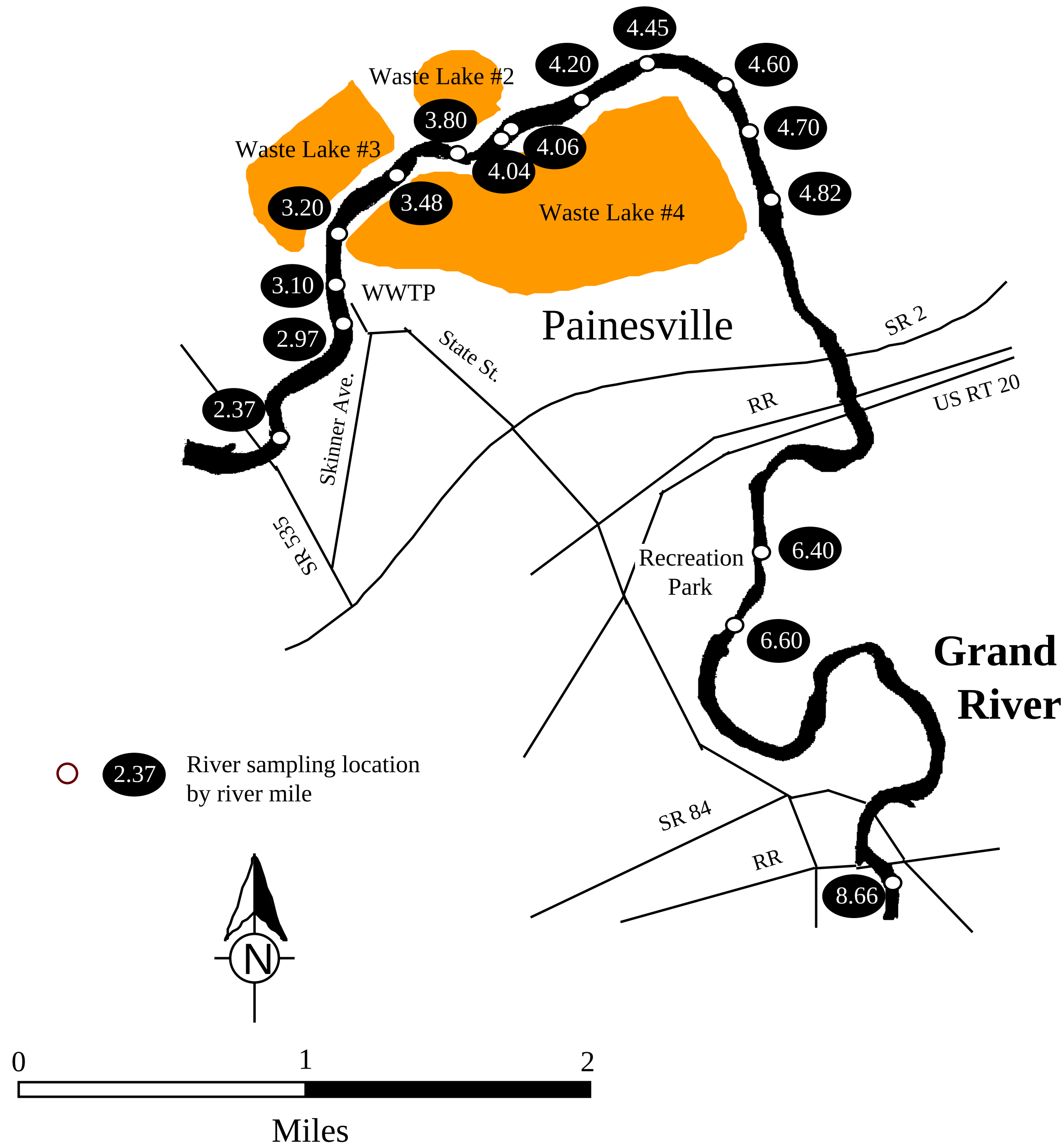

Figure 2. Map of the Grand River study area showing principal streams, landmarks, the Diamond Shamrock waste lagoons, and Ohio EPA sampling locations, 1994.

METHODS

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

Determining Use Attainment Status

The attainment status of aquatic life uses (*i.e.*, FULL, PARTIAL, and **NON**) is determined by using the biological criteria codified in the Ohio Water Quality Standards (WQS; Ohio Administrative Code [OAC] 3745-1-07, Table 7-17). The biological community performance measures which are used include the Index of Biotic Integrity (IBI) and Modified Index of Well-Being (MIwb), based on fish community characteristics, and the Invertebrate Community Index (ICI) which is based on macroinvertebrate community characteristics. The IBI and ICI are multimetric indices patterned after an original IBI described by Karr (1981) and Fausch *et al.* (1984). The ICI was developed by Ohio EPA (1987b) and further described by DeShon (1995). The MIwb is a measure of fish community abundance and diversity using numbers and weight information and is a modification of the original Index of Well-Being originally applied to fish community information from the Wabash River (Gammon 1976; Gammon *et al.* 1981).

Performance expectations for the principal aquatic life uses in the Ohio WQS (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 the aquatic life use is FULL if all three indices (or those available) meet the applicable biocriteria, PARTIAL if at least one of the indices does not attain and performance at least fair, and **NON**-attainment if all indices fail to attain or any index indicates poor or very poor performance. Partial and non-attainment indicate that the receiving water is impaired and does not meet the designated use criteria specified by the Ohio WQS.

Habitat Assessment

Physical habitat was evaluated using the Qualitative Habitat Evaluation Index (QHEI) developed by the Ohio EPA for streams and rivers in Ohio (Rankin 1989, 1995). Various attributes of the habitat are scored based on the overall importance of each to the maintenance of viable, diverse, and functional aquatic faunas. The type(s) and quality of substrates, amount and quality of instream cover, channel morphology, extent and quality of riparian vegetation, pool, run, and riffle development and quality, and gradient are some of the metrics used to determine the QHEI score which generally ranges from 20 to 100. The QHEI is used to evaluate the characteristics of a stream segment, as opposed to the characteristics of a single sampling site. As such, individual sites may have poorer physical habitat due to a localized disturbance yet still support aquatic communities closely resembling those sampled at adjacent sites with better habitat, provided water quality conditions are similar. QHEI scores from hundreds of segments around the state have indicated that values greater than 60 are *generally* conducive to the existence of warmwater faunas. Scores greater than 75 frequently typify habitat conditions which have the ability to support exceptional warmwater faunas.

Macroinvertebrate Community Assessment

Macroinvertebrates were sampled quantitatively in the Grand River using multiple-plate, artificial substrate samplers (modified Hester/Dendy samplers) in conjunction with a qualitative assessment of the available natural substrates. During the present study, macroinvertebrates collected from the natural substrates were also evaluated using an assessment tool currently in the testing and refinement phase. This method relies on tolerance values derived for each taxon, based upon the abundance data for that taxon from artificial substrate (quantitative) samples collected throughout Ohio. To determine the tolerance value of a given taxon, ICI scores at all locations where the taxon has been collected are weighted by its abundance on the artificial substrates. The mean of the weighted ICI scores for the taxon results in a value which represents its relative level of tolerance on the ICI's 0 to 60 scale. For the qualitative collections in the Grand River study area, the median tolerance value of all organisms from a site resulted in a score termed the Qualitative Community Tolerance Value (QCTV). The QCTV shows potential as a method to supplement existing assessment methods using the natural substrate collections. QCTV scores for sampling locations in the Grand River study area were used in conjunction with other aspects of the community data to make evaluations and were not unilaterally used to interpret quality of the sites or aquatic life use attainment status.

Fish Community Assessment

Fish were sampled using the boat method pulsed DC electrofishing gear, used at a frequency of one or two samples at each site.

Tissue and Sediment Assessment

Fish were sampled for biomarkers and tissue analysis using pulsed DC electrofishing gear using boat methods. Fish whole body and fillet samples were collected in September, 1994 for tissue analysis. Fish tissue sampling procedures are detailed in the Manual of Ohio EPA Surveillance Methods and Quality Assurance Practices (Ohio EPA 1989a). Fine grained sediment samples were collected in the upper six inches of bottom material at each location using decontaminated stainless steel scoop samplers (decontamination followed the procedures outlined in FSOP 10.01, DERR Sampling Guidance, Vol. III, Ohio EPA 1992). Collected sediment was placed into decontaminated clear glass jars with teflon lined lids, placed on ice (to maintain 4˚C) and shipped to an Ohio EPA contract lab. Common carp were collected for biomarker processing during normal community assessment sampling. Fish blood, liver, spleen, and bile samples were collected in the field and transported to the Environmental Monitoring Systems Laboratory, U.S.EPA in Cincinnati for specific biomarker analyses. An analysis of the biomarker results will be provided by U.S. EPA at a later date. All sediment, unionid mussel tissue, fish tissue, biomarker, and biological sampling locations are listed in Table 1.

Causal Associations

Using the results, conclusions, and recommendations of this report requires an understanding of the methodology used to determine the use attainment status and assigning probable causes and sources of impairment. The identification of impairment in rivers and streams is straightforward - the numerical biological criteria are the principal arbiter of aquatic life use attainment and impairment (partial and non-attainment). The rationale for using the biological criteria in the role of principal arbiter within a weight of evidence framework has been extensively discussed elsewhere (Karr *et al.* 1986; Karr 1991; Ohio EPA 1987a,b; Yoder 1989; Miner and Borton 1991; Yoder 1991; Yoder 1995). Describing the causes and sources associated with observed impairments relies on an interpretation of multiple lines of evidence including water chemistry data, sediment data, habitat data, effluent data, biomonitoring results, land use data, and the biological response signatures (Yoder and Rankin 1995) within the biological data itself. Thus the assignment of principal causes and sources of impairment in this report do not represent a true "cause and effect" analysis, but rather represent the association of impairments (based on response indicators) with stressor and exposure indicators whose links with the biosurvey data are based on previous research or experience with analogous situations and impacts. The reliability of the identification of probable causes and sources is increased where many such prior associations have been identified. The process is similar to making a medical diagnosis in which a doctor relies on multiple lines of evidence concerning patient health. Such diagnoses are based on previous research which experimentally or statistically linked symptoms and test results to specific diseases or pathologies. Thus a doctor relies on previous experience in interpreting symptoms (*i.e.*, multiple lines from test results) to establish a diagnosis, potential causes and/or sources of the malady, a prognosis, and a strategy for alleviating the symptoms of the disease or condition. As in medical science, where the ultimate arbiter of success is the eventual recovery and the well-being of the patient, the ultimate measure of success in water resource management is restoration of lost or damaged ecosystem attributes including aquatic community structure and function. While there have been criticisms of misapplying the metaphor of ecosystem "health" compared to human patient "health" (Suter 1993) here we are referring to the process for identifying biological integrity and causes/sources associated with observed impairment, not whether human health and ecosystem health are analogous concepts.

RESULTS AND DISCUSSION

Sediment Chemistry

Sediment samples were collected at six locations in the Grand River by the Ohio EPA during November 1994. All sampling locations are indicated by river mile in Figure 2. Samples were analyzed for semivolatile organic compounds, pesticides, PCBs, target analyte list (TAL) metals, hexavalent chromium, total organic carbon (TOC), and grain size. Specific chemical parameters tested and results are listed in Appendix Tables 1, 2, and 3.

- Sediment samples were evaluated using guidelines established by the Ontario Ministry of the Environment (Persaud *et al.* 1993). The guidelines define two levels of ecotoxic effects and are based on the chronic, long term effects of contaminants on benthic organisms. A *Lowest Effect Level* is a level of sediment contamination that can be tolerated by the majority of benthic organisms. The *Severe Effect Level* is the sediment concentration of a compound that would be detrimental to the majority of benthic species. When any parameters are at or above the Severe Effect Level guideline the sediment is considered highly contaminated and will likely have a significant effect on the benthic biological community. The guidelines detailed in Persaud *et al*. (1993) do not include evaluations of volatile organic compounds, several PAHs and metals, and most non-PAH semivolatile organic compounds.

- All sediment values for cadmium, copper, iron, lead, manganese, nickel, and zinc were below the Lowest Effect Levels and all values for arsenic were below the EQLs except at RM 4.04, which at 11.0 mg/kg exceeded the Lowest Effect Level (6.0 mg/kg), but was well below the Severe Effect Level (33.0 mg/kg). Chromium at RMs 4.04 and 4.06 had values of 70.6 mg/kg and 79.5 mg/kg, respectively; both values exceeded the Lowest Effect Level (26 mg/kg), but were below the Severe Effect Level (110.0 mg/kg). Hexavalent chromium was detected at four of the nine sample sites with values ranging from 1.83 mg/kg to 5.04 mg/kg (RM 4.04). All mercury results were below EQL (<0.80 mg/kg).

- All pesticide and PCB results were below EQLs except for 4,4'-DDD at RM 4.06 with a value of 3.6 ug/kg, which is below the Lowest Effect Level (Persaud *et al.* 1993).

- All semivolatile organic compounds measured in sediments from the Grand River were below the EQLs except for the following exceptions: fluoranthene (380 ug/kg) at RM 4.82 and phenanthrene (470 ug/kg), fluoranthene (650 ug/kg), pyrene (630 ug/kg), benzo(a)anthracene (360 ug/kg), and chrysene (380 ug/kg) at RM 4.04. All values were below the Lowest Effect Levels (Persaud *et al.* 1993).

Physical Habitat for Aquatic Life

Physical habitat was evaluated in the Grand River at each 1994 fish community sampling location. Qualitative Habitat Evaluation Index (QHEI) scores at each location are detailed in Table 3. The Grand River within the study area was comprised of two main habitat types - free flowing stream and Lake Erie estuary conditions.

- Stream morphology of the Grand River upstream from RM 4.7 is free-flowing with well developed riffle, pool, and run sequences. The sampling location at RM 6.6 consisted of well developed riffles and runs, a well defined main chute and numerous large boulders. Bottom substrates were predominated by cobble and gravel. The QHEI at RM 6.6 was 77.5, highest in the study area, and indicative of good to excellent stream and riparian habitat. At RM 6.6, the total number of warmwater habitat attributes were considerably higher than the total of modified warmwater habitat attributes.

- The Grand River segment downstream from RM 4.7 is influenced by Lake Erie water levels. The stream is no longer free flowing with the direction and speed of current dependent on lake level conditions in Lake Erie. No riffles were present in this estuary area with biologically available vegetated backwaters also absent. Gravel, cobble, and sand were the predominant substrates and, although boulders, logs, and woody debris were present, their overall abundance was sparse. During the 1994 study, the upper 100 meters of the fish sampling zone at RM 4.6 was free flowing; the lower 400 meters were influenced by Lake Erie water. QHEI scores for the three sampling locations in the estuary ranged between 53.5 and 62.0. These scores indicate that this area is capable of supporting warmwater biological communities typical of Lake Erie river mouth areas.

Table 3. Qualitative Habitat Evaluation Index (QHEI) matrix showing modified and warmwater habitat characteristics for the Grand River, 1994.

Table 3. Qualitative Habitat Evaluation Index (QHEI) matrix showing modified and warmwater habitat characteristics for the Grand River, 1994.

Key QHEI Components

River Mile	QHEI	Gradient (ft/mile)	WWH Attributes: No Channelization or Recovered	Boulder/Cobble/Gravel Substrates	Silt Free Substrates	Good/Excellent Substrates	Moderate/High Sinuosity	Extensive/Moderate Cover	Fast Current/Eddies	Low/Normal Overall Embeddedness	Max. Depth > 40 cm	Low/No Riffle Embeddedness	**Total WWH Attributes**	MWH Attributes, High Influence: Channelized or No Recovery	Silt/Muck Substrates	Low Sinuosity	Sparse/No Cover	Max. Depth < 40 cm (WD/HW)	Total **H.I. MWH Attributes**	MWH Attributes, Moderate Influence: Recovering Channel	Heavy/Moderate Silt Cover	Sand Substrates (Boat)	Hardpan Substrate Origin	Fair/Poor Development	Low/No Sinuosity	Only 1-2 Cover Types	Intermittent & Poor Pools	No Fast Current	High/Mod. Overall Embeddedness	High/Mod. Riffle Embeddedness	No Riffle	Total **M.I. MWH Attributes**	**MWH H.I./WWH Ratio**	**MWH M.I./WWH Ratio**
(03-001) Grand River																																		
Year: 94																																		
6.6	77.5	6.21	■	■		■		■		■	■	■	7						0					▲			▲					2	0.13	0.38
4.6	62.0	0.10	■	■		■				■	■		5			●			1	▲			▲	▲			▲	▲	▲			6	0.33	1.33
4.2	54.5	0.10	■	■							■		3			●			1	▲			▲	▲			▲	▲		▲		6	0.50	2.00
3.2	53.5	0.10	■	■							■		3			●			1	▲			▲	▲			▲	▲		▲		6	0.50	2.00

Macroinvertebrate Community

Macroinvertebrate communities were sampled during the summer of 1994 at four locations in the Grand River from Recreation Park (RM 6.4) to upstream from the Painesville WWTP at RM 3.1 (Table 1). Summarized results from the 1994 macroinvertebrate sampling are compiled in Table 4. ICI metrics, scores, and raw data tables by river mile are attached as Appendix Tables 8 and 9. Also included in Table 4 are data collected in 1987 by the Ohio EPA. A detailed discussion of this data is provided in Ohio Environmental Protection Agency (1987c).

- The 1994 data indicated the presence of fair to good macroinvertebrate communities throughout the study area (Figure 3). ICI scores ranged from 16 (fair) upstream from the Painesville WWTP (RM 3.1) to 32 at Recreation Park (RM 6.4).

- The upstream site at Recreation Park (RM 6.4) consisted of fast current through large boulders separated by long runs with good habitat quality. The artificial substrates were vandalized with only three of five substrates remaining and the block moved 100 ft. downstream. The site was evaluated based on the qualitative sample which indicated a very good macroinvertebrate community, including 58 total taxa and an EPT taxa richness of 17 (8 mayfly taxa, 2 stonefly taxa, and 7 caddisfly taxa).

- The site at RM 4.7 was set at the base of a large riffle during high flow. The current when retrieved was much slower and seemed to be influenced by Lake Erie seiches. The artificial substrates also appeared to have been stepped on; this area is heavily fished by sports fisherman. Results indicated the presence of a very good macroinvertebrate community with the total taxa being 81 (47 quantitative taxa and 47 qualitative taxa), and an EPT taxa richness of 18. This sampling location is in the transition zone between the free flowing upper reach with an EWH use designation and the lake influenced lower reach; the transition zone is considered part of the estuary/harbor and the interim estuary/harbor criterion is applied. The site had an ICI score of 30 which exceeded the interim criterion of 22 and indicated full attainment of the WWH aquatic life use designation.

- The site at RM 4.2 was adjacent to the waste disposal area and in the estuary/harbor reach. An ICI score of 26 indicated the presence a good macroinvertebrate community with 56 total taxa and an EPT taxa richness of 6. Aquatic worms (Oligochaeta) were the predominant group comprising 53% of the total organisms collected.

- The site at RM 3.1 was just upstream from the Painesville WWTP discharge and at the lower end of the waste disposal lagoons. An ICI score of 16 indicated a fair macroinvertebrate community not attaining the interim criterion. The predominant taxon was of the midge genus *Glyptotendipes* comprising 83% of the total organisms collected. There were 28 total taxa and an EPT taxa richness of 2. This indicated a toxic stress on the benthic community beyond that related solely to leachate from the waste disposal lagoons. This may have been caused by a complex interaction between river water with the high ionic concentrations associated with the leachate from the lagoons, lake water, and the WWTP effluent.

Table 4. Summary of macroinvertebrate data collected from artificial substrates (quantitative sampling) and natural substrates (qualitative sampling) in the Grand River, August to September, 1994.

Stream/ River Mile	Relative Density	Total Taxa	Quantitative Taxa	Qualitative Taxa	Qualitative EPT[a]	ICI	Narrative Evaluation
Grand River - 1994							
		Erie-Ontario Lake Plain Ecoregion - EWH Use Designation					
6.4	42	58	27	43	17	32[b]	Very Good (Quant sample was vandalized; evaluation based on qual. sample)
		Erie-Ontario Lake Plain Ecoregion - WWH Use Designation Interim estuary and harbor biocriteria apply					
4.7	131	81	47	47	18	30	Very Good
4.2	309	56	44	29	6	26	Good
3.1	879	28	14	19	2	16*	Fair
Grand River - 1987							
		Erie-Ontario Lake Plain Ecoregion - EWH Use Designation					
6.2	1,117	77	44	64	27	46	Exceptional
		Erie-Ontario Lake Plain Ecoregion - WWH Use Designation Interim estuary and harbor biocriteria apply					
4.3	441	66	42	45	11	34	Very Good
3.0	1,104	50	33	29	6	22	Good

Ecoregional Biocriteria: Erie-Ontario Lake Plain (EOLP)
(from OAC 3745-1-07, Table 7-17)

INDEX	***WWH***	***EWH***	***MWH[b]***	***Interim Estuary***
ICI	34	46	22	22

* Significant departure from ecoregional biocriterion (>4 ICI units).
ns Nonsignificant departure from the ecoregional biocriterion (≤ 4 or ICI units).
a EPT= total Ephemeroptera (mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies) taxa richness.
b The narrative evaluation using the qualitative sample is based on best professional judgment utilizing sample attributes such as taxa richness, EPT taxa richness, and community composition and is used in lieu of the ICI when artificial substrates are lost or deemed not useable.
c Modified Warmwater Habitat for channel modified areas.

GRAND RIVER

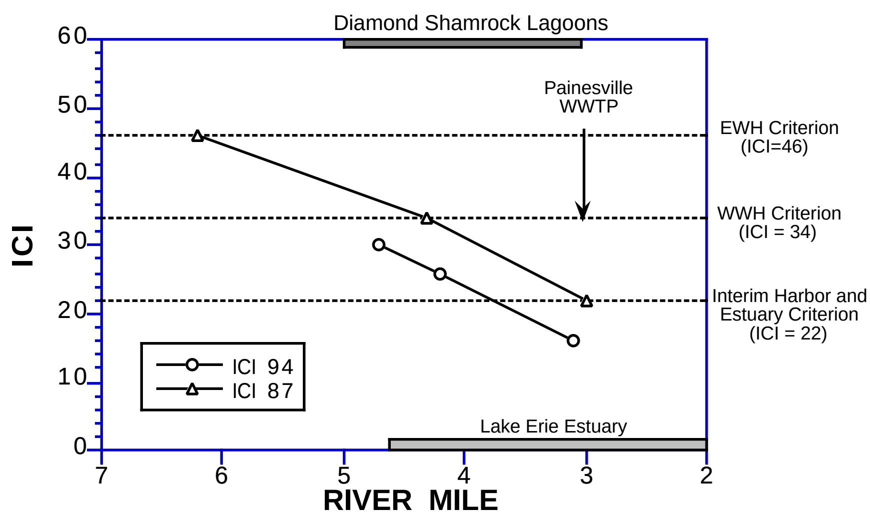

Figure 3. Longitudinal performance of the Invertebrate Community Index (ICI) in the Grand River, 1994.

Fish Community

A total of 590 fish representing 34 species were collected from the Grand River between August and September, 1994. The sampling effort included a cumulative distance electrofished of 3.4 km at four locations (Table 5, Figure 2). Relative numbers and species collected per location are presented in Appendix Tables 10 and 11.

- The fish community in the Grand River at RM 6.6 (upstream free-flowing section) was reflective of exceptional quality. The IBI (54) and MIwb (9.6) scores exceeded the EWH biocriteria. Pollution sensitive fish species predominated the catch, comprising over 67% of the community.

- Sampling at RM 4.6 included free-flowing conditions in the upper 100 meters of the fish collecting zone and estuary habitat downstream. A downstream current was observed at RM 4.6 during both fish sampling events. Interim estuary WWH biocriteria were used to evaluate this site because most of the sampling zone was influenced by Lake Erie's water level. Fish sampling results fully achieved the interim WWH estuary biocriteria with IBI and MIwb scores of 49 and 8.5, respectively. Fish community conditions were considered marginally good to exceptional. Waste lagoons were located along both sides of the Grand River at the RM 4.6 sampling location.

- Two fish sampling sites (RMs 4.2 and 3.2) were located in the Grand River estuary along the Diamond Shamrock waste lagoons and upstream from the Painesville WWTP. A decline in IBI (41 and 28, respectively) and MIwb (7.3 and 7.1, respectively) scores were observed at these two locations in comparison to upstream locations. However, the scores were achieving the interim estuary WWH biocriteria. Fish community results were reflective of fair to good conditions. At least part of the decline in the fish community was attributable to reduced habitat and flow conditions associated with the estuary and the placement of waste lagoon fill along the river banks. Habitat conditions were represented by very little in-water structural material (logs, trees, boulders, and aquatic vegetation). Fish sampling results from RM 3.2 collected on August 10, 1994 were substantially reduced compared with the second pass collected on September 1, 1994. This site was located at the downstream end of the waste lagoons and immediately upstream from the Painesville WWTP. The variation in results at RM 3.2 indicated that temporally impaired water quality conditions influenced fish community composition.

Table 5. Fish community indices from the Grand River based on pulsed D.C. electrofishing at sites sampled by Ohio EPA, 1994. Sites were sampled using boat methods. Relative number and weight are per 1.0 km. The Grand River within the study segment is represented by both EWH and WWH aquatic life use designations in the Ohio Water Quality Standards. Interim estuary and harbor criteria were used in evaluating the data in the lower 4.6 miles of the Grand River.

Stream/ River Mile	Number of Species	Mean Cumulative Species	Mean Relative Number	Mean Relative Weight	QHEI	Mean Modified Index of Well-Being	Mean Index of Biotic Integrity	Narrative Evaluation[a]
Grand River - 1994								
		Erie-Ontario Lake Plain Ecoregion - EWH Use Designation						
6.6	24	-	350	51.3	77.5	9.7	54	Exceptional
		Erie-Ontario Lake Plain Ecoregion - WWH Use Designation Interim estuary and harbor biocriteria apply						
4.6	17.5	23	248	35.7	62.0	8.5	49	M. Good-Exceptional
4.2	15	21	115	19.3	54.5	7.3[ns]	41	Fair- Good
3.2	13	16	87	11.6	53.5	7.1[ns]	28[ns]	Fair
Grand River - 1987								
		Erie-Ontario Lake Plain Ecoregion - EWH Use Designation						
6.1								
		Erie-Ontario Lake Plain Ecoregion - WWH Use Designation Interim estuary and harbor biocriteria apply						
4.4								
3.0								

Ecoregion Biocriteria: Erie-Ontario Lake Plain (EOLP)
(from Ohio Administrative Code 3745-1-07, Table 7-17)

INDEX	WWH	EWH	MWH[b]	Interim Estuary
IBI - Boat	42	48	24	32
MIwb - Boat	8.7	9.6	5.8	7.5

* Significant departure from ecoregional biocriterion (>4 IBI units or >0.5 MIwb units); poor and very poor results are underlined.

ns Nonsignificant departure from the ecoregional biocriteria ($\leq$ 4 IBI units or $\leq$ 0.5 MIwb units).

a Narrative evaluation is based on MIwb and IBI scores, when available.

b Modified Warmwater Habitat for channel modified areas.

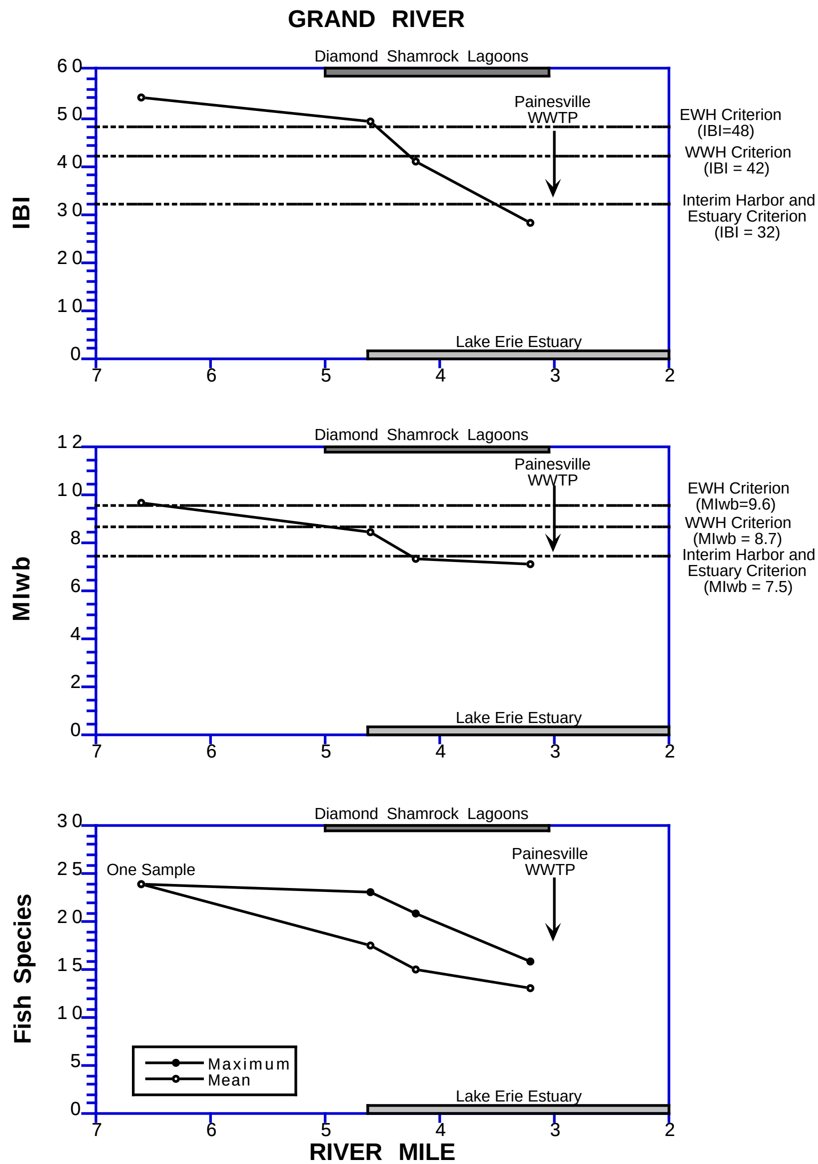

Figure 4. Longitudinal performance of the Index of Biotic Integrity (IBI), Modified Index of Well-being (MIwb), and number of species in the Grand River, 1994.

Fish Tissue

Fish tissue samples were collected from four locations on the Grand River from RM 6.6 to RM 3.2 and analyzed for pesticides, PCBs, cadmium, chromium, lead, mercury, and percent lipids in September 1994. Six species were collected for analysis. Specific chemical parameters tested and results are listed in Appendix Tables 4 and 5.

- Most of the pesticide results were below the EQL values. However, heptachlor epoxide, dieldrin, endrin aldehyde, methoxychlor, and 4,4'-DDT and metabolites were detected at low levels.

- Two PCB mixtures, Aroclors-1254 and 1260, were identified and quantified. Two of the nine samples had detectable levels of Aroclor-1254. These were laboratory split duplicate samples (smallmouth buffalo) from RM 3.2 with values of 690 ug/kg and 840 ug/kg. Five of the nine samples had detectable levels of Aroclor-1260 ranging from 58.0 ug/kg to 210 ug/kg. These samples included smallmouth buffalo, channel catfish, smallmouth bass, and walleye. The smallmouth buffalo from RM 3.2, based on a comparison to Ohio Department of Health PCB consumption guidelines (Vandermeer 1994), would be considered moderately elevated (850 ug/kg) to highly elevated (1,050 ug/kg).

- Mercury was detected in five of the nine tissue samples; concentrations ranged from 0.12 mg/kg to 0.41 mg/kg. All were below the Food and Drug Administration (FDA) consumption action level of 1.0 mg/kg. There were also detected levels of cadmium at low levels ranging from 0.004 mg/kg to 0.014 mg/kg. Chromium was detected at levels ranging from 0.30 mg/kg to 1.65 mg/kg with two samples being elevated (1.23 mg/kg at RM 3.2 and 1.65 mg/kg at RM 4.2) when compared with other samples.

Unionid Mussel Tissue

Tissue analyses were done on samples of two species of unionid mussels, *Leptodea fragilis* (fragile papershell) and *Potamilus alatus* (pink heelsplitter) from RM 4.0. Analyses included pesticides, PCBs, cadmium, chromium, hexavalent chromium, lead, mercury, and percent lipids. Specific chemical parameters tested and results are listed in Appendix Tables 6 and 7.

- All PCBs were below the EQLs and all pesticides were below the EQLs except 4,4' DDE which was at low concentrations of 1.6 ug/kg in (*L. fragilis*) and 1.9 ug/kg in (*P. alatus*

- Mercury and hexavalent chromium were below the EQLs in both samples. Cadmium (0.11 mg/kg and 0.19 mg/kg), chromium (0.31 mg/kg and 0.21 mg/kg), and lead (0.13 mg/kg and 0.08 mg/kg) were present at low concentrations.

TREND ASSESSMENT

Changes in Macroinvertebrate Performance: 1987 - 1994

- The macroinvertebrate communities between RMs 6.2 and 3.0 were sampled during 1987 as part of a larger survey of the Grand River basin. Historical results have indicated macroinvertebrate communities in the good to exceptional range (Figure 3), with ICI scores ranging from 24 at RM 3.0 to 48 at RM 6.2.

- Although the artificial substrates were vandalized at RM 6.4 in 1994, qualitative assessments of macroinvertebrate community performance documented in the area of RMs 6.4 and 6.2 between sampling years were comparable with very good to exceptional results. There was a decline in the macroinvertebrate community results in the area of RMs 4.3 and 4.2 between 1987 and 1994 with a drop in ICI scores from 36 (very good) to 26 (good); both results fully achieved the interim estuary criterion. Macroinvertebrate results at RMs 3.1/3.0 from 1987 to 1994 declined from good (ICI = 24) to fair (ICI = 16). This site is just upstream from the Painesville WWTP and under the influence of Lake Erie seiches which could have resulted in an enlarged stagnant mixing zone. Additionally, historic data (Ohio Environmental Protection Agency 1987c) indicated water quality problems resulting from leachate (e.g. dissolved solids, chlorides, calcium, and sodium) in the area of the waste disposal lagoons.

Changes in Fish Community Performance: 1987 - 1994

- The fish communities between RMs 7.0 and 3.0 were sampled during 1987 as part of a larger survey of the Grand River basin and during 1993 as part of an estuary study. Historical results have indicated fish communities in the fair to exceptional range, with IBI values ranging from 27 to 54 and MIwb scores ranging between 5.9 and 9.4.

- Comparable results were documented in the area of RMs 6.6 and 6.1 between sampling years with IBI values of 54 and MIwb values ranging between 9.4 and 9.7. A general improvement in fish sampling results was observed at RM 4.6 between 1993 and 1994, with IBI values of 37 (1993) and 49 (1994) and MIwb scores of 7.8 (1993) and 8.5 (1994). Improved conditions were also observed in the area of RMs 4.4/ 4.2 and RMs 3.2/ 3.0 between 1987 and 1994 (Figure 5). Fish collections at RMs 3.2/3.0 from 1987 and 1994 were highly variable between sampling dates, with the lowest fish index scores occurring during lower flow conditions in the Grand River. Results from both years reflected water quality conditions conducive to causing impairment to the fish community.

Changes in Water Quality: 1987 - 1990

- Surface water samples were not collected as part of the 1994 survey, but a review of surface water sample data collected by the Ohio EPA Water Quality Modeling Section in September 1990 showed a similar trend to that discussed in Ohio Environmental Protection Agency (1987c). A substantial increase in TDS, sodium, calcium, and chlorides was detected in samples from the area of the waste disposal lagoons and downstream from the lagoons compared with upstream samples (personal communication Mary Ann Silagy). This increase in TDS would cause an increase in conductivity which is illustrated in Figure 1 (Appendix Table 12). The Painesville WWTP was upgraded to a tertiary treatment process in 1980 and they are considered to have a high quality effluent; the contribution of TDS to the Grand River would be negligible (Marie Underwood, Ohio EPA, personal communication).

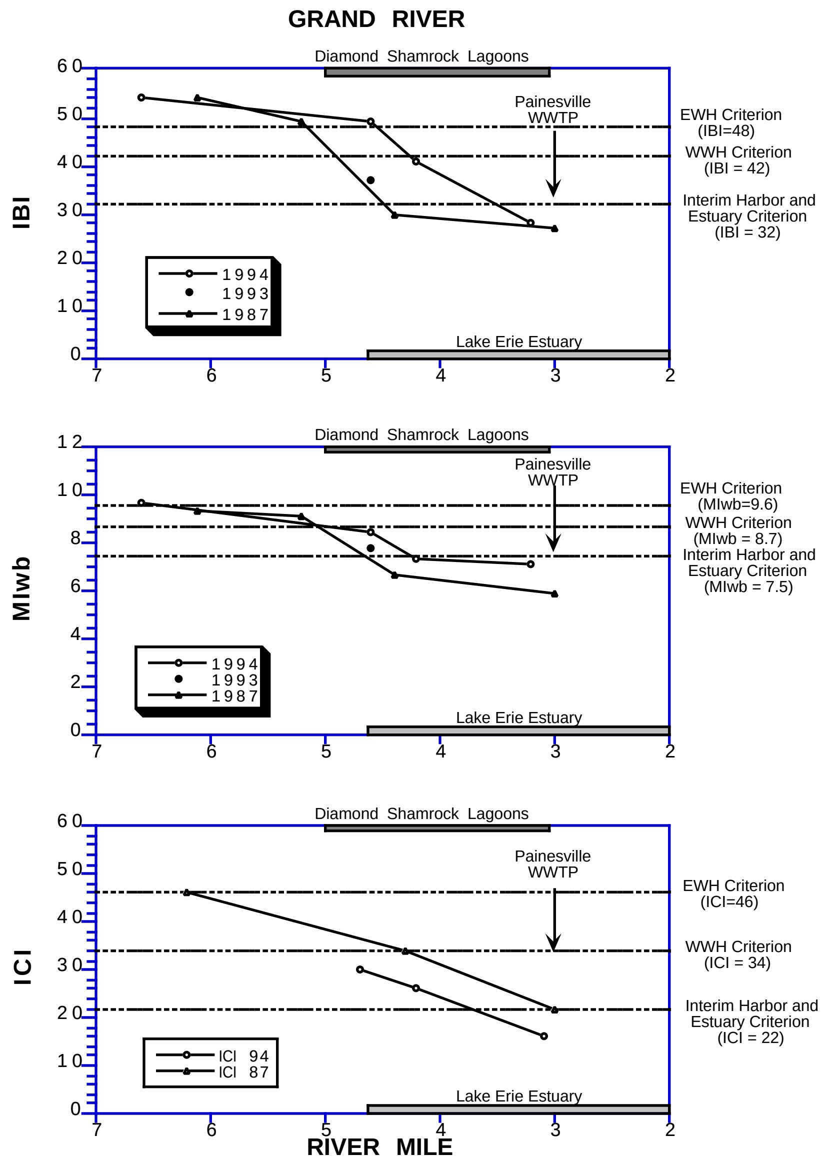

Figure 5. Longitudinal trend of the Index of Biotic Integrity (IBI), Modified Index of Well-being (MIwb), and Invertebrate Community Index (ICI) from the Grand River, 1987 and 1994.

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APPENDIX TABLES TO:

Biological and Sediment Quality Study of the Grand River in the Vicinity of the Diamond Shamrock Waste Lagoons Area

1994

Lake County, Ohio

August 15, 1995

OEPA Technical Report MAS/1995-8-11

Appendix Table 1. Semivolatile parameters measured in sediment collected from the Grand River study area, 1994 by Ohio EPA.

Appendix Table 1. Semivolatile parameters measured in sediment collected from the Grand River study area, 1994 by Ohio EPA. Depth of sediment sample is noted in parentheses.

	Sampling Location - by River Mile						
Parameter	**2.37** (0-4”)	**2.97** (0-6”)	**3.48** (0-6”)	**3.48D** (0-6”)	**3.80** (0-3”)	**4.06** (0-4”)	**4.45** (0-6”)
Phenol (ug/kg)	<330	<330	<330	<330	<330	<330	<330
Bis(2-chloroethyl) ether (ug/kg)	<330	<330	<330	<330	<330	<330	<330
2-Chlorophenol (ug/kg)	<330	<330	<330	<330	<330	<330	<330
1,3-Dichlorobenzene (ug/kg)	<330	<330	<330	<330	<330	<330	<330
1,4-Dichlorobenzene (ug/kg)	<330	<330	<330	<330	<330	<330	<330
Benzyl alcohol (ug/kg)	<660	<660	<660	<660	<660	<660	<660
1,2-Dichlorobenzene (ug/kg)	<330	<330	<330	<330	<330	<330	<330
2-Methylphenol (ug/kg)	<330	<330	<330	<330	<330	<330	<330
Bis(2-chloroisopropyl) ether (ug/kg)	<330	<330	<330	<330	<330	<330	<330
3+4-Methylphenol (ug/kg)	<330	<330	<330	<330	<330	<330	<330
N-Nitroso-di-n-propylamine (ug/kg)	<330	<330	<330	<330	<330	<330	<330
Hexachloroethane (ug/kg)	<330	<330	<330	<330	<330	<330	<330
Nitrobenzene (ug/kg)	<330	<330	<330	<330	<330	<330	<330
Isophorone (ug/kg)	<330	<330	<330	<330	<330	<330	<330
2-Nitrophenol (ug/kg)	<330	<330	<330	<330	<330	<330	<330
2,4-Dimethylphenol (ug/kg)	<330	<330	<330	<330	<330	<330	<330
Benzoic acid (ug/kg)	<1,700	<1,600	<1,600	<1,700	<1,600	<1,600	<1,600
Bis(2-chloroethoxy) methane (ug/kg)	<330	<330	<330	<330	<330	<330	<330
2,4-Dichlorophenol (ug/kg)	<330	<330	<330	<330	<330	<330	<330
1,2,4-Trichlorobenzene (ug/kg)	<330	<330	<330	<330	<330	<330	<330
Naphthalene (ug/kg)	<330	<330	<330	<330	<330	<330	<330
4-Chloroaniline (ug/kg)	<660	<660	<660	<660	<660	<660	<660
Hexachlorobutadiene (ug/kg)	<330	<330	<330	<330	<330	<330	<330
4-Chloro-3-methylphenol (ug/kg)	<660	<660	<660	<660	<660	<660	<660
2-Methylnaphthalene (ug/kg)	<330	<330	<330	<330	<330	<330	<330
Hexachlorocyclopentadiene (ug/kg)	<330	<330	<330	<330	<330	<330	<330
2,4,6-Trichlorophenol (ug/kg)	<330	<330	<330	<330	<330	<330	<330
2,4,5-Trichlorophenol (ug/kg)	<330	<330	<330	<330	<330	<330	<330
2-Chloronaphthalene (ug/kg)	<330	<330	<330	<330	<330	<330	<330
2-Nitroaniline (ug/kg)	<1,700	<1,600	<1,600	<1,700	<1,600	<1,600	<1,600
Dimethyl phthalate (ug/kg)	<330	<330	<330	<330	<330	<330	<330
Acenaphthylene (ug/kg)	<330	<330	<330	<330	<330	<330	<330
3-Nitroaniline (ug/kg)	<1,700	<1,600	<1,600	<1,700	<1,600	<1,600	<1,600
Acenaphthene (ug/kg)	<330	<330	<330	<330	<330	<330	<330
2,4-Dinitrophenol (ug/kg)	<1,700	<1,600	<1,600	<1,700	<1,600	<1,600	<1,600
4-Nitrophenol (ug/kg)	<1,700	<1,600	<1,600	<1,700	<1,600	<1,600	<1,600
Dibenzofuran (ug/kg)	<330	<330	<330	<330	<330	<330	<330
2,4-Dinitrotoluene (ug/kg)	<330	<330	<330	<330	<330	<330	<330
2,6-Dinitrotoluene (ug/kg)	<330	<330	<330	<330	<330	<330	<330
Diethylphthalate (ug/kg)	<330	<330	<330	<330	<330	<330	<330
4-Chlorophenyl phenyl ether (ug/kg)	<330	<330	<330	<330	<330	<330	<330
Fluorene (ug/kg)	<330	<330	<330	<330	<330	<330	<330

Appendix Table 1. Continued.

Parameter	Sampling Location - by River Mile 2.37 (0-4”)	2.97 (0-6”)	3.48 (0-6”)	3.48D (0-6”)	3.80 (0-3”)	4.06 (0-4”)	4.45 (0-6”)
4-Nitroaniline (ug/kg)	<330	<330	<330	<330	<330	<330	<330
4,6-Dinitro-2-methylphenol (ug/kg)	<1,700	<1,600	<1,600	<1,700	<1,600	<1,600	<1,600
N-Nitrosodiphenylamine * (ug/kg)	<330	<330	<330	<330	<330	<330	<330
4-Bromophenyl phenyl ether (ug/kg)	<330	<330	<330	<330	<330	<330	<330
Hexachlorobenzene (ug/kg)	<330	<330	<330	<330	<330	<330	<330
Pentachlorophenol (ug/kg)	<1,700	<1,600	<1,600	<1,700	<1,600	<1,600	<1,600
Phenanthrene (ug/kg)	<330	<330	<330	<330	<330	<330	<330
Anthracene (ug/kg)	<330	<330	<330	<330	<330	<330	<330
Di-n-butylphthalate (ug/kg)	<330	<330	<330	<330	<330	<330	<330
Fluoranthene (ug/kg)	<330	<330	<330	<330	<330	<330	<330
Pyrene (ug/kg)	<330	<330	<330	<330	<330	<330	<330
Butyl benzyl phthalate (ug/kg)	<330	<330	<330	<300	<330	<330	<330
3,3’-Dichlorobenzidine (ug/kg)	<660	<660	<660	<660	<660	<660	<660
Benzo(a)anthracene (ug/kg)	<330	<330	<330	<330	<330	<330	<330
Bis(2-Ethylhexyl) phthalate (ug/kg)	<330	<330	<330	<330	<330	<330	<330
Chrysene (ug/kg)	<330	<330	<330	<330	<330	<330	<330
Di-n-octyl phthalate (ug/kg)	<330	<330	<330	<330	<330	<330	<330
Benzo(b)fluoranthene (ug/kg)	<330	<330	<330	<330	<330	<330	<330
Benzo(k)fluoranthene (ug/kg)	<330	<330	<330	<330	<330	<330	<330
Benzo(a)pyrene (ug/kg)	<330	<330	<330	<330	<330	<330	<330
Indeno(1,2,3-cd)pyrene (ug/kg)	<330	<330	<330	<330	<330	<330	<330
Dibenz(a,h)anthracene (ug/kg)	<330	<330	<330	<330	<330	<330	<330
Benzo(g,h,i)perylene (ug/kg)	<330	<330	<330	<330	<330	<330	<330

* - Cannot be distinguished from diphenylamine.

Appendix Table 1. Continued.

Parameter	Sampling Location - by River Mile 4.82 (0-6")	4.04 (0-6")	8.66 (0-6")
Phenol (ug/kg)	<330	<330	<330
Bis(2-chloroethyl) ether (ug/kg)	<330	<330	<330
2-Chlorophenol (ug/kg)	<330	<330	<330
1,3-Dichlorobenzene (ug/kg)	<330	<330	<330
1,4-Dichlorobenzene (ug/kg)	<330	<330	<330
Benzyl alcohol (ug/kg)	<660	<660	<660
1,2-Dichlorobenzene (ug/kg)	<330	<330	<330
2-Methylphenol (ug/kg)	<330	<330	<330
Bis(2-chloroisopropyl) ether (ug/kg)	<330	<330	<330
3+4-Methylphenol (ug/kg)	<330	<330	<330
N-Nitroso-di-n-propylamine (ug/kg)	<330	<330	<330
Hexachloroethane (ug/kg)	<330	<330	<330
Nitrobenzene (ug/kg)	<330	<330	<330
Isophorone (ug/kg)	<330	<330	<330
2-Nitrophenol (ug/kg)	<330	<330	<330
2,4-Dimethylphenol (ug/kg)	<330	<330	<330
Benzoic acid (ug/kg)	<1,700	<1,700	<1,600
Bis(2-chloroethoxy) methane (ug/kg)	<330	<330	<330
2,4-Dichlorophenol (ug/kg)	<330	<330	<330
1,2,4-Trichlorobenzene (ug/kg)	<330	<330	<330
Naphthalene (ug/kg)	<330	<330	<330
4-Chloroaniline (ug/kg)	<660	<660	<660
Hexachlorobutadiene (ug/kg)	<330	<330	<330
4-Chloro-3-methylphenol (ug/kg)	<660	<660	<660
2-Methylnaphthalene (ug/kg)	<330	<330	<330
Hexachlorocyclopentadiene (ug/kg)	<330	<330	<330
2,4,6-Trichlorophenol (ug/kg)	<330	<330	<330
2,4,5-Trichlorophenol (ug/kg)	<330	<330	<330
2-Chloronaphthalene (ug/kg)	<330	<330	<330
2-Nitroaniline (ug/kg)	<1,700	<1,700	<1,600
Dimethyl phthalate (ug/kg)	<330	<330	<330
Acenaphthylene (ug/kg)	<330	<330	<330
3-Nitroaniline (ug/kg)	<1,700	<1,700	<1,600
Acenaphthene (ug/kg)	<330	<330	<330
2,4-Dinitrophenol (ug/kg)	<1,700	<1,700	<1,600
4-Nitrophenol (ug/kg)	<1,700	<1,700	<1,600
Dibenzofuran (ug/kg)	<330	<330	<330
2,4-Dinitrotoluene (ug/kg)	<330	<330	<330
2,6-Dinitrotoluene (ug/kg)	<330	<330	<330
Diethylphthalate (ug/kg)	<330	<330	<330
4-Chlorophenyl phenyl ether (ug/kg)	<330	<330	<330
Fluorene (ug/kg)	<330	<330	<330

Appendix Table 1. Continued.

Parameter	**Sampling Location** - by River Mile **4.82** (0-6”)	**4.04** (0-6”)	**8.66** (0-6”)
4-Nitroaniline (ug/kg)	<330	<330	<330
4,6-Dinitro-2-methylphenol (ug/kg)	<1,700	<1,700	<1,600
N-Nitrosodiphenylamine * (ug/kg)	<330	<330	<330
Bromophenyl phenyl ether (ug/kg)	<330	<330	<330
Hexachlorobenzene (ug/kg)	<330	<330	<330
Pentachlorophenol (ug/kg)	<1,700	<1,700	<1,600
Phenanthrene (ug/kg)	<330	**470**	<330
Anthracene (ug/kg)	<330	<330	<330
Di-n-butylphthalate (ug/kg)	<330	<330	<330
Fluoranthene (ug/kg)	**380**	**650**	<330
Pyrene (ug/kg)	<330	**630**	<330
Butyl benzyl phthalate (ug/kg)	<330	<330	<330
3,3’-Dichlorobenzidine (ug/kg)	<670	<660	<660
Benzo(a)anthracene (ug/kg)	<330	**360**	<330
Bis(2-Ethylhexyl) phthalate (ug/kg)	<330	**520**	<330
Chrysene (ug/kg)	<330	**380**	<330
Di-n-octyl phthalate (ug/kg)	<330	<330	<330
Benzo(b)fluoranthene (ug/kg)	<330	<330	<330
Benzo(k)fluoranthene (ug/kg)	<330	<330	<330
Benzo(a)pyrene (ug/kg)	<330	<330	<330
Indeno(1,2,3-cd)pyrene (ug/kg)	<330	<330	<330
Dibenz(a,h)anthracene (ug/kg)	<330	<330	<330
Benzo(g,h,i)perylene (ug/kg)	<330	<330	<330

* - Cannot be distinguished from diphenylamine.

Appendix Table 2. Pesticides, PCBs, total organic carbon, and grain size parameters measured in sediment collected from the Grand River study area, 1994 by Ohio EPA.

Appendix Table 2. Pesticides, PCBs, total organic carbon, and grain size parameters measured in sediment collected from the Grand River study area, 1994 by Ohio EPA. Depth of sediment sample is noted in parentheses.

	Sampling Location - by River Mile						
Parameter	**2.37** (0-6”)	**2.97** (0-6”)	**3.48** (0-6”)	**3.48D** (0-6”)	**3.80** (0-6”)	**4.06** (0-6”)	**4.45** (0-6”)
Pesticides (ug/kg)							
alpha-BHC	<1.6	<1.7	<1.7	<1.6	<1.6	<1.6	<1.7
gamma-BHC (Lindane)	<1.6	<1.7	<1.7	<1.6	<1.6	<1.6	<1.7
beta-BHC	<1.6	<1.7	<1.7	<1.6	<1.6	<1.6	<1.7
Heptachlor	<1.6	<1.7	<1.7	<1.6	<1.6	<1.6	<1.7
delta-BHC	<1.6	<1.7	<1.7	<1.6	<1.6	<1.6	<1.7
Aldrin	<1.6	<1.7	<1.7	<1.6	<1.6	<1.6	<1.7
Heptachlor epoxide	<1.6	2.1	<1.7	<1.6	<1.6	<1.6	<1.7
Endosulfan I	<1.6	<1.7	<1.7	<1.6	<1.6	<1.6	<1.7
4,4’-DDE	<3.3	<3.3	<3.3	<3.3	<3.3	<3.3	<3.3
Dieldrin	<3.3	<3.3	<3.3	<3.3	<3.3	<3.3	<3.3
Endrin	<3.3	<3.3	<3.3	<3.3	<3.3	<3.3	<3.3
4,4’-DDD	<3.3	<3.3	<3.3	<3.3	<3.3	**3.6**	<3.3
Endosulfan II	<3.3	<3.3	<3.3	<3.3	<3.3	<3.3	<3.3
4,4’-DDT	<3.3	<3.3	<3.3	<3.3	<3.3	<3.3	<3.3
Endrin aldehyde	<3.3	<3.3	<3.3	<3.3	<3.3	<3.3	<3.3
Endosulfan sulfate	<3.3	<3.3	<3.3	<3.3	<3.3	<3.3	<3.3
Methoxychlor	<16	<17	<17	<16	<16	<16	<17
Chlordane (technical)	<82	<83	<83	<82	<82	<82	<83
Toxaphene	<82	<83	<83	<82	<82	<82	<83
PCBs (ug/kg)							
PCB-1016	<33	<33	<33	<33	<33	<33	<33
PCB-1221	<66	<66	<66	<66	<66	<66	<66
PCB-1232	<33	<33	<33	<33	<33	<33	<33
PCB-1242	<33	<33	<33	<33	<33	<33	<33
PCB-1248	<33	<33	<33	<33	<33	<33	<33
PCB-1254	<33	<33	<33	<33	<33	<33	<33
PCB-1260	<33	<33	<33	<33	<33	<33	<33
Total Organic Carbon (mg/kg)							
TOC	9,080	8,030	11,700	7,270	11,800	18,900	25,300
Grain Size (Percent)							
Gravel	0.3	0.0	0.0	0.1	4.6	0.1	3.0
Sand	52.5	33.0	53.7	50.0	55.9	42.2	40.7
Silt	38.8	55.6	48.8	41.2	31.8	48.6	45.1
Clay	8.4	11.4	7.5	8.7	7.7	9.1	11.2

Appendix Table 2. Continued.

	Sampling Location - by River Mile		
Parameter	**4.82** (0-6”)	**4.04** (0-6”)	**8.66** (0-6”)
Pesticides (ug/kg)			
alpha-BHC	<1.6	<1.6	<1.7
gamma-BHC (Lindane)	<1.6	<1.6	<1.7
beta-BHC	<1.6	<1.6	<1.7
Heptachlor	<1.6	<1.6	<1.7
delta-BHC	<1.6	<1.6	<1.7
Aldrin	<1.6	<1.6	<1.7
Heptachlor epoxide	<1.6	<1.6	<1.7
Endosulfan I	<1.6	<1.6	<1.7
4,4’-DDE	<3.3	<3.3	<3.3
Dieldrin	<3.3	<3.3	<3.3
Endrin	<3.3	<3.3	<3.3
4,4’-DDD	<3.3	<3.3	<3.3
Endosulfan II	<3.3	<3.3	<3.3
4,4’-DDT	<3.3	<3.3	<3.3
Endrin aldehyde	<3.3	<3.3	<3.3
Endosulfan sulfate	<3.3	<3.3	<3.3
Methoxychlor	<16	<16	<17
Chlordane (technical)	<82	<82	<83
Toxaphene	<82	<82	<83
PCBs (ug/kg)			
PCB-1016	<33	<33	<33
PCB-1221	<66	<66	<66
PCB-1232	<33	<33	<33
PCB-1242	<33	<33	<33
PCB-1248	<33	<33	<33
PCB-1254	<33	<33	<33
PCB-1260	<33	<33	<33
Total Organic Carbon (mg/kg)			
TOC	5,950	13,100	5,260
Grain Size (Percent)			
Gravel	2.8	0.3	0.9
Sand	57.1	16.0	13.3
Silt	35.9	64.5	69.1
Clay	4.2	19.2	16.7

Appendix Table 3. Target analyte list (TAL) metals and hexavalent chromium measured in sediment collected from the Grand River study area, 1994 by Ohio EPA.

Appendix Table 3. Target analyte list (TAL) metals and hexavalent chromium measured in sediment collected from the Grand River study area, 1994 by Ohio EPA. Depth of sediment sample is noted in parentheses.

	Sampling Location - by River Mile						
Parameter	**2.37** (0-6")	**2.97** (0-6")	**3.48** (0-6")	**3.48D** (0-6")	**3.80** (0-6")	**4.06** (0-6")	**4.45** (0-6")
Metals (mg/kg)							
Aluminum	3,279	3,890	3,810	3,280	3,020	3,630	3,530
Antimony	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0
Arsenic	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0
Barium	17.9	17.0	21.3	18.3	10.4	22.3	21.6
Beryllium	0.41	0.44	0.35	0.31	0.30	0.32	0.31
Cadmium	1.59	1.63	1.80	1.45	1.42	1.73	1.55
Calcium	2,350	2,880	3,750	3,430	4,500	4,730	2,180
Chromium	11.0	12.3	19.8	18.2	4.9	79.5	15.5
Cobalt	4.3	4.2	4.9	4.0	3.3	4.4	3.9
Copper	9.9	9.8	9.9	7.0	7.5	9.1	7.5
Iron	11,400	12,900	14,200	13,000	11,200	12,600	13,000
Lead	8.0	7.6	10.0	11.5	7.2	10.5	5.5
Magnesium	1,330	1,450	1,700	1,270	1,210	1,530	1,340
Manganese	146	146	217	187	96.7	273	134
Nickel	8.4	8.3	9.2	7.1	6.5	8.7	9.4
Potassium	372	401	430	329	354	383	388
Selenium	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0	<10.0
Silver	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0	<5.0
Sodium	90.0	130	240	237	1,560	68.3	<50.0
Thallium	<80.0	<80.0	<80.0	<80.0	<80.0	<80.0	<80.0
Vanadium	5.4	5.6	6.0	4.8	4.6	6.2	5.6
Zinc	39.3	37.5	41.5	35.8	43.0	40.8	29.8
Hexavalent chromium	<0.20	<0.20	<0.20	4.56	3.90	<0.20	<0.20
Mercury	<0.80	<0.80	<0.80	<0.80	<0.80	<0.80	<0.80

Appendix Table 3. Continued.

Parameter	Sampling Location - by River Mile **4.82** (0-6”)	**4.04** (0-6”)	**8.66** (0-6”)
Metals (mg/kg)			
Aluminum	3,080	5,000	3,880
Antimony	<10.0	<10.0	<10.0
Arsenic	<10.0	11.0	<10.0
Barium	15.0	17.3	26.7
Beryllium	0.30	0.36	0.34
Cadmium	1.69	1.89	1.40
Calcium	7,660	16,300	765
Chromium	<4.0	70.6	<4.0
Cobalt	3.7	5.2	4.5
Copper	8.2	10.6	6.6
Iron	13,200	14,000	13,400
Lead	8.0	12.5	6.8
Magnesium	1,310	210	1,050
Manganese	106.0	175	199
Nickel	6.9	11.4	7.2
Potassium	424.0	634	329
Selenium	<10.0	<10.0	<10.0
Silver	<5.0	<5.0	<5.0
Sodium	2,540	1,290	55
Thallium	<80.0	<80.0	<80.0
Vanadium	5.6	8.1	5.6
Zinc	34.0	47.6	27.6
Hexavalent chromium	1.83	5.04	<0.20
Mercury	<0.80	<0.80	<0.80

Appendix Table 4. Pesticides, PCBs, cadmium, chromium, lead, mercury, and lipid analyses of fish tissue collected from the Grand River study area, 1994 by Ohio EPA.

Appendix Table 4. Pesticides, PCBs, cadmium, chromium, lead, mercury, and lipid analyses of fish tissue collected from the Grand River study area, 1994 by Ohio EPA.

	Sampling Location - by River Mile					
Parameter	**3.2** Smallmouth buffalo SOFC	**3.2D** Smallmouth-buffalo SOFC	**4.2** Channel catfish SFFC	**4.6** Smallmouth-bass SOFC	**6.6** Walleye SOF	**3.2** Largemouth bass SOF
Pesticides (ug/kg)						
alpha-BHC	<1.6	<1.6	<1.6	<1.6	<1.6	<1.7
gamma-BHC (Lindane)	<1.6	<1.6	<1.6	<1.6	<1.6	<1.7
beta-BHC	<1.6	<1.6	<1.6	<1.6	<1.6	<1.7
Heptachlor	<1.6	<1.6	<1.6	<1.6	<1.6	<1.7
delta-BHC	<1.6	<1.6	<1.6	<1.6	<1.6	<1.7
Aldrin	<1.6	<1.6	<1.6	<1.6	<1.6	<1.7
Heptachlor epoxide	**4.4**	**3.5**	**4.8**	<1.6	<1.6	<1.7
Endosulfan I	<1.6	<1.6	<1.6	<1.6	<1.6	<1.7
4,4'-DDE	**55.0**	**36**	<3.3	<3.3	**15.0**	**5.6**
Dieldrin	**18.0**	**13**	<3.3	<3.3	<3.3	<3.3
Endrin	<3.2	<3.3	<3.3	<3.3	<3.3	<3.3
4,4'-DDD	**23.0**	**17.0**	<3.3	<3.3	**3.7**	<3.3
Endosulfan II	<3.2	<3.3	<3.3	<3.3	<3.3	<3.3
4,4'-DDT	**8.4**	**4.7**	<3.3	<3.3	<3.3	<3.3
Endrin aldehyde	**5.2**	<3.3	<3.3	<3.3	**12.0**	<3.3
Endosulfan sulfate	<3.2	<3.3	<3.3	<3.3	<3.3	<3.3
Methoxychlor	<16.0	<16.0	**14**	<16.0	<16.0	<17.0
Chlordane (technical)	<81.0	<81.0	<82.0	<82.0	<81.0	<83.0
Toxaphene	<81.0	<81.0	<82.0	<82.0	<81.0	<83.0
PCB's (ug/kg)						
PCB-1016	<48.0	<49.0	<49.0	<48.0	<47.0	<47.0
PCB-1221	<97.0	<98.0	<98.0	<95.0	<94.0	<95.0
PCB-1232	<48.0	<49.0	<49.0	<48.0	<47.0	<47.0
PCB-1242	<48.0	<49.0	<49.0	<48.0	<47.0	<47.0
PCB-1248	<48.0	<49.0	<49.0	<48.0	<47.0	<47.0
PCB-1254	**690**	**840**	<49.0	<48.0	<47.0	<47.0
PCB-1260	**160**	**210**	**200**	**58.0**	**170**	<47.0
Metals (mg/kg)						
Cadmium	**0.010**	**0.014**	**0.004**	<0.004	**0.010**	<0.004
Chromium	<0.04	**1.23**	**1.65**	**0.30**	<0.04	<0.04
Lead	<0.10	<0.10	<0.10	<0.10	<0.10	<0.10
Mercury	**0.41**	<0.08	**0.12**	<0.15	**0.41**	**0.26**
Lipids (Percent)						
	1.64	1.76	12.0	1.08	0.12	1.11

Appendix Table 4. Continued.

	Sampling Location - by River Mile		
Parameter	**6.6** Common carp SOFC	**4.6** Largemouth-bass SOFC	**6.6** Smallmouth bass SOFC
Pesticides (ug/kg)			
alpha-BHC	<1.7	<1.6	<1.6
gamma-BHC (Lindane)	<1.7	<1.6	<1.6
beta-BHC	<1.7	<1.6	<1.6
Heptachlor	<1.7	<1.6	<1.6
delta-BHC	<1.7	<1.6	<1.6
Aldrin	<1.7	<1.6	<1.6
Heptachlor epoxide	<1.7	<1.6	<1.6
Endosulfan I	<1.7	<1.6	<1.6
4,4'-DDE	**6.7**	**5.5**	**7.6**
Dieldrin	<3.3	<3.2	<3.3
Endrin	<3.3	<3.2	<3.3
4,4'-DDD	<3.3	<3.2	<3.3
Endosulfan II	<3.3	<3.2	<3.2
4,4'-DDT	<3.3	<3.2	<3.2
Endrin aldehyde	<3.3	**3.2**	**4.1**
Endosulfan sulfate	<3.3	<3.2	<3.3
Methoxychlor	<17	<16	<16
Chlordane (technical)	<83.0	<82.0	<82.0
Toxaphene	<83.0	<82.0	<82.0
PCB's (ug/kg)			
PCB-1016	<46.0	<46.0	<50.0
PCB-1221	<93.0	<91.0	<99.0
PCB-1232	<46.0	<46.0	<50.0
PCB-1242	<46.0	<46.0	<50.0
PCB-1248	<46.0	<46.0	<50.0
PCB-1254	<46.0	<46.0	<50.0
PCB-1260	<46.0	<46.0	<50.0
Metals (mg/kg)			
Cadmium	**0.007**	<0.004	<0.004
Chromium	<0.04	<0.04	<0.04
Lead	<0.10	<0.10	<0.10
Mercury	<0.08	<0.08	**0.14**
Lipids (Percent)	0.84	0.67	1.50

Appendix Table 5. Semivolatile organic compounds analyses of fish tissue collected from the Grand River study area, 1994 by Ohio EPA.

Appendix Table 5. Semivolatile organic compounds analyses of fish tissue collected from the Grand River study area, 1994 by Ohio EPA.

	Sampling Location - by River Mile					
Parameter	**3.2** Smallmouth buffalo SOFC	**3.2D** Smallmouth buffalo SOFC	**4.2** Channel catfish SFFC	**4.6** Smallmouth bass SOFC	**6.6** Walleye SOF	**3.2** Largemouth bass SOF
Phenol (ug/kg)	<330	<330	<1,700	<330	<330	<330
Bis(2-chloroethyl) ether (ug/kg)	<330	<330	<1,700	<330	<330	<330
2-Chlorophenol (ug/kg)	<330	<330	<1,700	<330	<330	<330
1,3-Dichlorobenzene (ug/kg)	<330	<330	<1,700	<330	<330	<330
1,4-Dichlorobenzene (ug/kg)	<330	<330	<1,700	<330	<330	<330
Benzyl alcohol (ug/kg)	<660	<660	<3,300	<660	<660	<660
1,2-Dichlorobenzene (ug/kg)	<330	<330	<1,700	<330	<330	<330
2-Methylphenol (ug/kg)	<330	<330	<1,700	<330	<330	<330
Bis(2-chloroisopropyl) ether (ug/kg)	<330	<330	<1,700	<330	<330	<330
3+4-Methylphenol (ug/kg)	<330	<330	<1,700	<330	<330	<330
N-Nitroso-di-n-propylamine (ug/kg)	<330	<330	<1,700	<330	<330	<330
Hexachloroethane (ug/kg)	<330	<330	<1,700	<330	<330	<330
Nitrobenzene (ug/kg)	<330	<330	<1,700	<330	<330	<330
Isophorone (ug/kg)	<330	<330	<1,700	<330	<330	<330
2-Nitrophenol (ug/kg)	<330	<330	<1,700	<330	<330	<330
2,4-Dimethylphenol (ug/kg)	<330	<330	<1,700	<330	<330	<330
Benzoic acid (ug/kg)	<1,700	<1,700	<8,300	<1,600	<1,600	<1,600
Bis(2-chloroethoxy) methane (ug/kg)	<330	<330	<1,700	<330	<330	<330
2,4-Dichlorophenol (ug/kg)	<330	<330	<1,700	<330	<330	<330
1,2,4-Trichlorobenzene (ug/kg)	<330	<330	<1,700	<330	<330	<330
Naphthalene (ug/kg)	<330	<330	<1,700	<330	<330	<330
4-Chloroaniline (ug/kg)	<660	<660	<3,300	<660	<660	<660
Hexachlorobutadiene (ug/kg)	<330	<330	<1,700	<330	<330	<330
4-Chloro-3-methylphenol (ug/kg)	<660	<660	<3,300	<660	<660	<660
2-Methylnaphthalene (ug/kg)	<330	<330	<1,700	<330	<330	<330
Hexachlorocyclopentadiene (ug/kg)	<330	<330	<1,700	<330	<330	<330
2,4,6-Trichlorophenol (ug/kg)	<330	<330	<1,700	<330	<330	<330
2,4,5-Trichlorophenol (ug/kg)	<330	<330	<1,700	<330	<330	<330
2-Chloronaphthalene (ug/kg)	<330	<330	<1,700	<330	<330	<330
2-Nitroaniline (ug/kg)	<1,700	<1,700	<8,300	<1,600	<1,600	<1,600
Dimethyl phthalate (ug/kg)	<330	<330	<1,700	<330	<330	<330
Acenaphthylene (ug/kg)	<330	<330	<1,700	<330	<330	<330
3-Nitroaniline (ug/kg)	<1,700	<1,700	<8,300	<1,600	<1,600	<1,600
Acenaphthene (ug/kg)	<330	<330	<1,700	<330	<330	<330
2,4-Dinitrophenol (ug/kg)	<1,700	<1,700	<8,300	<1,600	<1,600	<1,600
4-Nitrophenol (ug/kg)	<1,700	<1,700	<8,300	<1,600	<1,600	<1,600
Dibenzofuran (ug/kg)	<330	<330	<1,700	<330	<330	<330
2,4-Dinitrotoluene (ug/kg)	<330	<330	<1,700	<330	<330	<330
2,6-Dinitrotoluene (ug/kg)	<330	<330	<1,700	<330	<330	<330
Diethylphthalate (ug/kg)	<330	<330	<1,700	<330	<330	<330
4-Chlorophenyl phenyl ether (ug/kg)	<330	<330	<1,700	<330	<330	<330
Fluorene (ug/kg)	<330	<330	<1,700	<330	<330	<330

Appendix Table 5. Continued.

Parameter	Sampling Location - by River Mile					
	3.2 Smallmouth buffalo SOFC	**3.2D** Smallmouth-buffalo SOFC	**4.2** Channel catfish SFFC	**4.6** Smallmouth-bass SOFC	**6.6** Walleye SOF	**3.2** Largemouth bass SOF
4-Nitroaniline (ug/kg)	<330	<330	<1,700	<330	<330	<330
4,6-Dinitro-2-methylphenol (ug/kg)	<1,700	<1,700	<8,300	<1,600	<1,600	<1,600
N-Nitrosodiphenylamine * (ug/kg)	<330	<330	<1,700	<330	<330	<330
4-Bromophenyl phenyl ether (ug/kg)	<330	<330	<1,700	<330	<330	<330
Hexachlorobenzene (ug/kg)	<330	<330	<1,700	<330	<330	<330
Pentachlorophenol (ug/kg)	<1,700	<1,700	<8,300	1,600	<1,600	<1,600
Phenanthrene (ug/kg)	<330	<330	<1,700	<330	<330	<330
Anthracene (ug/kg)	<330	<330	<1,700	<330	<330	<330
Di-n-butylphthalate (ug/kg)	<330	<330	<1,700	<330	<330	<330
Fluoranthene (ug/kg)	<330	<330	<1,700	<330	<330	<330
Pyrene (ug/kg)	<330	<330	<1,700	<330	<330	<330
Butyl benzyl phthalate (ug/kg)	<330	<330	<1,700	<330	<330	<330
3,3'-Dichlorobenzidine (ug/kg)	<660	<660	<3,300	<660	<660	<660
Benzo(a)anthracene (ug/kg)	<330	<330	<1,700	<330	<330	<330
Bis(2-Ethylhexyl) phthalate (ug/kg)	<330	**470**	<1,700	<330	**370**	**390**
Chrysene (ug/kg)	<330	<330	<1,700	<330	<330	<330
Di-n-octyl phthalate (ug/kg)	<330	<330	<1,700	<330	<330	<330
Benzo(b)fluoranthene (ug/kg)	<330	<330	<1,700	<330	<330	<330
Benzo(k)fluoranthene (ug/kg)	<330	<330	<1,700	<330	<330	<330
Benzo(a)pyrene (ug/kg)	<330	<330	<1,700	<330	<330	<330
Indeno(1,2,3-cd)pyrene (ug/kg)	<330	<330	<1,700	<330	<330	<330
Dibenz(a,h)anthracene (ug/kg)	<330	<330	<1,700	<330	<330	<330
Benzo(g,h,i)perylene (ug/kg)	<330	<330	<1,700	<330	<330	<330

* - Cannot be distinguished from diphenylamine.

Appendix Table 5. Continued.

	Sampling Location - by River Mile		
	6.6 Common carp SOFC	4.6 Largemouth-bass SOFC	6.6 Smallmouth bass SOFC
Phenol (ug/kg)	<330	<330	<330
Bis(2-chloroethyl) ether (ug/kg)	<330	<330	<330
2-Chlorophenol (ug/kg)	<330	<330	<330
1,3-Dichlorobenzene (ug/kg)	<330	<330	<330
1,4-Dichlorobenzene (ug/kg)	<330	<330	<330
Benzyl alcohol (ug/kg)	<660	<670	<660
1,2-Dichlorobenzene (ug/kg)	<330	<330	<330
2-Methylphenol (ug/kg)	<330	<330	<330
Bis(2-chloroisopropyl) ether (ug/kg)	<330	<330	<330
3+4-Methylphenol (ug/kg)	<330	<330	<330
N-Nitroso-di-n-propylamine (ug/kg)	<330	<330	<330
Hexachloroethane (ug/kg)	<330	<330	<330
Nitrobenzene (ug/kg)	<330	<330	<330
Isophorone (ug/kg)	<330	<330	<330
2-Nitrophenol (ug/kg)	<330	<330	<330
2,4-Dimethylphenol (ug/kg)	<330	<330	<330
Benzoic acid (ug/kg)	<1,700	<1,700	<1,700
Bis(2-chloroethoxy) methane (ug/kg)	<330	<330	<330
2,4-Dichlorophenol (ug/kg)	<330	<330	<330
1,2,4-Trichlorobenzene (ug/kg)	<330	<330	<330
Naphthalene (ug/kg)	<330	<330	<330
4-Chloroaniline (ug/kg)	<660	<670	<660
Hexachlorobutadiene (ug/kg)	<330	<330	<330
4-Chloro-3-methylphenol (ug/kg)	<660	<670	<660
2-Methylnaphthalene (ug/kg)	<330	<330	<330
Hexachlorocyclopentadiene (ug/kg)	<330	<330	<330
2,4,6-Trichlorophenol (ug/kg)	<330	<330	<330
2,4,5-Trichlorophenol (ug/kg)	<330	<330	<330
2-Chloronaphthalene (ug/kg)	<330	<330	<330
2-Nitroaniline (ug/kg)	<1,700	<1,700	<1,700
Dimethyl phthalate (ug/kg)	<330	<330	<330
Acenaphthylene (ug/kg)	<330	<330	<330
3-Nitroaniline (ug/kg)	<1,700	<1,700	<1,700
Acenaphthene (ug/kg)	<330	<330	<330
2,4-Dinitrophenol (ug/kg)	<1,700	<1,700	<1,700
4-Nitrophenol (ug/kg)	<1,700	<1,700	<1,700
Dibenzofuran (ug/kg)	<330	<330	<330
2,4-Dinitrotoluene (ug/kg)	<330	<330	<330
2,6-Dinitrotoluene (ug/kg)	<330	<330	<330
Diethylphthalate (ug/kg)	<330	<330	<330
4-Chlorophenyl phenyl ether (ug/kg)	<330	<330	<330
Fluorene (ug/kg)	<330	<330	<330

Appendix Table 5. Continued.

	Sampling Location - by River Mile		
	6.6 Common carp SOFC	**4.6** Largemouth-bass SOFC	**6.6** Smallmouth bass SOFC
4-Nitroaniline (ug/kg)	<330	<330	<330
4,6-Dinitro-2-methylphenol (ug/kg)	<1,700	<1,700	<1,700
N-Nitrosodiphenylamine * (ug/kg)	<330	<330	<330
4-Bromophenyl phenyl ether (ug/kg)	<330	<330	<330
Hexachlorobenzene (ug/kg)	<330	<330	<330
Pentachlorophenol (ug/kg)	<1,700	<1,700	<1,700
Phenanthrene (ug/kg)	<330	<330	<330
Anthracene (ug/kg)	<330	<330	<330
Di-n-butylphthalate (ug/kg)	<330	<330	<330
Fluoranthene (ug/kg)	<330	<330	<330
Pyrene (ug/kg)	<330	<330	<330
Butyl benzyl phthalate (ug/kg)	<330	<330	<330
3,3'-Dichlorobenzidine (ug/kg)	<660	<670	<660
Benzo(a)anthracene (ug/kg)	<330	<330	<330
Bis(2-Ethylhexyl) phthalate (ug/kg)	**2300**	**750**	<330
Chrysene (ug/kg)	<330	<330	<330
Di-n-octyl phthalate (ug/kg)	<330	<330	**370**
Benzo(b)fluoranthene (ug/kg)	<330	<330	<330
Benzo(k)fluoranthene (ug/kg)	<330	<330	<330
Benzo(a)pyrene (ug/kg)	<330	<330	<330
Indeno(1,2,3-cd)pyrene (ug/kg)	<330	<330	<330
Dibenz(a,h)anthracene (ug/kg)	<330	<330	<330
Benzo(g,h,i)perylene (ug/kg)	<330	<330	<330

* - Cannot be distinguished from diphenylamine.

Appendix Table 6. Semivolatile organic compounds analyses of unionid mussel tissue collected from the Grand River study area, 1994 by Ohio EPA.

Appendix Table 6. Semivolatile organic compounds analyses of unionid mussel tissue collected from the Grand River study area, 1994 by Ohio EPA.

Parameter	**Sampling Location** - by River Mile **4.0** *Leptodea fragilis* Soft tissue composite	 **4.0** *Potamilus alatus* Soft tissue composite
Phenol (ug/kg)	<330	<330
Bis(2-chloroethyl) ether (ug/kg)	<330	<330
2-Chlorophenol (ug/kg)	<330	<330
1,3-Dichlorobenzene (ug/kg)	<330	<330
1,4-Dichlorobenzene (ug/kg)	<330	<330
Benzyl alcohol (ug/kg)	<660	<660
1,2-Dichlorobenzene (ug/kg)	<330	<330
2-Methylphenol (ug/kg)	<330	<330
Bis(2-chloroisopropyl) ether (ug/kg)	<330	<330
3+4-Methylphenol (ug/kg)	<330	<330
N-Nitroso-di-n-propylamine (ug/kg)	<330	<330
Hexachloroethane (ug/kg)	<330	<330
Nitrobenzene (ug/kg)	<330	<330
Isophorone (ug/kg)	<330	<330
2-Nitrophenol (ug/kg)	<330	<330
2,4-Dimethylphenol (ug/kg)	<330	<330
Benzoic acid (ug/kg)	<1,700	<1,700
Bis(2-chloroethoxy) methane (ug/kg)	<330	<330
2,4-Dichlorophenol (ug/kg)	<330	<330
1,2,4-Trichlorobenzene (ug/kg)	<330	<330
Naphthalene (ug/kg)	<330	<330
4-Chloroaniline (ug/kg)	<660	<660
Hexachlorobutadiene (ug/kg)	<330	<330
4-Chloro-3-methylphenol (ug/kg)	<660	<660
2-Methylnaphthalene (ug/kg)	<330	<330
Hexachlorocyclopentadiene (ug/kg)	<330	<330
2,4,6-Trichlorophenol (ug/kg)	<330	<33
2,4,5-Trichlorophenol (ug/kg)	<330	<330
2-Chloronaphthalene (ug/kg)	<330	<330
2-Nitroaniline (ug/kg)	<1,700	<1,700
Dimethyl phthalate (ug/kg)	<330	<330
Acenaphthylene (ug/kg)	<330	<330
3-Nitroaniline (ug/kg)	<1,700	<1,700
Acenaphthene (ug/kg)	<330	<330
2,4-Dinitrophenol (ug/kg)	<1,700	<1,700
4-Nitrophenol (ug/kg)	<1,700	<1,700
Dibenzofuran (ug/kg)	<330	<330
2,4-Dinitrotoluene (ug/kg)	<330	<330
2,6-Dinitrotoluene (ug/kg)	<330	<330
Diethylphthalate (ug/kg)	<330	<330
4-Chlorophenyl phenyl ether (ug/kg)	<330	<330
Fluorene (ug/kg)	<330	<330

Appendix Table 6. Continued.

Parameter	**Sampling Location** - by River Mile **4.0** *Leptodea fragilis* Soft tissue composite	 **4.0** *Potamilus alatus* Soft tissue composite
4-Nitroaniline (ug/kg)	<330	<330
4,6-Dinitro-2-methylphenol (ug/kg)	<1,700	<1,700
N-Nitrosodiphenylamine * (ug/kg)	<330	<330
4-Bromophenyl phenyl ether (ug/kg)	<330	<330
Hexachlorobenzene (ug/kg)	<330	<330
Pentachlorophenol (ug/kg)	<1,700	<1,700
Phenanthrene (ug/kg)	<330	<330
Anthracene (ug/kg)	<330	<330
Di-n-butylphthalate (ug/kg)	<330	<330
Fluoranthene (ug/kg)	<330	<330
Pyrene (ug/kg)	<330	<330
Butyl benzyl phthalate (ug/kg)	<330	<330
3,3'-Dichlorobenzidine (ug/kg)	<660	<660
Benzo(a)anthracene (ug/kg)	<330	<330
Bis(2-Ethylhexyl) phthalate (ug/kg)	<330	<330
Chrysene (ug/kg)	<330	<330
Di-n-octyl phthalate (ug/kg)	<330	<330
Benzo(b)fluoranthene (ug/kg)	<330	<330
Benzo(k)fluoranthene (ug/kg)	<330	<330
Benzo(a)pyrene (ug/kg)	<330	<330
Indeno(1,2,3-cd)pyrene (ug/kg)	<330	<330
Dibenz(a,h)anthracene (ug/kg)	<330	<330
Benzo(g,h,i)perylene (ug/kg)	<330	<330

* - Cannot be distinguished from diphenylamine.

Appendix Table 7. Pesticides, PCBs, cadmium, chromium, hexavalent chromium, lead, mercury, and lipid analyses of unionid mussel tissue collected from the Grand River study area, 1994 by Ohio EPA.

Appendix Table 7. Pesticides, PCBs, cadmium, chromium, hexavalent chromium, lead, mercury, and lipid analyses of unionid mussle tissue collected from the Grand River study area, 1994 by Ohio EPA.

	Sampling Location - by River Mile	
	4.0	**4.0**
	Leptodea fragilis	Potamilus alatus
Parameter	Soft tissue composite	Soft tissue composite
Pesticides (ug/kg)		
alpha-BHC	<0.83	<0.82
gamma-BHC (Lindane)	<0.83	<0.82
beta-BHC	<0.83	<0.82
Heptachlor	<0.83	<0.82
delta-BHC	<0.83	<0.82
Aldrin	<0.83	<0.82
Heptachlor epoxide	<0.83	<0.82
Endosulfan I	<0.83	<0.82
4,4’-DDE	**1.9**	**1.6**
Dieldrin	<1.7	<1.6
Endrin	<1.7	<1.6
4,4’-DDD	<1.7	<1.6
Endosulfan II	<1.7	<1.6
4,4’-DDT	<1.7	<1.6
Endrin aldehyde	<1.7	<1.6
Endosulfan sulfate	<1.7	<1.6
Methoxychlor	<8.3	<8.2
Chlordane (technical)	<41.0	<41.0
Toxaphene	<41.0	<41.0
PCB’s (ug/kg)		
PCB-1016	<8.3	<46
PCB-1221	<17.0	<91
PCB-1232	<8.3	<46
PCB-1242	<8.3	<46
PCB-1248	<8.3	<46
PCB-1254	<8.3	<46
PCB-1260	<8.3	<46
Metals (mg/kg)		
Cadmium	0.11	0.19
Chromium	0.31	0.21
Lead	0.13	0.08
Mercury	<0.08	<0.08
Hexavalent chromium	<4.0	<4.0
Lipids (Percent)	1.4	1.0

Appendix Table 8. Raw macroinvertebrate data by river mile for the Grand River, 1994.

Ohio EPA Water Quality Monitoring and Assessment Section
Macroinvertebrate Collection

Collection Date: 09/29/94 River Code: 03-001 River: Grand River RM: 6.40

Taxa Code	Taxa	Quan	Qual
00653	*Eunapius fragilis*	0	+
01320	*Hydra sp*	4	
01801	*Turbellaria*	0	+
03360	*Plumatella sp*	0	+
03600	*Oligochaeta*	5	
05800	*Caecidotea sp*	0	+
11110	*Baetis armillatus*	0	+
11130	*Baetis intercalaris*	14	+
11150	*Labiobaetis propinquus*	0	+
11650	*Procloeon sp (w/ hindwing pads)*	0	+
13400	*Stenacron sp*	3	+
13540	*Stenonema mediopunctatum*	1	+
13561	*Stenonema pulchellum*	17	+
16324	*Serratella deficiens*	0	+
18100	*Anthopotamus sp*	0	+
22001	*Coenagrionidae*	0	+
22300	*Argia sp*	0	+
23909	*Boyeria vinosa*	0	+
24900	*Gomphus sp*	0	+
34140	*Acroneuria internata*	0	+
34700	*Agnetina capitata complex*	0	+
45300	*Sigara sp*	0	+
47600	*Sialis sp*	0	+
50315	*Chimarra obscura*	0	+
52200	*Cheumatopsyche sp*	9	+
52430	*Ceratopsyche morosa group*	6	+
52540	*Hydropsyche dicantha*	0	+
52620	*Macrostemum zebratum*	0	+
53501	*Hydroptilidae*	1	+
59120	*Ceraclea flava complex*	0	+
59970	*Petrophila sp*	1	+
60300	*Dineutus sp*	0	+
68075	*Psephenus herricki*	0	+
68901	*Macronychus glabratus*	0	+
69400	*Stenelmis sp*	0	+
71100	*Hexatoma sp*	0	+
77120	*Ablabesmyia mallochi*	4	
77750	*Hayesomyia senata or Thienemannimyia norena*	4	
80360	*Corynoneura "celeripes" (sensu Simpson & Bode, 1980)*	8	
80370	*Corynoneura lobata*	4	
80410	*Cricotopus (C.) sp*	2	
80420	*Cricotopus (C.) bicinctus*	48	+
80430	*Cricotopus (C.) tremulus group*	2	
81280	*Nanocladius (Plecopteracoluthus) n. sp*	0	+
82141	*Thienemanniella xena*	8	+
83040	*Dicrotendipes neomodestus*	10	
83820	*Microtendipes "caelum" (sensu Simpson & Bode, 1980)*	2	
84450	*Polypedilum (P.) convictum*	0	+
84470	*Polypedilum (P.) illinoense*	12	
84888	*Xenochironomus xenolabis*	0	+
85500	*Paratanytarsus sp*	4	
85625	*Rheotanytarsus exiguus group*	20	+
85800	*Tanytarsus sp*	6	
85814	*Tanytarsus glabrescens group*	14	
85840	*Tanytarsus guerlus group*	6	
93200	*Hydrobiidae*	0	+
93900	*Elimia sp*	0	+
96900	*Ferrissia sp*	1	+

No. Quantitative Taxa: 27 Total Taxa: 58

No. Qualitative Taxa: 43 ICI: **32**

Number of Organisms: 216 Qual EPT: **17**

Ohio EPA Water Quality Monitoring and Assessment Section
Macroinvertebrate Collection

Collection Date: 09/29/94 River Code: 03-001 River: Grand River RM: 4.70

Taxa Code	Taxa	Quan/Qual	
00653	*Eunapius fragilis*	0	+
01320	*Hydra sp*	4	
01801	*Turbellaria*	24	+
03121	*Paludicella articulata*	1	
03360	*Plumatella sp*	0	+
03600	*Oligochaeta*	158	+
05800	*Caecidotea sp*	1	
05900	*Lirceus sp*	2	
06700	*Crangonyx sp*	1	
11130	*Baetis intercalaris*	0	+
11250	*Centroptilum sp (w/o hindwing pads)*	1	
11670	*Procloeon irrubrum*	2	
12200	*Isonychia sp*	0	+
13000	*Leucrocuta sp*	0	+
13400	*Stenacron sp*	28	+
13561	*Stenonema pulchellum*	20	+
14950	*Leptophlebia sp or Paraleptophebia sp*	6	
16700	*Tricorythodes sp*	6	+
17200	*Caenis sp*	41	
18100	*Anthopotamus sp*	0	+
22001	*Coenagrionidae*	0	+
22300	*Argia sp*	28	+
23909	*Boyeria vinosa*	0	+
24710	*Dromogomphus spinosis*	0	+
26705	*Macromia illinoiensis*	0	+
34140	*Acroneuria internata*	0	+
34700	*Agnetina capitata complex*	0	+
42700	*Belostoma sp*	5	+
47600	*Sialis sp*	0	+
50315	*Chimarra obscura*	0	+
50906	*Psychomyia flavida*	0	+
51400	*Nyctiophylax sp*	1	
51600	*Polycentropus sp*	3	
52200	*Cheumatopsyche sp*	0	+
52430	*Ceratopsyche morosa group*	0	+
52540	*Hydropsyche dicantha*	0	+
52620	*Macrostemum zebratum*	0	+
53800	*Hydroptila sp*	0	+
58505	*Helicopsyche borealis*	0	+
59500	*Oecetis sp*	0	+
59970	*Petrophila sp*	1	
60300	*Dineutus sp*	0	+
65800	*Berosus sp*	2	
68901	*Macronychus glabratus*	0	+
69400	*Stenelmis sp*	0	+
71900	*Tipula sp*	0	+
77120	*Ablabesmyia mallochi*	3	
77750	*Hayesomyia senata or Thienemannimyia norena*	9	+
77800	*Helopelopia sp*	30	+
79085	*Telopelopia okoboji*	0	+
80310	*Cardiocladius obscurus*	0	+
80370	*Corynoneura lobata*	4	
80410	*Cricotopus (C.) sp*	6	
80420	*Cricotopus (C.) bicinctus*	9	+
80430	*Cricotopus (C.) tremulus group*	21	
81630	*Parakiefferiella sp*	3	
82141	*Thienemanniella xena*	6	
82710	*Chironomus (C.) sp*	3	
83040	*Dicrotendipes neomodestus*	21	
83050	*Dicrotendipes lucifer*	15	
83820	*Microtendipes "caelum" (sensu Simpson & Bode, 1980)*	3	+
84020	*Parachironomus carinatus*	0	+
84302	*Phaenopsectra punctipes*	24	
84315	*Phaenopsectra flavipes*	6	
84450	*Polypedilum (P.) convictum*	0	+
84460	*Polypedilum (P.) fallax group*	9	
84470	*Polypedilum (P.) illinoense*	12	
84540	*Polypedilum (Tripodura) scalaenum group*	45	
84790	*Tribelos fuscicorne*	21	
84800	*Tribelos jucundum*	3	
84960	*Pseudochironomus sp*	0	+
85500	*Paratanytarsus sp*	21	
85800	*Tanytarsus sp*	3	
85814	*Tanytarsus glabrescens group*	12	
87540	*Hemerodromia sp*	25	
89501	*Ephydridae*	1	
93200	*Hydrobiidae*	0	+
93900	*Elimia sp*	1	+
95100	*Physella sp*	0	+
96900	*Ferrissia sp*	4	+

Ohio EPA Water Quality Monitoring and Assessment Section
Macroinvertebrate Collection

Collection Date: 09/29/94 River Code: 03-001 River: Grand River RM: 4.70

Taxa Code	Taxa	Quan/Qual		Taxa Code	Taxa	Quan/Qual
98600	*Sphaerium sp*	0	+			

No. Quantitative Taxa:	47	Total Taxa:	81
No. Qualitative Taxa:	47	ICI:	**30**
Number of Organisms:	655	Qual EPT:	**18**

Ohio EPA Water Quality Monitoring and Assessment Section
Macroinvertebrate Collection

Collection Date: 09/29/94 River Code: 03-001 River: Grand River RM: 4.20

Taxa Code	Taxa	Quan/Qual	
01320	*Hydra sp*	21	
01801	*Turbellaria*	46	+
03600	*Oligochaeta*	816	
05900	*Lirceus sp*	0	+
06810	*Gammarus fasciatus*	20	+
13400	*Stenacron sp*	17	+
14950	*Leptophlebia sp or Paraleptophebia sp*	6	
17200	*Caenis sp*	80	+
18100	*Anthopotamus sp*	1	
21200	*Calopteryx sp*	1	
22001	*Coenagrionidae*	3	+
22300	*Argia sp*	6	+
23909	*Boyeria vinosa*	0	+
24930	*Gomphus lividus*	0	+
25300	*Ophiogomphus sp*	0	+
27409	*Neurocordulia yamaskanensis*	0	+
47600	*Sialis sp*	0	+
51206	*Cyrnellus fraternus*	26	+
51600	*Polycentropus sp*	11	
52200	*Cheumatopsyche sp*	0	+
52540	*Hydropsyche dicantha*	0	+
53600	*Agraylea sp*	1	
53800	*Hydroptila sp*	17	+
59001	*Leptoceridae*	1	
60800	*Haliplus sp*	0	+
60900	*Peltodytes sp*	0	+
63300	*Hydroporus sp*	0	+
65800	*Berosus sp*	14	
68901	*Macronychus glabratus*	2	+
69400	*Stenelmis sp*	2	+
77115	*Ablabesmyia janta*	45	
77120	*Ablabesmyia mallochi*	10	+
77800	*Helopelopia sp*	35	
78650	*Procladius sp*	5	
82730	*Chironomus (C.) decorus group*	10	+
82820	*Cryptochironomus sp*	20	+
83040	*Dicrotendipes neomodestus*	40	+
83050	*Dicrotendipes lucifer*	50	+
83051	*Dicrotendipes simpsoni*	10	
83300	*Glyptotendipes (G.) sp*	45	
83820	*Microtendipes "caelum" (sensu Simpson & Bode, 1980)*	5	
83900	*Nilothauma sp*	10	
84300	*Phaenopsectra obediens group*	5	
84302	*Phaenopsectra punctipes*	10	
84470	*Polypedilum (P.) illinoense*	5	
84520	*Polypedilum (Tripodura) halterale group*	45	
84540	*Polypedilum (Tripodura) scalaenum group*	10	
84790	*Tribelos fuscicorne*	25	
84960	*Pseudochironomus sp*	0	+
85201	*Cladotanytarsus species group A*	5	
85500	*Paratanytarsus sp*	5	
85800	*Tanytarsus sp*	15	
85814	*Tanytarsus glabrescens group*	25	
87540	*Hemerodromia sp*	7	
95100	*Physella sp*	12	+
96900	*Ferrissia sp*	1	+

No. Quantitative Taxa: 44 Total Taxa: 56

No. Qualitative Taxa: 29 ICI: **26**

Number of Organisms: 1546 Qual EPT: **6**

Ohio EPA Water Quality Monitoring and Assessment Section
Macroinvertebrate Collection

Collection Date: 09/29/94 River Code: 03-001 River: Grand River RM: 3.10

Taxa Code	Taxa	Quan/Qual	
01320	*Hydra sp*	1	
01801	*Turbellaria*	3	+
03600	*Oligochaeta*	0	+
04685	*Placobdella ornata*	0	+
04962	*Mooreobdella fervida*	0	+
05800	*Caecidotea sp*	0	+
06810	*Gammarus fasciatus*	3	+
13400	*Stenacron sp*	3	
22001	*Coenagrionidae*	0	+
23909	*Boyeria vinosa*	0	+
53800	*Hydroptila sp*	0	+
54300	*Oxyethira sp*	0	+
60900	*Peltodytes sp*	0	+
65800	*Berosus sp*	2	
69400	*Stenelmis sp*	6	+
77800	*Helopelopia sp*	37	
78650	*Procladius sp*	0	+
80500	*Cricotopus (Isocladius) reversus group*	555	
82730	*Chironomus (C.) decorus group*	0	+
83002	*Dicrotendipes modestus*	0	+
83050	*Dicrotendipes lucifer*	37	
83300	*Glyptotendipes (G.) sp*	3663	+
84300	*Phaenopsectra obediens group*	37	
84540	*Polypedilum (Tripodura) scalaenum group*	37	
87540	*Hemerodromia sp*	2	
95100	*Physella sp*	10	+
96900	*Ferrissia sp*	0	+
98600	*Sphaerium sp*	0	+

No. Quantitative Taxa: 14 Total Taxa: 28

No. Qualitative Taxa: 19 ICI: **16**

Number of Organisms: 4396 Qual EPT: **2**

Appendix Table 9. Invertebrate Community Index (ICI) metrics and scores for the Grand River study area, 1994.

River Mile	Drainage Area (sq mi)	Number of: Total Taxa	Mayfly Taxa	Caddisfly Taxa	Dipteran Taxa	Percent: Mayflies	Caddisflies	Tanytarsini	Other Dipt/NI	Tolerant Taxa	Qual. EPT	Ecoregion	ICI
GRAND RIVER — 03-001													
Year: 94													
6.40	687.0	27(4)	4(2)	3(4)	16(6)	16.2(4)	7.4(2)	23.1(4)	52.8(0)	30.5(0)	17(6)	3	**32**
4.70	698.0	47(6)	7(4)	2(2)	25(6)	15.9(4)	0.6(0)	5.5(2)	72.5(0)	29.8(0)	18(6)	3	**30**
4.20	698.0	44(6)	4(2)	5(4)	23(6)	6.7(4)	3.6(0)	3.2(2)	84.6(0)	55.2(0)	6(2)	3	**26**
3.10	701.0	14(2)	1(0)	0(0)	7(6)	0.1(2)	0.0(0)	0.0(0)	99.7(0)	0.2(6)	2(0)	3	**16**

Appendix Table 10. Summary of relative numbers of fish and species collected at each location by river mile sampled in the Grand River area, 1994. Relative numbers are per 1.0 km.

	RM 3.2	RM 4.2	RM 4.6	RM 6.6
GIZZARD SHAD	–	–	17.0	–
RAINBOW TROUT	–	–	3.0	–
SMALLMOUTH BUFFALO	1.0	–	–	–
SILVER REDHORSE	4.0	–	–	5.0
BLACK REDHORSE	2.0	5.0	29.0	52.5
GOLDEN REDHORSE	8.0	6.0	24.0	55.0
NORTHERN HOG SUCKER	–	12.0	35.0	40.0
WHITE SUCKER	–	2.0	–	2.5
SPOTTED SUCKER	2.0	–	1.0	–
COMMON CARP	1.0	7.0	2.0	5.0
RIVER CHUB	–	–	1.0	–
SILVER SHINER	–	5.0	12.0	32.5
ROSYFACE SHINER	–	–	1.0	–
STRIPED SHINER	3.0	2.0	18.0	7.5
SPOTFIN SHINER	1.0	1.0	2.0	5.0
SAND SHINER	–	1.0	5.0	2.5
BLUNTNOSE MINNOW	12.0	1.0	–	–
YELLOW BULLHEAD	–	1.0	–	–
BRINDLED MADTOM	–	–	–	2.5
TROUT-PERCH	–	–	–	2.5
WHITE CRAPPIE	–	–	2.0	5.0
BLACK CRAPPIE	–	1.0	–	2.5
ROCK BASS	10.0	23.0	36.0	42.5
SMALLMOUTH BASS	6.0	14.0	30.0	30.0
LARGEMOUTH BASS	4.0	4.0	5.0	–
GREEN SUNFISH	–	1.0	–	2.5
BLUEGILL SUNFISH	–	6.0	1.0	7.5
PUMPKINSEED SUNFISH	28.0	18.0	10.0	12.5
WALLEYE	1.0	–	–	2.5
YELLOW PERCH	–	–	1.0	2.5
BLACKSIDE DARTER	–	2.0	4.0	7.5
LOGPERCH	3.0	2.0	5.0	15.0
JOHNNY DARTER	1.0	–	–	–
FRESHWATER DRUM	–	1.0	4.0	7.5
Total Relative Number	87.0	115.0	248.0	350.0
Total Number of Species	16	21	23	24
Distance Sampled (kilometers)	1.00	1.00	1.00	0.40
Number of Passes	2	2	2	1

Appendix Table 11. **Index of Biotic Integrity (IBI) metrics and scores by river mile for locations sampled in the Grand River study area, 1994.**

River Mile	Type	Date	Drainage area (sq mi)	Number of: Total species	Sunfish species	Sucker species	Intolerant species	Percent of Individuals: Rnd-bodied suckers	Simple Lithophils	Tolerant fishes	Omni-vores	Top carnivores	Insect-ivores	DELT anomalies	Rel.No. minus tolerants /(1.0 km)	IBI	Modified Iwb
Grand River - (03-001)																	
Year: 94																	
6.60	A	09/01/94	687	23(5)	6(5)	5(3)	3(3)	44(5)	63(5)	3(5)	2(5)	21(5)	74(5)	0.0(5)	340(3)	54	9.7
4.60	A	08/10/94	698	12(3)	2(3)	4(3)	2(3)	41(5)	54(5)	1(5)	1(5)	41(5)	55(5)	1.2(3)	168(1) *	46	7.8
4.60	A	09/01/94	698	19(3)	4(5)	3(3)	4(5)	33(3)	51(5)	1(5)	11(5)	22(5)	63(5)	0.0(5)	322(3)	52	9.1
4.20	A	08/10/94	698	16(3)	5(5)	3(3)	2(3)	17(1)	30(3)	17(3)	13(5)	38(5)	48(3)	0.0(5)	100(1) *	40	7.1
4.20	A	09/01/94	698	13(3)	3(3)	4(3)	1(1)	24(3)	33(3)	4(5)	4(5)	33(5)	62(5)	0.0(5)	106(1) *	42	7.6
3.20	A	08/10/94	701	10(3)	2(3)	3(3)	0(1)	28(3)	36(3)	12(1)	12(1)	24(1)	64(1)	0.0(1)	44(1) **	22	6.3
3.20	A	09/01/94	701	15(3)	2(3)	5(3)	1(1)	15(1)	23(1)	16(3)	16(3)	24(5)	60(5)	0.0(5)	104(1) *	34	7.8

▲ - IBI is low end adjusted.