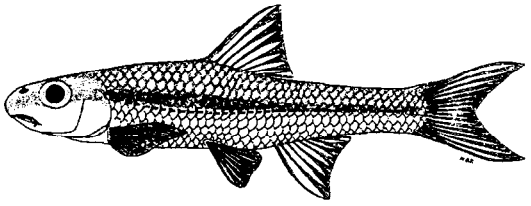
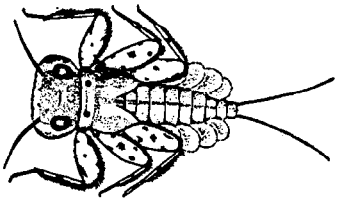
State of Ohio
Environmental Protection Agency

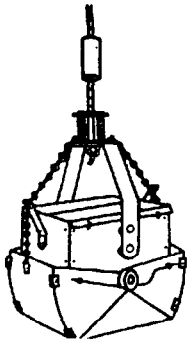
Ecological Assessment Section
Division of Water Quality
Planning & Assessment

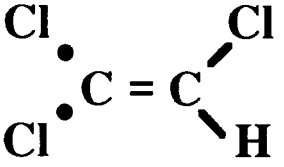
Investigation of Sediment and Surface Water Impacts in the Muskingum River, McConnelsville, Ohio

Morgan County (Ohio)









Trichloroethene (TCE)

January 25, 1993

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

Investigation of Sediment and Surface Water Impacts in the Muskingum River, McConnelsville, Ohio.

T & N Glacier Clevite
Gould Co.
Malta WTP

McConnelsville, Ohio

January 25, 1993

OEPA Technical Report EAS/1993-1-1

prepared for

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

prepared by

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INTRODUCTION

The Muskingum River study area included the mainstem upstream from Gould (RM 52.6) to the McConnelsville dam (RM 48.8) and a small section of Slemmons Creek. Slemmons Creek sediments were collected in the vicinity of Brocks junkyard (RM 1.3 - 1.0). Sampling points were located to evaluate potential contaminants from Gould (RM 51.8), T & N Glacier Clevite (RM 51.7) and the Malta WTP (RM 50.2). In addition, sampling was conducted adjacent to the McConnelsville well field (which is being investigated for elevated levels of trichloroethene). The results of the surface water and sediment data collected in this study, along with previous Ohio EPA data, will be used to determine levels of river-based contaminants, potential sources, pollutant pathways and levels of concern adjacent to the McConnelsville well field. Fish were collected during 1992 for tissue analyses; however, analytical results are not expected until July, 1993.

Specific objectives of this evaluation were to:

1) sample sediment and surface water to determine the potential for the Muskingum River to contribute contaminants to the McConnelsville well field;

2) determine if fish are bioaccumulating chemical contaminants;

3) re-assess specific metals and solvents of concern in surface water and sediment adjacent to the Gould/ T & N area;

4) assess surface water and sediment in the Muskingum River adjacent to the Malta WTP well field discharge.

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

CONCLUSIONS

In June 1992 Ohio EPA's DWQPA staff, at the request of DERR, conducted sediment and surface water sampling in the Muskingum River in the vicinity of Gould, T & N, Malta well field and the McConnelsville well field. The results of these sampling events, along with previous data collected by Ohio EPA, are summarized below.

- Lead and copper sediment concentrations were extremely elevated in the Muskingum River adjacent to Gould and T & N. A review of the Ohio EPA sediment database revealed that these are the highest copper and lead levels ever documented in the State of Ohio. Significant levels of copper (4350 ug/l maximum) and lead (3950 ug/l maximum) have been documented in the effluent discharges from Gould and T & N, respectively.

- The highest metal concentrations in sediment were measured in the Muskingum River between RM 51.8 and RM 51.58, an area adjacent to and slightly downstream from Gould and T & N. In addition to copper and lead, other metals occurring at extremely elevated levels included arsenic, chromium and zinc.

- Tetrachloroethene, trichloroethene and 1,2-dichloroethene (including cis-1,2-dichloroethene) were documented at significant levels in the sediment adjacent to Gould and T & N. Maximum sediment levels for tetrachloroethene, trichloroethene and 1,2-dichloroethene were 3433 mg/kg, 573 mg/kg and 351 mg/kg, respectively. These concentrations are considered very high and are comparable to highly contaminated sites such as the Fields Brook "Superfund" site in Ashtabula, Ohio.

- Although highly elevated concentrations of several metal and organic compounds were observed in the Muskingum River sediment, the area of impact did not appear to extend much beyond the boundaries of the Gould/ T & N facilities. Background levels of the highly elevated parameters were observed within 0.3 miles downstream from Gould/ T & N. This compares well with results observed in effluent discharges from Gould and T & N and the interaction with the Muskingum River . Elevated levels of copper, lead, tetrachloroethene, trichloroethene, and 1,2-dichloroethene in the Muskingum River appear to be restricted to within the Gould/ T & N mixing zone area. All other stations sampled downstream from Gould/ T & N reported relatively low water concentrations of these parameters.

- 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (2378-TCDD), 2,3,7,8-tetrachlorodibenzofuran (2378 TCDF) and other dioxin and furan congeners were measured in the sediment of the Muskingum River adjacent to the Malta WTP well field discharge. 2378 - TCDD total toxicity equivalents (TTE) for the two samples collected indicated relatively low levels of dioxin/furan contamination. TTE values (13.2 ppt and 29.0 ppt) were substantially less than mine reclamation criteria (100 ppt 2378 TCDD TTEs) and the CDC action level (1 ppb 2378-TCDD/ or 1 ppb TTE as is commonly used by regulatory programs). Dioxin and dibenzofuran contaminant levels indicate that the sampling site is not significantly contaminated by pentachlorophenol (based upon the relatively low octa and hepta dioxin congeners which are associated with PCP).

- PCBs, pesticides and semivolatile organic compounds tested in sediment samples were considered low, with most parameters not detected. Aside from bis(2-ethylhexyl) phthalate, semivolatile compounds in surface water samples were not detected (PCBs and pesticides were not tested in surface water).

- 1991 sampling of the Muskingum River in the vicinity of the Malta WTP well field wastewater discharge documented elevated levels of 1,1-dichloroethene (90 ug/l), 1,1,1-trichloroethane (266 ug/l) and pentachlorophenol (10.9 ug/l). All three of the parameter concentrations exceeded the 30-day average water quality standard. None of these parameters exceeded the lab detection limit during the 1992 sampling.

- Samples of Muskingum River sediment and surface water adjacent to the McConnelsville well field indicated good environmental quality, with nearly all organic chemicals tested reported as not detected and metals indicative of good water/sediment quality.

- Biological monitoring of the Muskingum River during 1988 revealed that the sampling station immediately upstream from Gould/ T & N showed full attainment of the Warmwater Habitat (WWH) aquatic life use designation. Fish indices declined significantly downstream from the Gould/ T & N area. Biological communities were in non-attainment of the WWH use. The degradation of the fish community immediately downstream from Gould/ T & N appears to be caused by chemical impacts associated with these two facilities. Recovery to partial attainment of the WWH use occurred downstream from the McConnelsville dam.

- T & N and Gould outfall 001 effluents repeatedly have been found to be acutely toxic to test organisms in bioassays conducted by the Ohio EPA.

RECOMMENDATIONS

- Soil sampling for PCP, dioxin and dibenzofuran should be conducted in the vicinity of the Malta Windows pentachlorophenol spill site. Three known spills have occurred (1973, 1974, 1980) where rainwater has displaced PCP oil stored in underground tanks. Although levels of these compounds were relatively low in the Muskingum River, the river is located at least 0.1 miles from the spill area.

- Dioxin and dibenzofuran should be tested in sediment samples collected in the Muskingum River where high levels of solvents (tetrachloroethene and trichloroethene) have been documented (RM 51.74).

METHODS

All chemical, physical, and biological field, laboratory, data processing, and data analysis methods and procedures adhere to those specified in the Manual of Ohio EPA Surveillance Methods and Quality Assurance Practices (Ohio Environmental Protection Agency 1989a) and Biological Criteria for the Protection of Aquatic Life, Volumes I - III (Ohio Environmental Protection Agency 1988a, 1988b, 1989b, 1989c), and The Qualitative Habitat Evaluation Index (QHEI); Rationale, Methods, and Application (Rankin 1989) for habitat assessment.

Attainment/non-attainment of aquatic life uses was determined by using biological criteria codified in Ohio Administrative Code (OAC) 3745-1-07, Table 7-17. The biological community performance measures that were used included the Index of Biotic Integrity (IBI) and the Modified Index of Well-being (MIwb), both of which are based on fish community characteristics and the Invertebrate Community Index (ICI) which is based on macroinvertebrate community characteristics.

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 was FULL if all three indices (or those available) meet the applicable criteria, PARTIAL if at least one of the indexes did not attain and performance did not fall below the fair category, and **NON** if all indices either failed to attain or any index indicated poor or very poor performance. The ICI index did not apply to the use attainment evaluation within impounded segments of the Muskingum River.

Physical habitat was evaluated using the Qualitative Habitat Evaluation Index (QHEI) developed by the Ohio EPA for streams and rivers in Ohio (Rankin 1989). Various attributes of the available habitat were scored based on their overall importance to the establishment of viable, diverse aquatic faunas. Evaluations of type and quality of substrate, amount of instream cover, channel morphology, extent of riparian canopy, pool and riffle development and quality, and stream gradient are among the metrics used to evaluate the characteristics of a stream segment, not just the characteristics of a single sampling site. As such, individual sites may have much poorer physical habitat due to a localized disturbance yet still support aquatic communities closely resembling those sampled at adjacent sites with better habitat, provided water quality conditions are similar.

During the sampling survey of 1992, sediment samples were collected at all but one location using decontaminated stainless steel scoops. Sediment at one location was collected using a decontaminated stainless steel Ekman dredge (decontamination followed the procedures outlined in FSOP 10.01, DERR Sampling Guidance, Vol III, 1992). Collected sediment was placed into clear glass jars with teflon lined lids, placed on ice (to maintain 4°C) and shipped to an Ohio EPA contract lab. Surface water samples were collected directly into sample containers, except for volatile organic compound samples. VOC samples were collected with a stainless steel bailer and the water poured into 40 ml glass vials. All water samples were shipped to an Ohio EPA contract lab.

RESULTS AND DISCUSSION

Sediment Chemistry (Tables 2-6)

Sediment samples were collected from the Muskingum River by the Ohio EPA during 1992 (9 samples analyzed for RCRA metals, semivolatile and volatile organic compounds, and PCB's; 4 samples analyzed for pesticides and two samples analyzed for dioxins and furans) and during 1988 (3 locations), 1986 (5 locations) and 1982 (6 locations). The 1992 samples were collected to assess levels of contaminants present in stream sediments in the vicinity of Gould, T & N, Malta WTP, and the McConnelsville well field.

- Lead and copper sediment concentrations were extremely elevated in the Muskingum River adjacent to Gould and T & N (RM 51.8 - 51.7). A review of the Ohio EPA sediment database revealed that the highest copper and lead levels in the State of Ohio were documented in the Muskingum River adjacent to Gould (copper) and T & N (lead).

- The highest metal concentrations in sediment were measured in the Muskingum River between RM 51.8 and RM 51.58, an area adjacent to and slightly downstream from Gould and T & N.

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

  Arsenic - Muskingum River from RM 51.80 to 51.74.
  Cadmium - Muskingum River from RM 51.80 to 51.74.
  Chromium - Muskingum River from RM 51.80 to 51.58.
  Copper - Muskingum River from RM 51.80 to 51.74.
  Lead - Muskingum River from RM 51.80 to 51.58.
  Zinc - Muskingum River from RM 51.98 to 51.58.

- Fifteen volatile organic compounds were quantified in the sediment of the Muskingum River. Of these, tetrachloroethene, trichloroethene and 1,2-dichloroethene (including cis-1,2-dichloroethene) were documented at significant levels in the sediment adjacent to Gould and T & N. Maximum sediment levels for tetrachloroethene, trichloroethene and 1,2-dichloroethene were 3433 mg/kg, 573 mg/kg and 351 mg/kg, respectively. Extremely elevated concentrations of these parameters (maximum values for tetrachloroethene, trichloroethene and cis-1,2-dichloroethene were 4700 mg/kg, 150 mg/kg and 1800 mg/kg, respectively) in the Muskingum River adjacent to T & N have also been reported in the Remedial Investigation report (1992). These three parameters were all less than lab detection limits upstream (RM 52.6-52.0) from Gould/ T & N and further downstream (RM 51.5 - 48.8). Sediment concentrations for

tetrachloroethene, trichloroethene and 1,2-dichloroethene were at background levels in areas adjacent to the Malta and McConnelsville well fields.

- Elevated concentrations of toluene (1.70 mg/kg maximum), vinyl chloride (0.44 mg/kg maximum) and 1,2,4-trimethylbenzene (0.315 mg/kg) were documented in Muskingum River sediments. The elevated levels of vinyl chloride and 1,2,4-trimethylbenzene were observed adjacent to Gould and T & N.

- Three semivolatile organic compounds were quantified in sediment samples collected from the Muskingum River. The highest semivolatile chemical measured in sediment was 3+4-methylphenol (14.0 ppm).

- 2,3,7,8-Tetrachlorodibenzo-*p*-dioxin (2378-TCDD), 2,3,7,8-tetrachlorodibenzofuran (2378 TCDF) and other dioxin and furan congeners were measured in the sediment of the Muskingum River adjacent to the Malta WTP well field discharge. 2378 - TCDD total toxicity equivalents (TTE) for the two samples collected indicated relatively low levels of dioxin/furan contamination. TTE values (13.2 ppt and 29.0 ppt) were substantially less than mine reclamation criteria (100 ppt 2378 TCDD TTEs) and the CDC action level (1 ppb 2378-TCDD/ or 1 ppb TTE as is commonly used by regulatory programs). Dioxin and dibenzofuran contaminant levels indicate that the sampling site is not significantly contaminated by pentachlorophenol (based upon the relatively low octa and hepta dioxin congeners which are associated with PCP). Measurement of pentachlorophenol within the sediment was less than the laboratory detection limit; however, the detection limit was 1,650 ppb.

- All PCB analyses were less than lab detection limits (80 -160 ppb).

- Pesticide levels were less than the lab detection limit at two of the four sample locations in the Muskingum River. Low levels of b-BHC (1.4 ppb), a-BHC (1.8 ppb) and heptachlor (3.2 ppb) were detected at two locations (upstream Gould and in the T & N mixing zone).

- All parameters measured in the two Slemmons Creek sediment sites were reflective of non-contaminated conditions.

Surface/ Effluent Water Quality (Tables 7 and 8)

Surface water samples were collected from the Muskingum River by the Ohio EPA during 1992 (9 samples analyzed for RCRA metals, semivolatile and volatile organic compounds) and at several locations during 1984 - 1991. The 1992 samples were collected to assess levels of contaminants present in stream surface water in the vicinity of Gould, T & N, Malta WTP, and the McConnelsville well field. Gould and T & N effluent samples presented in this report were collected by Ohio EPA between 1984 and 1992

- Significant levels of copper (4350 ug/l maximum) and lead (3950 ug/l maximum) have been documented in the effluent discharges from Gould and T & N, respectively. The T & N mixing zone samples from the 1992 study had significantly elevated lead levels, with values exceeding the 30-day average water quality criteria. Elevated levels of both copper and lead in the Muskingum River appear to be restricted to within the Gould/ T & N mixing zone area. All other stations sampled (upstream and downstream from Gould/ T & N) reported relatively low copper and lead surface water concentrations.

- Tetrachloroethene, trichloroethene and cis-1,2-dichloroethene have been documented in the effluent from both Gould and T & N. Significant levels of tetrachloroethene are discharged in the T & N effluent (810 ug/l maximum) and have been documented in the mixing zone (780 ug/l maximum) . An evaluation of the outside mixing zone maximum and 30-day average tetrachloroethene water quality criteria indicates that several mixing zone samples have exceeded the tetrachloroethene criteria.

- Outside of the mixing zone area of Gould/ T & N, tetrachloroethene, trichloroethene and cis-1,2-dichloroethene concentrations in the Muskingum River were at or below lab detection limits.

- 1991 sampling of the Muskingum River in the vicinity of the Malta WTP well field wastewater discharge documented elevated levels of 1,1-dichloroethene (90 ug/l), 1,1,1-trichloroethane (266 ug/l) and pentachlorophenol (10.9 ug/l). All three of the parameter concentrations exceeded the 30-day average water quality standard. None of these parameters exceeded the lab detection limit during the 1992 sampling.

- Samples of Muskingum River surface water adjacent to the McConnelsville well field indicated good water quality, with reported organic chemicals all less than 2.5 ug/l.

- Excluding bis(2-ethylhexyl) phthalate, all semi-volatile organic compounds were not detected in Muskingum River surface waters.

1988 Aquatic Life Use Attainment (Table 9)

During 1988, Ohio EPA conducted a biological assessment of the lower Muskingum River. The assessment included evaluating the fish and macroinvertebrate communities in the vicinity of the Gould/ T & N effluent discharges. Results of the evaluation are presented in Table 9. Attainment status was based upon comparisons with other large river results.

- The sampling station immediately upstream (RM 52.5/ 52.3) from Gould/ T & N showed full attainment of the Warmwater Habitat (WWH) aquatic life use designation.

- Fish indices declined significantly downstream from the Gould/ T & N area (RM 51.6). Biological communities were in non-attainment of the WWH use. Index of Biotic Integrity (IBI) values declined from 44 (RM 52.5) to 32 (RM 51.6) and modified Index of Well-Being (MIwb) values dropped from 8.7 to 7.1. The degradation of the fish community at RM 51.6 appears to be caused by chemical impacts associated with Gould and T & N. These two sites, along with sites immediately downstream of the Ohio Power Co. Muskingum River EGS, were the only areas of the Muskingum River not attaining the WWH use.

- Recovery to partial attainment of the WWH use occurred downstream from the McConnelsville dam (RM 48.8/48.9)

Effluent Bioassays

The Ohio EPA has conducted four acute toxicity bioassays of the T & N effluent discharge since 1984, and three acute toxicity tests of the Gould effluent discharge between 1981 and 1987. Both facilities have shown acute toxicity in each effluent test conducted.

- T & N outfall 001 effluents were acutely toxic to only *Ceriodaphnia dubia* and not *Pimephales promelas* during the 1984 and 1988 tests. The 1992 tests resulted in acute toxicity in both test organisms exposed to 001 effluent. The LC50 (lethal concentration where 50 % of the organisms die) and EC50 (effect concentration where 50 % of the organisms show adverse effects) values during the 1992 tests ranged between 20.7 and 100% effluent concentration. Near-field testing (within the mixing zone) during 1988 and 1992 found no toxicity to test organisms. Chemical water quality analyses of effluent used in the 1992 tests revealed elevated levels of lead, cis-1,2-dichloroethene, tetrachloroethene and trichloroethene which could have contributed to the acute toxicity observed.

- All three tests of the Gould 001 effluent were acutely toxic to *C. dubia* (or *Daphnia pulex*). Test results did not show any toxicity to fathead minnows. Chemical analyses of the 001 effluent revealed elevated concentrations of copper and lead.

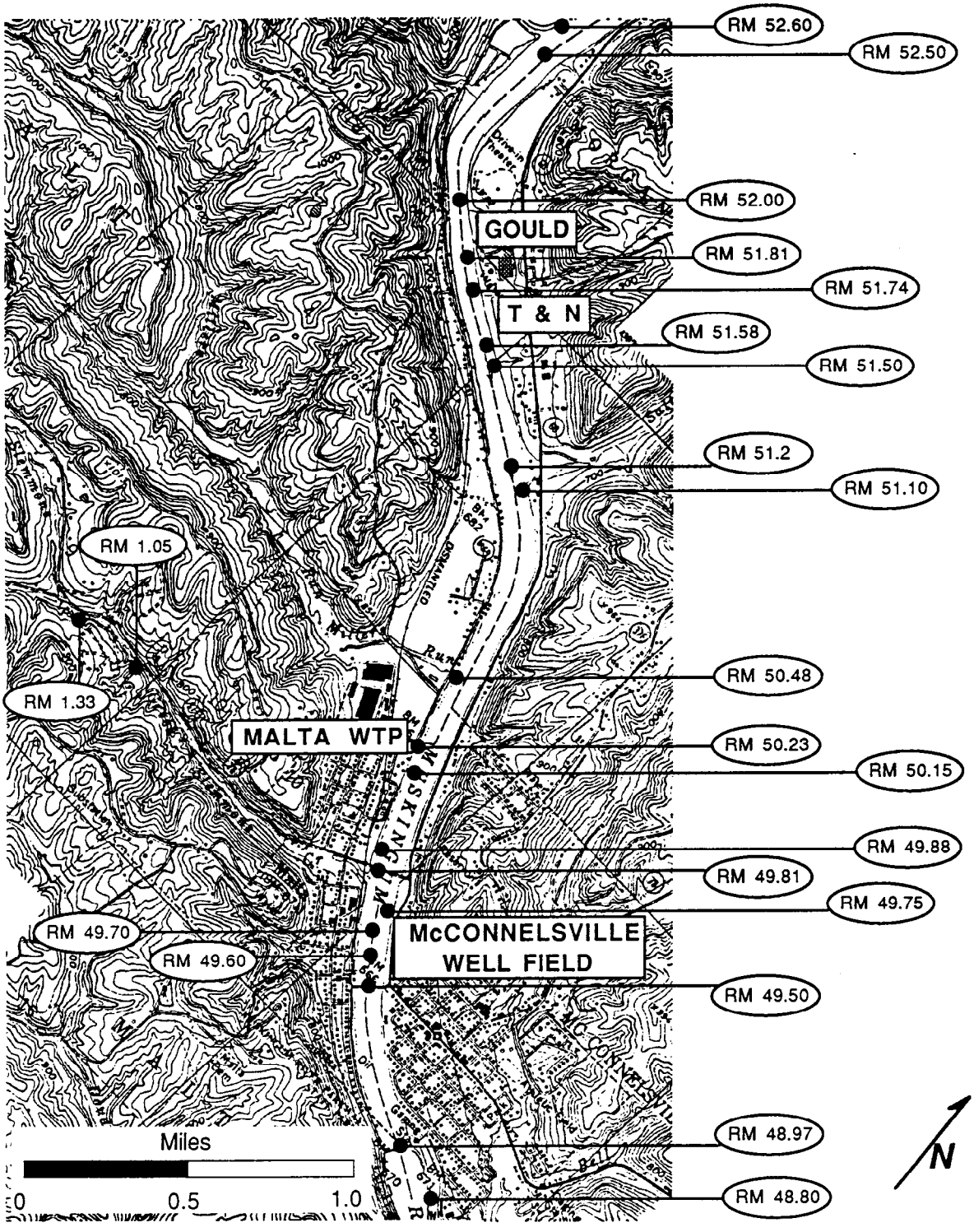

Figure 1. Map of the Muskingum River and Slemmons Creek sediment and water sampling sites indicated by river mile (RM).

Table 1. Muskingum River **sediment** and **water** semivolatile and volatile organic compounds, metals, pesticide and dioxin/furan contamination in the McConnelsville area, 1982 - 1992. Water samples include effluent data from Gould and T & N.

Parameter	Range of Detected Values Sediment (ppm)	Water (ppb)
	VOLATILE COMPOUNDS	
Trichloroethene	0.278 - >573	7 - 17.3
Tetrachloroethene	7.5 - >3433	0.7 - 810
cis-1,2-Dichloroethene	0.593 - >351	1.7 - 48.8
1,2-Dichloroethene (total)	1.1 - 1.7	20
Acetone	0.21	19J - 22J
Carbon Disulfide	0.002J - 0.003J	1.0 - 41
Chloromethane	0.007J	0.9 - 2.7
1,1-Dichloroethane	0.002J -0.12	1.0
1,2-Dichloroethane	ND	1.9
1,1-Dichloroethene	0.010J	90
1,1,1-Trichloroethane	0.035	0.3 - 266
Xylene (total)	0.002J	0.6
Styrene	ND	10.7
Ethylbenzene	ND	0.6
Toluene	0.006 - 1.70	0.1
Benzene	0.002J	ND
2-Butanone	0.042J - 0.056J	ND
Chloroethane	0.003J - 0.19	ND
Vinyl chloride	0.30 - 0.44	ND
	METALS	
Arsenic, Total	2.57-53.3	2-3
Barium, Total	43.9-168	45-385
Cadmium, Total	0.45-5.0	0.4-2.0
Chromium, Total	7-191	24-90
Copper, Total	9- 5,170	10- 4,350
Lead, Total	16-15,300	2- 3,950
Mercury, Total	ND	0.38
Nickel, Total	16-15,600	40-900
Silver, Total	17.3	ND
Zinc, Total	50-521	10-269
	SEMIVOLATILE COMPOUNDS	
Di-n-butyl phthalate	0.409-0.777	NA
3+4-Methylphenol	14.0	NA
Bis(2-ethylhexyl) phthalate	0.248J-1.40	3J
Diethyl phthalate	ND	4.5
Pentachlorophenol	ND	10.9
	PESTICIDES	
a-BHC	0.0018J	NA
b-BHC	0.0014J	NA
Heptachlor	0.0032J	NA

Table 1. Continued.

Parameter	Range of Detected Values Sediment (ppt)	Water (ppb)
	DIOXINS / FURANS	
2378- TCDD	0.97 - 1.0	NA
12378- PeCDD	0.97 - 2.5	NA
123478 - HxCDD	2.7 - 6.8	NA
123678 - HxCDD	6.5 - 18.9	NA
123789 - HxCDD	7.3 - 18.4	NA
1234678 - HpCDD	205 - 720	NA
OCDD	3640 - 7310	NA
2378 - TCDF	5.8 - 6.6	NA
12378 - PeCDF	1.9 - 2.8	NA
23478 - PeCDF	2.2 - 3.3	NA
123478 - HxCDF	9.2 - 15.9	NA
123678 - HxCDF	3.8 - 8.9	NA
234678 - HxCDF	4.5 - 7.5	NA
1234678 - HpCDF	62.0 - 163	NA
1234789 - HpCDF	5.7 - 13.9	NA
OCDF	158 - 402	NA
Total TCDD	6.6 - 9.1	NA
Total PeCDD	4.5 - 11.9	NA
Total HxCDD	71.1 - 167	NA
Total HpCDD	398 - 1250	NA
Total TCDF	57.7 - 69.6	NA
Total PeCDF	33.0 - 59.6	NA
Total HxCDF	80.4 - 225	NA
Total HpCDF	140 - 463	NA

J = less than limit of practical quantitation but greater than zero.
NA - not analyzed.
ND - not detected.

Table 2. Summary of specific chemical parameters measured in sediment, surface water and effluent within the Muskingum River study area, 1982 - 1992.

River Mile (Location)	Lead	Copper	Tetrachloro-ethene	Trichloro-ethene	1,2-Dichloro-ethene[1]
			SEDIMENT mg/kg (ppm)		
Muskingum River					
52.6-52.0 (Upst. Gould/ T & N)	16-36.9	9-24.6	<0.050	<0.050	<0.050
51.8 (Gould Effluent Area)	17-**7700**	21.6-**5170**	<0.005-**4.227**	<0.005-0.278	<0.005-0.593
51.7 (T & N Effluent Area)	**251-15,300**	53.1-**3210**	<0.005->**3,433**	<0.005->**573**	**1.10->351**
51.6-51.5 (Dst. T & N)	57.8-**170**	31.9-90.5	<0.050	<0.050	<0.050
51.1-48.8 (McConnelsville)	16.1-50.7	14.7-29.2	<0.050	<0.050	<0.050
			WATER ug/l (ppb)		
Muskingum River					
52.6-52.0 (Upst. Gould/ T & N)	<3	<10-12	<5	<5	<5
51.8 (Gould Effluent)	<2-38	**145-4350**	**750**	7.5	10.1
51.8 (Gould Mixing Zone)	<3	11	<5-**597**	<2.5-15.9	<2.5-8.5
51.7 (T & N Effluent)	**71-3950**	<10-**410**	63.2-**810**	8.1-17.3	13.9-39.0
51.7 (T & N Mixing Zone)	**431-692**	28-30	**170-780**	7-10.9	<5-48.8
51.5-51.2 (Dst. T & N)	7	16	0.7-6	<5	<5
51.1-48.8 (McConnelsville)	<3-12	10-20	<5	<5	<5

1 - Includes cis and trans 1,2-dichloroethene.

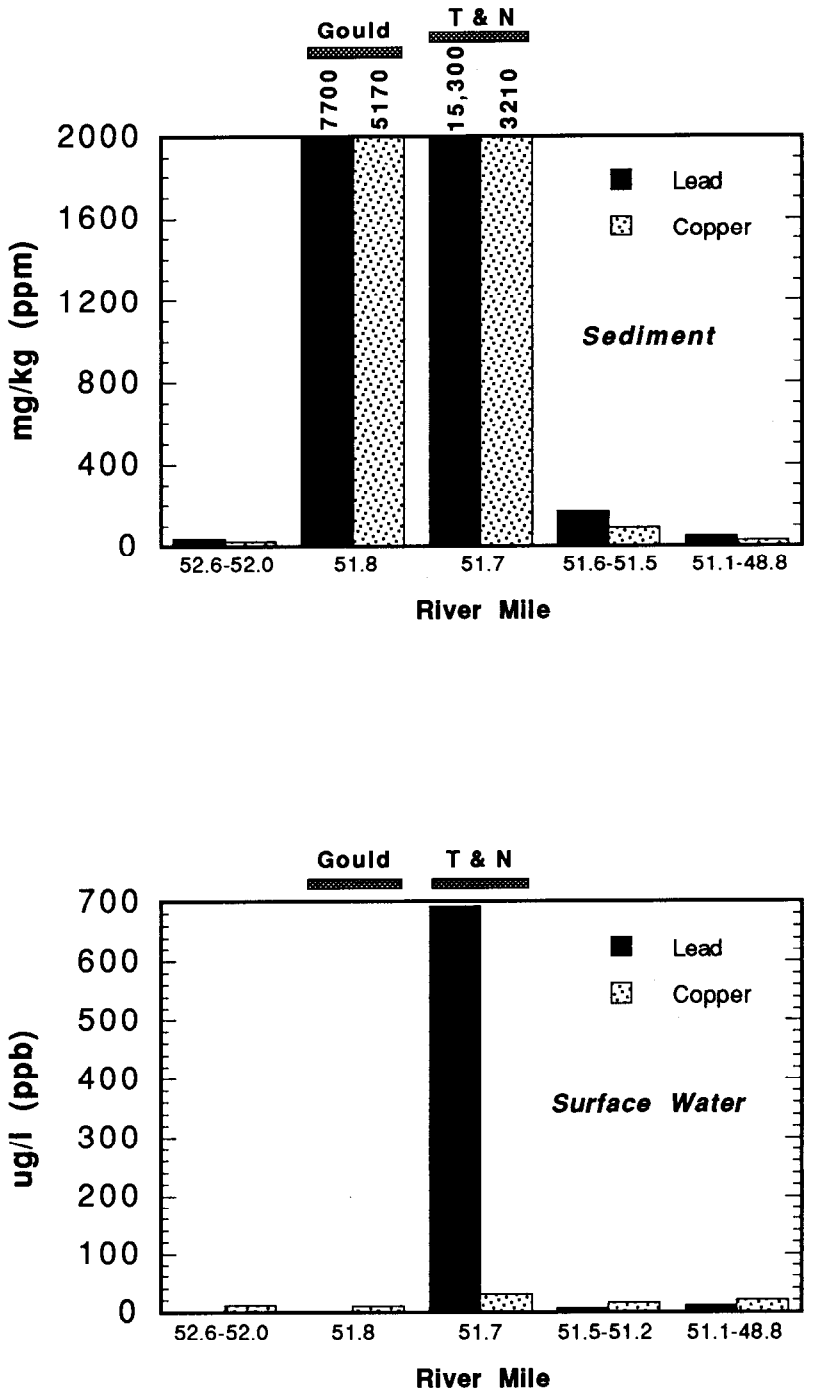

Figure 2. Summary of lead and copper levels in sediment and surface water from the Muskingum River, McConnelsville, Ohio. Plotted values represent maximum concentrations within respective river mile locations.

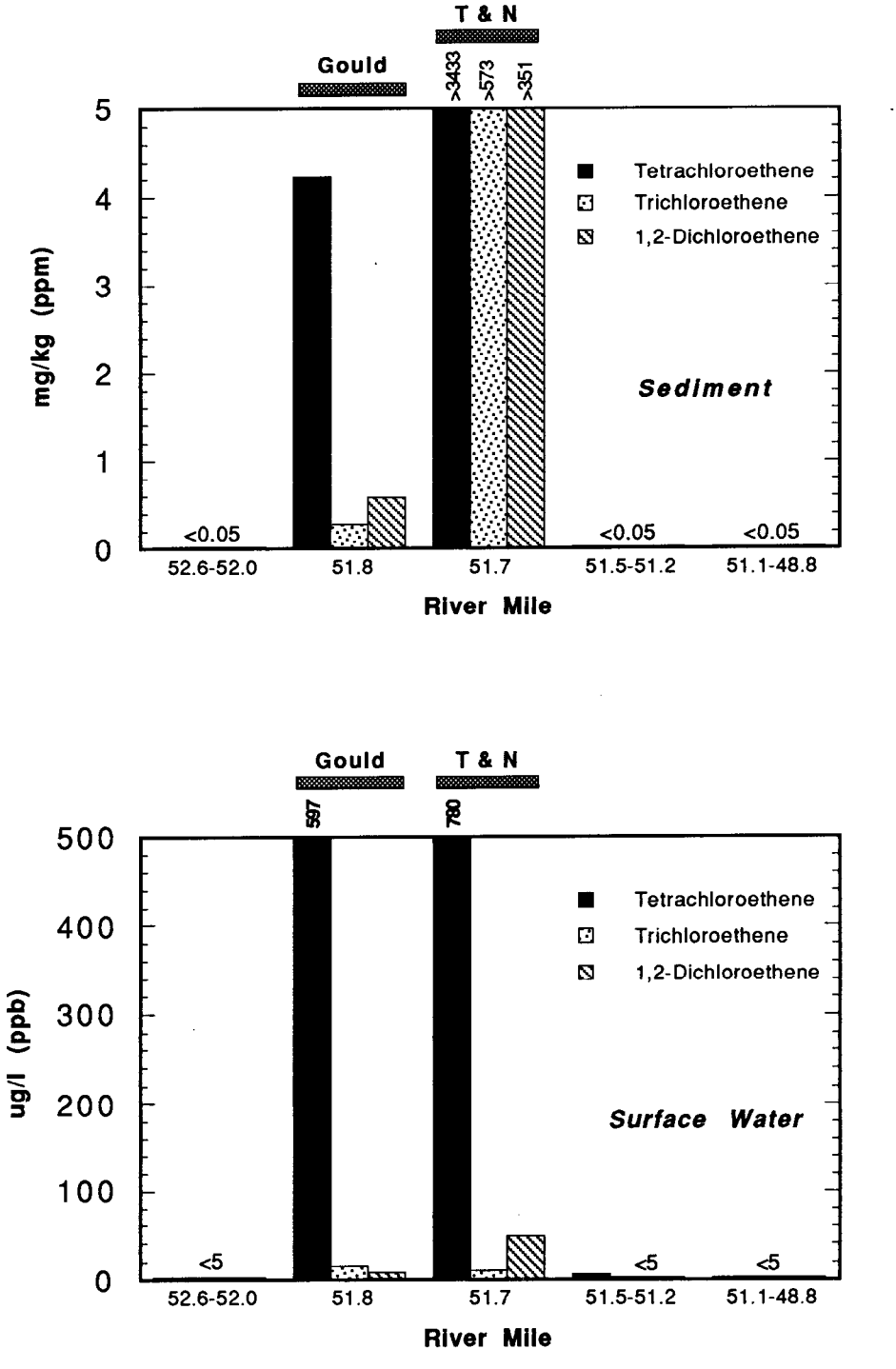

Figure 3. Summary of tetrachloroethene, trichloroethene and 1,2-dichloroethene levels in sediment and surface water from the Muskingum River, McConnelsville, Ohio. Plotted values represent maximum concentrations within respective river mile locations.

Table 3. Metal contaminant levels in sediment collected from the Muskingum River and Slemmons Creek, McConnelsville, Ohio between 1982 and 1992. NA = not analyzed. Sediment evaluations were based upon criteria in Kelly and Hite (1984). Evaluations with two letters (e.g. a and b) indicates that the reported less than value could be either non-elevated or slightly elevated.

	METALS - mg/kg (ppm) dry weight										
Stream River Mile (Location) Lab/Lab Number/Year	Arsenic	Barium	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Selenium	Silver	Zinc
Muskingum River											
52.60 (Oilspring Run) Betz/C0612618/ 1992	<10a,b	68.4	<1.0a,b	12.8a	23.8a	18.4a	<0.1a,b	NA	<10	<2.0	NA
52.50 (Upst. Gould) OEPA/ C5534/ 1986	2.57a	NA	0.45a	17.2b	16.6a	30.4b	NA	43.7	NA	NA	127c
52.00 (Upst. Gould) Betz/ C0612620/ 1992	<10a,b	75.8	<1.0a,b	14.1a	16.2a	18.3a	<0.1a,b	NA	<10	<2.0	NA
52.00 (Upst. Gould) OEPA/ C8212/ 1988	3a	NA	NA	7a	9a	16a	NA	16	NA	NA	50a
51.98 (Upst. Gould) ODH/ - /1982	NA	NA	NA	36.9c	24.6a	36.9b	NA	59.8	NA	NA	**179**d
51.80 (Gould Effluent) Betz/ C0612627/ 1992	<10a,b	71.3	<1.0a,b	14.0a	21.6a	17.0a	<0.1a,b	NA	<10	<2.0	NA
51.80 (Gould Effluent) OEPA/ C8230/ 1988	**17**d	116	**2**d	29c	**1200**e	**1120**e	NA	36	NA	NA	**181**d
51.80 (Gould Effluent) OEPA/ C5535/ 1986	**53.3**e	NA	1.50c	**58.4**d	**5170**e	**7700**e	NA	41.4	NA	NA	**200**d
51.80 (Gould Effluent) ODH/ - /1982	NA	NA	NA	**90.1**e	**1250**e	**386**e	NA	66.2	NA	NA	**232**d
51.74 (T & N Effluent) Betz/ C0612622/ 1992	<10a,b	43.9	1.90c	21.9b	**296**c	**15,300**e	<0.1a,b	NA	<10	17.3	NA
51.74 (T & N Effluent) Betz/ C0612623/ 1992 *(Duplicate of lab number C0612622)*	<10a,b	72.2	<1.0a,b	16.3b	77.8c	**787**e	<0.1a,b	NA	<10	<2.0	NA
51.74 (T & N Effluent) OEPA/ C8213/ 1988	**24**d	168	**5**d	**191**e	**3210**e	**4320**e	NA	15,600	NA	NA	**521**e
51.74 (T & N Effluent) OEPA/ C5536/ 1986	11.4c	NA	1.07c	**40.6**d	53.1b	**251**e	NA	89.6	NA	NA	**254**d
51.74 (T & N Effluent) ODH/ - /1982	NA	NA	NA	**140**e	**2000**e	**12,600**e	NA	817	NA	NA	138c

Table 3. Continued.

Stream River Mile (Location) Lab/Lab Number/Year	METALS - mg/kg (ppm) dry weight										
	Arsenic	Barium	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Selenium	Silver	Zinc
Muskingum River											
51.58 (Dst. T & N Effluent) ODH/ - /1982	NA	NA	NA	**50.9**d	90.5c	**170**e	NA	54.1	NA	NA	**181**d
51.50 (Dst. T & N) Betz/ C0612628/ 1992	<10a,b	65.5	<1.0a,b	15.9a	31.9a	57.8c	<0.1a,b	NA	<10	<2.0	NA
51.10 (Dst. Salt Run) Betz/ C0612631/ 1992	<10a,b	67.3	<1.0a,b	16.6b	19.3a	26.3a	<0.1a,b	NA	<10	<2.0	NA
51.06 (Dst.Salt Run) ODH/ - /1982	NA	NA	NA	23.6c	19.6a	27.5a	NA	49.1	NA	NA	106c
50.23 (Malta WTP) Betz/ C0612637/ 1992	<10a,b	74.5	<1.0a,b	12.0a	14.7a	16.1a	<0.1a,b	NA	<10	<2.0	NA
49.88 (State Route 37) ODH/ - /1982	NA	NA	NA	33.7c	26.2a	50.7c	NA	63.8	NA	NA	158c
49.75 (McConnelsville WTP) Betz/ C0612633/ 1992	<10a,b	74.0	<1.0a,b	13.3a	15.3a	34.9b	<0.1a,b	NA	<10	<2.0	NA
48.98 (McConnelsville dam) OEPA/ C5540/ 1986	3.74a	NA	0.64b	23.7c	29.2a	41.5c	NA	43.2	NA	NA	150c
48.97 (McConnelsville dam) OEPA/ C5541/ 1986	4.97a	NA	0.58b	23.3c	24.0a	32.8b	NA	48.7	NA	NA	145c
48.80 (McConnelsville Lock Channel) Betz/ C0612634/ 1992	<10a,b	55.5	<1.0a,b	17.8b	18.3a	23.6a	<0.1a,b	NA	<10	<2.0	NA
48.78 (McConnelsville Lock Channel) OEPA/ S-147/ 1990	10.1b	NA	0.52b	22.4b	18.9a	32.6b	NA	33.0	<0.71	NA	114c
Slemmons Creek											
1.33 (Upst. Brocks Junkyard) Betz/ C0612609/ 1992	<10a,b	217	<1.0a,b	19.4b	27.7a	50.0c	<0.1a,b	NA	<10	<2.0	NA
1.05 (Dst. Brocks Junkyard) Betz/ C0612607/ 1992	<10a,b	106	<1.0a,b	17.4b	25.6a	20.4a	<0.1a,b	NA	<10	<2.0	NA

a - non elevated; b - slightly elevated; c - elevated; d - highly elevated; e - extreme.
Arsenic: a <8.0, b ≥8.0, c ≥ 11; Cadmium: a <0.5, b ≥0.5, c ≥1.0; Mercury: a <0.07, b ≥0.07, c ≥0.10.

Table 4. Semivolatile organic compound contaminant levels in sediment collected from the Muskingum River and Slemmons Creek, McConnelsville, Ohio, 1992.

SEMIVOLATILE ORGANIC COMPOUNDS

Stream River Mile (Location)	Year	Lab Number (Laboratory)	Sample Type	Parameter	Concentration (ppm)
Muskingum River					
52.60 (Oilspring Run)	1992	C0612618 (Betz)	Grab	All compounds	None detected
52.00 (Upst. Gould)	1992	C0612620 (Betz)	Grab	All compounds	None detected
51.80 (Gould Effluent)	1992	C0612627 (Betz)	Grab	All compounds	None detected
51.74 (T & N Effluent)	1992	C0612622 (Betz)	Grab	All compounds	None detected
51.74 (T & N Effluent) *Duplicate of Lab Number C0612622*	1992	C0612623 (Betz)	Grab	3+4-Methylphenol	14.0
51.50 (Dst. T & N)	1992	C0612628 (Betz)	Grab	All compounds	None detected
51.10 (Dst. Salt Run)	1992	C0612631 (Betz)	Grab	All compounds	None detected
50.23 (Malta WTP)	1992	C0612637 (Betz)	Grab	Di-n-butyl phthalate Bis(2-ethylhexyl) phthalate	0.409 0.503
49.75 (McConnelsville WTP)	1992	C0612633 (Betz)	Grab	Di-n-butyl phthalate Bis(2-ethylhexyl) phthalate	0.639 0.248J
48.80 (McConnelsville Lock Channel)	1992	C0612634 (Betz)	Grab	Di-n-butyl phthalate Bis(2-ethylhexyl) phthalate	0.777 1.40
Slemmons Creek					
1.33 (Upst. Brocks Junkyard)	1992	C0612609 (Betz)	Grab	All compounds	None detected
1.05 (Dst. Brocks Junkyard)	1992	C0612607 (Betz)	Grab	All compounds	None detected

J = less than limit of practical quantitation but greater than zero.

Table 5. Volatile organic compound contaminant levels in sediment collected from the Muskingum River and Slemmons Creek, McConnelsville, Ohio, 1988 - 1992.

VOLATILE ORGANIC COMPOUNDS (sediment)

Stream River Mile (Location)	Year	Lab Number (Laboratory)	Sample Type	Parameter	Concentration (ppm)
Muskingum River					
52.60 (Oilspring Run)	1992	C0612626 (Betz)	Grab	Toluene	0.006
52.00 (Upst. Gould)	1992	C0612625 (Betz)	Grab	Toluene	1.700
51.80 (Gould Effluent)	1992	C0612621 (Betz)	Grab	Toluene	0.86
				Benzene	0.002J
				Chloromethane	0.007J
51.80 (Gould Effluent)	1988	01989* (OEPA)	Grab	cis-1,2-Dichloroethene	0.593
				Tetrachloroethene	4.227
				Trichloroethene	0.278
				1,2,4-Trimethylbenzene	0.315
51.74 (T & N Effluent)	1992	C0612624 (Betz)	Grab	2-Butanone	0.056J
				Carbon disulfide	0.003J
				Toluene	0.005
				Xylenes (total)	0.002J
				1,2-Dichloroethene (total)	1.100
				Vinyl chloride	0.440
51.74 (T & N Effluent) *Duplicate of Lab Number C0612624*	1992	C0612619 (Betz)	Grab	Acetone	0.210
				2-Butanone	0.042J
				Carbon disulfide	0.002J
				Chloroethane	0.003J
				1,1-Dichloroethane	0.002J
				Toluene	0.004J
				1,2-Dichloroethene (total)	1.700
				Vinyl chloride	0.300
51.74 (T & N Effluent)	1988	01867** (OEPA)	Grab	cis-1,2-Dichloroethene	>351
				Tetrachloroethene	>3433
				Trichloroethene	>573
51.74 (T & N Effluent)	1988	01988***(OEPA)	Grab	cis-1,2-Dichloroethene	320
				Tetrachloroethene	7.5
51.50 (Dst. T & N)	1992	C0612630 (Betz)	Grab	Toluene	1.200
51.10 (Dst. Salt Run)	1992	C0612629 (Betz)	Grab	All compounds	None detected

Table 5. Continued.

VOLATILE ORGANIC COMPOUNDS (sediment)

Stream River Mile (Location)	Year	Lab Number (Laboratory)	Sample Type	Parameter	Concentration (ppm)
Muskingum River					
50.23 (Malta WTP)	1992	C0612639 (Betz)	Grab	Chloroethane	0.190
				1,1-Dichloroethane	0.120
				1,1-Dichloroethene	0.010J
				Toluene	0.180
				1,1,1-Trichloroethane	0.035
49.75 (McConnelsville WTP)	1992	C0612632 (Betz)	Grab	All compounds	None detected
48.80 (McConnelsville Lock Channel)	1992	C0612635 (Betz)	Grab	All compounds	None detected
Slemmons Creek					
1.33 (Upst. Brocks Junkyard)	1992	C0612610 (Betz)	Grab	Acetone	0.090J
1.05 (Dst. Brocks Junkyard)	1992	C0612608 (Betz)	Grab	Acetone	0.095J

J = less than limit of practical quantitation but greater than zero.
* - sample analyzed past holding time.
** - method development was not complete when sample was analyzed.
*** - data validation study not complete.

Table 6. Dioxin and furan contaminant levels in sediment collected from the Muskingum River, McConnelsville, Ohio, 1992.

DIOXINS AND FURANS

Parameter	**RM 50.23** (Betz Number C0612636) Concentration (ppt)	Toxicity Equivalent (ppt) [1]	**RM 50.23** (Betz Number C0612638) Concentration (ppt)	Toxicity Equivalent (ppt) [1]
2378- TCDD	1.0	1.0	0.97	0.97
12378- PeCDD	0.97	0.49	2.5	1.25
123478 - HxCDD	2.7	0.27	6.8	0.68
123678 - HxCDD	6.5	0.65	18.9	1.89
123789 - HxCDD	7.3	0.73	18.4	1.84
1234678 - HpCDD	205	2.05	720	7.20
OCDD	3640	3.64	7310	7.31
2378 - TCDF	5.8	0.58	6.6	0.66
12378 - PeCDF	1.9	0.10	2.8	.014
23478 - PeCDF	2.2	1.10	3.3	1.65
123478 - HxCDF	9.2	0.92	15.9	1.59
123678 - HxCDF	3.8	0.38	8.9	0.89
234678 - HxCDF	4.5	0.45	7.5	0.75
123789 - HxCDF	ND	0.01	ND	0.01
1234678 - HpCDF	62.0	0.62	163	1.63
1234789 - HpCDF	5.7	0.05	13.9	0.14
OCDF	158	0.16	402	0.40
Total TCDD	6.6	-	9.1	-
Total PeCDD	4.5	-	11.9	-
Total HxCDD	71.1	-	167	-
Total HpCDD	398	-	1250	-
Total TCDF	57.7	-	69.6	-
Total PeCDF	33.0	-	59.6	-
Total HxCDF	80.4	-	225	-
Total HpCDF	140	-	463	-
2378 TCDD Total Toxicity Equivalent (TTE)		**13.2**		**29.0**

[1] - 2378 TCDD toxicity equivalents.

Table 7. Volatile organic compound contaminant levels in surface water collected from the Muskingum River and effluent from Gould and T & N, McConnelsville, Ohio, 1984 - 1992.

VOLATILE ORGANIC COMPOUNDS (water)

Stream River Mile (Location)	Year	Lab Number (Laboratory)	Sample Type	Parameter	Concentration (ppb)
Muskingum River					
52.60 (Oilspring Run)	1992	C0612600 (Betz)	Grab	All compounds	None detected
52.00 (Upst. Gould)	1992	C0612601 (Betz)	Grab	All compounds	None detected
51.81 (Gould Effluent)	1989	02508 (OEPA)	Grab	Carbon Tetrachloride	11.8
				cis-1,2-Dichloroethene	10.1
				Tetrachloroethene	750
				Trichloroethene	7.5
51.81 (Gould Mixing Zone)	1992	C0612603 (Betz)	Grab	All compounds	None detected
51.81 (Gould Mixing Zone)	1989	03066 (OEPA)	Grab	Tetrachloroethene	597*
				cis-1,2-Dichloroethene	8.5
				Trichloroethene	15.9
51.81 (Gould Mixing Zone)	1988	01993 (OEPA)	Grab	Tetrachloroethene	9.4
51.74 (T & N Effluent)	1992	05546 (OEPA)	Composite	Trichloroethene	17.3
				Tetrachloroethene	276
				cis-1,2-Dichloroethene	37.0
				1,1,1-Trichloroethane	1.8
51.74 (T & N Effluent)	1992	05502 (OEPA)	Composite	Trichloroethene	10.3
				Tetrachloroethene	280
				cis-1,2-Dichloroethene	39.0
				1,1,1-Trichloroethane	1.6
51.74 (T & N Effluent)	1989	02509 (OEPA)	Grab	Trichloroethene	8.2
				Tetrachloroethene	810
				Ethylbenzene	0.6
				Xylene (total)	0.6
				Styrene	10.7
				cis-1,2-Dichloroethene	14.8
51.74 (T & N Effluent)	1989	03065 (OEPA)	Grab	Trichloroethene	14.8
				Tetrachloroethene	578
				cis-1,2-Dichloroethene	20.6
51.74 (T & N Effluent)	1987	0625 (OEPA)	Composite	Trichloroethene	8.1
				Tetrachloroethene	63.2
				Toluene	0.1
				1,1,1-Trichloroethane	0.3
				Carbon Tetrachloride	0.2

Table 7.Continued.

VOLATILE ORGANIC COMPOUNDS (water)

Stream River Mile (Location)	Year	Lab Number (Laboratory)	Sample Type	Parameter	Concentration (ppb)
Muskingum River					
51.74 (T & N Effluent)	1984	HM-1596 (ODH)	Grab	Trichloroethene	15.5
				Tetrachloroethene	500
				cis-1,2-Dichloroethene	13.9
51.74 (T & N Mixing Zone)	1992	C0612604 (Betz)	Grab	Acetone	19J
				Carbon disulfide	41
				Tetrachloroethene	150**
				1,2-Dichloroethene (total)	20
				Trichloroethene	7
51.74 (T & N Mixing Zone) *Duplicate of Lab Number C0612604*	1992	C0612602 (Betz)	Grab	Acetone	22J
				Carbon disulfide	39
				Tetrachloroethene	170**
				Trichloroethene	8
				cis-1,2-Dichloroethene	18
51.74 (T & N Mixing Zone)	1988	01992 (OEPA)	Grab	Trichloroethene	10.9
				Tetrachloroethene	780*
				cis-1,2-Dichloroethene	48.8
51.50 (Dst. T & N)	1992	C0612606 (Betz)	Grab	Tetrachloroethene	6
51.2 (Upst. Harlos Trailer)	1988	01991 (OEPA)	Grab	Tetrachloroethene	0.7
51.10 (Dst. Salt Run)	1992	C0612605 (Betz)	Grab	All compounds	None detected
51.10 (Dst. Salt Run)	1991	04962 (OEPA)	Grab	Chloromethane	1.2
50.48 (Upst. Malta WTP)	1991	04961 (OEPA)	Grab	Chloromethane	0.9
50.28 (Upst. Malta WTP)	1991	04975 (OEPA)	Grab	All compounds	None detected
50.23 (Malta WTP)	1992	C0612643 (Betz)	Grab	All compounds	None detected
50.23 (Malta WTP well wastewater)	1991	04950 (OEPA)	Grab	Chloromethane	1.6
				1,1-Dichloroethane	1.0
				1,2-Dichloroethane	1.9
				1,1-Dichloroethene	90**
				1,1,1-Trichloroethane	266**
				Pentachlorophenol	10.9**
50.15 (Upst. S.R. 37)	1991	04960 (OEPA)	Grab	Chloromethane	1.9
				1,1,1-Trichloroethane	0.8
				Carbon Disulfide	1.0

Table 7.Continued.

VOLATILE ORGANIC COMPOUNDS (water)

Stream River Mile (Location)	Year	Lab Number (Laboratory)	Sample Type	Parameter	Concentration (ppb)
Muskingum River					
50.15 (Upst. S.R. 37)	1991	04958 (OEPA)	Grab	Chloromethane Carbon Disulfide	2.4 1.0
50.15 (Upst. S.R. 37)	1991	04959 (OEPA)	Grab	Chloromethane Carbon Disulfide	1.5 3.0
49.81 (S.R.37)	1991	04956 (OEPA)	Grab	Chloromethane Carbon Disulfide	2.3 1.0
49.81 (S.R.37)	1991	04957 (OEPA)	Grab	Chloromethane Carbon Disulfide	2.5 2.0
49.75 (McConnelsville WTP)	1992	C0612644 (Betz)	Grab	All compounds	None detected
49.70 (McConnelsville WTP)	1991	04953 (OEPA)	Grab	Chloromethane	2.3
49.70 (McConnelsville WTP)	1991	04954 (OEPA)	Grab	Chloromethane	2.2
49.70 (McConnelsville WTP)	1991	04955 (OEPA)	Grab	Chloromethane	2.3
49.70 (McConnelsville WTP)	1988	02004 (OEPA)	Grab	Tetrachloroethene	0.9
49.68 (McConnelsville WTP)	1991	04949 (OEPA)	Grab	cis-1,2-Dichloroethene	1.7
49.60 (Malta Boat Launch)	1991	04952	Grab	Chloromethane	2.7
49.50 (Dst. McConnelsville well field)	1991	04951 (OEPA)	Grab	Chloromethane	1.5
49.47 (Main St., McConnes.)	1988	01866 (OEPA)	Grab	Tetrachloroethene	1.5
48.97 (USGS gage)	1988	01756 (OEPA)	Grab	Tetrachloroethene	1.5
48.80 (McConnelsville Lock Channel)	1992	C0612645 (Betz)	Grab	All compounds	None detected

* - Exceedance of the outside mixing zone maximum water quality criteria.
**- Exceedance of the outside mixing zone 30-day average water quality criteria.
J = less than limit of practical quantitation but greater than zero.

Table 8. Mean values (minimum and maximum values in parentheses) of selected metal parameters measured in the Muskingum River, Gould effluent and T & N effluent, 1986 - 1992. Values are reported in ug/l. Less than detection limit values were set at the detection limit for calculating means.

Stream River Mile	METALS (water) Cadmium-T	Chromium-T	Copper-T	Lead-T	Mercury-T	Nickel-T	Zinc-T
Muskingum River							
52.65	- (<0.2)	- (<30)	- (<10)	- (2)	- NA	- (<40)	- (15)
52.60	- (<5)	- (<10)	- (12)	- (<3)	- (<0.2)	- NA	- NA
52.50	0.2 (<0.2)	30 (<30)	10 (<10)	2 (<2-2)	- NA	40 (<40)	10 (<10)
52.00	- (<5)	- (<10)	- (11)	- (<3)	- (<0.2)	- NA	- NA
51.81 (Gould Effluent)	1.1 (0.4-2)	30 (<30)	**800.6 (145-4350)**	11.2 (<2-38)	- NA	40 (<40)	27.5 (<10-50)
51.81 (Gould Mixing Zone)	- (<5)	- (<10)	- (11)	- (<3)	- (0.38)	- NA	- NA
51.74 (T & N Effluent)	0.2 (<0.2-0.6)	35 (<30-90)	**74** (<10-**410**)	**729 (71-3950)**	- NA	180 (<40-900)	36.6 (<10-180)
51.74 (T & N Mixing Zone)	5 (<5)	10 (<10)	29 (28-30)	561.5 **(431*-692*)**	0.2 (<0.2)	- NA	- NA
51.50	- (<5)	- (<10)	- (16)	- (7)	- (<0.2)	- NA	- NA
51.10	- (<5)	- (<10)	- (12)	- (<3)	- (<0.2)	- NA	- NA
50.23	- (<5)	- (<10)	- (13)	- (<3)	- (<0.2)	- NA	- NA
49.83	0.2 (<0.2-0.4)	30 (<30-30)	10.2 (<10-15)	3.4 (<3-12)	- NA	53.9 (<40-430)	25.3 (<10-269)
49.75	- (<5)	- (<10)	- (13)	- (<3)	- (<0.2)	- NA	- NA
48.98	- (<0.2)	26.8 (24-<30)	- (<10)	- (3)	- NA	- (<40)	87.5 (25-150)
48.97	- (<0.2)	- (<30)	- (20)	- (3)	- NA	- (<40)	- (145)
48.80	- (<5)	- (<10)	- (11)	- (<3)	- (<0.2)	- NA	- NA

* - Exceedance of outside mixing zone 30-day average water quality criteria.

Table 9. Aquatic life use attainment status for the Warmwater Habitat (WWH) use designation in the impounded segment of the Muskingum River mainstem based on data collected during September & October 1988. Underlined river miles are *tailwaters sites* and all other sites are impoundment habitat. **Night electrofishing samples** are in boldface type.

RIVER MILE Fish/Invert.	IBI	MIwb	ICI	QHEI[a]	Attainment Status (WWH)[b]	Comments
86.0/85.2	30*	8.4ns	(38)	48	PARTIAL	Ellis Dam pool site
84.7/84.8	50	10.1	48	74	FULL	*Ellis Dam tailwaters*
78.5/78.4	42	9.8	(10)	57	FULL	Ust. point sources
77.8/78.0	44	8.5ns	(12)	51	FULL	Dst. ARMCO
77.0/ -	44	8.5ns	--	50	FULL	Zanesville dam pool
75.7/76.0	46	9.8	46	72	FULL	*Zanesville dam tailwaters*
73.8/74.0	40	9.5	(16)	52	FULL	Dst. Zanesville WWTP
73.0/ -	38ns	8.2ns	--	57	FULL	Dst. Moxahala Creek
69.0/70.3	38ns	8.8	(16)	54	FULL	Philo dam pool
69.0/ -	36ns	9.4	--	54	FULL	**Night sample**
67.4/67.4	52	11.1	38	83	FULL	*Philo dam tailwaters*
63.0/62.8	44	8.6	(26)	60	FULL	Rokeby pool (upper)
63.0/ -	40	9.6	--	60	FULL	**Night sample**
56.4/56.4	42	10.0	20*	77	PARTIAL	*Rokeby dam tailwaters*
52.5/52.3	44	8.7	(6)	54	FULL	Ust. Gould/ T & N
51.6/51.6	32*	7.1*	(10)	48	NON	Dst. T & N/Gould
49.4/49.1	32*	7.9*	(10)	65	NON	Dst. Malta/ McConnelsville
48.8/48.9	48	10.2	30*	82	PARTIAL	*McConnelsville tailwaters*
43.7/43.5	42	7.9*	(22)	54	PARTIAL	Stockport pool
39.5/39.3	38ns	9.2	28*	72	PARTIAL	*Stockport tailwaters*
36.8/34.3	40	8.3ns	(12)	61	FULL	Luke Chute pool
33.6/33.5	42	9.2	32ns	80	FULL	*Luke Chute tailwaters*
30.3/31.5	46	9.2	(22)	54	FULL	Ust. Muskingum R. EGS
30.3/ -	42	9.6	--	54	FULL	**Night sample**
28.1/28.3	34*	6.9*	(22)	49	NON	Muskingum R. EGS disch.
28.1/ -	34*	7.9*	--	49	NON	**Night sample**
26.1/25.6	30*	8.5ns	(16)	64	PARTIAL	Beverly pool (lower)
24.8/24.8	38ns	9.9	28*	74	PARTIAL	*Beverly tailwaters*
18.5/18.2	32*	9.0	(14)	58	PARTIAL	Lowell dam pool
14.0/ -	44	10.4	--	83	(FULL)	*Lowell dam tailwaters*
9.4/ -	38ns	8.9	--	69	FULL	Devola dam pool
9.4/ -	42	9.7	--	69	FULL	**Night sample**
5.7/ -	42	9.6	--	63	(FULL)	*Devola tailwaters*
2.7/ -	30*	8.8	--	64	PARTIAL	Ohio R. influence
2.7/ -	40	9.5	--		FULL	**Night sample**

Ecoregion Biocriteria: Western Allegheny Plateau (WAP)

INDEX - Site Type	WWH[c]	EWH	MWH
IBI - Boat	40	48	30
Mod. Iwb - Boat	8.6	9.6	6.6
ICI	36	46	N/A

* significant departure from ecoregion biocriteria (> 4 IBI or ICI units; 0.5 Iwb units).

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

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

b ICI values in parentheses are impoundment habitats; use attainment based on one organism group is parenthetically expressed; WAP ecoregion biocriteria apply to boat sites.

c Warmwater Habitat (WWH), Exceptional Warmwater Habitat (EWH), and Modified Warmwater Habitat (MWH) for impoundments.

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Appendix 1

Semivolatile, Volatile, Pesticides/PCB's and Heavy Metal Compounds Analyzed for Ohio EPA 1982 -1992 Muskingum River Sediment and Surface Water Samples. Chemical parameters varied between different sampling years and stations.

METALS

Aluminum
Arsenic
Barium
Cadmium
Calcium
Chromium
Copper
Iron
Lead
Magnesium
Manganese
Mercury
Nickel
Potassium
Selenium
Silver
Sodium
Zinc

SEMIVOLATILE COMPOUNDS

Acenaphthene
Acenaphthylene
Anthracene
Benzo (A) anthracene
Benzo(A) pyrene
Benzo(B) fluoranthene
Benzo(G,H,I) perylene
Benzo(K) fluoranthene
Benzoic acid
Benzyl alcohol
Benzylbutyl phthalate
Bis(2-chloroethoxy) methane
Bis(2-chloroethyl) ether
Bis(2-chloroisopropyl)ether
Bis(2-ethylhexyl) phthalate
4-Bromophenyl phenyl ether
4-Chloroaniline
4-Chloro-3-methyl phenol
2-Chloronaphthalene
2-Chlorophenol
4-Chlorophenyl phenyl ether
Chrysene
Benzidine
N-nitrosodimethylamine
Dibenzo(A,H) anthracene
Dibenzofuran
1,2-Dichlorobenzene
1,3-Dichlorobenzene
1,4-Dichlorobenzene
3,3'-Dichlorobenzidine
2,4-Dichlorophenol
Diethyl phthalate
2,4-Dimethylphenol
Dimethyl phthalate
Di-N-butyl phthalate
2,4-Dinitrophenol
2,4-Dinitrotoluene
2,6-Dinitrotoluene
Di-N-octyl phthalate
Fluoranthene
Fluorene
Hexachlorobenzene
Hexachlorobutadiene
Hexachloroethane
Hexachloropentadiene
Indeno (1,2,3-CD) pyrene
Isophorone
2-Methyl-4,6-Dinitrophenol
2-Methylnaphthalene
Naphthalene
2-Nitroaniline
3-Nitroaniline
4-Nitroaniline
Nitrobenzene
2-nitrophenol
4-Nitrophenol
N-nitrosodiphenyl amine
N-Nitroso-N-propylamine
Pentachlorophenol
Phenanthrene
Phenol
Pyrene
1,2,4-Trichlorobenzene
2,4,5-Trichlorophenol
2,4,6-Trichlorophenol
2-Methylphenol
4-Methylphenol

Appendix 1 (Continued)

VOLATILE COMPOUNDS

Acetone	Chloroethane	1,2-Dichloropropane	Tetrachloroethene
Benzene	2-Chlorotoluene	cis-1,3-Dichloropropene	Toluene
Bromodichloromethane	Chloroform	Trans-1,3-dichloropropene	1,1,1-Trichloroethane
Bromoform	Chloromethane	Ethylbenzene	1,1,2-Trichloroethane
Bromomethane	Dibromochloromethane	2-Hexanone	Trichloroethene
2-Butanone	1,1-Dichloroethane	Methylene chloride	1,2,3-Trichlorobenzene
Carbon disulfide	1,2-Dichloroethane	4-Methyl-2-pentanone	Vinyl chloride
Carbon tetrachloride	1,1-Dichloroethene	Styrene	Total Xylenes
Chlorobenzene	Trans-1,2-dichloroethene	1,1,2,2-Tetrachloroethane	1,2-Dichloroethene (total)
Bromobenzene	n-Butylbenzene	sec-Butylbenzene	tert-Butylbenzene
cis-1,2-Dichloroethene	4-Chlorotoluene	Bromochloromethane	1,2-Dibromo-3-chloropropane
1,2-Dibromoethane	Dibromomethane	1,2-Dichlorobenzene	1,3-Dichlorobenzene
1,1-Dichloropropene	1,4-Dichlorobenzene	Dichlorodifluoromethane	1,2,4-Trimethylbenzene
n-Propylbenzene	2,2-Dichloropropane	1,3-Dichloropropane	1,3,5-Trimethylbenzene
Trichlorofluoromethane	Isopropylbenzene	4-Isopropyltoluene	1,2,3-Trichloropropane
1,1,1,2-Tetrachloroethane	1,2,3-Trichloropropane		

PESTICIDES

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

PCBs

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

DIOXINS AND FURANS

2378- TCDD	2378 - TCDF
12378- PeCDD	12378 - PeCDF
123478 - HxCDD	23478 - PeCDF
123678 - HxCDD	123678 - HxCDF
123789 - HxCDD	234678 - HxCDF
1234678 - HpCDD	123478 - HxCDF
OCDD	1234678 - HpCDF
Total TCDD	1234789 - HpCDF
Total PeCDD	123789 - HxCDF
Total HxCDD	OCDF
Total HpCDD	Total TCDF
	Total PeCDF
	Total HxCDF
	Total HpCDF

Appendix 2

Raw chemical data: 1982-1992

AVAILABLE UPON REQUEST

FISH TISSUE SUMMARY

Fish tissue samples were collected from the Muskingum River by the Ohio EPA during 1992. Whole body composites and individual fish representing four species were analyzed for pesticides, PCBs, metals and pentachlorophenol (Tables 1 and 2).

- One PCB aroclor (1260) was identified and quantified. Seven samples representing four species were analyzed for PCBs in the Muskingum River from 1992. All seven samples had detectable levels of Aroclor-1260 measured (0.170 - 0.390 mg/kg); however, all values were below Ohio's Water Quality Standard (any whole sample of any representative aquatic organism shall not exceed 0.64 ppm PCBs). All values were also below the FDA 2.0 ppm total PCB level of concern in edible portions.

- Nineteen pesticide compounds were tested for in seven fish tissue samples (four species). All values were below lab detection limits. Detection levels for pesticides varied from between 17 ug/kg and 830 ug/kg.

- One semivolatile organic compound (pentachlorophenol) was measured in seven fish samples representing four species. All values were reported as 'none detected'; however, the lab detection limit was quite high (32 mg/kg - 150 mg/kg).

- Four heavy metals (barium, copper, mercury and zinc) were detected in five fish whole body samples from the 1992 sampling sites. Six other metal parameters (arsenic, cadmium, chromium, lead, selenium and silver) tested in whole body fish samples were reported as 'none detected.' Two of five fish samples had detectable levels of mercury (0.1 ug/kg and 0.2 ug/kg); however, values were below the FDA 1.0 ppm mercury level of concern in edible portions. Zinc was detected in all five fish samples analyzed, with values ranging from 20 mg/kg to 87 mg/kg. Copper was reported at or above the lab detection limit of 1.0 mg/kg in three of five fish samples analyzed, with values ranging from 1.0 mg/kg to 2.0 mg/kg.

Table 1. Summary of chemical parameters detected in fish tissue (whole body) samples from the Muskingum River collected during 1992. NA - not analyzed, ND - none detected.

	FISH TISSUE (mg/kg)				
River Mile (location) Fish species (ID number)	PCB Aroclor-1260	Zinc	Mercury	Barium	Copper
51.6 (Dst. T & N. Gould)					
Spotted bass (MC-FT-06) - composite sample	0.180	NA	NA	NA	NA
Spotted bass (MC-FT-07) - composite sample	NA	24	ND	ND	2.0
Spotted bass (MC-FT-04) - single fish	0.210	20	0.1	ND	ND
Channel catfish (MC-FT-05) - single fish	0.390	NA	NA	NA	NA
Common carp (MC-FT-01) - composite sample	0.210	NA	NA	NA	NA
Common carp (MC-FT-03) - composite sample	NA	57	0.2	1.3	1.0
RM 50.1 (Dst. Malta WTP)					
Spotted bass (MC-FT-12) - composite sample	0.160	NA	NA	NA	NA
Spotted bass (MC-FT-14) - composite sample	NA	25	ND	ND	ND
Freshwater drum (MC-FT-11) - single fish	0.170	NA	NA	NA	NA
Common carp (MC-FT-08) - composite sample	0.250	NA	NA	NA	NA
Common carp (MC-FT-10) - composite sample	NA	87	ND	ND	1.7

Table 2. List of chemical parameters measured in fish tissue samples from the Muskingum River, 1992.

METALS

Arsenic	Copper	Selenium
Barium	Lead	Silver
Cadmium	Mercury	Zinc
Copper		

PESTICIDES

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

PCBs

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

SEMIVOLATILE COMPOUNDS

Pentachlorophenol