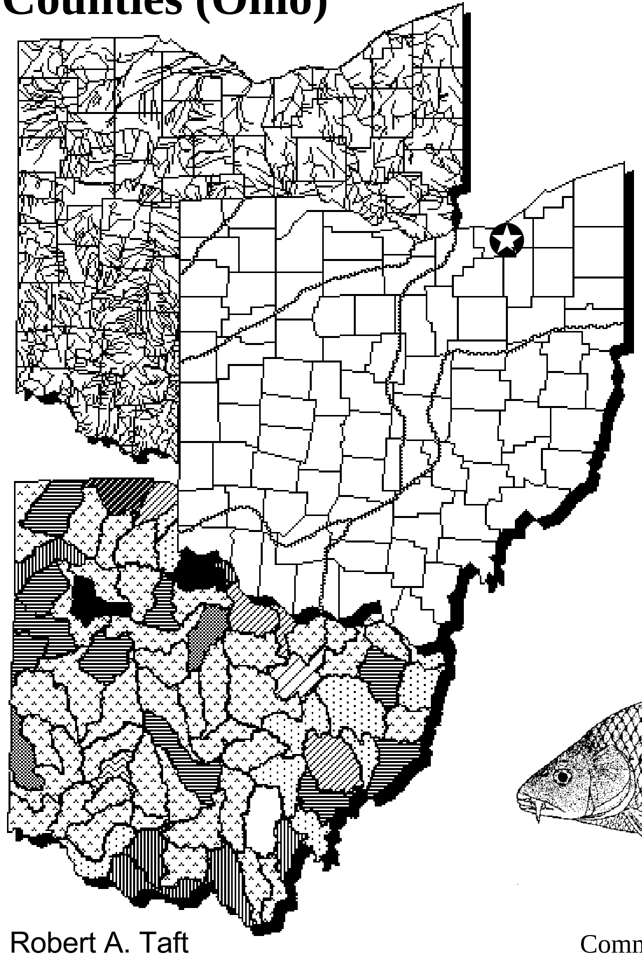
State of Ohio
Environmental Protection Agency

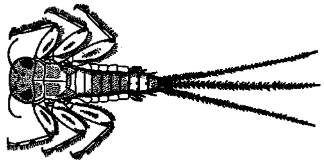
Ecological Assessment Unit
Division of Surface Water

Biological and Water Quality Study of the Cuyahoga River and Selected Tributaries

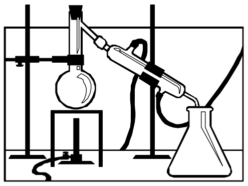
Volume 1

Geauga, Portage, Summit, and Cuyahoga Counties (Ohio)





Mayfly *(Stenonema)*



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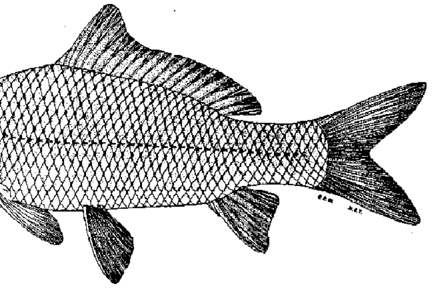

Common Carp *(Caprodes carpio)*

Robert A. Taft
Governor, State of Ohio
Christopher Jones
Director, Ohio Environmental Protection Agency

August 15, 1999

P.O. Box 1049, Lazarus Government Center, 122 South Front Street, Columbus, Ohio 43266-1049

Biological and Water Quality Study
of the
Cuyahoga River and Selected Tributaries

Geauga, Portage, Summit and Cuyahoga Counties, (Ohio)

August 15, 1999

OEPA Technical Report MAS/1997-12-4

Volume 1

prepared by

State of Ohio Environmental Protection Agency
Division of Surface Water
Monitoring and Assessment Section
1685 Westbelt Drive
Columbus, Ohio 43228
and
Surface Water Section
Northeast District Water Quality Section
2110 East Aurora Road
Twinsburg, Ohio 44087

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NOTICE TO USERS

Ohio EPA incorporated biological criteria into the Ohio Water Quality Standards (WQS; Ohio Administrative Code 3745-1) regulations in February 1990 (effective May 1990). These criteria consist of numeric values for the Index of Biotic Integrity (IBI) and Modified Index of Well-Being (MIwb), both of which are based on fish assemblage data, and the Invertebrate Community Index (ICI), which is based on macroinvertebrate assemblage data. Criteria for each index are specified for each of Ohio's five ecoregions (as described by Omernik 1988), and are further organized by organism group, index, site type, and aquatic life use designation. These criteria, along with the existing chemical and whole effluent toxicity evaluation methods and criteria, figure prominently in the monitoring and assessment of Ohio's surface water resources.

The following documents support the use of biological criteria by outlining the rationale for using biological information, the methods by which the biocriteria were derived and calculated, the field methods by which sampling must be conducted, and the process for evaluating results:

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

Ohio Environmental Protection Agency. 1987b. Biological criteria for the protection of aquatic life: Volume II. Users manual for biological field assessment of Ohio surface waters. Div. Water Qual. Monit. & Assess., Surface Water Section, Columbus, Ohio.

Ohio Environmental Protection Agency. 1989b. Addendum to Biological criteria for the protection of aquatic life: Volume II. Users manual for biological field assessment of Ohio surface waters. Div. Water Qual. Plan. & Assess., Ecological Assessment Section, Columbus, Ohio.

Ohio Environmental Protection Agency. 1989c. Biological criteria for the protection of aquatic life: Volume III. Standardized biological field sampling and laboratory methods for assessing fish and macroinvertebrate communities. Div. Water Quality Plan. & Assess., Ecol. Assess. Sect., Columbus, Ohio.

Ohio Environmental Protection Agency. 1990. The use of biological criteria in the Ohio EPA surface water monitoring and assessment program. Div. Water Qual. Plan. & Assess., Ecol. Assess. Sect., Columbus, Ohio.

Rankin, E.T. 1989. The qualitative habitat evaluation index (QHEI): rationale,methods, and application. Div. Water Qual. Plan. & Assess., Ecol. Assess. Sect., Columbus, Ohio.

Since the publication of the preceding guidance documents new publications by Ohio EPA have become available. The following publications should also be consulted as they represent the latest information and analyses used by Ohio EPA to implement the biological criteria.

DeShon, J.D. 1995. Development and application of the invertebrate community index (ICI), pp. 217-243. in W.S. Davis and T. Simon (eds.). Biological Assessment and Criteria: Tools for Risk-based Planning and Decision Making. Lewis Publishers, Boca Raton, FL.

Rankin, E. T. 1995. The use of habitat assessments in water resource management programs, pp. 181-208. in W. Davis and T. Simon (eds.). Biological Assessment and Criteria: Tools for Water Resource Planning and Decision Making. Lewis Publishers, Boca Raton, FL.

Yoder, C.O. and E.T. Rankin. 1995a. Biological response signatures and the area of degradation value: new tools for interpreting multimetric data, pp. 263-286. in W. Davis and T. Simon (eds.). Biological Assessment and Criteria: Tools for Water Resource Planning and Decision Making. Lewis Publishers, Boca Raton, FL.

Yoder, C.O. and E.T. Rankin. 1995b. Biological criteria program development and implementation in Ohio, pp. 109-144. in W. Davis and T. Simon (eds.). Biological Assessment and Criteria: Tools for Water Resource Planning and Decision Making. Lewis Publishers, Boca Raton, FL.

Yoder, C.O. and E.T. Rankin. 1995c. The role of biological criteria in water quality monitoring, assessment, and regulation. Environmental Regulation in Ohio: How to Cope With the Regulatory Jungle. Inst. of Business Law, Santa Monica, CA. 54 pp.

Yoder, C.O. 1995. Policy issues and management applications for biological criteria, pp. 327-344. in W. Davis and T. Simon (eds.). Biological Assessment and Criteria: Tools for Water Resource Planning and Decision Making. Lewis Publishers, Boca Raton, FL.

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

Ohio EPA, Division of Surface Water
Monitoring and Assessment Section
1685 Westbelt Drive
Columbus, Ohio 43228-3809
(614) 728-3377

FOREWORD

What is a Biological and Water Quality Survey?

A biological and water quality survey, or "biosurvey", is an interdisciplinary monitoring effort coordinated on a waterbody specific or watershed scale. This effort may involve a relatively simple setting focusing on one or two small streams, one or two principal stressors, and a handful of sampling sites or a much more complex effort including entire drainage basins, multiple and overlapping stressors, and tens of sites. Each year Ohio EPA conducts biosurveys in 10-15 different study areas with an aggregate total of 250-300 sampling sites.

Ohio EPA employs biological, chemical, and physical monitoring and assessment techniques in biosurveys in order to meet three major objectives: 1) determine the extent to which use designations assigned in the Ohio Water Quality Standards (WQS) are either attained or not attained; 2) determine if use designations assigned to a given water body are appropriate and attainable; and 3) determine if any changes in key ambient biological, chemical, or physical indicators have taken place over time, particularly before and after the implementation of point source pollution controls or best management practices. The data gathered by a biosurvey is processed, evaluated, and synthesized in a biological and water quality report. Each biological and water quality study contains a summary of major findings and recommendations for revisions to WQS, future monitoring needs, or other actions which may be needed to resolve existing impairment of designated uses. While the principal focus of a biosurvey is on the status of aquatic life uses, the status of other uses such as recreation and water supply, as well as human health concerns, are also addressed.

The findings and conclusions of a biological and water quality study 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 are eventually incorporated into Water Quality Permit Support Documents (WQPSDs), State Water Quality Management Plans, the Ohio Nonpoint Source Assessment, and the Ohio Water Resource Inventory (305[b] report).

Hierarchy of Indicators

A carefully conceived ambient monitoring approach, using cost-effective indicators comprised of ecological, chemical, and toxicological measures, can ensure that all relevant pollution sources are judged objectively on the basis of environmental results. Ohio EPA relies on a tiered approach in attempting to link the results of administrative activities with true environmental measures. This integrated approach is outlined in Figure 1 and includes a hierarchical continuum from administrative to true environmental indicators. The six "levels" of indicators include: 1) actions taken by regulatory agencies (permitting, enforcement, grants); 2) responses by the regulated community (treatment works, pollution prevention); 3) changes in discharged quantities (pollutant loadings); 4) changes in ambient conditions (water quality, habitat); 5) changes in

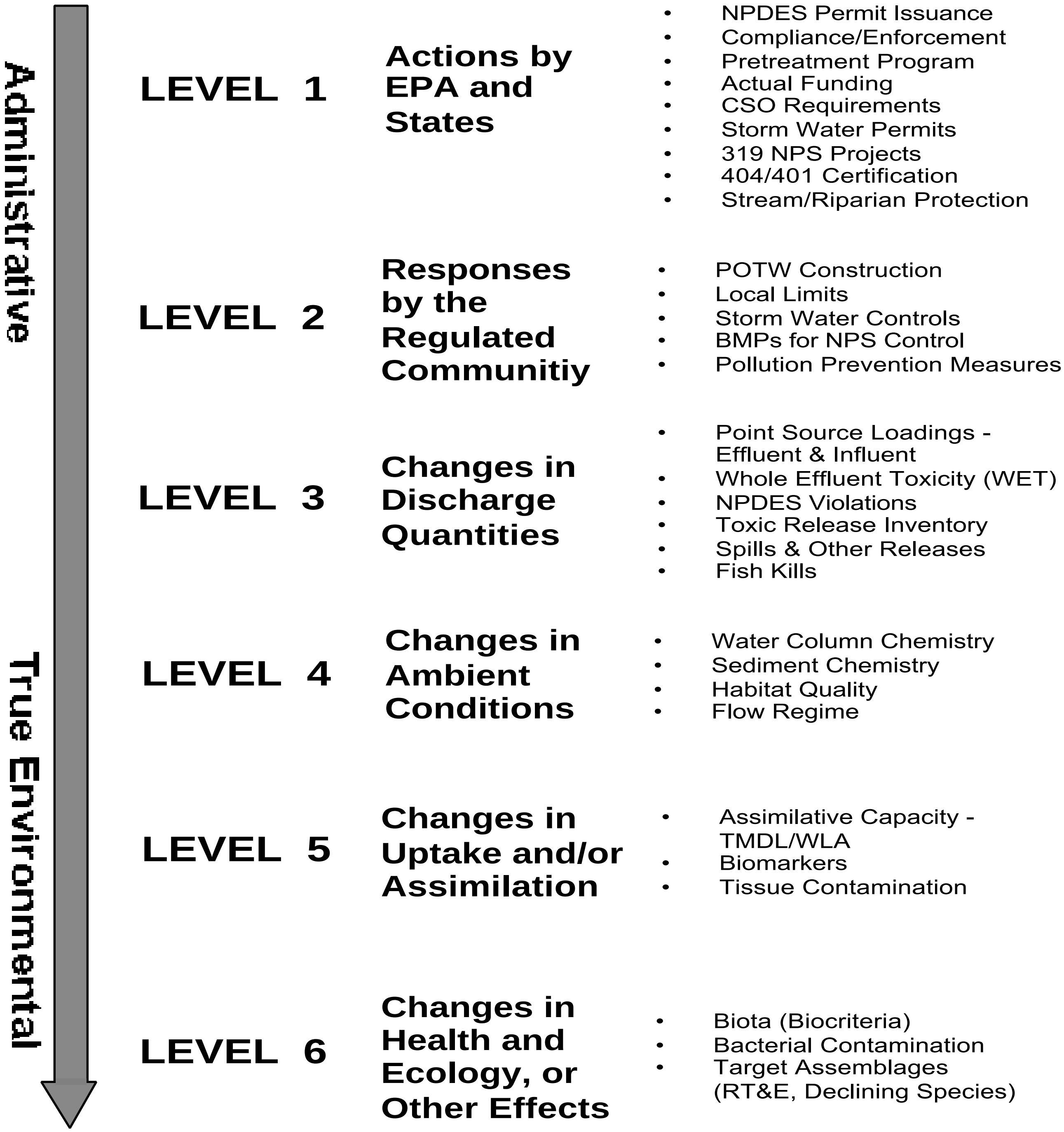

Figure 1. Hierarchy of administrative and environmental indicators which can be used for water quality management activities such as monitoring and assessment, reporting, and the evaluation of overall program effectiveness. This is patterned after a model developed by U.S. EPA (1995).

uptake and/or assimilation (tissue contamination, biomarkers, wasteload allocation); and, 6) changes in health, ecology, or other effects (ecological condition, pathogens). In this process the results of administrative activities (levels 1 and 2) can be linked to efforts to improve water quality (levels 3, 4, and 5) which should translate into the environmental "results" (level 6). Thus, the aggregate effect of billions of dollars spent on water pollution control since the early 1970s can now be determined with quantifiable measures of environmental condition.

Superimposed on this hierarchy is the concept of stressor, exposure, and response indicators. *Stressor* indicators generally include activities which have the potential to degrade the aquatic environment such as pollutant discharges (permitted and unpermitted), land use effects, and habitat modifications. *Exposure* indicators are those which measure the effects of stressors and can include whole effluent toxicity tests, tissue residues, and biomarkers, each of which provides evidence of biological exposure to a stressor or bioaccumulative agent. *Response* indicators are generally composite measures of the cumulative effects of stress and exposure and include the more direct measures of community and population response that are represented here by the biological indices which comprise Ohio's biological criteria. Other response indicators could include target assemblages, *i.e.*, rare, threatened, endangered, special status, and declining species or bacterial levels which serve as surrogates for the recreational uses. These indicators represent the essential technical elements for watershed-based management approaches. The key, however, is to use the different indicators *within* the roles which are most appropriate for each.

Describing the causes and sources associated with observed impairments revealed by the biological criteria and linking this with pollution sources involves an interpretation of multiple lines of evidence including water chemistry data, sediment data, habitat data, effluent data, biomonitoring results, land use data, and biological response signatures within the biological data itself. Thus the assignment of principal causes and sources of impairment represents the association of impairments (defined by response indicators) with stressor and exposure indicators. The principal reporting venue for this process on a watershed or subbasin scale is a biological and water quality report. These reports then provide the foundation for aggregated assessments such as the Ohio Water Resource Inventory (305[b] report), the Ohio Nonpoint Source Assessment, and other technical bulletins.

Ohio Water Quality Standards: Designated Aquatic Life Uses

The Ohio Water Quality Standards (WQS; Ohio Administrative Code 3745-1) consist of designated uses and chemical, physical, and biological criteria designed to represent measurable properties of the environment that are consistent with the goals specified by each use designation. Use designations consist of two broad groups, aquatic life and non-aquatic life uses. In applications of the Ohio WQS to the management of water resource issues in Ohio's rivers and streams, the aquatic life use criteria frequently result in the most stringent protection and restoration requirements, hence their emphasis in biological and water quality reports. Also, an emphasis on protecting for aquatic life generally results in water quality suitable for all uses. The five different aquatic life uses currently defined in the Ohio WQS are described as follows:

1) *Warmwater Habitat (WWH)* - this use designation defines the “typical” warmwater assemblage of aquatic organisms for Ohio rivers and streams; *this use represents the principal restoration target for the majority of water resource management efforts in Ohio.*

2) *Exceptional Warmwater Habitat (EWH)* - this use designation is reserved for waters which support “unusual and exceptional” assemblages of aquatic organisms which are characterized by a high diversity of species, particularly those which are highly intolerant and/or rare, threatened, endangered, or special status (*i.e.,* declining species); *this designation represents a protection goal for water resource management efforts dealing with Ohio’s best water resources.*

3) *Coldwater Habitat (CWH)* - this use is intended for waters which support assemblages of cold water organisms and/or those which are stocked with salmonids with the intent of providing a put-and-take fishery on a year round basis which is further sanctioned by the Ohio DNR, Division of Wildlife; this use should not be confused with the Seasonal Salmonid Habitat (SSH) use which applies to the Lake Erie tributaries which support periodic “runs” of salmonids during the spring, summer, and/or fall.

4) *Modified Warmwater Habitat (MWH)* - this use applies to streams and rivers which have been subjected to extensive, maintained, and essentially permanent hydromodifications such that the biocriteria for the WWH use are not attainable *and where the activities have been sanctioned and permitted by state or federal law;* the representative aquatic assemblages are generally composed of species which are tolerant to low dissolved oxygen, silt, nutrient enrichment, and poor quality habitat.

5) *Limited Resource Water (LRW)* - this use applies to small streams (usually <3 mi.^{2} drainage area) and other water courses which have been irretrievably altered to the extent that no appreciable assemblage of aquatic life can be supported; such waterways generally include small streams in extensively urbanized areas, those which lie in watersheds with extensive drainage modifications, those which completely lack water on a recurring annual basis (*i.e.*, true ephemeral streams), or other irretrievably altered waterways.

Chemical, physical, and/or biological criteria are generally assigned to each use designation in accordance with the broad goals defined by each. As such, the system of use designations employed in the Ohio WQS constitutes a “tiered” approach in that varying and graduated levels of protection are provided by each. This hierarchy is especially apparent for parameters such as dissolved oxygen, ammonia-nitrogen, temperature, and the biological criteria. For other parameters such as heavy metals, the technology to construct an equally graduated set of criteria has been lacking, thus the same water quality criteria may apply to two or three different use designations.

Ohio Water Quality Standards: Non-Aquatic Life Uses

In addition to assessing the appropriateness and status of aquatic life uses, each biological and water quality survey also addresses non-aquatic life uses such as recreation, water supply, and human health concerns as appropriate. The recreation uses most applicable to rivers and streams are the Primary Contact Recreation (PCR) and Secondary Contact Recreation (SCR) uses. The criterion for designating the PCR use is simply having a water depth of at least one meter over an area of at least 100 square feet or where canoeing is a feasible activity. If a water body is too small and shallow to meet either criterion the SCR use applies. The attainment status of PCR and SCR is determined using bacterial indicators (*e.g.,* fecal coliforms, *E. coli)* and the criteria for each are specified in the Ohio WQS.

Water supply uses include Public Water Supply (PWS), Agricultural Water Supply (AWS), and Industrial Water Supply (IWS). Public Water Supplies are simply defined as segments within 500 yards of a potable water supply or food processing industry intake. The Agricultural Water Supply (AWS) and Industrial Water Supply (IWS) use designations generally apply to all waters unless it can be clearly shown that they are not applicable. An example of this would be an urban area where livestock watering or pasturing does not take place, thus the AWS use would not apply. Chemical criteria are specified in the Ohio WQS for each use and attainment status is based primarily on chemical-specific indicators. Human health concerns are additionally addressed with fish tissue data, but any consumption advisories are issued by the Ohio Department of Health are detailed in other documents.

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INTRODUCTION

The 1996 Cuyahoga River mainstem study area extended from East Branch Reservoir in Geauga county to the lower reaches of the navigation channel in Cleveland (RMs 90.9-0.5). Biological and water quality sampling was also conducted in selected Cuyahoga River tributaries including: the West Branch of the Cuyahoga River, Bridge Creek, Black Brook, Breakneck Creek, Potter Creek, Mud Brook, Sand Run, Yellow Creek, Furnace Run, Brandywine Creek, Chippewa Creek, Mill Creek, Big Creek, Morgan Run and, Kingsbury Run. Sediment samples were also collected at 6 mainstem locations and in 14 tributaries as part of a regional survey of sediment quality. In addition to the Cuyahoga River mainstem survey, a separate intensive biological and water survey of the Little Cuyahoga River basin was also conducted during the summer of 1996 (Ohio EPA 1998).

In addition to the 1996 sampling, the Ohio EPA Northeast District Office also conducted chemical/physical sampling and algal community analysis from two stations in Long Lake, one of the Portage Lakes near Akron, during the summer of 1998. A separate assessment of the Little Cuyahoga River basin was completed in 1996 and the results reported separately (Ohio EPA 1998).

Historical surveys conducted by the Ohio EPA in the Cuyahoga River basin include basin-wide chemical and biological surveys in 1984 and 1991, mainstem biological surveys between Akron and Lake Erie in 1985, 1986, 1987, and 1988, and intensive chemical and biological surveys of the Little Cuyahoga River subbasin in 1986 and 1996. Extensive chemical and continuous D.O. monitoring for modeling of the lower mainstem and navigation channel was conducted in 1990-91 (Ohio EPA 1993). In addition,water quality data has been collected monthly from the Cuyahoga River National Ambient Water Quality Monitoring Network (NAWQMN) stations at Independence (RM 13.18), Lower Harvard Ave (RM 7.10) and West Third Avenue (RM 3.26) over the past 20 to 26 years. A new monthly station was added in 1994 at Shalersville (RM 64.3) to monitor expected changes in water quality due to anticipated land development in this section of the watershed. Biological sampling has also been routinely conducted at the NAWQMN stations over the same period.

Together with United States Geological Survey (USGS), City of Akron, Northeast Ohio Regional Sewer District (NEORSD), and National Park Service personnel, Ohio EPA conducted extensive bacteriological sampling in the reach between Akron and Cleveland in 1989-90. USGS conducted additional bacteriological sampling in 1991-93 from the reach under peak flow conditions (USGS Francy *et. al.* 1993). Fish tissue collections were made in 1989-1992 in the mainstem and outer harbor for the Cuyahoga River Remedial Action Plan (RAP) and biomarker sampling was conducted in the Akron area in 1991 in cooperation with the United States Environmental

Protection Agency (USEPA).

The City of Akron routinely collects water quality information from stations upstream from their water treatment plant at Lake Rockwell (dam at RM 57.7) and has performed several biological and water quality surveys of the Cuyahoga River and Little Cuyahoga River in and near the city. The NEORSD also performs routine sampling and has completed biological and water quality surveys of the Cuyahoga River and numerous tributaries within their service area.

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 State Water Quality Management Plans, the Ohio Nonpoint Source Assessment, and the biennial Water Resource Inventory (305[b] report).

SUMMARY

Cuyahoga River

Compared to a similar survey by Ohio EPA in 1991, biological and water quality conditions in the Cuyahoga River reflected minimal change in 1996. In the upper mainstem between East Branch Reservoir and Hiram Rapids, reservoir releases, drainage from wetlands, and past channelization activity continue to contribute to severe dissolved oxygen depletion, elevated ammonia concentrations and depressed biological community performance (Table 1; Figure 2). Both chemical and biological quality improved with increased distance downstream and reached good (fish) to exceptional quality (macroinvertebrates) prior to entering Lake Rockwell.

Downstream from Lake Rockwell, biological index scores decreased relative to the free-flowing reach upstream. Impounded habitat in Kent and Munroe Falls, low dissolved oxygen (D.O.), and nutrient enrichment are the primary causes of impairment in the stream segment. Flow alteration at the Lake Rockwell dam, including lack of flow and possible changes in chemical quality, is the major contributor to the low dissolved oxygen values based upon a mathematical model developed by the Ohio EPA for the Middle Cuyahoga River TMDL (*i.e.*, total maximum daily load). High sediment oxygen demand, lack of aeration in the dam pools, and discharges of oxygen demanding substances from Lake Rockwell and point source discharges in the Kent and Ravenna areas also contribute to low D.O. in this increasingly urbanized section of the river.

Further downstream, biological communities improved and marginally met WWH biological criteria in the turbulent, free flowing reach between the Ohio Edison dam pool and Little Cuyahoga River (RMs 42.3-44.6). The unique habitat conditions in the gorge help to ameliorate potential water quality impacts from Akron combined sewers in this section.

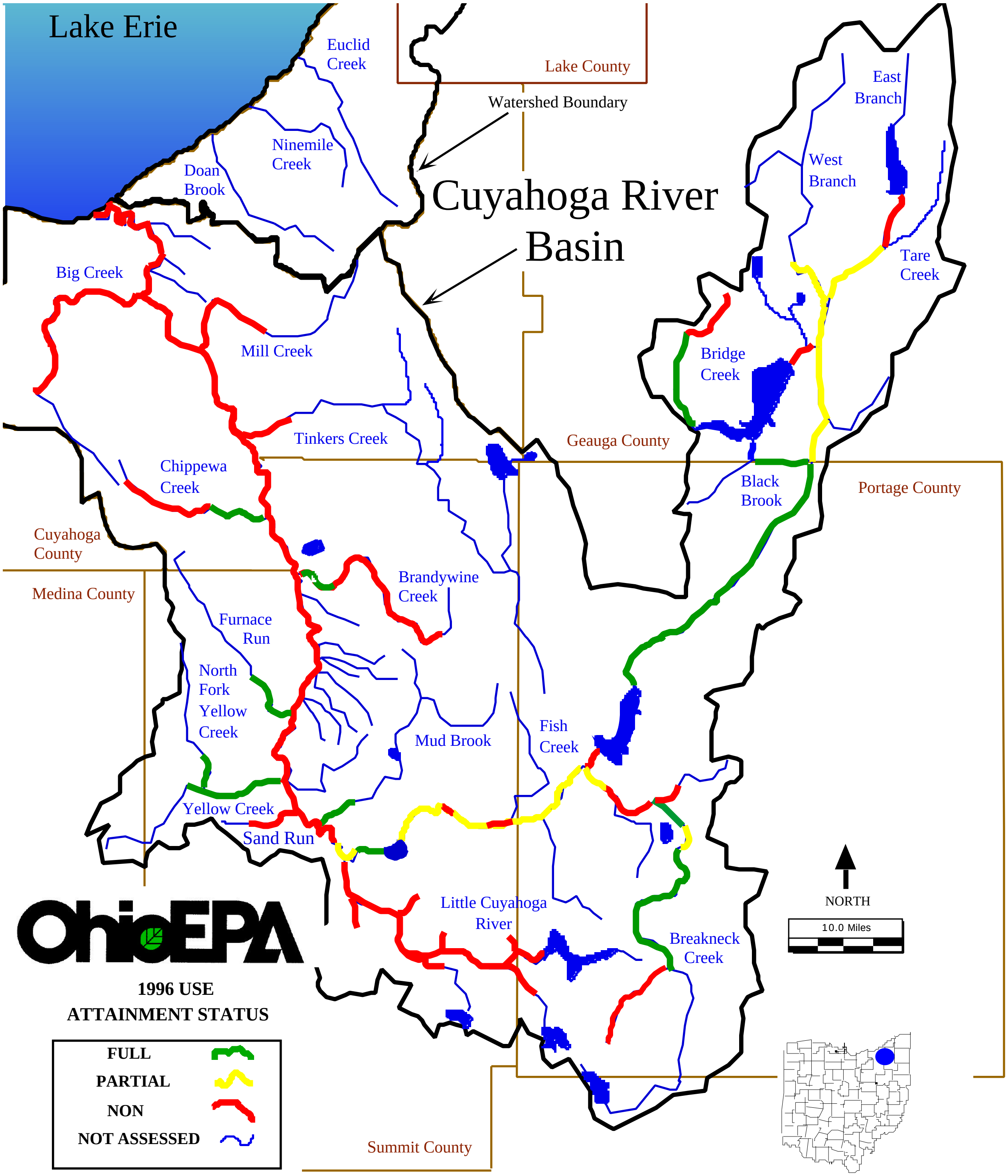

Figure 2. Warmwater habitat (WWH) attainment status of streams sampled within the 1996 Cuyahoga River basin study area.

Results from the 1991 Cuyahoga River survey implicated the Akron sewer system (WWTP, CSOs, SSOs) as a significant source of pollutant loadings and chemical and biological impacts. Community health (particularly among the fish) declined downstream from the Little Cuyahoga River and remained in non-attainment downstream to Cleveland. Rain event sampling showed sewer overflows and previously unreported chlorinated secondary bypasses from the Akron WWTP were significant sources of oxygen demanding wastes and fecal coliform bacteria contamination between Akron and Cleveland.

The 1996 survey results below Akron were similar to 1991. Biological communities remained in non-attainment downstream from the Akron CSOs and experienced further declines downstream from the Akron WWTP (Figure 2). Fish community health was generally poor to very poor with only minimal recovery between Akron and Cleveland. Macroinvertebrates were not as severely impacted as the fish but both organism groups scored below WWH biocriteria (fair to very poor ranges) for a minimum of four river miles downstream from the Akron WWTP. Macroinvertebrates tended to reflect excessive organic enrichment while fish exhibited more chronic or toxic influences downstream from Akron. These results however, are an improvement over the very poor performance exhibited in 1984.

During dry weather, the mainstem was in substantial compliance with chemical water quality criteria. However, elevated nutrient levels persisted well downstream from the Akron WWTP, an indication of chronic enrichment between Akron and Cleveland. The lack of assimilation suggests nutrient uptake by algae was either suppressed or nutrients were present in concentrations saturating to algal uptake rates. Suppressed uptake rates may indicate chronic toxicity or sunlight limitation due to high levels of suspended solids. Saturated uptake rates demonstrate nutrients present in levels exceeding assimilative capacity. Further study is needed on algal uptake rates.

Following rainfall events, significant Water Quality Standards (WQS) criteria exceedences for heavy metals and fecal coliform bacteria were associated with combined sewer overflows, urban runoff, and Akron WWTP bypasses. Continuous monitor results from Akron also showed numerous, short term instances of low dissolved oxygen concentrations, primarily upstream from the Akron WWTP. The results appeared to particularly implicate “first-flush” discharge events associated with Akron CSOs. However, the most severe biological impairment extended several miles downstream from the combined CSO and WWTP discharges.

In Cleveland, the NEORSD Southerly WWTP was considered an additional source of stress to an already impaired river system. Phosphorus, nitrate, and zinc concentrations, already elevated downstream from Akron, were further increased downstream from NEORSD. Fish communities were poor and exhibited elevated levels of external anomalies both upstream and downstream from the discharge. Effluent bioassays were not acutely toxic, but chronic toxicity was often associated with both the effluent and receiving stream, particularly *upstream* from the WWTP.

In the navigation channel, biological and water quality improvement has been significant to the extent that a few tolerant fish populations now inhabit sections that were virtually devoid of fish in the mid 1980s. Concentrations of most pollutants have been substantially lowered and minimum dissolved oxygen concentrations have risen above anoxia. Reduced industrial production, elimination of discharges, and improvements in municipal wastewater treatment in Cleveland and Akron are probable reasons for the trend. However, at most sites these positive changes in water quality have only resulted in raising biological quality from “very poor” to “poor”. The prospects for significant additional improvement are low due to the channel’s morphology and inherent habitat limitations.

Fish communities experienced continued poor performance downstream from Akron and index values decreased relative to 1991 at many mainstem sites (see Figure 11). The difference in IBI and MIwb scores was due to fewer species and fewer total number of fishes collected at a site in 1996 compared to 1991. Flows were lower under drought conditions in 1991 compared to 1996, with flows on sampling days respectively averaging 51.3 and 91.1 cfs. The higher flows were associated with lower MIwb scores ($t = -2.67$, $P = 0.0100$ for the regression of MIwb on flow). The drought may have augmented the number of fish and species due to fish seeking refuge from intermittent tributaries, as evidenced by the presence of redside dace, a headwater species, at RM 38.6 in 1991. Alternately, lower index scores in the upper mainstem, upstream from Lake Rockwell, appeared associated with declines in water quality between surveys. Diel dissolved oxygen concentrations measured by Datasondes™ in this section were substantially lower, and showed more violations of water quality standards in 1996 than 1991, supporting this alternate hypothesis. IBI and MIwb scores downstream from Akron in 1996 were comparable to scores obtained in 1984 and 1988; however, the increased number of sensitive species and corresponding shifts in associated impact types documented in 1991 continued in 1996 (Figure 3).

Given the relatively unchanged state of discharges in Akron and Cleveland, the lack of difference between 1991 and 1996 surveys was not particularly surprising. Excepting dechlorination, overall treatment processes at the WWTPs have not changed significantly. Pollutant loadings and flows have remained constant, and recent monitoring shows that wet-weather secondary bypasses at the Akron WWTP are a significant, but historically unquantifiable loadings source. Rain-induced “shock loadings” of pollutants from sewer overflows and urban runoff contribute to mainstem impacts. Additional improvements in the Akron to Cleveland reach are not considered likely without further efforts to control and reduce these pollutant loadings, particularly from Akron.

Analysis of the effects of urban land use on biological communities in the Cuyahoga River basin showed strong negative correlations between increasingly impervious watersheds and declining biological health (Yoder *et. al.* 1999). However, the effects of imperviousness and associated cofactors (e.g., urban runoff, altered hydrology) may be offset by land use practices. Biological impacts were exacerbated in basins subject to additional stressors such as CSOs and SSOs, concentrated urban/industrial land usage, "legacy" pollutants, or habitat alterations (*i.e.*, impoundments, channelization). Conversely, subbasins with estate-type residential watersheds (*i.e.*, large lot sizes) and intact physical habitats maintained comparatively good biological quality, even at higher levels of urbanization. This strongly suggests that the form, manner and type of development influences the level of urbanization supported by a watershed. The difference in results underscores the importance of maintaining natural features within a watershed including instream habitat, wooded riparian buffers, and green space.

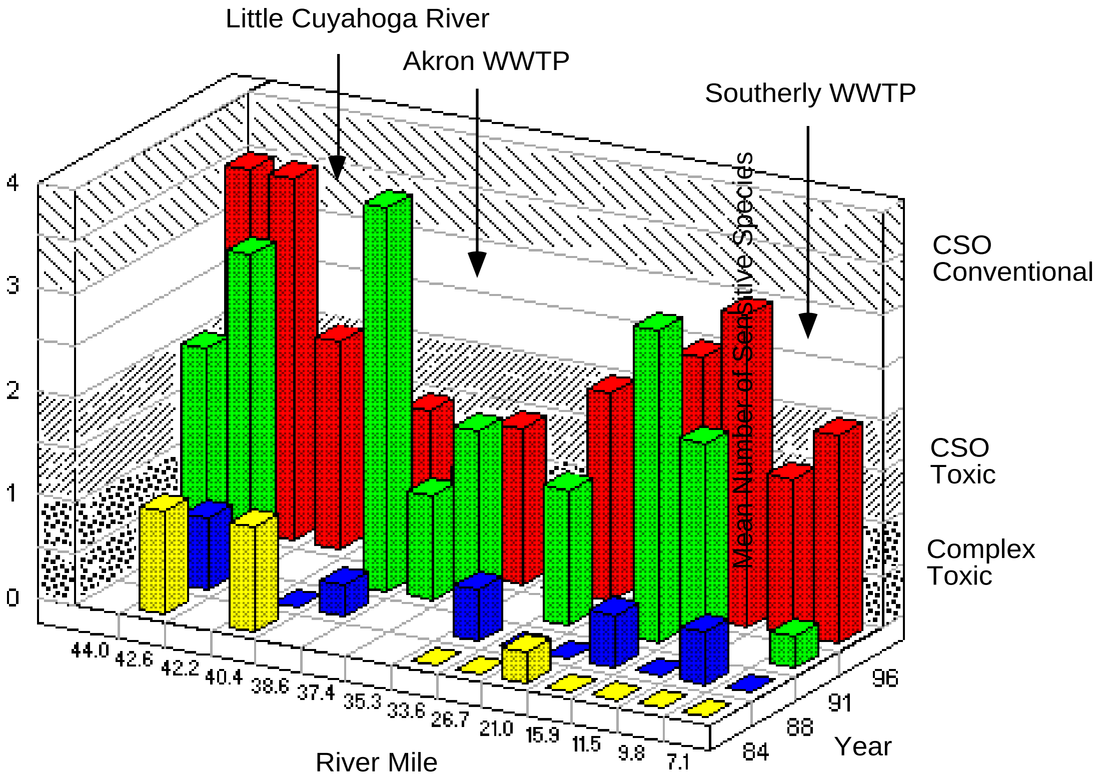

Figure 3. Mean numbers of sensitive fish species collected from the Cuyahoga River and associated impact types from Akron to Cleveland, 1984-1996.[1]

[1] Improving trends in the Akron to Cleveland reach based on analysis of the number of sensitive fish species was discussed in the 1991 TSD (Ohio EPA 1994, Figure 3). Since then an error was discovered in the plot. "Cumulative" numbers of sensitive species were plotted on the y axis instead of the correct, "average" number per site. For this reason, an inflated number of sensitive species were displayed at some sites and, as a result, the magnitude of change in the fish community was somewhat overstated. Despite the error, the general trend of improvement from the severe "complex toxic" conditions observed in the 1980s to the somewhat less severe "CSO toxic" and "CSO conventional" associated impact type in 1991 continued in 1996.

Table 1. Aquatic life use attainment status in the Cuyahoga River basin based on data collected from June to September 1991-1996. Attainment status for lotic habitats are based on biocriteria for the Erie/Ontario Lake Plain ecoregion of Ohio (OAC 3745-1-07, Table 7-17). Attainment status in lake influenced sections of the Cuyahoga River mainstem (*i.e.*, lacustuary and navigation channel; RMs 7.0-0.0) are evaluated using an interim set of criteria developed for Lake Erie river mouths (Ohio EPA 1999a,b Draft). All fish sites were sampled using boat methods unless otherwise indicated.

RIVER MILE		Modified			Attainment	
Fish/Invert.	IBI	MIwb	ICI^{a}	QHEI^{b}	Status^{c}	Comments
Cuyahoga River (1996)						
Erie/Ontario Lake Plain - Warmwater Habitat (WWH) Use Designation						
90.9^{w}/90.9	32*	NA	28*	67.5	**NON**	Dst. East Branch Reservoir
87.2/87.3	28*	6.4*	30^{ns}	42.5	PARTIAL	Dst. Tare Creek (wetland)
83.8/84.1	29*	7.7*	42	47.0	PARTIAL	Dst. West Branch Cuy. R.
80.5/80.4	39^{ns}	7.0*	40	48.0	PARTIAL	Dst. Ladue Res.(wetland)
75.8^{w}/75.8	38	7.6^{ns}	44	69.0	FULL	Winchell Rd.
71.7/71.7	44	8.6^{ns}	44	75.5	FULL	Pioneer Trail Rd.
65.1/67.6	47	8.1*	40	78.5	PARTIAL	Dst. Infirmary Rd.
64.5^{w}/64.2	39	7.5^{ns}	52	85.5	FULL	Ust. Lake Rockwell
57.5^{w}/57.6	32*	5.6*	24*	56.5	**NON**	Dst. Lake Rockwell
56.0^{w}/56.1	34*	6.7*	32^{ns}	67.5	PARTIAL	Dst. Breakneck Creek
54.2/54.4	28*	7.6*	44	70.0	PARTIAL	Kent urban area
53.4/53.4	31*	6.7*	38	64.0	PARTIAL	Dst Kent WWTP
52.0/ --	30*	7.5*	--	54.0	(**NON**)	Ust Fishcreek WWTP-dam pool
51.0/ --	30*	6.2*	--	48.5	(**NON**)	Dst Fishcreek WWTP-dam pool
48.7/49.8	26*	7.1*	42	56.0	PARTIAL	Dst Munroe Falls Dam
48.0/48.0	24*	6.7*	44	46.5	**NON**	Dst. Waterworks Park
46.0/45.9	28*	6.7*	34	67.0	PARTIAL	Dst. Cuyahoga Falls
44.0^{w}/44.0	35^{ns}	7.6^{ns}	38	76.0	FULL	Dst. Ohio Edison (gorge)
42.8^{w}/42.8	38	6.9*	40	82.0	PARTIAL	Ust. Little Cuyahoga River
42.0/41.9	26*	6.9*	34	68.5	PARTIAL	Dst L Cuy. R. & Rack #36
38.6/38.0	26*	6.1*	32^{ns}	76.0	**NON**	Ust. Akron WWTP
37.4/37.4	*19*	*5.1*	*24*	*NA*	*NA*	*Akron WWTP Mix Zone*
37.2/37.1	21*	5.5*	26*	78.0	**NON**	Dst. Akron WWTP
35.3/35.3	20*	5.6*	28*	77.5	**NON**	Ira Road
33.3/33.3	17*	4.8*	24*	60.5	**NON**	Bolanz Road

Table 1. (continued).

RIVER MILE Fish/Invert.	IBI	Modified MIwb	ICI[a]	QHEI[b]	Attainment Status[c]	Comment
Cuyahoga River (1996) *continued*						
27.2/26.5	22*	5.4*	36	74.5	**NON**	Boston Mills
22.0/ --	13*	3.9*	--	60.0	(**NON**)	Ust. Station Rd. dam
-- /20.7	--	--	46	--	(FULL)	Station Rd. dam tailwaters
16.5/17.0	15*	5.7*	42	66.0	**NON**	Pleasant Valley Road
15.9/15.6	22*	6.4*	44	69.5	**NON**	Dst. Tinkers Cr. (NAWQMS)
11.5/11.0	18*	6.2*	46	69.5	**NON**	Ust. Southerly WWTP
10.4/10.5	*31*	*4.5*	*26*	*NA*	*NA*	*Southerly Mix Zone*
9.6/9.7	17*	4.7*	36	66.0	**NON**	Dst. Southerly WWTP
8.3/8.3	17*	5.6*	36	67.0	**NON**	Ust Bradley Rd. Smelters
7.2/7.1	14*	4.0*	24*	68.5	**NON**	Dst. Big Creek
Lake Erie Lacustuary - WWH Use Designation[d]						
5.6/5.8	21*	5.8*	40*	41.5	**NON**	Ust. Nav. Channel
Navigation Channel - LRW Use Designation[d] ***(Very Poor*** = ***Non-attainment)***						
4.8/5.0	18	**4.7***	28	--	PARTIAL	Dst. LTV
4.2/4.3	31	5.8	14	33.0	FULL	Dst. LTV
3.1/3.3	22	**4.8***	**10***	33.0	PARTIAL	Center Street
1.3/1.2	21	**4.8***	**10***	40.0	PARTIAL	Ust. Detroit Ave.
0.5/ --	24	5.2	--	32.0	(FULL)	Near mouth
Cuyahoga River (1994)						
Lake Erie Lacustuary - WWH Use Designation[d]						
7.0/6.9	14*	5.3*	36*	69.5	**NON**	Dst. Big Creek
-- /6.6	--	--	34*	--	(**NON**)	Upper Harvard Ave.
Navigation Channel - LRW Use Designation[d]						
4.8/5.0	19	5.5	22	31.0	FULL	Dst. LTV
0.2/0.5	22	**4.9***	22	--	PARTIAL	Near mouth
Cuyahoga River (1993)						
Erie/Ontario Lake Plain - WWH Use Designation						
-- /42.8	--	--	28*	--	(**NON**)	Ust. Little Cuyahoga R.
-- /39.7	--	--	32[ns]	--	(FULL)	Dst. Little Cuyahoga R.
-- /35.3	--	--	28*	--	(**NON**)	Ira Road
-- /15.6	--	--	48	--	(FULL)	Dst. Tinkers Creek

Table 1. (continued).

RIVER MILE Fish/Invert.	IBI	Modified MIwb	ICI[a]	QHEI[b]	Attainment Status[c]	Comment
West Branch Cuyahoga River (1996)						
		Erie/Ontario Lake Plain - WWH Use Designation				
0.9^{w}/0.9	48	7.0*	42	64.0	PARTIAL	Dst. wetlands
Bridge Creek (1996)						
		Erie/Ontario Lake Plain - WWH Use Designation				
11.2^{w}/11.2	28*	NA	P*	56.0	**NON**	Wetland influence
8.5^{w}/8.5	50	NA	VG	71.5	FULL	Dst. wetlands
0.5^{w}/1.3	30*	5.9*	28*	55.5	**NON**	Dst. LaDue Reservoir
Black Brook (1996)						
		Erie/Ontario Lake Plain - WWH Use Designation				
1.8^{w}/1.8	36^{ns}	NA	40	64.0	FULL	Dst. LaDue Reservoir
Breakneck Creek (1996)						
		Erie/Ontario Lake Plain - WWH Use Designation				
-- /14.7	--	--	50	--	(FULL)	Homestead Ave. (Ref. Site)
9.5^{w}/ --	46	NA	--	67.5	(FULL)	Lake Road
6.8^{w}/6.9	30*	NA	44	66.5	PARTIAL	Summit Rd (Ref. Site)
5.2^{w}/5.2	40	NA	46	86.5	FULL	Ust. Wahoo Ditch
3.1^{w}/3.1	38	5.1*	48	56.5	**NON**	Dst. Wahoo Ditch
1.7^{w}/1.8	15*	4.6*	40	59.0	**NON**	Dst. Franklin Hills WWTP
0.2^{w}/0.1	44	7.2*	44	69.0	PARTIAL	Dst. abandoned landfill
Potter Creek (1996)						
		Erie/Ontario Lake Plain - WWH Use Designation				
1.8^{w}/1.5	24*	NA	34	41.0	**NON**	Reference Site
Wahoo Ditch (1996)						
	Erie/Ontario Lake Plain - Modified Warmwater Habitat (MWH) Use Designation					
--/ 0.4	--	--	P*	--	**(NON)**	Dst. Ravenna WWTP
Mud Brook (1996)						
		Erie/Ontario Lake Plain - WWH Use Designation				
0.3^{w}/ --	8.0	36^{ns}	--	67.0	(FULL)	Near mouth

Table 1. (continued).

RIVER MILE Fish/Invert.	IBI	Modified MIwb	ICI[a]	QHEI[b]	Attainment Status[c]	Comment
Sand Run (1996)						
Erie/Ontario Lake Plain - Undesignated - WWH Use Designation Recommended						
0.3^{w}/0.2	26*	NA	P*	59.0	**NON**	Near mouth
Yellow Creek (1996)						
Erie/Ontario Lake Plain - WWH Use Designation						
1.5^{w}/0.1	38	7.9	VG	71.0	FULL	Dst. North Fork / at mouth
Brandywine Creek (1996)						
Erie/Ontario Lake Plain - WWH Use Designation						
7.0^{w}/7.0	30*	NA	P*	56.0	**NON**	Dst. Hudson WWTP
0.4^{w}/0.3	--[d]	--[d]	MG	66.5	(FULL)	Near mouth
Furnace Run (1996)						
Erie/Ontario Lake Plain - WWH Use Designation						
0.9^{w}/0.9	48	NA	E	70.0	FULL	Ambient
Chippewa Creek (1996)						
Erie/Ontario Lake Plain - WWH Use Designation						
6.1^{w}/6.1	34*	NA	--	67.5	(**NON**)	Ust. Norton Landfill
3.8^{w}/3.8	20*	NA	--	43.0	(**NON**)	Dst. Landfill, bedrock
0.3^{w}/3.8	46	NA	--	68.5	(FULL)	At mouth, dst. waterfalls
Tinkers Creek (1996)						
Erie/Ontario Lake Plain - WWH Use Designation						
0.2^{w}/0.1	24*	7.0*	F*	70.0	**NON**	At mouth
Big Creek (1996)						
Erie/Ontario Lake Plain - WWH Use Designation						
7.8^{H}/7.8	28*	NA	F*	64.5	**NON**	Ust. CSOs
2.5^{w}/2.5	26*	5.1*	P*	50.5	**NON**	Dst. CSOs
0.2^{w}/0.2	28*	5.4*	P*	53.0	**NON**	At mouth

Table 1. (continued).

RIVER MILE Fish/Invert.	IBI	Modified MIwb	ICI[a]	QHEI[b]	Attainment Status[c]	Comment
Mill Creek (1996)						
		Erie/Ontario Lake Plain - WWH Use Designation				
4.3[H]/3.4	20*	NA	P*	68.5	**NON**	Urban
0.2[H]/0.2	18*	NA	F*	60.0	**NON**	Dst Landfills, CSOs, urban

Ecoregion Biocriteria: Erie/Ontario Lake Plain (EOLP) and Lake Erie Lacustuaries[e]

INDEX - Site Type	WWH	EWH	MWH[f]	Lake Erie Lacustuary RMs 7.0-5.6 (WWH/EWH)	Navigation Channel RMs 5.6-0.0 (LRW)[g]
IBI - Headwaters	40	50	24	--	--
IBI - Wading	38	50	24	--	--
IBI - Boat	40	48	24	42/50	>17
Mod. Iwb - Wading	7.9	9.4	6.2	--	--
Mod. Iwb - Boat	8.7	9.6	5.8	8.5/9.5	>5.0
ICI	34	46	22	42/52	>10

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* - significant departure from ecoregional biocriteria; poor and very poor results are underlined.

[ns] - nonsignificant departure from ecoregional biocriteria for WWH or EWH (<4 IBI or ICI units; <0.5 MIwb units).

[a] - Narrative evaluation used in lieu of ICI (E=Excellent, VG=Very Good, G=Good, MG=Marginally Good, F=Fair; P=Poor).

[b] - Qualitative Habitat Evaluation Index (QHEI) values based on the new version (Rankin 1989).

[c] - Attainment status based on one organism group is parenthetically expressed.

[d] - Fish sampling results invalidated due to excessive stream conductivity levels.

[e] - Lake Erie lacustuary communities are evaluated using an interim set of metric scoring criteria based on sampling from other flooded river mouths in the drainage (Ohio EPA 1999a,b Draft). The scores are not directly comparable to biocriteria for lotic streams and rivers.

[f] - Modified Warmwater Habitat for channel modified areas.

[g] - The use designation for the navigation channel between June and January is Limited Resource Water. The criteria listed exceed “Very Poor” conditions.

w- wading fish sampling method.

CONCLUSIONS

Upper Cuyahoga River

- East Branch Reservoir to Lake Rockwell (RMs 90.86 to 64.3)

Low dissolved oxygen (D.O.) is the primary water quality concern in the upper Cuyahoga River watershed. The upper reaches between East Branch Reservoir and Black Brook (RMs 91-76) receive hypolimnetic (bottom) and epilimnetic (top) releases from Akron water supply reservoirs and are characterized by sluggish flow, historic channel modification, and influences from extensive wetlands. Significant D.O. depletion was encountered in the same reach, particularly downstream from the East Branch Reservoir and Tare Creek wetland complex near Burton (RMs 91-87). As in previous surveys, D.O. levels gradually improved in the lower 10-15 river miles between Hiram Rapids and Lake Rockwell.

Ammonia-nitrogen-concentrations were chronically elevated downstream from the East Branch Reservoir (RM 91.07), apparently the result of reservoir releases. The concentrations did not exceed water quality criteria (based on temperature and pH) but, coupled with low dissolved oxygen levels, may exacerbate biological impacts in the upper watershed.

Fish and macroinvertebrate communities were in non-attainment and partial attainment of WWH (fair to good quality) in the upper reaches of the mainstem. Biological impacts corresponded with the low D.O., elevated ammonia, and marginal habitat quality found in the same reach. Like the water quality trends, communities improved with increased distance downstream and reached good to exceptional quality prior to reaching Lake Rockwell.

Biological and water quality trends in the upper watershed were generally similar to those found in the 1991 survey.

Middle and Lower Cuyahoga River

- Lake Rockwell to Big Creek (RMs 57.97 - 7.1)

Between Lake Rockwell and Akron, biological index scores decreased relative to the free-flowing reach upstream (Table 1). Low dissolved oxygen levels, flow alteration and habitat modification associated with reservoir releases and impoundments, and nutrient enrichment were considered the primary causes of impairment. Further downstream, biological communities improved and marginally met WWH biological criteria in the turbulent, free flowing reach between the Ohio Edison dam pool and Little Cuyahoga River (RMs 42.3-44.6). The unique habitat conditions in the gorge help to ameliorate potential water quality impacts from Akron combined sewers in this section.

Datasonde™ "continuous" monitors have documented numerous exceedences of the D.O. criterion between Lake Rockwell and Cuyahoga Falls. The most severe D.O. depletion was observed downstream from Lake Rockwell and in the Munroe Falls dam pool where concentrations averaged less than 5 mg/l. More recently, sampling conducted in 1998 encountered severe D.O. depletion beginning downstream from Lake Rockwell and extended several miles downstream. Hypolimnetic releases from Lake Rockwell and, conversely, periodic elimination of the releases during low flows were considered major contributors to the depressed D.O. levels. In addition, impounded habitats in Kent and Munroe Falls reduce habitat quality and reaeration, and act as nutrient sinks. The combination of these factors, coupled with nutrient loadings from WWTPs in the Kent and Ravenna areas contributed to the low D.O. levels. Further downstream, D.O. concentrations generally increased between the Munroe Falls dam and the Little Cuyahoga River due to higher stream gradient and turbulent flows.

The American Whitewater Association lists the Cuyahoga River near Akron for canoeing and kayaking with class III to class V ratings from Broad St to Cuyahoga St. These ratings highlight the existing and potential high quality recreational use of this segment of the river.

Akron combined sewers discharged a total of 296 million gallons of combined flow in 1996. The CSOs discharged following as little as 0.1 inch of rain per hour. The Ohio Canal receives the greatest volume of combined sewer flow while the Little Cuyahoga River receives the largest number of discharge events. These discharges contribute to serious water quality impacts in the Cuyahoga River and the Little Cuyahoga River basin. The adverse effects include stream discoloration, odor, debris and litter, dissolved oxygen depletion, excessive bacteria levels and exceedences of chemical criteria, including acutely toxic concentrations of heavy metals.

Continuous monitor data from the city of Akron detected low D.O. concentrations both immediately upstream and downstream from the Akron WWTP during the summers of 1994-96. Concentrations were below 5 mg/l on six different dates during the summer of 1996 and 39 days during the summer of 1995. Most of the measurements were recorded at the 801 (upstream WWTP) sampling site and most were short lived, possibly corresponding to first flush events. However, the low D.O.s did not appear to be positively correlated to flow (*i.e.*, CSOs may discharge following rain events that are either too small or too localized to significantly affect mainstem flows). The results indicate potential chronic effects on biological communities from loadings of oxygen demanding substances associated with Akron CSOs. However, biological impairment was most severe downstream from both the CSO and WWTP discharges.

Excepting D.O., the Cuyahoga River was in substantial compliance with chemical WQS criteria during dry weather. However, nitrate-nitrite, phosphorus, and zinc tended to increase in a step wise function below the Akron, NEORSD Southerly, and LTV (zinc) discharges. Chronic enrichment and lack of nutrient assimilation between Akron and Cleveland suggests nutrient uptake by algae was either suppressed, or nutrients were present in concentrations saturating to algal uptake rates. Suppressed uptake rates may indicate chronic toxicity or light limitation due to high levels of suspended solids. Saturated uptake rates demonstrate nutrients present in levels exceeding assimilative capacity.

Fecal coliform numbers continue to exceed the 1000/100 ml Primary Contact Recreation criterion between Akron and Cleveland when stream flow is elevated due to rain runoff. A similar finding was reported by the USGS in their extensive bacteriological survey of the lower Cuyahoga River (Francy *et.al.* 1993). The study concluded that the most significant source of fecal coliform bacteria was from bypasses of the secondary treatment process at the Akron WWTP.

Biological impairment in the Cuyahoga River downstream from Akron was manifest most strongly in the fish. Fish communities were poor or very poor at nearly all sites between Akron and Cleveland, beginning downstream from the Little Cuyahoga River. Both organism groups were in the fair to very poor ranges downstream from the Akron WWTP for a minimum of four river miles. Macroinvertebrates tended to reflect enrichment effects while fish exhibited more chronic or toxic influences downstream from Akron. In contrast to the fish communities, macroinvertebrates gradually improved and reached very good to exceptional quality upstream from Cleveland.

The Cuyahoga River has shown considerable improvement in recent decades, but stresses from multiple pollution sources (beginning well upstream in the Akron area) continue to impact fish communities downstream to Cleveland. The chronic impairment of the fish community, elevated levels of DELT anomalies (*i.e*, deformities, eroded fins, lesions, and tumors), and persistently high background nutrient levels suggest chronic toxic influences and an exceedence of the assimilative capacity. Surveys in the 1990s have detected incremental improvements in biological community health and a lessening of the severely toxic conditions encountered during the 1980s. However, there has been little change, positive or negative, downstream from Akron since 1991 (Table 9; Figures 3, 10, 12).

Cuyahoga River Lacustuary
- Big Creek to Lake Erie (RM 7.0-0.0)

In the navigation channel, cumulative loadings and flows from the 21 LTV outfalls make it one of the largest point source discharges in the Cuyahoga River basin. However, few chemical WQS criteria exceedences were detected near the plant and biological communities from the navigation channel were in full or partial attainment of the interim biological criteria for the Limited Resource Water designation. Potential steel plant impacts were generally masked by the already degraded conditions upstream and the poor habitat and water quality conditions in the navigation channel.

Poor and very poor biological communities coincide with the lack of suitable habitat, low dissolved oxygen, and chronically elevated ammonia and zinc levels between LTV and Lake Erie. While LTV appears a major source of zinc loadings, anaerobic decomposition of organic compounds in sediments may contribute to the elevated ammonia-N levels. Under summer pH and temperature conditions, the average level of ammonia-nitrogen downstream from the LTV complex could exceed chronic toxicity levels.

Chemical water quality conditions in the navigation channel continued to show improvement in 1996. Since the elimination of the LTV coking ovens in 1992-93, ammonia concentrations near the plant are often below the chronic WWH criterion. Total cyanide was not analyzed in 1996 but stream concentrations were expected to drop since the coking plant was considered a major source of the compound (Ohio EPA 1994). Perhaps the most significant water quality improvement in the navigation channel is the increased levels of dissolved oxygen. Since 1993, monthly ambient monitoring at West Third Street (RM 3.26) has routinely found minimum summer D.O. levels above the new 1.5 mg/l navigation channel standard for fish migration. D.O. levels below 1.5 mg/l however, were occasionally collected from other locations (NEORSD 1996). Like the ammonia trends, improvements in D.O. possibly resulted from elimination of the coking plant discharges and improved management of sewers within the NEORSD service area.

Cuyahoga River Tributaries

Biological and water quality sampling was conducted in fourteen Cuyahoga River tributaries during the 1996 survey (Table 1); the sampling results are summarized below.

West Branch Cuyahoga River (confluence RM 84.9)

The West Branch is a low gradient swamp-wetland influenced stream but sampling near the mouth revealed a lack of chemical WQS exceedences and generally very good biological communities. A fair MIwb score (7.3) resulted in partial WWH attainment and was considered a result of habitat limitations associated with the low-gradient and fine substrates. Despite the limiting nature of the habitat, the overall biotic integrity of the stream was considered good.

Black Brook (joins Cuyahoga River at RM 76.64)

Biological communities maintained good quality but appeared enriched downstream from the Black Brook Dike/LaDue Reservoir outlet (RM 2.64). Extremely high densities of filter-feeding midges suggest high suspended solids levels, possibly planktonic algae from the shallow epilimnetic reservoir release. Based on similarities in macroinvertebrate community composition, enrichment influences extended downstream from Black Brook and into the Cuyahoga mainstem. Chemical sampling detected occasional high solids levels in both streams but the concentrations appeared related to turbidity.

Bridge Creek (confluence RM 83.29)

Bridge Creek communities were in non-attainment and reflected extensive wetland habitat in the headwaters (RM 11.2). Macroinvertebrates were considered poor but fairly typical of swampy habitats. The fish community did not meet the WWH biocriterion but the predominance of grass pickerel, a top carnivore, indicated a high level of biological integrity for the marshy habitat. Fish and macroinvertebrates reached exceptional quality upstream from LaDue Reservoir (RM 8.5), but well downstream from the marshy conditions in the headwaters. This section of the stream is in an area typical of good warmwater habitat conditions (*i.e.*, hard bottom, coarse substrates, well developed riffle/pool habitats). Downstream from LaDue Reservoir, biological and water quality conditions were significantly impacted. Low dissolved oxygen levels and flow alteration stemming from the bottom releases contributed to the fair quality fish and macroinvertebrates at RMs 1.3 and 0.5.

Breakneck Creek (confluence RM 56.82)
Excepting one fish sample from an extensively pooled habitat, biological communities were of good to exceptional quality and in full attainment of WWH criteria in the upper 5-15 miles of Breakneck Creek. These sites were upstream from the Ravenna and Franklin Hills WWTPs and all known point source discharges.

Fish communities reflected significant impacts beginning downstream from the Ravenna WWTP (RM 3.1) and further, more severe degradation downstream from the Franklin Hills WWTP (RM 1.8). A poor MIwb score at RM 3.1 and very poor scores for both indices at RM 1.8 resulted in an approximate 2.5 mile section of non-attainment. In contrast, macroinvertebrate communities experienced some declines, but maintained good quality throughout the reach. No chemical WQS exceedences were detected, but the WWTPs had noticeable impacts on ammonia, nitrate, dissolved solids, and D.O. concentrations downstream.

Prior to entering the Cuyahoga River, Breakneck Creek fish communities improved to the fair range and biological communities were in partial attainment of WWH criteria. Elevated nutrient levels extended downstream into the Cuyahoga River but their contribution to low mainstem D.O. concentrations observed near Kent was indeterminate.

Since the 1996 survey, additional fish sampling and water quality investigations have been conducted in the reach downstream from the Franklin Hills WWTP. Results show substantial improvement in IBI scores (from very poor in 1996 to good in 1999) and lesser improvements in the MIwb (from poor to fair). Investigation into causes and sources continues, but longitudinal declines in IBI and MIwb scores in Breakneck Creek are probably a result of the combined effects of nutrient and oxygen demanding substances from the Ravenna and Franklin Hills WWTP. A recent model completed for the Middle Cuyahoga River TMDL shows the oxygen sag from these point source discharges coincide with the lowest IBI/MIwb scores.

Wahoo Ditch (joins Breakneck Creek at RM 4.8)
Macroinvertebrate communities were very poor downstream from the Ravenna WWTP and in non-attainment of the existing modified warmwater habitat (MWH) designation. Nitrate,

phosphorus and ammonia concentrations were substantially higher in Wahoo Ditch than in Breakneck Creek downstream and one dissolved oxygen measurement violated the MWH criterion. Potential biological impacts associated with the discharge however, were secondary to the severely limited, ditch-like habitat conditions. Loadings from the Ravenna WWTP have declined since the 1980s, but erratic treatment performance remained problematic into the 1990s.

Potter Creek (Congress Lake Outlet Tributary)
Potter Creek was in non-attainment of the designated WWH designation due to the poor quality of the fish community. Fish populations appeared impacted by historic stream modification and agricultural runoff. Phosphorus and suspended solids values were higher than average for the Breakneck Creek basin and probably result from extensive agricultural land use in the subbasin.

Mud Brook (confluence RM 39.78), Yellow Creek (conf. RM 37.16), Furnace Run (conf. RM 33.08), *Lower* Chippewa Creek (conf. RM 20.88)
Biological communities near the mouth of each tributary were in full attainment of the designated WWH criteria. Large portions of these streams are located in or near the Cuyahoga Valley National Recreation Area (CVNRA) and serve an important function as fish refugia and repopulation epicenters for the Cuyahoga River mainstem. The drainages are mostly forested and characterized by high stream gradient, intact physical habitat, and few, if any, WQS criteria exceedences. Urbanization in the watersheds was generally light or confined to flatter terrain located in the headwaters.

Little Cuyahoga River (confluence RM 42.27; see Ohio EPA 1998), Sand Run (conf. RM 39.12), Tinkers Creek (conf. RM 16.36), Mill Creek (conf. RM 11.49), Big Creek (conf. RM 7.2)
These watersheds were characterized by hardened urban landscapes which often included CSOs discharges (Mill Creek, Big Creek, Little Cuyahoga River), a predominance of effluent flow (Tinkers Creek), and marginal physical habitat, substrate, and riparian quality. Most experienced numerous chemical WQS criteria exceedences, pollutant spills and unauthorized discharges (Ohio EPA 1994), intermittent toxicity, and a legacy of historic environmental insults. Fish and macroinvertebrate communities were generally of poor quality and in non-attainment of WWH biocriteria.

Analysis of urban watersheds in the Cuyahoga basin (Ohio EPA 1997) shows a negative correlation between the percentage of urban land use in the watersheds (and associated chemical and physical impacts) and the quality of instream biological communities. These Cuyahoga River tributaries typified the extensively urbanized and degraded watersheds described in the study.

Brandywine Creek (confluence RM 24.17)
Biological communities in upper Brandywine Creek (RM 7.0) were in non-attainment and impacted by low D.O. and elevated ammonia levels downstream from the Village of Hudson #5

WWTP (RM 7.95). Chemical and biological quality showed some improvement near the mouth but an unknown source of high conductivity, first documented by NEDO in 1995, was encountered near the mouth during 1996 fish sampling. The levels were sufficient to disrupt electrofishing equipment efficiency and negate fish sampling results at the mouth. Despite the invalid results, the fish collection included the pollution sensitive redside dace and was not considered indicative of severe impacts. The marginally good condition of the macroinvertebrates at RM 0.2 resulted in full WWH attainment in the lower reaches of Brandywine Creek. Since the 1996 survey, the Hudson WWTP has been eliminated. The source of high conductivity remains unknown.

Chippewa Creek (confluence RM 20.88)
Compared to a 1984 survey, fish populations in the upper portion of the watershed were relatively unchanged and remained in non-attainment (poor quality). The Norton landfill had no noticeable effect on either the fish community or water quality of Chippewa Creek. Chippewa Creek was in substantial compliance with chemical WQS criteria throughout it’s length.

Substantial improvement in the fish community was documented near the mouth of Chippewa Creek. The comparative lack of improvement in the upper watershed was attributed to failing septic systems, nonpoint sources and upstream migration barriers posed by waterfalls which may hamper recruitment from downstream populations.

RECOMMENDATIONS

Status of Aquatic Life Uses

Some streams evaluated in this study were originally designated for aquatic life uses in the 1978 Ohio WQS. The techniques used then did not include standardized approaches to the collection of instream biological data or numerical biological criteria. Since this study may represent the first time biological data were used to evaluate and establish aquatic life use designations in these streams (e.g., Sand Run), some changes may appear to constitute "downgrades" (*i.e.*, EWH to WWH, WWH to MWH, etc.) or "upgrades" (*i.e.*, LWH to WWH, WWH to EWH, etc.). However, these changes should not be so construed because this would represent the first use of an objective and robust use evaluation system and database. Ohio EPA is under obligation by a 1981 public notice to review and evaluate all aquatic life use designations outside the WWH use before basing any permitting actions on the existing, unverified use designations. Thus, some of the following aquatic life use recommendations constitute a fulfillment of that obligation. Recommended changes or additions to stream designations based on the 1995 Cuyahoga River survey results are noted in Table 2.

Sand Run

- Previously undesignated, Sand Run is a small, high gradient drainage that originates in the Akron suburb of Fairlawn and enters the Cuyahoga River at RM 39.12. Physical habitat conditions at the mouth (QHEI = 59) were somewhat marginal but considered adequate to support WWH communities. While there was evidence of habitat degradation from urban runoff, channel morphology was natural and the riparian border was intact. Biological community health was poor/very poor, apparently a result of flashy stream flow, embedded substrates, and urban drainage in the headwaters. Considering the lack of channel maintenance, historic channel modification, and large watershed size (*i.e.*, >3 sq.mi.), Warmwater Habitat is considered the most applicable aquatic life use designation.

Table 2. Recommended changes in waterbody use designations for the Cuyahoga River basin study area. New use designations appear in bold italics and are designated with a ▲.

Stream Segment	**Use Designations**													**Comments**
		Aquatic Life Habitat						**Water Supply**			**Recreation**			
	SRW	**WWH**	**EWH**	**MWH**	**SSH**	**CWH**	**LRW**	**PWS**	**AWS**	**IWS**	**BW**	**PCR**	**SCR**	
Sand Run - entire length		▲										▲		

Status of Non-Aquatic Life Uses

With the exception of the previously undesignated Sand Run, no changes in existing non-aquatic life use designations are recommended.

- Sand Run was previously undesignated. Habitats in this small, urban stream included pool depth greater than one meter behind a low-head dam in a City of Akron Park near the mouth. For this reason, the Primary Contact Recreation designation is considered appropriate.

Other Recommendations

- Efforts should continue to abate impacts from CSOs and urban runoff in the Akron and Cleveland metropolitan areas. Monitoring should continue to evaluate the effectiveness of control strategies.

- The sources of total suspended solids that are being discharged to the Cuyahoga River mainstem needs to be identified, and actions taken to control loss of soil through implementation of BMPs.

- The results of the 1996 survey indicated that nutrient enrichment in the form of phosphorus and nitrate nitrogen may be a significant cause of non-attainment of the fish community between the Akron and NEORSD Southerly WWTPs. It is recommended that future studies be conducted on the dynamics of the algae communities (both planktonic and periphyton) in this stream segment in relation to uptake of phosphorus and nitrogen compound concentrations and potential limitation by suspended sediments.

- Fecal coliform bacteria levels continue to exceed the Primary Contact Recreation criteria in the Cuyahoga River between Akron and the mouth after rain events. The Akron WWTP has been identified as the primary contributor to high concentrations of fecal coliform bacteria in the river. Akron needs to address the apparent inadequate disinfection of their secondary treatment bypasses. Other sources of fecal coliform bacteria in the watershed, such as CSOs, urban runoff, and other non-point sources, should be identified, prioritized, and corrective actions taken to reduce concentrations in the river.

- The exceedences of stream temperature criteria in the navigation channel segment downstream from the LTV steel complex should be addressed in future NPDES permit renewals.

- Efforts should continue to study the effects from Akron water supply reservoirs on the upper Cuyahoga River. Monitoring should be implemented to evaluate the effectiveness of management strategies if implemented.

- Discussions should continue with the City of Akron and other affected parties concerning water management in the section of the Cuyahoga River between Lake Rockwell and Cuyahoga Falls.

- Ohio EPA should develop a comprehensive strategy to address WWTP expansion decisions in the Cuyahoga basin. Particular concern should apply to tributaries or stream reaches that have the potential to function as biological repopulation epicenters for the distribution of fish downstream. Among these tributaries are Breakneck Creek, Yellow Creek, Furnace Run, Mud Run, and lower Chippewa Creek. The Edison gorge section of the mainstem should also be considered as a significant repopulation source for the lower mainstem.

- Mill Creek and Big Creek in the Cleveland metropolitan area receive point source discharges and polluted runoff from many sources but neither stream has been evaluated for sediment PAHs *(i.e.*, poly-aromatic hydrocarbons). PAHs are a family of organic compounds that are commonly derived from fossil fuel processing or combustion or from industrial processes. High sediment PAH concentrations have been linked to tumors in brown bullead catfish by

Paul Bauman and others (Bauman *et. al.* 1982).

- No additional pollutant loadings should be permitted in the Mill Creek and Big Creek watersheds. A more comprehensive survey of the Big Creek subbasin is needed to specifically identify problem areas and sources of impact. In Mill Creek, recent construction of a large chamber to store combined flow after rain events should reduce impacts to Mill Creek; those sources of impact that remain have been documented by the NEORSD.

Future Monitoring Needs

Tinkers Creek Subbasin

- The effects of the high concentrations of nitrate and phosphorus on nutrient dynamics and stream fish communities should be investigated. Elevated nutrients may be acting to limit the biological potential, particularly among fish communities, in Tinkers Creek. If found to have a deleterious effect, the feasibility and economic impact of nitrate or phosphorus removal at WWTPs should then be investigated.

- Nonpoint sources of suspended solids should be identified and best management land use and/or construction practices should be developed for the Tinkers Creek subbasin. Additional investigations should be conducted to learn the source of the elevated ambient levels of suspended solids.

Mill Creek and Big Creek Subbasins

- Monitoring at the mouths of each tributary is needed to document potential improvements following continued sewage system remediation and implementation efforts.

Furnace Run

- Furnace Run is an important fish repopulation epicenter for the mainstem of the Cuyahoga River within the CVNRA. Any additional loadings of pollutants proposed for the watershed should be carefully scrutinized by OEPA.

Brandywine Creek

- Excessively high conductivity levels have been encountered in Brandywine Creek on two occasions in 1995 and 1996. Further attempts should be made to locate the source of the dissolved solids. In addition, expected recovery trends should be monitored after the Hudson WWTP discharge was eliminated in 1998 and tied into the Cuyahoga Valley Interceptor.

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 (1994). 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, 1994). 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 in-stream 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.

Fish Community Assessment

Fish were sampled using wading or boat method pulsed DC electrofishing gear. The wading method was used at a frequency of one or two samples at each site. The boat method was used at a frequency of two samples at each site. IBI metric scores and raw fish sampling data from the 1996 sites can be found in Appendix C.

Macroinvertebrate Community Assessment

Macroinvertebrates were sampled quantitatively using multiple-plate, artificial substrate samplers (modified Hester/Dendy) in conjunction with a qualitative assessment of the available natural substrates. ICI metric scores and raw sampling data from the 1996 sites can be found in Appendix D.

Area of Degradation Value (ADV)

An Area Of Degradation Value (ADV; Yoder and Rankin 1995) was calculated for the study area based on the longitudinal performance of the biological community indices. The ADV portrays the length or "extent" of degradation to aquatic communities and is simply the distance that the biological index (IBI, MIwb, or ICI) departs from the applicable biocriterion or the upstream level of performance (Figure 4). The “magnitude” of impact refers to the vertical departure of each index below the biocriterion or the upstream level of performance. The total ADV is represented by the area beneath the biocriterion (or upstream level) when the results for each index are plotted against river mile. The results are also expressed as ADV/mile to normalize comparisons between segments and other streams and rivers.

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 1994). 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

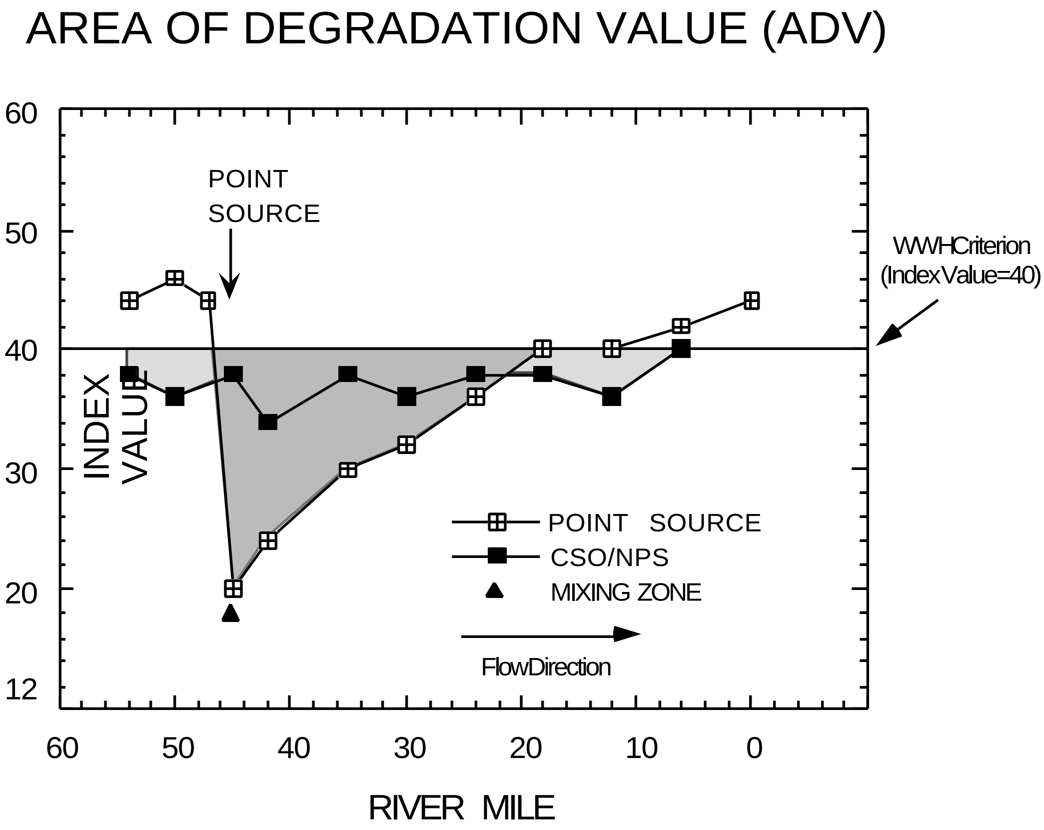


Figure 4. Graphic illustration of the Area of Degradation Value (ADV) based on the ecoregion biocriterion (WWH in this example). The index value trend line indicated by the unfilled boxes and solid shading (area of departure) represents a typical response to a point source impact (mixing zone appears as a solid triangle); the filled boxes and dashed shading (area of departure) represent a typical response to a nonpoint source or combined sewer overflow impact. The blended shading represents the overlapping impact of the point and nonpoint sources.

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.

STUDY AREA

Cuyahoga River Basin

The Cuyahoga River basin drains 813 square miles and includes 1,220 stream miles spanning parts of Geauga, Portage, Summit and Cuyahoga counties, emptying into Lake Erie at Cleveland. A more detailed description of basin and watershed characteristics can be found in Ohio EPA 1994 (1991 survey results). The 1996 survey area included almost ninety-one river miles of the Cuyahoga mainstem from East Branch Reservoir in Geauga county to Lake Erie. Seventeen basin tributaries were also sampled and a major study of the Little Cuyahoga River watershed was conducted during the same period (Ohio EPA 1998). A listing of 1996 chemical and biological sampling locations can be found in Table 3a.

The City of Akron has 41 combined sewer overflows and the Northeast Ohio Regional Sewer District in Cleveland has 74 of their permitted 135 combined sewer overflow outfalls within the Cuyahoga watershed. A longitudinal (upstream to downstream) listing of significant point source discharges in the Cuyahoga River basin are listed in Table 3b.

Table 3a. Sampling locations (effluent sample-E, water chemistry-C, sediment-S, macro invertebrates-M, fish-F, Datasonde-D) in the Cuyahoga River study area, 1996.

Stream/ River Mile	Sample Type	Latitude / Longitude	Landmark	USGS 7.5 min. Quad
Cuyahoga River				
90.9	F,M,D	41 30 10 / 81 05 49	SR 608	East Claridon
90.86	C	41 30 10 / 81 05 49	SR 608, Dst. E. Br. Reservoir	East Claridon
87.36	M,D	41 27 55 / 81 07 34	SR 87	Burton
87.26	C.F,D	41 27 53 / 81 07 39	SR 87	Burton
86.1	D	41 27 24 / 81 08 49	Dst. Burton WWTP	Burton
85.5	D	41 26 54 / 81 09 03	Dst. Burton WWTP	Burton
84.9	D	41 26 24 / 81 09 08	Dst. Burton WWTP	Burton
84.1	M	41 25 45 / 81 09 14	Ust. Russell Park	Burton
83.8	F,C	41 25 30 / 81 09 24	Russell Park	Burton
83.5	D	--	Russell Park	Burton
80.51	F,C,S,D	41 23 12 / 81 09 29	SR 422	Burton
80.4	M	41 23 07 / 81 09 27	SR 422	Burton
75.83	C,F,M,S	41 20 26 / 81 10 01	Winchell Rd.	Mantua
71.7	C,F,M,D	41 18 02 / 81 12 11	Pioneer Trail	Mantua
67.56	M,C,D	41 16 06 / 81 14 46	Infirmary Rd.	Mantua
65.1	F	41 14 57 / 81 16 29	Coit Rd.	Kent
64.5	F	41 14 59 / 81 16 51	SR 303-Shalersville	Kent
64.3	S	41 14 42 / 81 17 09	SR 303-Shalersville	Kent
63.26	C	41 14 42 / 81 17 11	SR 303-Shalersville	Kent
64.2	M,D	41 14 36 / 81 17 28	SR 303	Kent
57.67	C,D,S	41 10 49 / 81 20 09	Ravenna Rd	Kent
57.6	M	41 10 47 / 81 20 09	Ravenna Rd	Kent
57.5	F	41 10 42 / 81 20 05	Ravenna Rd	Kent
57.1	D	--	Ravenna Rd	Kent
56.1	M	41 10 02 / 81 20 51	Standing Rock Cemetery	Kent
56.0	F	41 10 02 / 81 20 51	Standing Rock Cemetery	Kent
55.8	C,D,S	41 10 02 / 81 20 57	Standing Rock Cemetery	Kent
55.4	D	--	Ust. Crain Ave.	Kent
54.8	D	--	Dst. Kent Dam	Kent
54.4	M	41 09 00 / 81 21 57	Fred Fuller Park	Kent
54.32	C	41 08 58 / 81 22 03	Fred Fuller Park	Kent
54.2	F	41 08 55 / 81 22 09	Fred Fuller Park	Kent
53.9	D	41 09 01 / 81 21 53	Fred Fuller Park	Kent
53.4	C,F,M,D,S	41 08 33 / 81 22 39	Dst Kent WWTP/Middlebury Rd	Hudson
52.85	D	--	Munroe Falls Dam pool	Hudson
52.55	D	--	Munroe Falls Dam pool	Hudson
52.22	D	--	Munroe Falls Dam pool	Hudson
52.0	F,D	41 08 21 / 81 23 32	Dam pool, ust. Fishcreek	Hudson
51.66	D	--	Dst. Fishcreek, ust. WWTP	Hudson
51.35	D	--	Dam pool, dst. Fishcreek WWTP	Hudson

Table 3a. (continued).

Stream/ River Mile	Sample Type	Latitude / Longitude	Landmark	USGS 7.5 min. Quad
Cuyahoga River (continued)				
51.0	F,D	41 08 13 / 81 25 41	Dam pool, dst. Fishcreek WWTP	Hudson
50.7	D	--	Dam pool, dst. Fishcreek WWTP	Hudson
50.0	C,S,D	41 08 30 / 81 26 12	Dam pool, ust. Munroe Falls Dam	Hudson
49.78	C,M,D	41 08 32 / 81 26 21	Dst. Munroe Falls Dam, SR 91	Hudson
48.7	F	41 08 51 / 81 27 22	Dst. Munroe Falls Dam, SR 91	Hudson
48.38	C	41 08 45 / 81 27 27	Dst. WaterWorks Park	Hudson
48.2	D	--	Dst. WaterWorks Park	Hudson
48.1	D	--	Dst. WaterWorks Park	Hudson
48.0	F,M	41 08 46 / 81 27 45	Dst. WaterWorks Park	Hudson
46.2	C,S	41 07 24 / 81 30 39	Dst Cuy. Falls-Broad Blvd.	Hudson
46.0	F	41 07 49 / 81 28 58	Dst Cuy. Falls/Ust Gorge Dam	Hudson
45.9	M	41 07 44 / 81 29 00	Dst Cuy. Falls/Ust Gorge Dam	Hudson
44.0	F,M,D	41 07 22 / 81 30 28	Edison Gorge	Akron West
43.8	C	41 07 24 / 81 30 39	Dst. Gorge Dam-Cascade Pk.	Akron, West
42.8	M,D	41 07 01 / 81 31 22	Cuyahoga St.	Akron West
42.6	C,S	41 07 01 / 8131 30	Cuyahoga St.	Akron, West
42.0	F	41 07 16 / 81 32 00	Dst L. Cuy. R & Rack 36	Akron, West
41.9	M	41 07 20 / 81 32 02	Dst L. Cuy. R & Rack 36	Akron, West
41.71	C	41 07 28 / 81 31 54	Dst. L. Cuyahoga/Rack 36	Akron, West
41.6	D	--	Dst. L. Cuyahoga/Rack 36	Akron, West
37.97	F,M	41 09 10 / 81 34 05	Ust. Akron WWTP	Peninsula
37.9	S	41 09 04 / 81 34 04	Ust. Akron WWTP	Peninsula
37.4	C,F,M	41 09 36 / 81 34 23	Akron WWTP mix zone	Peninsula
37.2	F,C	41 09 44 / 81 34 28	Bath Rd.	Peninsula
37.1	M	41 09 04/ 81 34 04	Bath Rd.	Peninsula
35.31	C,S,F,M,D	41 10 53 / 81 35 02	Ira Rd.	Peninsula
33.3	F,M	41 12 00 / 81 34 09	Bolanz Rd	Peninsula
33.22	C,D	41 12 07 / 81 34 07	Bolanz Rd.	Peninsula
29.08	S,D	41 14 32 / 81 32 59	Peninsula	Peninsula
27.2	F	41 15 16 / 81 33 15	Boston Mills	Northfield
26.5	C,M	41 15 46 / 81 33 37	Boston Mills Rd.	Northfield
22.0	F	41 19 02 / 81 35 05	Ust Station Rd.dam pool	Northfield
20.8	C	41 07 01 / 81 31 30	Station Rd.	Northfield
20.7	M	41 19 13 / 81 35 16	Station Rd. (tailwaters)	Northfield
17.3	C	41 21 20 / 81 35 53	Fitzwater Rd.	Northfield
17.0	M	41 21 38 / 81 36 03	Fitzwater Rd.	Northfield
16.5	F	41 21 17 / 81 36 27	Fitzwater Rd.	Northfield
15.9	F	41 22 15 / 81 36 53	Hillside Rd.	Northfield
15.6	M	41 22 44 / 81 36 53	Hillside Rd.	Northfield
13.18	C	41 23 43 / 81 37 48	Independence gage	Clev.- South
11.5	F	41 25 04 / 81 38 30	Ust. Southerly WWTP	Cleveland South
11.0	M,D	41 25 04 / 81 38 50	Ust. Southerly @ RR	Cleveland South

Table 3a. (continued).

Stream/ River Mile	Sample Type	Latitude / Longitude	Landmark	USGS 7.5 min. Quad
Cuyahoga River (continued)				
10.95	C	41 25 50 / 81 38 52	Ust. Southerly @ RR	Clev.- South
10.5	M	41 25 10 / 81 39 22	Southerly mix zone	Cleveland South
10.4	F	41 25 16 / 81 39 27	Southerly mix zone	Cleveland South
9.7	C,M	41 25 37 / 81 39 57	@ SW interceptor	Clev.- South
9.6	F	41 25 39 / 81 40 02	@ SW interceptor	Clev.- South
8.3	C,M,F	41 26 22 / 81 40 15	Ust. Bradley Rd. smelters	Clev.- South
7.2	F	41 26 51 / 81 41 05	Dst. Big Creek	Clev.- South
7.1	C	41 26 52 / 81 41 06	Lower Harvard Ave.	Clev.- South
7.0	S	41 26 54 / 81 41 02	Lower Harvard Ave.	Clev.- South
5.8	M	41 27 50 / 81 40 47	Ust. Shipping Channel	Cleveland South
5.6	C,F	41 27 53 / 81 40 37	@ LTV 802 intake	Cleveland South
5.0	C,M	41 28 14 / 81 40 09	Clark Ave.	Clev.- South
4.8	F	41 28 23 / 81 40 10	Clark Ave.	Clev.- South
4.3	C,	41 28 41 / 81 40 24	Ust. Kingsbury Run	Clev.- South
3.26	C,M	41 29 17 / 81 41 07	West Third St.	Clev.- South
3.1	F	41 29 1 / 28 14 117	West Third St.	Clev.- South
1.4	C,S	41 29 22 / 81 42 13	Dst Columbus Ave @ bend	Clev.- South
1.3	F	41 29 20 / 81 42 15	Dst Columbus Ave @ bend	Clev.- South
1.2	M	41 29 26 / 81 42 17	Dst Columbus Ave @ bend	Clev.- South
0.5	F	41 29 53 / 81 42 21	Near mouth	Clev.- South
0.0	S	41 30 14 / 81 42 44	Mouth	Clev.- South
West Branch Cuyahoga River (Confluence RM 84.9)				
0.87	C,M,F	41 27 02 / 81 09 32	Rapids Road	Middlefield
Bridge Creek (Confluence RM 83.29)				
11.22	C,M,F	41 24 35 / 81 16 02	Stafford Rd Ust. LaDue Res.	South Russell
8.46	C,M,F,D	41 22 39 / 81 15 51	Taylor May Rd.	South Russell
1.32	C,M,D	41 24 49 / 81 10 34	Stafford Rd Dst. LaDue Res.	Burton
0.5	F	41 25 07 / 81 10 03	Dst. LaDue Res.	Burton
Black Brook (Confluence RM 76.64)				
1.78	C,M,F,D	41 21 02 / 81 11 46	Fox Rd.	Mantua
Breakneck Creek (Confluence RM 56.82)				
14.7	M	41 05 12 / 81 18 04	End of Homestead Ave.	Suffield
14.6	C,S	41 05 14 / 81 17 59	End of Homestead Ave.	Suffield
12.7	S	41 05 58 / 81 16 20	Tallmadge Rd.	Suffield
9.5	F	41 07 24 / 81 16 14	Sandy Lake Rd.	Suffield
7.0	C,S	41 08 22 / 81 16 15	Summit Rd.	Kent
6.9	M	41 08 25 / 81 16 14	Summit Rd.	Kent
6.8	F	41 08 22 / 81 16 07	Summit Rd.	Kent

Table 3a. (continued).

Stream/ River Mile	Sample Type	Latitude / Longitude	Landmark	USGS 7.5 min. Quad
Breakneck Creek (continued)				
5.19	C,M,F,D	41 08 54 / 81 16 56	Lakewood Rd	Kent
3.08	C,M,F,D	41 08 40 / 81 18 29	Fox Powder Mill Rd.	Kent
1.8	M	41 09 17 / 81 19 04	SR 59	Kent
1.66	C,F,D	41 09 21 / 81 19 08	SR 59	Kent
0.4	S	41 09 55 / 81 19 57	Near Mouth	Kent
0.28	C,D	41 09 59 / 81 20 17	Near Mouth	Kent
0.2	F	41 10 07 / 81 20 15	Near Mouth	Kent
0.1	M	41 10 08 / 81 20 15	Near Mouth	Kent
Wahoo Ditch (Confluence RM 56.82/4.8)				
0.39	C,M	41 09 05 / 81 16 47	Lakewood Rd	Kent
Potter Creek (Confluence RM 56.82/1.67/10.22)				
1.6	C,S	41 02 34 / 81 17 45	Trares Rd	Suffield
1.8	M	41 02 34 / 81 17 59	Trares Rd	Suffield
1.5	F	41 02 37 / 81 17 46	Trares Rd	Suffield
Sand Run (Confluence RM 39.12)				
0.4	F	41 08 30 / 81 33 53	Park Rd.	Peninsula
0.20	C,M	41 08 55 / 81 33 53	Park Rd.	Peninsula
Yellow Creek (Confluence RM 37.16)				
1.5	F	41 09 43 / 81 35 54	Dst. North Fork	Peninsula
0.14	C	41 09 48 / 81 34 34	Riverview Rd.	Peninsula
0.1	M	41 09 38 / 81 34 31	Riverview Rd.	Peninsula
North Fork Yellow Creek (Confluence RM 37.16/4.64)				
0.3	S	41 09 43 / 81 38 13	Ust Robinwood Hills WWTP	Peninsula
Furnace Run (Confluence RM 33.1)				
0.9	M,F,S	41 12 14 / 81 35 01	Covered Bridge	Peninsula
0.27	C	41 12 05 / 81 34 25	Everett Rd.	Peninsula
Chippewa Creek (Confluence RM 20.88)				
6.03	C,M,F	41 19 21 / 81 40 27	Avery Rd.	Broadview Heights
3.72	C,M,F	41 19 21 / 81 38 40	Harris Rd.	Broadview Heights
3.45	S	41 19 16 / 81 38 26	Old Royalton Rd.	Broadview Heights
0.36	C,M,F	41 19 01 / 81 35 32	Riverview Rd.	Northfield
Brandywine Creek (Confluence RM 24.16)				
7.02	C,M,F	41 15 36 / 81 29 20	Hines Hill Rd.	Twinsburg
0.4	F	41 17 09 / 81 33 31	Tecumseh Box Co. Rd.	Northfield

Table 3a. (continued).

Stream/ River Mile	Sample Type	Latitude / Longitude	Landmark	USGS 7.5 min. Quad
Brandywine Creek (continued)				
0.3	M	41 17 09 / 81 33 40	Tecumseh Box Co. Rd.	Northfield
0.24	C	41 17 08 / 81 33 46	Tecumseh Box Co. Rd.	Northfield
Tinkers Creek (Confluence RM 16.36)				
28.8	S	41 12 54 / 81 22 25	Near Herrick Nature Prsrv	Kent
25.0	S	41 15 46 / 81 23 40	Near Herrick Nature Prsrv	Kent
0.2	F	41 21 57 / 81 36 26	Canal Rd.	Northfield
0.1	C,M	41 21 53 / 81 36 33	Canal Rd.	Northfield
Pond Brook (Confluence RM 16.36/22.51)				
4.5	S	41 20 31 / 81 24 20	Ust Aurora Shores	Twinsburg
Mill Creek (Confluence RM 11.49)				
5.6	S	41 25 27 / 81 35 05	McCracken Rd	Shaker Heights
4.3	F	41 25 57 / 81 36 21	Garfield Park	Shaker Heights
3.4	M	41 26 23 / 81 37 01	Broadway Blvd. nr. hospital	Shaker Heights
3.5	S	41 26 16 / 81 36 53	Broadway Blvd. nr. hospital	Shaker Heights
3.1	C	41 26 10 / 81 36 31	Ust. Landfills	Clev.- South
0.2	M,F,S	41 25 22 / 81 38 13	Canal Rd.	Clev.- South
0.12	C	41 26 33 / 81 37 23	Canal Rd.	Clev.- South
Big Creek (Confluence RM 7.2)				
7.8	C	41 24 32 / 81 45 18	Park Dr.	Clev.- South
2.58	C	41 27 03 / 81 43 32	Ust. Zoo @ Brookside Park	Clev.- South
2.5	M,F	41 27 02 / 81 43 24	Ust. Zoo @ Brookside Park	Clev.- South
0.23	C,D	41 26 48 / 81 41 18	Jennings Rd.	Clev.- South
Ford Branch Big Creek (Confluence RM 7.2/4.37)				
0.1	S	41 26 46 / 81 45 19	Near mouth	Clev.- South
Morgan Run (Confluence RM 5.07)				
0.01	C	41 28 11 / 81 40 8	At mouth	Clev.- South
Kingsbury Run (Confluence RM 4.15)				
0.10	C	41 28 53 / 81 40 36	At Mouth	Clev.- South

Table 3b. Location of significant point source discharges by receiving stream and river mile within the Cuyahoga River basin.

Point Source Dischargers	Receiving Stream	River Mile
Cuyahoga River		
Hans Rothenbuhler & Sons	Unnamed Trib. to Tare Creek	88.5/1.09/3.7
Middlefield WWTP	Unnamed Trib. to Sperry Pond	88.02/1.8
Burton WWTP	Cuyahoga River	86.4
Mantua WWTP	Cuyahoga River	69.18
Portage Co. Twin Lakes WWTP	Unnamed Trib. to Cuyahoga River	57.82/0.7
Akron Water Treatment Plant (WTP)	Unnamed Trib. to Cuyahoga River	57.82/0.2
Akron WTP	Cuyahoga River	57.81
Akron WTP	Cuyahoga River	57.61
Portage Co. Franklin Hills WWTP	Breakneck Creek	56.82/2.52
Ravenna WWTP	Wahoo Ditch via Homman Avenue Ditch	56.82/4.8/0.5/0.85
Kent WWTP	Cuyahoga River	53.9
Summit County Fishcreek WWTP	Cuyahoga River	51.4
Cuyahoga Falls WTP	Cuyahoga River	48.4
Akron CSOs	Cuyahoga River	RMs 45.1 - 41.3
Akron CSOs	Little Cuyahoga River	42.3
Akron WWTP	Cuyahoga River	7.45
Hudson WWTP	Brandywine Creek	24.16/7.95
Twinsburg, Bedford Heights, Bedford, Solon, Streetsboro, Aurora Shores, Auror Westerly WWTPs	Tinkers Creek basin	16.4
Cleveland CSOs	Mill Creek basin	11.5
Cleveland CSOs	West Creek basin	11.05
NEORSD Southerly WWTP	Cuyahoga River	10.57
Cleveland CSOs	Cuyahoga River	RMs 11.4 - 0.3
Cleveland CSOs	Spring Creek basin	Unknown
Cleveland CSOs	Big Creek basin	7.2
LTV Steel	Cuyahoga River	6.8-4.5
Cleveland CSOs	Burke Brook basin	5.3
Cleveland CSOs	Morgan Run basin	5.07
Cleveland CSOs	Kingsbury Run basin	4.15

RESULTS AND DISCUSSION

Upper Cuyahoga River - Headwaters to Lake Rockwell (RMs 90.9 to 63.2)

Pollutant Loadings - Headwaters to Lake Rockwell

Several small point sources discharge to the upper Cuyahoga River basin but only two, the Burton WWTP (RM 86.4) and Mantua WWTP (RM 69.18), discharge directly to the mainstem. The Middlefield WWTP and Hans Rothenbuhler & Sons (Middlefield Swiss Cheese) WWTP are located on small unnamed tributaries that eventually drain to a large wetland complex on Tare Creek near Burton. A few small package plant discharges and numerous on-site septic tank systems are also scattered throughout the drainage. None of the discharges exceed 1.0 mgd capacity and most are much smaller.

The Hans Rothenbuhler & Sons (Middlefield Swiss Cheese) WWTP has had slightly increasing flows since 1991. Despite the increasing flows, five day biochemical oxygen demand (BOD_5) loadings show a decreasing trend. This facility has had a history of compliance problems and is conducting sampling and modelling activities to gather information for an expansion request.

The Middlefield Village WWTP has had slightly increasing flows since 1991 but decreasing loadings of suspended solids (TSS), total phosphorus, and ammonia-nitrogen.

The Village of Burton WWTP has had slightly increasing flows since 1991 and requested expansion from 0.27 to 0.35 MGD.

The Village of Mantua is evaluating plant expansions from their current capacity of 0.30 MGD, to 0.45, 0.6, or 1.0 MGD. Flows from the WWTP are variable with relatively large annual fluctuations and no apparent trend for most of their pollutant loadings. Despite the fluctuations in flow, ammonia-nitrogen loadings has shown a steady decline since 1992 (Figure 5).

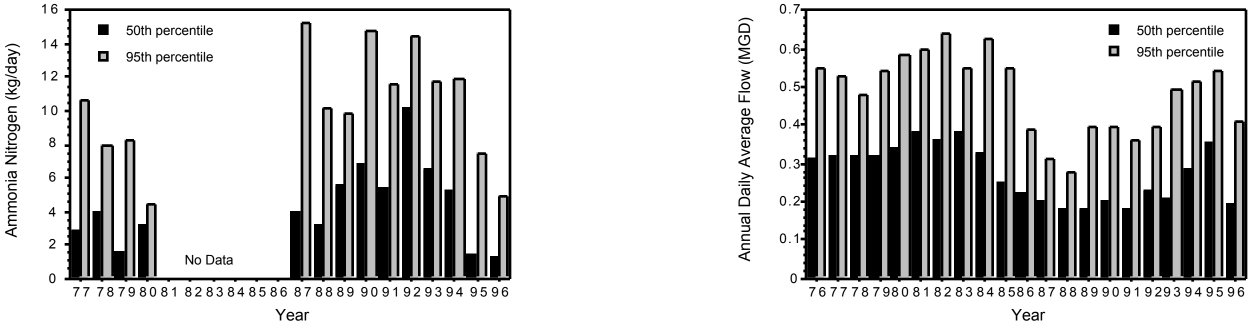


Figure 5. Annual median and 95th percentile loadings of ammonia-nitrogen (kg/day), and discharge (mgd) from the Mantua WWTP, 1976-96.

Surface Water Quality - Headwaters to Lake Rockwell

Flow hydrographs for the Hiram, Portage Path and Independence gauges for 1996 are shown in Figure 6. The Cuyahoga River is a heavily managed river system with many dams, reservoirs, canals and other hydromodifications. The Hiram gauge is influenced by storage and releases from LaDue and East Branch Reservoirs. These reservoirs release water during lower flows to supplement the City of Akron drinking water supply at Lake Rockwell which removes approximately 39 MGD. This withdrawal and the storage of water in Mogadore reservoir effect flows at the Portage Path gauge, immediately upstream from the Akron WWTP. Downstream from Akron, water is also diverted from the Cuyahoga River into the bed of the old Ohio and Erie canal at Station Road. This diversion was previously used as an industrial water supply, but is now primarily used for recreational purposes within the Cuyahoga Valley National Recreation Area (CVNRA). The Ohio Department of Natural Resources diverts approximately 4.2 MGD from the Tuscarawas River basin to the Cuyahoga River basin via the Ohio and Erie Canal for industrial use and to replenish water lost to the Ohio River Basin from the Akron drinking water distribution system. The Little Cuyahoga River was dammed to form Mogadore Reservoir which was used for industrial water supply by the City of Akron. It is now used primarily for recreation. In the Breakneck Creek Basin, the City of Ravenna uses approximately 2.0 MGD from Lake Hodgson and the City of Kent diverts 0.5 MGD into recharge basins for drinking

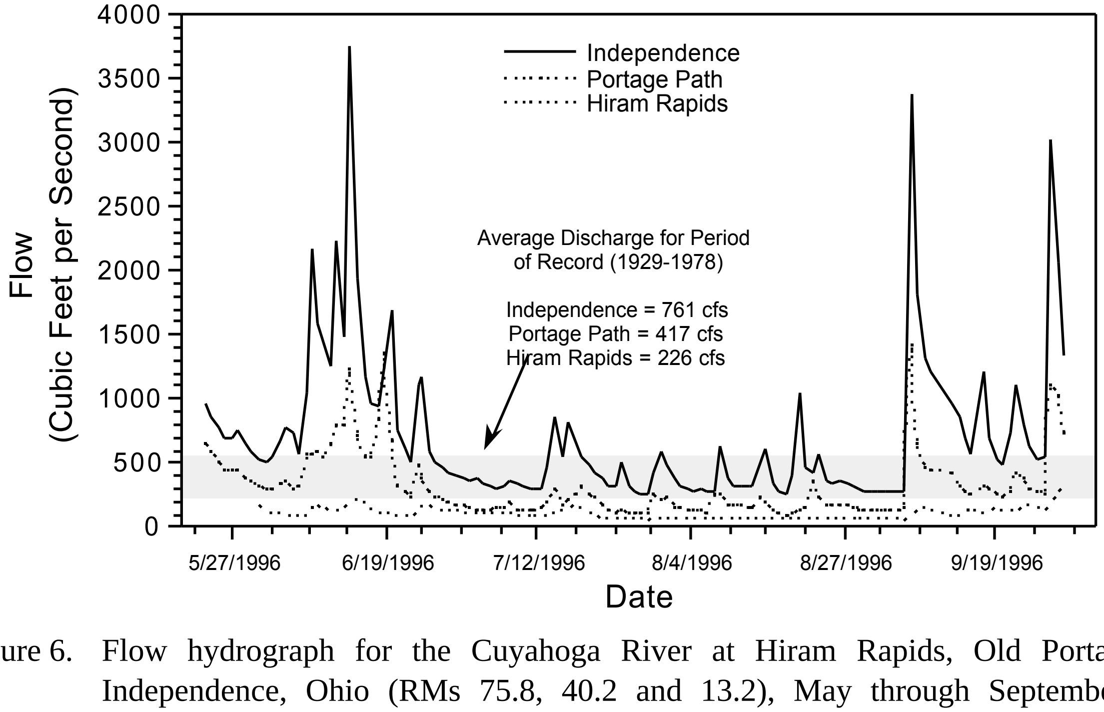


Figure 6. Flow hydrograph for the Cuyahoga River at Hiram Rapids, Old Portage and Independence, Ohio (RMs 75.8, 40.2 and 13.2), May through September,1996. Average daily flow [226-761 cfs] from May through November for period of record 1929 to 1978 [all inclusive dates]) are indicated on the flow hydrograph.

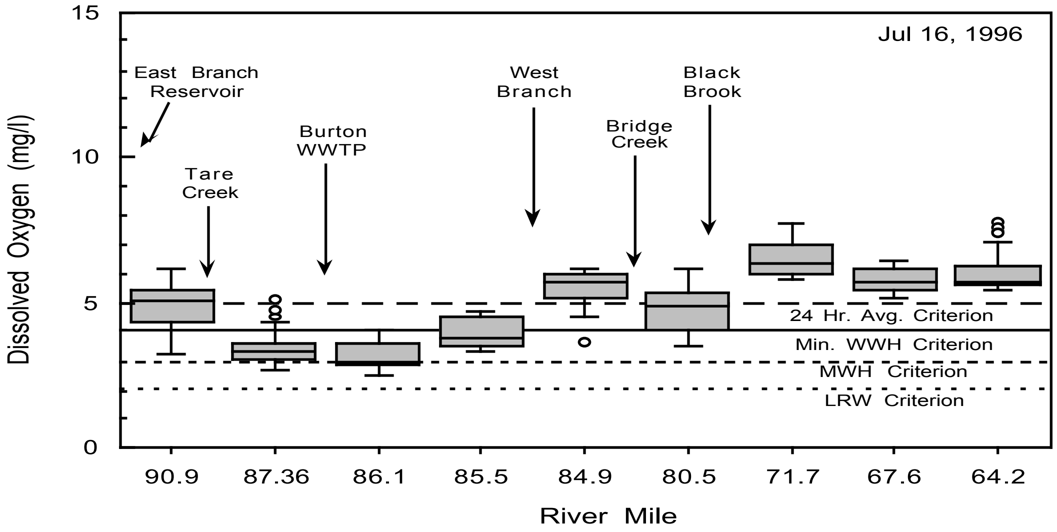
water supplies. There are other smaller control structures within the basin as well as modifications to natural lakes which were modified to increase storage capacity for use by the Beaver and Ohio canals. Like Mogadore Reservoir and the Ohio Canal, many of the structures and modifications no longer serve the original purposes for which they were designed. Table 4 lists the significant reservoirs within the Cuyahoga basin and their storage capacities.

Table 4. Significant Cuyahoga River reservoirs and storage capacities (from ODNR, Division of Water).

Reservoir / Low head dam	Water Body	Dam River Mile	Storage Capacity (acre feet)
East Branch	Cuyahoga River	91.07	4600
Wendall R. LaDue	Bridge Creek	2.25	18100
Wendall R. LaDue	Black Brook	2.64	18100
Mogadore	Little Cuyahoga River	12.78	700
Lake Rockwell	Cuyahoga River	57.97	8172
Kent	Cuyahoga River	54.87	200
Munroe Falls	Cuyahoga River	50.0	NA
Cuyahoga Falls	Cuyahoga River	46.2	56
Ohio Edison	Cuyahoga River	45.0	589
Station Rd (canal diversion)	Cuyahoga River	20.8	0

Grab water samples (5X) were collected from 13 mainstem and tributary stations between June 27 and August 16 in the Upper Cuyahoga River watershed (Appendix A, Table 1). The samples were collected during non-storm events to assess point source dischargers impacts. All stations were sampled on the same day to reduce sampling variance. The sampling was conducted during an average to slightly wet year with the lowest flow in the river at the Hiram Rapids gauge during the 1996 sampling at 63 cfs. The Q7-10 at the gauge is 15 cfs.

Datasonde™ continuous monitors suggest severe D.O. depletion in the upper reaches of the mainstem and gradual improvements with increased distance downstream (Figure 7; Table 5). During two sampling runs in July and August, 68% of the measurements from sites between the East Branch Reservoir and Burton (RM 90.0-87.26) fell below the minimum WWH criterion (4 mg/l). Between Burton and Bridge Creek (RMs 86.1-80.5) almost 60% of the measurements fell below the daily average criterion (5 mg/l). Mean D.O. concentrations were less then 4 mg/l between RMs 90.9 and 83.5 and less then 5 mg/l as far downstream as RM 80.5. Excepting a decline between Hiram Rapids and Mantua (RM 71.7), D.O. saturation gradually improved



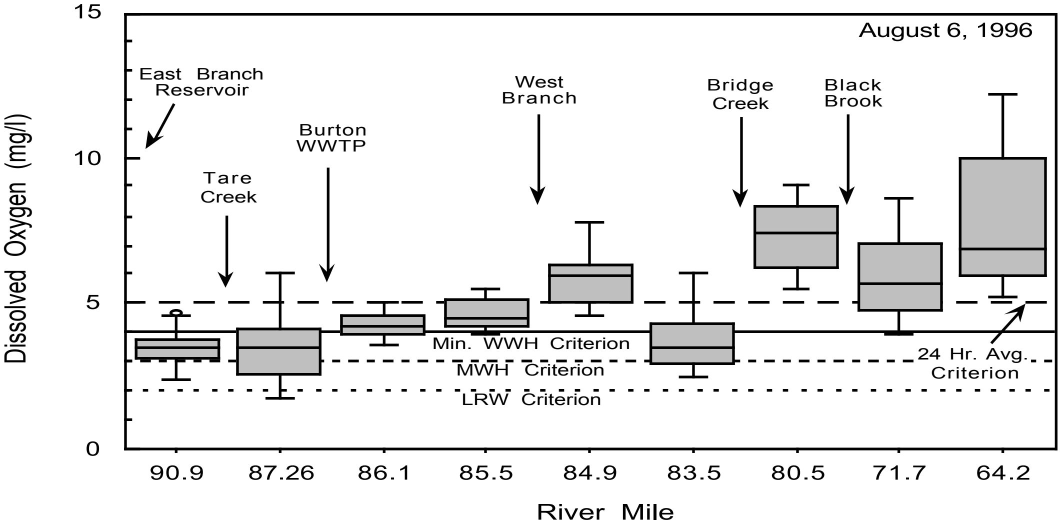


Figure 7. Datasonde™ continuous monitor results from the upper Cuyahoga River between East Branch Reservoir and Lake Rockwell collected on July 16 (upper plot) and August 6 (lower plot), 1996.

between Bridge Creek and Lake Rockwell with all measurements above the WWH criterion.

Dissolved oxygen trends from chemical grab samples were similar to the Datasonde™ results (Figure 8). D.O. depletion was most severe downstream from the Tare Creek wetlands complex near Burton (RM 87) where all measurements were below WWH criteria; four of five measurements fell below the 4 mg/l minimum criterion.

Nitrogen-ammonia concentrations were chronically elevated downstream from the Akron East Branch Reservoir (RM 91.07) then gradually decreased downstream towards Lake Rockwell (Figure 8). The concentrations may be attributed to hypolimnetic releases from East Branch Reservoir. This conclusion is supported by data showing ammonia-N concentrations also increased downstream from the Lake Rockwell outlet. The concentrations did not exceed water quality criteria but, coupled with low dissolved oxygen levels and flow alterations, may exacerbate biological impacts in the upper watershed.

The City of Akron has collected limited monthly water quality information from the upper Cuyahoga River watershed since at least 1975 but, sampling at most of the stations began in the early 1990s. The most recent data includes results for pH, temperature, dissolved oxygen, phosphorus, conductivity and total ash at 14 sampling locations. The data for summer samples collected from the mainstem are comparable to the data collected by Ohio EPA during the 1991 and 1996 surveys.

Akron’s sampling program includes tributaries and stream segments not assessed by Ohio EPA. Their sampling documents low dissolved oxygen concentrations in other tributaries in the upper watershed (Figure 9). The low dissolved oxygen concentrations are likely a result of the low gradient, wetland nature of many stream segments in the upper watershed. The Akron data also indicate that total phosphorus concentrations at Hiram Rapids (RM 75.83) have declined significantly since the early 1980s (Figure 10). The decline can be attributed to reduction of phosphorus loadings from municipal WWTPs and especially reductions from the Hans Rothenbuhler and Sons (Middlefield Swiss Cheese) discharge. The concentrations of other analytes at all other sampling locations have remained constant since the initiation of sampling.
Fecal coliform bacteria counts were low throughout the upper watershed.

The highest nitrate-nitrite concentrations and lowest D.O. levels were found downstream from the Tare Creek wetlands near Burton (RM 87). This trend indicates nitrification may be contributing to the low dissolved oxygen levels.

Total suspended solids (TSS) concentrations in the mainstem of the Cuyahoga increased slightly downstream from the West Branch, Black Brook and the Village of Mantua (see Figure 22 on page 66). A Black Brook sample collected on July 9 during a LaDue reservoir surface release had a very high suspended solids levels (70 mg/l). The high TSS and brown discoloration in Black Brook could have been a result of sediment loss from the reservoir, scour of the stream bed, or erosion of stream banks from the increased flow. The possible contribution of planktonic algae from the lake overflow to the solids levels could not be confirmed. The source(s) of higher TSS concentrations at other locations is unknown, but is probably a result of poor land use practices.

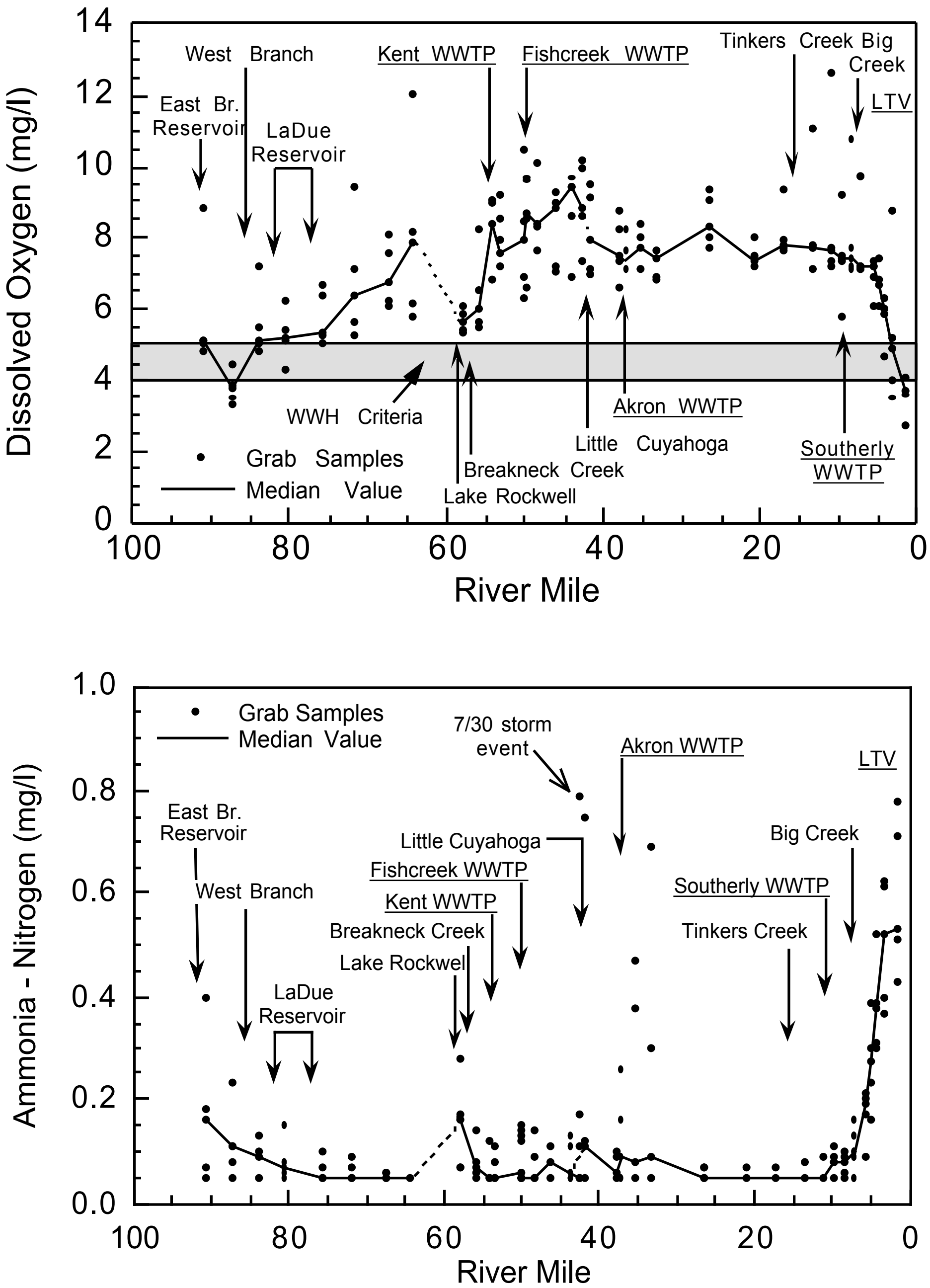


Figure 8. Dissolved oxygen and ammonia-nitrogen concentrations in chemical grab samples collected from the Cuyahoga River, June-September, 1996.

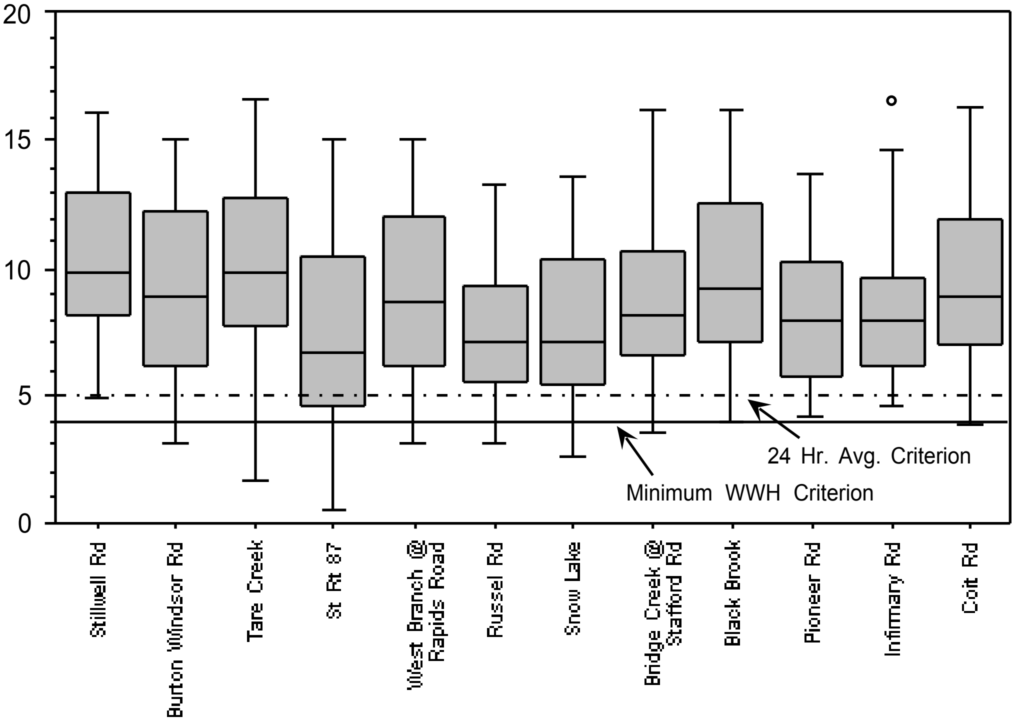


Figure 9. Historical D.O. data from grab samples collected monthly and bimonthly by the City of Akron in the upper Cuyahoga River basin, 1981-1997.

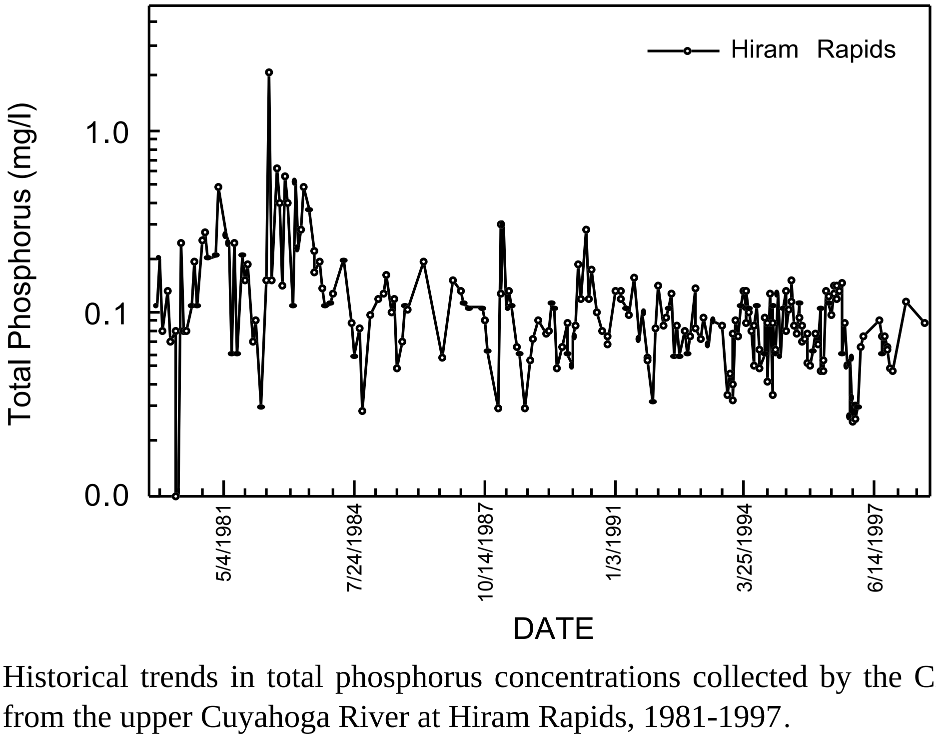


Figure 10. Historical trends in total phosphorus concentrations collected by the City of Akron from the upper Cuyahoga River at Hiram Rapids, 1981-1997.

Table 5. Exceedences of Ohio EPA Warmwater Habitat criteria (OAC 3745-1) for chemical/physical parameters measured in the Cuyahoga River study area, 1996 (units are µg/l for metals, S.U. for pH, colonies per 100 ml for bacteria, and mg/l for all others). Concentrations in **BOLD** type indicate acute exceedences (metals), secondary contact recreation exceedences (fecal coliform bacteria), or dissolved oxygen concentrations below the 24 hour daily minimum.

Stream Name	River Mile	Exceedence: Parameter (value)
Cuyahoga River	90.9	**D.O. (3.4)**§, **(2.4, 3.3)**§§, (4.9)§;
		Total Phosphorus (1.48)Δ
	90.86	D.O. (4.8)*
	87.36	**D.O. (3.4)**§, **(2.7)**§§
	87.26	**D.O. (3.5)**§, **(1.7)**§§;
		D.O. (3.9, 3.8, 3.5, 3.3)**, (4.5)*
	86.1	**D.O. (3.2)§, (2.5, 3.5)**§§, (4.2)§
	85.5	**D.O. (3.9)**§, (**3.3, 3.9**)§§, (4.6)§
	84.9	**D.O. (3.6)**§§, (4.6)§§
	83.8	D.O. (4.85)*
	83.5	**D.O. (3.7)**§, (**2.45**)§§
	80.51	**D.O. (3.6)**§§, (4.3)*, (4.8)§,
	71.7	**D.O. (3.9)**§§
	63.26	Total Phosphorus (1.08)Δ
	57.7	**D.O. (3.9)**§§, (4.9)§;
	55.8	D.O. (4.2)§§
	53.45	D.O. (4.6)§§
	52.85	D.O. (4.I)§§
	52.0	**D.O. (3.9)**§, **(2.7)**§§
	51.66	D.O.(4.25)§§
	51.35	**D.O.(3.9)**§§
	48.2	D.O. (4.I)§§
	42.60	**Total Cu (34)***, Total Pb (56)*
		Fecal coliform bacteria (2,100, 200,000)††
	41.6	**Total Cu (110)****, **Total Zn (691)****; Total Pb (236)*;
		Fecal coliform bacteria (140,000, 190,000)††, (1,100)†
	38.0	**D.O. (<3.0)**^;
		Fecal coliform bacteria (2,400)††, (1,700)†

Table 5. continued.

Stream Name	River Mile	Exceedence: Parameter (value)
Cuyahoga River	37.2	**D.O. (<3.0)^; Fecal coliform bacteria (2600††)**
(continued)	13.2	Total Cu (20)*; Total Pb (19)*; **Fecal coliform bacteria (6900)††**
	11.0	Total Pb (20)* **Fecal coliform bacteria (5,400)††**
	9.8	**Fecal coliform bacteria (5,900)††**
	8.3	Total Pb (21)*; Total Cu (21)*
	7.2	**Fecal coliform bacteria (3,900)††**
	5.0	Temperature (29.0 °C)*
	3.6	**Total Zn (266)****
West Br. Cuyahoga River		No Exceedances
Black Brook		No Exceedances
Bridge Creek	1.32	D.O. (4.0, 4.7, 4.9)*
Breakneck Creek	3.1	D.O. (4.7)§§
Potter Creek		No Exceedances
Wahoo Ditch	0.39	D.O. (3.9)*
Sand Run	0.20	**Total Cu (64)****; **Total Zn (326)****; Total Pb (44)*; **Fecal coliform bacteria (39,000)††**
Yellow Creek	0.10	**Fecal coliform bacteria (2,800)††**
Furnace Run	0.90	**Fecal coliform bacteria (8,700)††**
Chippewa Creek		No Exceedances
Brandywine Creek	7.0	Ammonia–N (1.44)*, D.O. (4.6., 4.5, 4.7, 4.9)*; Fecal coliform bacteria (2000)†; Total Phosphorus (1.41, 1.24, 1.56)∆
	0.24	D.O. (4.2)*
Tinkers Creek		No Exceedances
Mill Creek	3.1	**Fecal coliform bacteria (18,000, 18,000)††**
	0.12	**pH (9.02)**** **Fecal coliform bacteria (10,000)††**
Big Creek	7.8	**Fecal coliform bacteria (3,100, 4,800, 7,500, 14,000, 17,000)††**
	3.1	**Fecal coliform bacteria (66,000)††**
	0.2	**D.O. (3.9)§§**; Total Pb (32)*; **Fecal coliform bacteria (2,500, 3,200, 13,000)††**, (1400)†

Table 5. continued.

Stream Name	River Mile	Exceedence: Parameter (value)
Morgan Run	--	No Exceedances
Kingsbury Run	--	No Exceedances

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* indicates an exceedence of numerical criteria for prevention of chronic toxicity (CAC).

****** indicates an exceedence of numerical criteria for prevention of acute toxicity (AAC).

† Exceedence of the Primary Contact Recreation Criterion.

†† Exceedence of the Secondary Contact Recreation Criterion.

§ 24 hour average exceedence value recorded from Datasonde™ units.

§§ Minimum values recorded from Datasonde™ units.

^ City of Akron Datasonde™ data at NPDES instream monitoring stations upstream and downstream from the Akron WWTP 001 discharge.

Δ exceedence of WQS guideline for daily average phosphorus (1 mg/l)

Physical Habitat for Aquatic Life - East Branch Reservoir to Lake Rockwell

Two distinct reaches exist in the upper Cuyahoga mainstem, a low gradient, wetlands influenced channel modified reach upstream from Hiram Rapids (RMs 90.9-80.5), and a higher gradient reach with typical riffle-pool-run sequences from Hiram Rapids to Lake Rockwell (RMs 75.8-64.5). Specific habitat characteristics of these two reaches, and those discussed in the following paragraphs, are detailed in the 1991 Cuyahoga River TSD (OEPA 1994). QHEI scores in the upper reach averaged 51.3 (± 5.5 SE, N = 4), suggesting habitat is potentially limiting to aquatic life. Ratios of modified habitat to warmwater habitat characteristics in the upper reach average 2:1 (Appendix B), owing to past channelization and natural wetland habitat influences. Ratios of greater than one reflect an increasing prevalence of modified habitat attributes and are generally indicative of declining habitat quality. Key habitat characteristics limiting to aquatic life are poor channel development, no fast current and silted substrates. Little channel recovery is expected due to low gradient; this, therefore, represents a lasting impairment.

Warmwater habitat attributes were more prevalent than modified attributes in the reach between Hiram Rapids and Lake Rockwell (ratio of modified to warmwater attributes = 0.42:1). The good channel development, high sinuosity, and low embeddedness reflected the lack of channel modifications within the reach. Overall, habitat in the reach was not limiting to aquatic life as QHEI scores averaged 77.1 (± 3.4 SE, N = 4) owing to the high number of warmwater habitat attributes.

Fish Community - East Branch Reservoir to Lake Rockwell

Fish community performance, as measured by the IBI and MIwb, decreased upstream from Lake Rockwell in 1996 relative to 1991 (Figure 11; Table 6). The proportion of tolerant fishes, omnivores, top carnivores, round-bodied suckers and simple lithophils in electrofishing samples did not change, or increased slightly (Figure 12). The tolerant, omnivore and top carnivore metrics measure the trophic structure of the community, and are sensitive to increases in organic enrichment. The simple lithophil metric is sensitive to habitat, and the round-bodied sucker metric reflects habitat and trophic conditions. The similarity in performance across each metric suggests that there were no fundamental changes in the structure, composition or trophic structure of the fish community between 1991 and 1996.

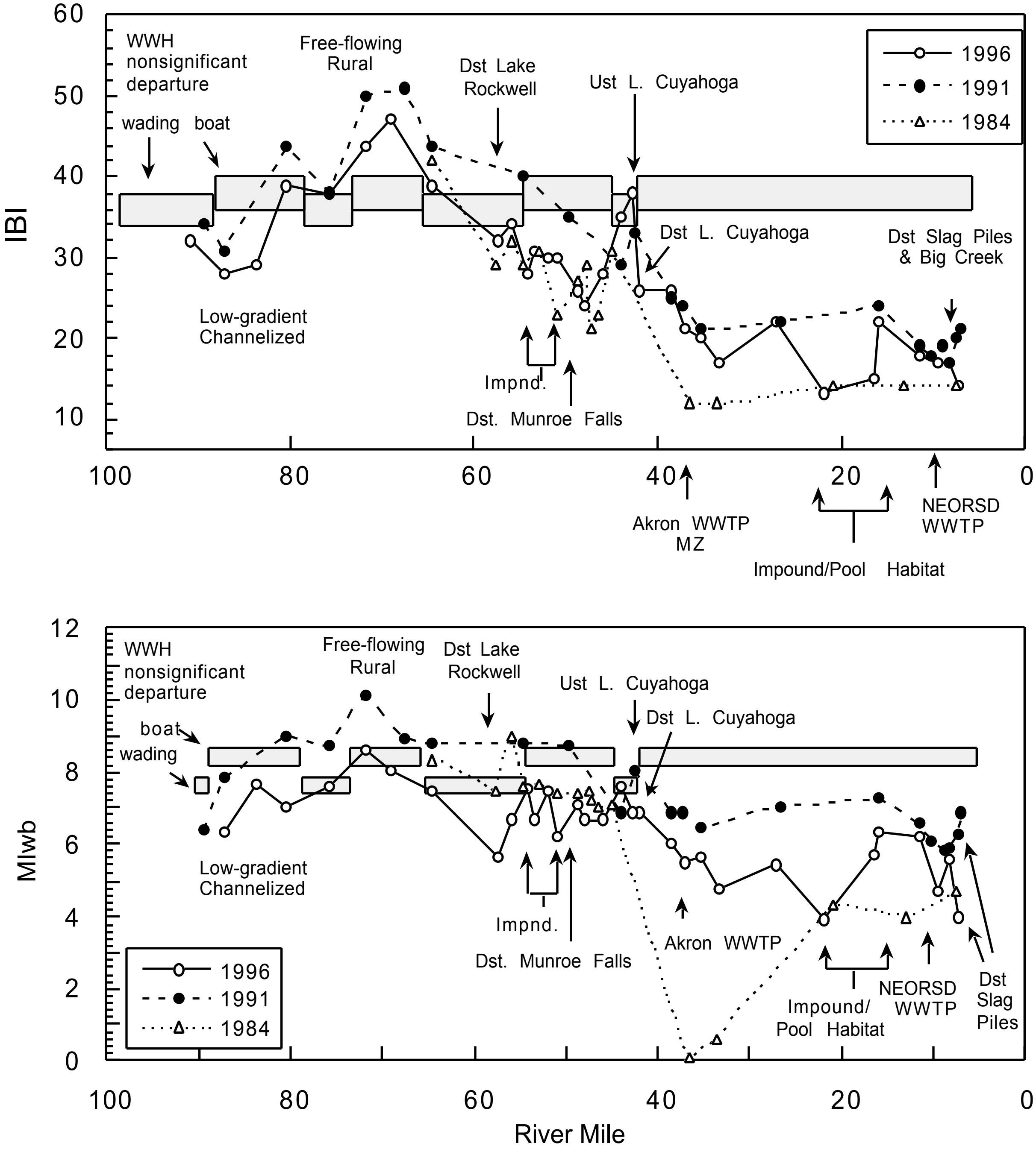


Figure 11. Longitudinal trend of the Index of Biotic Integrity (IBI) and Modified Index of Well-Being (MIwb) in the Cuyahoga River, 1984, 1991, and 1996

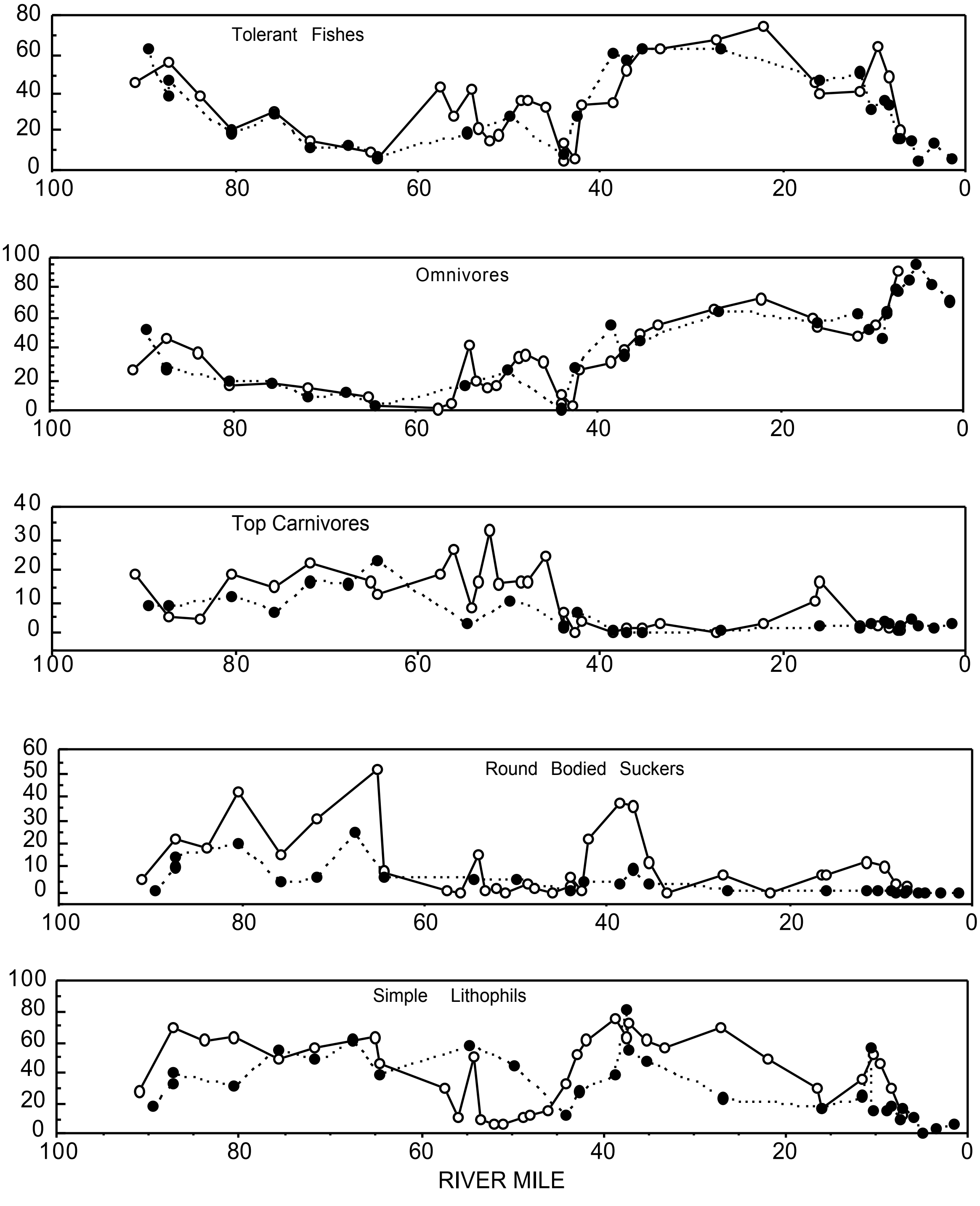


Figure 12. Percentages of tolerant taxa, omnivores, top carnivores, round-bodied suckers, and simple lithophils in the Cuyahoga River, 1996 (hollow circles) and 1991 (solid dots).

Table 6. Fish community indices from samples collected in the Cuyahoga River basin study area, 1996.

River Mile	Mean Number Species	Cumulative Species	Mean Rel. No (No./0.3 km)	Mean Rel. Wt. (kg/0.3 km)	QHEI	Mean MIwba	Mean IBI	Narrative Evaluation
Cuyahoga River								
		Erie Ontario Lake Plain - WWH Use Designation (Existing)						
90.9[D]	15.0	15	249	12.75	67.5	NA	32*	Fair
87.2[A]	13.0	19	148	29.39	42.5	6.4*	28*	Fair
83.8[A]	16.5	23	275	62.24	47.0	7.7*	29*	Fair
80.5[A]	13.5	16	148	62.91	48.0	7.0*	39ns	Fair/M. Good
75.8[D]	15.0	17	164	14.88	69.0	7.6ns	38	M.Good/Good
71.7[A]	15.5	18	303	105.82	75.5	8.6ns	44	M.Good/Good
65.1[A]	17.5	22	229	68.68	78.5	8.1*	47	Fair/V. Good
64.5[D]	16.0	20	166	11.35	85.5	7.5ns	39	M.Good/Good
57.5[D]	11.0	15	81	4.07	56.5	5.6*	32*	Poor/Fair
56.0[D]	12.0	14	78	11.96	67.5	6.7*	34*	Fair
54.2[A]	17.0	21	253	117.98	70.0	7.6*	28*	Fair
53.4[A]	14.0	16	194	90.61	64.0	6.7*	31*	Fair
52.0[A]	14.0	16	221	59.99	54.0	7.5*	30*	Fair
51.0[A]	10.0	12	137	58.31	48.5	6.2*	30*	Poor/Fair
48.7[A]	15.5	19	220	85.87	56.0	7.1*	26*	Fair
48.0[A]	14.0	17	184	74.99	46.5	6.7*	24*	Fair/Poor
46.0[A]	14.0	14	320	112.61	67.0	6.7*	28*	Fair
44.0[D,E]	13.0	15	905	16.21	76.0	7.6ns	35ns	M.Good
42.8[D]	14.0	17	1038	41.18	82.0	6.9*	38	Fair/Good
42.0[A]	12.0	14	311	75.32	68.5	6.9*	26*	Fair
38.6[A]	10.5	13	149	22.38	76.0	6.1*	26*	Poor/Fair
37.4[A]	*7.5*	*10*	*280*	*76.84*		*5.1*	*19*	*mix zone*
37.2[A]	9.5	13	130	27.28	78.0	5.5*	21*	Poor
35.3[A]	11.5	14	197	30.19	77.5	5.6*	20*	Poor
33.3[A]	8.5	11	170	18.96	60.5	4.8*	17*	V. Poor/Poor
27.2[A]	13.0	15	255	56.06	74.5	5.4*	22*	Poor
22.0[A]	7.0	11	73	28.48	60.0	3.9*	13*	V. Poor
16.5[A]	9.5	13	67	32.94	66.0	5.7*	15*	Poor/V. Poor
15.9[A]	14.0	19	105	51.48	69.5	6.4*	22*	Fair/Poor
11.5[A]	14.5	21	157	53.92	69.5	6.2*	18*	Poor
10.4[A]	*4.0*	*7*	*260*	*14.62*	--	*4.5*	*31*	*mix zone*
9.6[A]	9.0	13	84	61.30	66.0	4.7*	17*	V. Poor/Poor
8.3[A]	12.5	17	138	68.19	67.0	5.6*	17*	Poor
7.2[A]	7.5	10	666	297.30	68.5	4.0*	14*	V. Poor

Table 6. continued.

River Mile	Mean Number Species	Cumulative Species	Mean Rel. No (No./0.3 km)	Mean Rel. Wt. (kg/0.3 km)	QHEI	Mean MIwba	Mean IBI	Narrative Evaluation
Cuyahoga River (continued)								
Lake Erie Lacustuary[b] - WWH Use Designation (Existing)								
5.6[A]	15.5	20	260	161.59	41.5	5.8*	21*	Poor
Navigation Channel[b] - LRW Use Designation (Existing) ***Very Poor*** = ***Non-attainment***								
4.8[A]	9.0	15	156	2.01	--	**4.7***	18*	Poor
4.2[A]	16.5	22	773	46.88	33.0	5.8*	31*	Poor/Fair
3.1[A]	4.5	7	128	1.27	33.0	**4.8***	22*	V. Poor /Poor
1.3[A]	10.0	17	143	10.36	40.0	**4.8***	21*	V. Poor /Poor
0.5[A]	6.5	9	647	9.05	32.0	5.2*	24*	Poor
Big Creek								
7.8[E]	7.0	7	1082	4.55	64.5	NA	28*	Fair
2.5[E]	7.0	7	804	3.64	50.5	5.1*	26*	Poor
0.2[E]	8.0	8	810	2.24	53.0	5.4*	28*	Poor/Fair
Mill Creek								
4.3[E]	3.0	3	120	1.60	68.5	NA	20*	Poor
0.2[D]	7.0	7	156	1.81	60.0	NA	18*	Poor
Tinkers Creek								
0.2[D]	16.0	16	173	3.98	70.5	7.0*	24*	Fair/Poor
Brandywine Creek								
7.0[E]	13.0	13	220	7.89	56.0	NA	30*	Fair
0.5[E]	5.0	5	130	0.81	66.5	--	--	Data Invalid
Furnace Run								
0.9[E]	17.0	17	702	7.27	70.0	NA	48	V. Good
Yellow Creek								
1.5[E]	14.0	14	1412	16.65	71.0	7.9	38^{ns}	Good/M.Good
Sand Run								
0.4[E]	6.0	6	282	2.06		NA	26*	Poor
Mud Brook								
0.3[E]	17.0	17	816	12.55	67.0	8.0	36^{ns}	Good/M.Good
Breakneck Creek								
9.5[D]	19.0	19	530	13.41	67.5	NA	46	V. Good
6.8[D]	13.0	13	86	6.38	66.5	NA	30*	Fair
5.2[D]	12.0	18	171	5.74	86.5	NA	40	Good
3.1[D]	12.0	16	90	5.05	56.5	5.1*	38	Poor/Good
1.7[D]	7.0	9	47	5.85	59.5	4.6*	15*	Poor/V. Poor
0.2[D]	15.0	18	120	4.00	69.0	7.2*	44	Fair/Good

Table 6. continued

River Mile	Mean Number Species	Cumulative Species	Mean Rel. No (No./0.3 km)	Mean Rel. Wt. (kg/0.3 km)	QHEI	Mean Miwba	Mean IBI	Narrative Evaluation
Potter Creek								
1.5^{E}	11.0	11	346	1.48	41.0	NA	<u>24</u>*	Poor
Black Brook								
1.8^{D}	15.0	15	174	14.75	66.0	NA	36^{ns}	M.Good
Bridge Creek								
11.2^{D}	9.0	9	220	9.12	56.0	NA	28*	Fair
8.5^{D}	19.0	19	1106	15.40	71.5	NA	50	Exceptional
0.5^{D}	11.0	11	112	2.75	55.5	5.9*	30*	Fair
West Branch Cuyahoga River								
0.9^{D}	17.0	17	492	6.14	64.0	7.0*	48	Fair/V.Good

Ecoregion Biocriteria: Erie-Ontario Lake Plain

	IBI			MIwb		
<u>Site Type</u>	<u>WWH</u>	<u>EWH</u>	<u>MWH</u>^{c}	<u>WWH</u>	<u>EWH</u>	<u>MWH</u>^{c}
Headwaters	40	50	24	NA	NA	NA
Wading	38	50	24	7.9	9.4	5.6
Boat	40	48	24	8.7	9.6	5.7
			<u>LRW</u>			<u>LRW</u>
L Erie Lacustuary (RMs 7.0-5.6)	42	50	--	8.5	9.5	--
Nav. Channel (RMs 5.6-0.0)	--	--	>17	--	--	>5.0

---

ns - Nonsignificant departure from biocriteria (<4 IBI units or <0.5 MIwb units).

* - Significant departure from applicable biocriteria (>4 IBI units or >0.5 MIwb units). Underlined scores are in the Poor or Very Poor range.

a - MIwb is not applicable to headwater streams with drainage areas < 20 mi2.

b - Lake Erie lacustuary fish communities are evaluated using an interim set of metric scoring criteria based on sampling from other flooded river mouths in the drainage (Ohio EPA 1999a,b Draft). The scores are not directly comparable to biocriteria for lotic streams and rivers.

A - Boat sampling method

D - Wading/sport yak sampling method

E - Longline sampling method

c - Modified warmwater habitat

Macroinvertebrate Community - East Branch Reservoir to Lake Rockwell

Macroinvertebrate performance as reflected by ICI showed improvement from 1991 and 1996 in the upper reaches of the Cuyahoga River (Figure 13; Table 7). Positive changes were most pronounced between Tare Creek and Black Brook (RMs 87.3-80.4) where ICI scores improved from "fair" in 1991 to the "marginally good" to "very good" ranges in 1996. In contrast, communities closest to the East Branch Reservoir outlet at RMs 90.9 and 89.5 reflected fair quality during both surveys.

One reason for the positive trend between Tare Creek and Black Brook appeared to be increased current velocities over the artificial substrate samplers in 1996. Communities retrieved from adequate current (*i.e.,* ≥0.3 ft./sec.) were predominated by flow dependent caddisflies and midges in 1996 while 1991 samples from slow or nondetectable currents were predominated by more pollution tolerant scuds and hemoglobin utilizing midges. Negative influences associated with slower current velocities may have been exacerbated by increased sediment deposition on the artificial substrates and the generally low background D.O. levels in this sluggish section of the river. The composition of natural substrate communities from these sites were more consistent between surveys as reflected by QCTV scores in the low performance range, and similarities in EPT taxa richness. The general trend of negative influences associated with reservoir releases, wetland drainage, and past channelization activities observed in 1991 continued, albeit to a lesser degree, in 1996. The trend of improvement to exceptional quality as the river flowed between East Branch Reservoir and Lake Rockwell (RMs 90.7-64.2) was common to both surveys.

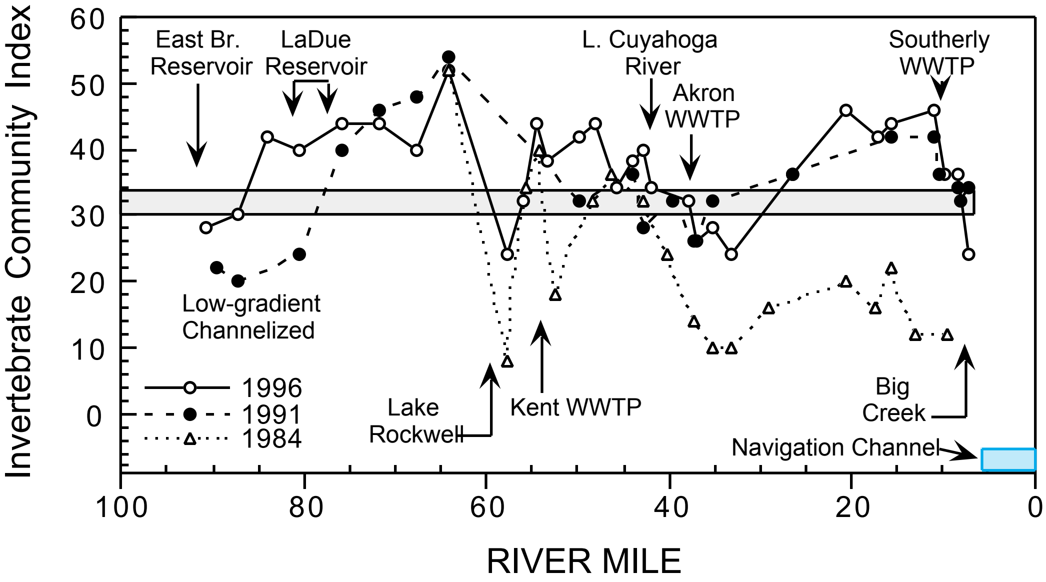


Figure 13. Longitudinal trend of the Invertebrate Community Index (ICI) in the Cuyahoga River, 1984, 1991, and 1996.

Further downstream, densities of the filter-feeding midge group, *Rheotanytarsus exiguus* increased sharply below Black Brook (RM 75.8) in both 1991 and 1996. The larvae are considered sensitive to toxic substances but tend to flourish in areas of strong current and high suspended solids (Simpson & Bode 1981). Similar high density populations were encountered in Black Brook, downstream from the Black Brook Dike reservoir release on LaDue Reservoir. These collections suggest significant enrichment stemming from the reservoir discharge. Despite the skewed populations, Cuyahoga River macroinvertebrate communities maintained very good quality downstream from the confluence. Population densities returned to upstream levels between Hiram Rapids and Lake Rockwell (RMs 75.8-64.2) and the ICI scores reflected very good to exceptional quality.

Table 7. Summary of macroinvertebrate data collected from artificial substrate samplers (quantitative sampling-Quant.) and natural substrates (qualitative sampling-Qual.) in the Cuyahoga River basin study area, July -September, 1991-1996. All streams are located in the Erie-Ontario Lake Plain (EOLP) and designated Warmwater Habitat unless indicated otherwise. Lake influenced sections of the Cuyahoga River mainstem (*i.e.*, lacustuary and navigation channel; RMs 7.0-0.0) are evaluated using an interim set of criteria developed for Lake Erie river mouths (Ohio EPA 1999a,b Draft).

Stream River Mile	Relative Density	Quant. Taxa	Qual. Taxa	Total Taxa	Qual. EPT[a]	QCTV[b]	ICI	Narrative Evaluation[c]
Cuyahoga River (1996)								
90.9	984	30	49	61	7	33.1	28*	Fair
87.3	646	44	43	72	4	29.4	30[ns]	Marg. Good
84.1	679	42	71	87	12	37.7	42	Very Good
80.4	713	41	46	63	10	32.8	40	Good
75.8	6980	35	55	68	11	37.0	44	Very Good
71.7	525	58	66	90	24	40.9	44	Very Good
67.6	492	51	60	80	17	35.0	40	Good
64.2	775	49	83	94	33	41.0	52	Exceptional
57.6	641	37	35	51	5	29.4	24*	Fair
56.1	411	39	51	66	10	33.4	32[ns]	Marg. Good
54.4	1492	41	51	67	11	38.4	44	Very Good
53.4	1654	32	45	60	9	35.9	38	Good
49.8	5435	25	42	50	11	37.7	42	Very Good
48.0	868	42	48	63	14	33.4	44	Very Good
45.9	864	43	25	49	9	39.5	34	Good
44.0	2346	31	35	44	8	37.7	38	Good

Table 7. (continued).

Stream River Mile	Relative Density	Quant. Taxa	Qual. Taxa	Total Taxa	Qual. EPT[a]	QCTV[b]	ICI	Narrative Evaluation[c]
Cuyahoga River (1996) continued								
42.8	4045	28	44	54	10	38.6	40	Good
41.9	3077	29	26	40	6	34.9	34	Good
38.0	1113	38	38	55	8	37.7	32[ns]	Marg. Good
37.4 (mix zone)	*2826*	*28*	*28*	*37*	*8*	*34.9*	*24*	*Fair*
37.1	5319	26	50	56	7	34.9	26*	Fair
35.3	8521	30	39	50	8	35.9	28*	Fair
33.3	2949	32	36	48	6	37.0	24*	Fair
26.5	2985	28	36	48	6	38.4	36	Good
20.7	3321	42	37	59	8	38.4	46	Exceptional
17.0	1641	36	46	59	12	38.4	42	Very Good
15.6	1989	35	35	52	8	37.0	44	Very Good
11.0	1235	39	36	54	8	37.7	46	Exceptional
10.5 (mix zone)	*701*	*40*	*42*	*54*	*8*	*34.5*	*26*	*Fair*
9.7	717	45	21	50	6	38.4	36	Good
8.3	409	41	36	55	9	38.7	36	Good
7.1	606	49	30	52	8	34.3	24*	Fair
		Lake Erie Lacustuary - interim criteria applied						
5.8	410	38	17	48	1	26.7	40*	Fair
		Navigation Channel -LRW use designation						
5.0	228	24	9	27	1	28.7	28*	Fair
4.3	560	14	12	20	0	22.4	14*	Poor
3.3	1053	15	8	19	0	24.9	10*	Very Poor
1.2	663	20	15	26	0	19.9	10*	Very Poor
Cuyahoga River (1994)								
		Lake Erie Lacustuary - interim criteria applied						
6.9	567	35	15	43	1	37.7	36*	Fair
6.6	371	35	11	39	0	31.7	34*	Fair
5.0	1645	34	10	41	0	22.6	22*	Poor
0.5	970	39	17	46	0	30.4	22*	Poor
Cuyahoga River (1993)								
42.8	4561	25	49	55	8	34.3	28*	Fair
39.7	2410	28	46	55	6	34.3	32[ns]	Marg. Good
35.3	3570	23	40	46	6	37.0	28*	Fair
15.6	1171	34	56	65	15	38.4	48	Exceptional

Table 7. (continued).

Stream River Mile	Relative Density	Quant. Taxa	Qual. Taxa	Total Taxa	Qual. EPT[a]	QCTV[b]	ICI	Narrative Evaluation[c]
West Branch Cuyahoga River (1996)								
0.9	1791	37	56	75	11	39.1	42	Very Good
11.2	NA	NA	22	22	1	22.6	NA	Poor
8.5	NA	NA	37	37	15	41.1	NA	Very Good
1.3	496	28	40	52	4	30.7	28*	Fair
Bridge Creek (1996)								
11.2	NA	NA	22	22	1	22.6	NA	Poor
8.5	NA	NA	37	37	15	41.1	NA	Very Good
1.3	496	28	40	52	4	30.7	28*	Fair
Black Brook (1996)								
1.8	7920	24	48	54	10	38.4	40	Good
Breakneck Creek (1996)								
14.7	254	41	54	68	9	38.4	50	Exceptional
6.9	1655	32	38	56	7	38.4	44	Very Good
5.2	1814	35	53	69	10	37.0	46	Exceptional
3.1	925	32	29	43	8	39.0	48	Exceptional
1.8	703	31	37	53	6	32.9	40	Good
0.1	577	43	43	63	6	36.4	44	Very Good
Potter Creek (1996)								
1.8	611	34	25	40	6	39.2	34	Good
Wahoo Ditch (1996)								
	Erie Ontario Lake Plain MWH Use Designation (Existing)							
0.4	NA	NA	25	NA	0	19.9	NA	Poor
Sand Run (1996)								
	Erie Ontario Lake Plain WWH Use Designation (Recomended)							
0.2	NA	NA	15	15	3	34.9	NA	Poor
Yellow Creek (1996)								
0.1	NA	NA	47	47	10	38.4	NA	Good
Furnace Run (1996)								
0.9	NA	NA	42	42	10	39.5	NA	Very Good
Brandywine Creek (1996)								
7.0	NA	NA	37	37	3	29.4	NA	Fair
0.2	NA	NA	42	42	10	37.0	NA	Marg. Good
Tinkers Creek (1996)								
0.1	NA	NA	32	32	5	34.9	NA	Fair

Table 7. (continued).

Stream River Mile	Relative Density	Quant. Taxa	Qual. Taxa	Total Taxa	Qual. EPT[a]	QCTV[b]	ICI	Narrative Evaluation[c]
Mill Creek (1996)								
3.4	NA	NA	12	12	1	32.8	NA	Poor
0.2	NA	NA	18	18	5	34.9	NA	Fair
Big Creek (1996)								
7.8	NA	NA	26	26	4	32.9	NA	Fair
2.5	NA	NA	25	25	5	31.7	NA	Poor
0.2	NA	NA	13	13	2	21.9	NA	Poor

Ecoregion Biocriteria: Erie/Ontario Lake Plain (EOLP)

INDEX	WWH	EWH	MWH[d]	LRW
ICI	34	46	22	--
Interim Lacustuary ICI	42	52	--	>10

---

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

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

[a] A qualitative narrative evaluation based on best professional judgement is used when quantitative data is not available to calculate the Invertebrate Community Index (ICI) scores.

[b] EPT= total Ephemeroptera (mayflies), Plectoptera (stoneflies) and Tricoptera (caddisflies).

[c] Qualitative Community Tolerance Value calculated as the median of the weighted ICI values for each taxa collected from the site. A general guideline used to distinguish high quality natural substrate communities from low quality assembleges is as follows: QCTV > 25th percentile of EOLP sites with good or exceptional ICI scores (i.e., QCTV> 37.15 = High Performance). QCTV < 75th percentile of EOLP sites with fair or poor ICI scores (i.e., QCTV< 34.3 = Low Performance).

[d] Modified Warmwater Habitat for channel modified areas.

Water Chemistry Trends- Headwaters to Lake Rockwell

The 1991 Ohio EPA survey of the Cuyahoga River (Ohio EPA 1994) concluded the combination of wetland drainage, reservoir releases and marginal habitat conditions was responsible for the low D.O. in the upper watershed. The 1996 survey results are consistent with that evaluation. Datasonde™ results, the City of Akron data, and the 1996 grab samples indicate significant D.O. depletion for about ten miles downstream from the East Branch Reservoir and Tare Creek wetland complex.

Compared to the 1991 survey, chronically low D.O. and elevated ammonia concentrations continue to be found downstream from East Branch Reservoir and Tare Creek wetland complex in 1996 (Figure 14). Mainstem D.O. violations of the minimum WWH criterion were noted at RMs 89.41 and 87.26 in both surveys. Low D.O. and elevated phosphorus levels were also found well downstream in 1991 at Pioneer Trail Road near Mantua (RM 71.7). A similar trend was not encountered in 1996 (Figure 14) and the cause of the low D.O. and source of elevated phosphorus remains unknown. No other significant changes in water quality in this river segment were noted since the 1991 survey.

Long term water quality sampling by the Akron Water Supply also indicates stable water quality conditions during the past ten years.

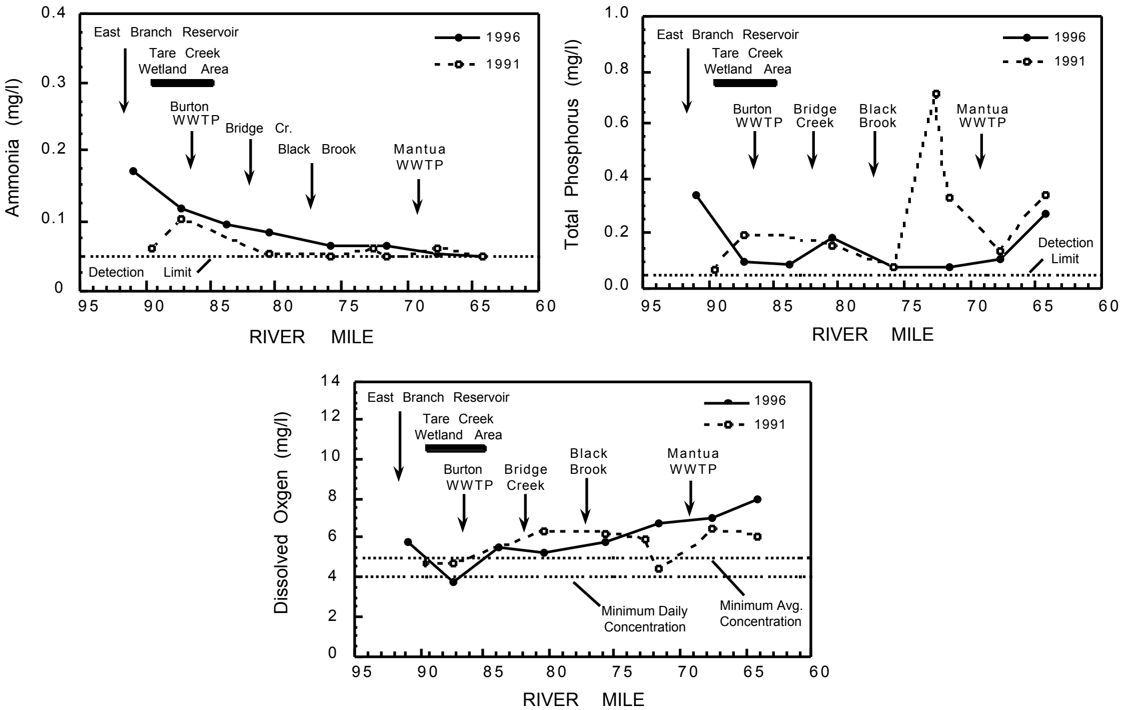


Figure 14. Longitudinal trends of mean ammonia-nitrogen, total phosphorus, and dissolved oxygen concentrations in the upper Cuyahoga River in 1991 and 1996.

Biological Trends - Headwaters to Lake Rockwell

Trends in biological community health were generally consistent with 1991 results and continued to reflect degraded conditions in the upper watershed near the East Branch Reservoir and Tare Creek wetland complex. Miles of non and partial attainment were relatively similar between surveys (Table 8) and tended to be concentrated in the upper reaches of the mainstem. Fish scores were somewhat lower in 1996 than in 1991 and this may be related to more severe D.O. stresses in the upper basin. Diel D.O. levels measured by Datasondes™ were significantly lower and showed more violations of water quality standards in 1996 than 1991. Improvements in ICI scores in this same section were considered largely a result of increased current velocities over the artificial substrates and not a significant change in water quality. Overall, ADV statistics reflect the general similarity in biological quality between surveys and the slightly lower quality of the fish community in 1996 (Table 8).

Table 8. Area of Degradation Values (ADV) statistics for the upper Cuyahoga River. Values were calculated using Erie Ontario Lake Plain WWH biocriteria as the baseline for community performance.

Stream (Year)			Biological Index Values		ADV Statistics				Attainment Status		
	Reach				Positive		Negative		(miles)		
Index	Upper RM	Lower RM	Mini-mum	Maxi-mum	ADV	**ADV/ Mile**	ADV	**ADV/ Mile**	Full	Partial	**Non**
Upper Cuyahoga River (1996)											
IBI			29	47	1193	**44.2**	449	**16.6**			
MIwb	91.0	64.0	6.4	8.6	340	**12.6**	864	**32.0**	11.2	11.3	**4.5**
ICI			28	52	2802	**103.7**	53	**1.9**			
Upper Cuyahoga River (1991)											
IBI			30	51	1787	**66.1**	118	**4.3**			
MIwb	91.0	64.0	6.4	10.2	1060	**39.2**	151	**5.6**	14.6	8.5	**3.9**
ICI			20	54	2134	**79.0**	928	**34.3**			

Middle and Lower Cuyahoga River
- Lake Rockwell to Big Creek (RMs 57.97 to 7.1)

Pollutant Loadings - Lake Rockwell to Big Creek
Between Lake Rockwell and the Little Cuyahoga River, two major municipal WWTPs discharge directly to the Cuyahoga River; the Kent WWTP (RM 53.85) and the Summit County Fishcreek WWTP (RM 51.45). Minor dischargers from the Akron and Cuyahoga Falls drinking water treatment plants and the Portage County Twin Lakes WWTP are also located within this segment. In addition, Breakneck Creek enters the Cuyahoga River at RM 56.18 and receives effluent from a major municipal WWTP (Ravenna WWTP via Wahoo Ditch) and the smaller, Franklin Hills WWTP. Further downstream, four of Akron's 36 combined sewer overflows are located in the gorge section of the Cuyahoga between the Edison Dam and Little Cuyahoga River.

From the Little Cuyahoga River to Big Creek, the much larger Akron and NEORSD (Cleveland Southerly) WWTPs discharge at RMs 37.4 and 10.5, respectively. While most Akron CSOs are located in the Little Cuyahoga River drainage, two discharge directly to the Cuyahoga between the confluence and the Akron WWTP. Combined sewers in Cleveland are mostly located in the Mill Creek and Big Creek basins and the navigation channel. Monthly Operating Report (MOR) data submitted by these entities indicates the following.

Kent WWTP
The City of Kent WWTP, NPDES permit number 3PD00031, is located at 641 Middlebury Road, Kent, Ohio 44240. The present design capacity is 5 MGD. Both median and 95th percentile flows from the Kent WWTP have remained steady since 1976. Median flows average near 3 MGD and, the 95th percentile flows have remained below design capacity suggesting that treatment efficiency should be high. Ammonia-nitrogen, phosphorus and total suspended solids loadings declined subsequent to plant upgrades in 1986 (Figure 15).

Forty-eight hour acute toxicity tests on *Ceriodaphnia dubia* and fathead minnows using the Kent WWTP effluent were conducted by the Ohio EPA on 5 August 1996. The tests showed no toxicity to either organism.

Summit County Fish Creek WWTP # 25
The Fish Creek WWTP, NPDES permit number 3PK00012, is located at 2910 North River Road, Stow, Ohio 44262. The present design capacity is 4 MGD. Flows from outfall 001 steadily increased after the plant went on-line in 1982, reaching the current design capacity in 1993. Median flows leveled off averaging slightly more than 4 MGD; however, the 95th percentile flows have progressively increased (Figure 16). Ammonia-nitrogen loadings from the plant have declined in the past three years, suggesting that treatment efficiency has been maintained despite increases in flow.

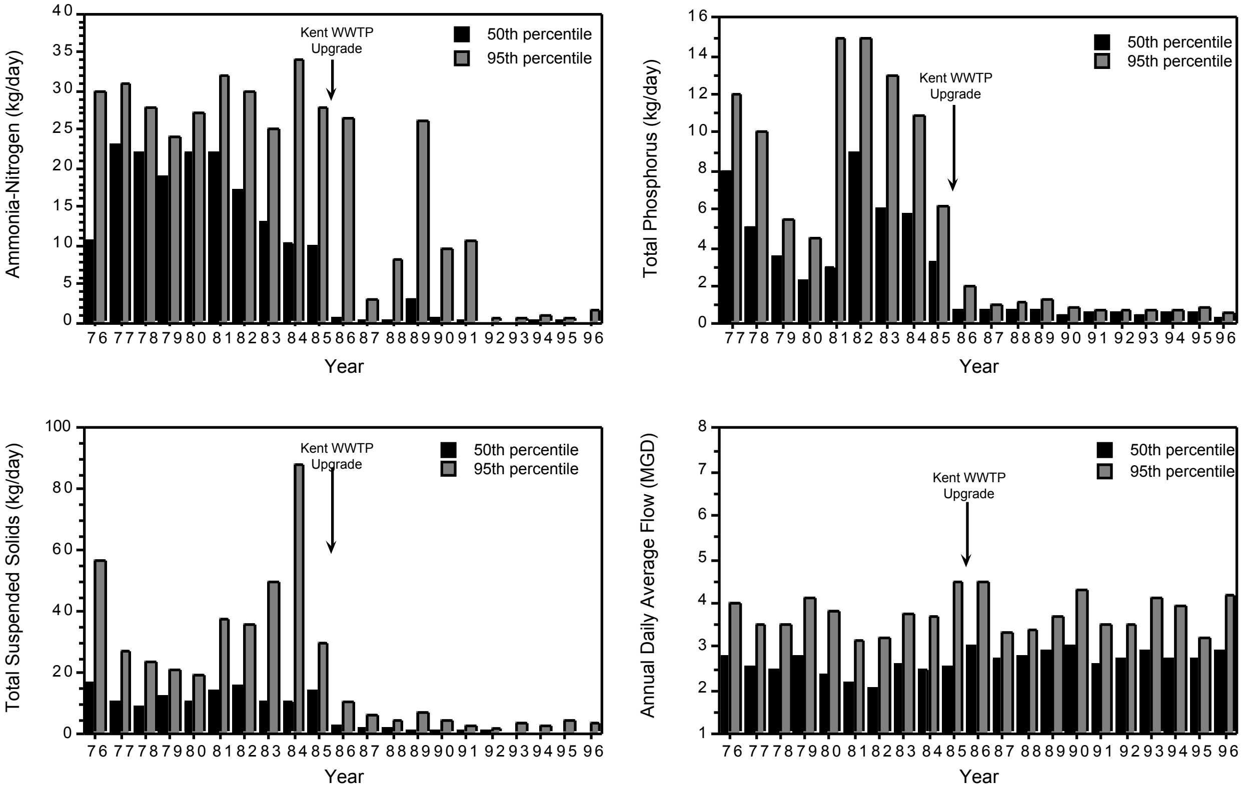


Figure 15. Annual median and 95th percentile loadings in kg/day of ammonia-nitrogen, total phosphorus, total suspended solids, and discharge (mgd) from the Kent WWTP, 1976-1996.

Forty-eight hour acute toxicity tests on *Ceriodaphnia dubia* and fathead minnows using Fishcreek WWTP effluent were conducted by the Ohio EPA on 4 April 1996 and 12 August 1996. The tests showed no toxicity to either organism.

Portage County Twin Lakes WWTP

The Portage County Twin Lakes WWTP discharges to an unnamed tributary which enters the Cuyahoga River at RM 57.82. This same tributary receives the effluent from the Akron water treatment plant (WTP) 001 outfall. Nitrogen-ammonia loadings from Twin Lakes have decreased since 1991.

Akron Water Treatment Plant (WTP)

The Akron drinking water treatment plant (WTP) has three wastewater discharges. Flows from all outfalls have been increasing since 1991. Outfall 001 is the discharge from the west backwash settling basin into an unnamed tributary at RM 57.82/0.2. Outfall 002 is the discharge from the

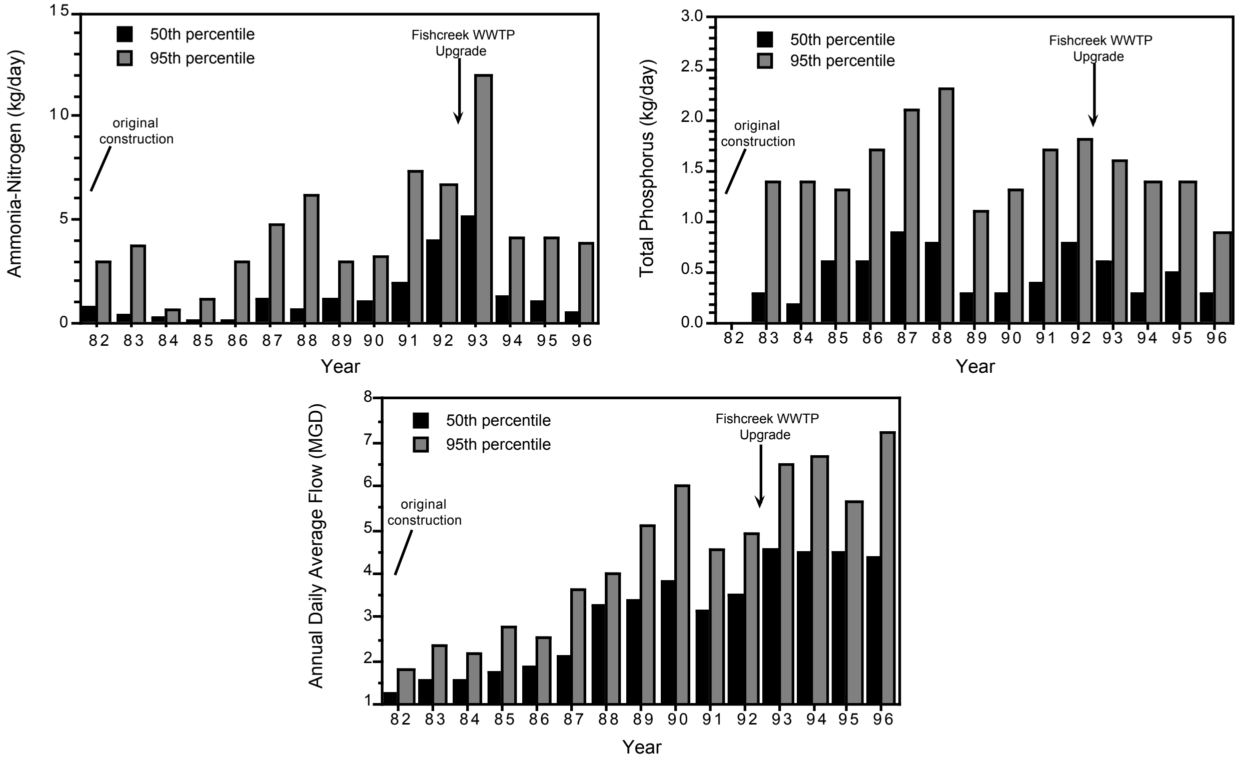


Figure 16. Annual median and 95th percentile loadings in kg/day of ammonia-nitrogen, total phosphorus, and discharge (mgd) from the Fishcreek WWTP, 1982-1996.

east backwash settling basin at RM 57.81 57.82/0.1, and outfall 003 is the discharge from the sanitary treatment system at RM 57.61. Ammonia-nitrogen loadings from 003 have been increasing since 1991.

Cuyahoga Falls WTP

The Cuyahoga Falls WTP discharges backwash water from their ionization softener to the Cuyahoga River at RM 48.4. The discharge is high in total dissolved solids but there has been no MOR data since 1991.

Akron WWTP

The Akron WWTP discharges to the Cuyahoga River mainstem at RM 37.45 via outfall 001. Average flow from the plant has remained relatively constant over the past 20 years, between 70 and 80 MGD. Since the 1991 intensive survey, major upgrades at the WWTP were limited to installation of a dechlorination system in 1996. The system has drastically reduced the loading of residual chlorine (Figure 17).

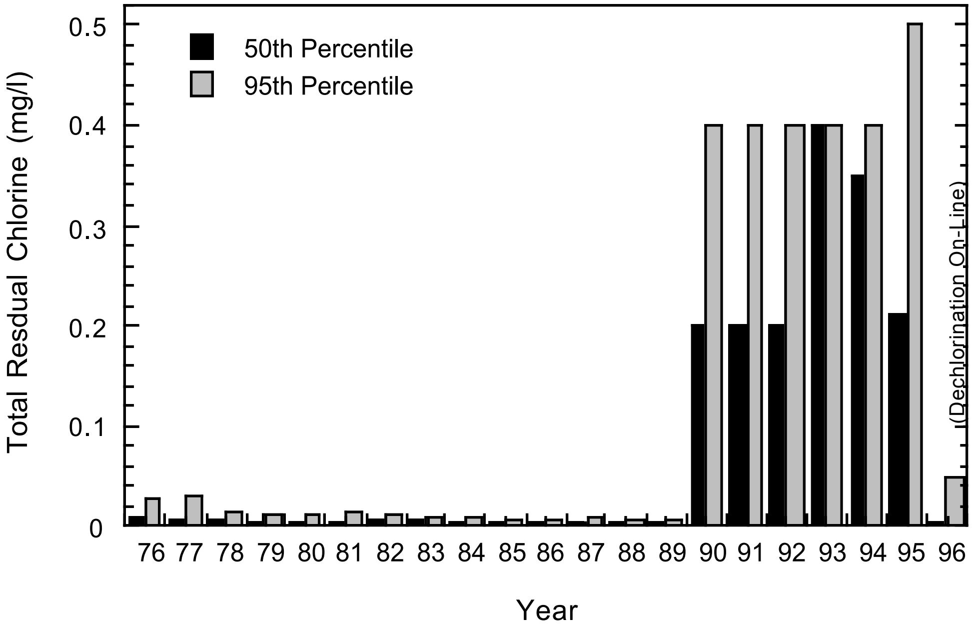


Figure 17. Annual median and 95th percentile concentrations of total residual chlorine discharged from the Akron WWTP, 1976-1996.

Due to a permit renewal, the WWTP began separate reporting at internal outfalls 602 (effluent from final settling tanks prior to mixing with secondary bypass) and 603 (secondary treatment bypass prior to mixing with effluent from final settling tanks) in 1994 for parameters such as BOD and TSS. Outfall 603 operates during storm events and is combined with the effluent from the final settling tanks prior to chlorination and discharge to the Cuyahoga River via 001. One hundred and eighteen bypass events were recorded during 1996, an average of nearly one every three days. Despite much lower mean annual flows, the bypass contributed a higher loading of BOD and TSS than outfall 602 during each reporting year (Figure 18).

Comparisons between the 1994-96 historical loadings are difficult due to past differences in permit reporting requirements for the various outfalls and bypasses. The 1991 TSD showed that drastic reductions in raw bypasses and secondary bypasses (not chlorinated) occurred through the 1980s. However, chlorinated secondary bypasses were not specifically monitored until after the 1994 permit modification. For these reasons, the most recent data are probably closest in estimating the actual BOD and TSS load discharged to the Cuyahoga River mainstem. The data indicate that substantial load reductions could result from increased control and treatment of the chlorinated secondary bypass discharge.

Thirty-two acute bioassay tests (48 hour) and 21 chronic tests (96 hour) were conducted on the 602 outfall between 1992 and 1996 using *Ceriodaphnia* and fathead minnows (Figure 19).

Effluent and far field samples were not considered acutely toxic (i.e., mortality was <20%) and only one upstream control test for *Ceriodaphnia* reached the 20% mortality level. Chronic tests were below Allowable Effluent Toxicity (AET) limits (1.1) for fish but exceeded AET in six of the 17 *Ceriodaphnia* tests; toxic units for these samples ranged from 1.2-3.2. These results indicated a lack of acute toxicity in the survey area. However, significant mortality was observed

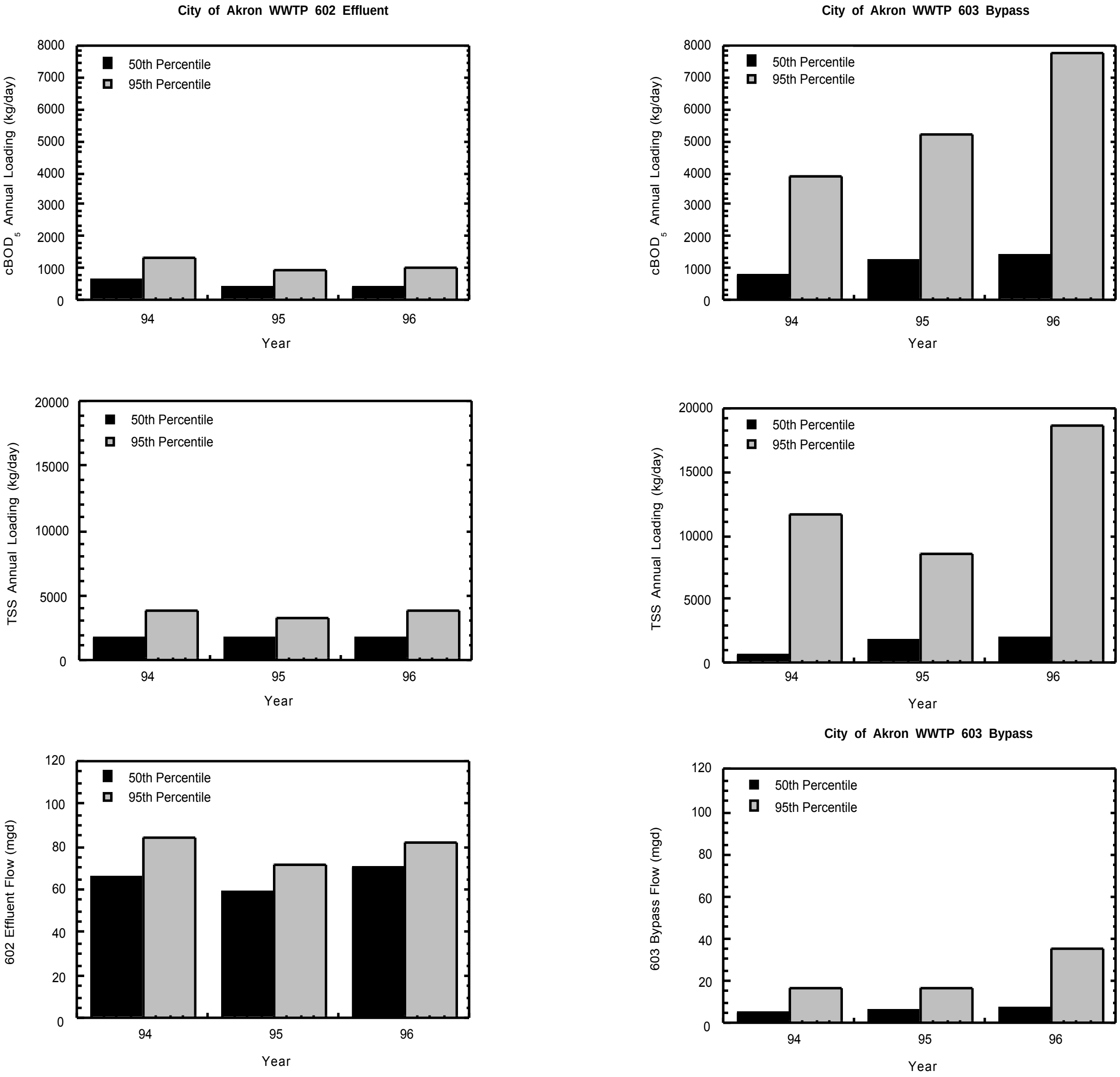


Figure 18. Annual median and 95th percentile loadings in kg/day of $cBOD_5$, total suspended solids, and discharge (mgd) from the Akron WWTP 602 outfall (full treatment) in the left column, and 603 outfall (bypass) in the right column, 1994-1996.

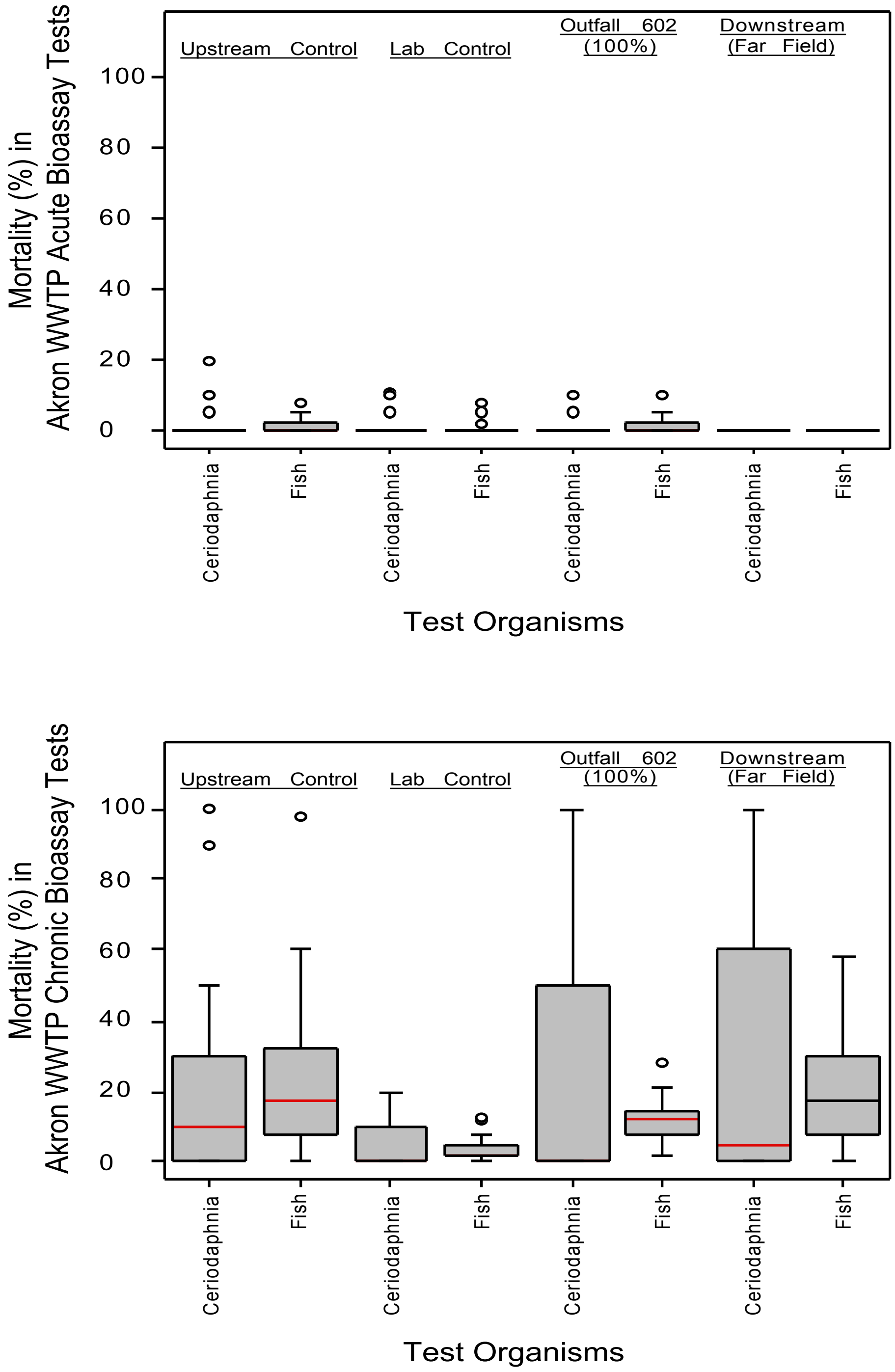


Figure 19. Box and whisker plots of percent mortality in acute and chronic bioassay test results from the Akron WWTP, 1992-1996.

during chronic testing in both organism groups, particularly in the upstream control and far-field samples. Mortality for one or more organism groups exceeded 30% in 12 of 21 samples (57.1%) during the 96 hour tests.

Northeast Ohio Regional Sewer District (NEORSD) WWTP

The NEORSD WWTP discharges to the Cuyahoga River at RM 10.57 via outfall 001. Pollutant loadings have remained relatively constant since 1991. The only significant difference was a reduction in total residual chlorine after dechlorination began in 1992. Chlorine toxicity was a possible cause of biological impairment in the mixing zone during the 1991 survey.

In addition to the WWTP, combined and sanitary sewer overflows (CSOs and SSOs) are located in the Mill Creek and Big Creek watersheds, and navigation channel. Sewer overflows, pollutant spills, and unauthorized discharges are a chronic problem in the NEORSD service area and the greater Cleveland area in general (Ohio EPA 1994). Also, many small package plants and thousands of individual home septic systems are located within Cuyahoga County and the Cuyahoga River drainage (Table 9). A significant portion of the septic systems are failing and discharge to surface waters.

Table 9. Approximate Number of Septic Systems in Cuyahoga County as of January 31, 1996. (Not all of these systems are within the Cuyahoga River Basin).

Bay Village	1	Garfield Heights	112	Olmsted Twp	1053
Beachwood	61	Glenwillow	100	Orange Village	650
Bedford	82	Gates Mills	835	Pepper Pike	1554
Bedford Heights	35	Highland Heights	514	Parma	1296
Berea	23	Hunting Valley	223	Parma Heights	30
Bentleyville	121	Independence	13	Richmond Hts	857
Bratenahl	6	Lyndhurst	6	South Euclid	6
Brecksville	611	Mayfield Heights	51	Solon	631
Broadview Heights	510	Mayfield Village	384	Strongsville	972
Brooklyn	4	Middleburg Heights	372	Seven Hills	638
Brooklyn Heights	10	Moreland Hills	952	Valley View	109
Brook Park	196	Maple Heights	14	Walton Hills	19
Chagrin Falls Twp	43	North Olmsted	21	Warrensville Hts	21
Chagrin Falls Village	74	North Royalton	1240	Woodmere	115
Euclid	9	Oakwood Village	149	Westlake	224
Fairview Park	4	Olmsted Falls	881		
				TOTAL	15,832

Thirty-four acute and thirteen chronic bioassay tests were conducted on the 001 outfall between 1994 and 1996 using *Ceriodaphnia* and fat-head minnows (*Pimephales promelas*). All the tests were conducted by NEORSD except for one acute test performed by the Ohio EPA. None of the 100% effluent tests were acutely toxic and, with few exceptions, upstream, near-field and far-field tests for *Ceriodaphnia* were not considered acutely toxic. Receiving stream mortality was evident in the fish and tended to be highest in the upstream controls; 9 of the 34 fat-head minnow tests (26.5%) had >20% mortality. Near-field and far-field samples downstream from the discharge were acutely toxic in 12% and 20% of the tests, respectively. In the 96-hour tests, chronic toxic units (TUc) for the effluent were >1.0 in 46% of tests for *Ceriodaphnia* but only one test (7.7%) for fish. Like the acute results for *Ceriodaphnia*, chronic effects in the upstream control and far-field samples were low; one exception was the Jan 22, 1997 test with 100% far-field mortality. Chronic effects on fish were more severe outside of the effluent, particularly in the upstream control. Fish mortality averaged 33% (range = 0%-73%) in the upstream control and 26% (range = 0%-51%) in far-field samples.

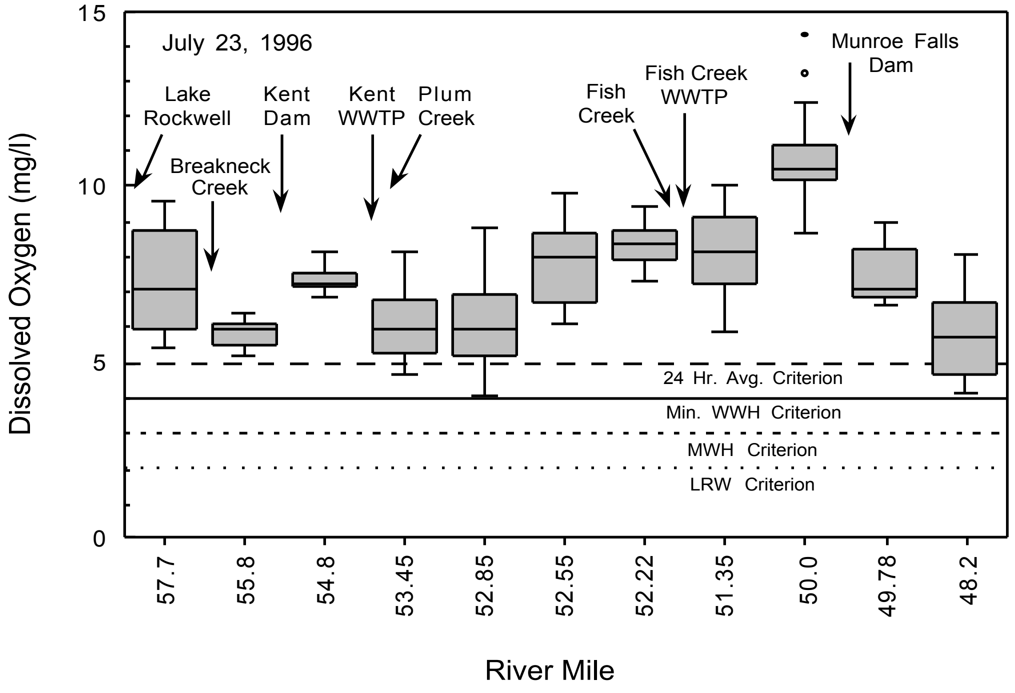
Surface Water Quality: Lake Rockwell to Big Creek

Grab water samples were collected from 18 mainstem and tributary stations five times in the middle Cuyahoga River watershed from June 20 to August 4. On each sample date, all stations were sampled on the same day to reduce sample variance. The lowest flow at the Old Portage gauge during the 1996 sampling was 127 cfs. The Q_{7-10} for the Old Portage gauge is 44 cfs.

Datasonde™ continuous monitors documented numerous exceedences of D.O. criteria between Lake Rockwell and Cuyahoga Falls (Figure 20). Minimum D.O. values fell below the 5 mg/l average criterion downstream from Breakneck Creek (55.8), downstream from the Munroe Falls dam (RM 48.2) and within the Munroe Falls Dam pool (RMs 53.45, 52.85, 51.66). The most severe D.O. depletion appeared in the Munroe Falls dam pool (RM 52.0) and downstream from Lake Rockwell (RM 57.7). During the two day sampling period in August, dissolved oxygen concentrations averaged less than 4 mg/l at RM 52.0 (immediately upstream from the Fish Creek WWTP) and less than 5 mg/l at RM 57.7.

A more recent Datasonde™ survey conducted in 1998 between Lake Rockwell and the Kent WWTP found minimum D.O. concentrations as low as 0.0 mg/l immediately below Lake Rockwell and significant D.O. depletion in the Cuyahoga for several miles downstream (Figure 21). All measurements fell below the minimum WWH criterion at the confluence with Breakneck Creek (RM 56.85) and concentrations did not consistently exceed WWH criteria until Fred Fuller Park, located between the Kent Dam and Kent WWTP (station RMs 54.6 and 54.1).

Nitrogen-ammonia trends downstream from Lake Rockwell (RM 57.97) were similar to the upper mainstem downstream from East Branch Reservoir. Elevated concentrations were found immediately downstream from the lake outlet and decreased with increased distance downstream.



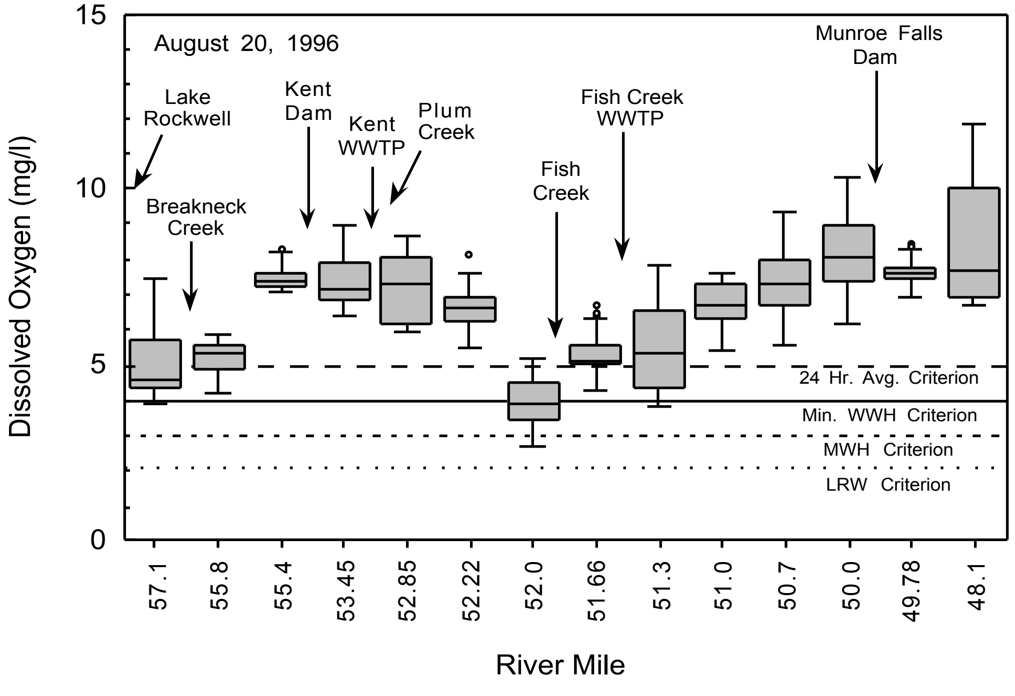


Figure 20. Datasonde™ continuous monitor results from the middle Cuyahoga River between Lake Rockwell and the Little Cuyahoga River. Samples were collected on July 23 (upper plot) and August 20 (lower plot), 1996.

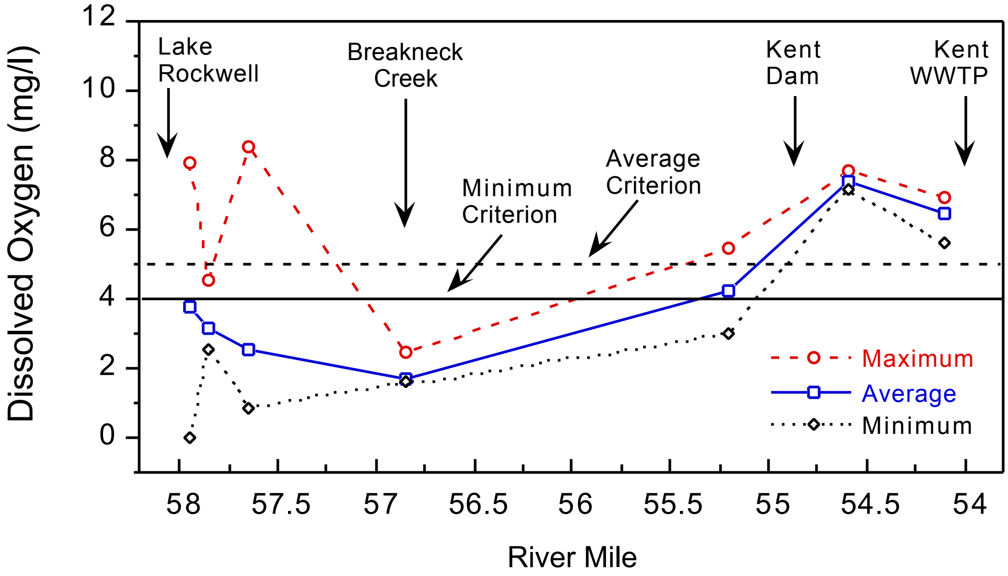


Figure 21. Maximum, average, and minimum D.O. concentrations measured with Datasonde™ continuous monitors from the Cuyahoga River between Lake Rockwell and the Kent WWTP, 1998.

The highest concentration downstream from the dam (0.28 mg/l) was recorded on June 20, immediately following an extended period of bottom release from Lake Rockwell (see Figure 8).

Median total phosphorus concentrations between Lake Rockwell and the Munroe Falls dam were generally between 0.08 and 0.10 mg/l. The median value for total phosphorus from small river reference sites in the Erie-Ontario Lake Plain is 0.06 mg/l (Ohio EPA 1999c), indicating this section of the Cuyahoga River was moderately enriched with respect to phosphorus. Nitrate-nitrite nitrogen concentrations increased downstream from Breakneck Creek, demonstrating that the Ravenna and Franklin Hills WWTPs contribute nitrogen loads to the mainstem. Median nitrate-nitrite nitrogen concentrations increase nearly five-fold downstream from the Kent and Fishcreek WWTPs compared to upstream, and little assimilation was evident through the reach and downstream from the Little Cuyahoga River. The lack of assimilation indicates that nitrogen is present in concentrations saturating to algal growth. High algal productivity combined with impounded conditions in the Munroe Falls dam pool results in dissolved oxygen concentrations frequently falling below levels limiting to aquatic life at night. Lake Rockwell also contributed to the enriched conditions by adding significant amounts of remineralized phosphorus and ammonia nitrogen to the Cuyahoga River. Nutrient loads from anoxic sediments in the low-head dam pools may also contribute to enrichment in the river.

Wet-weather sampling in 1996 revealed severe impacts on water quality downstream from Akron CSOs. A series of “first flush” samples were collected on July 30 at RMs 42.6 and 41.7 following a brief, heavy downpour. At both sites the stream was grossly contaminated, both visually and chemically, following the discharges. The color of the river turned from green to dark grey and had an odor of sewage. Numerous containers and other types of trash and litter were floating downstream. Chemical analysis revealed exceedences of acute and chronic standards for zinc (691 ug/l) and copper (110 ug/l maximum), chronic exceedences for lead (236 ug/l maximum) (Figure 22; Table 5), and gross exceedences of primary and secondary criteria for fecal coliform bacteria (maximum 200,000 counts/100 ml). Ammonia, phosphorus, and suspended solids concentrations were sharply elevated but remained within applicable standards. In contrast, all chemical parameters achieved WQS criteria immediately prior to CSO discharges. Datasonde™ readings from the city of Akron monitor also indicated a drastic reduction in D.O. levels (dropping below 3.0 mg/l) on the same date. Following the storm, river levels at the Old Portage gage doubled but still remained well below average flow levels for the summer period of record.

The July 30th storm caused severe surcharging of Akron sewers near Cuyahoga Street (RM 42.6) at Cascade Park. The surge of runoff created a 15-20 foot fountain of combined sewage and storm flow from a manhole near Rack 32. The city later inspected and cleaned the sewers, removing more than 297 cubic yards of accumulated materials. The sediment and debris had reduced hydraulic capacity and contributed to the surcharge.

Rain-induced exceedences for lead, copper, zinc, and fecal coliform bacteria were also detected in Sand Run (a small urban tributary near Akron) following a localized storm event in September. However, the exceedences were considered quite temporal and mainly a result of exceptionally high suspended solids levels (> 2,100 mg/l) immediately following the heavy rain. Heavy metals tend to sorb to silt particles which could account for the elevated levels.

Akron combined sewers discharged a total of 296 million gallons of combined flow in 1996. Akron CSOs discharge with as little as 0.1 inch of rain per hour. Most of the combined flow on a volume basis is into the Ohio Canal. The Little Cuyahoga River receives the largest number of discharge events.

Akron performed a CSO system wide study in 1994 in partial compliance with Ohio EPA Findings and Orders (F&Os). This extensive survey documented conditions in the Cuyahoga and Little Cuyahoga Rivers similar to conditions found during the 1991 Ohio EPA survey. As a result of their study, Akron requested WQS variance for many of the streams in their service area. The Ohio EPA did not concur with the city’s evaluation of the data.

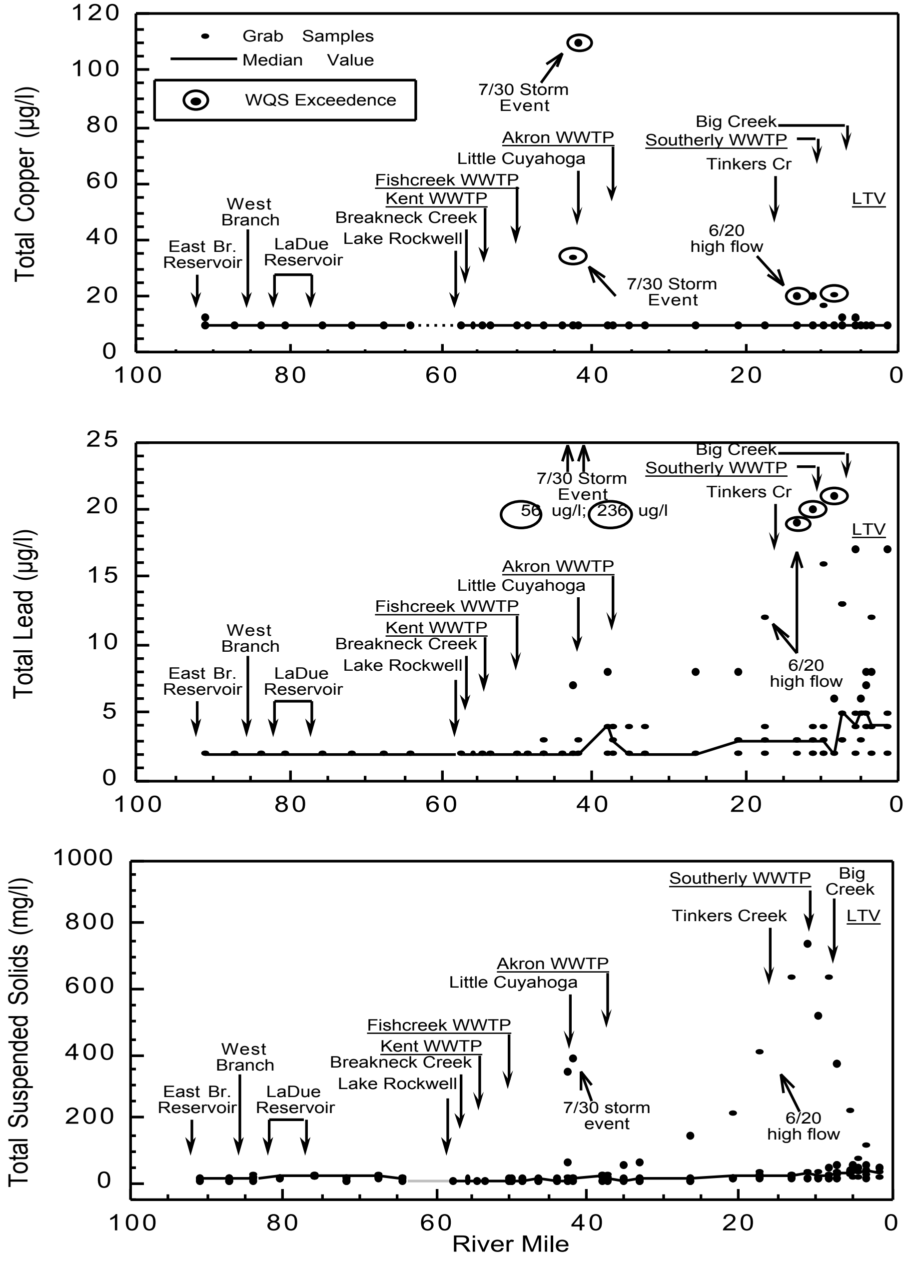


Figure 22. Total copper, lead, and suspended solids concentrations in chemical grabs from the Cuyahoga River, June-September, 1996. Lead and copper concentrations that exceed WQS criteria are circled.

Low dissolved oxygen and elevated ammonia-nitrogen concentrations were periodically detected downstream from the Akron CSOs and WWTP. Continuous daily Datasonde™ data collected by the city of Akron from June to September 1996 found dissolved oxygen below 5 mg/l on six different dates, both upstream and downstream from the WWTP. During the summer of 1995, 39 different days had daily minima below 5 mg/l and three dates had daily averages below 5 mg/l. Most of these measurements were recorded at the 801 (upstream WWTP) sampling site. The results indicate potential chronic effects on biological communities from loadings of oxygen demanding substances associated with Akron CSOs. Downstream from the WWTP, ammonia-nitrogen levels in the 0.3 to 0.8 mg/l range were detected in several samples. However, the highest concentrations were found below CSOs following the July 30 storm event (see Figure 8).

Under baseflow conditions, a number of noteworthy trends in the water chemistry were observed downstream from Akron. Both nitrate-nitrite and total phosphorus increased sharply in a step type manner below the Akron and NEORSD Southerly WWTPs, an indication of chronic nutrient enrichment on the downstream ecosystem (Figure 23). The levels did not change appreciably between Akron and Cleveland, an additional 25 miles downstream. Outside of Tinkers Creek (RM 16.36), there are no major sources of nutrients that could maintain the elevated concentrations through this segment. This suggests nutrient uptake by algae was either suppressed or nutrients were present in concentrations saturating to algal uptake rates. Suppressed uptake rates may indicate chronic toxicity or light limitation due to high levels of suspended solids. Saturated uptake rates demonstrate nutrients present in levels exceeding assimilative capacity.

Excepting rain event samples, heavy metals concentrations in the lower 40 miles of the Cuyahoga River were well below chronic criteria to protect aquatic life. The most noteworthy trend was a significant increase in total zinc below first, the Akron WWTP, next the NEORSD Southerly WWTP, and finally the LTV Steel complex in the navigation channel area (see Figure 22). Average 1996 total zinc concentrations increased from less than 20 ug/l upstream from the Akron WWTP to a value slightly higher than 100 ug/l below the LTV complex.

During dry weather, fecal coliform bacteria exceeded the Primary Contact Recreation criterion at RMs 41.6 (1100/100 ml) and 38.0 (2400/100 ml). Both sites are downstream from the Little Cuyahoga River and Akron CSOs but upstream from the Akron WWTP. During wet weather, much higher coliform counts were found between Akron and Cleveland (RMs 42.6-7.2) than at base flows (Figure 24). Bacteria levels ranging as high as 140-200,000/100 ml were measured immediately downstream from active CSO discharges in Akron (Table 5).

Monthly operating data reports from the Akron WWTP also suggest chronically high fecal coliform and zinc levels near the discharge. Between 1992 and 1997, a total of 280 bacteriological samples were collected upstream and downstream from the WWTP. Median and 75th percentile

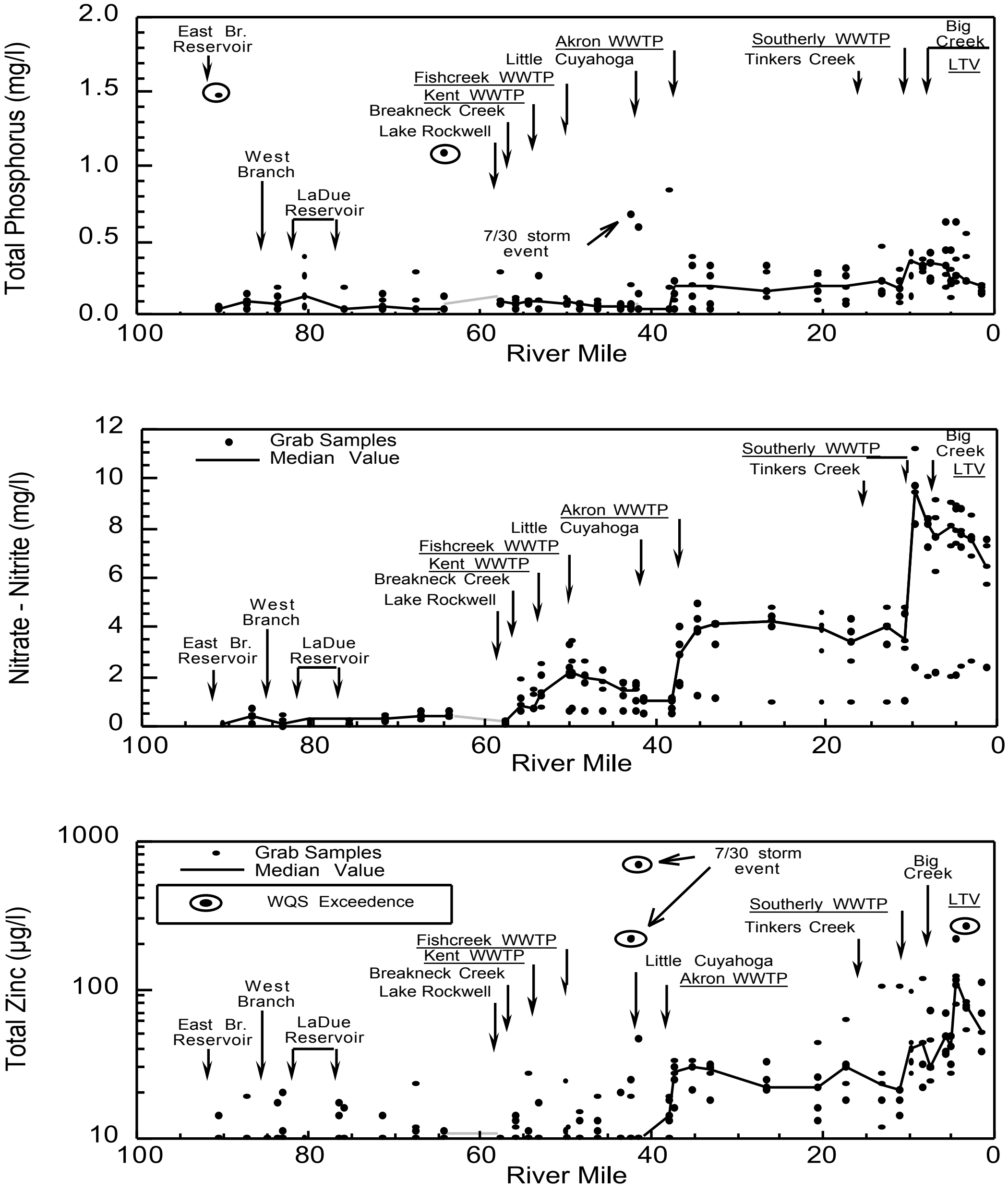


Figure 23. Total phosphorus, nitrate-nitrite, and zinc concentrations in chemical grabs from the Cuyahoga River, June-September, 1996. Zinc concentrations that exceed hardness adjusted WQS criteria and phosphorus concentrations that exceed the Agency's 1.0 mg/l interim guideline are circled.

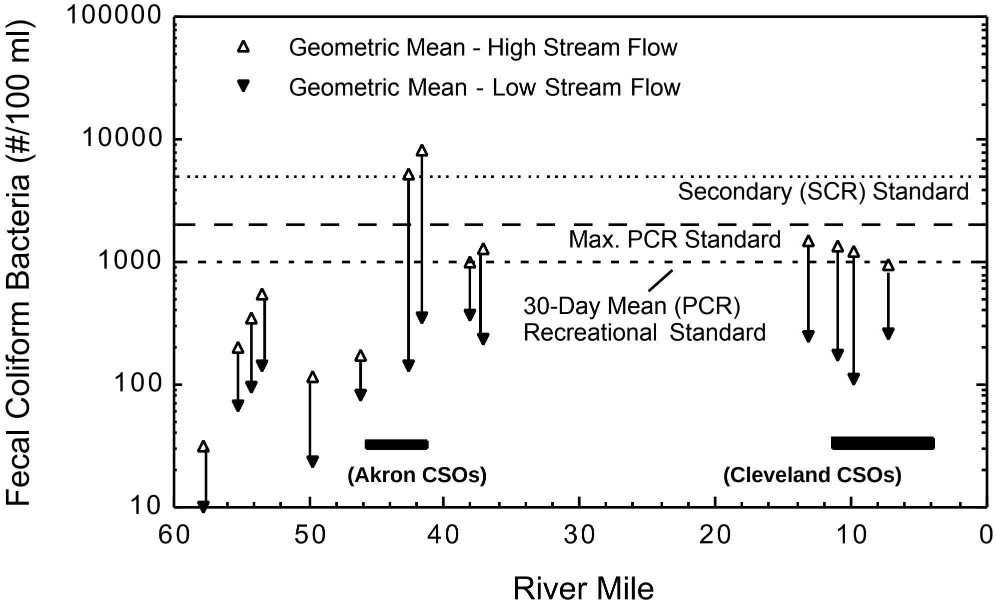


Figure 24. Geometric means of fecal coliform bacteria samples from the Cuyahoga River in the Akron and Cleveland area, 1996.

concentrations upstream approached the maximum fecal coliform criteria for primary contact (2,000 colonies/100 ml.) and secondary contact (5,000 colonies/100 ml.), respectively. Similar but somewhat lower concentrations were found downstream from the WWTP. Zinc concentrations exceeded detection limits in all samples (n=178) downstream from the WWTP. Median and 75th percentile concentrations fell in the 30-50 ug/l range. These levels are two to three times higher than those encountered in similar sized rivers from the EOLP ecoregion containing good or exceptional fish communities (Rankin *et. al.* 1996).

A bacteriological study conducted by the USGS following rain events (Francy *et.al.* 1993) found grossly elevated fecal coliform bacteria counts in the Cuyahoga River downstream from Akron. The most significant source of fecal coliform bacteria was from bypasses of the secondary treatment process at the Akron WWTP.

During the 1996 survey, a high stream flow sample run was conducted on June 20th. Visually the lower reaches of the Cuyahoga River were very turbid due to suspended soil particles. The observations were confirmed by chemical results showing extremely elevated suspended solids levels which reached a high of 740 mg/l immediately upstream from the NEORSD Southerly WWTP (see Figure 23). Lead, copper, and zinc concentrations were also elevated and several lead and copper concentrations exceeded chronic WQS criteria in the Cleveland area between

RMs 13.2 and 8.3. A strong correlation between elevated lead and suspended solids levels in the 1991 survey (particularly following rain events) suggested some heavy metals were associated with nonpoint sources, rather than point source discharges (Ohio EPA 1994).

Physical Habitat for Aquatic Life - Lake Rockwell to Cuyahoga Falls
The Cuyahoga River between Lake Rockwell and Cuyahoga Falls (RMs 57.5-48.0) flows through a series of impoundments. These hydromodifications caused modified habitat attributes to outnumber warmwater habitat attributes by approximately 1.86:1, and resulted in a mean QHEI score of 58.9 (± 3.0 SE, *N* = 8). The average QHEI score suggests that the macrohabitats in the reach are marginally suited to typical warmwater stream faunas. Modified attributes limiting to aquatic life common throughout the reach included silt covered and embedded substrates, poor channel development, low sinuosity, no fast current, and no riffles.

Physical Habitat for Aquatic Life - Cuyahoga Falls to Big Creek
Downstream from Cuyahoga Falls (RMs 46.0-7.2), the river is generally free flowing, with the exception of the Ohio Edison dam pool and the Station Road dam. Warmwater habitat attributes are generally more prevalent than modified attributes within the reach, as reflected by the mean QHEI score of 70.4 (± 1.6 SE, *N* = 16), and provide suitable habitat for warmwater stream faunas (Appendix B). Habitat features typical of the reach include boulder, cobble and gravel substrates, a sinuous and well developed channel containing riffles, pools and runs, and moderate amounts of woody debris. Attributes impairing overall habitat quality were silt cover, embedded substrates, and severe bank erosion collectively imparted by flashy stream flows and poor flood plain land-use practices downstream from Akron.

Fish Communities: - Lake Rockwell to Big Creek
Downstream from Lake Rockwell, IBI scores decreased relative to the free-flowing reach upstream, primarily as a result of low dissolved oxygen levels and impounded habitat. Compared to the good conditions upstream, communities remained in the fair to poor ranges from Lake Rockwell to Cuyahoga Falls (RMs 57.5-46.0) before experiencing modest recovery in the Edison gorge area (RMs 44.0-42.8). Compositionally, the IBI decreased owing to the loss of habitat sensitive round-bodied suckers and simple lithophils, and an increase in the relative abundance of tolerant fishes. The relative abundance of tolerant fishes within the reach between Lake Rockwell and Munroe Falls was highest downstream from Breakneck Creek at Fuller Park, suggesting pollutant loads associated with Breakneck Creek were influencing the Cuyahoga River mainstem. Further declines in IBI scores were measured in a short free flowing reach downstream from Munroe Falls, and may be related to nutrient enrichment and the resulting increased algal productivity from the Kent and Fish Creek WWTPs. A surface scum of what appeared to be blue-green algae was present in the Munroe Falls dam pool. Blue-green algae are favored by enriched conditions and low nitrogen to phosphorus ratios (i.e., high phosphorus concentrations; Hecky and Kilham 1988). Nutrient loads from anoxic sediments in the low-head dam pools may also contribute to the enriched conditions.

The Modified Index of well-being (MIwb) scores also decreased downstream from Lake Rockwell, falling almost consistently in the fair range between Lake Rockwell and the Ohio Edison Dam pool (RMs 57.5-46.0). Consequently, neither fish index met the respective WWH criterion within the approximately eleven mile reach.

IBI scores improved in the high gradient, free flowing reach between the Ohio Edison dam pool and the confluence with the Little Cuyahoga River, marginally meeting the WWH biological criterion. This section of the river currently supports more sensitive fish species than any mainstem section downstream and has become increasingly important as a fish refugia upstream from most Akron area discharges. Habitat conditions throughout the Akron to Cleveland area are adequate to support WWH communities (QHEI = 70.4 [± 1.6 SE, *N* = 16]). However, the high gradient, exposed bedrock and turbulent flow in the gorge section are unique and may help ameliorate impacts from the current CSO discharges.

Community performance decreased considerably downstream from the confluence with the Little Cuyahoga River. Habitat does not explain the decrease in community performance. In fact, index scores decreased independently of habitat quality in this reach (Figure 25), indicating gross water quality impacts. The relative abundance of tolerant and omnivorous fishes increased, while top carnivores and round-bodied suckers were nearly eliminated, and the total number of species and individuals declined. These changes represent a fundamental disturbance in the structure and function of the fish community related to pollution impacts from the Little Cuyahoga River. The decrease in number of sensitive species downstream from the Little Cuyahoga River (see Figure 11 and Figure 3) further suggests conditions are chronically toxic (Yoder and Rankin 1995).

Fish community index scores from the Akron WWTP mixing zone were lower than at sites immediately upstream and downstream. The low numbers (as reflected by the MIwb) and loss of round-bodied suckers may indicate an avoidance response to the effluent. Community response signatures suggest at least a chronic toxic influence.

Downstream from Akron, modest recovery in MIwb scores occurred between the Station Road dam pool and the Southerly WWTP indicating slightly improved water quality. However, excepting a fair MIwb score at RM 15.6, communities were in the poor or very poor ranges throughout the reach. Recovery appeared to be briefly interrupted by the Southerly WWTP, ad halted entirely downstream from the slag pile leachate adjacent to Bradley Road and the confluence with Big Creek.NEORSD mixing zone communities improved compared to 1991 when conditions appeared toxic and impacted by high residual chlorine. Fish avoided the mixing zone in 1991. In contrast,1996 IBI scores were 13-14 points higher than the surrounding mainstem stations and 11 points higher than the 1991 mixing zone score. Pollution sensitive hog suckers numerically predominated the mixing zone during one of the two 1996 sampling passes.

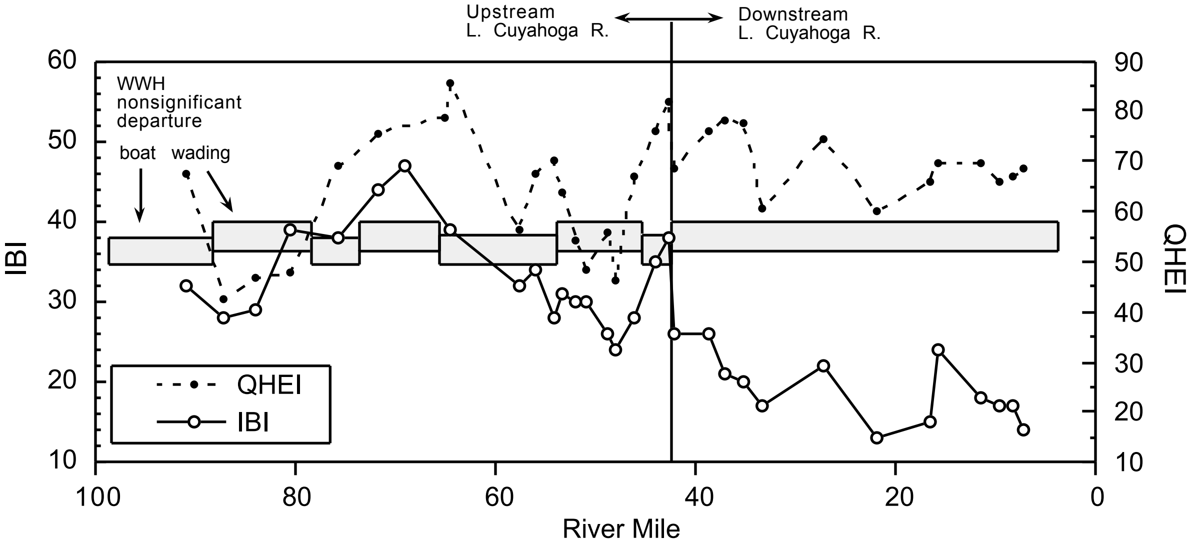


Figure 25. Longitudinal trend of IBI and QHEI scores at Cuyahoga River sampling sites in 1996.

Percentages of DELT anomalies, already elevated downstream from Akron, underwent further increases through the Cleveland area. Similar to the 1991 survey, highest percentages were found between the NEORSD WWTP and the Cuyahoga River lacustuary which begins at rm 7.0. However, 1996 percentages were consistently higher both upstream and downstream from the WWTP, with some sites approaching 1984-87 survey levels. The results indicate continued impacts well downstream from Akron and additional stresses as pollution loads from a variety of sources enter the mainstem throughout Cleveland and its suburbs. Chronic impairment in the lower Cuyahoga River and the high incidence of anomalies suggest chronic toxicity and a system exceeding its assimilative capacity. Discharges from the NEORSD WWTP were considered an additional source of stress to the already impaired system.

Macroinvertebrate Communities - Lake Rockwell to Big Creek

Macroinvertebrate community health declined from exceptional upstream from Lake Rockwell (ICI = 50 at RM 64.2) to fair immediately downstream at RM 57.6 (ICI = 26). Thirty-three taxa of mayflies, caddisflies and stoneflies were found at the upstream site compared to only eight downstream from the lake release. Low dissolved oxygen and elevated ammonia in the tailwaters were a probable source of impact. Communities improved to the good and very good ranges between Breakneck Creek and the Kent WWTP (RMs 56.1-54.4) and maintained good quality between Kent and the Little Cuyahoga River (RMs 53.4-42.8). However, none of the sites approached the exceptional quality found upstream from Lake Rockwell. ICIs declined below the Little Cuyahoga River but remained in the lower good or marginally good ranges prior to the discharge of the Akron WWTP. Akron WWTP mixing zone samples reflected an enrichment response with sharp increases in community density and the percentage of oligochaetes and hemoglobin-utilizing midges (i.e., *Chironomus riparius* group). Both organism groups are included on the Ohio EPA tolerant taxa list (Ohio EPA 1987b) and are often associated with gross organic enrichment. The continued abundance of the filter-feeding midges of the *Rheotanytarsus exiguus species* group, suggested enriched, but not acutely toxic conditions.

Conditions remained in the fair range between the WWTP and Bolanz Road (RM 33.0), about four miles downstream (see Figure 13 on page 48). The WWH biocriterion was not reached for an additional seven miles downstream at Boston Mills (ICI=36 at RM 26.5). Communities in this reach continued to reflect enriched conditions, reaching a maximum density of 8,521 organisms/sq.ft. at RM 35.3. Gradual recovery continued downstream from Akron and community health reached very good to exceptional levels in a ten-mile stretch from Station Road to the Southerly WWTP (RM 20.9-11.0).

NEORSD mixing zone communities showed some improvement compared to 1991 when conditions appeared toxic and impacted by high residual chlorine. A predominance of the toxics tolerant midge, *Cricotopus bicinctus*, very low population densities, and severe gill damage in hydropsychid caddisfly specimens reflected exposure to high chlorine levels In 1991. The 1996 collections were similar in ICI scoring (26) and community composition. However, increases in density, the absence of gill damage to caddisflies, and improved composition in the qualitative sample (field observations) suggested a lessening of toxicity and lower residual chlorine levels. Overall conditions in the mixing zone were not considered acutely toxic, although a low-grade or chronic toxic influence could not be ruled out.

Downstream from the NEORSD WWTP, ICI scores fell compared to upstream sites but maintained good quality before dropping to fair immediately downstream from Big Creek (ICI=24 at RM 7.1). Longitudinal trends were very similar to 1991 collections except for indications of greater impacts downstream from Big Creek in 1996. Biological response signatures in the macroinvertebrates downstream from the NEORSD WWTP were not indicative of significant toxicity.

Trend Assessment - Lake Rockwell to Big Creek

Surface Water Quality Trends

Downstream from Akron, lack of change in phosphorus and nitrate-nitrite concentrations between the 1991 and 1996 surveys indicates a chronic nutrient enrichment impact (Figure 26). It is possible that the fish community in this segment of the Cuyahoga River has reached a nutrient enrichment barrier that will prohibit future attainment of the IBI WQS biocriterion until such time that reductions in phosphorus and/or nitrate nitrogen occurs.

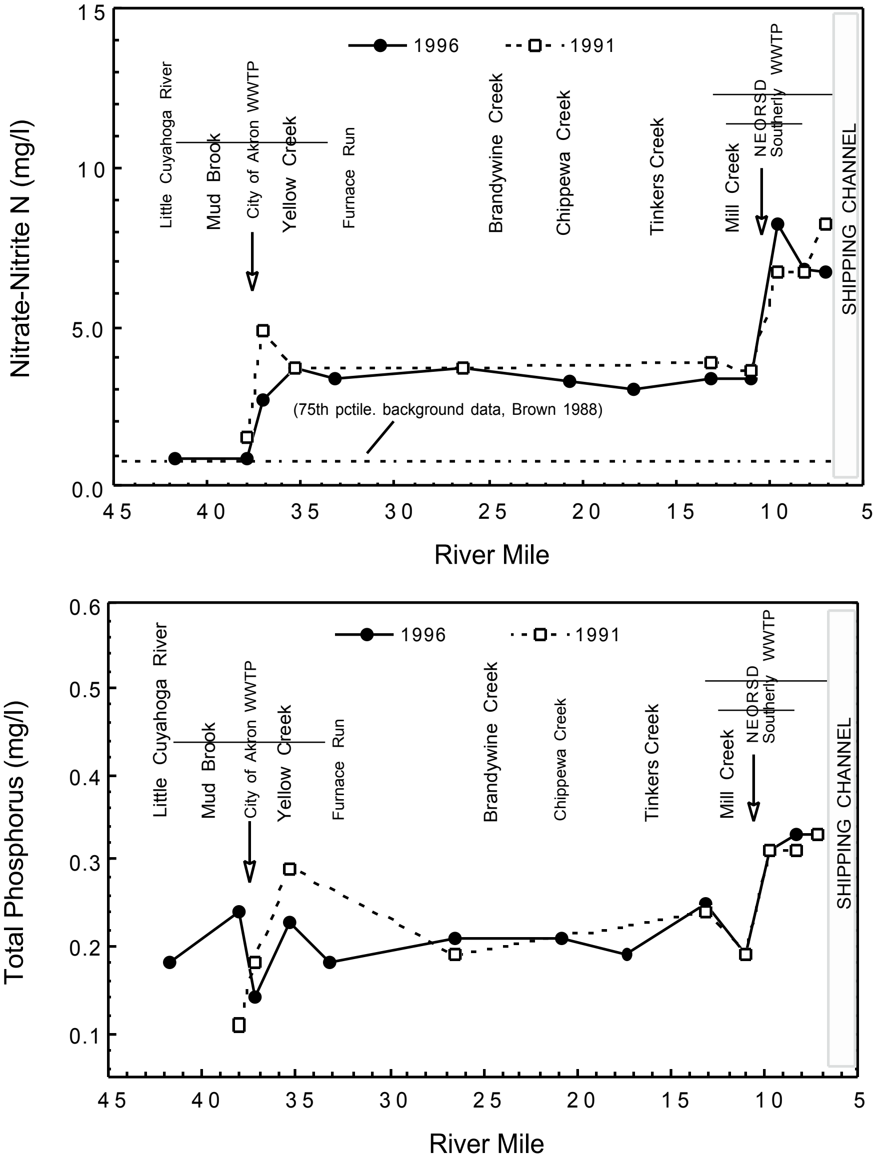


Figure 26. Mean nitrate-nitrite and total phosphorus concentrations from the Cuyahoga River between Akron and Cleveland, 1991-1996.

Daily tons of TSS recorded at the USGS gauge at Independence for the 1995 water year was 183,796 at an annual total discharge of 266,399 cfs, which was little changed from the total tons of TSS reported in the 1991 water year (i.e., 236,540 tons at 417,059 annual cfs). These data do not indicate any significant increase in TSS loadings to the lower Cuyahoga River between the 1991 and 1996 Ohio EPA surveys (Figure 27).

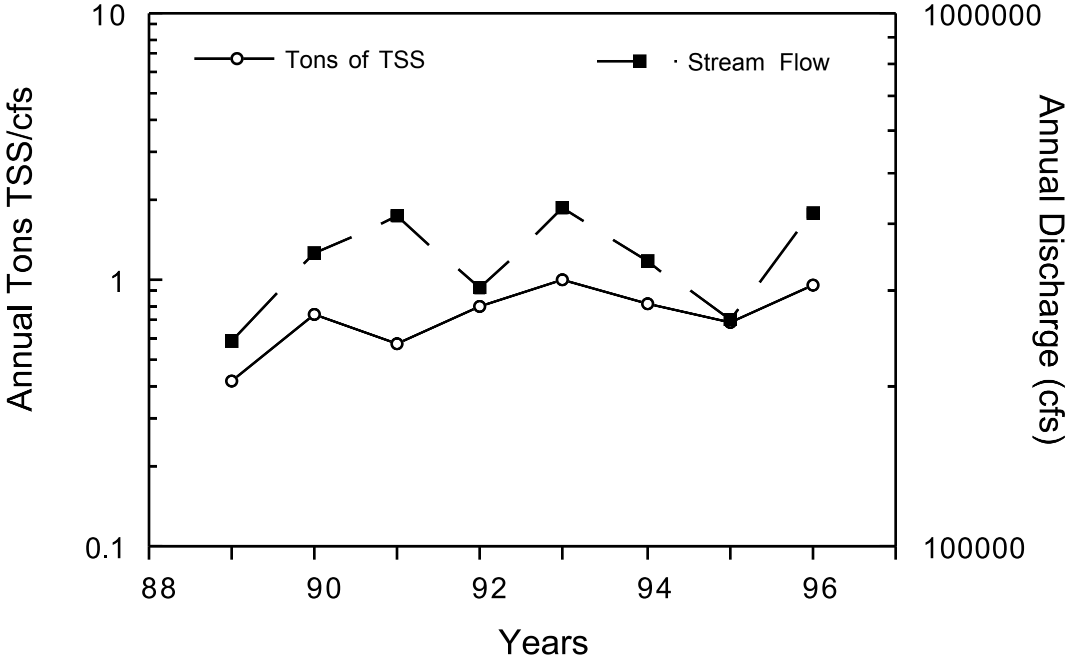


Figure 27. Historical trends in annual discharge and total suspended solids (TSS) loadings from the Cuyahoga River at RM 13.2 (Independence gage), 1989-1996 (USGS data).

Comparison of fecal coliform bacteria data collected in 1991 and 1996 indicates little overall change in levels. Average values continue to be less than the 1000/100 ml Primary Contact Recreation criterion at base flow conditions; however, as was found in 1991, fecal coliform numbers continue to exceed the 1000/100 ml PCR criterion throughout the lower Cuyahoga River segment when stream flow is elevated due to rain runoff. A similar finding was reported by the USGS in their extensive bacteriological survey of the lower Cuyahoga River (Francy *et. al.* 1993).

<u>Biological Trends</u>

Compared to the 1991 intensive survey, there was minimal change in Cuyahoga River quality in 1996. Biological communities continued to fall into non-attainment downstream from the Little Cuyahoga River and Akron. During dry weather, the mainstem is in substantial compliance with chemical WQS criteria. However, following rainfall events, significant exceedences for heavy metals and fecal coliform bacteria were associated with combined sewer overflows in Akron, urban runoff, and Akron WWTP bypasses. Excessive turbidity was assumed to be related to nonpoint sources.

An improving trend upstream from the Little Cuyahoga River coincides with the elimination of the Ohio Edison thermal discharge in the fall of 1991, repair or replacement of leaking and broken sewer lines in Akron and Cuyahoga Falls (e.g., Babb Run watershed), and removal of sewer blockages. Aggressive maintenance of the sewer systems is an important factor to support the continued full attainment within this reach. The Cascade Park/Edison gorge area currently supports more sensitive fish species than any mainstem section downstream and has become increasingly important as a fish refugia upstream from the Little Cuyahoga River. Habitat conditions throughout the Akron to Cleveland area are adequate to support WWH communities but the high gradient, exposed bedrock and turbulent flow are unique and may help ameliorate impacts from the current CSO discharges.

Fish community performance, as measured by the IBI and MIwb in 1996, decreased relative to 1991 at most mainstem sites (see Figure 11). The difference in IBI and MIwb scores was due to fewer number of species and fewer total number of fishes collected at a site in 1996 compared to 1991. Flows were lower under drought conditions in 1991 compared to 1996, with flows on sampling days respectively averaging 51.3 and 91.1 cfs. The higher flows were associated with lower MIwb scores (t = - 2.67, P = 0.0100 for the regression of MIwb on flow). The drought may have augmented the number of fish and species due to fish seeking refuge from intermittent tributaries, as evidenced by the presence of redside dace, a headwater species, at RM 38.6 in 1991. Given the similarity in metrics reflecting functional aspects of the fish community, no notable differences in habitat quality, and the differential sampling efficiency between years, water quality did not appear to deteriorate, or conversely, improve between 1991 and 1996. An increase in the number of sensitive species, documented in 1991, continued in 1996 (see Figure 3).

ADV statistics reflect the relatively consistent biological performance between 1991-96 (Table 10). The river remains in non-attainment between Akron and Cleveland, fish communities continue to perform poorly, and negative ADV statistics continue to reflect significant impacts to biological quality since 1991.

Table 10. Area of Degradation Values (ADV) statistics for the lower Cuyahoga River. Values were calculated using Erie Ontario Lake Plain WWH biocriteria as the baseline for community performance.

Stream (Year)			Biological Index Values		ADV Statistics				Attainment Status		
	Reach				Positive		Negative		(miles)		
Index	Upper RM	Lower RM	Minimum	Maximum	ADV	**ADV/ Mile**	ADV	**ADV/ Mile**	Full	Partial	**Non**
Lower Cuyahoga River (1996)											
IBI	42.9	7.0	13	38	11	**0.3**	5931	**165.2**	0.2	3.3	**32.4**
MIwb			3.9	7.4	0	**0.0**	4796	**133.5**			
ICI			24	46	2581	**71.9**	262	**7.3**			
Lower Cuyahoga River (1991)											
IBI	42.9	7.0	17	33	0	**0.0**	4682	**130.4**	0.0	2.9	**33.0**
MIwb			5.8	8.1	2	**0.0**	2350	**65.4**			
ICI			26	42	2114	**58.9**	78	**2.1**			
Lower Cuyahoga River (1984)											
IBI	42.9	7.0	12	27	0	**0.0**	7707	**214.7**	0.0	0.8	**35.1**
MIwb			0.1	7.4	0	**0.0**	8985	**250.2**			
ICI			10	32	10	**0.2**	4863	**135.4**			

Cuyahoga River Lacustuary - Big Creek to Lake Erie (RMs 7.0 to 0.0)

Pollutant Loadings - Cuyahoga River Lacustuary

LTV Steel

The LTV Steel complex has 21 NPDES outfalls located between RMs 6.74 and 4.7 (Table 11). Fourteen of the outfalls are active and include five process discharges. Outfalls 002, 017 and 022 are related to steel rolling and finishing. The 005 and 027 discharges contain process and non-contact cooling water from blast furnaces. Median flows in 1996 resulted in a combined discharge of 98.684 MGD, making LTV the single largest source of effluent flow to the Cuyahoga River. The three largest outfalls are the 005 (47.333 MGD median flow), 014 (31.897 MGD), and 027 (12.099 MGD). Outfall 014, a non-process discharge, is a combination of non-contact cooling water, water softener, filter and boiler blowdown, storm water, ground water, and City of Cleveland West 3rd Street storm sewer discharge.

Table 11. Major Discharge and Tributary Locations by River Mile in the Cuyahoga River Lacustuary and Navigation Channel. (Bold type indicates the five process outfalls).

Cuyahoga River	River Mile
Lotic Habitat (WWH criteria apply)	
1) Biology	Headwaters-RM 7.0
2) Chemistry	Headwaters-RM 5.6
Big Creek	7.20
Lacustuary (Upstream limit for use of interim lacustuary biocriteria)	7.00
LTV 002	**6.74**
LTV 022	**6.00**
N&SS RR Bridge	
1) Downstream limit of WWH Criteria for Chem. (June-January)	5.60
2) Downstream limit of Biocriteria (January-June)	5.60
3) Upstream limit of Navigation Channel; LRW Criteria Apply (June-January)	5.60
LTV 005	**5.39**
LTV 027	**5.07**
Morgan Run (Coke Ovens #1 & #2 eliminated; 1992-93)	5.05
LTV 014	4.91
LTV 017	**4.70**
Zaclon (discharge eliminated)	4.60
Downstream limit of WWH Criteria for Temperature (June-January)*	4.50
Kingsbury Run	4.125
Lake Erie	
1) Downstream limit of WWH Criteria for Chem. (January-June)	0.00

* Temperature criteria for “Lake Erie Tributary Estuaries”, found in Table 7-13(H) of the WQS, defines the upstream limit of the estuary as the “average Lake Erie high water mark” (*i.e.,* RM 4.5).

Long term analysis of changes in pollutant loadings from the LTV steel complex is complicated by the fact that no single parameter has been monitored from all 14 active outfalls over time. For example, ammonia-nitrogen loadings were monitored at only three of the 14 active NPDES discharges in 1996 (outfalls 005, 014, and 027). The combined average loading from the three outfalls was 198 kg/day, a value similar to the 1996 average loading of ammonia-nitrogen from the NEORSD Southerly WWTP. One of the most widely sampled parameters is oil-grease, which has been sampled from outfalls 002, 005, 014, 022, and 027 from 1992 to 1996. These data indicate relatively constant loadings of oil-grease, with a combined average annual loading of about 1000 kg/day. This value would be expected to significantly underestimate the actual annual loading of oil-grease from the 21 known NPDES discharge pipes along the LTV property due to lack of data on oil-grease loadings during rain runoff. Another problem with analysis of long term trends is the fact that effluent monitoring requirements have changed over time, making accurate determinations of loadings difficult or impossible to calculate. Also, use of the river for cooling water makes accurate estimates of net loadings for parameters such as TSS even more problematic (Ohio EPA 1994).

Since installation of wastewater treatment in the 1970s, there have been no significant upgrades in treatment processes. Declines in pollutant loadings over the last two decades have primarily resulted from installation of recycle systems in the 1980s, reductions in production levels, and elimination of industrial processes. Most recently, the closure of the last LTV coking ovens in 1992 and 1993 eliminated a significant source of ammonia and cyanide loadings.

Use Designation Status and Standards - Cuyahoga River Lacustuary

Different biological and water quality criteria apply to the lower Cuyahoga River as it changes from lotic (*i.e.*, free-flowing) to freshwater lacustuary, and then enters the navigation channel (see Table 11). For water chemistry, the lotic section extends through Cleveland as far downstream as the N&SS railroad bridge (RM 5.6). Warmwater Habitat chemical criteria apply to this section throughout the year. The remainder of the river between the N&SS railroad bridge and Lake Erie (RM 5.6-0.0) is dredged to a 23 foot depth for large ship navigation. This segment is designated Limited Resource Water (LRW) from June to January or when flows at the Independence gage fall below 703 cfs. In addition, a 1.5 mg/l D.O. standard developed specifically for the channel is applied during these periods. During the remainder of the year, the normal WWH chemical criteria apply throughout the length of the river to Lake Erie.

Segment delineations for the application of biological criteria are somewhat different from the water chemistry. For the biology, the lotic segment extends as far downstream as RM 7.0 (0.2 miles downstream from Big Creek), where the river slows and flow is largely influenced by Lake

Erie water levels. Standard WWH criteria developed for the Erie-Ontario Lake Plain ecoregion are used in the lotic segment. In the remainder of the river, an interim set of criteria developed for assessing Lake Erie lacustuary environments is employed (Ohio EPA 1999a,b Draft). The Cuyahoga River lacustuary extends from RM 7.0-0.0 and is designated Warmwater Habitat from RM 7.0-5.6 (the N&SS railroad bridge) and Limited Resource Water in the navigation channel (RMs 5.6-0.0). Like water chemistry, the LRW designation is in effect for the biology from June to January or when flows fall below 703 cfs. Biological criteria do not apply to the navigation channel during the remainder of the year.

In the navigation channel, establishment of permanent warmwater communities was considered unrealistic due to severe habitat limitations, channel morphology and inherently low dissolved oxygen levels. Because of the biological and physical limitations, WWH chemical criteria were considered either too restrictive or unattainable during much of the year. Water quality impacts in the channel are most acute during the fall and summer months, when river flows are low or temperatures are elevated. Biological integrity is considered least vulnerable during this same period since spring migration and reproduction periods for fish are largely completed before the summer months. For these reasons, the LRW designation was employed only to protect against rapidly lethal conditions (*i.e.*, acute toxicity) during these most stressful periods. For water chemistry, the acute or “outside mixing zone maximum” standards apply. For biological communities, fish and macroinvertebrates that score above “very poor” meet standards. Non-attainment occurs when *all* index values are in the very poor range and communities are in partial attainment if at least *one* index is above “very poor”. Full attainment is realized if *all* scores are “poor” or better.

From January through May when flows exceed 703 cfs, the aquatic life use in the navigation channel is “fish passage” and is designed to support passage of warmwater fish during migratory periods. Chemical criteria are the same as WWH criteria during these periods but biological criteria do not apply. [For a complete description of aquatic life use designations for the lower Cuyahoga River, see the October 16, 1997 revision of the Ohio WQS (Ohio Administrative Code 3745-1; pages 26-01 to 26-08].

Surface Water Quality - Cuyahoga River Lacustuary

WQS criteria exceedences between Big Creek and the navigation channel (RM 7.1-5.6) were limited to a single fecal coliform bacteria sample. Within the navigation channel, LRW exceedences were limited to a single zinc violation at RM 3.27. Outside of dissolved oxygen, exceedences of chronic standards in the navigation channel were also the exception; one departure for average temperature was detected at RM 5.0, downstream from several LTV cooling water discharges.

In the lower three river miles of the navigation channel, average D.O. levels fell below 5.0 mg/l (WWH standard) with lowest concentrations at the most downstream site (RM 1.46). However, no measurements were below the 1.5 mg/l navigation channel standard. Ammonia-nitrogen concentrations were in the 0.3 to 0.8 mg/l range between LTV and the mouth and tended to rise with increased distance downstream. At typical summer pH and temperature ranges, average levels of ammonia-nitrogen downstream from LTV could exceed chronic WWH criteria. In addition to the steel plant and CSO discharges into the lacustuary, anaerobic decomposition of organic compounds in sediment may contribute to the elevated ammonia-N levels.

Excepting zinc, heavy metals concentrations from the lacustuary fell well below chronic WQS criteria. Zinc concentrations, already elevated downstream from the Akron and NEORSD WWTPs, underwent additional increases downstream from LTV, averaging slightly higher than 100 ug/l.

Water Quality Trends - Cuyahoga River Lacustuary

Chemical water quality has improved significantly in the lower reaches of the Cuyahoga mainstem compared to pre 1970s conditions and to lesser degrees, from historical surveys in the 1980s and early 1990s. Near the head of the lacustuary at Harvard Ave. (RM 7.1), long term monitoring shows significant declines in ammonia following the start of denitrification at the NEORSD Southerly WWTP (Figure 28). Within the navigation channel, ammonia levels that routinely exceeded LRW criteria in the 1960s and 1970s declined to levels associated with Modified Warmwater Habitat (MWH) criteria in the 1980s (Figure 29). Since the elimination of the LTV coking ovens in 1992-93, concentrations of ammonia are often below the chronic WWH criterion. However, background levels in the lower channel remain quite elevated, apparently due

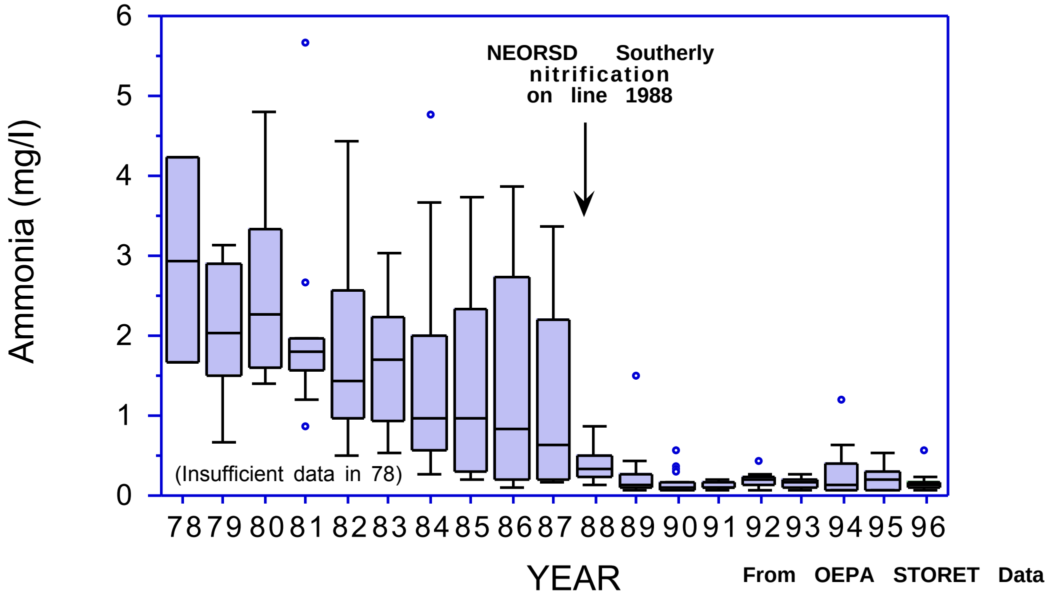


Figure 28. Historical trend of ammonia-N concentrations from the Cuyahoga River at Harvard Ave. (RM 7.1), 1978 to 1996.

to anaerobic decomposition of organic compounds in anoxic sediments and the resultant formation of ammonia.

Perhaps the most significant water quality improvement in the navigation channel is the increased levels of dissolved oxygen. Since 1993, monthly ambient monitoring at West Third Street (RM 3.26) has routinely found minimum summer D.O. levels above the new 1.5 mg/l navigation channel standard for fish migration (Figure 29). However, data collected from the navigation channel segment at other locations in 1995 and 1996 does indicate occasional dissolved oxygen values below 1.5 mg/l (NEORSD 1996). Like ammonia trends, improvements in D.O. possibly resulted from elimination of the coking plant discharges and improved management of sewers within the NEORSD service area.

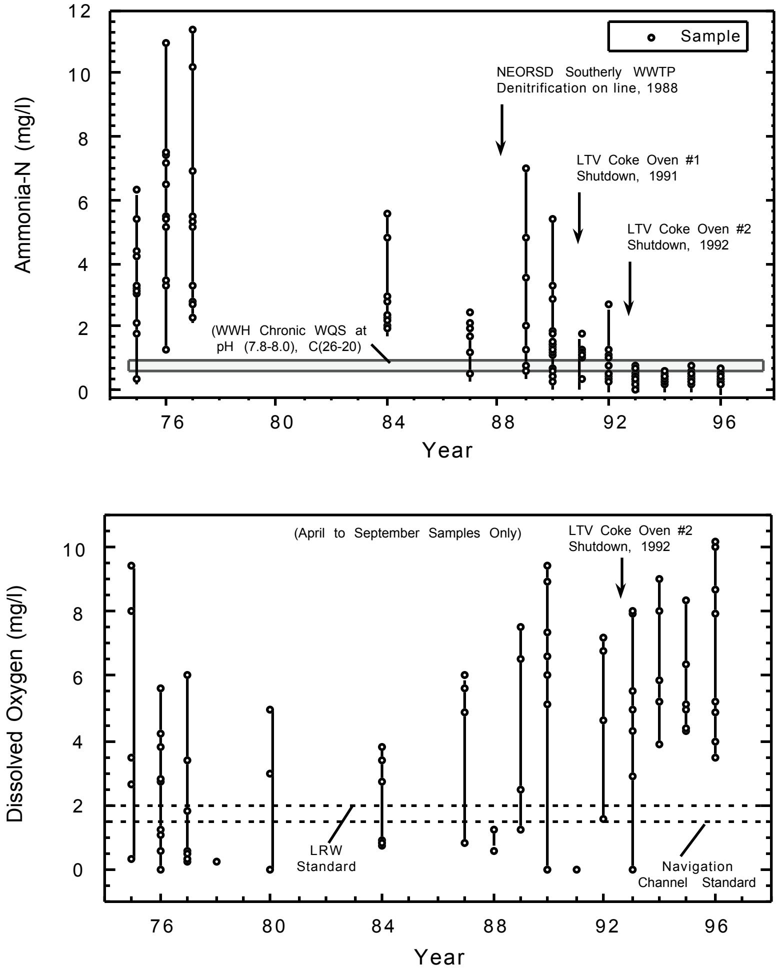


Figure 29. Historical trend of ammonia-N and dissolved oxygen concentrations from the Cuyahoga River ship channel at West Third Street (RM 3.26), 1976 to 1996.

Despite elimination of the Zaclon discharge, (a former source of zinc loadings at RM 4.6), zinc concentrations continue to increase sharply downstream from LTV (Figure 30). The most recent results suggest LTV remains a major source of zinc discharging into the navigation channel.

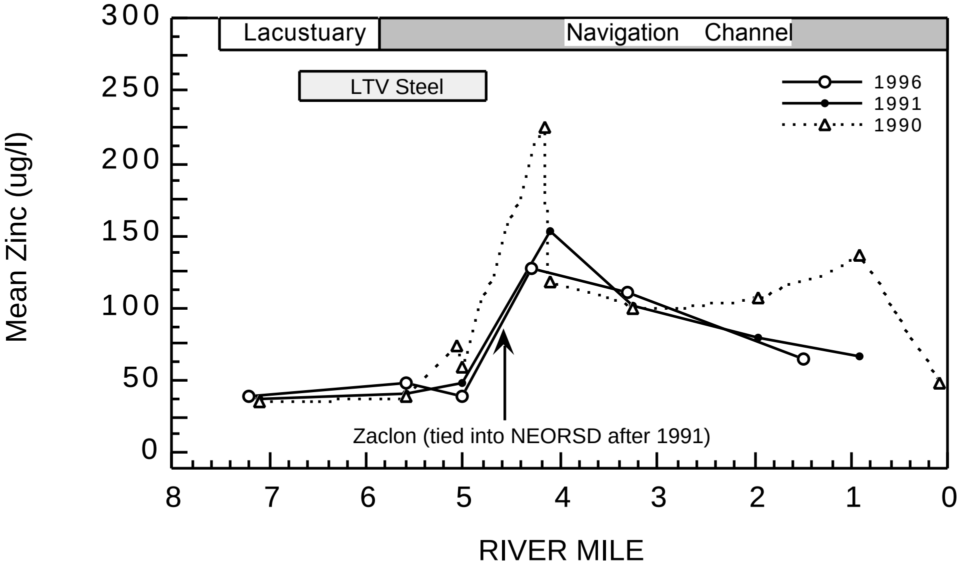
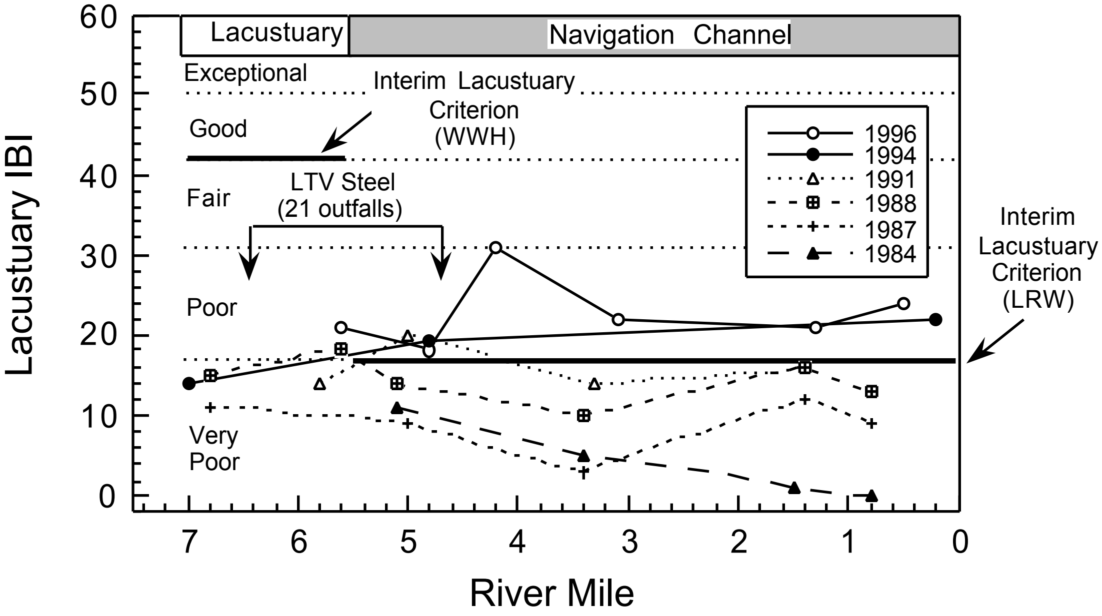


Figure 30. Historical trend in mean zinc concentrations from the Cuyahoga River lacustuary and navigation channel (RMs 7.0-0.0), 1990-1996.

Biological Trends - Cuyahoga River Lacustuary

Biological communities from the navigation channel were generally poor (Tables 6 and 7) but reflected attainment of the LRW aquatic life use designation (i.e., better than “very poor”) based on the interim Lake Erie lacustuary criteria (Ohio EPA 1999a,b Draft). Fish communities have shown improvement in trophic conditions (reflected in the IBI) but little change in abundance and diversity (as illustrated in the MIwb) (Figure 31). As a result, a few tolerant fish populations now inhabit sections that were nearly devoid of fish up to the mid 1980s. Sharp declines in the percentage of DELT anomalies also reflect a lessening of severely toxic influences over the past ten to fifteen years. Macroinvertebrate trends show significant positive change (from “very poor” to “fair”) at only one site near LTV and the former coking oven discharges (Figure 32). The improvement coincides with the elimination of ammonia-N and cyanide loadings from coking operations between 1992 and 1993. Further downstream, the lack of improvement appears a result of channel morphology, declining oxygen levels, and increased ammonia-nitrogen.

Positive changes in water quality have generally resulted only in raising biological quality from the “very poor” to “poor” ranges. The prospects for further improvement within the navigation channel are low due to the inherent physical habitat limitations [mean QHEI = 34.5 (± 1.8 SE, *N* = 4)].



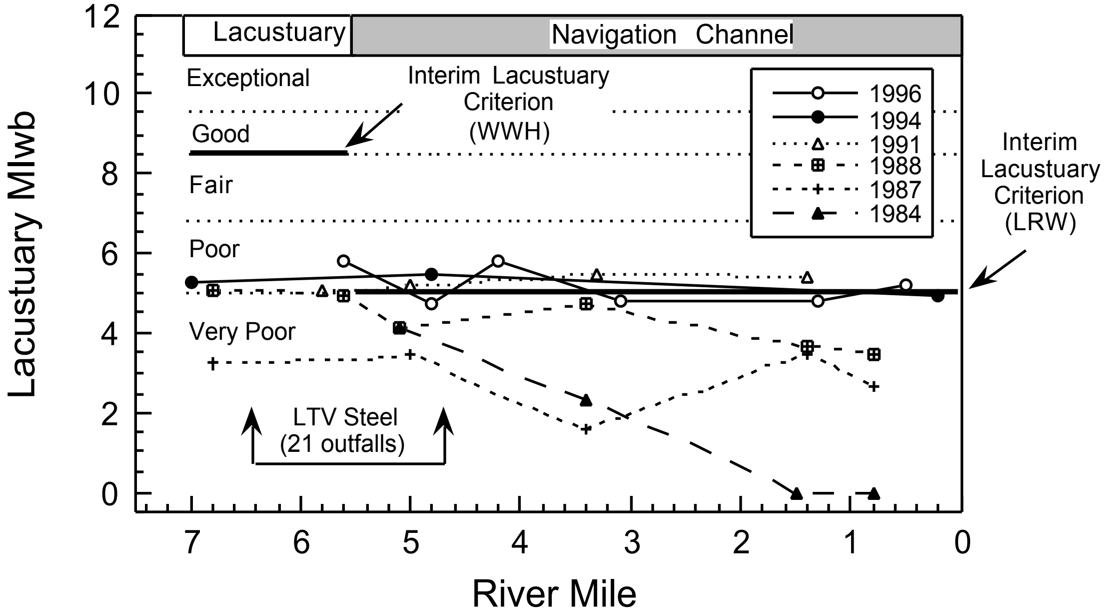


Figure 31. Fish community trends in the Cuyahoga River lacustuary and navigation channel (RMs 7.0-0.0), 1984-1996. Fish assemblages were evaluated using an interim set of IBI and MIwb criteria developed for Lake Erie river mouths (Ohio EPA 1999a,b Draft).

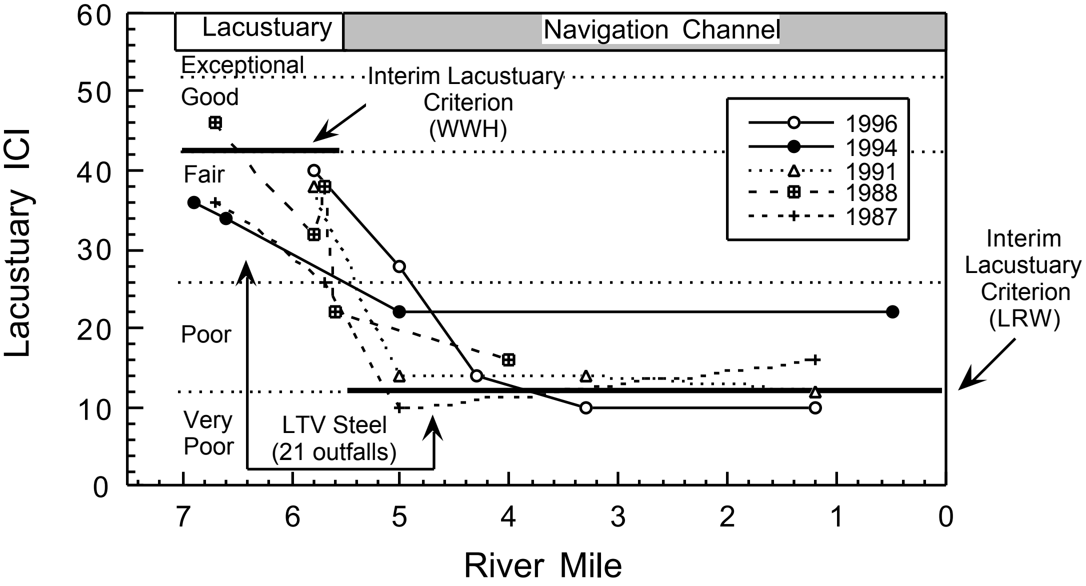


Figure 32. ICI trends in the Cuyahoga River lacustuary and navigation channel (RMs 7.0-0.0), 1987-97. Macroinvertebrates were evaluated using an interim set of criteria developed for Lake Erie river mouths (Ohio EPA 1999a,b Draft).

Sediment Quality

Cuyahoga River Basin

Sediment samples were collected at 48 sites within the Cuyahoga River basin in 1996. Twenty-six of these samples were collected as part of USEPA grants to study sediments in streams tributary to Lake Erie. The samples were analyzed for heavy metals, particle size, base neutral acid extractable compounds (BNAs), pesticides, polychlorinated biphenyls (PCBs) and total organic carbon (TOC). Additional analyses for nutrients, sulfates and volatile organic compounds (VOCs) were also performed on samples for the Lake Erie tributary study. A summary of the heavy metals and particle size results are presented in Table 12. Sediment organics, TOC, and nutrient results are shown in Appendix A, Tables 2a-2c.

Sediment Metals

The heavy metal sediment results, except mercury, were evaluated using interquartile ranges derived from Erie Ontario Lake Plain (EOLP) ecoregion sediment reference data. The interquartile ranges were labelled as non-elevated, slightly elevated, highly elevated and extremely elevated. Because of insufficient sample size in the Ohio EPA database, mercury results were evaluated using the same statistical approach, but the ranges were derived from Illinois stream data (Kelly and Hite, 1984).

The elements with the greatest frequency of highly elevated and extremely elevated values were copper, followed by iron, lead, chromium and mercury. The highest concentrations of heavy metals were found downstream from Breakneck Creek in the Kent area, downstream from the Akron WWTP and in the navigation channel. As in 1991, the heavy metal sediment concentrations upstream from Lake Rockwell (RM 57.8) were generally lower than the concentrations downstream from the dam. The concentrations in the sediments upstream from Lake Rockwell remained constant from 1991 to 1996. The concentrations of all heavy metals appeared to have increased at the Cuyahoga Street site (RM 42.6). There was no other apparent pattern in the concentrations of heavy metals in mainstem sediments from 1991 compared to 1996.

Sediments collected below the Munroe Falls dam contained arsenic, cadmium and zinc in concentrations likely to affect the most sensitive benthic macroinvertebrates. Zinc and lead concentrations in one set of water quality grab samples collected from the reach downstream from Cuyahoga Falls were acutely toxic to aquatic life. Metals are not apparently limiting to aquatic life in the Munroe Falls dam pool in relation to the magnitude of impairment associated with habitat and low dissolved oxygen. However, water column metals may account for a significant portion of the variation in Invertebrate Community Index (ICI) scores in the Cuyahoga River given the high concentrations downstream from the Akron CSOs. Therefore, loadings of metals from upstream sources in the Kent and Ravenna areas may exacerbate impairment.

The median values for all metals were similar between mainstem and tributary sites but both the highest and lowest concentrations for lead and copper were in the tributaries. Little Cuyahoga River sediments had a general increase in lead concentrations from the headwaters to the mouth. The highest mercury concentration in the entire watershed was immediately downstream from Mogadore Reservoir near the Little Cuyahoga River headwaters.

Sediment Organics

Polynuclear aromatic hydrocarbons (PAHs), which are a subset of BNA compounds, were detected in sediment samples from urban, suburban and rural settings. The frequency and concentration of these compounds were greatest in urban areas and in areas near transportation corridors. This suggests that compounds from road surfaces, railroad beds and internal combustion engine byproducts may be the largest contributor of these compounds to the Cuyahoga River basin sediments. The highest concentration of PAHs was in the Little Cuyahoga River at Massillon Road in Akron which is upstream from known CSOs but downstream from reconstruction of Interstate 76. The highest concentration of PAHs in the mainstem was in the Akron urban area and downstream from the Akron WWTP.

The concentration pattern of PCBs and pesticides in the Cuyahoga River mainstem were somewhat similar to the pattern of heavy metals. The highest concentrations were found downstream from Breakneck Creek in the Kent area and downstream from the Akron WWTP. However, the navigation channel samples contained an intermediate concentration of PCBs and the lowest concentration of pesticides. A more extensive evaluation of these sediments is currently being performed.

Table 12: Heavy metals concentrations in mg/kg dry weight from sediments within the Cuyahoga River basin. Percent sands is the percentage (weight to weight) of particles in the sample greater than 60µ (settling time <0.5 minutes).

Sampling Site	River Mile	As	Cd	Cr	Cu	Fe	Pb	Hg	Zn	% Sands
Cuyahoga River										
U.S. 422	80.5	6.77	0.319	8.5	10	1330	25	0.01405	55	45.4
Winchel Road	75.8	10	0.394	14	11	20100	19	0.02785	94	59.5
Route 303 (Shalersville)	64.5	--	--	--	--	--	--	0.0542	--	--
Route 303 (Shalersville)	*64.3*	--	--	--	--	--	--	*0.0763*†	--	*47.8*
dst Lake Rockwell	57.7	12.5	0.237	9	**45**	12600	25	0.0541	64	82
Standing Rock	55.2	32.5‡	0.722‡	**60**	**62**	27300†	**78**	0.134‡	202‡	65
Breakneck Creek										
Near Homestead Ave.	15.55	--	0.5†	13.5	1.8	25253	20.1	0.0864†		62
	13.3	--	--	--	--	--	--	0.0708†	--	--
Tallmadge Road	12.7	--	**6.7**	20.8‡	**119***	31231†	30.5†	0.0708†	--	76
Summit Road	7.0	--	**14.8***	8.5	6.1	19874	0.3	0.0442	--	68
Summit Rd	*7.0*	--	--	--	--	--	--	*0.0372*	--	*66*
Near Mouth	0.4	18.2	0.284	**48**	16	21300	14	0.0965†	138‡	72
Potter Creek										
Trares Road	1.5	--	0.6†	9.7	17.8†	27939†	18.8	0.0681	--	55
Dst Kent WWTP	53.4	18.3†	1.76	**60**	**46**	28000	**72**	0.14‡	194‡	66
Munroe Falls Dam Pool	50.0	20.4†	1.19‡	**37**	34‡	25400	56‡	**0.394**	163‡	47
Ust Ohio Edison	46.2	14.1	0.948‡	25	20†	17500	16	0.124‡	52	83
Cuyahoga Street	42.6	--	0.2	10.2	12.3	16599	41.1†	**0.358**	--	72
Little Cuyahoga River										
Martin Road	12.7	--	0.4	7.5	**80.8**	**69345**	38.6†	**6.06**	--	86
Union Oil Trib.										
Route 532	0.56	--	0.1	1.4	0.05	3	6.5	0.0106	--	94
Ust Wingfoot L. Outlet	11.0	--	0.2	11.2	28.9‡	30386†	28	0.0437	--	85
Wingfoot Lake Outlet										
Waterloo Road	3.1	--	0.6†	29.4‡	**105.4**	**98119**	63.7‡	0.0528	--	77
@ Mouth	0.5	--	4.1	**39.4**	**112.1***	**67800**	65.9‡	0.0892†	--	53
Gilchrist Road	11.2	--	--	--	--	--	--	--	--	--
Skelton Road	9.7	11.5	0.735‡	28‡	16	20500	39†	0.0492	156‡	81
dst Route 91	8.5	11.8	0.669†	25‡	23	20000	39†	0.0792†	**230**	79

Table 12: (continued).

Sampling Site	River Mile	As	Cd	Cr	Cu	Fe	Pb	Hg	Zn	% Sands
Little Cuyahoga River (continued)										
Massilon Road	7.3	7.12	0.396	18	17	17200	64‡	0.0425	155‡	92
Springfield Lake Outlet										
Delaware Avenue	2.9	--	4.1	12.5	**85.6**	44854‡	162.7	0.0924†	--	58
Seiberling Road	7.1	5.59	0.448†	21‡	14	11600	37†	**1.36**	148‡	93
Bank Street	5.1	8.16	0.47†	26‡	21	21300	**108**	0.034	**211**	96
Ust Camp Brook	4.2	13.4	0.418†	7.5	28‡	17800	**109**	0.134‡	155‡	94
Camp Brook										
Eastwood Avenue	0.1	--	0.1	3.5	11.9	11230	10.7	0.00945	--	96
North Street	4.1	9.24	0.588†	17	31‡	16900	**120**	0.0778†	165‡	95
Otto Street	1.8	12.4	0.293	21‡	17	16800	46‡	0.0302	130†	--
Police Firing Range	0.3	16.3	0.673†	21‡	**51**	25300	**111**	0.157‡	**235**	82
@ Mouth	0.1	--	0.5†	13.5	**100.7**	11945	**96.5**	--	--	--
Ust Akron WWTP	38.0	--	0.4	10.9	**36**	23405†	59.5‡	0.0912†	--	20
North Fork Yellow Creek										
Ust Robinwood Hills	0.3	--	0.2	5.4	**65.6**	**64921**	11.3	0.0299	--	57
Ira Road	35.3	--	--	--	--	--	--	--	--	--
Furnace Run										
Near Mouth	0.9	--	0.1	6.8	**67.9**	**78625**	10.8	0.0285	--	51
Route 303 (Peninsula)	29.0	--	0.3	9.6	25.1‡	22618	31.1†	0.0903†	--	14
Chippewa Creek										
Riverview Road	3.45	--	0.4	26.1‡	**129.7***	**123741**	40.3†	0.0305	--	55
Tinkers Creek										
Herrick Nature Prsrv	28.8	--	0.4	11.7	4.9	29712†	22.3	0.0697	--	48
Hudson Aurora Road	25.0	--	0.2	6.3	22.1†	17522	11.3	0.0539	--	76
Pond Brook										
Ust Aurora Shores WWTP	4.5	--	0.2	8.1	**43.3**	42325‡	6.2	0.0347	--	68
Mill Creek										
McCracken Road	5.6	--	0.2	5.9	24.7‡	16340	11	0.01015	--	88
Dst Old Bridge	3.5	--	0.2	5.6	25.5‡	16375	16.2	0.01135	--	91
Near Mouth	0.2	--	0.8‡	14.6	**66.2**	21124	56.2‡	0.119‡	--	83
Ford Branch Big Creek										
Near Mouth	0.1	--	2.6	**46.9**	**170.3***	21011	**141.1**	**0.18**	--	73
Nr Lower Harvard Av.	7.0	--	0.7‡	10.5	2.0	38373‡	29.7†	0.0462	--	65

Table 12. (continued).

Sampling Site	River Mile	As	Cd	Cr	Cu	Fe	Pb	Hg	Zn	% Sands
Cuyahoga River (continued)										
Kingsbury Run										
At Mouth	0.1	13.9	**2.17**	**79**	**91**	35100‡	**107**	0.123‡	**435**	56
Near Mouth	0.2	--	--	--	--	--	--	--	--	--
At Mouth	0.0	--	**1.5**	23.4‡	**248.8***	**127806**	49.4‡	0.106‡	**1365**	56

† – Concentration slightly elevated based upon sediment data from: 1-) EOLP Ohio reference sites (all metals except mercury, or 2-) Illinois streams (mercury only, Kelly and Hite, 1984).

‡ – Concentration elevated based upon sediment data from: 1-) EOLP Ohio reference sites (all metals except mercury, or 2-) Illinois streams (mercury only, Kelly and Hite, 1984).

Values in **Bold** – Concentration highly elevated based upon sediment data from:
1-) EOLP Ohio reference sites (all metals except mercury, or
2-) Illinois streams (mercury only, Kelly and Hite, 1984).

Values in **Bold and Underlined** – Concentration extremely elevated based upon sediment data from:
1-) EOLP Ohio reference sites (all metals except mercury, or
2-) Illinois streams (mercury only, Kelly and Hite, 1984).

* – Indicates the concentration exceeds the Ontario **Severe Effect Level** (Ontario, 1993)

Italics - indicate duplicate samples.

Cuyahoga River Tributaries

Breakneck Creek

Pollutant Loadings

Two municipal wastewater treatment plants discharge to the Breakneck Creek watershed, the Franklin Hills WWTP on Breakneck Creek (RM 56.82/2.52) and the Ravenna WWTP discharges to Homan Avenue Ditch, a tributary of Wahoo Ditch (RM 56.82/4.8/0.5/0.85).

Ravenna WWTP

The Ravenna WWTP, NPDES permit number 3PD00018, is located at 3722 Hommon Avenue, Ravenna, Ohio 44266. The present design capacity is 2.3 MGD during the summer and 2.8 MGD in the winter. While median flows average near the design capacity, 95th percentile flows have increasingly exceeded the capacity (Figure 33). Under normal operation, ammonia nitrogen and total Kjeldahl nitrogen loads have decreased, especially since 1988. However, 95th percentile loadings for both parameters have increased, demonstrating wider and wider separation between normal and extreme treatment performance (Figure 33). Ravenna has had a history of wet weather bypasses from the WWTP. The loadings trends show that the plant operates well dry weather

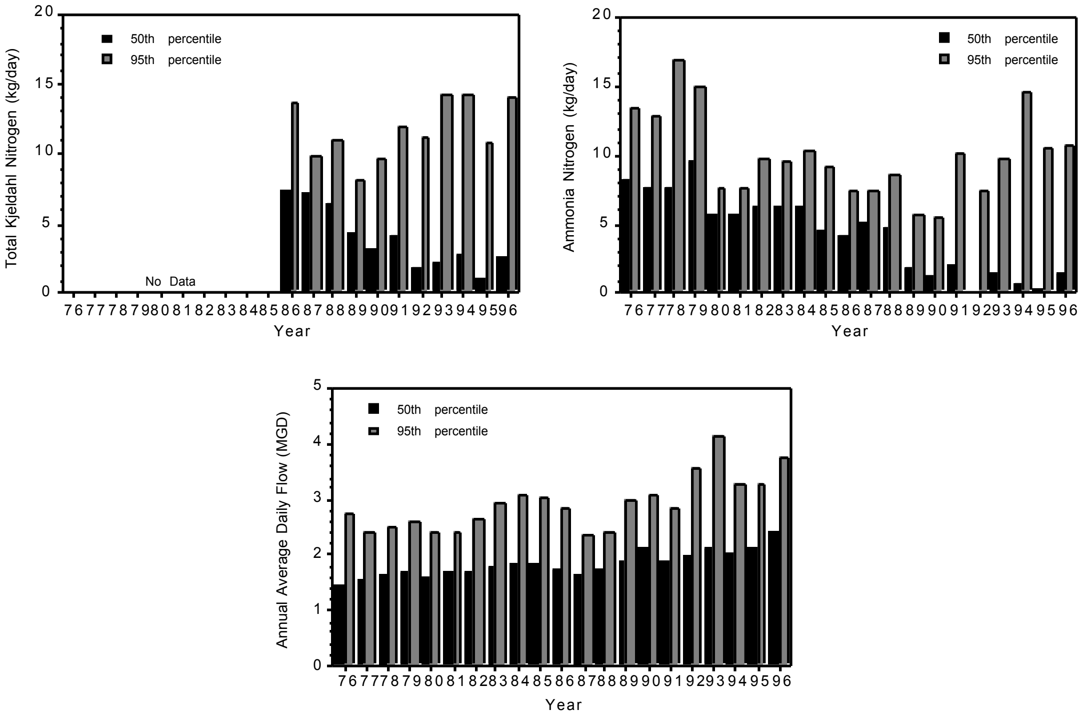


Figure 33. Annual median and 95th percentile loadings in kg/day of total kjeldahl nitrogen (TKN), ammonia-nitrogen, and discharge (mgd) from the Ravenna WWTP, 1976-96.

but is increasingly unable to handle peak flows. A recently requested expansion and upgrade of their treatment system, if approved, should result in improved plant performance and eliminate treatment bypasses.

Forty-eight hour acute toxicity tests on the Ravenna WWTP effluent using *Ceriodaphnia dubia* and fathead minnows were conducted by Ohio EPA on 22 April and 1 October 1996 and by the entity on 7 October 1997. The 22 April and 7 October tests showed no toxicity to either organism. However, the 1 October test revealed acute toxicity to *C. dubia* as 60% mortality occurred in the undiluted effluent sample compared to both upstream and laboratory control water.

Franklin Hills WWTP

The Franklin Hills WWTP is a 1 MGD extended aeration plant owned and operated by Portage County. Additional treatment includes sand filtration and ultraviolet light disinfection. The plant serves primarily residential and commercial properties near the cities of Kent and Ravenna. Flows at the WWTP have steadily increased since construction in 1976 and currently averages around 0.5 MGD (Figure 34). The plant was originally designed and built as an activated sludge

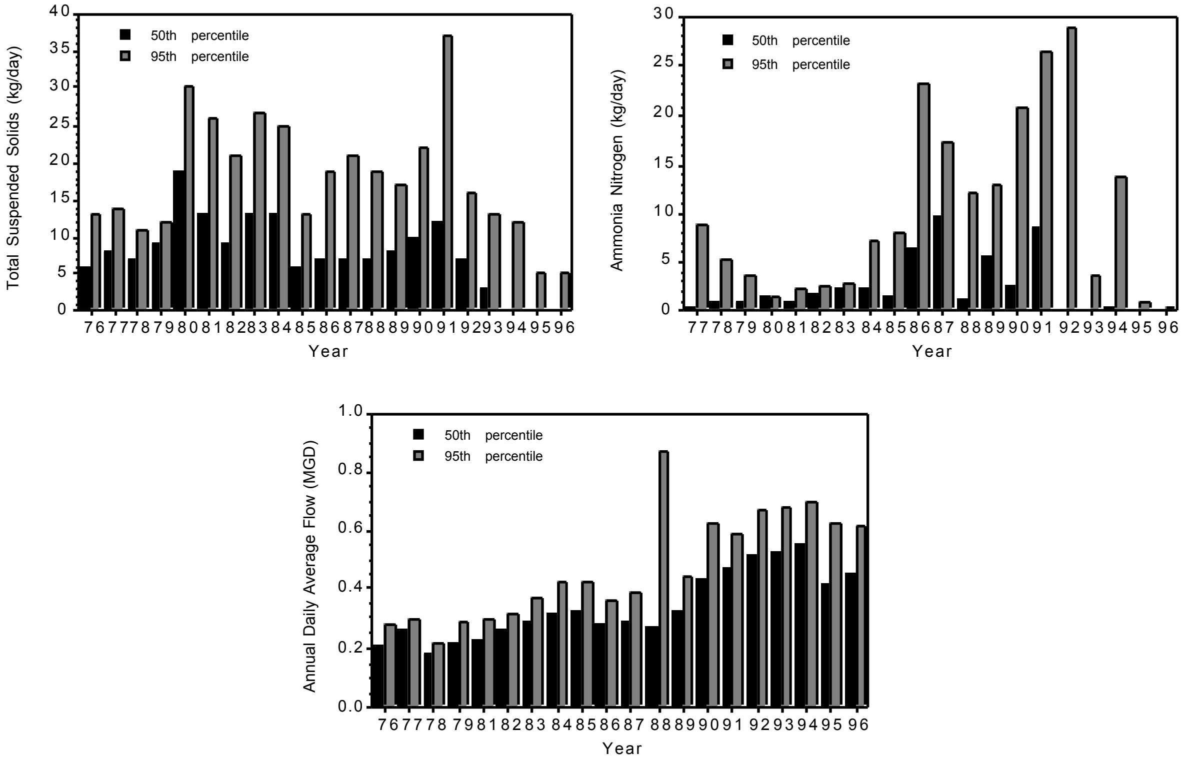


Figure 34. Annual median and 95th percentile loadings in kg/day of total suspended solids, ammonia-nitrogen, and discharge (mgd) from the Franklin Hills WWTP, 1976-96.

plant. Conversion to extended aeration and filtration in the early 1990's has dramatically improved treatment and decreased stream loadings for suspended solids and ammonia-N (Figure 34).

Portage County has contracted with the city of Ravenna to accept wastewater from county properties that are outside the city limits. When these sewer connections were made, the county also installed valves that would allow the wastewater to be diverted from the Ravenna WWTP to Franklin Hills. Portage County is now considering whether to expand the Franklin Hills WWTP to 2 MGD to accept current and future flow from Ravenna Township and Rootstown Township which currently goes to Ravenna.

Surface Water Quality

All Breakneck Creek samples from RM 14.6 to the mouth were in compliance with chemical WQS criteria. While the standards were not exceeded, the Ravenna and Franklin Hills WWTPs had discernable impacts on Breakneck Creek. Median nitrate-nitrite nitrogen concentrations increased an order of magnitude downstream from the Ravenna WWTP via Wahoo Ditch (from 0.2 mg/l to 2.0 mg/l), and peaked downstream from the Franklin Hills WWTP. Phosphorus and ammonia-nitrogen concentrations were high in Wahoo Ditch with peak concentrations of 0.65 mg/l and 2.5 mg/l, respectively (Figure 35). However, only ammonia-nitrogen concentrations

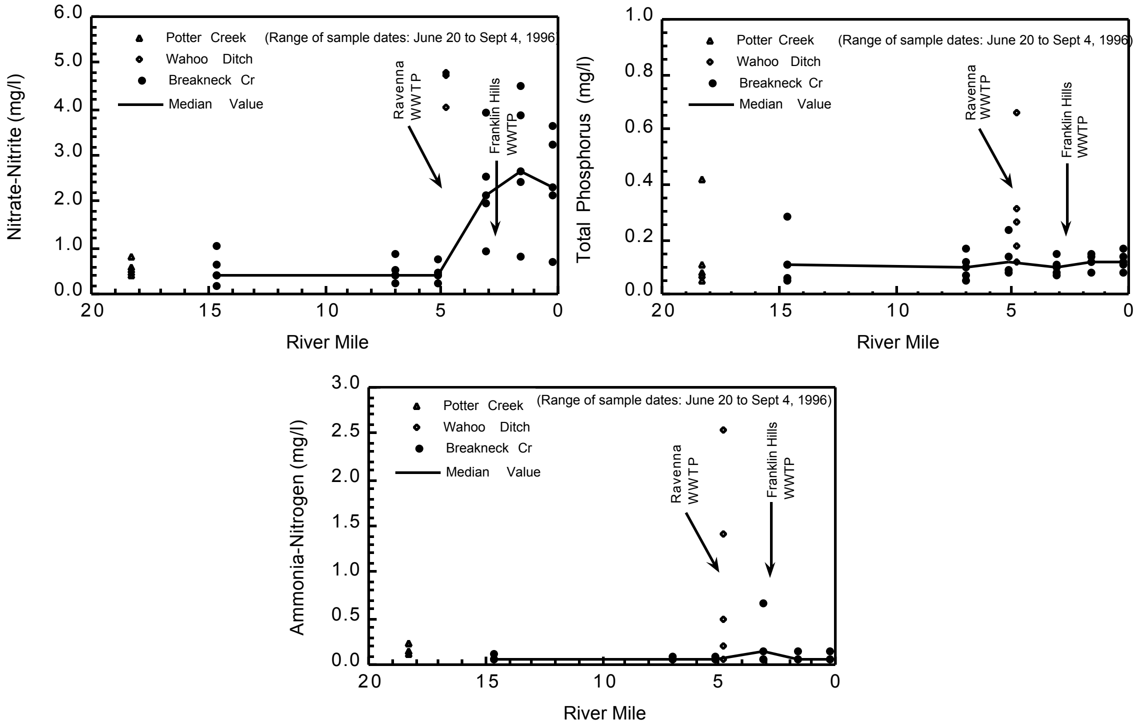


Figure 35. Nitrate-nitrite, total phosphorus, and ammonia-nitrogen concentrations from the Breakneck Creek basin, 1996.

were detectably higher in Breakneck Creek downstream from Wahoo Ditch, suggesting that the phosphorus was readily assimilated but the nitrogen was not. The high-ammonia nitrogen concentrations found in Wahoo Ditch correspond to the high 95th percentile loadings from the Ravenna WWTP. Dissolved oxygen concentrations declined slightly downstream from the Franklin Hills WWTP in both grab and Datasond™ "continuous" measurements but the concentrations did not fall below WWH criteria.

Nitrate-nitrite concentrations in the Cuyahoga River mainstem increase downstream from Breakneck Creek, demonstrating that the Ravenna and Franklin Hills WWTPs contribute nitrogen loads to the Cuyahoga mainstem (see Figure 35 on page 93).

Physical Habitat for Aquatic Life

Breakneck Creek is a low gradient swamp stream with channel modifications in several reaches. Consequently, the habitat is generally composed of a relatively high proportion of modified attributes (Appendix B). Despite the natural habitat limitations, and those artificially imparted, habitat is generally conducive to warmwater stream communities given the mean QHEI score of 67.5 (± 4.3 SE, *N* = 6). Positive habitat characteristics common throughout Breakneck Creek include abundant instream cover supplied by the largely intact wooded riparian corridor and submerged aquatic vegetation, and deep pools. Boulder, cobble and gravel substrates were present at locations not previously channelized. Negative habitat attributes common to most sites were silt cover, embedded substrates and fair channel development. Sites at RMs 3.1 and 1.7 were previously channelized.

Fish Communities

Upstream from the influence of point sources, the fish communitiy and habitat was an excellent example of a swamp stream with lush submerged aquatic vegetation, northern pike, five species of darters, and horneyhead chubs. Station RM 6.8 was essentially one long deep pool; consequently, electrofishing efficiency was reduced and the IBI score (30) dropped below the WWH criterion.

The Franklin Hills WWTP, and to a lesser extent the Ravenna WWTP significantly impacted the fish community in Breakneck Creek (Figure 36). IBI scores clearly plummeted downstream from the Franklin Hills outfall (RM 1.7), despite having similar habitat to the site upstream (RM 3.1). Toxic conditions were indicated by the very low numbers of individuals and few species captured while electrofishing. Evidence for the Ravenna WWTP contributing to the decline is given by the increased percentage of tolerant fishes at RM 3.1 relative to RM 5.2, and the low MIwb score (Table 6). The MIwb score continued to decline downstream from Franklin Hills before recovering at the mouth. These results suggest that the impairment caused by the Ravenna WWTP was not merely augmented by the Franklin Hills WWTP, but severely exacerbated by it.

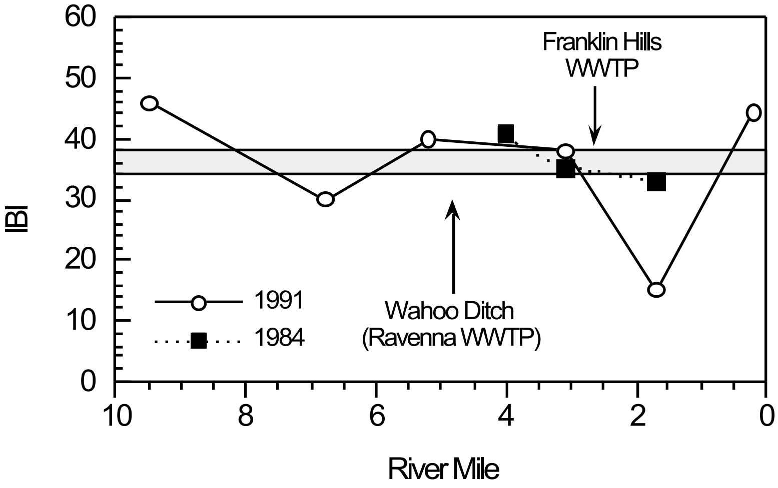


Figure 36. Longitudinal trend of the IBI in Breakneck Creek in 1996 and 1984.

Macroinvertebrates

Macroinvertebrate communities upstream from the Ravenna and Franklin Hills WWTPs were in the very good and exceptional ranges (Table 7). Communities remained exceptional (ICI = 48) downstream from the Ravenna WWTP at RM 3.1 but declined to good (ICI = 40) below the Franklin Hills WWTP (Figure 37). The quality of the natural substrate community downstream from Franklin Hills also declined as evidenced by the drop in QCTV scores from 39.0 (high

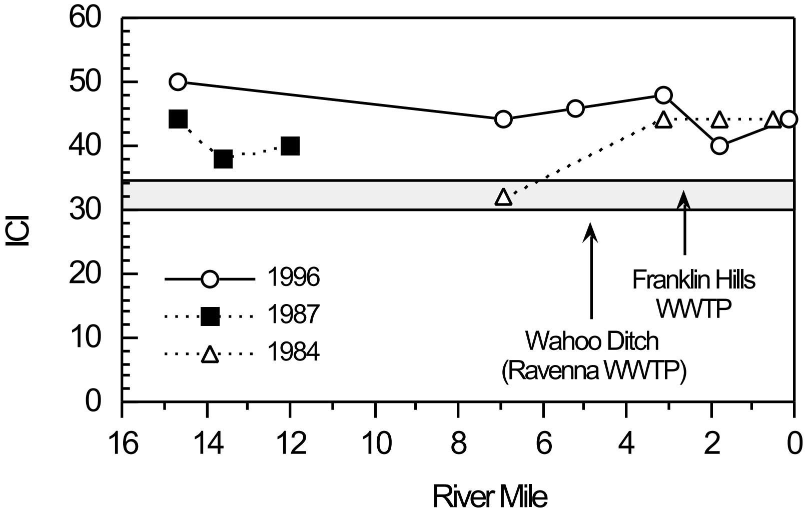


Figure 37. Longitudinal trend of the ICI in Breakneck Creek in 1996, 1987, and 1984.

performance range) at RM 3.1 to 32.9 (low performance range) at RM 1.8. Despite apparently lower habitat quality and heavy siltation at RM 3.1, lower quality communities were found downstream at RM 1.8. The declines may reflect additional wastewater inputs from Franklin Hills.

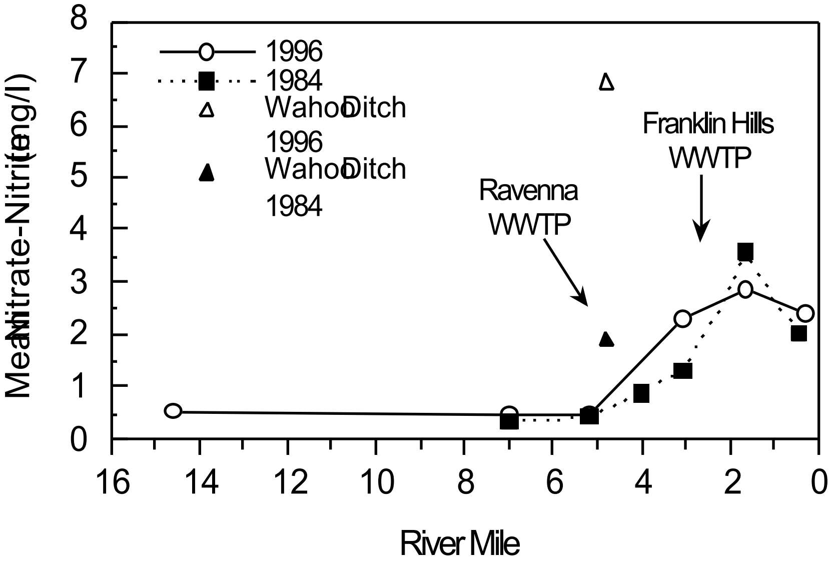
Chemical and Biological Trends

Breakneck Creek samples were collected and analyzed in 1983 and 1984 as part of the stream regionalization project. Except for nitrogen compounds, there was no apparent change in water quality in samples collected from the 1996 survey compared to the 1983-4 sampling. The current sample results indicate a decline in in-stream ammonia-N concentrations in Wahoo Ditch downstream from the Ravenna WWTP discharge and in Breakneck Creek downstream from both the Ravenna and Franklin Hills WWTPs (Figure 38). The lower ammonia-N concentrations coincides with an increase in Nitrate-Nitrite concentrations (Figure 38) which indicates that the ammonia-N is treated and converted to Nitrate-Nitrite at the WWTP instead of in the stream. The in-stream declines in ammonia-N and increases in Nitrate-Nitrite concentrations coincide with upgrades at the two WWTPs.

Historical macroinvertebrate sampling at eight Breakneck Creek sites between 1984 and 1987 suggests little change either upstream or downstream from point source discharges in Ravenna and Franklin Hills (Figure 37). Each sampling site between RMs 14.7 and 0.5 reached or exceeded the WWH biocriterion, reflecting marginally good to exceptional quality. The 1996 results showed a somewhat more noticeable decline downstream from the Franklin Hills WWTP but ICI scores remained above the WWH criterion.

A preliminary evaluation of the 1996 bioassessment data indicated a severe drop in both fish indices in Breakneck Creek downstream from the Franklin Hills plant. The biological response signature indicated in-stream toxicity. As a result, additional investigations and sampling was performed in an attempt to determine the cause of the decline. Investigations included searching for unknown discharges, mathematical modeling of the stream system, performing bioassay tests on Franklin Hills effluent, pre-treatment inspections at commercial facilities and an evaluation of the impact from two closed landfills in the watershed. The most significant impacts found as a result of the investigations were from failing septic systems in Franklin Township near the Franklin Hills discharge. Flows from these failing systems, however, were minimal.

Because of the impacts observed in 1996, additional fish sampling was conducted in 1999 near the Franklin Hills WWTP (Table 13). The 1999 fish sampling shows a dramatic improvement in both the IBI and MIwb in Breakneck Creek compared to the 1996 survey. All three of the 1996 sampling sites either met the IBI EOLP criteria or were within non-significant departure. None of the sites met the MIwb criteria which indicates probable impacts to the fish community due to nutrient enrichment. The 1999 modeling results indicate that the lowest D.O. concentration in



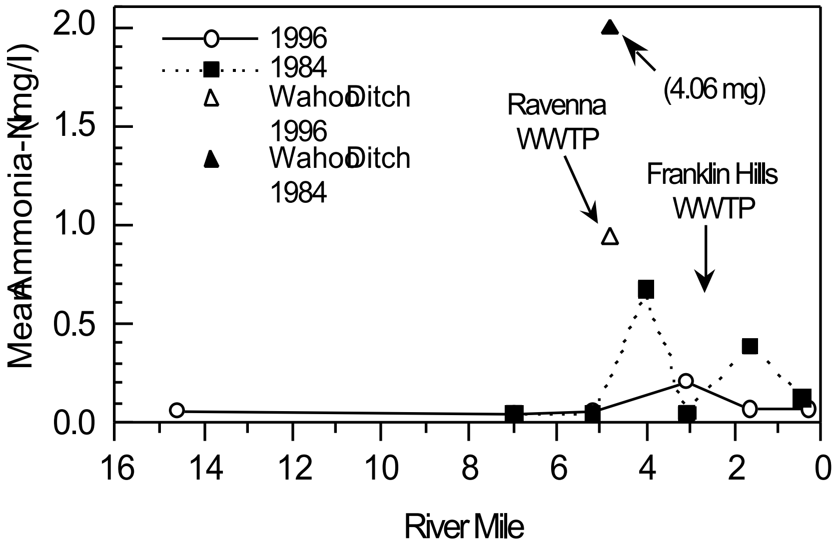


Figure 38. Historical trends in mean Ammonia and Nitrate-nitrite concentrations in Breakneck Creek and Wahoo Ditch, 1984-1996

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Breakneck Creek occurs just downstream from the Franklin Hills WWTP at the same location where the biologic community performed the worse. This indicates that the apparent toxicity observed in the 1996 survey was either exacerbated the in-stream D.O., or the low D.O. mimicked the toxicity signature and was the prime reason for the poor community performance. Bypasses at the Ravenna WWTP may have been a significant cause of the poor community performance observed in 1996. Since 1996, reduction in sewer system infiltration and inflow (I&I) and improved operation at the Ravenna WWTP have reduced the occurrence and severity of the Ravenna by-passes (Figure 33).

Table 13. Fish community indices from samples collected in the Breakneck Creek basin study area, 1996 and 1999.

River Mile	Mean Number Species	Cumu-lative Species	Mean Rel. No (No./0.3 km)	Mean Rel. Wt. (kg/0.3 km)	QHEI	Mean MIwb[a]	Mean IBI	Narrative Evaluation
Breakneck Creek (1996)								
			Erie Ontario Lake Plain - WWH Use Designation (Existing)					
9.5^{D}	19	19	530	13.41	67.5	NA	46	V. Good
6.8^{D}	13	13	86	6.38	66.5	NA	30*	Fair
5.2^{D}	12	18	171	5.74	86.5	NA	40	Good
3.1^{D}	12	16	90	5.05	56.5	5.1*	38	Poor/Good
1.7^{D}	7	9	47	5.85	59.5	4.6*	15*	Poor/V. Poor
0.2^{D}	15	18	120	4.00	69.0	7.2*	44	Fair/Good
Breakneck Creek (1999)								
			Erie Ontario Lake Plain - WWH Use Designation (Existing)					
2.6^{D}	15	15	128	4.85	--	7.1*	44	Fair/Good
2.5^{D}	14	14	133	3.04	--	6.3*	40	Fair/Good
1.6^{D}	16	16	162	9.69	--	7.2*	42	Fair/Good

Ecoregion Biocriteria: Erie-Ontario Lake Plain

	IBI			MIwb		
Site Type	WWH	EWH	MWHc	WWH	EWH	MWHc
Headwaters	40	50	24	NA	NA	NA
Wading	38	50	24	7.9	9.4	5.6

---

a - MIwb is not applicable to headwater streams with drainage areas < 20 mi2.

ns - Nonsignificant departure from biocriteria (<4 IBI units or <0.5 MIwb units).

* - Significant departure from applicable biocriteria (>4 IBI units or >0.5 MIwb units). Underlined scores are in the Poor or Very Poor range.

Potter Creek

Surface Water Quality

Potter Creek was in compliance with Ohio chemical WQS criteria during 1996. No chemical or physical exceedences of acute or chronic criteria were found. In general, surface water quality in Potter Creek was better than in Breakneck Creek. However, total phosphorus and suspended solids values were higher than the average for other stations in the Breakneck Creek basin. These higher values are probably due to extensive agriculture within the Potter Creek subbasin.

Physical Habitat for Aquatic Life

A previously channelized, though not routinely maintained headwater stream, habitat in Potter Creek is characterized by modified attributes (Appendix B), and is therefore of limited ability to support normal warmwater stream communities.

Fish Communities

Potter Creek is recovering from prior channelization. A narrow riparian corridor has been reestablished and the creek is regaining free flowing characteristics. However, the habitat remains disturbed by embedding silt and poor channel development; thus, the condition of the fish community (poor) was correspondingly degraded (Table 6).

Macroinvertebrates

ICI scores were in the lower good range in Potter Creek both in 1996 (ICI=36) and 1984 (ICI=34). Natural substrate communities were also consistent as attested by identical QCTV scores of 39.2. The scores exceed the 25th percentile of good and exceptional sites in the ecoregion, suggesting consistently good performance.

Wahoo Ditch

Surface Water Quality

Due to its severe channel modification and small drainage, the aquatic life use designation in Wahoo Ditch is Modified Warmwater Habitat (MWH). The ditch was sampled at RM 0.39, downstream from the Ravenna WWTP which enters via Homan Ditch at RM 0.50. Chemical exceedences of the less restrictive, modified Ohio WQS criteria were limited to a D.O. measurement (1 of 5) that fell below the 24 hour average criterion (*i.e.*, <4 mg/l.). Ammonia concentrations were quite high (maximum 1.4 mg/l) and were elevated compared to Breakneck Creek. However, the concentrations did not exceed the less restrictive, MWH criterion.

Fish Communities

Fish were not sampled in Wahoo Ditch.

Macroinvertebrates

Macroinvertebrate community health was poor at RM 0.4 and reflected the severely altered, ditch-like habitat (Table 7). The stream was choked with emergent vegetation and algae and the soft muck substrates were several feet thick. Potential impacts associated with the Ravenna

WWTP on Homan Ditch were masked by the severe habitat limitations. Conditions in 1996 were very similar to 1984 collections when poor quality communities were found in modified habitats both upstream and downstream from Homan Ditch.

Bridge Creek

Pollutant Loadings

The Ohio EPA has approved a Geauga County proposal for a 0.07 MGD WWTP to serve the Auburn Corners area. The plant is being constructed to eliminate failing septic systems in the area. The plant will meet very strict effluent limits because the discharge will directly enter LaDue Reservoir. After conventional treatment, the discharge will flow into a "polishing lagoon" for additional treatment prior to discharge into the reservoir.

A proposed county WWTP to serve an industrial park along the upper section of Bridge Creek was canceled by the County Commissioners.

Surface Water Quality

Three of five D.O. measurements downstream from the LaDue Reservoir outlet (RM 1.32) were below the 24-hour average dissolved oxygen criterion (5 mg/l). Mean dissolved oxygen concentrations were substantially lower downstream from the reservoir outlet (4.9 mg/l) than upstream from the reservoir (8.7 mg/l at RM 8.5) or in the wetland section at RM 11.2 (6.7 mg/l). The results suggested low dissolved oxygen levels were attributable to the LaDue Reservoir release. All other chemical parameters were well below WQS criteria.

Physical Habitat for Aquatic Life

Three sites were evaluated along Bridge Creek, two upstream from LaDue Reservoir, and one downstream. The most upstream site flowed through a mix of swamp and marsh wetlands, and the habitat was commensurately limited, especially by the lack of riffles. Riffle-pool-run sequences were established downstream by RM 8.5, increasing the proportion of warmwater habitat attributes. Downstream from LaDue Reservoir, the creek again flows through a mix of swamp and marsh wetlands, the channel is moderately developed, substrates are embedded with silt and cover was lacking. Despite habitat limitations at the upstream and downstream most sites, the habitat in Bridge Creek is capable of supporting warmwater stream communities.

Fish Communities

Sites with three distinctly different habitats were sampled in Bridge Creek. Habitat at the upstream site supported a fish assemblage reflecting the mixture of swamp and marsh wetlands through which the creek flows. Although the IBI did not meet the WWH biological criterion, grass pickerel, a top carnivore, was the most abundant fish present, indicating an efficient transfer of energy and a fully functional fish assemblage for the given habitat.

Further downstream at RM 8.5, the habitat is amenable to more "typical" stream assemblages as the creek flows through glacial deposits and gradient increases. In fact, an exceptional headwater assemblage of fish was present; however, an elevated abundance of stonerollers indicated nutrient enrichment from adjacent pastures and unrestricted cattle access.

Fish communities at the most downstream site (RM 0.5) were decidedly impacted by a combination of low dissolved oxygen and nutrient enrichment stemming from bottom releases and flow alteration by La Due Reservoir. Intolerant species were eliminated, the number and proportion of darters, suckers and simple lithophils reduced, and the proportion of tolerant and omnivorous fishes increased. Consequently, neither the MIwb nor the IBI met the respective WWH biological criterion.

Macroinvertebrates

Macroinvertebrates were poor in the wetland section upstream from LaDue Reservoir (RM 11.2). The very low QCTV score (22.8) and lack of EPT taxa (1) reflected the poor quality community, typical for marshy, bog-like habitats. Further downstream at RM 8.5 , communities improved to very good quality in more typical riffle/pool habitats immediately upstream from the lake.

Macroinvertebrates collected from artificial substrates downstream from LaDue Reservoir were fair (ICI = 28). Relatively pollution tolerant flatworms, scuds, and isopods (included in the Other Dipteran/Non Insect metric) accounted for about 60 percent of total organisms. EPT taxa richness (4) and the QCTV score also declined sharply compared to upstream, suggesting water quality impacts from reservoir releases and adjacent wetland drainage.

Black Brook

Surface Water Quality

No chemical or physical exceedences of the WWH acute or chronic criteria were found in Black Brook (RM 1.78). However, a highly elevated TSS concentration (70 mg/l) was recorded in Black Brook on July 9 during a no rain, high flow event. The July 9 measurement coincided with a 25 mgd top-water release from LaDue Reservoir located 0.86. miles upstream. However, the high TSS and brown discoloration in Black Brook could have resulted from sediment loss in the reservoir, scour of the stream bed, or erosion of stream banks with increased flow. Therefore, the possible contribution of planktonic algae from the lake overflow could not be confirmed.

Physical Habitat for Aquatic Life

Habitat in Black Brook, having been previously channelized, is dominated by modified characteristics. However, flow augmentation from LaDue Reservoir combined with woody debris from the reestablished riparian buffer has facilitated pool formation and channel development. Consequently, sufficient function has been restored to the channel to provide habitat for warmwater assemblages as indicated by the QHEI score of 66.0.

Fish Communities

Black Brook, having recovered substantially from channelization, marginally supported a WWH fish assemblage. Lingering effects on the fish assemblage from habitat modifications were evident in the low numbers of minnow, headwater and lithophilic species, and slightly elevated abundance of tolerant fishes. Recovery was given by the presence of four darter species, four sensitive species, and low relative abundance of pioneering species.

Macroinvertebrates

Macroinvertebrate communities downstream from the LaDue Reservoir/Black Brook Dike outlet reflected good water quality (ICI = 40) but populations appeared highly enriched (Table 7). Densities of filter feeding tanytarsini midges (*Rheotanytarsus exiguus* group) approached 6,000 per square foot, indicating significant levels of suspended organic material (Simpson and Bode 1981). Similar, sharp increases in midge densities continued downstream from Black Brook in the Cuyahoga River mainstem at Hiram Rapids (RM 74.1). Suspended, planktonic algae from the shallow reservoir release was considered a potential source of enrichment.

West Branch Cuyahoga River

Surface Water Quality

All chemical parameters from the mouth of the West Branch met Ohio WQS criteria.

Physical Habitat for Aquatic Life

The West Branch is a swamp stream with attendant habitat limitations, specifically moderate to low channel development and sinuosity, slow current, and silt or muck substrates. Despite these limitations, excellent habitat features are present owing to light development in the watershed and wide riparian borders. The channel is not destabilized (except near Rapids Road due to construction); consequently, fine grained substrates were not mobilized allowing the establishment of rooted aquatic macrophytes. Woody debris added habitat complexity and enhanced channel morphometry.

Fish Communities

The West Branch is a low gradient swamp-wetland influenced stream; consequently, the fish community is naturally limited by the habitat relative to streams harboring coarse substrates and riffle-pool-run sequences. The habitat limitation is manifest in metrics sensitive to subtle disturbances in the depressed numbers of intolerant, sunfish and sucker species. Conversely, despite sandy substrates, the high relative abundance of simple lithophils and insectivores demonstrates the stability of the habitat on a seasonal basis owing to a wide and mature riparian forest. Despite the limiting nature of the habitat, the fish assemblage was nearly exceptional.

Macroinvertebrates

The ICI score of 42 at RM 0.9 reflected a very good macroinvertebrate community (Table 7). The relatively high community density (1791 organisms/sq.ft.) and predominance of filter feeding midges (66 percent *Rheotanytarsus exiguus* group) suggests high background levels of suspended solids and moderate enrichment. Eleven EPT taxa and six varieties of freshwater mussels were collected from natural substrates, an indication of good water quality and habitat conditions.

Sand Run

Surface Water Quality

Sand Run at RM 0.2 consistently met Ohio chemical WQS criteria during dry weather. However, severe water quality impacts were observed immediately following a rain event on September 17. Acute exceedences for copper (64 ug/l) and zinc (326 ug/l), a chronic exceedence for lead (44 ug/l), and a Secondary Contact Recreation exceedence for coliform bacteria (39,000 colonies/100 ml) were detected during high flow. The total suspended solids concentration of 2,140 mg/l was exceptionally high, reflecting the extremely turbid conditions immediately following the runoff event. Phosphorus and ammonia concentrations also increased but remained below WQS criteria. In contrast, ammonia, phosphorus, heavy metals, and suspended solids were generally at or below laboratory detection limits during base flows. The upper reaches of Sand Run drain the extensively urbanized city of Fairlawn. Data from RM 0.2 reveal significant potential for slug type impacts following urban runoff events.

No previous chemical samples have been collected at this site.

Physical Habitat for Aquatic Life

Habitat in Sand Run was impaired by urban runoff and stormwater from the city of Fairlawn. The channel was sinuous and developed, contained a variety of substrates of differing sizes, and was bordered by a wide riparian corridor. However, flashy stream flows due to stormwater severely eroded the banks and sustrates were extensively embedded. Consequently, the habitat was marginally suited to warmwater habitat faunas. In addition to urban development in the headwaters, about five to seven small low-head dams are also located along the length of the stream.

Fish Communities

Fish communities in Sand Run were severely impacted by urban stormwater runoff from the city of Fairlawn. Effects of flashy flows were evident in severe bank erosion, embedded substrates, and a destabilized channel. As such, only six species were collected, of which three were tolerant and composed 97% of the community.

Macroinvertebrates

Collections near the mouth found only fifteen total taxa and three EPT taxa in very low densities. While most populations were not particularly pollution tolerant (QCTV =34.2), stream quality was considered poor and reflected impacts from urban runoff.

Mud Brook

Surface Water Quality

Chemical samples were not collected from Mud Brook.

Physical Habitat for Aquatic Life

Mud Brook contains habitat capable of supporting typical warmwater stream assemblages as warmwater habitat attributes remain present. Flashy stream flows due to stormwater were evidenced by sand streaks and embedded substrates.

Fish Communities

Though marginally meeting the WWH biological criteria, the fish community in Mud Brook was depressed across all IBI component metrics, save DELTs, owing to the relatively high degree of suburbanization in the watershed.

Macroinvertebrates

Macroinvertebrates were not sampled in Mud Brook.

Yellow Creek

Surface Water Quality

Chemical results from Yellow Creek (RM 0.1) showed no Ohio WQS criteria exceedences excepting one fecal coliform bacteria sample (2800 colonies/100ml). The concentration exceeded the maximum Primary Contact Recreation criterion and was probably a result of higher, rain induced flows. The generally good water quality conditions found in 1996 were very similar to the previous survey in 1991.

Physical Habitat for Aquatic Life

Yellow Creek, at the site evaluated, contains good to excellent habitat having a well developed and sinuous channel composed of boulders, cobbles and gravel. A wooded riparian corridor supplied woody debris to the stream channel. Silt and embedding fines were apparent, however, suggesting problematic land use in the upper watershed.

Fish Communities

Yellow Creek, like Furnace Run, is another relatively intact stream supporting fish communities meeting the WWH biological criteria. Notably present were numerous redside dace, a species highly sensitive to habitat and water quality perturbations. Although the IBI score decreased to 38 in 1996 from 42 in 1991, the decrease was likely due to sampling in slightly different locations and normal variability, not a decrease in habitat or water quality as more sensitive species and darters were collected in 1996.

Macroinvertebrates

Natural substrate sampling at the mouth of Yellow Creek continues to reflect very good water quality conditions. Total taxa richness (54), EPT taxa richness (10) and the QCTV score of 38.4 were consistent with other high quality streams in the northeast section of the state (Table 7). Previous samples from the mouth in 1988 and RM 1.7 in 1991 have revealed consistently stable conditions and very good stream quality.

Furnace Run

Surface Water Quality

The results at RM 0.9 showed good chemical water quality except for one Fecal Coliform Bacteria count (8700 colonies/ 100ml) that exceeded the Primary Contact Recreation criterion. This high value was probably due to higher rain induced flows. Nutrient concentrations including total phosphorus (0.08 mg/l) and ammonia-nitrogen (below laboratory detection limit of 0.05 mg/l) were very low.

Physical Habitat for Aquatic Life

Warmwater habitat attributes were generally intact in Furnace Run reflecting the overall rural land use in the subwatershed. A variety of substrate types and sizes were present, siltation was not problematic, and the channel was not modified. Row crop agriculture encroached on the stream.

Fish Communities

Furnace Run is an enclave of good water quality and intact stream habitat in the otherwise marginalized or degraded Cuyahoga River watershed downstream from Akron. Accordingly, the fish community is relatively intact, reflected in the IBI score of 48. As such, Furnace Run represents an important source of diversity in the Cuyahoga River basin. Component metrics sensitive to subtle water quality or habitat perturbations were slightly depressed, probably owing to removal of riparian vegetation and row crop agriculture in adjacent fields. Fish community performance has shown slight improvement since 1984.

Macroinvertebrates

Exceptional quality macroinvertebrate communities were collected from Furnace Run at RM 0.9

(Table 7). Aspects of community composition such as total taxa richness (53), EPT taxa richness (16) and the QCTV score (39.7) were consistently high and nearly identical to previous collections from 1988 and 1991.

Brandywine Creek

Pollutant Loadings

Hudson is the only municipal WWTP with a discharge to Brandywine Creek. Ohio EPA documented instream WQS criteria violations for dissolved oxygen in the early 1990s. The Agency initiated enforcement action which resulted in a fine, a temporary city-wide construction ban and installation of temporary auxiliary treatment facilities. Water quality modelling indicated that conventional treatment technologies would not allow the WWTP to expand and meet Water Quality Standards. As a result, the WWTP was abandoned in 1998 and the discharge was routed to the Cuyahoga Valley Interceptor for treatment at the NEORSD Southerly WWTP.

Surface Water Quality

Grab water chemical samples were collected at two locations (RM 7.0 and 0.1) in the Brandywine Creek subbasin to document potential impacts from the discharge of the Village of Hudson WWTP (RM 7.95). The Hudson WWTP will be tied into the NEORSD Cuyahoga Valley Interceptor (CVI). The consent order construction schedule is as follows: Complete construction by May 6, 1998, eliminate discharge and all overflows and bypasses by June 17, 1998.

Chemical grab sampling revealed dissolved oxygen concentrations below the 5.0 mg/l daily average criterion in 80% of the samples (*i.e.*, 4.5, 4.6, 4.7, and 4.9 mg/l). D.O. exceedences were not observed in Brandywine Creek during a previous, 1991 survey, but were predicted under low flow conditions by Wasteload Allocation Modeling conducted by Ohio EPA. Elevated total phosphorus was also noted at RM 7.0 (mean = 0.908 mg/). Mean phosphorus concentrations recovered to 0.155 mg/l at the mouth (RM 0.1), but remained elevated compared to reference conditions (median = 0.06 mg/l for small rivers in the EOLP ecoregion). The Hudson WWTP was considered the source of the elevated phosphorus. All other chemical results were similar to those found in 1991.

High conductivity readings above the 2400 µmho/cm criterion were discovered in Brandywine Creek near the mouth during routine monitoring in 1995. The high readings were traced back to the reach upstream from Hines Hill Road but the source of the high conductivity was not found.

Physical Habitat for Aquatic Life

Brandywine Creek at RM 7.0 was previously channelized, as reflected in the high ratio of modified to warmwater habitat attributes (Appendix B). Though exhibiting modest recovery, the channel is neither sinuous nor developed, is embedded by silt, and consequently only marginally provides habitat for warmwater assemblages. The habitat at RM 0.5 is comprised of mostly warm water habitat features; however, silt and severe bank erosion encouraged by upstream landuse detracted from the habitat.

Fish Communities

The fish assemblage at RM 7.0 lacked headwater, sensitive and lithophilic species, as well as darters and sculpins, and had an elevated abundance of tolerant fishes. Collectively these attributes reflected habitat modification from prior channelization, suburban stormwater discharge, and generally poor water quality.

Abnormally high conductivity at RM 0.5 due to an unknown discharge significantly reduced electrofishing efficiency, and consequently precluded interpretation of IBI metrics at this sampling site. While scores were invalidated, the few fish captured included sensitive varieties (e.g., redside dace) and were not indicative of severe impacts.

Macroinvertebrates

Downstream from the Hudson WWTP at RM 7.0, macroinvertebrate communities were predominated by relatively tolerant hydropsychid caddisflies and leeches. The low EPT taxa richness (3), absence of mayflies, and the low QCTV score (median tolerance value = 29.4) suggested fair quality and impacts from sewage. The degraded communities improved to a marginally good condition seven miles downstream at the mouth.

Tinkers Creek

Surface Water Quality

The 1996 Tinkers Creek water chemistry data collected at RM 0.1 showed no exceedences of WQS Criteria. However, nitrate concentrations continue to be markedly elevated with a mean 6.81 mg/l (the 1991 mean was 7.6 mg/l). In contrast to lower Tinkers Creek, the median nitrate concentration from similarly sized reference streams in the EOLP ecoregion is 0.425 mg/l (n=298) (Ohio EPA 1999c). The excessive nitrates reflect the effluent dominated nature of the creek and improved ammonia nitrification at the major municipal WWTPs in the basin. While certainly less toxic than ammonia, it is possible that elevated nitrates may limit biological potential in Tinkers Creek. Water quality conditions at the mouth have not changed appreciably when compared to 1991 results.

Physical Habitat for Aquatic Life

Physical habitat at the mouth of Tinkers Creek is capable of supporting a typical warmwater stream fauna; the QHEI score was 70.5. The channel was sinuous and well developed, and contained boulder, cobble and gravel substrates. Woody debris was also present in the channel.

Again, effects of urban stormwater were evident in the relatively sparse cover and embedded substrates.

Fish Communities

As documented in 1984 and 1991, the fish community at RM 0.2 in Tinkers Creek was degraded. However, the shallow trend toward improvement following increased sewage treatment was continued in 1996 as evidenced by the collection of greenside darters (3 individuals), and a decrease in percent composition of tolerant and omnivorous fishes.

Macroinvertebrates

Natural substrate collections from the mouth of Tinkers Creek in 1996 continue to reflect fair water quality (Table 7). Communities were predominated by hydropsychid caddisflies, baetid mayflies, and blackflies.

Mill Creek

Surface Water Quality

Chemical samples were collected at RM 3.1 (adj to State Route 14) and at the mouth of Mill Creek (RM 0.1).

At RM 3.1, Secondary Contact Recreation criterion violations for fecal coliform bacteria were detected under both wet and dry weather conditions (18,000 colonies/100ml on July 23 and September 17, respectively). The NEORSD and municipal sewer systems in the Maple Heights/upper Mill Creek area has had chronic problems with collapsed sewer lines, sewer line blockages, illegal tie-ins, etc. (NEORSD annual reports, 1992-96). The bacteriological results provided further evidence of the need for rehabilitation of the sewer system in this area.

Bacteriological sampling at RM 0.1 (Canal Road) also revealed a Secondary Contact Recreation criterion exceedence following the September 17 storm event (Table 5). The most likely source(s) were CSOs, common trench sewers, and urban runoff. The results still represent a positive change from the 1991 survey when extremely high coliform levels resulted from a blocked sewer line and raw sewage discharges near RM 0.4. A 1984 intensive survey reveled severe water quality impacts associated with dry-weather CSOs on Mill Creek. Rehabilitation of the sewers and elimination of CSOs in much of the Mill Creek watershed was considered largely responsible for improvements in 1996.

Ammonia-nitrogen concentrations near the mouth of Mill Creek were chronically elevated during 1996 (mean=0.8 mg/l). Leachate from the abandoned City of Cleveland Old Mill Creek Landfill located immediately upstream was considered a primary source. The landfill is situated on the banks of Mill Creek and the exposed solid wastes have entered the creek for decades. Since the

1996 survey, work was completed to remediate the landfill and eliminate waste erosion to the stream. Again, the 1996 results represent a positive change compared to 1991, when ammonia concentrations as high as 3.58 mg/l were associated with the CSOs, landfills and a raw sewage discharge in the lower basin.

No heavy metals WQS criteria exceedences were recorded in Mill Creek in 1996 but concentrations of most metals increased following the September 17 rain event. Lead levels at RM 0.1 (23 ug/l) approached the chronic WQS criterion on the same date.

Since the 1996 survey, NEORSD began construction of a deep tunnel to store combined flow to reduce impacts to Mill Creek. Additional information on Mill Creek and the sewer project is available from the NEORSD.

Physical Habitat for Aquatic Life

Mill Creek is an urban influenced stream but retains many warmwater habitat attributes. Channel morphology was relatively well developed and sinuous, and original cobble and gravel substrates were present. Collectively, positive habitat attributes resulted in QHEI scores of 60.0 and 68.5 at RMs 0.2 and 4.4, respectively, suggesting habitat is not limiting to aquatic life. However, the creek is affected negatively by stormwater and urban runoff, as substrates were embedded and cover was sparse.

Fish Communities

Urban stormwater and CSOs combined to degrade fish communities in Mill Creek. Similar to Big Creek, the community lacked species sensitive to habitat disturbance, reflecting flow alteration. However, tolerant fishes composed most or all of the community, suggesting a higher degree of toxicity. CSO abatement was evident in the return of fish in the reach between RM 3.0 and 4.4 in 1996; no fish were collected in this reach in 1984.

Macroinvertebrates

Macroinvertebrate community health in Mill Creek ranged from poor at RM 3.4 to fair at RM 0.2 (Table 7). In the upper watershed, urban runoff, flashy stream flow, and periodic, unauthorized sewage discharges were likely sources of impact. The stream was clear but a pronounced odor of raw sewage was detected in the margins. Pollution tolerant blackflies predominated the samples and populations densities, taxa richness (12), and EPT taxa richness (1) were all quite low. Collections at RM 3.4 still represented an improvement over a 1984 survey when macroinvertebrates from RMs 5.6 and 2.8 reflected very poor quality and the stream bottom was blanketed with raw sewage and sewage bacteria.

Sampling near the mouth in 1996 indicates gradual improvement over the poor and very poor conditions observed in 1991 and 1984, respectively (Table 7). The increase in EPT taxa richness and QCTV scores during each sampling year was evidence of improving conditions.

Big Creek

Surface Water Quality

The results of the three sites monitored on Big Creek (RMs 7.8, 3.1 and 0.2) indicated no Ohio WQS criteria exceedences excepting numerous violations of the Primary Contact Recreation criterion for Fecal Coliform bacteria (Table 5). Predominant sources of impairment include CSOs, sanitary sewer overflows (SSOs), and urban runoff. NEORSD and Ohio EPA personnel have responded to numerous reports of sanitary discharges into Big Creek. Many of these were illegal tie-ins to storm sewers that were easily remediated, while other problems such as blockages or breaks have become more frequent. Many problems seem to stem from Parma and other areas in the Stickney Creek watershed (confluence RM 4.91).

Total phosphorus at the mouth was below laboratory detection limits in 80% of the samples. Ammonia-nitrogen concentrations averaged 0.17 mg/l (0.18 mg/l in 1991), well below the WQS criterion. Water quality has changed little since the previous survey in 1991.

An oily sheen observed at RM 0.2 in 1991, continued to seep into Big Creek from the former Research Oil property near Jennings Road. Temporary remedial measures were in place in 1996 and included harbor booms and absorbent pads to contain the leaking oil, and a vacuum truck to periodically remove oil captured behind the booms. Permanent site remediation has since been completed. The source of contamination was excavated and removed and the discharge to Big Creek was eliminated.

Physical Habitat for Aquatic Life

Though warmwater habitat attributes were more prevalent than modified attributes, macrohabitats at the three sites evaluated in Big Creek were marginally suited to supporting warmwater stream faunas owing to stormwater and urban runoff. Flashy scouring flows denuded the channel of natural cover, leaving behind fractured shale bedrock and artifical substrates (concrete and bricks) as the principle cover type. Riffles were embedded with silt and pulverized bedrock. Effects of urban runoff were most manifest at the mouth, where the channel was braided with small gravel and pulverized shale. Because of the erodible nature of the parent shale bedrock, the channel was generally well developed and sinuous, especially at the most upstream site, and recovered free flowing character within the confines of revetments at RM 3.1. The mean QHEI score was 56.0 (± 4.3 SE, $N = 2$).

Fish Communities

Neither IBI nor MIwb scores met the WWH criteria at any of the three sampling locations in Big Creek. The communities lacked sensitive species, darters, insectivores and simple lithophils, implying habitat limitation. Stoneroller minnows dominated the catch at all sites; consequently, the proportional metrics for tolerant and omnivorous fishes scored well. This combination of community attributes reflects habitat impacts, and organic and nutrient enrichment related to urban stormwater and CSOs. Habitat alterations due to flashy flows, and the resultant effects on the fish community, were most evident at RM 0.2 where the fish community was composed almost entirely of young of the year fishes, but in similar proportions to upstream, evidencing recent colonization.

The fish community sampled in 1996 appeared to improve compared to 1984, due to an increase in the number of species and total number of individuals, and a decrease in the percentage of DELTs. Otherwise, metrics performed similarly. The improvement likely reflects dry weather CSO and SSO abatement efforts.

Macroinvertebrates

Macroinvertebrate community health declined from fair at RM 7.8 to poor at RMs 2.5 and 0.2 (Table 7). Predominant populations collected from the natural substrates shifted from hydropsychid caddisflies and isopods upstream to pollution tolerant leeches, midges, and baetid mayflies at the downstream sites. Sharp declines in QCTV scores from upstream to downstream were also indicative of degraded conditions through Cleveland.

Community performance improved in 1996 when compared to the grossly polluted conditions observed in 1984. Compared to 1991 sampling, conditions near the mouth in 1996 (poor) were similar between surveys.

Chippewa Creek

Surface Water Quality

No chemical or physical exceedances of the WWH acute or chronic WQS criteria were found in Chippewa Creek. The upper watershed has not responded as expected to the elimination of several wastewater treatment facilities in the 1980s. The most elevated concentrations of contaminants in the creek are in the upper watershed which gradually declined (better water quality) towards the mouth. The Norton Landfill had no discernable impact on the water quality of Chippewa Creek.

The Cuyahoga County Board of Health (CCBH) in 1996 collaborated with Ohio EPA in a study of the Chippewa Creek watershed. They concluded that failing septic systems may have the most significant impact upon the water quality of the creek.

Physical Habitat for Aquatic Life

The CCBH conducted an intensive survey of stream habitats in Chippewa Creek in 1996 at 49 stations within the 5.45 river mile study area (Chippewa Creek Stream Monitoring Project Preliminary Report, Summer of 1996, The Cuyahoga County Board of Health, unpub.). Physical habitats in Chippewa Creek were predominated by warmwater attributes as evidenced by a mean QHEI of 67.9 (range 45.5-88.5; Table 14). Substrates varied between sites, but consisted primarily of cobble, bedrock, sand, and gravel. Finer grained sediments were more common near the mouth. An alternating series of riffles, runs and pools were present at most sites. There are at least two waterfalls on Chippewa Creek (RM 2.2 and RM 3.5) that may be a barrier to fish migration.

Fish Communities

A total of 19 species were collected within Chippewa Creek. Most of these species were located at just one site near the mouth (RM 0.3). Upstream from the mouth (RMs 6.1 and 3.8), there were only eight species collected (white sucker, blacknose dace, creek chub, central stoneroller, bluegill, largemouth bass and green sunfish). The centrarchids were represented at the upstream sites by only a few individuals. Stoneroller and blacknose dace minnows were, by far, the most numerous at the upstream sites and comprised 75% of the total catch. These species comprised only 51% of the individuals at the site near the mouth.

Fish community performance in Chippewa Creek ranged from very good to poor (Table 15) with overall good quality physical habitats (average QHEI of 60) and no exceedences of Ohio WQS criteria. The highest mean IBI score of 46 occurred at the most downstream site at RM 0.30. The lowest score of 20 was recorded in the middle portion of the river at RM 3.8 downstream from the Norton Landfill. This sampling site was characterized by poor habitat due to extensive amounts of bedrock in the stream. The most upstream site at RM 6.1 met the warmwater habitat criterion with an IBI score of 38.

The low IBI score downstream from the Norton landfill was attributed to the bedrock habitat in the stream and not to influences from the landfill. The upstream site was characterized by good pool, riffle, run development and the downstream site was characterized by a step-wise series of runs or pools separated by short vertical drops. The resultant change in habitat from a QHEI of 67.5 upstream from the landfill to a QHEI of 43 downstream from the landfill is the cause of the change in the IBI scores. These two upstream sampling sites in Chippewa Creek had similar fish communities. Both sites had low species richness, a lack of headwater, intolerant and sensitive species, and low numbers of darters, suckers and simple lithophills. Conversely, percentages of omnivores and tolerant species were high, resulting in minimum scores. The difference in the scoring between the two sites was primarily the change in the ratio of creek chub (tolerant) to stoneroller populations and the collection of a single largemouth bass at the upstream site at RM 6.1.

The impoverished fish communities in the upper watershed are probably related to several influences. Failing septic systems, high TSS levels from nonpoint sources, poor habitat and upstream migration barriers posed by waterfalls are possible explanations for the condition of the upstream communities.

Table 15. Fish community indices from samples collected in the Chippewa Creek study area, 1996.

River Mile	Mean Number Species	Cumulative Species	Mean Rel. No (No./0.3 km)	Mean Rel. Wt. (kg/0.3 km)	QHEI	Mean MIwb[a]	Mean IBI	Narrative Evaluation
Chippewa Creek								
6.1[E]	7.0	7	1442	NA	67.5	NA	34*	Fair
3.8[E]	6.0	6	537	NA	43.0	NA	20*	Poor
0.3[E]	19.0	19	2315	NA	68.5	NA	46	Very Good

Ecoregion Biocriteria: Erie-Ontario Lake Plain

	IBI			MIwb		
Site Type	WWH	EWH	MWHc	WWH	EWH	MWHc
Headwaters	40	50	24	NA	NA	NA

a - MIwb is not applicable to headwater streams with drainage areas < 20 mi2.

E - Long-line sampling method.

* - Significant departure from applicable biocriteria (>4 IBI units or >0.5 MIwb units). Underlined scores are in the Poor or Very Poor range.

Trend Assessment

Surface Water Trends

Water quality samples were collected in 1988 as part of a water quality survey of Chippewa Creek to determine what impacts may be associated with the Norton Landfill. Based upon the limited samples collected in these studies, it appears that nutrient levels have declined slightly, while other water quality indicators have not significantly changed.

Macroinvertebrate Community Trends

NEDO staff conducted a macroinvertebrate survey of Chippewa Creek in 1988. The survey concluded that the stream was not meeting WWH potential and the Norton Landfill was not having a significant impact upon the stream. The 1996 survey reached the same conclusions. However, the 1988 survey found that the macroinvertebrate community was dominated by mayfly and caddisfly nymphs while very impoverished communities were found at all stations sampled in 1996. There were no obvious water quality related reasons for the declines observed in 1996. The results may simply reflect the first-time sampling efforts by CCBH and the need for additional refinement in collection techniques.

Fish Community Trends

Ohio EPA conducted a fish survey of Chippewa Creek in 1984 (RM 0.7) and in 1988 (RMs 4.1 and 6.1). The 1988 report on the survey concluded that the stream was not meeting WWH potential and the Norton Landfill was not having a significant impact upon the stream. Data from the 1996 survey indicate that the fish community in the upper portion of the watershed has changed little since 1988. IBI scores remained in the fair range at RM 6.1 while the poor quality of the fish at RM 3.8 was considered largely related to habitat and not indicative of a declining trend downstream from the landfill. There was significant improvement in the fish from 1984 to 1996 at the station near the Cuyahoga confluence. Eight more species were collected in 1996 than in 1984 and the IBI increased from 30 (fair) to 46 (very good).

Long Lake (Portage Lakes), Summit County
Summary of 1998 Ohio EPA Survey
Division of Surface Water, Northeast District Office

Summary

Long Lake is the final water body in a highly regulated series of lakes located within the Portage Lakes State Park. The lake has a glacial origin but had been modified to serve the Ohio canal system in the early 1900's. The lake hydrology is unique in that the outflow is at the terminus of the United States continental divide and water leaving the lake is regulated daily to discharge into both the Lake Erie basin (Little Cuyahoga River) and the Ohio River basin (Tuscarawas River) via the Ohio canal. The lake use is mostly small boat fishing and the game fishery is managed by the Ohio Department of natural Resources.

The lake was previously sampled by Ohio EPA in 1976 and 1993. A nutrient survey was conducted by Kent State University in 1993 and a follow-up assessment of the lake ecosystem was conducted in 1998 by the Ohio EPA. For the 1998 survey, chemical/physical field sampling results, trophic status data, and a survey of Long Lake algal species are located in Appendix A, Tables 3-4.

Trophic state data from the most recent 1998 survey showed a highly significant increase in total phosphorus concentration as compared to previous studies [1990-1993 median range = 60-80 ug/l, 1998 median = 120 ug/l (Figure 39)]. However, there was no significant change in total chlorophyll-a concentrations [1990-1993 median range = 30-60 ug/l, 1998 median = 35 ug/l (Figure 39)], or Secchi disk transparency [1990-1993 range = 0.6-0.8 m, 1998 median = 0.7 m (Figure 39)].

Measured ratios of total nitrogen to total phosphorus were below 10:1 in all but one sample (Table 16). One explanation for the lack of association between phosphorus and chlorophyll is that the lake phytoplankton in 1998 was limited more by available nitrogen than by phosphorus. This idea is suggested by the N:P ratios less than 10:1, some as low as 1:1. In general, N:P ratios less than 16:1 suggest the possibility of increasing nitrogen limitation of algae production. Another possibility is that the form of phosphorus in the lake water in 1998 was not biologically available to the algae. Many forms of phosphorus bind to organic molecules, clay, and silt particles and are not available for uptake by aquatic plants and algae. Thus it is possible to have a relatively high concentration of total phosphorus with low chlorophyll pigments if the phosphorus is not in a dissolved form that is available to enter the algae cells.

The possible causes of increased total phosphorus measured during the 1998 survey include: (1) resuspension of organic matter and/or silt particles during the in-lake disposal of dredged soils from the Ohio DNR dredging of one of the four inlet channels (Stone Creek) in 1998; (2) increased loadings of phosphorus from the watershed such as the Summit County Upper Tusca-

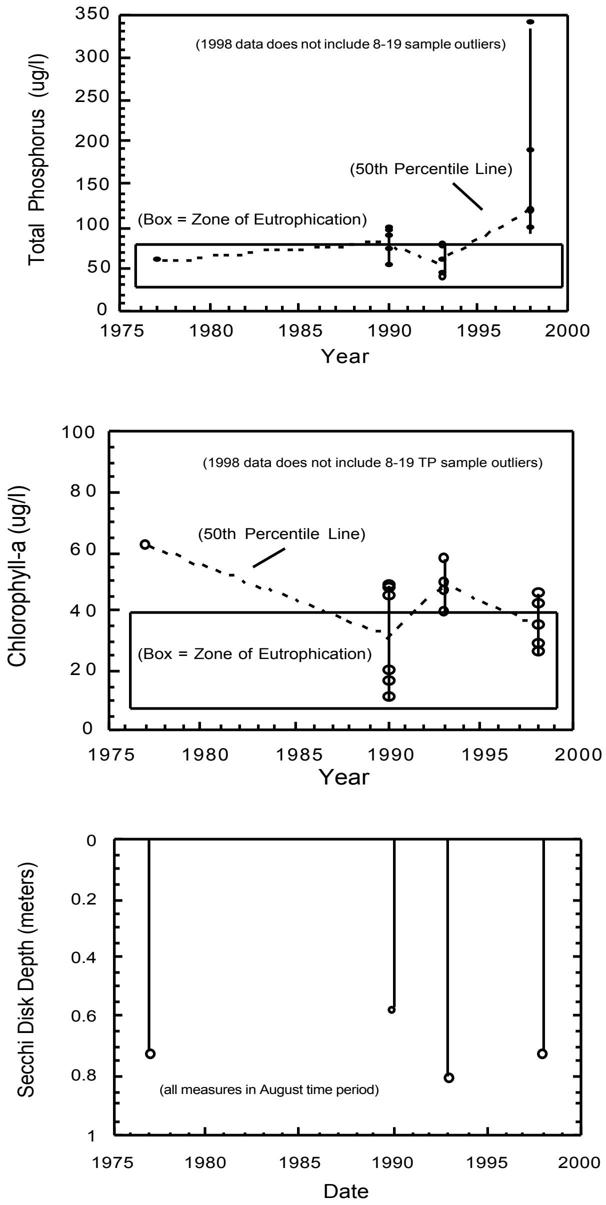

Figure 39. Historical trends in total phosphorus (ug/l), chlorophyll-a (ug/l), and August sechi disk depth measurements (meters) from Long Lake, Stations L-1 (south end) and L-2 (north end), 1976-1998.

Table 16. Results of trophic state parameters collected from Long Lake Stations L-1 (south end) and L-2 (north end), May-October, 1998.

Lake Station/ Parameters	Date Collected (m/day) 05/11	06/24	07/23	08/19	10/01
Station L1 (south end)					
Chlorophyl-a (ug/l)	54.5	35.1	45.9	34.6	-----
Secchi disk depth (meters)	0.82	0.65	0.64	0.69	-----
Nitrate (NO_2-NO_3) (ug/l)	110	<100	-----	<100	-----
TKN (Total Kjeldahl-N) (ug/l)	600	1000	-----	800	-----
Total Nitrogen (ug/l) (NO_2-NO_3+TKN)	710	1050*	-----	850*	-----
Total Phosphorus (ug/l)	47	190	100	1170	-----
Nitrogen/Phosphorus Ratio	15:1	6:1	-----	0.7:1	-----
Station L2 (north end)					
Chlorophyl-a (ug/l)	36.4	26.2	43.4	31.5	29.1
Secchi disk depth (meters)	0.79	0.75	0.65	0.77	0.68
Nitrate (NO_2-NO_3) (ug/l)	240	<100	-----	<100	<100
TKN (Total Kjeldahl-N) (ug/l)	1700	1000	-----	800	700
Total Nitrogen (ug/l) (NO_2-NO_3+TKN)	1940	1050*	-----	850*	750*
Total Phosphorus (ug/l)	210	120	100	870	340
Nitrogen/Phosphorus Ratio	9:1	9:1	-----	1:1	2:1

* For NO_2-NO_3 concentrations below detection, a value of one half the detection limit was used in the determination to total N.

rawas WWTP, which stopped treating to remove phosphorus from their discharge in 1995. This WWTP discharge has increased average flow from less than 1.0 mgd in 1995 to greater than 2.0 mgd in 1998, and (3) changes in the regulation of outflow from Long Lake into the Tuscarawas River and Ohio Canal from Long Lake over the past five year in order to maintain a daily minimum flows in the Ohio Canal. Continued monitoring of total phosphorus after the Stone Creek dredging project is completed will help determine the contribution this dredging project may have had on phosphorus levels during the 1998 survey.

Other threatened conditions observed in Long Lake in 1998 include low dissolved oxygen and elevated levels of ammonia-N and manganese in bottom waters in the summer, a common observation in nutrient enriched lakes in Ohio. Elevated levels of lead, arsenic, and zinc in the sediment in 1993 survey were not detected in 1998, which suggests that these metals are not evenly distributed along the lake bottom. A fecal coliform bacteria sample collected near the outlet of Stone Creek was at 12/100 ml, and a second sample near the boat ramp was 64/100 ml, both values being less than the 200/100 ml bathing water standard. A survey of the algae species in 1998 (see Appendix A, Table 4) showed high numbers of blue green algae in the summer months, another indication of the nutrient enriched condition of the lake.

Long Lake is one of the few inland lakes in Ohio where Ohio EPA has conducted a detailed electro-fishing survey of the entire fish community. The survey was conducted in 1986 on three different days. During this survey the Ohio EPA documented the presence of two rare species of fish, the Iowa Darter, listed as state “Special Interest” and the Pugnose Minnow, listed as state “Endangered”. The potential for rare aquatic plants also exists given the glacial origin of the lake ecosystem, however, no survey of aquatic plants has been conducted. In 1986 the overall fish community was dominated by Bluegill sunfish (40 to 60 % of all fish collected), Warmouth sunfish (9 to 20 %), and Bluntnose Minnow (1 to 18 %). Other game fish collected included White and Black Crappie, Largemouth Bass, Yellow Perch, and Pumpkinseed Sunfish. It is recommended that a follow-up survey using the Ohio EPA IBI sample methods be conducted to determine if the fish community has changed over time since the 1986 survey.

In 1988 the Ohio EPA developed a multi-metric lake condition evaluation method known as the Ohio Lake Condition Index, the most recent revision being found in the Ohio EPA 1996 305(b) Water Resources Inventory Report. Using data collected in 1998 Long Lake scored a Lake Condition Index (LCI) value of 39.1, which indicates the lake should be given high priority for future funding to develop a comprehensive lake and watershed management plan. In general, lakes in Ohio with LCI values over 31 show increased signs of impairment for recreational, aquatic life, or public drinking water supply uses.

Analysis of fish tissue samples collected in 1993 and 1994 by the Ohio Department of Natural Resources did not show chemicals of concern in Largemouth Bass above Ohio Department of Health fish consumption restrictive consumption “action levels”. In June 1997, the Ohio

Department of Health issued a statewide fish tissue consumption advisory for children age 6 and under and for women of childbearing age. The advisory is due to low level statewide mercury contamination, with the likely source being atmospheric deposition. The advisory is to “eat no more than one meal of fish (any species) per week from any Ohio body of water”. No other more restrictive advisories are listed specifically for Long Lake based on the 1993 and 1994 data collected.

A variety of possible lake and watershed management options are recommended for Long Lake: long term monitoring of game fish species to allow for optimal management of populations; a survey of the aquatic plants to determine the extent of lake coverage and the potential presence of rare species that are known to exist in other glacial lakes in Northeast Ohio; controls on loadings of nutrients to the lake from both point and non-point sources--especially phosphorus and nitrogen compounds; long term monitoring of nutrient and chlorophyll-a concentrations; and a detailed analysis of the loadings of nutrients from the four major inflow streams in relation to the regulated inflow from North Reservoir.

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Appendices to

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State of Ohio Environmental Protection Agency
Division of Surface Water
Ecological Assessment Section
1685 Westbelt Drive
Columbus, Ohio 43228-3809
and
Nonpoint Source Management Section
P.O. Box 163669
1800 WaterMark Drive
Columbus, Ohio 43216-3669
and
Surface Water Section
Northeast District Office
2110 East Aurora Road
Twinsburg, Ohio 44087

Appendices are available electronically on the Ohio EPA Division of Surface Water Home Page at:
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