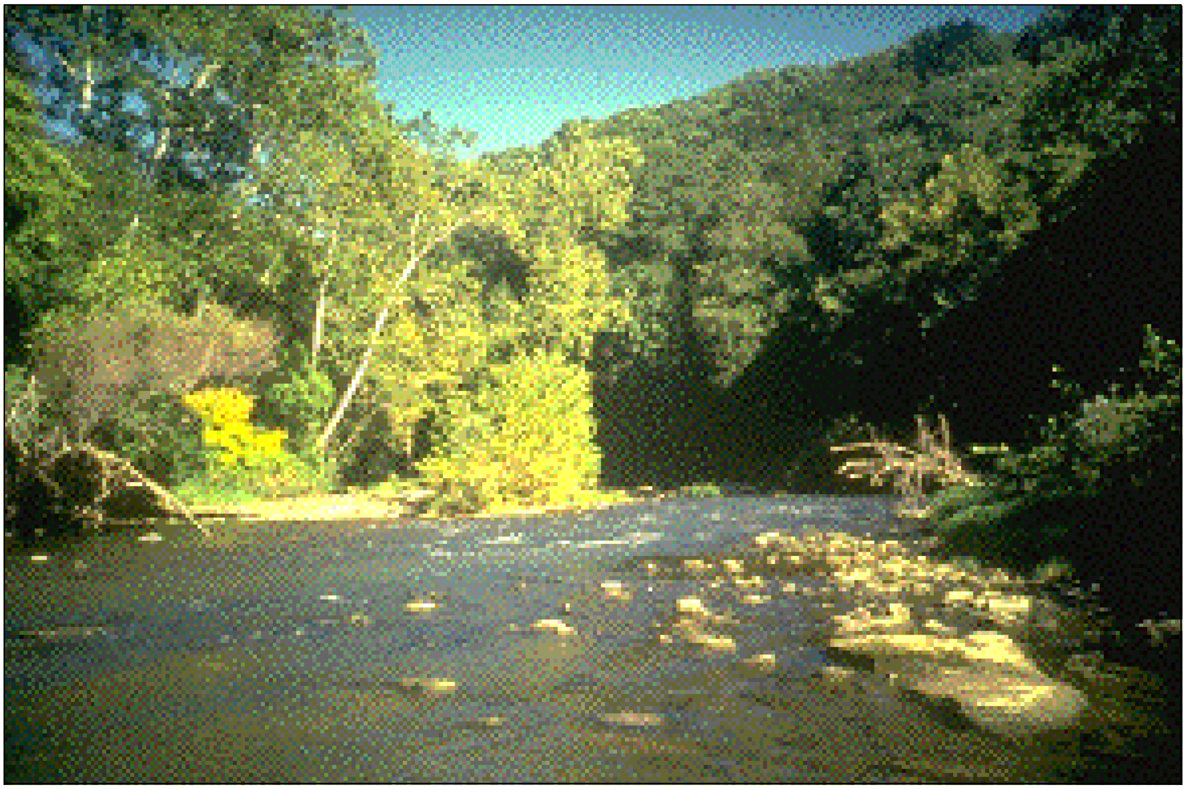
Ohio Water Resource Inventory



Volume I:
Summary, Status, and Trends

1994

Division of Surface Water
Monitoring & Assessment Section

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Volume 1: Summary, Status, and Trends

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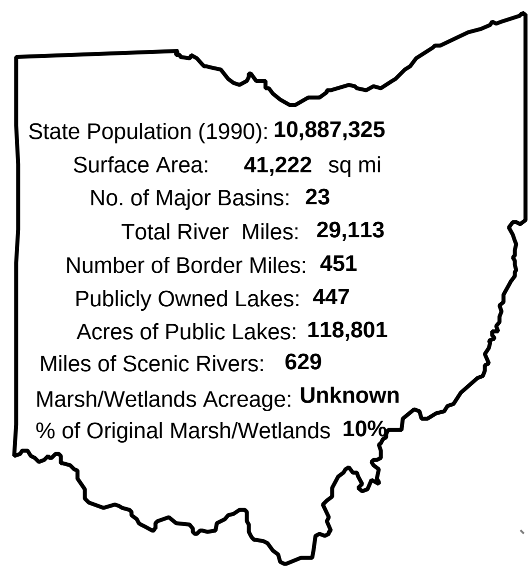
Section 1

Introduction

Ohio is a water rich state with more than 29,000 miles of named and designated rivers and streams, a 451 mile border on the Ohio River, more than 188,000 acres among more than 450 lakes, ponds, and reservoirs (118,800 acres publicly owned), and more than 230 miles of Lake Erie shoreline (Map 1-1). Ohio is an economically important and diverse state with strong manufacturing and agricultural industries. Many of the historical patterns of environmental impact in Ohio are related to the geographical distribution of basic industries, land use, mineral resources, and population centers. Also important, however, is an understanding of Ohio's geology, land form, land use, and other natural features as these determine the basic characteristics and ecological potential of streams and rivers. Ohio EPA bases the selection, development, and calibration of ecological, toxicological, and chemical / physical indicators on these factors. These are then employed via systematic ambient monitoring to provide information about existing environmental problems, threats to existing high quality waters, and successes in abating some past and current water pollution problems in Ohio's surface waters.



Map 1-1. Atlas of Ohio statistics.

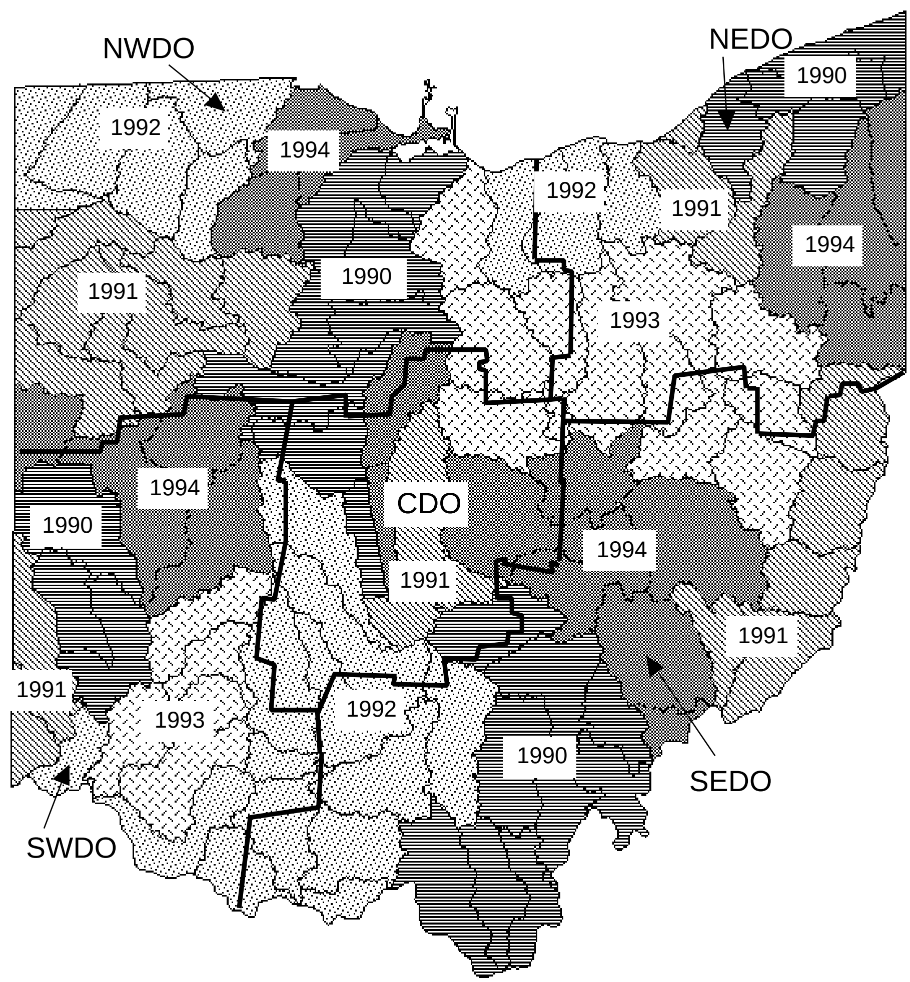
The 1994 Ohio Water Resource Inventory focuses on: (1) the status of Ohio's surface and ground water resources through the 1992 data year, (2) trends in the biological integrity of selected stream and river segments, (3) the incorporation of biological data from other state agencies and institutions in Ohio as a part of the statewide assessment, (4) an evaluation about the potential for using volunteer collected biological data as evaluated-level assessments, and (5) and a forecast of the status of Ohio's rivers and streams through the year 2000 in an attempt to assess the likelihood of meeting the Ohio 2000 goal of 75% full attainment. Underlying all of this is the theme that a prescriptive, technology-based, or even water quality-based approach to water resource management are *alone* insufficient to deal with many emerging problems. When water quality problems were predominated by much more "obvious" causes, many of which could be easily seen (and smelled), the application of standard wastewater treatment technology (*e.g.*, secondary treatment, BPT, BAT) resulted in noticeable aesthetic, chemical, and ecological improvements in the aquatic environment. The problems remaining today, while comparatively more complex and subtle, are nonetheless real. Thus new approaches to water resource management will need to be relied upon.

"Simply stated the control of chemicals alone does not assure the restoration of water resource integrity (Karr et al. 1986)."

Water resources in Ohio and elsewhere continue to be affected by many other human activities beyond those targeted by the NPDES permit process. Yet the major focus of water programs is still on this permit process. Nonpoint sources are beginning to be addressed through the CWA (*e.g.,* Section 319) and other approaches. The resources allocated thus far, however, are insufficient and the approaches promoted by USEPA are too preoccupied with water column chemical effects. Several of the "non-chemical" impacts that adversely affect water resource integrity include: direct habitat alterations due to channel modifications, impoundment, and riparian encroachment, land use activities such as suburban, industrial, and commercial development, utility construction, solid waste disposal, and hydrological modifications such as wetlands destruction, water withdrawals, and drainage enhancement. From an environmental perspective most of these activities are uncontrolled and some have resulted in a further decline in water resource integrity during the 1980s and 1990s. Simply stated the control of chemicals alone does not assure the restoration of water resource integrity (Karr *et al.* 1986).

A monitoring approach, integrating biosurvey data that reflects the integrity of the water resource directly, with water chemistry, physical habitat, bioassay, and other monitoring and source information must be central to accurately define these varied and complex problems. Such information must also be used in tracking the progress of efforts to protect and rehabilitate water resources. The arbiter of the success of water resource management programs must shift from a reliance on achieving administrative goals (numbers of permits issued, dollars spent, or management practices installed) and a preoccupation with chemical water quality to more integrated and holistic measurements with water resource integrity as a goal.

Beginning in 1990 Ohio instituted a "5-Year Basin" approach to monitoring and NPDES permit reissuance for its intensive survey efforts (Map 1-2). This effort should allow the Ohio EPA, provided sufficient resources are available, to monitor major sources of pollution (point and nonpoint) and to begin remediation efforts for these sources. This schedule has been devised so that monitoring data is collected ahead of permit reissuance or BMP implementation. Such an effort required a shift in the schedule for reissuing major NPDES permits. Furthermore, 14 plus years of using



Map 1-2. Subbasin sampling schedule for Ohio EPA's 5-year basin approach to monitoring and NPDES permit reissuance. The years of scheduled field work are indicated by major subbasin (i.e., 1991 indicates the year of field monitoring). SWDO = Southwest District; SEDO = Southeast District; CDO = Central District; NWDO = Northwest District; NEDO = Northeast District.

an integrated biosurvey approach to monitor major sources of pollution has put Ohio EPA in a position to monitor ambient conditions before and after the installation of water quality based pollution controls. This effort should result in a shift toward using environmental results as measures of the success of regulatory actions and away from the regulatory action itself as a measure of success.

Why This Report Emphasizes Aquatic Life Use Support

Ohio surface water bodies are assigned to various beneficial "use" categories in the Ohio Water Quality Standards (WQS; OAC 3745-1) related to: (1) aquatic life; (2) public water supply; (3) agricultural water supply; (4) industrial water supply; and, (5) recreational uses. WQS to protect the non-aquatic life uses (2-5) are primarily based on chemical indicators and criteria. Human health is protected through various routes of exposure which includes direct body contact and consumption based exposures (*i.e.*, contaminated edible portions of fish and wildlife). While it is possible to base protective measures on these criteria, it is much more difficult to practically measure true human health responses in the ambient environment. The emphasis of this report is on aquatic life use attainment because: (1) aquatic life criteria frequently result in the most stringent requirements compared to those for the other use categories, (*i.e.*, protecting for aquatic life uses should assure the protection other uses), (2) aquatic life uses apply to virtually *every* Ohio waterbody and the diverse criteria (*i.e.*, includes conventionals, nutrients, toxics, habitat, physical, and biological factors, etc.) apply to all water resource management issues, (3) aquatic life uses and the accompanying chemical, physical, and biological criteria provide a comprehensive and accurate ecosystem perspective toward water resource management that promotes the protection of "ecological integrity", (4) Ohio has an extensive and comprehensive database of aquatic life, physical habitat, water chemistry, sediment, and effluent data, most of which is readily accessible via electronic databases. Comparably accessible databases for toxic organic contaminants are in development and include fish tissue contamination, effluent concentrations, and information about the impacts of the unregulated disposal of hazardous wastes. These databases will figure prominently in future 305(b) reports. The

"... aquatic life criteria often times result in the most stringent requirements ..."

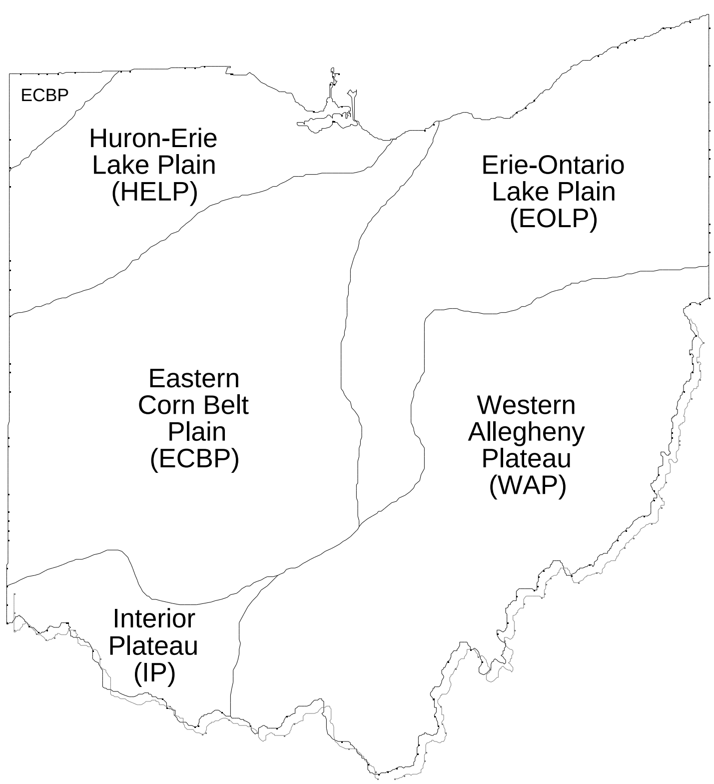
first effort to assess the statewide fish tissue contaminant database since 1977 appears in Volume II.

Background

This section provides information that will be useful in interpreting the patterns of pollution impacts in Ohio discussed in this document.

Ohio Ecoregions

Central to Ohio EPA's use of ambient biological, chemical, and physical information is the concept of "ecoregions." Omernik's (1987) ecoregions are land-surface areas that are grouped based on similarities in land use, potential natural vegetation, land surface form, and soils. These underlying factors determine the character of watersheds and have a profound influence on background water quality and the type and composition of the biological communities in a stream or river and the manner in which human impacts are exhibited. The following is a brief description of Ohio's five ecoregions (Map 1-3) mostly taken from Omernik and Gallant (1988)



Map 1-3. Ohio Ecoregions

"... ecoregions...have a profound influence on background water quality and the type and composition of the biological communities in a stream or river..."

Huron Erie Lake Plain (HELP): This former lake bed is distinguished by its soils (fine lake silts) with very poor drainage. In Ohio, this area is largely the remnant of the Black Swamp which was a forested wetland. Most of this region was channelized and drained for cropland by the turn of the 20th century. Stream gradients are extremely low with most less than 1-2 ft/mi. This region has the most widespread and severe agricultural impacts of any of the Ohio ecoregions which is related to the lack of woody riparian vegetation, channelization, and low stream gradients that virtually preclude any recovery of original stream habitats.

Interior Plateau (IP): The Interior Plateau is transitional between the Eastern Corn Belt Plain and Western Allegheny Plateau ecoregions. In Ohio, streams are often predominated by limestone bedrock and flat rubble. There is a transition in relief from the rolling till plains in the northwest toward the hillier Allegheny Plateau. Stream valley dissection is the greatest along the Ohio River and nearer the WAP. There is also a transition in land use from agriculture and livestock in the west to timber and forest lands in the eastern section.

Erie Ontario Lake Plain (EOLP): A region characterized by moderate to high relief intermediate between the rolling Eastern Corn Belt Plain and the hillier Western Allegheny Plateau. Land use varies between cropland, pasture, livestock and forest lands; not as heavily agricultural as the HELP ecoregion nor as heavily forested as the WAP ecoregion. This area contains the major urban areas of Cleveland, Akron/Canton, and Youngstown, which are major centers of heavy industry in Ohio.

Eastern Corn Belt Plain (ECBP): A region of extensive (>75%) cropland agriculture on a gently rolling glacial till plain crossed by end moraines, kames, and outwash plains. Some streams have been channelized, but not to the extent of the Huron Erie Lake Plain. The better streams have some wooded riparian vegetation remaining containing species such as cottonwood, sycamore, silver maple, black willow, and box elder. Besides cropland agriculture, this ecoregion is characterized by pasture, small woodlots, and small to medium urban areas. Unlike the

EOLP ecoregion, this area lacks the extensively developed, heavy industrial centers.

Western Allegheny Plateau (WAP): This is a highly dissected ecoregion (steep valleys) of sandstone, siltstone, shale, and limestone with the highest relief in the state. It largely comprises the unglaciated region of the state and, because of its relief, is the most heavily forested ecoregion in Ohio. Coal mining and timber harvesting are among the major land uses in this region with some agriculture occurring on the valley floors. This is also the least densely populated area of Ohio.

A Brief History of Impacts to Ohio's Surface Waters

The first large influx of settlers in Ohio in the early 1800s resulted in the first major changes in Ohio's landscape. Prior to European settlement, Ohio supported a small population of Native Americans whose permanent impact on the landscape of Ohio was minor and localized. More than 95 percent of Ohio was wooded and the remainder consisted of wetlands and prairies, dry tall grass, and wild plum (Trautman 1981). The smaller streams in Ohio had permanent flow most of the year and small springs were common (Trautman 1981). This was undoubtedly related to the permanent and stable vegetative cover that was present. In contrast to the streams of today, pre-European settlement stream substrates were characterized by gravels and cobbles that were free from clayey silts. In fact Kilbourn (c. f. Lee 1894 in Trautman 1981) stated that the streams north of Columbus were: "clear lively streams of pure water as ever flowed from a fountain, with small gravel and in places large pebble bottom."

...streams north of Columbus were: "clear lively streams of pure water as ever flowed from a fountain..." (Kilbourn - late 1800s).

The presence of many extremely intolerant fish species recorded (Trautman 1981) during this period (*e.g.,* harelip sucker, crystal darter) demonstrates the clear water, pristine nature of Ohio's streams then. The high ecological integrity of these streams can be hypothetically illustrated by a "cumulative frequency distribution" (CFD) of Index of Biotic Integrity scores that, based on the species assemblages, were likely during this period (Figure 1-1). The further to the right a line is on the graph the greater the proportion of sites that have high biological integrity. Thus in the 1700s and early 1800s most streams in Ohio were essentially pristine and would likely have scored very high on the biological indices used by Ohio EPA (early species records discussed in Trautman [1981] corroborate this assertion).

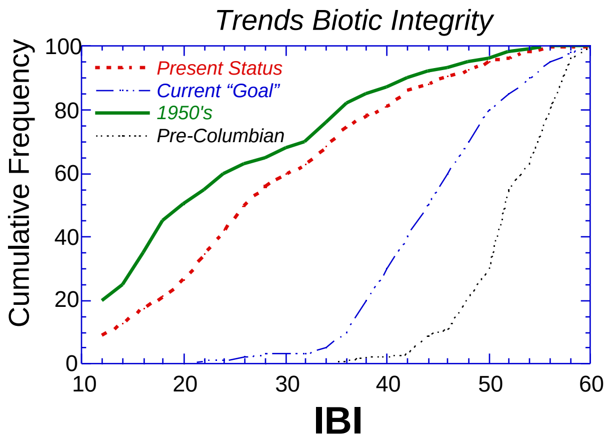


Figure 1-1. Hypothetical cumulative frequency distributions of the Index of Biotic Integrity during pre-Columbian times, the probable low point in stream quality (early 1950s), the present status, and the attainable goal for Ohio streams given present landuse, population, etc.

European settlers, however, exacted great changes on the landscape in the mid to late 1800s. The roughly 24 million acres of forest that existed in 1800 was cut to 4 million acres (Figure 1-2) by 1883 (Laub 1979). Along with the increase in population (from 3,000 in the 1700s to over 3 million by 1880) it is easy to visualize the rapid pressures that were put on the state's natural resources. The hypothetical CFD for the IBI in Ohio streams in the 1880s (Figure 1-1) illustrates the loss of much of the original pristine nature of Ohio waters as forests were removed and watersheds significantly altered. Forest cover continued to decline (Figure 1-2) until the 1930s as agriculture was extended to marginal farmland in areas such as the hilly Western Allegheny Plateau. These changes further affected the remaining high quality waters in Ohio.

"The roughly 24 million acres of forest that existed in 1800 was cut to 4 million acres by 1883 (Laub 1979)."

Increases in both the industrial base of Ohio and in Ohio's population in the 1940s and 1950s also had significant effects on Ohio's streams and rivers. Before the advent of modern wastewater treatment technology, many tons of human and industrial waste were discharged, either untreated or minimally treated, into Ohio's streams and rivers. This period was likely the greatest in terms of the magnitude and severity of degradation to Ohio streams and rivers. Trautman (1981) records that for many large rivers, especially with large populations or industrial development nearby (*e.g.*, Mahoning River, Scioto River, etc.) biological communities were largely composed of a few tolerant species (*e.g.*, goldfish, carp, bullheads, sludge worms, etc.) and that many of these had eroded fins and other signs of chronic stress. The hypothetical CFD for this period is skewed toward the left side of the graph that indicates a greater proportion of streams with poor and very poor biological integrity.

The late 1960s, 1970s, and 1980s were a period extensive construction and upgrading of wastewater treatment plants (WWTPs) across Ohio. Much of this was directly related to Clean Water Act mandates to improve the quality of the nation's waters and restore the chemical, physical, and biological integrity. Between 1970 and 1987 alone, $3.7 billion dollars was invested in publicly owned wastewater treatment facilities with $2.7 billion of this received through the federal construction grants program (Ohio EPA 1990a). The result of this effort is a decline (but *not* the elimination) in the number of streams with poor and very poor biological communities. The CFD based on actual data collected in the late 1980s through 1991 illustrates a substantial decline in the proportion of streams in very poor condition. The trend section of this report (Section 4) provides more detail on instream biological integrity changes related to water quality improvements.

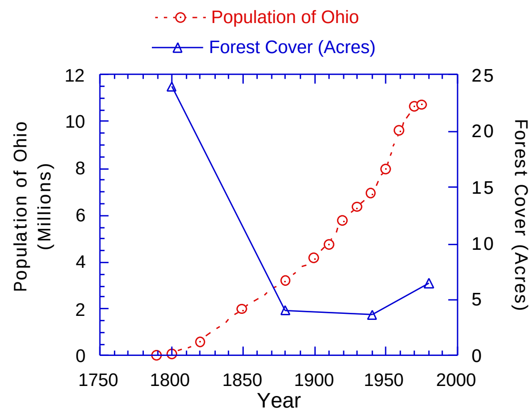


Figure 1-2. Forest cover and European population of Ohio from the 1700s to 1990.

"... a high level of biological diversity and integrity is attainable in most Ohio waters under present land use activities."

It is more than obvious that a return to pre-settlement conditions is not likely for much of Ohio. This does not mean, however, that further improvements in water resource quality in Ohio are not possible. Biological community information from "least impacted" reference sites in streams and rivers throughout the state indicate that a high level of biological diversity and integrity is attainable in most Ohio waters under present land use activities. To accomplish this will require the realization that the definition of a stream or riverine ecosystem includes not only the chemical composition of the water column, but the integrity of the instream physical habitat, floodplain and riparian vegetation areas as well. This realization is especially needed in day-to-day water resource management efforts.

A failure to adopt these concepts will result not only in an incomplete success in achieving the objectives of the Clean Water Act and the Ohio WQS, but a continuing decline in the nation's water resources.

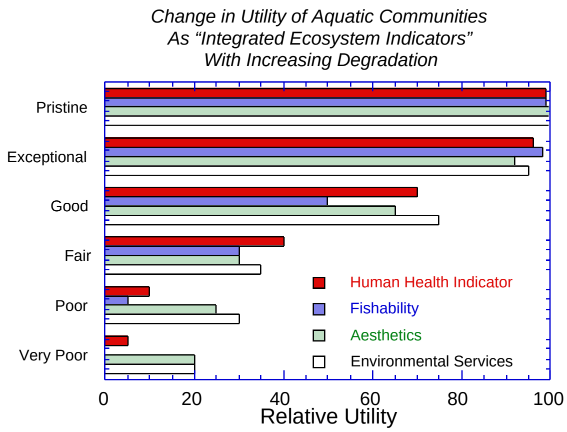


Figure 1-3. Change in the hypothetical utility of aquatic communities to man with increasing degradation and pollution.

Relatively intact ecosystems provide substantial environmental services of unrealized importance to long-term, sustainable environmental quality. The biological components of these systems act as a warning system that can indicate eventual threats to human health, degradation of the aesthetic qualities, reductions in the quality and quantity of recreational opportunities, and other ecosystem services. Some of these other services include reliable and safe supplies of water for human consumption and industrial production, processing of human and other waste products, sediment transport, and the purification of both ground and surface waters. As the integrity of Ohio's surface waters is degraded through the discharge of chemicals, disposal of liquid and solid wastes, habitat degradation and loss, alteration of the hydrologic cycle, and encroachment on riparian zones, the ability of streams and rivers to both provide beneficial services and act as "environmental indicators" is reduced (Figure 1-3).

"... intact ecosystems provide substantial environmental services..."

*T*he conversion of aquatic ecosystems away from predominantly self-sustaining systems to highly modified systems needing artificial maintenance requires both high economic expenditures and comparatively inefficient, external anthropogenic energy inputs to provide even a semblance of the same ecosystem services. A model of the relationship between "community stability" (*i.e.*, the ability of an ecosystem to attain and maintain its potential) and the "energy subsidy" required to maintain the ecosystem at its present level of "services" is illustrated in Figure 1-4 (Anderson and King 1976). As land use becomes increasingly devoted to intensive anthropogenic activities (*e.g.*, urbanization, agriculture, mining, forestry, etc.,) the energy subsidy required for the maintenance of ecosystem services increases. There is a point, however, where the impacts of the land use activities on the ecosystem exceed the ability of the external inputs of energy to adequately compensate for the declining stability or integrity. The results include ecosystems that provide only a fraction of their original services or services that are not comparable to the costs of the external energy inputs (*i.e.*, subsidy) needed to maintain that fractional benefit. Conversely, the tendency for altered ecosystems to revert to their climax phase over time requires the expenditure of external energy to maintain the ecosystem in an altered state (*e.g.*, agriculture drainage maintenance, dredging, mowing, herbicide applications, etc.). Thus the costs can arise as a result of both the desire to "reclaim" or mimic lost ecosystem attributes and services as well as those required to maintain ecosystems in an altered state.

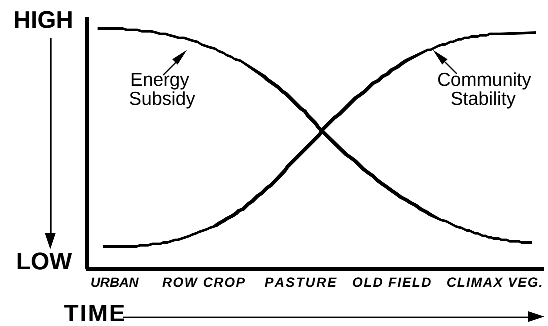


Figure 1-4. Relationship between land use (x axis) and community stability, and the energy subsidy required for the maintenance of ecosystem services. Note that there is a point where the input of external energy fails to produce an "equivalent" of ecosystem services as portrayed by community stability (adapted from Anderson and King 1976).

Many of the "costs" to maintain services in altered ecosystems are either indirect or paid diffusely (through user fees, assessments, and taxes) by the general populace. Without these external expenditures of energy (usually involving the direct or indirect use of fossil fuels) for maintenance of land use activities, ecosystems would begin to revert to their climax state (although it may require decades or even centuries). For example, the suppression of riparian and aquatic vegetation growth to maintain drainage and tillable acreage along a Huron/Erie Lake Plain ecoregion headwater stream is one of several external expenditures (*i.e.*, energy subsidy) needed to keep the ecosystem in its current degraded state. At the same time, this effort also contributes to the increased delivery of sediment and pesticides from upland runoff, increased streambed erosion, downstream flooding, logjams, and increased sedimentation in Lake Erie harbors. While this may result in comparatively minimal maintenance costs to an individual land user, the general population "pays" for the removal of sediment in Lake Erie harbor areas (estimated to be $67 million/year) through increased dredging costs, disposing of contaminated sediments, increased costs of water treatment, and the decline of fisheries, wildlife, and other *self-sustaining* environmental services. As for the latter, added costs are realized in the need to artificially rear and propagate desirable species (often non-native) of fish and wildlife to supplement and even replace populations lost to the impacts of diffuse and cumulative ecosystem degradation. Moreover, the cost to remove excess sediment and pesticides from surface waters used for domestic water supplies is transmitted directly to the user.

Ecosystems that posses or reflect integrity (as envisioned by the biological integrity goal of the Clean Water Act) are characterized by the following attributes (Karr *et al.* 1986):

"... 98% of lotic ecosystems are degraded to a detectable degree (Benke 1990)."

- the inherent potential of the system is realized;
- the system and its components are stable;
- the system retains a capacity for self repair when perturbed or injured; and,
- minimal or no external support for community maintenance is required.

Impaired ecosystems, which lack integrity, have exceeded their capacity to withstand and rapidly recover from perturbations. Some ecosystems are likely to become further degraded under incremental increases in stress. Too many rivers and streams nationwide fail to exhibit the characteristics of healthy ecosystems. Some estimates indicate that as many as 98% of lotic ecosystems are degraded to a detectable degree (Benke 1990). Karr *et al.* (1985) illustrated the extent to which the Illinois and Maumee River basin fish communities have declined during the past half century, two-thirds of the original fauna being lost from the former and more than 40% of the latter. Losses of naiad mollusks and crayfish have been even greater. This information indicates that lotic ecosystems are in trouble nationwide, an indication that existing water resource protection and management have been essentially ineffective in preventing large scale declines of aquatic faunas, particularly those impacted by habitat degradation, excess sedimentation, and nutrient enrichment.

Section 4 of this report quantifies and examines the character and trends in specific threats and sources of aquatic life use impairment in Ohio's rivers and streams.

The Use of Environmental Indicators

The U.S. EPA and other federal and state agencies have recently renewed emphasis on the use of environmental indicators. U.S. EPA has produced a "Vision Statement" that summarizes their commitment to the use of these tools to evaluate their water programs:

> "EPA will use environmental indicators, together with measures of activity accomplishments, to evaluate the success of our programs. Working in partnership with others, we will be able to report status and trends of U.S. and global environmental quality to the public, Congress, states, the regulated community, and the international community. National program managers will use environmental indicators to determine where their programs are achieving the desired environmental results, and where inadequate results indicate strategies need to be changed. *Over time, as more complete data are reported, environmental indicators will become the Agency's primary means of reporting and evaluating success.*" [Italics ours]

"...environmental indicators will become the Agency's [USEPA] primary means of reporting and evaluating success."

There is a large gap, however, between this vision statement and the implementation of indicators within EPA programs and between it and the support for ***adequate*** state monitoring programs that include indicators. Nationally, tracking of the use attainment status of surface water resources has suffered from an insufficient and biased collection of ambient data. Additionally, there has been an over-reliance on chemical-specific data to the exclusion of more integrative, direct measures of water resource integrity. Without the availability of direct and holistic measures of water resource integrity, tracking of the success of pollution abatement has focused on management activities (*e.g.,* permit issuance) instead of environmental results. The failure to use more direct measures of biological integrity has led to a criticism of the effort to monitor the effects of reduced pollutants in surface waters (U.S. GAO 1986). Although the effluent loadings of many chemical parameters have been reduced since the passage of the original Clean Water Act (Smith *et al.* 1987) it has been difficult to relate this to improvements in aquatic life uses other than in specific instances (U.S. GAO 1986). Considering the $50 billion spent and the additional $118 billion projected for municipal WWTP construction up to the year 2000 (U. S. EPA 1982) more effort needs to be devoted toward directly quantifying the environmental results of these activities.

Chemical criteria as surrogates of aquatic life use impairment have traditionally been used *alone* to produce estimates of the extent (*e.g.*, miles) waterbodies are attaining or not attaining their use or to detect trends. They provide, however, little consistent information on the severity of pollution other than degree and frequency of chemical exceedences of water quality criteria. This approach to measuring the severity of an impairment can vary among parameters especially when the complex and variable relationship between timing, frequency, and duration is considered. Reliance on chemical monitoring *alone* may overlook the fact that: 1) pollution is frequently episodic and can be missed by typical chemical monitoring programs, 2) some chemical parameters that cause degradation may not be measured or be easily detected, and 3) degradation to stream resources may also be caused by non-chemical causes such as nutrients (indirect effects), sediment, and habitat destruction, variables that most chemical monitoring programs cannot easily consider. The goals of the Clean Water Act are fundamentally biological in nature. Estimating the integrity of the biota provides a direct measure of the severity and extent of use impairments that can be used to track the progress of pollution control over time, and this relates specifically to the goals of the Clean Water Act.

Which Biological Indicators?

For streams and rivers, biological community indices such as the Index of Biotic Integrity (IBI), Invertebrate Community Index (ICI), and modified Index of well-being (MIwb) can provide a consistent framework for estimating both the extent (*e.g.*, miles) and severity (departure from ecoregion standard) of impairment. Further information on these indices can be found in Karr (1981), Fausch *et al.* (1984) and Ohio EPA (1987a,b; 1989a,b). Ohio EPA has developed some simple methods based on these indices to estimate the extent and severity of aquatic life use impairment in waterbodies using weighting factors that account for different potentials of the biota related to ecoregion and aquatic life use based peculiarities (Area of Degradation Value - ADV; see Ohio EPA 1990a). Multimetric parameters such as the IBI and ICI are *not* diversity indices. They differ by their use of an array of ecologically relevant information based on the principles of community structure and function. As such they provide a more thorough and less variable estimate of integrity than the traditional, single dimension diversity indices. These indices are direct measures of biotic integrity and are the integrated end-product of the major environmental components (*i.e.*, water chemistry, energy dynamics, flow, habitat, and biotic factors as illustrated in Figure 1-4) that determine the integrity of the water resource.

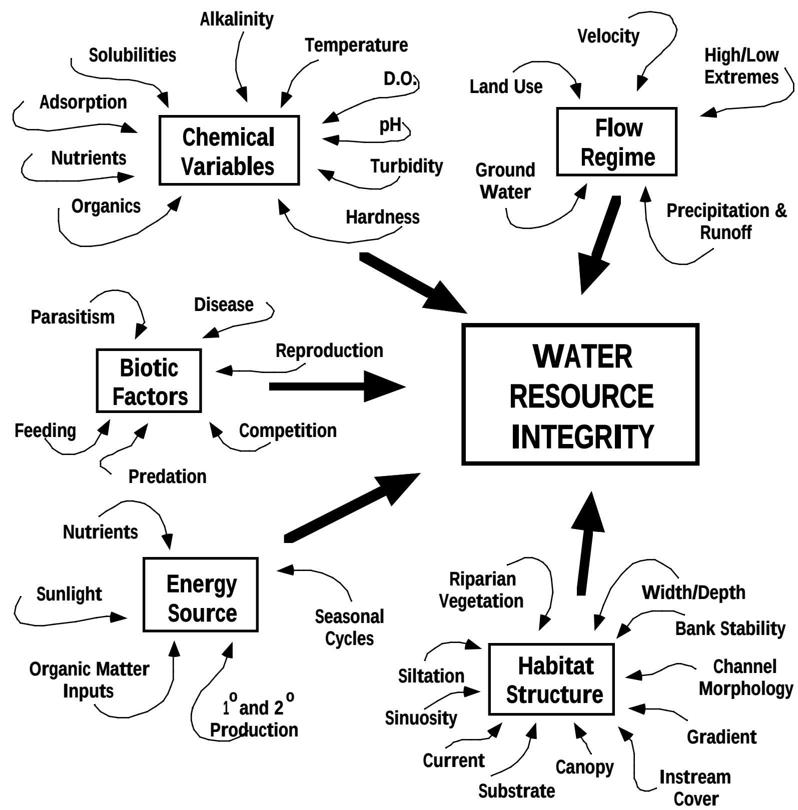


Figure 1-5. The five principal factors, with some of their important chemical, physical, and biological components that influence and determine the integrity of surface water resources (modified from Karr et al. 1986).

These indicators fit well with the theme of an integrated monitoring strategy as a part of the solution to monitoring the progress of water resource management efforts. Not only can we more accurately determine the attainment or non-attainment of aquatic life uses, but we can distinguish increments of impairment as well. Such information will provide an improved understanding of water resource problems which is crucial to the protection and restoration of surface waters.

Methodology For Assessing Use Attainment

This section describes the procedures used by the Ohio EPA to assess the attainment/non-attainment of aquatic life use criteria. The Ohio EPA monitors and assesses surface water resources in Ohio using an "ecosystem" approach. This includes the use of an array of "tools" including water chemistry, physical and habitat assessment, and the direct sampling of the resident biota. In addition, direct threats to human health including fish tissue contamination, bacteriological threats, and drinking water contaminants are also monitored. Aquatic life use attainment status is categorized into the following classes: (1) FULL attainment of use, (2) FULL attainment of use, but attainment is threatened, (3) PARTIAL attainment of use, and (4) **NON**-attainment of use (Ohio EPA 1987b).

"The Ohio EPA monitors and assesses surface water resources in Ohio using an "ecosystem" approach."

Ohio Water Quality Standards (WQS)

Ohio EPA has employed the concept of tiered aquatic life uses in the Ohio Water Quality Standards (WQS) since 1978. Aquatic life uses in Ohio include the Warmwater Habitat (WWH), Exceptional Warmwater Habitat (EWH), Cold Water Habitat (CWH), Seasonal Salmonid Habitat (SSH), Modified Warmwater Habitat (three subcategories: channel-modified, MWH-C; mine affected, MWH-A; and impounded, MWH-I), Limited Resource Water (LRW), and the now defunct Limited Warmwater Habitat (LWH) designations. Each of these use designations is defined in the Ohio WQS (OAC 3745-1). Table 2-1 lists the size of waterbodies for each aquatic life and non-aquatic life use assigned to Ohio surface waters. The lengths (miles) of designated uses by stream and river size category are illustrated in Figure 2-1.

Water quality standards constitute the numerical and narrative criteria that, when achieved, will presumably protect a given designated use. Chemical-specific criteria serve as the "targets" for wasteload allocations conducted under the TMDL (Total Maximum Daily Load) process. This is used to determine water quality-based effluent limits for point source discharges and, theoretically, load allocations for nonpoint source BMPs (Best Management Practices). Whole effluent toxicity limits consist of acute and chronic endpoints (based on laboratory toxicity tests) and are based on a dilution method similar to that used to calculate chemical-specific limits. The biological criteria are used to directly determine aquatic life use attainment status for the EWH, WWH, and MWH use designations as is stated under the definition of each in the Ohio WQS. The aquatic life uses are briefly described as follows:

***EWH* (Exceptional Warmwater Habitat) -** This is the most protective use assigned to warmwater streams in Ohio. Chemical-specific criteria for dissolved oxygen and ammonia are more stringent than for WWH, but are the same for all other parameters. Ohio's biological criteria for EWH applies uniformly statewide and is set at the 75th percentile index values of all reference sites combined. This use is defined in the Ohio WQS (OAC 3745-1-07[B][1][c]).

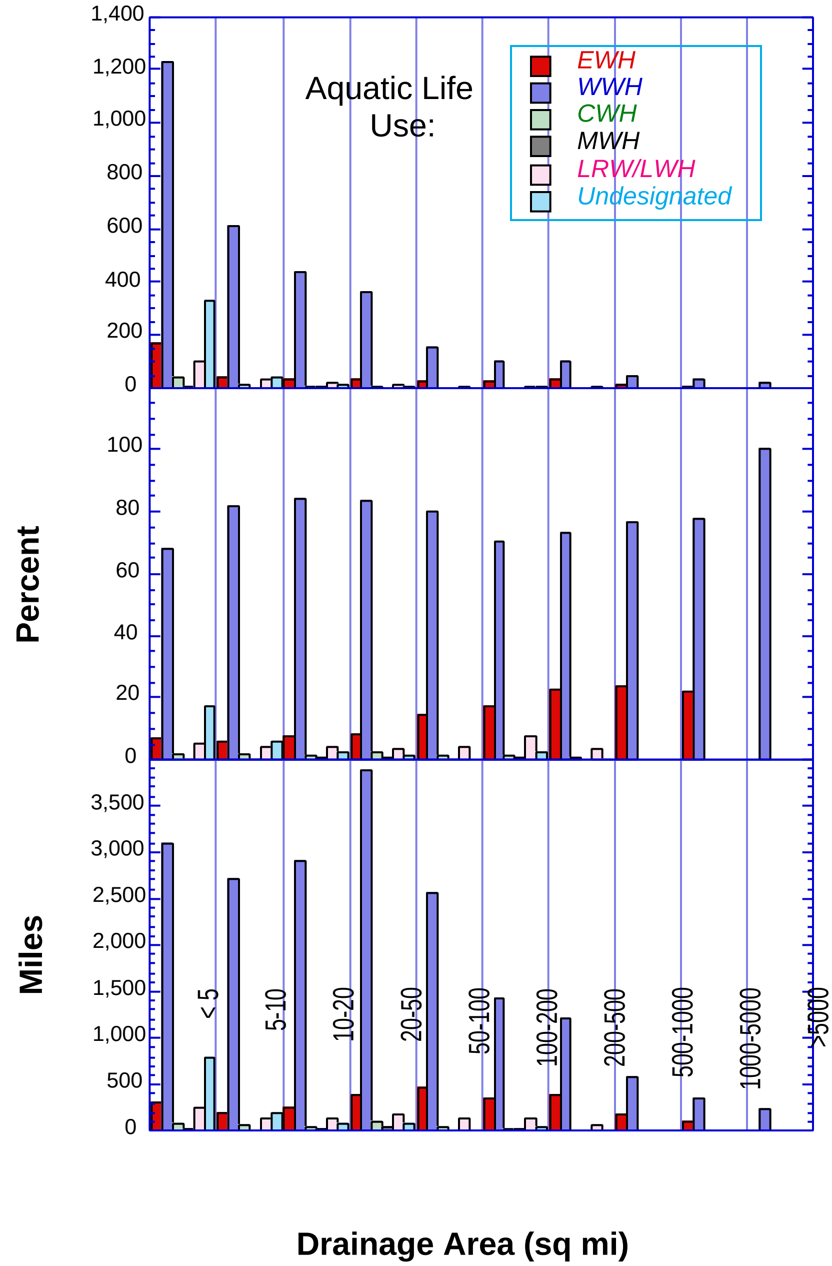


Figure 2-1. Distribution of streams in Ohio EPA's database by aquatic life use and stream size category . Panel A: number of streams; Panel B: % of streams in a drainage size category; Panel C: miles by drainage area category.

WWH (Warmwater Habitat) - WWH is the most widely applied use designation assigned to warmwater streams in Ohio. The biological criteria vary by ecoregion and site type for fish and are set at the 25th percentile index values of the applicable reference sites in each ecoregion. A modified procedure was used in the extensively modified HELP ecoregion. This use is defined in the Ohio WQS (OAC 3745-1-07[B][1][a]).

MWH (Modified Warmwater Habitat) - This use was first adopted in 1990 is assigned to streams that have had *extensive* and irretrievable physical habitat modifications. The MWH use does not meet the Clean Water Act goals and therefore requires a Use Attainability Analysis. There are three subcategories: MWH-A, non-acidic mine runoff affected habitats; MWH-C, channel modified habitats; and MWH-I, extensively impounded habitats. The chemical-specific criteria for dissolved oxygen and ammonia are less stringent (and the HELP criteria are less stringent than other ecoregions) than WWH, but criteria for other parameters are the same. Biological criteria were derived from a separate set of modified reference sites. The biocriteria were set separately for each of three categories of habitat impact. The MWH-C and MWH-I subcategory biocriteria were also derived separately for the HELP ecoregion. The MWH-A applies only within the WAP ecoregion. This use is defined in the Ohio WQS (OAC 3745-1-07[B][1][d]).

LRW (Limited Resource Waters) - This use is restricted to streams that cannot attain even the MWH use due to extremely limited habitat conditions resulting from natural factors or those of anthropogenic origin. Most streams assigned to this use have drainage areas <3 sq. mi. and are either ephemeral, have extremely limited habitat (with no realistic chance for rehabilitation), or have severe and irretrievable acid mine impacts. Chemical-specific criteria are intended to protect against acutely toxic or nuisance conditions. There are no formal biological criteria. This use is defined in the Ohio WQS (OAC 3745-1-07[B][1][g]) and was formerly known as the Nuisance Prevention use designation, which is being phased out of the WQS.

LWH (Limited Warmwater Habitat) - This use was adopted in 1978 to act as a temporary "variance" mechanism for individual segments that had point source discharges that were not capable of meeting the 1977 Clean Water Act mandates. The process of phasing this use designation out of the WQS has been underway since 1985. Chemical-specific criteria were varied for selected parameters, otherwise the criteria for the remaining parameters were the same as for the WWH use. In 1985 all of the LWH segments were placed in a "reserved" status pending a Use Attainability Analysis for each segment. To date 90 of the LWH segments have been revised to either WWH or LRW.

SSH (Seasonal Salmonid Habitat) - This use designation was introduced in 1985 and is assigned to habitats that are capable of supporting the passage of Salmonids between October and May. Another use designation applies during the remaining months. Several tributaries to Lake Erie are so designated. This use is defined in the Ohio WQS (OAC 3745-1-07[B][1][e]).

CWH (Coldwater Habitat) - This use includes streams that are capable of supporting cold water aquatic organisms and/or put-and-take Salmonid fishing. This use is defined in the Ohio WQS (OAC 3745-1-07[B][1][f]).

Besides the previously described aquatic life use designations the State Resource Water (SRW) classification is also assigned on a stream and/or segment specific basis. The attributes necessary to assign the SRW classification are described in the Ohio WQS (OAC 374—1-05, Anti-degradation Policy). SRW classifications have also been revised as a by-product of the biosurvey efforts. Since the initial adoption of tiered uses in 1978, the assessment of the appropriateness of existing aquatic life use designations has continued. As of June 1992 there have been a total of 394 changes to segment and stream specific aquatic life uses in six different WQS rule making changes since 1985. The majority of these changes have included the deletion of the State Resource Waters (SRW) classification (116 segments), redesignation of EWH to WWH (95), the designation of previously unlisted streams (84), and the redesignation of the now defunct Limited Warmwater Habitat (LWH) use designation to either WWH or LRW (90). Most of these segments were originally designated for aquatic life uses in the 1978 Ohio WQS. The techniques used then did not include standardized instream biological data or numerical biological criteria. Therefore, because the basin, mainstem, and sub-basin biosurveys subsequently initiated in 1979 represented a "first use" of standardized biological data to evalu-

"...the basin, mainstem, and sub-basin biosurveys subsequently initiated in 1979 represented a "first use" of standardized biological data to evaluate and establish aquatic life use designations..."

ate and establish aquatic life use designations, many revisions were made. Certain of the 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, it is inappropriate to consider the changes as such because the 1985 through 1992 revisions constituted the first and continuing use of an objective and robust biological evaluation system and database. The 1978-1992 changes are summarized in Figure 2-2 of the 1992 report (Ohio EPA 1992).

Ohio EPA is also under obligation by a 1981 public notice to review and evaluate all aquatic life use designations outside of the WWH use, prior to calculating water quality-based effluent limitations for point sources. Many of the recommended revisions are a fulfillment of that obligation.

Key Point

The Use of USEPA Stream Length Estimates Nationwide Should Improve Consistency of 305(b) Reporting Among States

There are various estimates of the total miles of streams and rivers in Ohio. The Ohio Department of Natural Resources estimates 43,917 total miles of perennial and intermittent (*i.e.,* streams that are either dry during or do not flow part of the year) streams and rivers in Ohio (Ohio DNR 1960). U.S. EPA (1991a) has estimated that Ohio has 61,532 total miles of streams (29,113 perennial; 29,602 intermittent; and 2,818 ditches and canals). This estimate is from a computer-digitized map of U.S. streams and rivers produced by the USGS (1:100,000 scale Digital Line Graph [DLG] method). The U.S. EPA version of this map is known as Reach File 3 (RF3). Ohio EPA has adopted the U.S. EPA estimate of *perennial* stream miles to promote consistency between 305(b) reports produced by all states. The origins of the discrepancies between the various estimates of stream and river mileage mentioned above will be more closely examined in future 305(b) reports. However, the most likely sources of the differences between the Ohio DNR and U.S. EPA estimates are the large number of small, minor tributaries that appear on the DLG maps and differing estimates of segment lengths. Not all of the perennial streams in Ohio have been assigned an aquatic life use designation nor have all of the existing uses been confirmed with ambient biosurvey information using the previously discussed procedures.

Table 2-1. Summary of classified aquatic and non-aquatic life uses for Ohio surface waters in the Ohio WQS (OAC 3745-1).

Use Designation	Classified for Use: Streams/Rivers (Miles)	Lakes (Number)	Lakes (Acres)	Lake Erie (Shore Miles)
Aquatic Life Uses				
Ohio Estimate: Total	43,917.0[1]	50,000	200,000[2]	236
Ohio Estimate: Perennial(Named)	24,348.7	—	—	—
USEPA Est: Total[3]	61,532.0	5,130	188,461	
USEPA Est: Perennial[3]	29,113.0	—	—	—
Ohio Estimate:				
EWH	2,991.7	—	193,903[4]	236
WWH	18,364.7	—	—	—
CWH	378.4	—	—	—
SSH	103.0	—	—	—
MWH	813.1	—	—	—
LWH	636.8	—	—	—
LRW	527.1	—	—	—
No Use	1271.2	—	—	—
Water Supply				
PWS	—	447	118,801	—
Recreation				
PC	22,412.8	50,000[5]	200,000[5]	236
SC	1,044.7	—	—	—
State Resource Waters				
SRW	3,812	447	118,801	—
Antidegradation Waters				
SHQW[6]	—	—	—	—

Abbreviations: **WWH** - Warmwater Habitat; **EWH** - Exceptional Warmwater Habitat; **CWH** - Coldwater Habitat; **SSH** - Seasonal Salmonid Habitat; **MWH** - Modified Warmwater Habitat; **LWH** - Limited Warmwater Habitat; **LRW** - Limited Resource Water; **PWS** - Public Water Supply; **BW** - Bathing Waters; **PC** - Primary Contact; **SC** - Secondary Contact; **SRW** - State Resource Waters; **SHQW** - Superior High Quality Waters.

[1]Estimated from ODNR (1960).
[2]Estimated from ODNR (unpublished)
[3]USEPA (1991a) estimate.
[4]All publicly owned lakes and reservoirs except Piedmont Reservoir.
[5]Lakes and Reservoirs and not specifically given a primary contact recreation use in OAC, but this use is assumed.
[6]Superior High Quality Waters are an additional classification recently proposed for antidegradation purposes.

Approximately 1271 miles of small streams (primarily watersheds less than 5 sq. mi. in area) in the Ohio database have not been designated. The precise difference between the U.S. EPA estimate of perennial stream miles and Ohio EPA's estimate of named or designated streams is due to the inclusion of undesignated streams in RF3 by USEPA and discrepancies in total lengths of individual streams between the two estimates. Use designations will continue to be reviewed and updated for named streams and assigned to unnamed streams as each is encountered within the schedule and resources assigned to the 5 Year Basin Approach.

The assessment of aquatic life use support and the assignment of causes and sources of impairment generally followed the guidelines set forth in *Guidelines for the Preparation of the 1994 State Water Quality Assessment (305(b)Report* (U. S. EPA 1993).

Table 2-2. U.S. EPA and Ohio DNR estimates of lake acreage by lake size.

Size	Number	Acres
	U.S. EPA Estimate (Total Lakes)	
<10 acres	3,788	17,415
10-500 acres	1,295	46,323
> 500 acres	47	124,723
Total	**5130**	**188,461**
	Ohio DNR Estimate (Publicly Owned)	
<10 acres	108	717
10-500 acres	293	22,321
> 500 acres	46	95,763
Total	**447**	**118,801**

"The identification of the impairment status of streams and rivers is straightforward - the Ohio biological criteria are the principal arbiter of aquatic life use attainment/non-attainment."

How Stream Segments Were Assessed: "Multiple Lines of Evidence"

A factor essential to an understanding the results of this report, and for comparing these results to other states' reports, is the methodology used for the assessment of "use attainment" and ascribing causes and sources of impairment. Ohio's intensive survey program is not "experimental" in nature although its foundation is based on an extensive and rigorous body of such work in the ecological literature. The identification of the impairment status of streams and rivers is straightforward - the Ohio biological criteria are the principal arbiters of aquatic life use attainment / non-attainment. The rationale for using biological criteria as the principal arbiter within a "weight of evidence" approach to aquatic life use assessment has been extensively discussed elsewhere (Karr *et al.* 1986; Ohio EPA 1987a,b; Yoder 1989; Miner and Borton 1991; Yoder 1991a). Ascribing the causes and sources *associated* with the observed impairment relies on an interpretation of multiple lines of evidence from water chemistry data, sediment data, habitat data, effluent data, biomonitoring results, land use data, and response signatures within the biological data itself. Thus cause and source associations are not based on a true "cause and effect" analysis, but rather are based on associations with stressor and exposure indicators whose links with the biosurvey data are based on previous research or experience with analogous impacts. The reliability of the identification of probable causes and sources increases where many such prior associations have been identified. The process is akin to making a medical diagnosis in which a doctor relies on multiple lines of evidence concerning a patient's health. Diagnoses are based on previous research that experimentally or statistically linked symptoms and test results to specific diseases or pathologies. Clearly, the doctor does not "experiment" on a patient, but relies on previous experience in interpreting the multiple lines of evidence (test results) to generate a diagnosis, potential causes or sources of the malady, a prognosis, and a strategy for alleviating the symptoms of the disease or condition. The ultimate arbiter of success is the eventual recovery and the well-being of the patient. While there have been criticisms of misapplying the metaphor of ecosystem "health" compared to human patient "health" (Suter 1993; e.g., concept of ecosystem as a super-organism) here we are referring to the process for identifying biological integrity and cause/source associations not whether human health and ecosystem health are analogous concepts.

"Direct measures of overall health that integrate all of the factors that could effect ecological integrity are essential for an accurate picture of an ecosystem's condition."

Water chemistry samples are analogous to various diagnostic tests (e.g., a blood sample) that may clearly identify a health problem, but that cannot provide a positive indication of the well-being of a patient. A serious water quality standard violation for a toxic parameter, for example, is likely to be a good indicator of impairment; however, the lack of a violation in no way confirms the presence of biological integrity. Direct measures of health that integrate all of the factors that could affect ecological integrity are essential for an accurate picture of an ecosystem's condition. The inclusion of biosurvey data, based on biocriteria, into a broad, integrated intensive survey program, is the best way to achieve when the goal is protecting and restoring aquatic life. Our work has shown that the inclusion of biosurvey data in ambient monitoring efforts can boost the detection of aquatic life use impairment by approximately 35-50% over that obtained with a simplified water column chemistry approach alone (*i.e.*, measuring exceedences of a suite of routinely monitored chemical parameters; Ohio EPA 1990a). The use attainment/non-attainment criteria for the biological indices are summarized by organism group, biological index, site type (fish), use designation, and ecoregion in Table 2-3 and on Map 2-1. The chemical-specific criteria in the Ohio WQS were used to assess chemically-based use attainment/non-attainment and generally follows U.S. EPA guidelines for assessing aquatic life support (U.S. EPA 1991b) with chemical data alone (Table 2-4).

Table 2-3. Decision criteria for determining use attainment based on biological data.

Non-Attainment
A.] Neither ICI, IBI, nor MIwb meets criteria for ecoregion
OR
B.] One organism group indicates a severe toxic impact (poor or very poor category) even if the other indicates attainment.
Partial Attainment
A.] One of two or two of three indices do not meet ecoregion criteria (and are not in the poor or very poor category)
Full Attainment
A.] All indices meet ecoregion criteria

"...the inclusion of biosurvey data in ambient monitoring efforts can boost the detection of aquatic life use impairment by approximately 35-50% over that obtained with a simplified water column chemistry approach alone..."

Segments with only water chemistry data that were assessed under previous U.S. EPA 305(b) report guidelines were *not* reassessed for this report. For water quality parameters without aquatic life criteria in the Ohio WQS (mostly nutrients, conventional substances, and naturally occurring metals), ambient results were compared to values from a set of "least impacted" regional reference sites. These "background" expectations were based on work in progress by Dennis Mishne, Ohio EPA, who is examining the ranges of variability of water chemistry and sediment data collected at "least impacted" reference sites by ecoregion (the same group of sites used to develop the biological expectations). This comparison was especially useful for watersheds impacted by nonpoint sources such as coal mining activities. The degree of deviation from reference site data provided an alternate screen for parameters generally associated with coal mining, but without aquatic life use criteria (*e.g.*, manganese, aluminum). Of the characteristic coal mining influenced parameters only pH was used to assess aquatic life use impairment (in the absence of biological data) because it is the only parameter with a WQS criteria value. The

Huron-Erie Lake Plain (HELP)

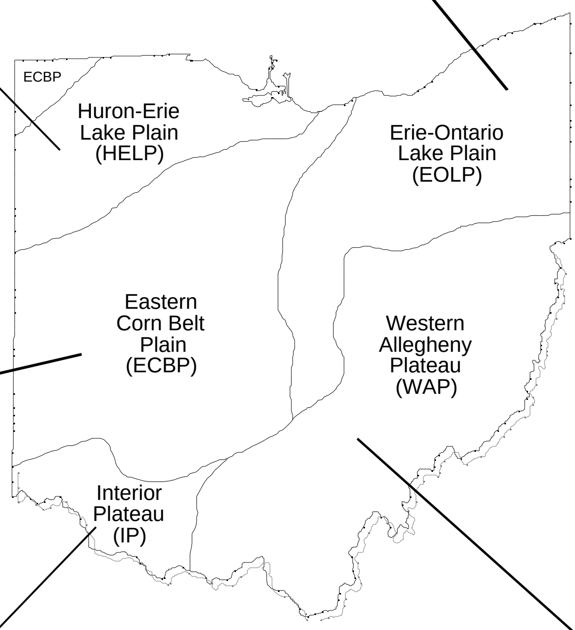
USE	SIZE	IBI	MIwb	ICI
WWH	H	28	NA	34
	W	32	7.3	34
	B	34	8.6	34
MWH-C	H	20	NA	22
	W	22	5.6	22
	B	20	5.7	22
MWH-I	B	30	5.7	NA

Erie Ontario Lake Plain (EOLP)

USE	SIZE	IBI	MIwb	ICI
WWH	H	40	NA	34
	W	38	7.9	34
	B	40	8.7	34
MWH-C	H	24	NA	22
	W	24	6.2	22
	B	24	5.8	22
MWH-I	B	30	6.6	NA

Eastern Corn Belt Plains (ECBP)

USE	SIZE	IBI	MIwb	ICI
WWH	H	40	NA	36
	W	40	8.3	36
	B	42	8.5	36
MWH-C	H	24	NA	22
	W	24	6.2	22
	B	24	5.8	22
MWH-I	B	30	6.6	NA



Interior Plateau (IP)

USE	SIZE	IBI	MIwb	ICI
WWH	H	40	NA	30
	W	40	8.1	30
	B	38	8.7	30
MWH-C	H	24	NA	22
	W	24	6.2	22
	B	24	5.8	22
MWH-I	B	30	6.6	NA

Western Allegheny Plateau (WAP)

USE	SIZE	IBI	MIwb	ICI
WWH	H	44	NA	36
	W	44	8.4	36
	B	40	8.6	36
MWH-C	H	24	NA	22
	W	24	6.2	22
	B	24	5.8	22
MWH-A	H	24	NA	30
	W	24	5.5	30
	B	24	5.5	30
MWH-I	B	30	6.6	NA

Statewide: Exceptional Criteria

USE	SIZE	IBI	MIwb	ICI
EWH	H	50	NA	46
	W	50	9.4	46
	B	48	9.6	46

Map 2-1. Ohio's Biocriteria. See text for descriptions of aquatic life uses.

other parameters were used to confirm mining impacts where pH was low and to screen waterbodies for further study. For streams without pH data or without a direct pH impairment, exceedences of the "background" concentrations for two or more of the other parameters were used to indicate moderate or major impacts.

Table 2-4. Categories of deviation from relatively unimpacted reference sites for parameters without aquatic life use water quality criteria.

No Effects
(*Within Range of Reference Sites*)

1. Mean and 90th % tile < Median of reference sites
2. Mean and 90th % tile < 75th %tile of reference sites AND Mean > Median of reference sites and 90th %tile < Median OR 90th % tile > Median of reference sites and Mean < Median.
3. Mean and 90th % tile < 75th %tile of reference sites AND Mean and 90th % tile > Median of reference sites.
4. Mean and 90th % tile < 2* UQ[1] + Median of reference sites AND Mean > 75th %tile of reference sites and 90th %tile < 2* UQ + Median OR 90th % tile > 75th %tile of reference sites and Mean < 2* UQ + Median.

Minor effects
(*Upper Range to Slightly Above Range of Reference Sites*)

1. Mean and 90th % tile > 75th %tile of reference sites AND Mean and 90th % tile < 2* UQ + Median of reference sites.
2. Mean and 90th % tile < 5* UQ + Median of reference sites AND Mean > 2* UQ + Median of reference sites and 90th %tile < 2* UQ + Median OR 90th % tile > 2* UQ + Median of reference sites and Mean < 2* UQ + Median.

Moderate effects
(*Values Significantly Above Range of Reference Sites*)

1. Mean and 90th % tile > 2* UQ + Median of reference sites AND Mean and 90th % tile < 5* UQ + Median of reference sites.
2. Mean and 90th % tile < 10* UQ + Median of reference sites AND Mean > 5* UQ + Median of reference sites and 90th %tile < 5* UQ + Median OR 90th % tile > 5* UQ + Median of reference sites and Mean < 5* UQ + Median.

Severe effects

1. Mean and 90th % tile > 5* UQ + Median of reference sites AND Mean and 90th % tile < 10* UQ + Median of reference sites.
2. Mean and 90th % tile > 10* UQ + Median of reference sites.

[1]UQ-Upper Quartile (75th percentile)

Table 2-5. Concentrations of ambient chemical parameters used to indicate increasing severity of mine affected waters compared to relatively unimpacted reference sites.

Parameter	Median	75th %tile	75th%tile +Median [UQ]	2*UQ + Med.	5*UQ + Med.	10*UQ + Med.
Field Conduct.	445.0	692.0	247.0	939.0	1680.0	2915.0
Lab Conduct.	481.0	739.0	258.0	997.0	1771.0	3061.0
pH[1]						
Chloride	24.6	43.7	19.1	62.8	120.1	215.6
Sulfate	129.0	242.7	113.7	356.4	697.5	1266.0
Iron	885.0	1495.0	610.0	2105.0	3935.0	6985.0
Manganese	135	300.5	165.5	466.0	962.5	1790.0
TDS	443.0	509.0	66.0	575.0	773.0	1103.0

[1]pH categories based on Ohio WQS and Ohio EPA (1980): No effects: 6.5-9.0; minor effects: 5.5-6.4; moderate effects: 4.5-5.4; severe effects < 4.5.

Table 2-6. Concentrations of fish tissue contaminants considered: (1) not elevated, (2) slightly elevated, (3) moderately elevated, (4) highly elevated, or (5) extremely elevated.

PCBs:

0-50 µg/kg **- not elevated**

51-300 µg/kg **- slightly elevated**

301-1000 µg/kg **- moderately elevated**

1001-1900 µg/kg **- highly elevated**

> 1900 µg/kg **- extremely elevated**

Other Parameters:

> FDA action level - **highly – extremely elevated**

Table 2-7. Classification of the types of monitoring data used to make aquatic life use assessments for the 1992 305(b) report arranged in decreasing order of confidence with regard to data rigor and accuracy.

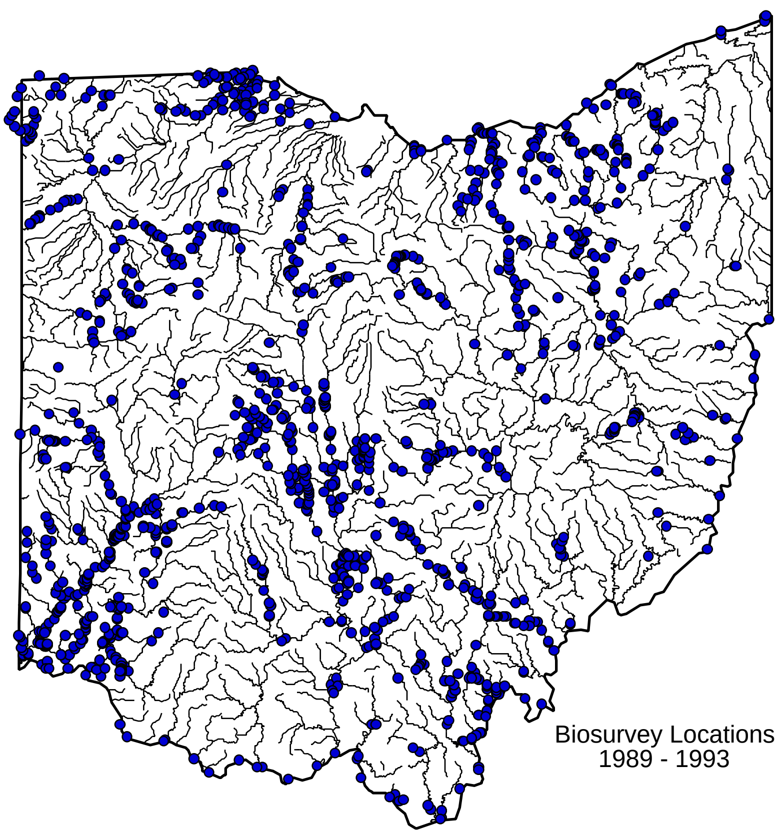
Description	Assessment Level[1]	Evaluated	Monitored
Most Confidence/Highest Accuracy			
Intensive survey with biological & water chemistry data, both fish and macroinvertebrates sampled[2]	700	—	MB
Intensive survey with biological & water chemistry data, only one biotic group (fish or macroinvertebrates) sampled	700	—	MB
Intensive survey with biological data only, fish or macro-invertebrates sampled	300	—	MB
Intensive survey with water chemistry data only.	200	—	MC
Intensive survey with water chemistry data only (pre-1988)	200	EC	—
Biological Fixed Stations and intensive biosurveys from before 1986.	300	EB	—
Chemical Fixed Stations (NAWQMN, NASQAN, IJC, etc.) Volunteer Monitoring (with good QA / QC procedures)	200	EC	—
Least Confidence[4]/Lower Accuracy			
Volunteer Monitoring (without QA / QC procedures)	100	ES	—
Survey / Source Data (Complaints, "opinion" surveys, etc.)[3]	100	ES	—

[1] More specific codes are provided in Appendix A.
[2] For headwater streams (< 20 square miles) streams are assigned a level 700 code where water chemistry and only the fish community were sampled.
[3] Aquatic life use attainment decisions are not made with source level data or data types not listed here. Source level data is used to flag areas for further study or to identify areas that are likely to be *impacted* (see Ohio Nonpoint Source Assessment).
[4] This data used to flag sites as possibly impacts but not used to determine aquatic life use impairment.

"The most rigorous data is from an "intensive" survey that includes water chemistry (effluent, water column, sediment), bioassay, physical habitat, and both fish and macro-invertebrate data."

The categories assigned to the monitoring data used in this assessment generally follow U.S. EPA guidelines with some exceptions as outlined in Table 2-7. The classification of data collection methods reflects the rigor of the data used and the resultant accuracy of the aquatic life use assessment. The most rigorous data is from an "intensive" survey that includes water chemistry (effluent, water column, sediment), bioassay, physical habitat, and *both* fish *and* macro-invertebrate data. For waterbodies where only water chemistry data was available, the identification

Map 2-2. Location of Ohio EPA biosurvey sampling stations during the period 1974 - 1988 (top panel) and 1989-1993 (bottom panel).



of chemical criteria exceedences (PARTIAL or **NON**-attainment), rather than the absence of such exceedences (FULL attainment), was the more reliable and environmentally accurate approach.

"...the confidence in the aquatic life use assessments was further increased when data from both fish and macroinvertebrates was available..."

The comparatively "narrow" focus of water chemistry data provides less confidence about aquatic life use attainment status than the broader-based biological community measures. Similarly, the confidence in the aquatic life use assessments was further increased when data from both fish and macroinvertebrates was available (particularly in complex situations) than when data from only one organism group was available (see Table 2-7). Toxicity testing (acute and / or chronic bioassays) results alone were not used to assess use attainment status nor were volunteer monitoring data, the results of "opinion" surveys, or unsubstantiated or anecdotal information. Such information, however, is quite useful for indicating areas of potential impairment or for suggesting when conditions may be changing.

"In addition to the Ohio Water Resource Inventory, Ohio EPA produces the Ohio Nonpoint Source Assessment (NPSA; Ohio EPA 1990b)..."

The assessments in this report relied primarily on monitored level data. The location of biosurvey sites across Ohio are illustrated in Map 2-2. The top panel illustrates sites sampled up to and including 1988 and the bottom panel sites sampled from 1989 through 1993. Although the intended focus of the Ohio Water Resource Inventory is broad (*i.e.*, the same data serves multiple purposes), the impetus for the development of much of the database was driven by point source issues (*i.e.*, NPDES permits, construction grants, etc.) and toward larger streams and rivers. For smaller streams there are proportionately less monitored level data to assess impacts such as nonpoint pollution. However, each subbasin or mainstem level survey was designed to assess all relevant sources of impact to water quality, habitat, and the biota. Also, the "extrapolability" of the results in the smaller watersheds is greater than for the larger rivers and streams. This has been especially enhanced by employing the ecoregion concept (Omernik 1987). Besides the Ohio Water Resource Inventory, Ohio EPA produces the Ohio Nonpoint Source Assessment (NPSA; Ohio EPA 1990b) which is coordinated by the Nonpoint Source Management Section within the Division of Surface Water. The Ohio NPSA summarizes the extent and types of nonpoint source pollution in Ohio's surface water and groundwater resources using all levels of available information. Because of this some estimates of the proportion of impaired waters by major source are different between the Ohio NPSA and the 305(b) report. The Ohio NPSA relies heavily on an extensive survey of over 200 local, county, state, and federal agencies in Ohio. Thus the information gained from these questionnaires is considered as "source" level data which is insufficient to assess aquatic life use impairment, but is useful for identifying potential areas of nonpoint source impacts. The Ohio NPSA also incorporates all of the monitored level data reported in the 1990 305(b) report. The results are further used to develop and implement the Ohio Nonpoint Source Management Program (NPSMP; Ohio DNR 1989) which is coordinated by the Ohio Department of Natural Resources, Division of Soil and Water Conservation.

"The Ohio NPSA relies heavily on an extensive survey of over 200 local, county, state, and federal agencies in Ohio."

The Ohio NPSA data is included in the Waterbody System (WBS). For areas of the state covered by intensive biological surveys, the effects of nonpoint sources have been assessed and are reflected in the WBS segment summaries and the discussion of causes and sources of impairment found in this volume. In the cases where survey level information was available without monitored level information a 'P' (Potential) magnitude code was indicated in the WBS. This level of nonpoint source assessment is limited to use as screen for a potential *impact* to a waterbody. The presence of sources *alone* is insufficient evidence for a direct impairment and can be verified with monitored-level data only. The source level assessments for each WBS segment appear in Appendix B of the 1992 report, and in more detail in the Ohio NPSA (Ohio EPA 1990b).

Highlights from nonpoint source education / demonstration projects funded by Section 319 grants between 1981 and 1987 are summarized in Ohio EPA (1991). Many of the original state and local contract agencies have applied for Section 319 implementation grants. It is a goal of Ohio EPA to be able to measure the actual environmental effectiveness of these activities by describing the results of monitored level evaluations in future 305(b) reports.

Biological Data Collected by Other State Agencies

The National Academy of Sciences, in a report on the state of surface water monitoring in the U.S (National Academy of Sciences 1977), listed three important deficiencies in monitoring programs. One of these was a lack of coordination between different agencies, boards, and institutions involved in surface water monitoring and water quality management. Differing reasons for monitoring are partly responsible for the lack of ease in sharing and using other agencies' data. However, other reasons include barriers such as incompatible data base management techniques and a lack of standardization of field methods. An informal working group that includes members from the Ohio EPA, Ohio DNR, Ohio Department of Transportation, and the Ohio State University Museum of Zoology has attempted to resolve some of these issues. The result has been an improved ability to share biological data, though the objectives for the original data collection may be different from the objectives of those who may later access the same data. For example the intensive monitoring effort by the ODNR-Division of Natural Areas and Preserves in the southern portion of the Scioto River and Southeast Ohio River tributaries basins was to assess the status and distribution of the rosyside dace (*Clinostomus funduloides*) in Ohio. Other geographically concentrated survey efforts are the result of surveys designed to assess the distribution and abundance of other endangered and threatened fish species. In contrast, data collected by the Ohio Department of Transportation is scattered throughout the state because of the primary objective to assess the environmental condition at bridge construction and replacement projects throughout Ohio. Fortunately, the active effort to share biological data between Ohio agencies and institutions has resulted in our ability to include it in this report.

"...the active effort to share biological data between Ohio agencies and institutions has resulted in our ability to include it in this report."

Biological data from other agencies used in this report includes fish community data collected by the Ohio DNR - Division of Natural Areas and Preserves, Ohio DNR - Division of Wildlife, the Ohio Department of Transportation (ODOT), and the Ohio State University Museum of Zoology (OSUMZ).

The use of other agencies and institutions environmental data has long been viewed as an untapped panacea to the problems of a lack of monitoring resources at the state and federal level. While this inherently seems attractive from a cost and efficiency standpoint, there are some important limitations. Each agency usually has different objectives for the monitoring efforts in which data is collected. While the aforementioned agencies have attempted to standardize and emulate the manner in which each collects fish community data, this does not eliminate differences in effort, variables reported, etc. A "phased" approach toward incorporating non-Ohio EPA data in the WBS database as either monitored or evaluated level information will be used.

Fortunately, much of the available fish community data is of acceptable quality and the collection methodologies each agency uses are not only documented and well known, but are essentially similar in most respects. However, a key "missing" dimension is the experience of having been at the sampling location to observe conditions first hand. This is a crucial element in the interpretation of the results, particularly the assignment of causes and sources of impairment.

The error tendencies of field biological information need to be understood to accurately incorporate "outside" data into assessments. Water chemistry data (especially grab sampling) is likely to be biased toward "missing" a problem that exists, but is not reflected in the results (Rankin and Yoder 1990). Thus, when relying on water chemistry data collected by other agencies (and Ohio EPA), it is used primarily to infer the presence of a problem, *not* the absence of a problem. In contrast, the error tendency of biological field data is more likely to result in the indication of an impairment when it does not exist. This is most frequently due to inadequate or differential sampling that results in the failure to secure an adequate or representative sample. In the case with other agencies biological data (as a first phase for 1992 305[b] report) it was used primarily to indicate *attainment* of the applicable aquatic life use.

"...when relying on water chemistry data collected by other agencies (and Ohio EPA), it is used primarily to infer the presence of a problem, not the absence of a problem."

Table 2-8. Hierarchy of ambient bioassessment approaches that use information about indigenous aquatic biological communities (NOTE: this applies to aquatic life use attainment only - it does not apply to bioaccumulation concerns, wildlife uses, human health, or recreation uses).

BIOASSESSMENT TYPE	SKILL REQUIRED[1]	ORGANISM GROUPS[2]	TECHNICAL COMPONENTS[3]	ECOLOGICAL COMPLEXITY[4]	ENVIRON MENTAL ACCURACY[5]	DISCRIM INATORY "POWER"[6]	POLICY RESTRIC TIONS[7]
1."Stream Walk" (Visual Obser-vations)	Non-biologist	None	Handbook[8]	Simple	Low	Low	Many
2.Volunteer Monitoring	Non-biologist to Technician	Inverte-brates	Handbook[9], Simple equipment	Low	Low to Moderate	Low	
3.Professional Opinion (EPA RBP Protocol V)	Biologist w/ experience	None or Fish/Inverts.	Historical records	Low to Moderate	Low to Moderate	Low	
4. EPA RBP Protocola I & II	Biologist w/ training	Inverte-brates	Tech. Manual,[10] Simple equip.	Low to Moderate	Low to Moderate	Low to Moderate	
5. Narrative Evaluations	Aquatic Biolo-gist w/training & experience	Fish &/or Inverts.	Std. Methods, Detailed taxonomy Specialized equip.	Moderate	Moderate	Moderate	
6.Single Dimen-sion Indices	(same)	(same)	(same)	Moderate	Moderate	Moderate	
7. EPA RBP Protocols III & V	(same)	(same)	Tech. Manual,[10] Detailed taxonomy, Specialized equip.	High	Moderate to High	Moderate to High	
8. Regional Reference Site Approach	(same)	(same)	Same plus baseline calibra ion of multi-metric evaluation mechanisms	High	High	High	Few

1 Level of training and experience needed to accurately implement and use the bioassessment type.
2 Organism groups that are directly used and/or sampled.
3 Handbooks, technical manuals, taxonomic keys, and data requirements for each bioassessment type.
4 Refers to ecological dimensions inherent in the basic data that is routinely generated by the bioassessment type.
5 Refers to the ability of the ecological end-points or indicators to differentiate conditions along a gradient of environmental conditions.
6 The relative power of the data and information derived to discriminate between different and increasingly subtle impacts.
7 Refers to the relationship of biosurveys to chemical-specific, toxicological (i.e., bioassays), physical, and other assessments and criteriathat serve as surrogate indicators of aquatic life use attainment/non-attainment.
8 Water Quality Indicators Guide: Surface Waters (U.S. Dept. Agric. 1990)
9 Ohio Scenic River Stream Quality Monitoring (Kopec and Lewis 1983).
10 U.S. EPA Rapid Bioassment Protocol (Plafkin et al. 1989).

IBI values were calculated, but were considered as *minimum* values for use attainment purposes. Data dimensions such as the presence or absence of intolerant and/or tolerant taxa, high species richness, and the relative distribution of individuals among various functional guilds were also examined since these are generally correlated with higher IBI scores that are commensurate with at least WWH use attainment. Other than through gross species misidentifications (unlikely to be a significant problem given the skilled professional staff at the above mentioned agencies) the data are considered accurate and reliable for this level of assessment. Indications of **NON**-attainment reflected in the results will be more thoroughly investigated in future 305(b) reports via consultations with the other agencies. This will further aid in the identification of causes and sources of the *suspected* **NON**-attainment. It is also an Ohio EPA goal to access historical fish community information (*i.e.*, pre-1975-80 data) to examine long-term changes in distribution and abundance, and to include other organism groups such as naiad mollusks, amphibians, and possibly birds to broaden the overall environmental assessment.

"It is... an Ohio EPA goal to access historical fish community information... for the purpose of examining long-term changes ..., and to include other organism groups such as naiad mollusks, amphibians, and possibly birds to broaden the overall environmental assessment.

Other Evaluation Approaches

There are several methods and procedures for the evaluation of water resources and biological integrity other than those used by Ohio EPA. These range from simple, visual assessments to more complex and comprehensive bioassessments. The U.S. Department of Agriculture, Soil Conservation Service has developed a guide for the assessment of water quality using a stream walk technique (USDA 1990). Minimum skill and ecological expertise is needed to use this method, hence its attractiveness. Other methods such as "volunteer" monitoring using stream macro-invertebrates (*e.g.*, Izaak Walton League "Save Our Streams", Ohio DNR SQM, etc.) are also usable by non-experts with a minimum of training and orientation. U.S. EPA's Rapid Bioassessment Protocols (RBP; Plafkin *et al.* 1989) specify five approaches of increasing complexity and ecological rigor. As with any environmental assessment technique, the more "dimensions" (*i.e.*, specific chemical, physical, and biological attributes) of the ecosystem measured the more comprehensive the resultant evaluation and hence the greater its accuracy. Accuracy is defined here as the ability and precision of an assessment to portray and evaluate

"Accuracy is defined...as the ability and precision of an assessment to portray and evaluate the true ecosystem condition."

the true ecosystem condition. The cost of obtaining information increases with its inherent complexity and accuracy, although the cost *per return on investment* declines. Regulatory decisions that can have multi-million dollar consequences are a strong argument for good monitoring information as the basis for decision making.

We have established a hierarchy of bioassessment types to demonstrate the relative capabilities of each of eight different approaches (Table 2-8). The purpose of this comparison is to illustrate that there are important and sometimes unrealized differences between different levels of bioassess-ment, not only in the cost and relative skill requirements, but also in the quantity, quality, and power of the information provided by each. The latter factors are often given less weight than the cost and skill components and we believe they are equally, if not more important considerations. In addition, there is an unfortunate tendency to equate the information derived from all biosurvey approaches and to "over sell" the capabilities of the simpler techniques.

"...the power and ability of a bioassessment technique ...are directly related to the data dimensions produced by each."

Our analyses reveal that the power and ability of a bioassessment technique to accurately portray biological community performance and ecological integrity, and discriminate ever finer levels of aquatic life use impairments are directly related to the data dimensions produced by each. For example, a technique that includes the identification of macroinvertebrate taxa to genus and species will produce more data dimensions than a technique limited to family level taxonomy. Similarly, the accuracy of an approach that employs two organism groups is likely more capable of accurately detecting a broad range of impairments than reliance on a single group. Approaches that rely on multi-metric evaluation mechanisms will yield greater information than a reliance on single dimension indices, and so on. Of the different bioassessment types included in Table 2-8, we have extensively tested volunteer monitoring (see next subsection), narrative evaluations, single-dimension indices, and the regional reference site approaches (Ohio EPA 1990c; Yoder 1991a). The remaining categories were inserted into the hierarchy based on ours and others use and knowledge of each.

The level of bioassessment *should* play an important role in the consideration and establishment of policy on the use of biosurvey information relative to its integrated use with chemical-specific and toxicity information (Yoder 1991a; Table 2-8). Certain simple types of biomonitoring approaches are inappropriate for classifying complex environmental problems; similarly a reliance on water chemistry data (exposure indicators) to the exclusion of biosurvey data may also be inappropriate. In regards to monitoring applications, water chemistry, bioassay, and biosurvey data have each been portrayed as an equal leg of a three-legged stool. However, this analogy is inadequate (Karr 1989) and obviously there will be situations in which one or two of the tools will yield more information than the others. The site-specific application of biosurvey information must be done with flexibility and in accordance with the aforementioned constraints. Simply continuing to rigidly equate each tool independently not only has some serious technical flaws, but may serve as a serious disincentive to states in constructing a more rigorous biosurvey approach. In contrast, an important incentive for states to construct a more rigorous and comprehensive biosurvey approach can be provided by permitting biocriteria policy flexibility. The advantage to a state is in increased programmatic flexibility while the return to U.S. EPA is an ecologically more rigorous, more accurate monitoring capability that will produce more comprehensive and reliable monitoring efforts nationwide. Concerns about potential abuses of biosurveys are minimized given the inherent error tendencies of biosurvey information (*i.e.*, "favorable" results cannot be produced by poor or under representative sampling). The improved ability to detect and characterize environmental problems with the more comprehensive approaches will lead to improved protection of our declining lotic resources. Given the present difficulties with the inequities between state monitoring and assessment capabilities this issue should be given serious consideration. Despite the disincentives mentioned above at least thirty states are currently using or developing biosurvey programs (USEPA Reg V, in preparation) because of the useful information they provide.

"The level of bioassessment should play an important role in the consideration and establishment of policy on the use of biosurvey information relative to its integrated use with chemical-specific and toxicity information..."

"...an important incentive for states to construct a more rigorous and comprehensive biosurvey approach can be provided by permitting biocriteria policy flexibility."

Volunteer Monitoring

"...environmental agencies need to be aware of the limitations of this approach, both technically and logistically, prior to depending on this as a major source of monitoring information."

U.S. EPA has recently been encouraging the use of ambient data collected by "volunteers" (U.S. EPA 1990a). For lotic systems this includes the qualitative sampling of macroinvertebrates and using a picture key to identify organisms and rate the sample on a scale from poor to excellent. For lakes it usually includes taking turbidity measurements using Secchi disks and observational information. The obvious and attractive advantages of this data are that it can generate substantial interest among the public about surface water resources and the attributes of these waters that are being protected by state agencies. It can also provide information at little or no cost to the government. However, environmental agencies need to be aware of the limitations of this approach, both technically and logistically, prior to depending on this as a major source of monitoring information. Data collected by volunteers can be useful to state agencies in waterbodies of special interest (*e.g.*, State Scenic Rivers) or in waterbodies where the state is unlikely to conduct monitoring.

In Ohio there are two major Volunteer programs of note. One is the "Stream Quality Monitoring" program coordinated by the Scenic Rivers section of the Ohio DNR, Division of Natural Area and Preserves. The other is the "Citizen Lake Improvement Program" (CLIP). The various groups and government agencies participating in volunteer monitoring efforts in Ohio are listed in Table 2-8. Although volunteer stream monitoring programs can provide useful ancillary information on the status of certain surface waters and information on emerging problems they *are not replacements* for more comprehensive state monitoring efforts. The Ohio EPA, for example, has a Five-year Basin Approach for systematically assessing stream and river basins in Ohio through standardized, integrated, and rigorous ambient monitoring including biosurvey data.

The Ohio DNR, Scenic Rivers volunteer monitoring program conducts annual stream quality assessments that are summarized in an annual report. The data are transferred by diskette to Ohio ECOS, Ohio EPA's biological information database.

Although U.S. EPA encourages the consideration of volunteer data in state monitoring networks and 305(b) reports, the information gained should be limited to the screening of potential problems. This is especially true of the stream macroinvertebrate collection efforts because the methods include skill dependent biological sampling, microhabitat selection and / or availability, and the identification of biological samples. The use of volunteer data is likely to be less restrictive if the efforts are limited to the collection of grab water samples or other comparatively simple measurements such as Secchi depth. The Ohio CLIP lakes effort is an example of such a program.

There is little information on the reliability and accuracy of volunteer collected biological data over a broad range of environmental conditions (*i.e.*, exceptional to very poor conditions). One recent effort in Ohio (Dilley 1991), compared the results from a volunteer biological sampling methodology (Ohio DNR, Scenic Rivers SQM) with Ohio EPA's biological community data collected at the same sites. This analysis represents a "best case" scenario because the SQM monitoring was performed by a single, trained and skilled investigator (*i.e.*, between sampler variability and individual operator errors were eliminated). The results showed a fairly good correspondence between the SQM results using CIV (Community Index Value) scores and the Ohio IBI and ICI at the extremes of the environmental spectrum. The correspondence was generally good (better for the ICI) between the CIV fair and poor categories and IBI / ICI values that did not attain the WWH criteria, and between the CIV exceptional category and IBI / ICI values that at least attained the WWH criteria. The correspondence was best between the CIV results and ICI where the SQM effort was performed in a riffle. CIV scores in the good range, however, corresponded to a wide range of IBI and ICI scores that both attained and failed to attain the WWH criteria. Furthermore, it was not possible to consistently distinguish between WWH (good) and EWH (exceptional) attainment using the CIV alone. These findings point out an inherent trait of qualitative methodologies in that they produce fewer data dimensions and hence less discriminatory power. While qualitative and narrative approaches can distinguish conditions at the extremes of the

"These findings point out an inherent trait of qualitative methodologies in that they produce fewer data dimensions and hence less discriminatory power."

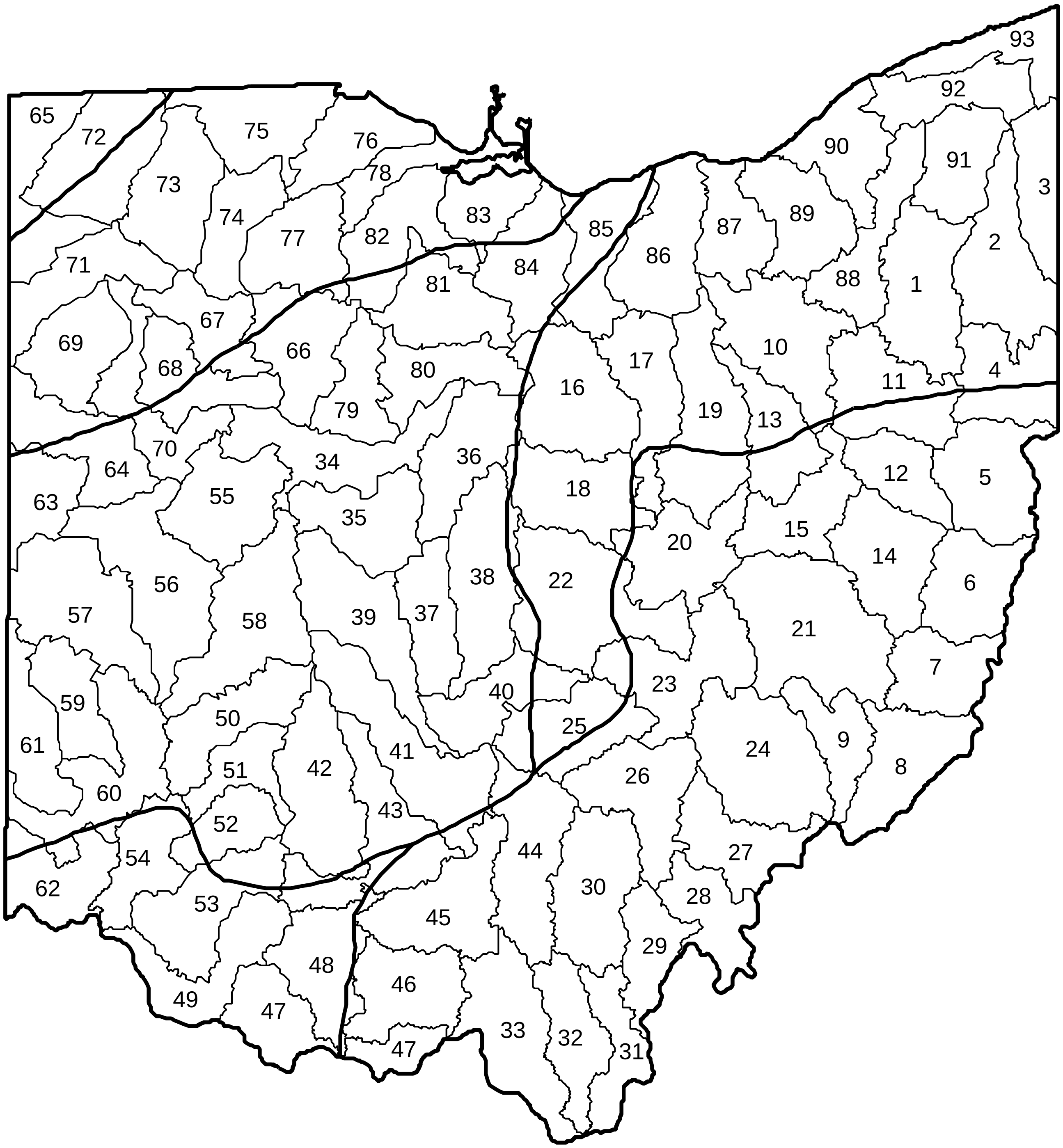
environmental spectrum (*i.e.*, poor vs. exceptional), each lacks the dimensional power to further distinguish the "in between" situations (Hilsenhoff 1991). This is not dissimilar to the findings of a comparison of qualitative, narrative biocriteria and regional reference site derived numerical biocriteria. In this comparison the narrative approach yielded erroneous results in 21-36% of the comparisons, with the error tendency being clearly toward *underestimating* a problem (Ohio EPA 1990c; Yoder 1991a). This particular analysis only points out the problems in the evaluation of the data, since the data set was generated by the same standardized Ohio EPA methods. Volunteer approaches introduce another significant source of error, sampling efficiency (includes both physical sampling effort and field identification of macro-invertebrate taxa). These types of problems and biases are common to any method and should be accounted for up front. The Dilley (1991) study provided some important insights into the limitations that should be placed on SQM type information. Further analysis of information from multiple field collectors (including less skilled volunteers) is needed to accept of this type of data as an *evaluated* level assessment. The primary purposes of the Ohio DNR Stream Quality Monitoring program are; (1) to educate and generate interest in specific scenic rivers, and (2) to develop and maintain a base of information to evaluate long-term changes in stream and river quality. This type of data will easily serve these purposes and provide Ohio EPA with useful indications of potentially emerging problems and whether high quality waters are being threatened.

"...the greatest interest...in using SQM as a monitoring tool has been shown by selected county Soil and Water Conservation Districts..."

To date, the greatest interest (outside of the Ohio DNR Scenic Rivers program) in using SQM as a monitoring tool has been shown by selected county Soil and Water Conservation Districts (SWCD) in implementing and monitoring the progress and results of Section 319 nonpoint source pollution abatement projects. This information is a potential source of useful information when interpreted within the constraints of the methodology. Ohio EPA has agreed to accept this data for inclusion in Ohio ECOS as a screening tool for nonpoint source assessments. Such data can be used, for example, to focus more intensive Ohio EPA watershed monitoring efforts.

Key to Map 2-4

1 - UPPER MAHONING RIVER
2 - LOWER MAHONING RIVER
3 - PYMATUNING CREEK
4 - LITTLE BEAVER CREEK
5 - CENTRAL TRIBS (YELLOW CREEK AND CROSS CREEK)
6 - CENTRAL TRIBS (SHORT CREEK AND WHEELING CR.)
7 - CENTRAL TRIBS (MCMAHON, CAPTINA, SUNFISH CR.)
8 - LITTLE MUSKINGUM RIVER
9 - DUCK CREEK
10 - UPPER TUSCARAWAS RIVER
11 - NIMISHILLEN CREEK;
12 - CONOTTON CREEK
13 - SUGAR CREEK
14 - STILLWATER CREEK
15 - LOWER TUSCARAWAS RIVER
16 - BLACK FORK, CLEAR FORK, ROCKY FORK MOHICAN R
17 - LAKE FORK, JEROME FORK, MUDDY FORK MOHICAN R
18 - KOKOSING RIVER
19 - KILLBUCK CREEK
20 -UPPER MUSKINGUM RIVER AND WAKATOMIKA CREEK
21 - WILLS CREEK
22 - LICKING RIVER
23 - MIDDLE MUSKINGUM RIVER
24 - LOWER MUSKINGUM RIVER
25 - UPPER HOCKING RIVER
26 - MIDDLE HOCKING RIVER
27 - LOWER HOCKING RIVER
28 - SE TRIBS (SHADE RIVER AND LEADING CREEK)
29 - SE TRIBS (LOWER RACCOON CREEK)
30 - SE TRIBS (UPPER RACCOON CREEK)
31 - SE TRIBS (LITTLE INDIAN GUYAN CREEK)
32 - SE TRIBS (SYMMES CREEK)
33 - SE TRIBS (LITTLE SCIOTO RIVER AND PINE CREEK)
34 - UPPER SCIOTO RIVER (AND LITTLE SCIOTO RIVER)
35 - SCIOTO RIVER (MILL CR.,BOKES CR., FULTON CR.)
36 - UPPER OLENTANGY RIVER
37 - LOWER OLENTANGY RIVER
38 - BIG WALNUT CREEK
39 - BIG DARBY CREEK
40 - WALNUT CREEK;
41 - MIDDLE SCIOTO RIVER (INCLUDING DEER CREEK)
42 UPPER PAINT CREEK
43 - LOWER PAINT CREEK (N. FK. AND ROCKY FK.)
44 - SALT CREEK;
45 - SCIOTO RIVER (SUNFISH CR.,BEAVER CR.)
46 - LOWER SCIOTO RIVER (AND SCIOTO BRUSH CREEK);
47 -SW TRIBS (EAGLE CREEK AND STRAIGHT CREEK)
48 - OHIO BRUSH CREEK
49 -SW TRIBS (WHITEOAK CR.,INDIAN CR., BEAR CR.)
50 - UPPER LITTLE MIAMI RIVER
51 - CAESAR CREEK
52 - TODD FORK
53 - EAST FORK LITTLE MIAMI RIVER
54 - LOWER LITTLE MIAMI RIVER
55 - UPPER GREAT MIAMI RIVER
56 - GREAT MIAMI RIVER AND LORAMIE CREEK
57 - STILLWATER RIVER
58 - MAD RIVER
59 - TWIN CREEK
60 - MIDDLE GREAT MIAMI RIVER
61 - FOURMILE CREEK
62 - LOWER GREAT MIAMI RIVER AND WHITEWATER R.
63 - WABASH RIVER
64 - ST. MARYS RIVER
65 - ST. JOSEPH RIVER
66 - BLANCHARD RIVER
67 - LOWER AUGLAIZE RIVER
68 - OTTAWA RIVER
69 - LITTLE AUGLAIZE RIVER
70 - UPPER AUGLAIZE RIVER;
71 - UPPER MAUMEE R. (INCLUDING GORDON CREEK);
72 - TIFFIN RIVER
73 - UPPER MIDDLE MAUMEE RIVER;
74 - LOWER MIDDLE MAUMEE RIVER
75 - LOWER MAUMEE RIVER (AND OTTAWA RIVER)
76 - LAKE ERIE TRIBS MAUMEE R. TO PORTAGE R.
77 - UPPER PORTAGE RIVER
78 - LOWER PORTAGE RIVER
79 - TYMOCHTEE CREEK
80 - UPPER SANDUSKY RIVER
81 - MIDDLE SANDUSKY RIVER
82 - LOWER SANDUSKY RIVER
83 - LAKE ERIE TRIBS SANDUSKY R. TO VERMIL-ION R
84 - VERMILION RIVER
85 - HURON RIVER;
86 - BLACK RIVER
87 - ROCKY RIVER
88 - UPPER CUYAHOGA RIVER
89 - LOWER CUYAHOGA RIVER
90 - LAKE ERIE TRIBS (CHAGRIN RIVER)
91 - UPPER GRAND RIVER
92 - LOWER GRAND RIVER \
93 - ASHTABULA RIVER AND CONNEAUT CREEK.



Map 2-4 Watersheds used for summarizing use attainment in Ohio.

Key To Map 2-5

01 - Hocking River Basin
- a - Hocking River
- b - Federal Creek
- c - Sunday Creek
- d - Monday Creek
- e - Rush Creek

02 - Scioto River Basin
- a - Scioto River
- b - Scioto Brush Creek
- c - Sunfish Creek
- d - Salt Creek
- e - Saltlick Creek
- f - Middle Fk. Salt Creek
- g - Paint Creek
- h - N. Fk. Paint Creek
- i - Rocky Fk. Paint Creek
- j - Rattlesnake Creek
- k - Deer Creek
- l - Big Darby Creek
- m - Little Darby Creek
- n - Walnut Creek
- o - Big Walnut Creek
- p - Alum Creek
- q - Olentangy River
- r - Whetstone Creek
- s - Mill Creek
- t - Little Scioto River
- u - Rush Creek

03 - Grand River Basin
- a - Grand River

04 - Maumee River Basin
- a - Maumee River
- b - Ottawa River
- c - Ten Mile Creek
- d - Swan Creek
- e - Beaver Creek
- f - Turkeyfoot Creek
- g - Tiffin River
- h - Mud Creek
- i - Powell Creek
- j - Flatrock Creek
- k - Blue Creek
- l - Prairie Creek
- m - Town Creek
- n - Little Auglaize River
- o - Blanchard River
- p - Ottawa River
- q - Auglaize River
- r - St. Mary's River
- s - St Josephs River
- t - W. Br. St. Josephs River
- u - Nettle Creek
- v - Fish Creek

05 - Sandusky River Basin
- a - Sandusky River
- b - Muddy Creek
- c - Wolf Creek
- d - Honey Creek
- e - Tymochtee Creek

06 - Central Tribs Basin
- a - Yellow Creek
- b - Cross Creek
- c - Short Creek
- d - Wheeling Creek
- e - Captina Creek
- f - Sunfish Creek
- g - Little Muskingum River
- h - Duck Creek
- i - E. Fk. Duck Creek

07 - Ashtabula Creek Basin
- a - Ashtabula River
- b - W. Br. Ashtabula River
- c - Conneaut Creek

08 - Little Beaver Creek Basin
- a - Little Beaver Creek
- b - N. Fk. L. Beaver Creek
- c - W. Fk. L. Beaver Creek
- d - M. Fk. L. Beaver Creek

09 - Southeast Tribs
- a - Shade River
- b - Leading Creek
- c - Raccoon Creek
- d - Little Raccoon Creek
- e - Symmes Creek
- f - Pine Creek
- g - Little Scioto River

10 - Southwest Tribs
- a - Ohio Brush Creek
- b - W. Fk. Ohio Brush Creek
- c - Straight Creek
- d - Whiteoak Creek

11 - Little Miami River Basin
- a - Little Miami River
- b - E. Fk. L. Miami River
- c - Todd Fork
- d - Caesar Creek

12 - Huron River Basin
- a - Huron River
- b - West Fork Huron River

13 - Rocky River Basin
- a - Rocky River
- b - W. Fk . Rocky River

14 - Great Miami River Basin
- a - Great Miami River
- b - Whitewater River
- c - Indian Creek
- d - Four Mile Creek
- e - Sevenmile Creek
- f - Twin Creek
- g - Mad River
- h - Buck Creek
- i - Stillwater River
- j - Greenville Creek
- k - Loramie Creek

15 - Chagrin River Basin
- a - Chagrin River

16 - Portage River Basin
- a - Portage River
- b - M. Br. Portage River
- c - S. Br. Portage River

17 - Muskingum River Basin
- a - Muskingum River
- b - Wolf Creek
- c - Meigs Creek
- d - Salt Creek
- e - Moxahala Creek
- f - Jonathan Creek
- g - Licking River
- h - N. Fk. Licking River
- i - Raccoon Creek
- j - S. Fk. Licking River
- k - Wakatomika Creek
- l - Wills Creek
- m - Slat Creek
- n - Leatherwood Creek
- o - Seneca Fork
- p - Tuscarawas River
- q - Stillwater Creek
- r - L. Stillwater Creek
- s - Connotton Creek
- t - Sugar Creek
- u - S. Fk . Sugar Creek
- w - Nimishillen Creek'
- x - Chippewa Creek
- y - Walhonding River
- z - Killbuck Creek
- aa - Kokosing River
- bb - Mohican River
- cc - Clear Fork
- dd - Black Fork
- ee - Lake Fork
- ff - Jerome Fork
- gg - Muddy Fork

18 - Mahoning River Basin
- a - Mahoning River
- b - Mosquito Creek
- c - Eagle Creek
- d - W. Br.Mahoning River
- e - Yankee Creek
- f - Pymatuning Creek

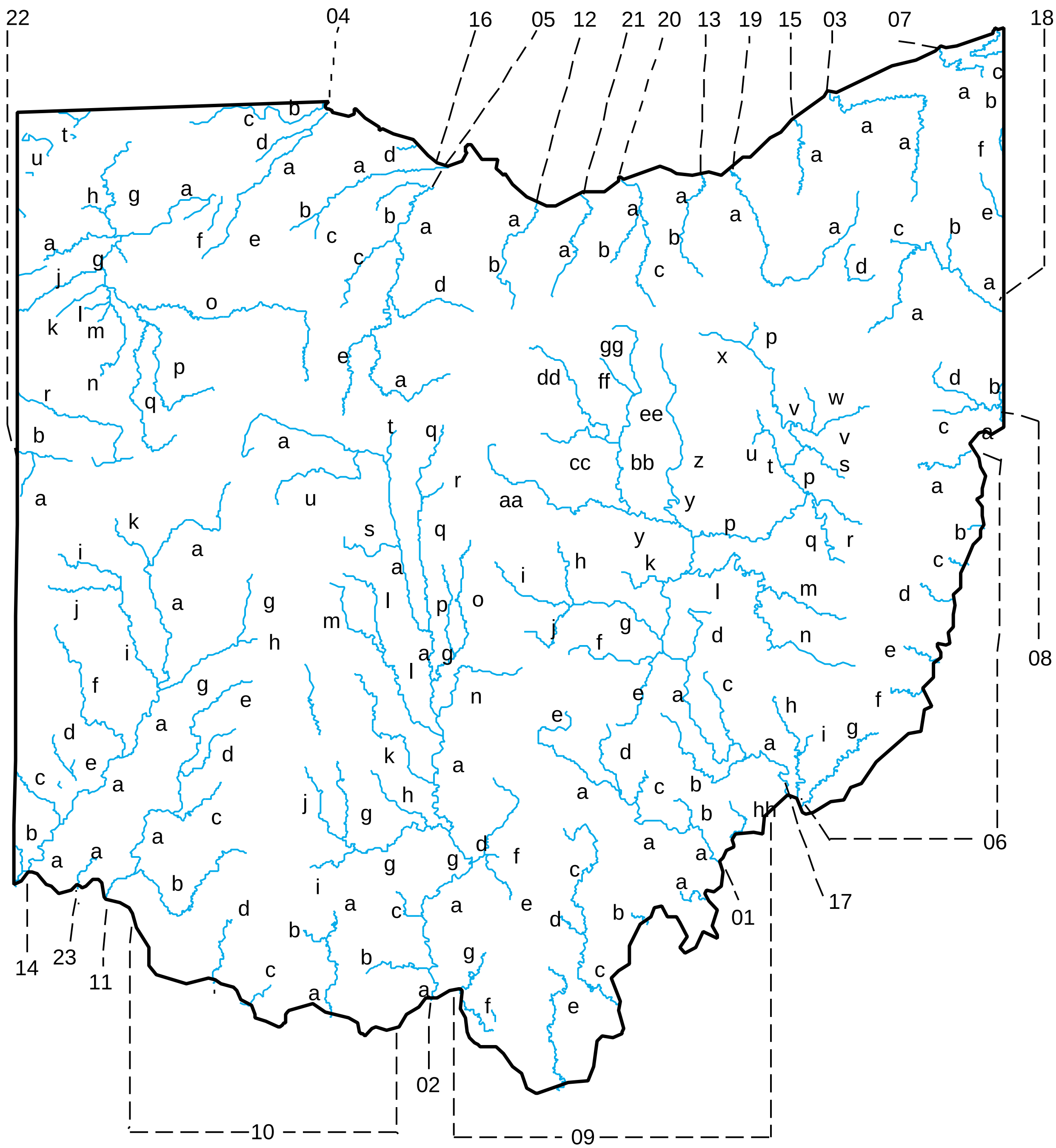
19 - Cuyahoga River Basin
- a - Cuyahoga River

20 - Black River Basin
- a - Black River
- b - W. Br. Black River

21 - Vermilion River Basin
- a - Vermilion River

22 - Wabash River Basin
- a - Wabash River
- b - Beaver Creek

23 - Mill Creek Basin
- a - Mill Creek
- c - E. Br. Black River



Map 2-5. Streams and rivers of Ohio with drainage areas > 100 sq mi.

Sources and Causes of Impairment

Sources and causes of PARTIAL or **NON**-attainment were assigned by waterbody segment as major (H), moderate (M), slight (S), or unverified potential impact (P) based on an integrated assessment of the available data and the interpretations of the biologists and scientists who planned and conducted the field investigations. Only causes and sources of impairment that are *presently* apparent or exist are listed. Potential causes and sources, the effects of which are not currently being exhibited, are listed as a "P" (potential impact). As a surface water recovers with time, some potential causes may become evident and will be listed then with one of the standard (H, M, or S) codes. Most of Ohio's streams and rivers are affected by multiple sources and causes, and these tend to be "layered" on one another. Thus, the reduction or elimination of one impact may reveal the presence of another underlying impact.

"Sources and causes of PARTIAL or NON attainment were assigned ...based on an integrated assessment of the available data and the interpretations of the biologists and scientists who actually planned and conducted the field investigations."

The assignment of causes and sources in the Waterbody System (WBS) is necessarily broad in comparison to the detailed assessments contained in the Technical Support Documents completed by Ohio EPA for each Five-year Basin study area. The delineation of WBS segments frequently does not coincide with "boundaries" of change in the ambient results. As such, the detailed information in these and other Ohio EPA documents supersede the information reported here. However, it is the analysis of the site specific information that provides the basis for the assignment of causes and sources in the 305(b) report. Subbasin boundaries are referenced in Map 2-4 and major streams (>100 sq. mi. drainage area) are illustrated in Map 2-5.

Section 3

Designated Use Support

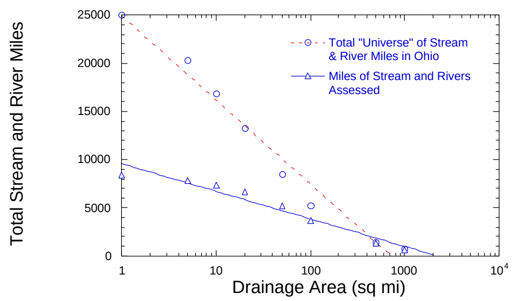


Figure 3-1. Total designated stream and river miles in Ohio and the total stream and river miles assessed by drainage area (measured at the downstream end of a waterbody segment).

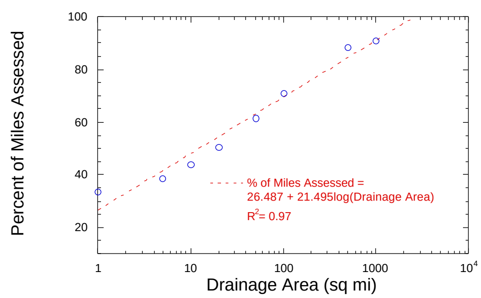


Figure 3-2. Proportion of designated stream and river miles assessed in Ohio by drainage area (measured at the downstream end of a waterbody segment).

Streams and Rivers

Aquatic life use support for this report is based on the assessment of 8,337 miles of streams and rivers (Table 3-1). This is 28.6% of the 29,113 miles of perennial streams miles or 13.5% of the 61,532 total stream miles in Ohio estimated to exist in Ohio by the U.S. EPA (see Section 2). Summary pie charts for all beneficial uses for rivers and streams, inland lakes, ponds, and reservoirs, and Lake Erie are arrayed at the end of this section in Figure 3-10. Although our sampling strategy is a focused rather than probabilistic one, our coverage on larger rivers is extensive (Figure 3-1 and 3-2). We have assessed 91% of rivers of greater than 1,000 sq mile drainage and 50% of all streams not considered headwaters (i.e., > 20 sq mi; Fig. 3-2). Thus, concern with database biases related to extrapolation from small sample sizes decreases with increasing stream size.

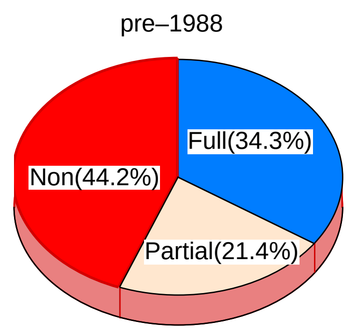


Figure 3-3. Full (open wedge), partial (hashed wedge), and non support (shaded wedge) of aquatic life criteria in Ohio streams and rivers based on monitoring information used in the 1988 305[b] report.

"Stream and river surveys...revealed widespread impairment from inadequately treated municipal and industrial wastewater."

Stream and river surveys in Ohio during the 1970s and 1980s revealed widespread impairment from inadequately treated municipal and industrial wastewater. Only 34.3% of streams and rivers fully supported aquatic life use criteria based on monitoring data collected prior to 1988 (Fig. 3-3). There

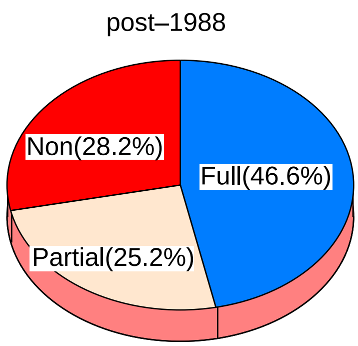


Figure 3-4. Full (open wedge), partial (hashed wedge), and non support (shaded wedge) of aquatic life criteria in Ohio streams and rivers based on based on monitoring information collected after the 1988 305[b] cycle and used in the 1994 305[b] report.

has been a trend of improving stream and river resource quality in Ohio since the 1980s, however, largely as a result of improved treatment at WWTPs. Data collected during the late 1980s and early 1990s reflected the substantial investments made to improve point source discharges of wastewater, particularly from municipal treatment plants. This data indicates the percent of miles of streams and rivers fully supporting aquatic life uses increased to 46.6% of miles monitored (Fig 3-4, Table 3-1). The proportion of stream miles not supporting aquatic life uses decreased from 44.2% to 28.2% of stream and river miles monitored after 1988 (Figs. 3-3 & 3-4, Table 3-1). The statistics for the individual assessment cycles show a similar pattern. The slightly higher percent of full support of aquatic life uses for 1992 cycle compared to the 1994 cycle does not represent a decline in abatement progress, but rather reflects the inclusion of several years of ODNR (Natural Areas and Preserves and Division of Wildlife) data on high quality streams in southeast Ohio. The nonrandom sampling approach requires caution when interpreting results from too short of a period (i.e., a single two-year assessment cycle).

"Data collected subsequent to 1988 indicates the percent of miles of streams and rivers fully supporting aquatic life uses increased to 46.6%...[from 34.3% prior to 1988]"

Stream waterbodies have been categorized by drainage area (sq. mi.) at the lower end of each stream and river segment. This permits the examination of aquatic life use support by stream size. In general, larger rivers, by virtue of higher flows and greater dilution, appear more resistant to the effects of point source discharges as compared to smaller rivers and streams while the smallest headwater streams are more severely affected by nonpoint sources (*e.g.*, hydromodification) and general watershed effects. Non support

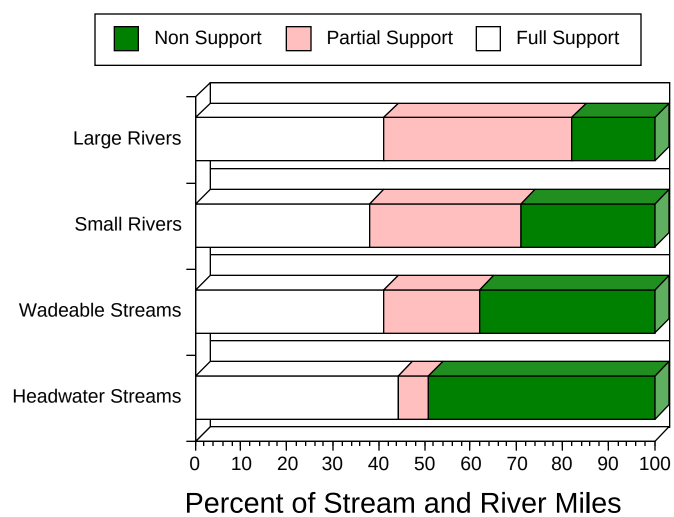


Figure 3-5. Support of aquatic life criteria in Ohio by watershed size: headwaters ≤ 20 sq. mi.; wadeable streams >20-200 sq. mi.; small rivers, >200-1000 sq. mi.; and, large rivers, ≥ 1,000 sq. mi. (based on information from the 1994 assessment cycle).

of aquatic life criteria increased with decreasing watershed size. Where nearly 50% of headwater (0-20 sq. mi. drainage) stream miles did not support aquatic life uses, only 18% of large rivers (> 1000 sq. mi.) did not support such uses (Fig. 3-5). The existence of significant problems remaining in larger and small rivers is reflected in the high proportion of streams in partial support compared to headwater streams and the small variation in full use support varied along a river and stream size gradient (Fig. 3-5).

Table 3-1. Aquatic life use attainment in Ohio streams and rivers based on our entire data base (1988 through 1994 assessment cycles), the post-1988 assessment cycles, and the individual 1988, 1990, 1992, 1994 assessment cycles.

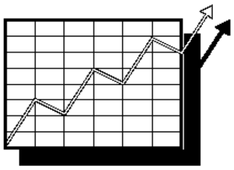
Year(s)	Fully Supporting	Fully Threatened	Partially Supporting	Not Supporting	Total Miles Monitored
		1988-1994 Assessment Cycles			
Miles	2,815.7	616.7	1,854.0	3,050.5	8,337.0
Percent	33.8%	7.4%	22.2%	36.6%	
		Total Full Support 41.1%		Total Impaired 58.9%	
		1990-1994 Assessment Cycles			
Miles	1312.9	409.0	932.1	1042.8	3,696.8
Percent	35.5%	11.1%	25.2%	28.2%	
		Total Full Support 46.6%		Total Impaired 55.4%	
		1988 Assessment Cycle			
Miles	2,051.3	361.4	1,506.5	3,109.7	7,029.0
Percent	29.2%	5.1%	21.4%	44.2%	
		Total Full Support 34.3%		Total Impaired 65.7%	
		1990 Assessment Cycle			
Miles	214.7	157.8	241.6	356.5	970.7
Percent	22.1%	16.3%	24.8%	36.8%	
		Total Full Support 38.4%		Total Impaired 61.6%	
		1992 Assessment Cycle			
Miles	643.3	191.5	449.9	440.1	1,724.9
Percent	37.3%	11.1%	26.1%	25.5%	
		Total Full Support 48.4%		Total Impaired 51.6%	
		1994 Assessment Cycle			
Miles	552.2	206.6	457.0	456.2	1,672.2
Percent	33.0%	12.4%	27.3%	27.3%	
		Total Full Support 45.4%		Total Impaired 54.6%	

Aquatic life use support also varied with the designated aquatic life. The EWH and CWH aquatic life uses had the greatest proportion of fully supporting and threatened stream and river miles (Table 3-2). These uses are the most sensitive aquatic life uses(*e.g*, habitats for intolerant fauna) and although they are resilient when impacts are abated (due to exceptional stream habitat) they are also susceptible to nonpoint source impacts such as habitat degradation and siltation. The high resource value of these streams makes them priorities for protection and restoration (see 'Threatened Streams and Rivers' later in this report).

Table 3-2. Use support summary by aquatic use for Ohio streams and rivers.

		Degree of Use Support				
Use	Miles/ %	Fully Supports	Fully Supports, Threatened	Partially Supports	Does Not Support	Total
			Aquatic Life (EWH)			
EWH	Miles	505.0	190.6	381.2	227.9	1304.9
	%	38.7	14.6	29.2	17.5	100
CWH	Miles	107.2	68.5	27.6	7.2	210.5
	%	50.9	32.6	13.1	3.4	100
WWH	Miles	2,014.2	340.8	1,337.1	2,134.5	5,826.7
	%	34.6	5.8	23.0	36.6	100
MWH	Miles	49.6	0.0	54.6	281.9	386.1
	%	12.9	0.0	14.1	73.0	100
LRW/	Miles	70.4	13.9	42.4	298.5	425.3
LWH	%	16.5	3.3	10.0	70.2	100
None	Miles	59.3	2.9	13.9	104.6	180.8
	%	32.8	1.6	7.7	57.9	100

The more limited resource streams (MWH, LWH, and LRW aquatic life uses) have the least proportion of their miles supporting uses even though criteria for these waters are less stringent than WWH, CWH, or EWH waters. This condition likely reflects the intensity and magnitude of human activity (e.g., agricultural and industrial) around these waters.



Forecasting Use Attainment

A large number of stream and river segments have been reassessed since point source pollution controls have been implemented to meet water quality standards. One benefit of the monitoring approach employed by Ohio EPA is the ability to forecast water quality changes into the future. A major challenge facing the Ohio EPA water programs is the goal of achieving full support of aquatic life uses in 75% of Ohio's streams and rivers by the year 2000. In order to determine if existing programs are likely to achieve this goal, we must attempt to look forward based on past observation.

"A major challenge facing the Ohio EPA water programs is the goal of achieving full support of aquatic life uses in 75% of Ohio's streams and rivers by the year 2000."

The current rate of improvement, projected from reassessment results observed between 1988 and 1994 (Fig. 3-6), is an accumulated addition of approximately 1-2%percent restored miles per year. This rate is largely the product of point source abatement efforts (Fig. 3-7). Based on the current and projected rate of restoration, 56.5%of streams and rivers monitored in the preceding two-year cycle will be fully supporting their aquatic life uses by the year 2000 (Fig. 3-5). Clearly, there is a gap between the 75% goal and the projected figures.

The improvements to date, although likely to fall short of the 75% goal, have been significant. By extrapolating the observed changes in aquatic life status after the 1988 cycle to all monitored stream and river miles, it is estimated that aquatic life uses have been restored in more than 1,000 miles of streams and rivers in which we had previously documented impairment. The predominant factor in this restoration of streams has been municipal wastewater treatment plant (WWTP) upgrades.

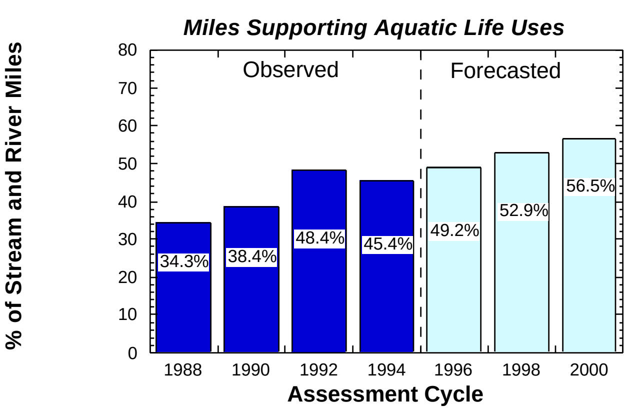


Figure 3-6. Observed increase in miles of streams fully supporting aquatic life uses between the 1988 and 1994 by assessment cycles (solid columns) and that forecasted through the year 2000 (hashed columns) based on the present rate (50%) of restoration. Full support as a percent of all assessed miles for a cycle is printed on each column.

The strongest, most robust data for documenting changes in water resource status are from those segments that been assessed multiple times. We have reassessed nearly 2,500 miles of streams and rivers in Ohio (Table 3-3). In these segments there has been a clear reduction in non-supporting miles and a concomitant increase in fully-supporting miles (Table 3-3). The percent of miles partially supporting aquatic life uses increased slightly reflecting (1) the typical recovery pattern of non-supporting miles incrementally improving with time, and (2) the “unmasking” of nonpoint source problems inhibiting full recovery of the waterbody (see Section 4).

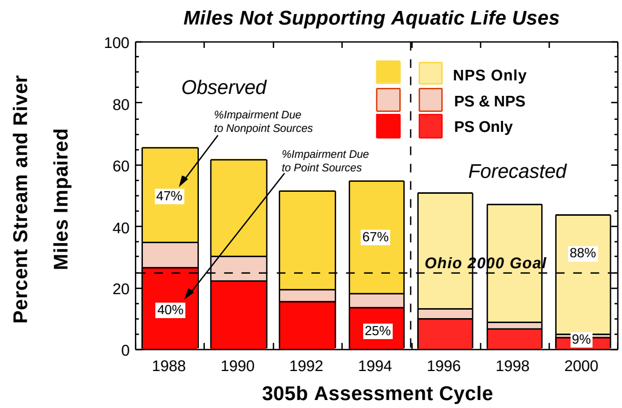


Figure 3-7. Percent of miles observed with impaired aquatic life uses by assessment cycle (left of dashed line) and that forecasted to the year 2000 (right of dashed line) based on the observed restoration rate. The proportion of impairment attributed to point sources only and point and nonpoint as a major source is represented by the hashed (lower) portion of each column.

Table 3-3. Use support summary for Ohio streams and rivers that have reassessed at least once. Statistics are summarized for the earliest and latest assessment cycles for which data exists.

		Degree of Use Support		
Fully Supports	Fully Supports, Threatened	Partially Supports	Does Not Support	Totals
		Earliest Assessment		
580.3 (23.4%)	177.7 (7.2%)	598.2 (24.2%)	1,120.2 (45.2%)	2,476.6 (100%)
		Latest Assessment		
927.2 (33.4%)	319.8 (11.5%)	754.7 (27.2%)	774.7 (27.9%)	2,776.5 (100%)

“The predominant factor in this restoration of streams has been municipal wastewater treatment plant (WWTP) upgrades.”

An analysis of the reassessed segments data shows that approximately 50% of the previous WWTP impacts are abated by the time a segment is reassessed. Thus it is likely that at least one-half of the 1138 miles of streams and rivers still reported as impaired by WWTPs will have already been restored. If the rate of restoration increases to 90%, the remaining miles of impairment due to WWTPs will be less than 50 miles by the year 2000. To meet the Ohio EPA’s year 2000 goal of 75% of streams and rivers fully supporting aquatic life criteria, total restoration will need to achieve a net increase of 18.5% over that forecasted during the next six years. Point sources are declining as major causes of impairment both proportionately

“...approximately 50% of the previous WWTP impacts are abated by the time a segment is reassessed.”

"total restoration will need to achieve a net increase of 18.5% over that forecasted during the next six years in order to meet the 75% goal."

and in absolute terms (shaded, lower portion of Fig. 3-7), while the remaining causes and sources, which are predominantly nonpoint, are emerging as the greatest limitations to the 75% goal.

Strategies To Increase the Rate of Restoration

Given that the current rate of restoration will increase the fully supporting fraction of streams to 56.5% by the year 2000, what actions can Ohio EPA take to accelerate restoration enough to meet the Ohio EPA year 2000 goal of 75% full use support? Merely accelerating the rate of point source restoration *alone* will not achieve the goal. Even if we assume the rate of point source related restoration is accelerated to the extent that 90% of the remaining impairment is abated by the year 2000 (elimination of most of the hashed portion on last column of Fig. 3-7), and no new nonpoint source impacts are unmasked, the Ohio EPA year 2000 goal will not be met.

"Merely accelerating the rate of point source restoration alone will not achieve the goal."

Restoration of 90% of the remaining point source related impairment by the year 2000 is forecast to result in 65.9% of waters fully supporting aquatic life uses, leaving a 9.1% shortfall from the Ohio EPA year 2000 goal of 75% full aquatic life use support. Clearly, new successes in controlling and abating other sources of impairment will be needed to attain the Ohio 2000 goal. Another factor that needs to be considered in projecting the rate of restoration is the role of increasing threats to full support of aquatic life use criteria. The most rapidly increasing threats are those related to urban and suburban development, watershed level modifications (*e.g.*, wetlands losses), and hydromodification. Increasing threats from nonpoint sources could erode gains made through point source abatement and result in a slowing in the rate of restoration. This would be an unanticipated deterrent to attaining the Ohio EPA year 2000 goal.

"...it is clear that new successes in controlling and abating other sources of impairment will be needed in order to attain the Ohio 2000 goal."

Recreation Uses in Streams and Rivers

Compared to aquatic life uses there is comparatively less information available about recreational use attainment/non-attainment. Ohio rivers and streams are assigned the recreational uses Primary Contact Recreation (PCR) or Secondary

Contact Recreation (SCR). Primary Contact Recreation streams and rivers are deep enough for full human body immersion activities such as swimming. Secondary Contact Recreation streams are only deep enough to permit wading and incidental contact (*e.g.*, canoeing), and as such, the fecal coliform bacterial criteria are less stringent than for PCR.

"The most rapidly increasing threats are those related to urban and suburban development, watershed level modifications (e.g., wetlands losses), and hydromodification."

The principal criteria for assessing whether the PCR and SCR uses are supported are fecal coliform bacteria counts. A total of 5,513 miles of rivers and streams have been assessed since 1978, with 1,842 miles assessed during the 1990 through 1994 reporting cycles (i.e., post-1988). Of this latter figure, 616 miles were new assessments and 1226 miles were reassessments. Because most data collection efforts are not intensive for this parameter the confidence in the accuracy of the data is less than that for aquatic life use studies. Even considering these caveats, however, the data does show some important patterns.

Table 3-4. Recreation use support summary for Ohio streams and rivers.

Degree of Use Support	Miles(%)	Percent of Assessed	Percent of Total[1]
	1988-1994		
Full	3,058.8	55.5	10.5
Partial	406.2	7.4	1.4
Non-Support	2,048.0	37.1	7.0
Totals:	**5,513.1**	**100.0**	**18.9**
	1990-1994		
Full	1,095.6	59.5	3.8
Partial	256.7	13.9	0.8
Non-Support	489.1	26.6	1.7
Totals:	**1,841.5**	**100.0**	**6.3**

[1] Perennial streams on the basis of USEPA (1991a) estimates

The observed improvements in recreation use support (Fig. 3-8, Table 3-4) are attributable to improvements in municipal wastewater treatment. The remaining, non-supporting stream and river miles are a result of: (1) urban runoff and combined sewer overflows; (2) unresolved WWTP treatment problems; (3) unsewered areas; and, (4) livestock and agricultural runoff. At the rate of observed improve-

Map 3-1. Aquatic life use attainment status of Ohio stream and river waterbodies with greater than a 100 square mile drainage area at the downstream terminus of the waterbody. Line type represents predominant aquatic life use status in the segment.

ment reflected in Fig. 3-8, 70.8% of stream and river miles should be fully supporting their recreation uses by the year 2000. This assumes, however, that the gains made between the 1988 and 1994 assessment cycles, attributable to WWTP improvements, will yield the same progress between the 1994 and year 2,000 assessment cycles. Depending on what proportion of the remaining problems are CSO, urban runoff, and agriculturally related this forecast may be overly optimistic.

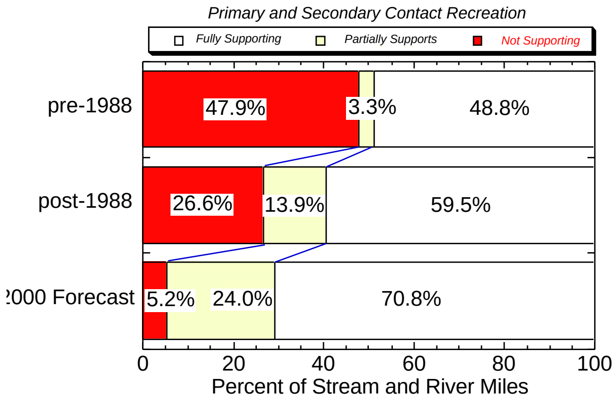


Figure 3-8. Miles of rivers and streams fully supporting, partially supporting, or not supporting recreational uses (primary or secondary contact) between the pre-1988 and post-1988 assessment cycles.

"...70.8% of stream and river miles should be fully supporting their recreation uses by the year 2000."

Site-specific Example

While conducting monitoring in the Cuyahoga River and through working with the Cuyahoga River RAP (Remedial Action Plan) subcommittees, Ohio EPA-NEDO surface water staff have been identifying sources of fecal coliform bacteria contamination in the middle section of the Cuyahoga River between Cleveland and Akron. The National Park Service plans to promote increased recreational use of the river (mainly canoeing) within the Cuyahoga River Valley National Recreational Area. However, fecal coliform bacteria counts historically have been regularly elevated above the Primary Contact Recreation use criterion. NEDO staff located a continuously flowing, dry-weather CSO in Akron, sewage from a leaking sanitary sewer flowing from a storm drain in Cuyahoga Falls, and a deteriorated sanitary sewer leaking into a tributary in Cuyahoga Falls. Corrective actions were undertaken by the cities of Akron and Cuyahoga Falls to eliminate these discharges. As a result of increased Ohio EPA monitoring and surveillance, the city of Akron has placed several CSOs under more frequent inspection and maintenance. There are also plans to upgrade the overflow alarm system in the near future. The city of Cuyahoga Falls had a sanitary sewer line re-grouted and replaced a large section of sanitary sewer in the Gorge Metropark area, spending more $150,000 to eliminate these sources of contamination. The result of this and other similar efforts throughout the lower basin is that fecal coliform bacteria counts have recently been within the PCR criteria during dry weather. The Little Cuyahoga River, however, continues to be a major source of fecal coliform bacterial contamination and additional sampling is planned to identify sources and initiate remedial actions.

Fish Tissue Contamination

"The degree and extent of contaminated fish tissues in rivers and streams is of great importance to the citizens of Ohio."

The degree and extent of contaminated fish tissues in rivers and streams is of great importance to the citizens of Ohio. Besides serving as a human health risk indicator, contaminated tissue is a useful indicator for identifying streams and rivers affected by hydrophobic toxic substances and for tracking pollution abatement efforts in such waters.

Table 3-5. Fish consumption concerns for Ohio streams and rivers.

Status	Miles	Percent of Assessed	Percent of Total[1]
	1988-1994 - (All Data)		
Not Elevated	990.2	42.0	3.4
Slightly / Moderately Elevated	615.1	26.1	2.1
High / Extremely Elevated or Partial Advisory	615.3	26.1	2.1
High / Extremely Elevated and All SpeciesAdvisory	137.4	5.8	0.5
Totals:	**2,358.1**	**100.0**	**8.1**
	1990-1994 Cycles Only		
Not Elevated	572.0	41.0	2.0
Slightly / Moderately Elevated	343.5	24.6	1.2
High / Extremely Elevated or Partial Advisory	385.5	27.6	1.3
High / Extremely Elevated and All SpeciesAdvisory	95.7	6.8	0.3
Totals:	**1,396.9**	**100.0**	**4.8**

[1] Perennial streams on the basis of USEPA (1991a) estimates

Ohio's fish tissue sampling program historically has been small in scope (approximately 50 sites / year) and the information herein reflects the results of that effort. However, in 1993, Ohio EPA, in cooperation with Ohio DNR, initiated a statewide monitoring effort for fish tissue contaminants and future reports will reflect this increased level of sampling. The data collected from 1978 to 1992, analyzed herein, will provide a base line for the future results. On the basis of all data collected from 1978 to 1992, elevated concentrations of PCBs, pesticides, metals, or other organic compounds, were not found in 42% of the monitored stream and river miles (Table 3-5). Definitions of concentrations considered elevated are listed in Table 2-6. Levels of contaminants considered slightly or moderately elevated were found in 26.1% of monitored stream miles. Highly or extremely elevated levels of contaminants comprised 26.1% of the total stream and river miles. State and / or local consumption advisories for selected species have been issued for only a small proportion of these latter miles. Health advisories for all species have been issued for 5.8% of the miles monitored for fish tissue contaminants. Slightly lower contamination levels were observed between data collected before and after 1988 (Fig. 3-9). A thorough assessment of trends awaits the data that will be generated by the intensive data collection efforts planned over the next several years.

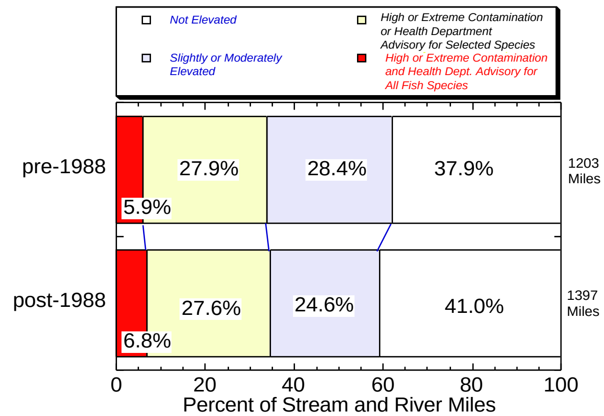


Figure 3-9. Miles of streams and rivers with fish tissue samples which exhibited no contamination, slightly or moderately elevated contamination, highly or extremely elevated contamination, or high and extreme contamination and in segments with a State or local health advisory, during pre-1988 and post-1988 assessment cycles

Lake Erie

Use attainment status in Lake Erie has not changed substantially over the last several years (Table 3-6). The fish consumption advisory for carp and channel catfish is still in effect. Data on the nearshore areas of Lake Erie is sparse. However, work has begun on developing biological assessment methodologies for fish and macroinvertebrates (see Section 9). The effects of recent introductions of exotic species (*e.g.*, zebra mussel) on the biological communities in Lake Erie are being intensively studied, but potential impacts are not clear at this time. Ohio EPA has recently collected round gobies (*Neogobius melanostomus*) near the Grand River estuary and is looking for specimens of the river ruffe (*Gymnocephalus cernua*). Hopefully, new data including the results of studies on the zebra mussel and informa-

"Data on the nearshore areas of Lake Erie is sparse. ...work has begun on developing biological assessment methodologies..."

"...information generated by the Remedial Action Plan (RAP) process will allow a significant expansion in reporting status and trends in future 305(b) cycles."

tion generated by the Remedial Action Plan (RAP) process will allow a significant expansion in reporting status and trends in future 305(b) cycles.

Table 3-6. Use attainment summary for Lake Erie.

	Degree of Use Support		
	Fully Supporting	Partially Supporting	Not Supporting
Aquatic Life	0	236	0
Recreation	231	5	0
Fish Consumption	0	236	0

Lakes, Ponds, & Reservoirs

Table 3-7 summarizes use attainment status for the exceptional warmwater habitat aquatic life use (*i.e.*, default use for all publicly owned reservoirs), public water supply, fish consumption, and recreation in Ohio's public lakes, ponds, and reservoirs. The lake data reported here differs from previous reports because information not based on ambient monitoring or the Lake Condition Index questionnaire was excluded to ensure a solid information base for future trend assessments. Use attainment / non-attainment was derived using specified parameters of the Ohio EPA Lake Condition Index (LCI) following guidelines described in Davic and DeShon (1989) and Volume III of this report. The paucity of long-term monitoring data limits the analysis to the present status of those publicly owned lakes that have been recently monitored. Volume III summarizes the data in detail and provides other required lake information.

Over the past six years, between 23,679 acres (fish tissue sampling) and 55,127 acres (recreation and public water supply uses) have been assessed for use support. Most fish tissue samples from the lakes monitored (99.2%, 23,499 ac.) have little or no contaminants in fish sampled from these lakes (Figure 13). Only two small lakes in northeast Ohio (180 acres total) have problems with elevated levels of PCBs. For the most part, the designated uses represented here (recreation, PWS, and aquatic life) are partially supporting these uses. Our assessment methodologies, based on the Ohio Lake Condition Index (LCI), are quite stringent and a classification of partial use may indicate a minor problem, such as low summer hypolimnetic dissolved oxygen. The LCI is extremely useful in identifying water resource problems for managers to improve lake condition and for classifying extremely high quality lakes that meet all the stringent conditions of the LCI. The nonsupport category of designated uses is the suitable identifier of more serious impairment in lakes. The recreation use is the only use where a major proportion of acres are not supporting the use.

Table 3-7. Use support summary for Ohio's 450 public lakes, ponds, and reservoirs greater than 5 acres in size.

	Degree of Use Support			
Use Designation	Fully Supports	Fully Supports, Threatened	Partially Supports	Does Not Support
		Aquatic Life (EWH)		
Number:	2	7	53	11
Acres:	271	10,911	41,110	2613
		Fish Consumption		
Number:	7	–	2	–
Acres:	23,499	0	180	0
		Public Water Supply		
Number:	3	2	55	13
Acres:	321	7,867	42,106	4,832
		Recreation		
Number:	7	4	37	25
Acres:	1,864	655	23,957	28,651

"...major causes of nonsupport of designated uses in lakes, ponds, and reservoirs are volume loss due to sedimentation, aesthetics, nuisance growths of aquatic plants, and nutrient and organic enrichment."

The major causes of nonsupport of designated uses in lakes, ponds, and reservoirs are volume loss due to sedimentation, aesthetics, nuisance growths of aquatic plants, and nutrient and organic enrichment. The sources of these impacts are generally nonpoint in origin and include agriculture, urban runoff, and septic systems. As for streams and rivers, abatement of nonpoint sources is a key for improvement in lake conditions in Ohio.

Ohio River

Assessment of the Ohio River focused on the level of support for the following designated uses: warmwater aquatic life use, public water supply, fish consumption, and recreation (Table 3-8). Detailed analyses of water quality and ecological condition can be found in the ORSANCO 1994 305(b) report (ORSANCO 1994) and Sanders (1993, 1994).

Table 3-8. Use attainment summary[1] for the Ohio River (Ohio waters only) in terms of river miles.

	Degree of Use Support Fully Supporting	 Partially Supporting	 Not Supporting
Aquatic Life (Warmwater)	293.4	61.3	95.1
Recreation[1]	0.0	372.3	77.5
Fish Consumption	0.0	449.8	0.0
Public Water Supply	449.8	0.0	0.0

[1] from ORSANCO (1994).
[2] 243.5 miles not assessed.

"...night electrofishing results indicate that the Ohio River mainstem ...supports relatively good fish assemblages."

ORSANCO (1994) reported that the Ohio River was partially attaining aquatic life uses in 61.3 miles due to exceedances of the acute copper criteria (though MIwb values were high). The 95.1 miles of the Ohio River in Ohio not attaining the aquatic life use was due primarily to numerous exceedences of the chronic total lead criterion and low MIwb values (ORSANCO 1994). The origin of these lead concentrations is thought to be the Kanawha River of West Virginia.

The Ohio EPA (Sanders 1994) and ORSANCO (1994) night electrofishing results indicate that the Ohio River mainstem (along the Ohio shoreline) supports good fish assemblages. Most samples collected in 1993 had greater than 20 species (mean 25.9, range: 17-33) and typically included several environmentally sensitive and characteristic large river species (*e.g.*, *Hiodon* spp., *Moxostoma* spp., *Percina* spp., and *Etheostoma* spp.). State rare, endangered, threatened, or special status species captured in 1993 include; Silver lamprey (*Ichthyomyzon unicuspis*), Ohio lamprey (*Ichthyomyzon bdellium*), mooneye (*Hiodon tergisus*), river redhorse (*Moxostoma*

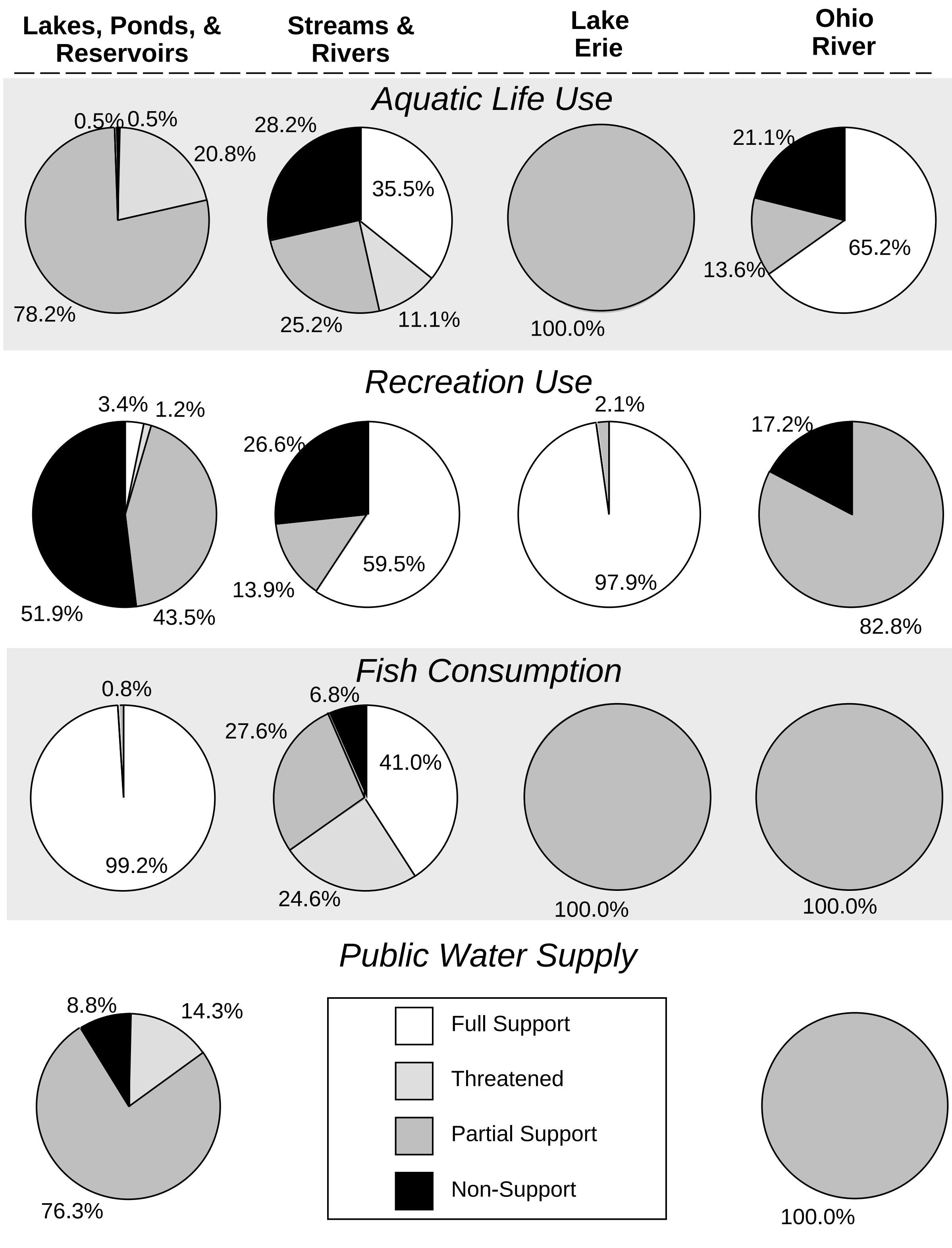


Figure 3-10. Pie chart summarizing use attainment status (post 1988) for Ohio lakes, ponds, and reservoirs (first column), streams and rivers (second column), Lake Erie (third column), and the Ohio River (fourth column).

Photo 1. Example of severe erosion to the banks of the Scioto River where riparian vegetation was removed and agricultural land uses encroached on the River.

carinatum), channel darter (*Percina copelandi*), slenderhead darter (*Percina phoxocephala*), and river darter (*Percina shumardi*) (Sanders 1994). The results of the Ohio EPA and ORSANCO night electrofishing efforts were further evaluated using Ohio EPA's modification of the Index of Biotic Integrity (IBI; Ohio EPA 1987b) for application to large rivers and the Modified Index of Well-Being (MIwb; Ohio EPA 1987b; Fig. 3-4). All of the 1993 Ohio EPA samples indicated at least "good" biological community performance on the basis of the MIwb.

Section 4

Causes and Sources of Non-support of Aquatic Life Uses in Ohio

The following chapter summarizes the principal sources and causes of aquatic life use impairment in Ohio. Here we examine trends in the major causes and sources of aquatic life impairment, forecast likely changes in causes and sources in the near future, and then discuss the various cause categories within the context of the principal source responsible for the impairment.

Much of what is presented here does not represent new knowledge. Trautman (1981) examined the various reasons why the fish populations throughout Ohio have declined or become threatened during the period 1750 through 1980. The introductory discussions of his book have not yet lost their relevance. In fact, much of the biological monitoring conducted by Ohio EPA since 1980 has, in part, extended the base of information presented by Trautman (1981). What we are able to bring to this discussion is an increasingly quantitative assessment of water resource integrity in Ohio and an understanding of what has changed since Trautman's observations. This report includes the usage of some types of data and analysis techniques that were not available before 1980.

Causes of aquatic life impairment are defined as the actual agents that affect the aquatic life use (*e.g.*, low dissolved oxygen, silt, habitat modification, etc.). Sources of impairment are the entities or activities from where the pollutant or effect originated (*e.g.*, municipal wastewater treatment plant, row crop agriculture, bank destabilization, etc.). For example, a source of heavy metals (a *cause* of impairment) may be a municipal wastewater treatment plant (WWTP) or an industrial operation (a *source* of impairment). Elevated nutrients (a cause) may lead to low dissolved oxygen (a cause) and originate from row crop production (a source). The extent (*miles* of stream or river impaired) of various causes and sources of impairment are listed in tables 4-1 and 4-2 for streams and rivers, tables 4-5 and 4-6 for lakes and reservoirs, and tables 4-7 and 4-8 for Lake Erie. Appendix A-2 summarizes the causes and sources of impairment for each individual water body segment. The causes and sources of impairment listed for a particular waterbody are those that actually elicit a response from the biological, chemical, or physical indicators, and excludes "potential" causes and sources that presently evoke no apparent response in any of the indicators. For example, in a stream severely impaired by toxics (a cause), all of the *current* impairment may be attributable to toxics, though other causes and sources may be present. Other causes that might exhibit impacts in the absence or reduction of the toxic impairment are not indicated. As the stream recovers with the elimination or control of the toxic cause, other causes (e.g., siltation from nonpoint sources) may become apparent at which time they will be listed as a cause of impairment. It is also reasonable to expect that the severity of the impairment would be less as the more severe toxic cause is abated and the "lesser" siltation cause becomes evident.

"We have assessed 50% of Ohio streams and rivers with greater than 20 sq mi drainage areas..."

The evaluation of causes and sources in this report increases in representativeness with stream size. We have assessed 50% of Ohio streams and rivers with > 20 sq mi drainage areas, 71 % of streams and rivers with > 100 sq mi drainage areas, and 91% of rivers with > 100 sq mi drainage areas (see Figs. 3-1 and 3-2). Although proportionately fewer small streams have been monitored, many perturbations that affect these streams show distinct and consistent ecoregional patterns that are characteristic of the major land and/or water uses in these areas. This is due to the greater similarity of watersheds that completely originate within the same ecoregion. Although the estimate of the proportion of streams and rivers impaired is approximate, the relative importance of various sources in these streams is nevertheless revealing.

Predominant Causes and Sources of Aquatic Life Impairment

Ohio's streams and rivers are impaired by different causes and sources of pollution and other activities. The pattern observed during the past six years has been one of: (1) a general lessening of point source related impairment; and, (2) an increase in nonpoint source related impairments. The latter is the result of the emergence of causes and sources which were "masked" as a major effect by the greater preva-

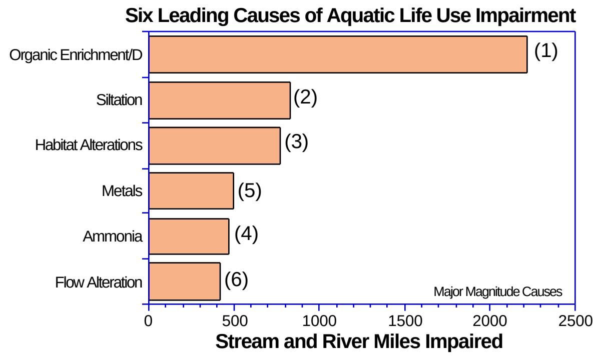


Figure 4-1. Six predominant "Major" causes of aquatic life impairment for Ohio streams and rivers. Numbers in parentheses are ranking from 1992 assessment cycle.

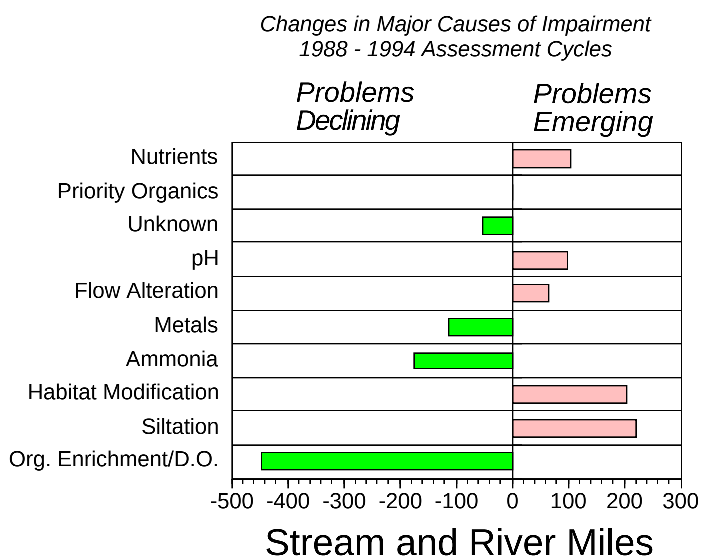


Figure 4-2. Improvements (reduction in impaired miles) and declines (increase in impaired miles) among the major causes of aquatic life impairment between the 1988 and 1994 assessment cycles.

lence and severity of past point source impairments rather than a net increase in severity of nonpoint impairment. Thus, as point source problems are abated, other problems are becoming increasingly evident. The top six major causes of impairment are organic enrichment/ low D.O., siltation, habitat modifications, ammonia, flow alteration and metals (Table 4-1, Figure 4-1). River specific causes and sources of impairment are listed in Appendix A which also reports extent of impairment (miles) and, where available, area of degradation values that reflect the *severity* of impacts on these waterbodies.

A comparison of the changes among the major causes of aquatic life impairment between pre-1988 and post-1988 assessment cycles (Fig. 4-2) provides an illustration of this change in the major causes and sources of impairment: Point source related causes have declined while nonpoint source related causes have emerged as major factors of aquatic life use impairment (Fig. 4-2). These nonpoint related causes largely existed in the stream segments, but their effects were of lesser magnitude (M,S) or were totally masked by more severe organic enrichment or toxicity (metals/ammonia). This also reflects the *relative* effectiveness of the programs to control point sources compared to the general lack of measures to control many habitat and sedimentation-related sources that predominate the emerging problems in these streams and rivers. The extent of these emerging problems, which will prevent Ohio from reaching its year 2000 goal of 75% of streams and rivers attaining aquatic life uses, argues for implementation of measures to deal with these problems. Appendix B

"Point source related causes have declined while nonpoint source related causes have emerged as major factors of aquatic life use impairment..."

summarizes the functions and benefits of riparian areas whose protection is essential if we are to deal effectively with habitat and sediment problems in Ohio. Because riparian areas are much less expensive to protect than restore, delaying their protection can be at a minimum more costly and at worst could preclude the full recovery of streams and rivers.

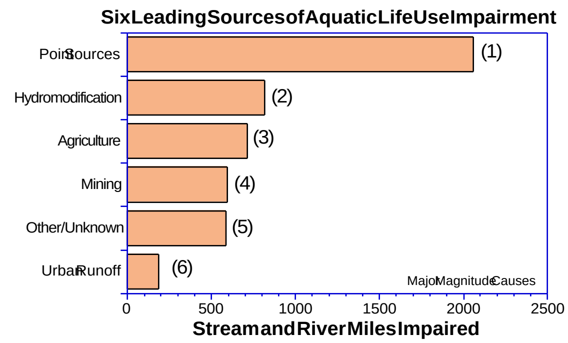


Figure 4-3. Six predominant "Major" causes of aquatic life impairment for Ohio streams and rivers. Numbers in parentheses are ranking from 1992 assessment cycle.

The term impaired is misleading because the range of impact severity it includes is too wide. For example, an "impaired" segment can encompass a situation where fish and macroinvertebrates deviate slightly, but significantly from the biocriteria, which we would classify as "fair", or a situation where the communities are essentially eliminated by toxic impacts, which we would classify as "very poor" (Fig. 4-4). The use of the 305(b) terminology of "non-support" is linked to (1) the early, heavy reliance on chemical criteria to assess streams for "use support" and graded responses (i.e., excellent, good, fair, poor, very poor) are difficult to accurately derive, and (2) the strong link to the "regulatory" approach of USEPA and the assessment of whether point source permit conditions are being "violated." Since USEPA is encouraging more widespread of biosurvey data they should consider promoting an alternate "grading" system for evaluating aquatic life conditions (e.g., excellent, good, fair, poor, very poor), rather than the current "pass / fail" system in place (i.e., attainment / non- attainment). The use of techniques such as Ohio's

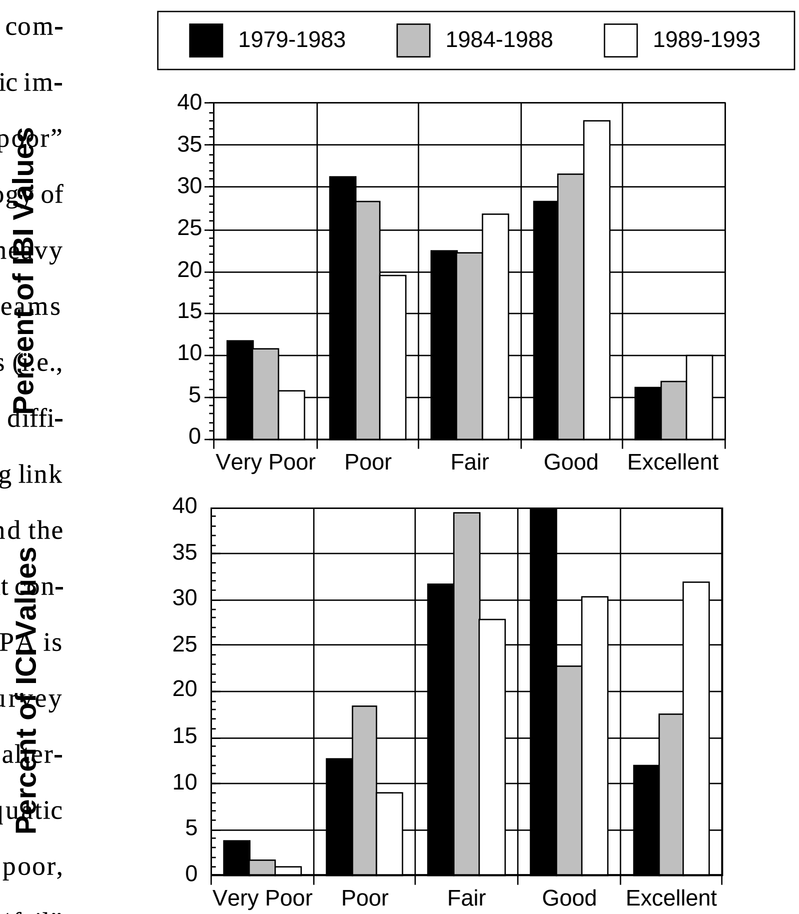


Figure 4-4. Categorization of IBI (top) and ICI (bottom) values into grades of very poor, poor, fair, good, and excellent among three sampling periods. The very poor, poor, and fair grades are considered impaired

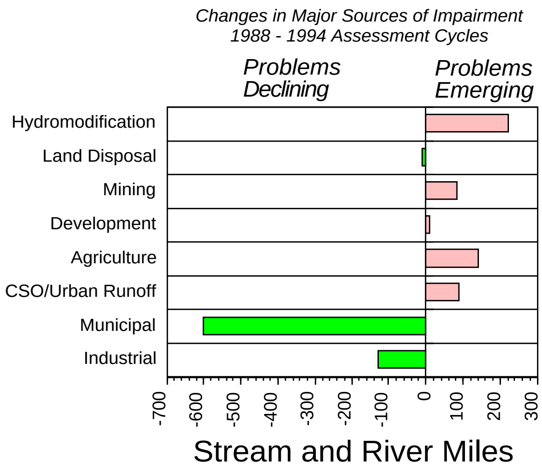


Figure 4-5. Improvement (reduction in impaired miles) and decline (increase in impaired miles) among the major sources of aquatic life use impairment between the 1988 and 1994 assessment cycles.

Area of Degradation Value (ADV) statistics provides a method for generating a graded ranking of aquatic condition.

The major sources of impairment (Table 4-2, Fig. 4-3) include municipal (including CSOs) and industrial discharges, hydromodification, runoff from agriculture, urban runoff, and mining. Point sources of pollution, such as municipal and industrial discharges have shown substantial declines as major sources of impairment (Figure 4-5), while nonpoint sources have emerged as increasingly important . As mentioned above many of these sources were masked by formerly severe point source impairments. Although point sources have declined in relative importance they are still significant factors and in some rivers they remain severe. This severity is reflected in the ADV scores discussed earlier. The twenty-five most *severely* impaired waterbodies as measured by ADV statistics are still predominated by municipal and industrial entities as major sources of impairment (Table 4-5). Some of these waters have not been reassessed since the early to mid 1980s (e.g., the Mahoning River which is being reassessed in 1994), while in others (Tinkers Creek, Ottawa River) point sources have persisted as major impediments to restoration.

"Point sources of pollution... have shown substantial declines as major sources of impairment..."

Recent "booms" in the suburbaniztion of previously rural watersheds could also affect stream and river recovery by; (1) greatly increasing loadings to small, previously unimpaired waters, (2) approaching or exceeding maximum allowable loadings in some high quality streams (e.g., Little Miami River), and (3) adding to existing hydromodification and runoff problems from poor land development practices that are occurring in a near vacuum of riparian protection guidelines (see Appendix B). As discussed earlier, a move to a graded system of assessments for this report would provide a more detailed assessment of progress or backsliding on environmental quality.

Table 4-1. Relative assessment of major, moderate, and minor causes of impairment (i.e., miles[1]) that result in partial and non-attainment of aquatic life uses or threaten the current full attainment status of aquatic life uses in Ohio streams and rivers during the 1988 through 1992 305(b) report cycles. Miles that were severely impacted are listed under "very poor." Major, moderate, and minor impacts refer to the high, moderate, and slight magnitude codes specified by the U.S. EPA guidance for the 305(b) report.

	1988-1994 305(b) Cycles			
Causes	Major Cause	Moderate Cause	Minor Cause	Threatened Use
Organic Enrichment / D	2216.6	602.2	207.4	131.1
Siltation	832.2	704.3	348.9	221.9
Habitat Alterations	771.5	531.8	222.6	238.4
Metals	495.0	352.1	186.2	40.5
Ammonia	472.4	292.0	33.5	9.2
Flow Alteration	416.0	195.9	72.2	19.3
pH	318.0	6.1	12.5	8.3
Unknown	217.3	142.3	122.0	28.5
Nutrients	105.0	146.8	109.8	35.5
Priority Organics	103.5	77.5	51.0	9.6
Pesticides	45.1	17.2	69.4	14.4
Oil & Grease	42.6	35.0	18.8	—
Other Inorganics	42.0	54.7	—	—
Salinity / TSD / Chloride	39.7	18.3	6.1	19.7
Nitrites	27.3	38.1	—	—
Thermal Modification	24.3	14.3	32.2	19.4
Taste and Odor	17.6	—	—	—
Chlorine	6.9	13.2	9.4	—
Pathogens	4.3	18.9	6.0	—
Suspended Solids	2.5	4.2	5.0	8.0
Filling & Draining	1.6	—	—	—
Non-Priority Organic	—	3.0	—	—
Radiation	—	2.5	—	—
Turbidity	—	—	13.9	—
Total Toxics	—	3.2	—	1.7
Exotic Species	—	23.7	—	—
Suspended Solids	0.5	2.2	—	—

1 These are "new" cause categories for the 1992 cycle of the report, past impairments that may fit in these categories may be classified under other cause categories.

Table 4-4 The 25 waterbodies with the most severely impaired aquatic life where sufficient biological data was available to calculate area of degradation values (ADV) for fish and/or macroinvertebrates.

WBID	Waterbody Name	Assess. Cycle	Full	Threat.	Partial	Non-Support	IBI ADV	ICI ADV	Major Sources
OH89 8	TINKERS CREEK	94	–	–	–	22.5	3312	405	Ind./Mun.
OH 2 12	MILL CREEK	88	–	–	10.1	10.8	1832	2920	Mun.
OH77 8	EAST BRANCH PORTAGE	90	–	–	–	18.0	1485	2873	CSO
OH11 5	NIMISHILLEN CREEK	92	–	–	–	11.9	2367	–	Ind./Spills
OH17 14	JEROME FORK MOHICAN	88	–	–	–	12.3	736	2141	Ind./Mun.
OH72 11	PRAIRIE CREEK	88	–	–	–	12.1	2067	–	Ind./Mun.
OH10 1	TUSCARAWAS RIVER	92	–	–	–	13.6	1910	246	Ind.
OH63 4	BEAVER CREEK	88	–	–	–	10.4	1872	–	Mun.
OH72 18	BRUSH CREEK	88	–	–	–	21.4	1261	1859	Mun.
OH16 19	ROCKY FORK MOHICAN R.	88	1.4	–	–	15.0	1802	–	Ind./Mun.
OH 2 27	MOSQUITO CREEK	88	–	–	–	11.8	1401	1717	Mun.
OH 2 20	MAHONING RIVER	88	–	–	–	8.5	1690	–	Mun./IPP
OH29 35	LEADING CREEK	94	–	–	7.1	2.9	1590	1672	Mining
OH64 26	KOPP CREEK	88	–	–	–	13.5	1619	–	Hab
OH89 14	CUYAHOGA RIVER	94	–	–	–	13.0	1587	27	Mun/CSO
OH10 19	LITTLE CHIPPEWA CR.	88	–	–	–	13.0	1566	–	Mun.
OH50 23	LITTLE MIAMI RIVER	88	–	–	–	9.7	1525	–	Ag/Hab
OH68 11	OTTAWA RIVER	94	–	–	–	6.5	1518	612	Ind/Mun /CSO
OH50 1	LITTLE MIAMI RIVER	88	–	–	–	12.8	1500	586	Mun.
OH41 28	OAK RUN	88	1.6	–	2.3	12.7	1500	–	Mun.
OH19 31	KILLBUCK CREEK	88	–	–	2.6	9.6	730	1456	Mun.
OH89 6	CUYAHOGA RIVER	94	–	–	–	9.2	1452	5	Mun.
OH86 13	WEST BRANCH BLACK R.	94	–	–	–	14.5	1443	252	Ag.
OH10 9	TUSCARAWAS RIVER	92	–	–	1.0	10.3	1406	401	Haz.
OH83 11	RACCOON CREEK	88	–	–	–	11.9	473	1394	Ind.

Source Abbreviations: Ind. - Industrial; Mun. - Municipal WWTPs; CSO - Combined Sewer Overflows; IPP - In-Place Pollutants (contaminated sediments); Hab. - Habitat Modifications; Ag. - Agriculture; Haz. - Hazardous Waste.

Table 4-2. Relative assessment of major, moderate, and minor sources (i.e., miles[1]) which cause impairment of aquatic life uses in Ohio rivers and streams during the 1988 through 1994 305(b) report cycles. Major, moderate, and minor impacts refer to the high, moderate, and slight magnitude codes specified by the U.S. EPA guidance for the 305(b) report.

Source	Major Source	Moderate Source	Minor Source	Threatens Use
POINT SOURCES	**2058.2**	**820.4**	**309.1**	**94.6**
Industrial	618.9	281.0	112.8	37.8
Municipal	1507.5	516.8	200.9	67.8
Combined Sewers	247.9	100.4	4.0	1.7
AGRICULTURE	**711.5**	**688.4**	**732.4**	**169.3**
Agriculture	239.6	168.7	103.8	84.3
Non-irrigated Crops	318.1	458.5	487.2	84.5
Irrigated Crops	29.8	14.6	–	–
Specialty Crops	4.5	13.7	–	–
Pasture Land	124.8	42.2	110.9	–
Feedlots	–	30.2	36.8	62.9
Aquaculture	–	15.1	15.0	–
Animal Holding	29.3	3.2	–	0.5
SILVICULTURE	**5.5**	**15.4**	**12.4**	**1.6**
Silviculture	–	5.4	0.5	1.6
Timber Harvesting	5.5	–	11.9	–
Timber Harv. Roads	–	10.0	–	–
CONSTRUCTION	**14.5**	**47.2**	**29.6**	**100.6**
Construction	3.0	3.0	5.0	1.0
Highway Constr.	0.5	7.2	–	0.6
Land Development	11.0	37.5	24.6	99.0
URBAN RUNOFF	**183.7**	**359.9**	**202.0**	**27.4**
Urban Runoff	189.4	357.1	197.9	19.4
Surface Runoff	–	15.8	4.0	8.0
RESOURCE EXTRACTION	**595.3**	**112.5**	**159.3**	**105.4**
Mining	109.5	19.1	5.1	–
Surface Mining	446.0	66.5	56.6	94.9
Subsurface Mining	38.4	18.6	51.7	5.7
Dredge Mining	–	1.1	–	9.4
Petroleum Activities	2.4	7.3	48.8	34.0
Mine Tailings	–	11.4	–	–
LAND DISPOSAL	**138.6**	**129.0**	**305.6**	**14.5**
Land Disposal	5.0	–	–	–
Sludge Disposal	–	2.0	10.2	–
Wastewater Disposal	–	11.0	3.0	–
Landfills	30.4	32.4	40.2	2.2
Industrial Land Trea	0.3	–	2.0	–
Septic Tanks	80.1	85.1	245.9	12.3
Hazardous Waste	–	22.8	0.5	4.7
HYDROMODIFICATION	**816.8**	**624.2**	**297.2**	**154.3**
Hydromodification	22.9	77.7	1.3	5.6
Channelization	540.7	295.0	179.1	52.4
Dredging	23.4	13.8	–	5.0
Dam Construction	73.3	94.2	41.1	8.8
Flow Regulation	110.2	55.7	12.2	10.6
Riparian Destruction	51.6	51.2	50.0	94.6

Table 4-2. continued.

Source	Major Source	Moderate Source	Minor Source	Threatens Use
Streambank Disturb.	115.1	90.0	13.5	14.3
Draining / Filling	22.0	4.7	–	–
OTHER	**463.9**	**304.2**	**205.4**	**64.9**
Misc.	107.3	43.5	22.8	1.8
Waste Storage	33.2	–	–	–
Highway maintenance	13.4	2.0	–	–
Spills	65.4	61.3	68.2	9.5
In-place contaminant	112.0	90.9	33.3	16.1
Natural Conditions	144.0	68.2	105.6	37.5
Recreational Activit	5.0	30.6	1.0	–

[1] Miles counted total more than total miles assessed because more than one source can be major, moderate, or minor in the same segment.

Table 4-3. Relative Assessment of major, moderate, and minor causes of impairment of aquatic life uses and threats to miles of streams that currently fully support aquatic life uses in segments that have been sampled and assessed more than once. Data reflects earliest and latest sampling efforts.

	Earliest Data				Latest Data			
Causes	H	M	S	T	H	M	S	T
Organic Enrichment / Dissolved Oxygen	1,082.4	208.6	6.4	28.8	520.9	215.6	63.6	65.0
Siltation	135.5	309.4	90.0	56.9	265.2	182.8	120.1	95.4
Habitat Alterations	154.5	255.3	97.4	23.0	242.7	175.3	59.9	141.9
Metals	289.1	206.1	85.3	0.5	156.3	79.2	76.3	19.7
Unknown	188.2	108.3	11.2	4.8	102.9	59.0	76.1	28.5
pH	74.2	37.6		1.3	98.3	2.1	10.6	7.9
Ammonia	282.1	207.7	16.4		89.4	68.9	7.2	6.6
Nutrients		9.0			85.4	84.3	104.0	35.5
Flow Alteration	63.6	33.1	31.5	4.5	63.8	114.9	10.7	9.9
Priority Organics	62.6	175.0	22.4		61.5	49.5	47.4	9.6
Salinity / TSD / Chlorides					33.1	8.5		
Oil & Grease	44.2	30.8	16.1		23.1	26.4	7.9	
Nitrites	14.1				22.1	32.1		
Other Inorganics	44.4		15.2		20.1	29.8		
Thermal Modification		17.0	21.3		18.7	9.3	17.0	19.4
Taste and Odor	12.1		6.0		17.6			
Pesticides	6.8				7.9	13.9	21.6	
Pathogens					3.0	16.4	6.0	
Suspended Solids					2.5	4.2	5.0	8.0
Chlorine	17.7	27.5	21.8		2.5	11.0		
Exotic Species						13.5		
Turbidity							13.9	
Total Toxics						3.2		1.7
Filling & Draining								
Radiation						2.5		
Non-Priority Organic						3.0		

Table 4-5 Relative assessment of causes of impairment (i.e., acres[1]) causing partial and non-attainment of designated uses in lakes, ponds, and reservoirs in Ohio. Major, moderate, and minor impacts refer to the high, moderate, and slight magnitude codes specified by the U.S. EPA guidance for the 305(b) report.

	1988-1992 305(b) Cycles		
Causes	Major Cause	Moderate Cause	Minor Cause
Nutrients	16631.1	5964.0	752.0
Turbidity	15629.0	4669.0	582.0
Siltation	15444.1	2589.0	2037.0
Habitat Alterations	12700.0	17.8	869.0
Organic Enrichment / Dissolved Oxygen	8739.0	2202.5	852.0
Noxious Aq. Plants	343.0	1955.0	365.8
Pathogens	300.0	994.0	1350.0
Ammonia	168.6	474.0	1277.0
Other Inorganics	85.0	1573.4	1624.0
pH	83.0	–	1190.0
Pesticides	57.0	860.0	4033.5
Low Nutrients	50.0	–	–
Metals	34.8	1196.0	1317.0
Thermal Modifications	23.0	–	11.8
Exotic Species	–	–	–
Total Toxics	–	–	–
Filling & Draining	–	–	–
Suspended Solids	–	2356.0	1284.0
Taste and Odor	–	23.4	17.0
Oil & Grease	–	1868.0	679.0
Radiation	–	–	17.0
Flow Alteration	–	57.0	679.0
Salinity / TSD / Chlorides	–	83.0	23.0
Chlorine	–	–	–
Non-Priority Organics	–	340.0	679.0
Priority Organics	–	40.0	2004.0
Unknown	–	–	786.6

Table 4-6. Relative assessment of sources of impacts (i.e., acres[1]) causing non-support of aquatic life uses in Ohio lakes, ponds, and reservoirs. Major, moderate, and minor impacts refer to the high, moderate, and slight magnitude codes specified by the U.S. EPA guidance for the 305(b) report.

Sources	Major Source	Moderate Source	Minor Source
POINT SOURCES	***1518.0***	***30513.0***	***5355.0***
Industrial	–	13002.0	4544.0
Municipal	1190.0	30491.0	2815.0
Combined Sewers	–	–	1350.0
Stormwater Sewers	277.0	1717.0	4033.0
Package Plants	94.0	1350.0	–
Wastewater Lagoon	51.0	–	–
AGRICULTURE	***29712.5***	***24993.5***	***4448.1***
Agriculture	25597.5	8325.0	310.0
Non-irrigated Crops	17470.0	2674.5	1371.0
Irrigated Crops	1350.0	785.0	1297.0
Specialty Crops	–	–	110.0
Pasture Land	1406.0	3740.5	1376.0
Feedlots	3418.0	12796.0	2724.5
Animal Holding	1954.0	13113.0	1234.1
SILVICULTURE	***255.0***	***2384.0***	***635.0***
Silviculture	51.0	2384.0	304.0
Timber Harvesting	204.0	–	127.0
Forest Management	–	–	427.0
Timber Harv. Roads	–	–	96.0
C***ONSTRUCTION***	***677.0***	***14212.0***	***2205.6***
Construction	101.0	14152.0	1325.0
Highway Constr.	37.0	12700.0	773.0
Land Development	539.0	12760.0	201.6
URBAN RUNOFF/ STORM SEWERS (NPS)	***740.0***	***18531.0***	***2341.0***
Urban Runoff	55.0	13063.0	1535.0
Storm Sewers	197.0	5634.0	2004.0
Industrial Runoff	–	1533.0	–
Surface Runoff	677.0	4099.0	2131.0
MINING	***270.0***	***2079.0***	***3005.0***
Mining	85.0	–	419.0
Surface Mining	85.0	539.0	361.0
Subsurface Mining	185.0	–	–
Petroleum Activities	–	1540.0	1325.0
Acid Mine Drainage	–	–	900.0
LAND DISPOSAL	***15016.0***	***12667.0***	***5068.0***
Land Disposal	–	–	10.0
Sludge Disposal	–	–	157.0
Landfills	–	123.0	2974.0
Industrial Land Treat.	–	–	1507.0
Septic Tanks	15016.0	12667.0	3455.0
HAB. MODIFICATION	***1094.8***	***19445.0***	***4768.0***
Hydromodification	900.0	5909.0	385.0
Channelization	–	679.0	2138.0
Dredging	–	–	604.0
Dam Construction	–	–	157.0

Table 4-6. continued.

Sources	Major Source	Moderate Source	Minor Source
Flow Regulation	–	157.0	2480.0
Riparian Destruction	194.8	12700.0	2707.0
Streambank Disturb.	183.0	12700.0	2382.0
OTHER	***109.0***	***30991.6***	***2506.5***
Atmos. Deposition	–	6854.0	–
Highway maintenance	–	–	23.0
Spills	–	3874.0	451.0
In-place contaminants	–	775.0	1482.0
Natural Conditions	109.0	29170.6	550.5
Recreational Activities	–	396.0	–
SOURCE UNKNOWN	***221.0***	**–**	**–**

1 Acres counted add to more than total acres because more than one source can be major, moderate, or minor in a segment.

Table 4-7 Relative assessment of causes of impairment (i.e., miles[1]) causing partial and non-support of designated uses in Ohio Lake Erie shoreline. Major, moderate, and minor impacts refer to the high, moderate, and slight magnitude codes specified by the U.S. EPA guidance for the 305(b) report.

	1988-1992 305(b) Cycles		
Causes	Major Cause	Moderate Cause	Minor Cause
Metals	86	119	10
Priority organics	4	53	133
Organic enrich. / DO	—	46	—
Nutrients	—	31	4
Other inorganics	—	—	4

1 Miles counted add to more than total miles because more than one source can be major, moderate, or minor in a segment.

Figure 4-6. Conceptual model of the response of the fish community as portrayed by the Index of Biotic Integrity and other community metrics with narrative descriptions of impact types and corresponding narrative biological performance expectations.

Map 4-1. Map showing categories of dissolved oxygen (mg/l) concentrations based on Ohio EPA intensive survey data from 1989 to 1993. Larger points indicate lower (= more severe) dissolved oxygen concentrations.

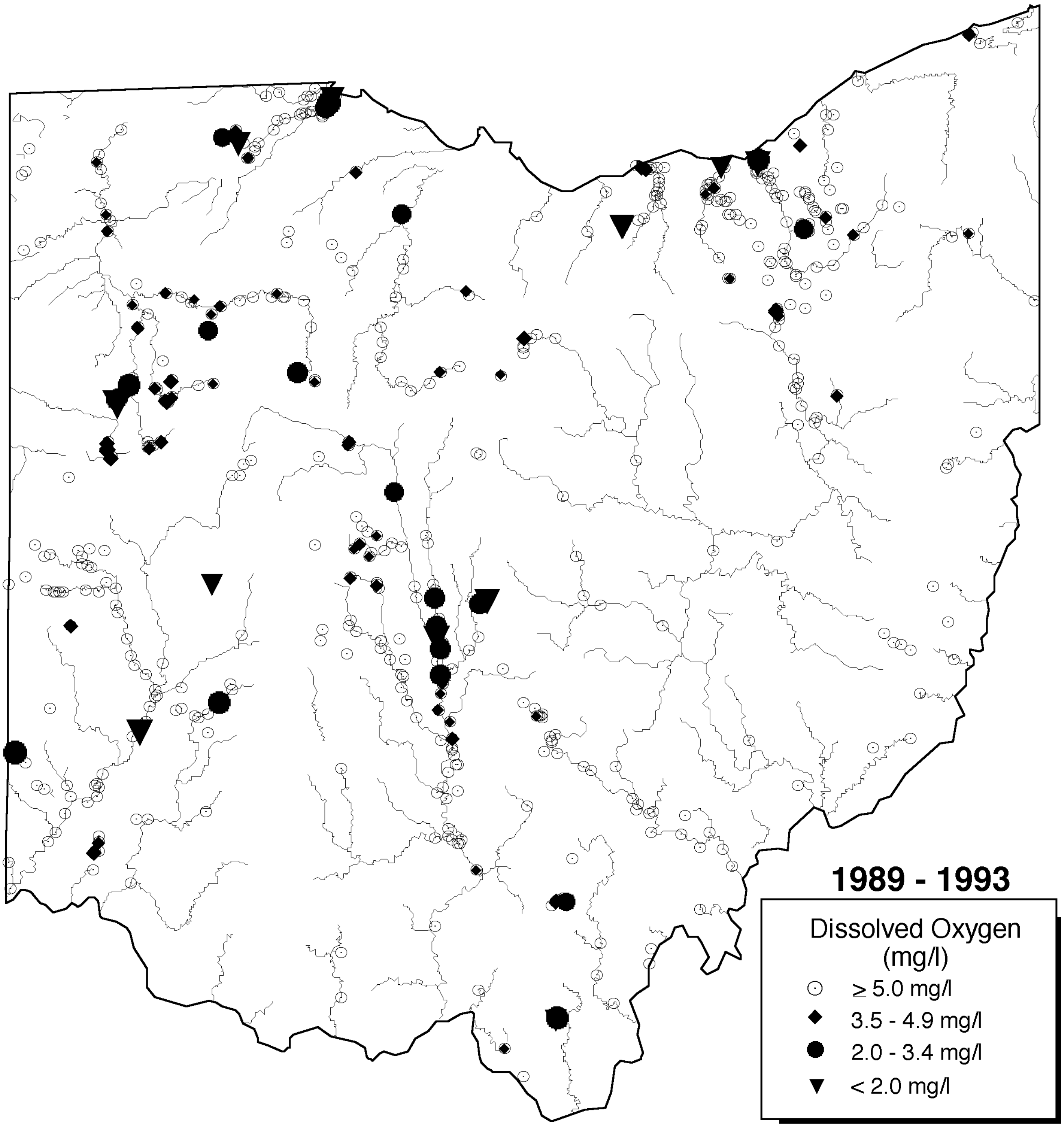


Table 4-8. Relative assessment of sources of impairment (i.e., acres[1]) causing partial and non-support of designated uses in Ohio Lake Erie shoreline. Major, moderate, and minor impacts refer to the high, moderate, and slight magnitude codes specified by the U.S. EPA guidance for the 305(b) report.

	1988-1992 305(b) Cycles		
Causes	Major Cause	Moderate Cause	Minor Cause
Point Sources	24	281	8.1
Nonpoint Sources	46	40	—
In-place Contaminants	—	15	18
Land Disposal	20	4	—
Other	—	15	15

[1] Miles counted add to more than total miles because more than one source can be major, moderate, or minor in a segment.

"The characteristics of many classes of impacts on aquatic life are predictable, and often offer diagnostic insight into the source or cause of a pollution problem..."

In this section, references will be made to the type of effects various that various causes have on aquatic life. The characteristics of many classes of impacts on aquatic life are predictable, and often offer diagnostic insight into the source or cause of a pollution problem (Yoder 1991b). Yoder (1991b) discussed some patterns in the biological data that were related to classes of impairment along a gradient of increasing severity of impact (Figure 4-6). This figure outlines the conceptual model of the response of aquatic life to environmental perturbations. Identification of the relationship between general impact types and this model has provided insights into the mechanisms through which different classes of pollutants act.

Specific discussions of the causes and sources responsible for impairment, or threatened impairment, in lakes, ponds, and reservoirs are covered in Volume III. Throughout this discussion, however, many of the same causes and sources that affect streams and rivers, especially those originating from nonpoint sources, also apply to lentic systems. The Ohio EPA Nonpoint Source Assessment (Ohio EPA 1990b) also summarizes threats and impacts to Ohio's public lakes.

Municipal Wastewater Treatment Plants

Ohio has hundreds of permitted municipal wastewater treatment plants (WWTP) that have discharges into Ohio surface waters. There are many smaller, unpermitted

WWTP discharges. Of the NPDES permitted discharges, 223 are considered *major* discharges based primarily on effluent volume and other characteristics. The remaining discharges are termed "minors", of which a few are termed "significant minors." Although many major WWTPs serve large metropolitan areas (*i.e.*, Cleveland, Columbus, Cincinnati, Akron, Toledo, and Dayton) smaller cities are also served by major WWTPs (Map 4-1).

The abatement of past WWTP impairments through upgraded treatment facilities is responsible for the greatest improvements in the integrity of Ohio surface water resources in the 1980s. However, this source also remains responsible for much of the remaining impairment to aquatic life uses. For example, based on the 1990 through 1994 305(b) cycles, municipal WWTPs are the principal source of impairment in 1508 miles of Ohio streams and rivers (30.7% of all impaired waters, major magnitude sources only, see Fig. 3-6). For small WWTPs, poor operation and maintenance is often responsible for the remaining impairments. At the larger, major municipal WWTPs the periodic inability to adequately treat peak flows during storm events (most Ohio cities have combined storm and sanitary sewer systems) leads to plant bypasses, and significant combined and sanitary sewer overflow problems.

"The abatement of past WWTP impairments through upgraded treatment facilities is responsible for the greatest improvements in the integrity of Ohio surface water resources in the 1980s."

Organic Enrichment/Dissolved Oxygen

In examining the agents of impact related to inadequate municipal wastewater treatment, conventional compounds (*i.e.*, oxygen demanding substances) and unionized ammonia-N are the primary causes of aquatic life use impairment. The effects related to the impairment caused by these substances ranges from an altered diel dissolved oxygen regime and "subtle" shifts in aquatic community composition and function (*e.g.*, reductions of sensitive species, increases in omnivores, etc.) to seriously depleted dissolved oxygen, acutely toxic unionized ammonia-N concentrations, and aquatic communities with only a few tolerant species and high rates of external fish anomalies (see Figure 4-6). These wide ranging impacts are lumped together as "organic enrichment / dissolved oxygen" causes, much of which is related to inadequate wastewater treatment. These were important influences in more than 2217 miles of impaired or partially impaired streams and rivers (45.2% of all impaired miles, down from 49% in the 1990 cycle). This was the number one cause (high [H] or moderate [M] magnitude) of impaired or partially impaired aquatic life uses listed in the 1988, 1990, and 1992 Ohio Water Resource Inventories.

An analysis in the 1990 305(b) report (Ohio EPA 1990a) showed that the severity of dissolved oxygen impacts caused by WWTP discharges was generally greater than that caused by nonpoint sources. As illustrated in Map 4-1, locations with low median dissolved oxygen levels tend to be concentrated in the larger urban areas and cities where most of the large WWTPs are located.

Ammonia

Unionized ammonia-N concentrations likewise remain as a principal cause of impairment to aquatic life uses. Although ammonia-N dropped from the 3rd leading major cause of impairment in 1988 to 4th in 1992, the aggregate extent of impairment (555 miles) is still significant.

Industrial Discharges

"...large amounts of toxic substances were discharged untreated or poorly treated into Ohio's streams and rivers."

Ohio has a large and diverse industrial manufacturing base. A by-product of this activity, however, is the need to dispose of a variety of waste substances, some of which are toxic. Prior to the development of contemporary water quality regulations, large amounts of toxic substances were discharged untreated or poorly treated into Ohio's streams and rivers. With the passage of the Clean Water Act amendments of 1972 a permitting system (National Pollution Discharge Elimination System) was established to reduce and regulate the pollutants that an entity may discharge. The quality of many Ohio rivers (*e.g.*, Mahoning River, Black River, Cuyahoga River, Ottawa River) has been historically degraded (some quite severely) by the discharge of industrial pollutants. While there have been substantial improvements in industrial waste water treatment in Ohio (see Trend section for improving conditions in large rivers), there are still many rivers and streams in that have poor and very poor biological performance which is related, at least partly, to industrial discharges (see Table 4-3).

Aquatic communities impacted by the toxic effects of industrial pollutants generally elicit a characteristic response which includes the following combination (see Figure 4-5); low species or taxa richness predominated by tolerant forms, very low abundance, high rates of anomalies on fish (*i.e.*, eroded fins, lesions, tumors, and deformities) and macroinvertebrates (deformed head capsules, etc.), and IBI and ICI scores in the poor and very poor ranges. This is a response signature of a complex mixture of toxic impacts that usually includes one or more industrial sources (Yoder 1991b). A map of locations where rates of anomalies greater than 5% (see Map 5-2) on fish shows that the occurrences are clustered near locations of heavy industrial development and impact.

"...heavy metals are responsible for approximately four to five times as many impaired miles as priority organics..."

Metals

Of the priority pollutants that impair aquatic life uses in Ohio surface waters and that are largely related to industrial sources, the heavy metals are responsible for approximately four to five times as many impaired miles as priority organics (high magnitude causes; Table 4-1). The subbasins most heavily impacted by heavy metals are those in the vicinity of major industries and large urban areas, especially in the Erie / Ontario Lake Plain ecoregion. Metals are discharged in both industrial and municipal effluents as well as in combined sewer overflows (CSOs) and urban runoff. There has been a declining trend, however, in the relative contribution of metals to statewide use impairment. Between 1988 and 1992, metals dropped from the third leading cause of non-attainment to fifth in terms of the proportion of miles impaired or partially impaired, but moved back to third in 1994. This was due to the more rapid restoration in impairments caused by ammonia and not due to an increase in metals. Highly elevated and extremely elevated concentrations of metals in sediments (see Map 5-1 in Section 5) are also clustered near cities that have or have recently had heavy industry (*e.g.*, Canton, Massillon, Youngstown, Cleveland, Lima, and Toledo). Rivers near large cities that do not have as extensive of a base of heavy industry (*e.g.*, Columbus and Dayton) generally have fewer sites with heavily contaminated sediment.

Priority Organics/Unknown Toxicity

Priority organic compounds and unknown causes of toxicity in streams and rivers are often associated with industrial processes. Recently there has been much emphasis on using whole effluent toxicity as a means to improve their control. Priority organics and unknown toxicity are most often found in regions with high population density and heavy industry such as the urban centers of the Erie-Ontario Lake Plain ecoregion. With the large number of complex and exotic chemicals now used in industry, it will be increasingly important to retain and increase our ability to identify toxic problem areas (*i.e.*, "hot spots") in surface waters. An integrated approach that incorporates instream assessments of aquatic communities, measures of whole effluent toxicity, traditional water quality and sediment chemistry measures, and some of the emerging diagnostic techniques (*e.g.*, biomarkers; see Section on Ohio EPA / U.S. EPA Biomarker research program), is the most cost effective and complete way currently available to *accurately* characterize areas where toxic pollution *is a problem*. More information on specific toxics problems is provided in Section 5.

"...impairment caused by CSOs is often interactive with municipal, industrial, and/or urban runoff impacts."

Combined Sewer Overflows (CSOs)

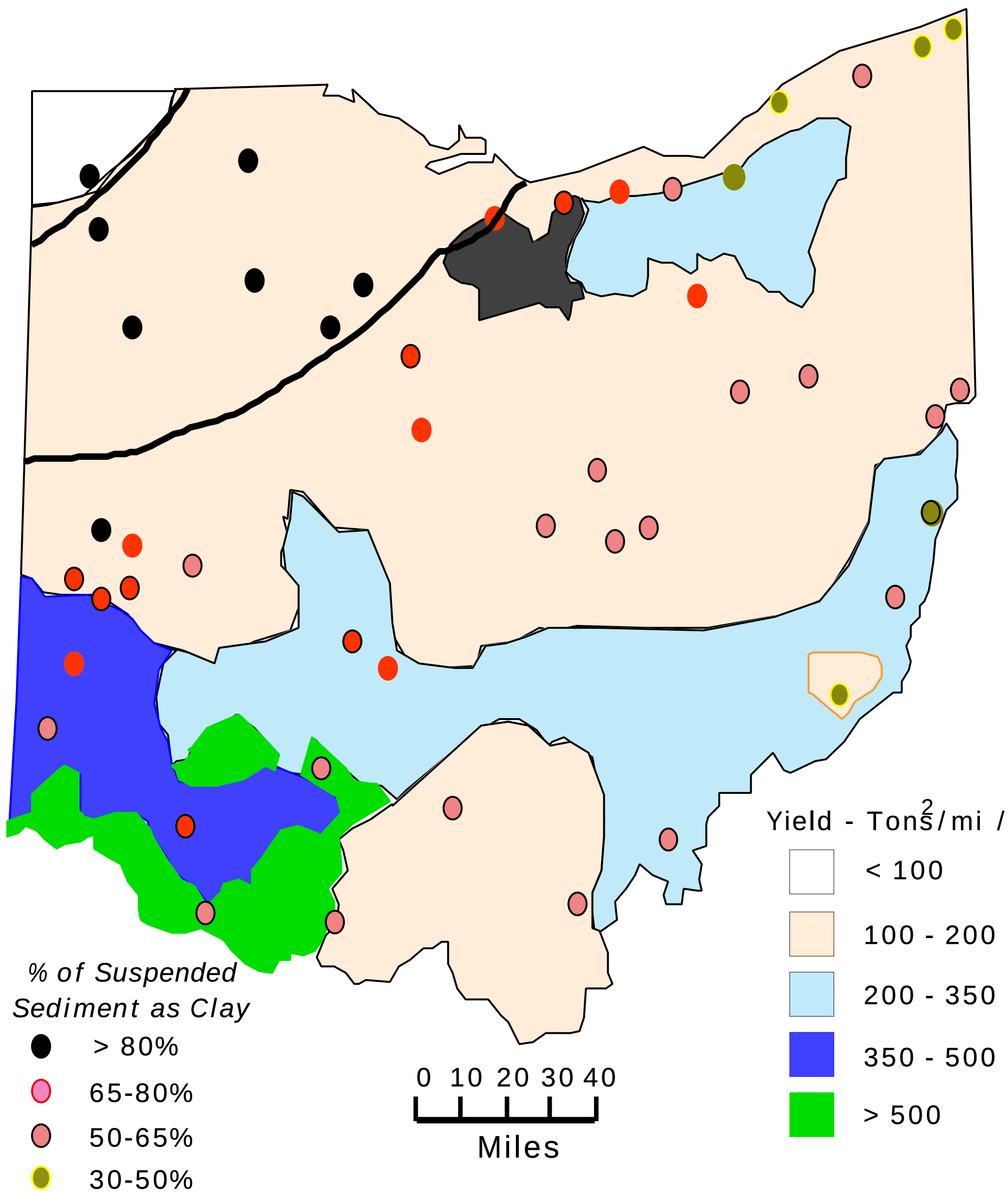
Aquatic life use impairment caused by CSOs is often interactive with municipal, industrial, and / or urban runoff impacts. Aquatic life responses to the influences of CSOs may differ depending on whether toxics discharged into the sanitary sewer system enter the surface water body via the CSOs. Biological response signatures generally include very high macroinvertebrate densities combined with single digit ICI scores (Yoder 1991b). Fish community response signatures can include elevated anomalies combined with mid-range IBI and MIwb scores indicative of organic enrichment. If toxic substances enter via the CSOs, the response signature will tend to resemble those just described for complex toxic impacts. Physical impacts can include sewage sludge and solids deposits which are delivered to the stream or river during overflow events. This is often exacerbated by impoundments that are frequent on the rivers and streams in most Ohio cities.

ADS, Inc. (Peter Keefe, personal communication) estimates that there are more than 2,000 CSOs in Ohio (this does not include sanitary overflows and bypasses that may outnumber CSOs by a factor of 10). Of these 2,000 CSOs, more than 360 are estimated to have dry weather discharges due to plugging, inadequate maintenance, inadequate size and design, failure of mechanical parts, or some other malfunction. Point source control efforts and regulations have historically concentrated on the control of direct WWTP effluents. However, U.S. EPA is now attempting to address CSO problems.

CSOs are a major or moderate magnitude source of impairment in 248 miles of the streams and rivers monitored by Ohio EPA. Often, CSO impacts are masked by existing impacts from industrial effluents or, more frequently, by WWTP discharges. One example of this phenomenon is the Scioto River downstream from Columbus. In the late 1970s the full extent of the impact from the Whittier Street CSO (approximately 90% of all CSO flow and load in Columbus) and other CSO discharges could not be distinguished from the impacts from the two Columbus WWTPs. As the impact from these two WWTPs has lessened, the impact from these CSOs has become more apparent.

Using a prescriptive approach to identify CSO abatement needs, U.S. EPA estimates substantial capital costs to control CSO discharges ($10-18 billion in Ohio; more than $100 billion nationally). Given this cost estimate regulatory agencies need to consider ways to (1) better identify and characterize the individual CSOs that are causing significant impacts, and (2) find alternatives to treating all of the flow in each CSO. A well designed monitoring approach that includes evaluation of both the ambient aquatic communities and the sewer system, particularly the sanitary side (P. Keefe, pers. comm.), will lead to a more accurate identification of the CSOs that have the most serious impacts and ultimately more cost-effective abatement strategies. This could result in substantial reductions (40-50% in Ohio)

Map 4-2. Map showing sediment yield in Ohio in tons/sq mi/year and percent clay in the suspended sediment. Map was modified from Antilla and Tobin (1978).



in CSO abatement costs that far outweigh the initial increase in up-front monitoring costs.

The impacts of CSOs and urban stormwater runoff must be considered beyond potential effects on the water column. The most important effects on aquatic life are the *cumulative* result of what each individual CSO and runoff event leaves behind, not merely what happens to water column chemistry during an event. In addition, many areas impacted by CSOs are simultaneously impacted by habitat modifications (*e.g.*, impoundments, riparian encroachment) and flow alterations. In Ohio, water withdrawals for public water supply purposes often occur just upstream from the CSO discharge area, which leaves little flow for the dilution and dispersal of pollutants. In combination with the previously mentioned habitat modifications, this can result in an enrichment that is not unlike a lake eutrophication effect in the pools of the receiving stream or river. Thus evaluating the effects of CSO discharges is complex, site specific, and requires ambient monitoring and other information beyond water column chemistry alone.

"...evaluating the effects of CSO discharges is complex, site specific, and requires ambient monitoring and other information beyond water column chemistry alone."

Agriculture

Agriculture is one of the largest and most dispersed industries in Ohio. Although agricultural impacts often receive attention as a principal cause of aquatic life impairment, much of the degradation is directly linked to poor agricultural practices and not merely the presence of farming. Many of Ohio's exceptional warmwater streams and rivers (Big and Little Darby Creeks, Twin Creek, Stillwater River, Kokosing River, etc.) have watersheds with land use predominated by agricultural activities. These streams have remained essentially intact because *the adjacent riparian vegetation and stream habitat have not been extensively degraded or encroached upon,* at least to the degree that has occurred in other regions of the State. Streams and rivers that have an adequate riparian buffer zone (vegetated with *woody plants* in lieu of grass filter strips) and instream habitats possess the ability to "assimilate" the runoff from agricultural land use, provided it is not a limiting factor.

"Streams and rivers that have an adequate riparian buffer zone...and instream habitat possess the ability to "assimilate" ...runoff from agricultural land use..."

"It is likely that the present estimates of impairment related to agricultural sources has been under estimated..."

Agricultural activities that have the greatest impacts on aquatic life include riparian vegetation degradation and removal, direct instream habitat degradation via channelization and other drainage improvement activities, sedimentation and siltation caused by stream bank erosion (which is strongly linked to riparian encroachment), and land use activities that result in and / or accelerate rill, gully, and sheet erosion. Acute or even chronic effects on aquatic life from normal pesticide usage are rare in Ohio compared to the other agricultural causes of impairment. However, there is concern about the impacts of pesticides on public water supplies in the agricultural regions of Ohio. Agriculture (and its impacts) is the most intensive land use activity in the HELP ecoregion, followed by the ECBP and then the EOLP , IP, and WAP, the latter of which is the most heavily forested ecoregion of Ohio. Statewide, agricultural sources are responsible for impairment (major and moderate magnitude sources) in more than 1400 miles of streams and rivers and more than 30,000 acres of lakes, ponds, and reservoirs (Tables 4-1 and 4-5). Agricultural activities also threaten existing use attainment in 169 miles of streams and rivers (up from 11 miles in the 1992 report) and may be a potential problem in more than 11,000 miles of streams and rivers that have not yet been evaluated with monitored level information (Ohio EPA 1991, 1992). It is likely that the present estimates of impairment related to agricultural sources has been under estimated primarily because monitored level assessments have been directed to streams and rivers impacted by point sources and urban impacts.

"Sedimentation resulting from agricultural activities is undoubtedly the most pervasive single cause of impairment from nonpoint sources."

Sedimentation and Siltation

Sedimentation resulting from agricultural activities is undoubtedly the most pervasive *single* cause of impairment from nonpoint sources. This cause is responsible for more major / moderate impairment (over 1500 miles of stream and rivers and 15,000 acres of lakes, ponds, and reservoirs) than any other cause except organic enrichment, with which it is closely allied in agricultural areas. If the monitored level database was distributed equally across the state, sedimentation would likely be the leading cause of impairment in terms of stream and river miles.

Sediment deposition in both lotic and lentic environments is a natural process. However, it becomes a problem when it exceeds the ability of the system to "assimilate" any excess delivery. Sediment deposited in streams and rivers comes primarily from stream bank erosion and in runoff from upland erosion. The effects are much more severe in streams and rivers with degraded riparian zones. Given similar rates of erosion, the effects of sedimentation are much worse in channel modified streams than in more natural, intact habitats. In channel modified streams the incoming silt and sediment remains within and continues to degrade the stream channel, instead of being deposited in the immediate riparian "floodplain." This also adds to and increases the sediment bedload that continues to impact the substrates long after the runoff events have ceased. Thus to successfully abate the adverse impacts of sediment we need to be concerned with what each event leaves behind amd also what takes place in the water column during each event.

"...the effects of sedimentation are much worse in channel modified streams than in more natural, intact habitats."

The effects of siltation on aquatic life are the most obvious in the ecoregions of Ohio where: (1) erosion and runoff are moderate to high, (2) clayey silts that attach to and fill the interstices of coarse substrates are predominant, and (3) streams and rivers lack the ability to expel sediments from the low flow channel which results in a longer retention time and greater deposition of silt in the low flow channel.

Estimates of gross erosion *alone* are not necessarily correlated with adverse impacts to aquatic communities, although this is a criterion for setting priorities for nonpoint source management efforts. Map 4-2 illustrates sediment yields in tons/mi^2/year across Ohio and the percentage of clay in suspended sediment samples estimated by USGS (Antilla and Tobin 1978). Some of the areas of Ohio (Map 4-2) that have the highest rates of gross erosion (*e.g.*, Interior Plateau and W. Allegheny Plateau ecoregions) have some of the most diverse and functionally healthy assemblages of aquatic life at least impacted reference and other sites (see Map 4-8). Many streams in these ecoregions have essentially intact riparian and instream habitat and thus are "insulated" against the naturally erosive conditions. The detrimental effects of sedimentation seem worst in the state where the proportion of clayey silts are highest, stream gradient is the lowest, and riparian encroachment and

"Estimates of gross erosion alone are not necessarily correlated with adverse impacts to aquatic communities..."

modification are extensive (*i.e.*, HELP and parts of the ECBP ecoregion). The direct effects of silt and sediment on aquatic life include substrate embeddedness that reduces the habitat space for macroinvertebrates and eliminates spawning habitat for fish.

"Nutrients that are delivered along with the sediment can result in major shifts in the trophic dynamics of aquatic ecosystems..."

Nutrients delivered along with sediments can result in major shifts in the trophic dynamics of aquatic ecosystems (see Figure 4-5). In lakes, high rates of sedimentation reduce lake volume and habitat, increase turbidity, and contribute to accelerated eutrophication.

Trautman (1981) believed that siltation was the most pervasive pollutant in Ohio. He related the reduction of many fish species in Ohio to deforestation, an increase in the intensity of farming, and the resultant increased silt load from each. For some species, the reduction in the distributional range is especially striking. For example, the bigeye chub (Figure 4-7) was at once ubiquitous throughout much of Ohio (Map 4-3 Left), and was widely distributed throughout the Huron/Erie Lake Plain ecoregion. Trautman (1981) reported a widespread decline in range and abundance through the 1970s. Data from Ohio EPA and other agencies during the period 1979-1991 indicates that this decline has continued and that viable populations occur in only a few, isolated locations (Map 4-3 Right; compiled from data collected by Ohio EPA, ODNR, OSUMZ and ODOT). Since 1980 the bigeye chub has been found only in a few disjunct watersheds where the riparian buffer is intact enough to minimize bank erosion and the delivery of sediment and clayey silts and water flow is essentially permanent. In such streams and rivers, clean sand and fine gravel remain in pools and riffles and there is the presence of cool, clear water. Most of the locations with strong populations occur near geological features such as escarpments, the glacial boundary, large end moraines, and the old Lake Erie beach ridges. These areas provide the optimum habitat for this and other similarly intolerant fish species. Areas of less optimal and marginal habitats have presumably become uninhabitable because of the excessive external inputs of detrimental substances and/or habitat loss.

The rosyface shiner and southern redbelly dace are two other fish species that have shown significant decline. Like the bigeye chub, the rosyface shiner (*Notropis rubensis*) has virtually disappeared from the HELP ecoregion and certain subregions of the ECBP (Map 4-4). The rosyface shiner was widely distributed in the Sandusky and Auglaize River drainages even into the 1950s, but has been essentially eliminated from these systems. Like the bigeye chub, this species has been extirpated from waters where agricultural and other land uses have encroached on the riparian areas enough to destroy habitat and increase siltation and turbidity.

"...16 additional species ... are in the process of significant declines...",

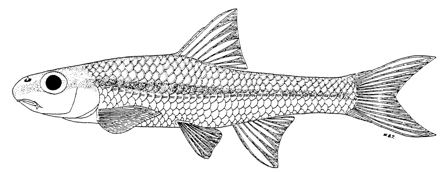


Figure 4-7. Line drawing of the bigeye chub (Notropis amblops) from Trautman (1981).

The decline of the southern redbelly dace, an inhabitant of small, high-quality headwater streams, has been piecemeal (Map 4-5). Many small streams have been severely altered through channelization for drainage and flood control or have had their woody riparian vegetation removed or encroached upon, extirpating populations of these species. Without nearby refugia for recolonization, many of these streams have lost populations of this species permanently, especially as more of a watershed is affected. The Chagrin River basin, which has had tremendous growth recently has lost most of its populations of this species (Map 4-5).

"Other groups of aquatic organisms such as the freshwater naiad mollusks have also shown substantial and even precipitous declines."

In contrast to the sensitive species discussed above, there has been an expansion of the distribution of some species tolerant to turbidity, degraded habitats, and nutrient enrichment. Goldfish and carp x goldfish hybrids, rare in high quality streams, have greatly increased their distribution near (1) urban/suburban population centers, (2) impoundments, and (3) areas with excessive nutrient enrichment (Map 4-6). The presence of this species and its hybrid is related to relaxed competition and predation in degraded streams and deposits of fines and organic sediments in pools and impounded areas. The emerald shiner is another turbidity tolerant species that has extended its range up major rivers that have had decreased transparency due to increased siltation/sedimentation and nutrient enrichment (Map 4-7). Trautman (1981) documented the eastward expansion of two silt and turbidity-tolerant plains-type species, the suckermouth minnow (*Phenacobius mirabilis*) (Map 4-8) and the orangespotted sunfish (*Lepomis humilis*) (Map 4-9) into turbid, silty

Ohio streams that were previously clean-bottomed and clear. These species have, since Trautman's (1981) work, expanded their range even into the Muskingum drainage, which Trautman (1981) felt may be resistant to invasion because of their glacial-outlet characteristics.

"Aquatic organisms have the ability to integrate and reflect the sum total of all disturbances in watersheds."

While the demise of this single species might seem trivial or of little direct economic consequence, it should be noted that this species presently *is not* listed on any of the Ohio DNR rare, endangered, threatened, or special status lists. In addition, many other once widely distributed Ohio fish species have also declined because of siltation, sedimentation, riparian habitat alteration, and watershed modifications (includes the drainage of wetlands), which changes the hydrologic regime, while far fewer species have benefited from these changes (Table 4-8). Of the 41 species listed by Ohio EPA as *extremely intolerant* or *intolerant to sensitive*, 25 are listed as endangered, threatened, or special status by the Ohio DNR, Division of Wildlife. This leaves 16 *additional* species that are in the process of significant declines, some of which are occurring more rapidly than others. Fish species that depend on clean, silt free substrates, the continuous presence of good quality water, good instream cover, and headwaters habitats seem to be most seriously affected. Presently the Ohio DNR, Division of Wildlife lists 25 species as endangered, 8 species as threatened, 13 species as special interest, 5 as extirpated, and 2 as extinct. This represents more than 30% of the Ohio fish fauna. This fraction is increased to more than 40% if the additional 16 declining species from Table 4-7 are included. If introduced species and those species that are on the fringe of their natural range are excluded, these percentages become even higher.

Other groups of aquatic organisms such as the freshwater naiad mollusks have also shown substantial and even precipitous declines. Certain species of macroinvertebrates, such as the mayfly *Stenonema mediopunctatum*, were undoubtedly more widely distributed and are now only found in abundance in streams and rivers with sufficient gradient to prevent silt from depositing in riffles and runs (see Map in 1992 report). These patterns are not encouraging and are potentially

***Map 4-3.** Historical distribution of the bigeye chub (Notropis amblops) in Ohio (Trautman 1981) compared to recent collections during the period from 1978 to 1994 (based largely on collections made by Ohio EPA, ODNR-Natural Areas and Preserves, ODNR-DOW, and Ohio DOT).*

Map 4-4. Historical distribution of the rosyface shiner (Notropis rubellus) in Ohio (Trautman 1981) compared to recent collections during the period from 1978 to 1994 (based largely on collections made by Ohio EPA, ODNR-Natural Areas and Preserves, ODNR-DOW, and Ohio DOT).

Map 4-5. Historical distribution of the southern redbelly dace (Phoxinus erythrogaster Rafinesque) in Ohio (Trautman 1981) compared to recent collections during the period from 1978 to 1994 (based largely on collections made by Ohio EPA, ODNR-Natural Areas and Preserves, ODNR-DOW, and Ohio DOT).

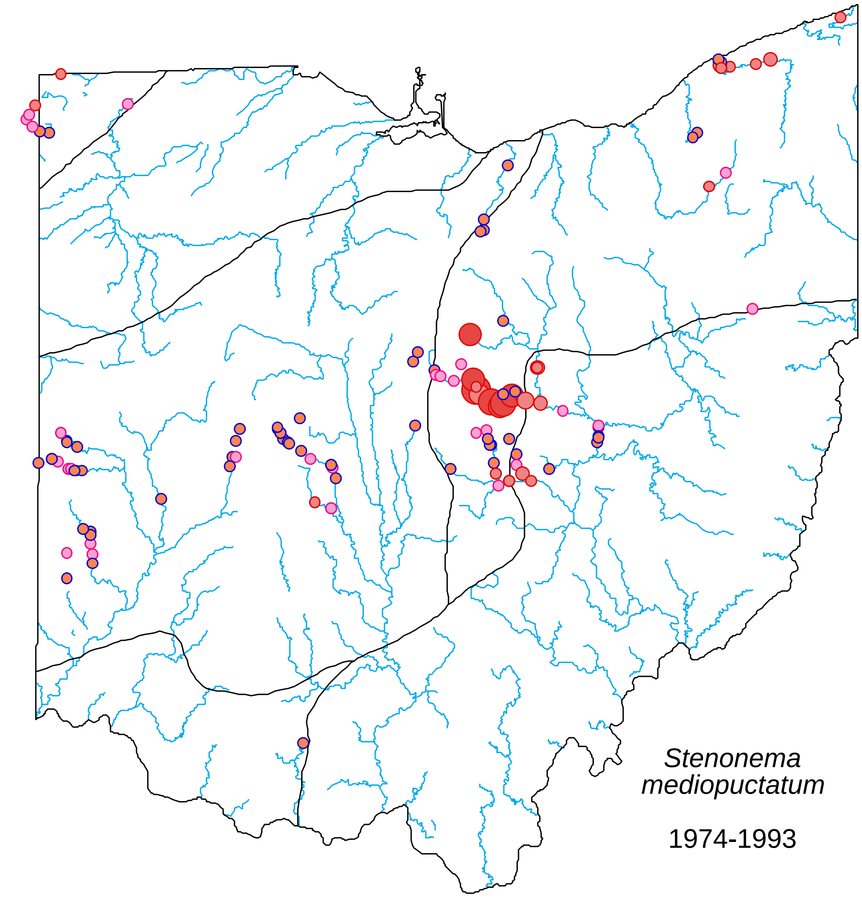
***Map 4-6.** Historical distribution of the goldfish (Carassius auratus) and carp X goldifsh hybrids in Ohio (Trautman 1981) compared to recent collections during the period from 1978 to 1994 (based largely on collections made by Ohio EPA, ODNR-Natural Areas and Preserves, ODNR-DOW, and Ohio DOT).*

Map 4-7. Historical distribution of the emerald shiner (Notropis atherinoides) in Ohio (Trautman 1981) compared to recent collections during the period from 1978 to 1994 (based largely on collections made by Ohio EPA, ODNR-Natural Areas and Preserves, ODNR-DOW, and Ohio DOT).

Map 4-8. Historical distribution of the suckermouth minnow (Phenacobius mirabilis) in Ohio (Trautman 1981) compared to recent collections during the period from 1978 to 1994 (based largely on collections made by Ohio EPA, ODNR-Natural Areas and Preserves, ODNR-DOW, and Ohio DOT).

Map 4-9. Historical distribution of the orangespotted sunfish (Lepomis humilis) in Ohio (Trautman 1981) compared to recent collections during the period from 1978 to 1994 (based largely on collections made by Ohio EPA, ODNR-Natural Areas and Preserves, ODNR-DOW, and Ohio DOT).

Map 4-10. Distribution of Stenonema mediopunctatum, a sensitive mayfly that occurs in Ohio and that has declined in response to large-scale land use changes.



"The key to halting and eventually reversing these trends first lies in recovering degraded riparian zones..."

symptomatic of other environmental problems that could eventually emerge to affect more direct human uses of surface waters.

Aquatic communities are not only indicators of acceptable environmental conditions for themselves, but also indicate that the water resource is of an acceptable quality for wildlife and human uses. Aquatic organisms have the ability to integrate and reflect the total of all disturbances in a watershed. While individual disturbances themselves may seem trivial, the aggregate result of these individual impacts emerges as a degraded and declining fauna on a major watershed scale. The key to halting and eventually reversing these trends first lies in recovering degraded riparian zones, properly managing watersheds for local impacts (includes land use activity set-backs, wetland preservation and restoration), and minimizing silt and sediment runoff from *all* upland land use activities, not just agriculture alone.

*Table 4-9. General tolerance and current population status of selected Ohio fish species relative to the impacts of sedimentation, habitat degradation, and watershed manipulation. Population status codes: (**D**) - Declining; (**I**) - Increasing; (**Ex**) - Extinct; (**E**) - Extirpated from Ohio.*

Extremely Intolerant	***Intolerant to Sensitive***	***Moderately to Highly Tolerant***
No. Brook Lamprey (D)[E]	Silver Lamprey (D)[T]	Common Carp (I)
Pugnose Minnow (D)[E]	Goldeye (D)[S]	Goldfish (I)
Pugnose shiner (E)[E]	Least Brook Lamprey (D)	Suckermouth Minnow (I)
Popeye Shiner (D)[E]	Hornyhead Chub (D)	Creek chub (I)
Bigeye Shiner (D)[E]	River Chub (D)	Fathead Minnow (I)
Blacknose Shiner (D)[E]	Tonguetied Minnow (D)[E]	Bluntnose Minnow (I)
Blackchin shiner (D)[E]	Rosyside Dace (D)[T]	Emerald shiner (I)
Blue Sucker (D)[E]	Redside Dace (D)	White Sucker (I)
Harelip Sucker (Ex)[E]	Northern Bigeye Chub (D)	Yellow Bullhead (I)
Northern madtom (D)[E]	Ohio Streamline Chub (D)	Black bullhead (I)
Mountain Madtom (D)[E]	Eastern Gravel Chub (D)	Green sunfish (I)
Scioto Madtom (E)[E]	Speckled chub (D)[S]	Orangespotted Sunfish (I)
Spotted Darter (D)[E]	Rosyface Shiner (D)	
Gilt Darter (E)[E]	Rosefin Shiner (D)	
Crystal Darter (E)[E]	Mimic Shiner (D)	
	So. Redbelly Dace (D)	
	Black Redhorse (D)	
	Greater Redhorse (D)[E]	
	River Redhorse (D)	
	Slenderhead Darter (D)[S]	
	Eastern Sand Darter (D)[S]	
	Variegate Dater (D)	
	Bluebreast Darter (D)[T]	
	Tippecanoe Darter (D)[T]	
	Least Darter (D)	

[E] Designated as an endangered species by Ohio DNR, Division of Wildlife.
[T] Designated as a threatened species by Ohio DNR, Division of Wildlife.
[S] Designated as a special interest species by Ohio DNR, Division of Wildlife.

"Nutrients are a major problem in Ohio's lakes, ponds, and reservoirs..."

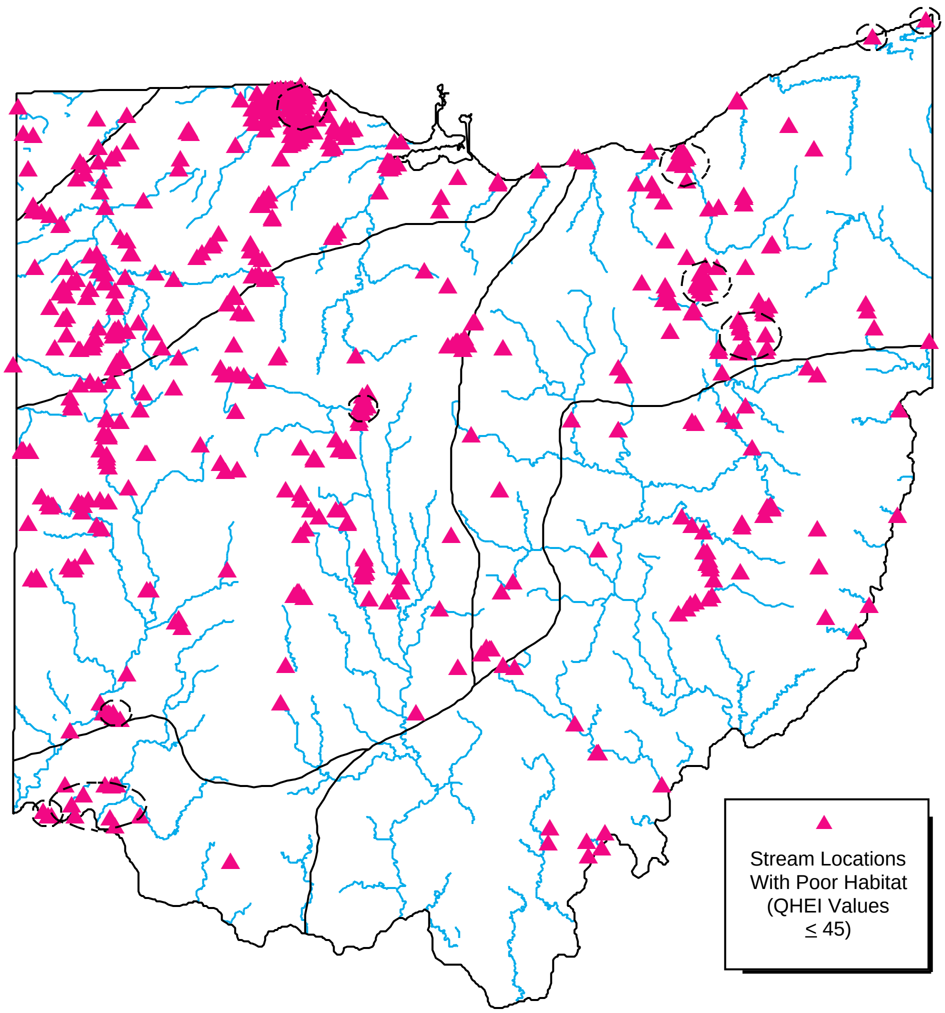
"Only streams with intact habitat can achieve the exceptional range of the IBI..."

Nutrient and Organic Enrichment

Another major impact from agricultural activities is organic enrichment from excessive nutrients delivered via runoff from fertilizer and organic wastes from livestock operations. The resulting impacts include a wide range of problems includ-

Map 4-11. QHEI (Qualitative Habitat Evaluation Index) scores ≤ 45 in Ohio. QHEI scores ≤ 45 generally indicate extensive habitat alterations. Circled points indicate locations affected by urban-industrial sources of habitat modification.

"The true extent of habitat degradation in Ohio is likely underestimated..."



ing severely depressed dissolved oxygen levels to indirect problems caused by greatly over-stimulated algal production. The aquatic community changes caused by nutrient enrichment and organic enrichment/low dissolved oxygen are summarized in Fig. 4-6.

Nutrients are a major problem in Ohio's lakes, ponds, and reservoirs and are responsible for the impairment of more than 22,000 acres (major and moderate magnitude impacts). Excessive nutrients in lakes also contributes to the greater than 10,000 acres with low dissolved oxygen in the hypolimnion (see Volume III for further discussion).

Although we have monitored a comparatively small proportion of the small streams impacted by agricultural sources, the data can be extrapolated in certain ecoregions. This is most apparent in the HELP, where most small streams are likely to have serious aquatic life degradation from a combination of organic enrichment from agricultural runoff, riparian encroachment, and channel modification. The important issue here is that the combination of these factors is responsible for the near universal historical degradation of aquatic life in the small streams in the HELP ecoregion. Only streams with intact habitat can achieve the exceptional range of the IBI and the map of EWH biological index scores illustrates well the habitat ravaged areas of Ohio.

Agricultural Related Habitat Modification

The modification of natural stream channels for agriculture drainage has undoubtedly resulted in some the most irretrievable impairments to aquatic life uses in Ohio. Habitat modification was the major cause of impairment in 732 miles of streams and rivers (Table 4-1, up from 639 miles in the 1992 report) making it the third leading cause of aquatic life impairment (Fig. 4-1). The true extent of habitat degradation in Ohio is likely underestimated, especially in the smaller rivers and streams of the Huron/Erie Lake Plain (HELP) and northern rim of the E. Corn Belt (ECBP) ecoregions. The streams of the HELP ecoregion have nearly all been deepened and straightened at least once to promote the subsurface drainage. This was accomplished largely in an area that once was a vast woodland swamp called the "Black Swamp." This activity has proceeded since the late 19th century and has had obvious and significant impacts on the indigenous biota, habitat, and water quality in the Maumee River drainage. Karr *et al.* (1985) reported that 44% of the fish species that once existed in Maumee River basin have either declined (26 species) or been extirpated (17 species), much of which is related to habitat loss.

Stream channelization reduces and eliminates pool depth, reduces habitat heterogeneity, increases the retention time for sediment in the stream channel, and reduces the retention time for water remaining in the channel. Streams channelized under the auspices of the Ohio Drainage Law (ORC 6131) are subject to routine "maintenance" activities which include herbicide application, tree removal, sand bar removal, and the snagging and clearing of accumulated woody debris. Although the latter are an important source of instream cover, it is believed to reduce the capacity of the channel to carry excess water. In addition, miles of stream are literally lost when streams are changed from sinuous, meandering channels to straight channels.

"In much of the HELP ecoregion productive row crop agriculture would not be possible unless sub-surface drainage is maintained."

In much of the HELP ecoregion productive row crop agriculture would not be possible unless sub-surface drainage is maintained. The intensity of agricultural activities in some areas, however, greatly exacerbates the negative effects of stream modification. Frequently, agricultural activities encroach on streams and rivers to the extent that the woody riparian buffer is reduced or eliminated. This results in destabilized stream banks, channel widening, and the eventual need for channel modifications. An inadequate riparian buffer also allows excess nutrients and sediments to runoff directly into streams (the effects of which were previously described).

Despite the negative effects of channel modifications, Ohio EPA has recognized that channel maintenance will likely keep certain streams, particularly those in the HELP ecoregion, in a permanently altered condition. These modifications will effectively prevent the attainment of the WWH biocriteria. Thus the Modified Warmwater Habitat (MWH) use designation was devised as a middle ground between the unattainable WWH use and the Limited Resource Waters (LRW). The MWH use also recognizes the reality of the Ohio drainage laws, the need for sub-surface drainage to support existing agricultural land uses, and the unlikelihood of any successful attempts to restore the original habitat in these waterbodies in the near future. The total miles of stream designated as MWH thus far (813 miles up from 134 miles in the 1992 report) is only 3.0% of the total designated stream miles. However, this use was only recently adopted (May 1990) and the number of stream miles assigned this use will increase as more segments are annually evaluated and reviewed.

"The MWH use also recognizes the reality of the Ohio drainage laws,... and the unlikelihood of any successful attempts to restore the original habitat in these waterbodies..."

In the ecoregions of Ohio other than the HELP, stream modification for sub-surface drainage is less widespread. Surface flooding is generally a more prevalent issue in these areas and workable alternatives to channelization are more likely to become available. The "need" for channel modifications in these areas is nearly always the result of adjacent land uses encroaching too closely to the stream or river channel. As the land use encroaches the "problems" with both direct and indirect by-products of the natural stream dynamics increase. Consequently, increasing external maintenance is needed to preserve the encroaching land use. This is a problem that is not unique to agriculture, but includes virtually every land use activity that occurs near Ohio streams and rivers. This may be one of the fastest growing water resource problems in the state.

"Maintaining and restoring good habitat quality is critical to maintaining diverse and functional assemblages of aquatic life in Ohio's streams and rivers."

Alternatives (*e.g.,* diking, avoidance, set backs, etc.) must be more vigorously pursued especially considering the environmental consequences of degraded habitat to aquatic communities (See Fig. 4-5). Maintaining and restoring good habitat quality is critical to maintaining diverse and functional assemblages of aquatic life in Ohio's streams and rivers. Intact aquatic habitats achieve higher biological index scores and are better able to resist and recover from point and nonpoint sources of pollution (Rankin 1989). Habitat protection and habitat restoration, however, are rarely considered in the assessment and management of point sources or as part of best management practices in reducing the effects of nonpoint pollution. This approach must undergo some significant change if we are to protect and restore impaired aquatic life uses that are principally due to these causes.

One step in this change is to recognize that stream and river habitat is wider than the wetted channel. Recent research has demonstrated the function of woody, streamside vegetation for processing excess nutrients and sediments that originate from adjacent land use activities. In the ecoregions of Ohio where the stream channel is composed of alluvial and glacial deposits, the stabilizing effect of woody vegetation is essential to not only maintaining instream habitat, but in the continual process of channel movement within the floodplain. Trees along streams and rivers are too often and inaccurately viewed as a liability, being thought responsible for constricting channel capacity and causing other problems. The subsequent removal of trees, however, is ultimately detrimental both to the aquatic habitat and to the adjacent land user. Increased bank destabilization and erosion resulting from the tree removal results not only in a wider, shallower lotic habitat with a reduced assimilative capacity, but in the outright loss of land to the greatly accelerated bank erosion.

"Good quality riparian buffer zones also provide critical habitat for many species of non-aquatic wildlife..."

Good quality riparian buffer zones also provide critical habitat for many species of non-aquatic wildlife and can act as corridors of migration for both aquatic and terrestrial species. Without these woody corridors, populations of these species could become isolated and become more prone to extirpation. This has certainly occurred for many populations of both aquatic and non-aquatic organisms in Ohio. Certain bird species are dependent on treed riparian areas for successful breeding. For example, the acadian flycatcher (Empidonax virescens) is a riparian zone "indicator" that requires approximately a 400-500 feet width of wooded area to nest successfully. The distribution of this bird species is correlated with the width of the wooded riparian zone along the mainstem. Such indicators, when used in combination with aquatic community information, provide a robust assessment of the health of the lotic ecosystem. It is this type of information that continues to reinforce the concept that streams and rivers must be protected as an ecosystem that includes the adjacent riparian zone beyond the wetted channel. Several publications provide useful information on protecting and restoring wooded riparian zones in Ohio (ODNR 1991, USDA 1991).

Other Land Use and Habitat Impacts

While much of the habitat degradation in Ohio streams and rivers is related to agricultural land use, many other activities contribute as well. Map 4-11 illustrates sampling locations across Ohio that have poor habitat quality as measured by the Qualitative Habitat Evaluation Index (QHEI; Rankin 1989). Although this map shows agriculture impacts on habitat, it also illustrates that habitat impacts related to suburban development, sewer line construction, dam construction, hydrological alterations, construction activities, mining, and silviculture are widespread.

Habitat degradation in urban and suburban areas often results when construction activities encroach on the stream channel and riparian vegetation is removed, and when channels are deepened and widened to increase channel capacity to more quickly disperse flood waters. Because of the high proportion of urban areas with impermeable surfaces, streams and rivers may experience increased fluctuations in flow especially when flow retention basins are poorly designed or not present. Such streams are usually characterized by a tolerant assemblage of organisms that can withstand the altered flow hydrograph, habitat modifications, and organic enrichment from urban runoff that results in increased algal production. This latter consequence takes place as the result of the combined effects of riparian vegetation removal, altered channel morphology, lack of flows during the summer months, and an excess of sediment and nutrients.

"Suburban development is one of the fastest growing threats to streams in Ohio."

Construction Activities

Construction activities have historically had significant effects on sedimentation largely through the comparatively vast amount of runoff that can originate from exposed soils without adequate erosion controls. This runoff can be several times greater than what is typical for other land uses. Recent stormwater regulations (November 1990) issued by U.S. EPA will likely require NPDES permits for certain construction activities. Many activities will fall under general permits related to: (1) construction activities, (2) surface coal mining, (3) and general industrial site runoff. These general permits will implement generic Best Management Practices (BMPs). The Ohio DNR, Division of Soil and Water has available training materials that demonstrate successful approaches to control of construction related run-off. A video training course "Keeping Soil on Construction Sites: Best Management Practices" is available from:

Ohio Federation of Soil &
Water Conservation Districts
Building E-2
Fountain Square
Columbus, Ohio 43224

(614)-265-6610

Suburban development is one of the fastest growing threats to streams in Ohio. This not only includes the direct impacts just described, but far field effects on larger mainstem rivers due to the export of sediment from construction sites located in the upper sections of tributaries. The most common habitat impairments that result from the export of clayey silts and sediment is the increased embeddedness of cobble and gravel substrates. This serves to eliminate interstices on which many benthic organisms and species of fish directly depend. This threat is the most serious in the streams and rivers designated as Exceptional Warmwater Habitat (EWH), State Resource Waters, and state scenic rivers.

In the Interior Plateau ecoregion a by-product of increasing suburban development additionally includes the routing of interceptor sewer lines to serve the expanded development. This has a devastating effect on the small, headwater streams of this ecoregion, particularly the high gradient streams in Hamilton and western Clermont Counties (Ohio EPA 1992).

Dams and Other Flow Alterations

The alteration of the hydrologic regimes of Ohio streams and rivers through dam construction, water withdrawals for public water supply purposes, canals, deforestation, and changes in landuse (*e.g.*, urbanization), have had, and continue to have profound effects on Ohio streams and rivers. The most popularly understood effect of dams is the interruption in migration patterns of fish species. However, other impacts of dams include habitat changes that eliminate obligate rheotactic species (*e.g.,* darters, some minnows, some suckers), alteration of the dissolved oxygen and temperature regimes downstream from dams (Robison and Buchanan 1988), and gravel starvation downstream of impoundments (Hill *et al.* 1991). This phenomenon is evident in several Ohio streams and rivers downstream from municipalities where low head dams deter the recovery of previously modified channels. This also has negative ramifications on the ability of these streams and rivers to assimilate organic wastes from CSOs and urban runoff.

"...low head dams deter the recovery of previously modified channels."

Hubbs and Pigg (1976) estimated that reservoirs in Oklahoma were a major proportion of the "hazard" to threatened fishes in that state. Dams on large, mainstem rivers generally have much greater impacts on system wide ecological integrity than dams located on headwater streams because: (1) they block access to more area of a basin or subbasin, (2) they are generally large and affect more river miles, and (3) large rivers are fewer in number than small streams (see Figure 2-1). Fortunately, in Ohio, most of the large reservoirs are on medium sized rivers and streams. However, navigation and low head dams are prevalent on Ohio's large rivers and have some of the same effects described above.

Water withdrawals can also have deleterious effects on streams and rivers depending on the timing and magnitude of the withdrawals. Regulations related to water withdrawals have focused on maintaining "minimum" flows required to protect some sensitive life stage of an aquatic organism (*e.g.*, spawning, young-of-the-year rearing areas, etc.). Recent work (Hill *et al.* 1991), however, indicates that protecting for minimum flows only may not adequately protect aquatic resources. Hill *et al.* (1991) discuss the importance of high flow events (within a regime of natural flows) for maintaining and creating diverse habitat conditions. They provided a list of seven possible watershed changes that occur when natural flood flows are reduced:

> "(1) valley floors no longer flood; (2) local water tables are no longer recharged; (3) stream bar and channel areas no longer become inundated and scoured; (4) sediment accretes on bars and channel edges; (5) side channels and backwater areas become disconnected from the main channel or abandoned by the mainstem as they fill in; (6) tributary channel confluences with mainstems locally aggrade and push out into the main channel; and, (7) the ratio of pools to riffles is significantly altered."

Although this research was primarily directed rivers of the western U.S., many warmwater streams and rivers in Ohio exhibit some of the negative attributes described above as a result of man-induced flow changes. Most at risk to these types of hydrological changes are EWH and other high quality streams and rivers. EWH waters such as Big Darby Creek contain strong populations of threatened and endangered species of fish, mollusks, etc. These species occur precisely because of the presence of the specific habitat types that would undoubtedly be changed if large quantities of water were withdrawn during high flows. Unfortunately, the reduction and loss of sensitive species in many other parts of the state indicates that water withdrawals from EWH streams would likely result in the reduction or loss of such species. This adds a new consideration to the siting of new surface water supplies including upground reservoirs. The attenuation of peak flows due to water withdrawals is not unlike the previously discussed effects of dams in deterring downstream channel recovery.

Interceptor Sewer Construction

The elimination of wastewater flows from small, package WWTP discharges to small, headwater streams has generally been accomplished by the regionalization of those flows. This option has been viewed as more desirable than upgrading and operating the small package WWTPs. The consolidation of sanitary wastewater flows into a single location not only eliminates many pollution problems, but eases the administrative burden in tracking compliance.

In 1990, the Ecological Assessment Section was requested to evaluate a proposed interceptor sewer project in the Taylor Creek subbasin in western Hamilton County.

Numerous small package WWTPs, many of which are poorly operated, and home aeration system and septic tank discharges, impact the headwaters of the subbasin. The 1990 sampling was limited to nine locations in the Taylor Creek watershed and adjacent Bluerock Creek. The findings of this sampling revealed some moderate degradation to the fish and macroinvertebrate communities at sites that were in the closest proximity to the package WWTPs. However, FULL attainment of the WWH use designation was found at four of the eight Taylor Creek subbasin locations (Ohio EPA 1990c). In addition, the physical habitat was essentially intact and easily capable of supporting the WWH use.

The Permit to Install (PTI) application submitted by the Hamilton Co. Metropolitan Sewer District (MSD) was denied. The design of the project included a network of nearly 19 miles of interceptor sewers that were designed to convey sanitary wastewater flows by gravity. This design necessitates the excavation and modification of many miles of stream beds. The PTI was denied on the basis that it would damage habitat and permanently prevent the attainment of the WWH use designation, particularly the biological criteria. Detailed information on the streams in this area and these projects in summarized in Ohio EPA (1992a, 1992b). Ohio EPA is using the results of this study to help formulate policy guidance for reviewing PTIs for future interceptor sewer projects.

Resource Extraction

Coal mining is the principal resource extraction activity in Ohio and is of major economic importance in the southeast part of the state. Although other forms of resource extraction are also scattered across Ohio (*e.g.*, sand and gravel extraction, clay mining, limestone quarrying, and salt mining) none have as extensive of an impact on water resource quality. Coal mining occurs primarily in the W. Allegheny Plateau ecoregion and is principally responsible for a variety of environmental perturbations. Most of the well-known problems are associated with low pH related to acidic surface mine runoff, particularly from unreclaimed and abandoned mines (Table 4-1). Mine related chemical impacts in the portions of the WAP ecoregion with a sandstone geotype are extensive. Several studies have attempted to

"The absolute extent of mining impacts in the WAP ecoregion are likely underestimated by this report."

inventory abandoned mine lands and their respective impacts on chemical water quality (Ohio DNR 1974; USDA 1985). Clearly, severe impairment of the resident biota exists in the highly acidic and heavily silted streams. However, much less is known about the *severity* of impairment to the biota in watersheds with less intensive mining and in areas with limestone geotypes. This lack of reliable and comprehensive information initially lead to the erroneous assignment of aquatic life use designations (*i.e.*, the now defunct Limited Warmwater Habitat use designation) in the 1978 water quality standards. These are being addressed via the Five-year Basin Approach as the opportunity arises to monitor these streams. Two recent examples are the biological and water quality surveys of the Hocking River mainstem and selected tributaries, and the Southeast Ohio River tributaries (Ohio EPA 1991b; 1991c). Many impacts from mining are non-toxic *per se* and are more related to increased sedimentation and periodic acidification from uncontrolled and abandoned mine lands runoff, mine shaft discharges, and direct stream channel modifications from relocations and encroachment on riparian zones. The absolute extent of mining impacts in the WAP ecoregion is likely underestimated by this report. Many impacts are presumed to be chemically severe and essentially irreversible. Thus, as a result, comparatively little effort has been expended on comprehensive biological characterizations, except through the Five-year Basin Approach.

"...streams severely impaired by acid mine runoff have no or only a few highly tolerant species and very few individuals."

The Ohio Nonpoint Source Assessment (Ohio EPA 1990b) suggests that more than 3000 miles of streams in Ohio are impacted, impaired, or threatened by mining, mostly in the W. Allegheny Plateau ecoregion. Where low pH has been documented as a moderate or major magnitude cause of impairment, the impacts to the aquatic biota are often more severe than from the toxic effects of heavy metals and priority organics. Like toxic impacted areas, streams severely impaired by acid mine runoff have no or only a few highly tolerant species and very few individuals. While stream channel and other macrohabitat characteristics are principally intact in many mine impacted WAP streams excessive sedimentation can result in the impairment of aquatic life uses. Wills Creek is an example of a stream that has severe sedimentation impacts that impair the WWH use, but retains a natural stream channel throughout most of the mainstem (Ohio EPA 1985b).

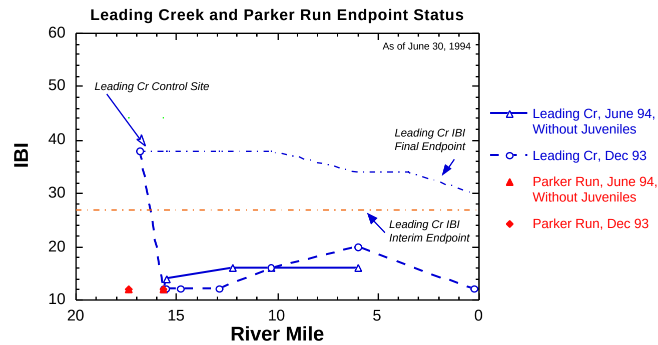


Figure 4-8. IBI data from Nov/Dec 1993 and June 1994 from Leading Creek and Parker Run with interim and final endpoints illustrated.

Recently there have been some significant improvements in the aquatic community performance of streams historically affected by severe mine drainage impacts. Raccoon Creek exhibited FULL attainment of the WWH use designation at a location that has been historically impaired (Ohio EPA 1991d). Unfortunately, such streams are also still subject to periodic pulses of low pH water during high flow events.

Meigs Mine Spill

Recently, during the summer of 1993, an accident at the Meigs #31 Mine resulted in a large (billion gallon) discharge to several streams in the Raccoon and Leading Creek drainages with severe impacts to aquatic life. Leading Creek, Parker Run, Strongs Run, Robinson Run, and Sugar Run, streams located in Meigs, Vinton, and Gallia counties in southeastern Ohio were subject to the discharge of untreated mine waters from late July to September 1993. Each of these streams suffered various degrees of impact, from near complete elimination of fish, mollusc, and macroinvertebrates in Leading Creek, Parker Run, and Strongs Run to less severe biological impacts in Sugar Run and Robinson Run. On the basis of historical data, pre-discharge data, and Ohio's biocriteria, *ecological endpoints* were derived for each of the impaired streams or stream segments for fish, macroinvertebrates, mollusks and amphibians (Ohio EPA 1994).

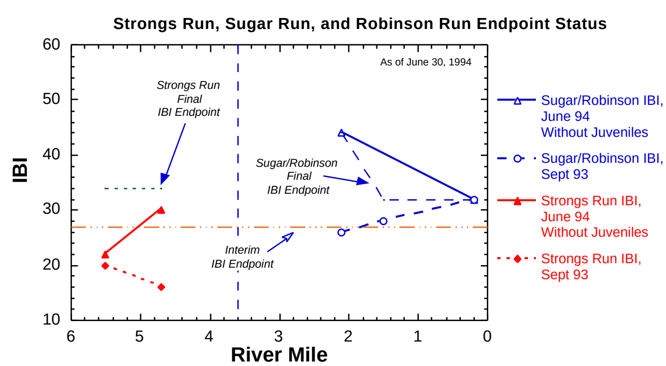


Figure 4-9. IBI data from Sept 1993 and June 1994 from Strongs, Sugar, and Robinson Runs with interim and final endpoints illustrated.

Leading Creek is a direct tributary of the Ohio River, and Parker Run, which received much of the direct discharge, is a tributary of Leading Creek. Strongs Run, a tributary of Raccoon Creek, and Sugar Run (a tributary of Robinson Run which discharges to Raccoon Creek) also received direct discharges of mine water. Post discharge fish sampling data, on which much of this status summary is based, were collected after the discharge in October 1993, November/ December 1993, and late June 1994. Macroinvertebrate samplers were collected in June of 1994, but have not yet been analyzed. An assessment of the achievement of interim endpoints cannot be finalized until November after all field data are collected and analyzed.

"...it is too early to ascertain whether recovery is on schedule or will be suppressed; however, the presence of young fish is encouraging."

The heavy covering of red precipitate that covered sites in Leading Creek as late as December has disappeared. Water column chemistry results have returned to pre-discharge conditions. Based on data collected in June, 1994, there has been successful fish spawning for many species in Leading Creek. Catches were dominated by juvenile fish, however, and few adults were captured. The recovery of the fish and macroinvertebrate communities during the remainder of the summer should provide evidence on whether less visible, residual problems remain. *The IBI values in Leading Creek and Parker Run are still substantially below the interim and final endpoints established for the streams, especially if the influences of juvenile fish on the index are removed (Fig. 4-8).* August and October samples should determine whether conditions have been suitable for the juveniles to mature into adult and subadults. Until these samples are collected it is too early to ascertain whether recovery is on schedule or will be suppressed; however, the presence of young fish is encouraging. Also encouraging was the discovery of spawning silver lampreys during a reconnaissance visit in early May indicating that this State "Threatened" species regularly uses Leading Creek for spawning

Strongs , Robinson , and Sugar Runs

In contrast to Leading Creek and Parker Run the recovery of fish communities in these streams has progressed much faster. Such a pattern was expected because of (1) the proximity of Raccoon Creek as a source of recolonizing species, (2) the lesser impact on Sugar Run and Robinson Run, and (3) the lesser volume of precipitate in Strongs Run (much of the aquatic life was killed by low pH levels). As illustrated in Fig. 4-9 the IBIs from June 1994 reached the final ecological endpoints in Sugar and Robinson Runs, even with juvenile fish removed from the IBI calculation. Strongs Run has also shown a strong recovery although juvenile fish still comprise a large part of the community. However, the significant adult population observed suggests these scores should increase this summer. All of the early samples from the Raccoon Creek tributaries, except for the upstream Strongs Run site with juveniles excluded, have so far met the interim IBI endpoint criterion (all sites out of "poor" range). *In fact, Robinson and Sugar Run have already provisionally achieved the final (2-year) IBI endpoints.*

Field work over the next five or more years will provide invaluable information on the rate at which streams can recover from such impacts. Future reports will deal with this data more fully.

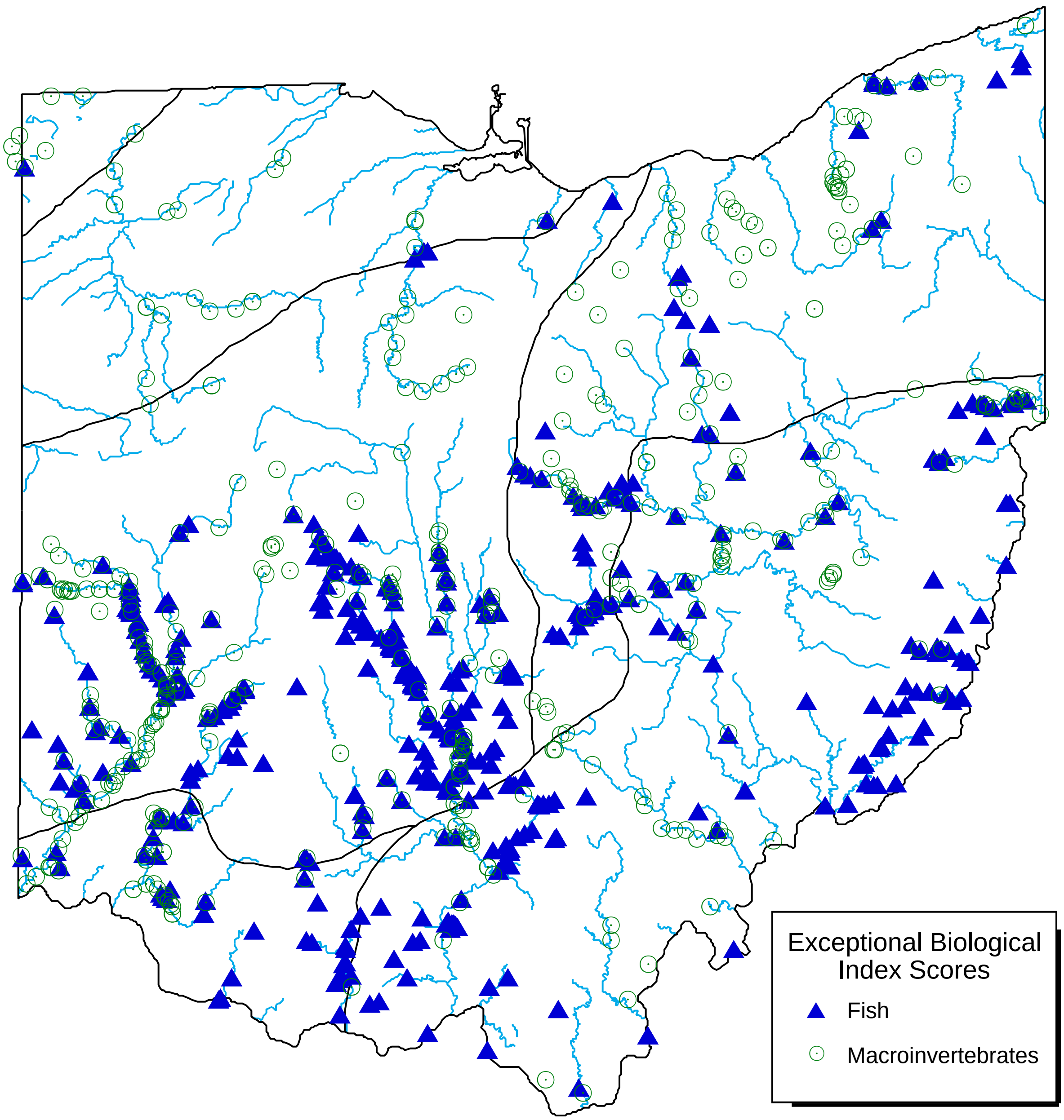
High Quality Waters

Although reports such as this emphasize the identification of problems in surface waters, Ohio possesses many high quality waters that exceed the minimum criteria for the Clean Water Act goal use (*i.e.*, WWH). More than 2,900 miles of the designated streams and rivers are assigned the Exceptional Warmwater Habitat aquatic life use. This comprises 10 % of the U.S. EPA estimate for perennial streams and 11.8% of all Ohio streams and rivers that have a designated aquatic life uses.

"...Ohio possesses many high quality waters that exceed the minimum criteria for the Clean Water Act goal use (i.e., WWH)."

Ohio has a nationally reputed scenic rivers program and currently has 12 rivers designated (Table 4-10). As a part of this program, citizen volunteer groups carry out monitoring in these rivers annually to act as an early warning system for potential impacts and to involve citizens in the protection of these streams (see *Volunteer Monitoring* in Section 2). This data is summarized in annual reports that compare the results of the citizen volunteers to reference sites. Copies can be obtained from:

Map 4-12. Locations on Ohio streams and rivers that score in the exceptional range of the IBI or ICI.



Ohio Department of Natural Resources
Division of Natural Areas and Preserves
Fountain Square Court
Columbus Ohio 43224 (614/265-6453)

Table 4-10. State designated scenic rivers in Ohio.

Stream/River	Year Designated	River Miles
Big[1] and Little Darby Creeks	1984	82
Chagrin River and tributaries	1979	49
Grand River and tributaries	1974	56[2]
Little Beaver Creek and tribs	1974	36[2]
Little Miami River	1969	105
Maumee River	1974	43
Olentangy River	1973	22
Sandusky River	1970s	65
Stillwater R.& Greenville Cr.	1980	83
Upper Cuyahoga River	1974	25

[1]Nature Conservancy has designated Big Darby Creek as a “Last Great Place” on earth because of its unique ecosystem.
[2] Part of this length designated as “Wild” river.

The Ohio EPA ambient biological survey approach, which is the principal basis for this report, provides information that is useful for illustrating the distribution of rivers and streams with high quality water and aquatic community assemblages throughout Ohio. Map 4-12 shows the distribution of exceptional index scores for fish and macroinvertebrates. These streams and rivers are those that have essentially intact physical features, which provides habitat for some of the highest quality aquatic assemblages in Ohio. Many of the watersheds in which these streams and rivers are located contain or are near conspicuous geomorphological features such as escarpments, glacial boundaries, and outwash valleys. Habitat ravaged areas, such as much of northwest Ohio, are generally lacking in exceptional fish communities, although exceptional macroinvertebrate communities, which more strongly reflect chemical water quality than habitat, are found at a few sites in this region. Exceptional streams are important because they are also the rivers and streams that afford the highest quality recreational opportunities for Ohioans.

Portions of several of the larger rivers in Ohio historically have had poor to very poor water quality (*i.e.*, Tuscarawas River, Scioto River, Great Miami River), but have recently demonstrated FULL or PARTIAL attainment of the EWH use designation (see Trend Section). The protection, enhancement, and continued maintenance of physical habitat and riparian zone integrity is essential to achieving and maintaining the full potential of these and other streams and rivers that are still water *quality* limited. Unfortunately, encroachment of land use activities is a continuing and even increasing problem along certain of these rivers and streams.

Threatened and Restorable High Quality Streams and Rivers

"...many high quality waters are threatened or impaired by nonpoint sources of pollution."

Although Ohio has made significant progress in restoring waters polluted by inadequately treated wastewater many high quality waters are threatened or impaired by nonpoint sources of pollution. Here we summarize information on those high quality waters that are (1) currently fully supporting their aquatic life uses, but are considered imminently threatened by some activity in their watershed that may cause a loss of this use, or (2) currently have impaired or partially impaired aquatic life uses considered restorable over a short period (i.e., < 10 years) or are impaired by an activity considered responsive to existing management options.

By focusing on such waters, Ohio can concentrate effort and funds on waters (1) that are of high ecological and recreational quality, (2) where dollars spent on removing identified threats can save typically more costly restoration dollars, and (3) where restoration of high quality can be achieved for minor costs. Incremental increases in siltation or loss of aquatic habitat can be insidious. Nearly imperceptible, gradual insults to stream habitat can create a situation where expectations for stream quality slowly decline with time. Although the status of streams and rivers in Ohio seems static and little changed it must be remembered that only 150 years ago Europeans had little permanent effect on most Ohio waters. Today less than half of those waters we have monitored are achieving goals for biological integrity scaled to the present landscape. The historical data that exists exhibits a pattern of species loss and ecological integrity over time (Trautman 1981). A focus on maintaining the highest quality waters and restoring the streams with the greatest ecological potential will (1) inspire public stewardship and high expectations for such waters, and (2) enhance the constituency for restoration of more severely impaired streams.

Identification of Threatened Waters

Threatened waters are defined as waters currently fully attaining their designated aquatic life use, that have some activities that are imminent threats to maintaining that use. Often, stream waterbodies that are threatened already have some portion of the segment impaired or partially impaired. Of the 113 threatened stream segments, 45 have no impairment in the segment, 29 have only partial impairment, and 39 segments have some impairment of all biological indices (not achieving biocriteria or one index in poor or very poor range). Threatened waters are also dis-proportionately comprised of EWH or CWH streams (35% of threatened segments versus 13% of all waters) because of their sensitivity to the predominant threats of silt and habitat destruction. The primary threats to high quality streams are physical in nature and include direct habitat modifications, such as riparian removal, or other disturbances to the riparian areas of streams, bank erosion, and siltation from agricultural or urbanization adjacent to the stream or along tributaries. The influence of tributaries to high quality streams is often underestimated as a source of impairment or a threat to those high quality waters. Thus, protection strategies for high quality waters need to consider these factors.

"The primary threats to high quality streams ... include direct habitat modifications, such as riparian removal..., bank erosion, and siltation..."

Restorable high quality streams include those with high quality habitat, but which have some minimal impairment or partial impairment and a nonpoint-related cause and source that is considered readily restorable (e.g., riparian removal versus unreclaimed strip mine). For this report, we are focusing on "restorable waters" where the impaired waters are part of a segment which is currently threatened. Thus, restoration and protection efforts in these candidate streams can coincide. Streams that currently meet these criteria are listed in Appendix I.

Trends in Water Resource Quality in Ohio

Perhaps the most important question that we are asked follows: "Is water quality improving or worsening?" The U.S. GAO (1986) criticized U.S. EPA for not being able to quantify improvements in water quality for the billions spent to improve WWTP effluents through the construction grants program. The failure to provide support, both programmatically and monetarily, for *adequate* state ambient monitoring programs has resulted in a lack of consistent and usable information to determine trends. U.S. EPA has responded to this by initiating the Environmental Monitoring and Assessment Program (EMAP) which is designed to provide a statistically based sampling design to provide uniform and consistent information to assess status and trends on a national or regional scale. The U.S. Geological Survey has also proposed the National Ambient Water Quality Assessment (NAWQA) which utilizes a major river basin design sampling approach. Both EMAP and NAWQA are presently in the pilot testing phase with full implementation scheduled for the mid-1990s.

The Ohio EPA biological, chemical, and physical database provides an opportunity to use comprehensive measures to indicate patterns and direction of change relative to improvements (or declines) in water resource integrity. Many previous attempts to examine trends have almost exclusively focused on water chemistry results at single sites sampled over many years. Identifying both spatial and temporal trends in biological community performance compared to least impacted reference conditions may offer the best measure of environmental results (Karr *et al.* 1986).

Unlike EMAP, the Ohio EPA database was not collected under a statistically random design for the location of sampling sites. The purpose of our effort was to provide river and subbasin specific information for the evaluation of WQS use designations and attainment/non-attainment of aquatic life goals on a local scale. Although the aggregate design is biased, the sheer number of sites sampled (Approximately 5000 locations) and thorough coverage of the streams and rivers with drainage areas greater than 100 sq. mi. (71% coverage) makes statewide comparisons possible. It should be noted that the Ohio EPA basin monitoring efforts generally employ a sampling site density of 10 times greater than that proposed by either EMAP or NAWQA.

Two types of trend analyses will be discussed: (1) statewide and regional patterns, and (2) stream and river segment specific trends.

Statewide/Regional Patterns

Statewide trends in water resource integrity were examined in streams and rivers at sampling sites where at least two years of data (between 1974 and 1993) were available. Most of these are concentrated in the larger rivers and streams (>100 sq. mi. drainage area) where follow-up surveys have been performed (*e.g.*, Scioto R., Blanchard R., Cuyahoga R., Great Miami R., Little Miami R., Ottawa R., Tuscarawas R., Hocking R., Big Darby Cr., Mill Cr., and several other smaller streams). This represents a good cross-section of the major streams and rivers, and point and nonpoint source pollution impacts, in Ohio. Over the next several years most of the major rivers and streams will have been re-sampled at least once through the continued implementation of the Five-year Basin Approach. This initial analysis will be augmented with data from these and other future efforts.

In this analysis, for sites with more than two years of data, trends represent the difference between the earliest and latest results. Sample sizes are 789 sites, 648 sites, and 358 sites for the IBI, MIwb, and ICI, respectively. Maps 4-13 through 4-15 illustrate these trends in each of these biological indices by location. Table 4-9 summarizes pertinent percentile shifts in the biological indices between the earliest and latest periods and the results of a paired t test (using a t statistic and Wilcoxon's Z test) between these periods as well for all data and for sites where the earliest data was below a typical WWH level. The comparison of the two different periods showed that the increased index scores were highly significant ($p < 0.0001$).

"One implication of these graphs is that the two year cycle for the 305(b) report is unnecessarily short if changes in water resource quality are to be detected."

For each index there has been a significant *average, positive* change in the distribution of index scores over time (Table 4-11, "all data"). Because this analysis includes all sites, including reference sites or those sites considered unimpacted, the change in impaired sites is underestimated in the average change. For example the average change in the IBI between the earliest and latest periods for all data combined was 3.2; however, the change between periods when the earliest IBI was less than 36 was 5.0 units (Table 4-11 "impaired sites"). The change in the IBI between the earliest and latest periods where the earliest IBI was greater than or equal to 36 was only 0.38 IBI units (0.16 for the MIwb, 0.2 for the ICI), a statistic illustrating the low variability in the IBI where anthropogenic influences are minimal.

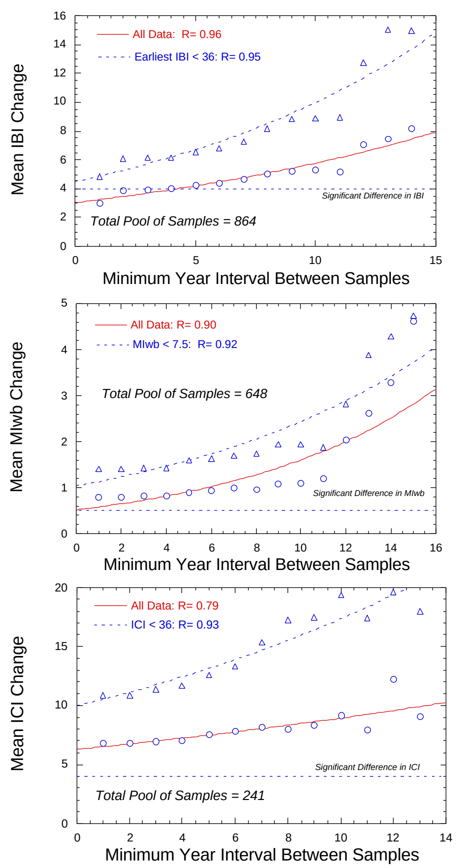


Figure 4-10. Change in mean index score between earliest and latest sampling years plotted by minimum interval between samples in Ohio streams for the IBI (top panel), MIwb (middle panel) or ICI (bottom panel). Dashed horizontal line represents minimum score change to be considered a significant change (i.e., outside range of typical natural variation). Dashed curves are exponential fits to data where earliest data was considered impaired, solid curves are exponential fits to all data regardless of initial index score.

The size of index shifts increases with the period between the samples in an exponential manner (Figure 4-10). With as little as a two year period between samples the mean IBI change off all sites is not much greater than the 4 units needed to show significant change. The MIwb and ICI show significant improvement sooner, but for all indices improvement increases exponentially with increasing time between samples. The exponential nature of this curve may be related to abatement of "easy" acute sewage related impairments in the early 1980s and future analyses of these data may return to a more linear, "slower" improvement as reflected in the short interval (more recent) portion of these curves. One implication of these graphs is that the two year cycle for the 305(b) report is unnecessarily short if changes in water resource quality are to be detected. With a five year cycle significant statewide changes would be detectable and would be more evident after the second such cycle (Figure 4-10).

Another way to visualize these trends is to examine changes in the cumulative frequency distribution (CFD) of biological index scores between each period (Figure 4-11). In each graph of Figure 4-11, the dashed lines represent the CFD of the earliest results, and the thin solid line represents the CFD of the latest results The third, thicker line represents the hypothetical distribution if all sites were achieving the aquatic life biocriteria "goal" under the present socioeconomic climate. This hypothetical line was generated with the assumption that the expectations for these sites approximate the distribution of aquatic life uses in Ohio (see Table 2-1).

Although significant improvements in aquatic life have been observed, clearly, a significant proportion of Ohio's rivers and streams remain chemically polluted and/or physically degraded. The macroinvertebrate ICI showed both the largest magnitude of increase (Figure 4-11, bottom) and shift in the frequency of sites "entering" into the good and exceptional range (*i.e.*, ICI scores equivalent to the WWH and EWH use designations), and sites "exiting" the poor and very poor ranges (*i.e.*, ICI scores <14). In contrast the fish community IBI had the greatest number of sites exiting the poor and very poor ranges, but fewer sites entering the good and exceptional range (*i.e.*, IBI scores equivalent to the WWH and EWH use designations; Figure 4-11, Table 4-11).

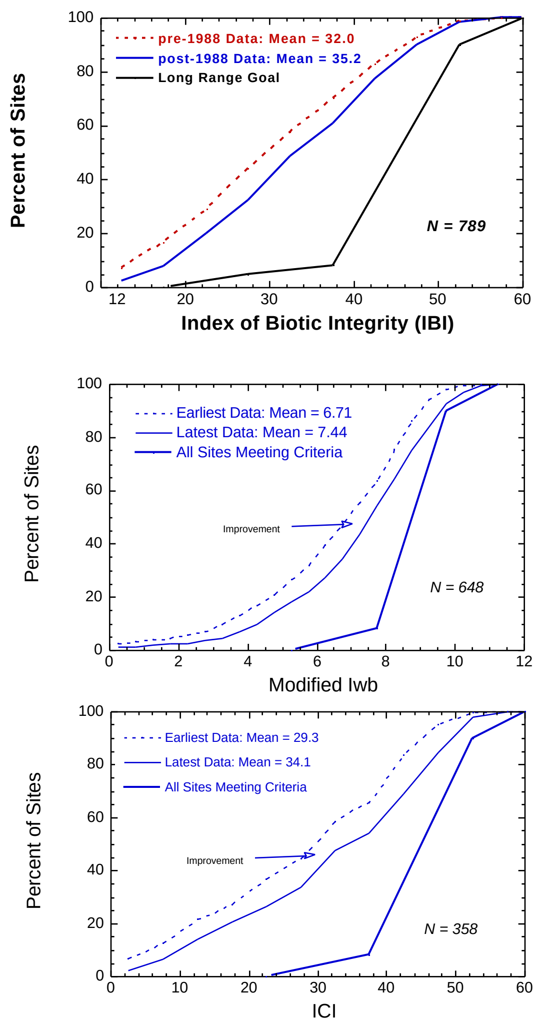


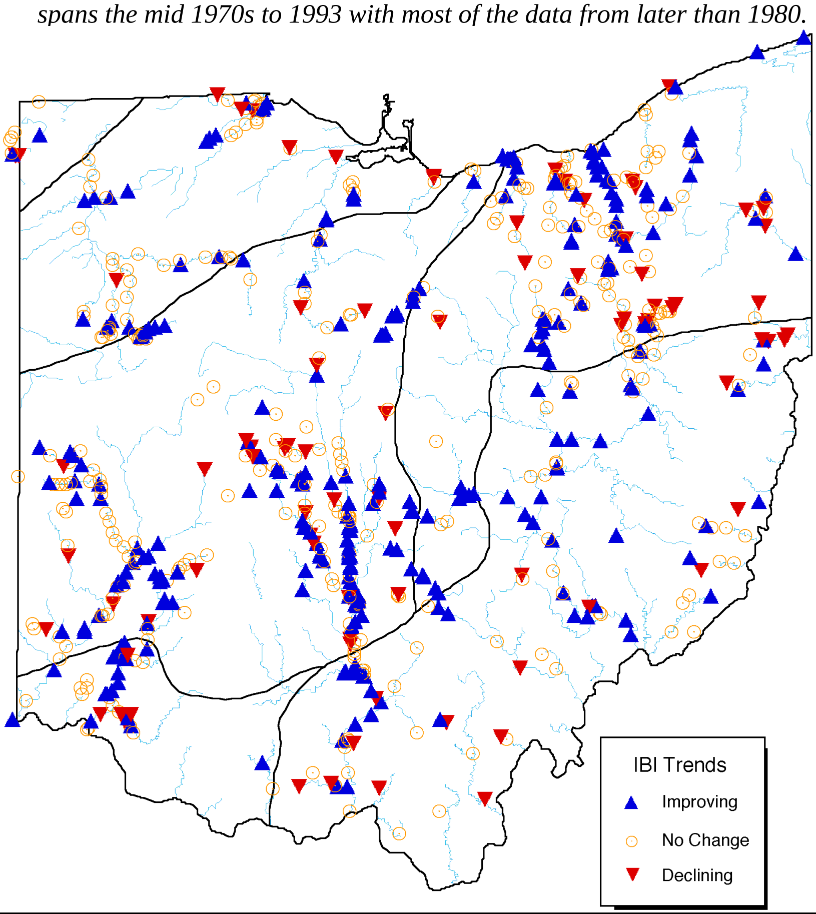
Figure 4-11. Trend data for Ohio streams with at least two years of data based on the IBI (top panel), MIwb (middle panel) or ICI (bottom panel). The solid curves on each graph represent the baseline goal for waters given Ohio's distribution of tiered aquatic life uses; horizontal lines illustrate cumulative percent breakdowns for each use in this goal.

Table 4-11. Summary of "paired" data sites with at least two years of biological data from streams in Ohio. Data pairs represent earliest and latest data for an index at a site. "All data includes reference and unimpacted sites; "impaired sites"excludes sites above an average index score (ICI, IBI - ≥36, MIwb - ≥7.5) for a WWH stream.

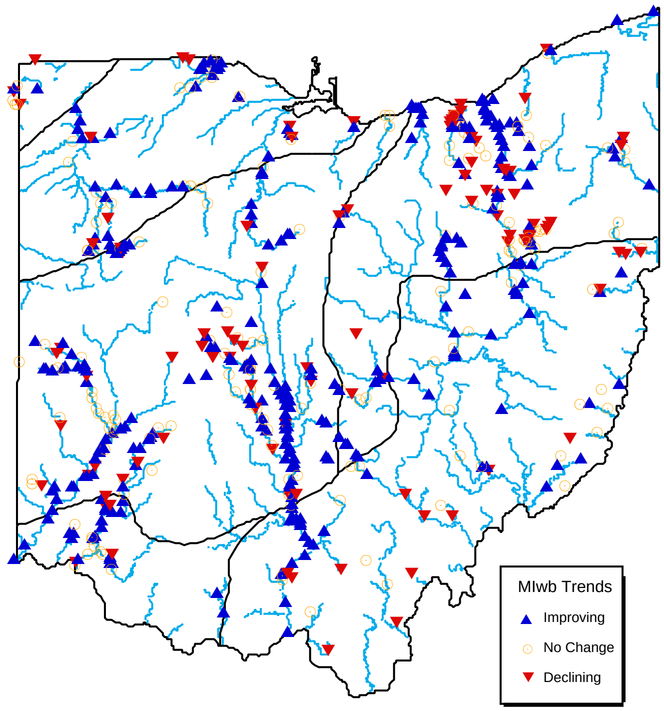
	Biological Index					
	IBI		***MIwb***		***ICI***	
	Earliest	*Latest*	*Earliest*	*Latest*	*Earliest*	*Latest*
All Data						
10th %tile	*16*	*20*	*3.57*	*4.49*	*8*	*12*
25th %tile	*23*	*26*	*5.30*	*6.30*	*16*	*24*
Median	*32*	*35*	*7.17*	*7.82*	*32*	*36*
75th %tile	*41*	*44*	*8.48*	*9.00*	*42*	*46*
90th %tile	*48*	*50*	*9.23*	*9.85*	*46*	*50*
Mean	*32.0*	*35.2*	*6.71*	*7.45*	*27.7*	*32.6*
Paired t-test	*788 df*		*647df*		*357 df*	
t value =	-11.78		-8.582		-7.30	
Mean difference	3.17		0.73		4.85	
(L minus E)	p <0.0001		p <0.0001		p <0.0001	
Wilcoxon (Z)	-11.01		-9.794		-7.38	
	p <0.0001		p <0.0001		p <0.0001	
"Sites Impaired During Earliest Period"						
10th %tile	*14*	*19*	*2.40*	*3.76*	*4*	*10*
25th %tile	*19*	*23*	*4.23*	*5.02*	*10*	*16*
Median	*25*	*29*	*5.56*	*6.68*	*20*	*28*
75th %tile	*30*	*35*	*6.60*	*7.82*	*28*	*40*
90th %tile	*33*	*41*	*7.14*	*8.90*	*32*	*48*
Mean						
Paired t-test	*474 df*		*360df*		*208df*	
t value =	-14.39		-13.49		-10.15	
Mean difference	5.02		1.24		8.69	
(L minus E)	p <0.0001		p <0.0001		p <0.0001	
Wilcoxon (Z)	-12.46		-11.77		-8.67	
	p <0.0001		p <0.0001		p <0.0001	

As illustrated on Maps 4-13 through 4-15 and Table 4-12, the rivers and streams with the greatest number of significantly improved sites include the Cuyahoga R., Scioto R., Hocking R., lower Tuscarawas River, and the Great Miami R. Although the improvement measured in each has been considerable, none have completely attained the applicable aquatic life criteria throughout their lengths. The classic pattern that has been observed is for the macroinvertebrate community (as measured by the ICI) to recover first, followed by fish abundance and biomass (MIwb) with the structural and functional characteristics (IBI) responding last. However, this sequence has been different in certain instances. The pattern and rate of recovery relate to the different mix of pollution problems present in each area. A few streams have shown little or no improvement and even declines in biological performance (*e.g.*, upper Tuscarawas R., Mill Cr., one section of the Sandusky River, Ottawa R., *etc.*,).

Map 4-13. Trends in the IBI at 789 stream and river sites in Ohio. Trends represent the latest vs. the earliest data at a site with multiple years of data. Data spans the mid 1970s to 1993 with most of the data from later than 1980.



Map 4-14. Trends in the MIwb at 648 stream and river sites in Ohio. Trends represent the latest vs the earliest data at a site with multiple years of data. Data spans from the mid 1970s to 1993 with most of the data from after 1980.



Map 4-15. Trends in the ICI at 358 stream and river sites in Ohio. Trends represent the latest vs. the earliest data at a site with multiple years of data. Data spans the mid 1970s to 1993 with most of the data from later than 1980.

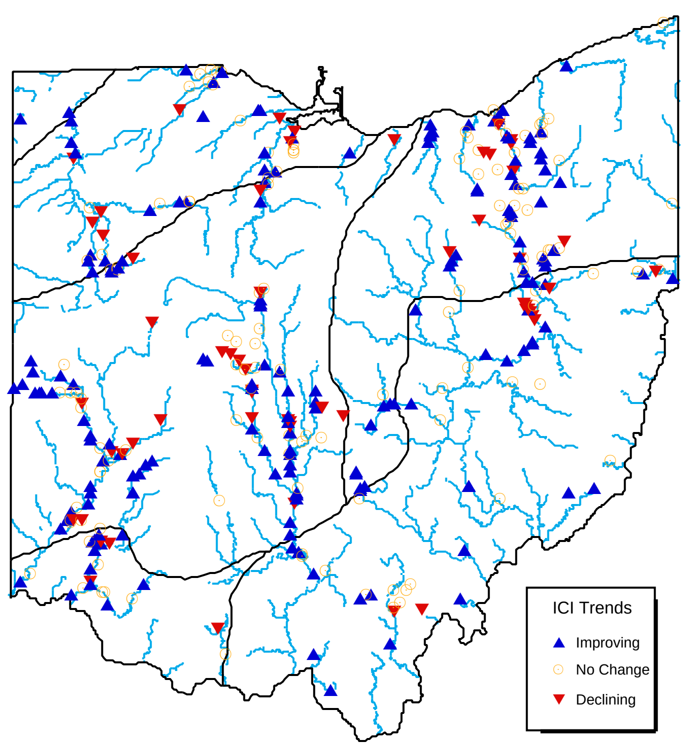


Table 4-12. Summary of "paired" data sites with at least two years of biological data and where the earliest samples were considered impaired for selected major rivers in Ohio. Data pairs represent earliest data from prior to 1990 and latest data subsequent to 1989 for an index at a site.

	Biological Index					
River	*IBI Change*	*N*	*MIwb Change*	*N*	*ICI Change*	*N*
Hocking River	12.4	5	2.36	5	36.7	6
Scioto River	14.5	27	2.87	27	15.1	11
Maumee River	3.2	13	0.44	13	1.0	2
Sandusky River	4.4	5	1.10	5	6.7	3
Little Miami River	5.2	6	0.63	6	21.2	5
Great Miami River†	5.3	20	1.90	20	18.0	2
Muskingum River	6.4	7	1.94	7	20.0	1
Tuscarawas River	4.5	4	2.10	4	14.0	3
Cuyahoga River	7.3	12	2.65	11	7.8	11
Black River	12.8	9	3.09	9	28.7	3

†Latest data is from 1989.

The significant improvements that have been observed are generally related to improved treatment and subsequent loading reductions by municipal WWTPs. The declines or lack of detectable improvements are more related to under-regulated, underrated, and previously unknown industrial sources, CSOs, habitat degradation, and nonpoint sources.

River and Stream Specific Trends in Water Resource Quality

As illustrated in Maps 4-13 through 4-15 the aquatic community performance of many streams and rivers in Ohio has improved. However, this analysis could be misleading because many streams have not yet reached the biocriteria goal and remain impaired by a variety of causes. Often the problems that remain following the abatement of point source problems can differ between ecoregions.

The previous 305(b) reports (Ohio EPA 1988, 1990, 1992) provided examples of river specific trends in water resource quality. We plan to start producing watershed-level summary fact sheets that will provide summary status reports in an easy to read format besides the more detailed "Technical Support Documents" we publish. These fact sheets will be more graphic-based and constructed around a core map summarizing the aquatic life use support of the watershed and including graphs and illustrations of trends, causes and sources or impairment, and any special concerns for a particular watershed. Other pertinent ecological information, such as unique habitats, Scenic River status, endangered or unique species information (not otherwise protected from disclosure) and ongoing restoration and protection efforts will also be highlighted. The schedule for producing these summarizes will coincide with our 5-year basin monitoring approach and they will be compiled for inclusion with the 5-year 305(b) cycle. Existing detailed Technical Support Documents and those in preparation are listed in Appendix J. Reports can be obtained by contacting the address on the cover of this report.

Section 5

Public Health/Aquatic Life Concerns

Toxics Concerns

River miles, shoreline miles of Lake Erie, and acres of lakes, ponds, and reservoirs not meeting aquatic life uses due to toxic impacts are summarized in Table 5-1. A listing of waterbodies with toxic or public health concerns are listed in Appendix C for segments with fish tissue contamination, Appendix D for segments with sediment contamination, Appendix E for segments with high proportions of fish with external abnormalities, Appendix G for areas with elevated fecal coliform counts (streams and rivers only), Table 5-3 for recent public drinking water supply closures, Appendix K for bathing area closures, and Appendix F for segments with fish consumption advisories. These tables are designed to meet the requirements for "Table 7" of the U.S. EPA guidance for the preparation of 1992 State Water Quality Assessments (U.S. EPA 1993).

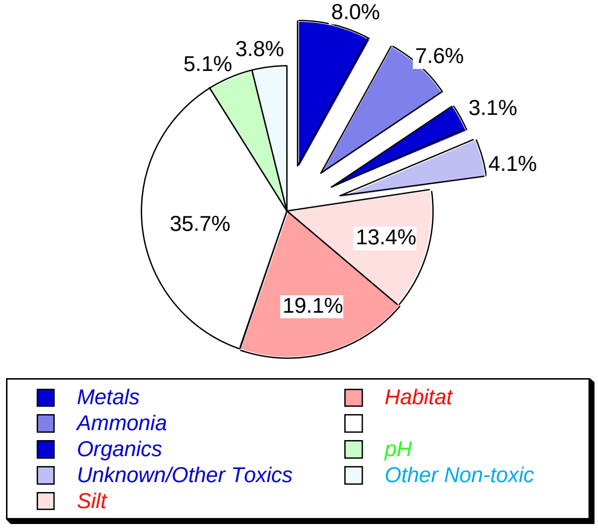


Figure 5-1. Major causes of aquatic life impairment in Ohio streams and rivers; toxic causes are exploded for emphasis.

Table 5-1. Miles monitored for and impaired by toxics as a major cause of impairment of aquatic life use in Ohio rivers and streams, lakes, ponds, and reservoirs, and Lake Erie.

	Size Monitored	*Size Impaired*
Streams, Rivers	*8337 mi*	*1,239.4 mi*
Lakes, Ponds, Res.	*39,974 ac*	*13,246 ac*
Lake Erie	*236.0 mi*	*236.0 mi*

Toxicity due to ammonia-nitrogen is the leading cause in terms of the most miles of impairment due to non-priority toxics in Ohio rivers and streams. Toxicity due to heavy metals are the leading cause of non-attainment due to *priority* toxic substances in Ohio (Figure 5-1). The toxic causes (major magnitude) of partial and non-attainment in Ohio are compared to the remaining causes of impairment (Figure 5-1).

Sediment Contamination

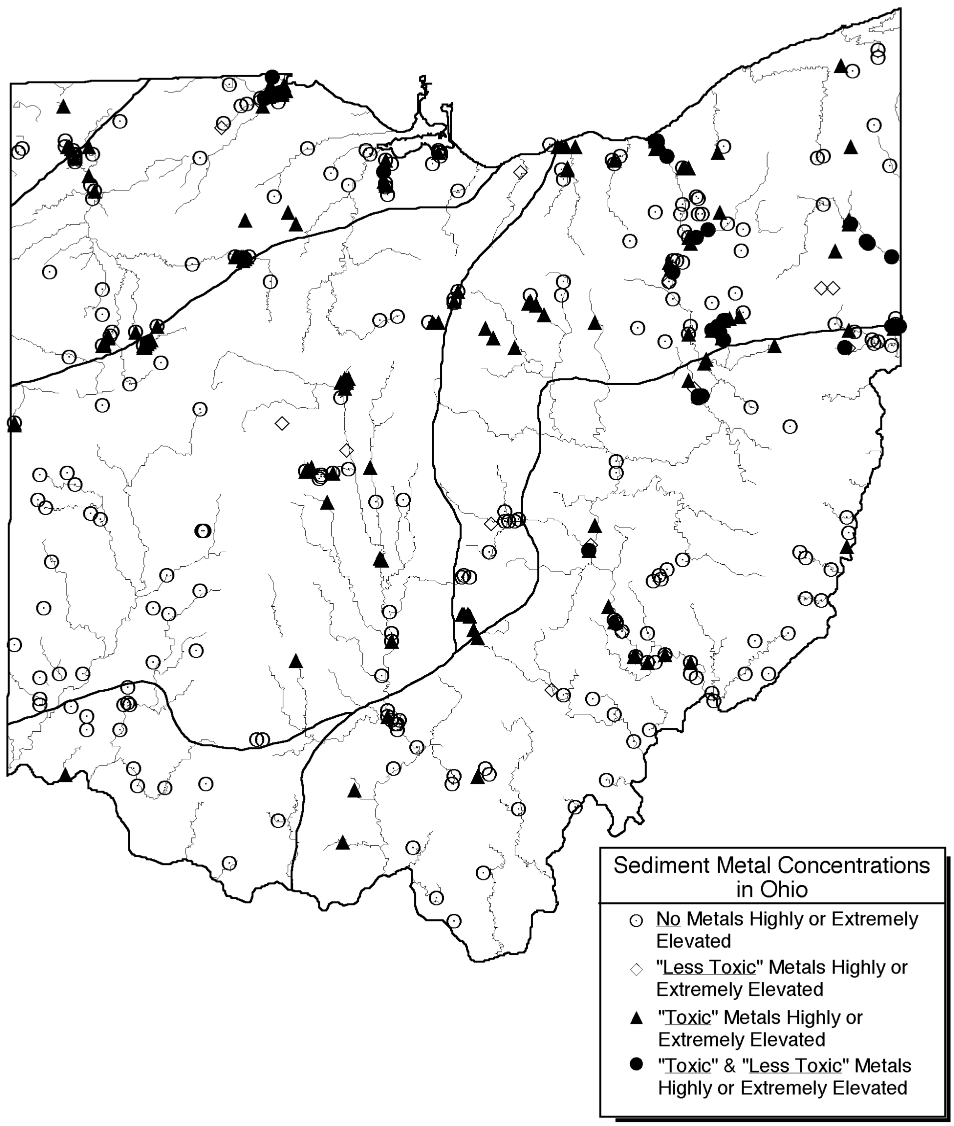
In-place contaminants, which consists primarily of heavy metal and organic contaminants, are a major or moderate source of impairment in more than 223 miles of streams and rivers, and 775 acres of lakes, ponds, and reservoirs. Many of the rivers and streams impaired by toxics in sediments are located within and downstream from the larger municipal and industrial areas of Ohio. Map 5-1 shows areas with highly elevated and extremely elevated heavy metal concentrations in bottom sediments. Each the individual waterbodies with elevated metals in bottom sediments are listed in Appendix D.

The definitions of highly elevated and extremely elevated metals in sediment is based on Ohio data using the categorization procedures of Kelly and Hite (1984) for Illinois. Ohio EPA is currently further summarizing Ohio's sediment database and we will also use percentile ranges for categorizing data that are less prone to be influenced by high outlier values. Kelly and Hite (1984) used increasing multiples of the standard deviation from reference site results to define five categories of increasingly contaminated bottom sediment.

The analysis of background conditions at least impacted reference sites provides; (1) the range of sediment concentrations at some of the same sites that are the prototypes for aquatic community performance expectations, (2) the ability to provide a framework or reference for interpreting concentrations in lieu of toxicity based criteria, and (3) the ability to consider ecoregional differences in the interpretation of sediment chemistry results. Examination of sites that have high sediment metals concentrations in combination with biological community condition can provide information about threshold concentrations that are associated with impaired community performance. This work, when completed, will be incorporated into the framework used to interpret biosurvey results and in the assignment of causes and sources of impairment.

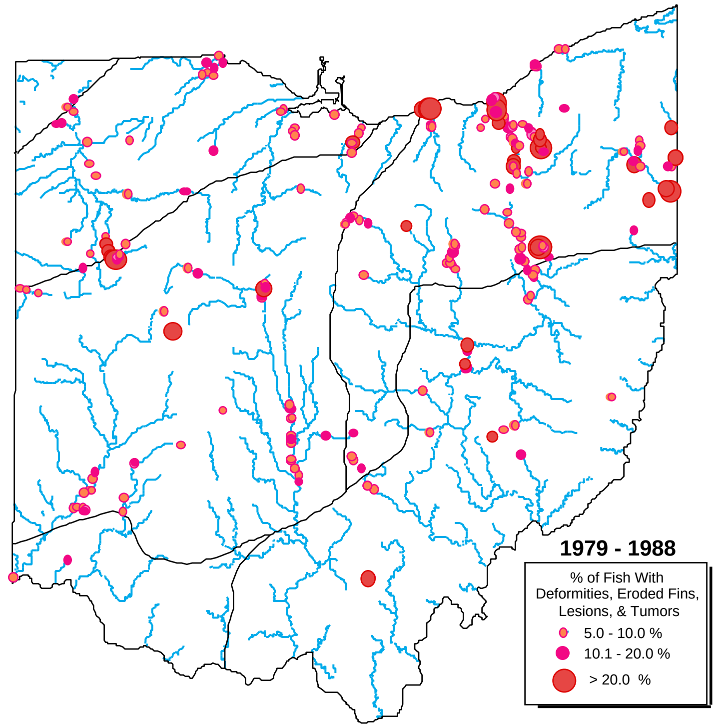
"External abnormalities in fish are strongly correlated with toxic conditions in streams and rivers..."

Map 5-1. River and stream sampling locations in Ohio with highly elevated and extremely elevated concentrations of metals in sediment.

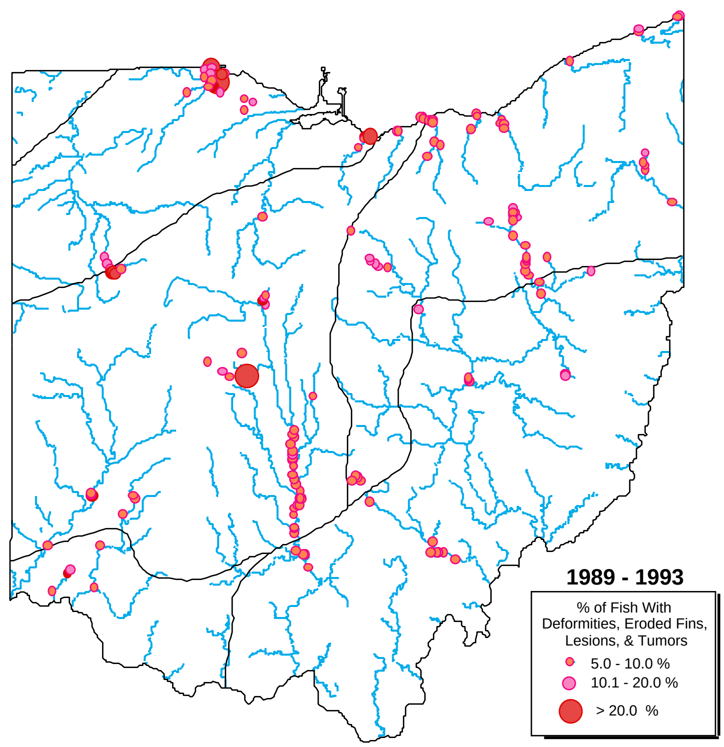


"As chemical pollution and other stresses increase, the rate of external abnormalities generally increases reaching >10-50% in extreme cases."

Map 5-2. River and stream sampling locations in Ohio with external abnormalities (deformities, eroded fins, lesions, and tumors) on greater than 5% of fish collected between 1979 and 1988.



Map 5-3. River and stream sampling locations in Ohio with external abnormalities (deformities, eroded fins, lesions, and tumors) on greater than 5% of fish collected between 1989 and 1993. (NOTE: certain rivers illustrated on Figure 5-2 (1979-1988 period) do not show on this figure because they have not been re-sampled (e.g.., Mahoning R., being resampled in 1994); thus the incidence of external anomalies in these rivers is presently unknown.



Fish abnormalities

One important component of the biosurveys is the identification of external abnormalities (*i.e.*, deformities, eroded fins, lesions, and tumors) on fish. Information is also being recorded about macroinvertebrate anomalies (*e.g.*, head capsule, mouthpart, and antennae deformities).

"...the highest rates of abnormalities are found in urban areas that contain heavy industry."

External abnormalities in fish are strongly correlated with toxic conditions in streams and rivers and provide a useful diagnostic tool when used in combination with other community data dimensions. A discussion of the association of high rates of external abnormalities with the complex toxic impact type in Ohio was provided in the 1990 Ohio Water Resource Inventory (Yoder 1990) and elsewhere (Yoder 1991b).

At the reference sites a very low incidence (*i.e.*, <0.1-1.0%) of external abnormalities is generally found. As chemical pollution and other stresses increase, the rate of external abnormalities generally increases reaching >10-50% in extreme cases. As gross pollution has abated over the past 10-15 years, intermediate and sensitive species (*e.g.*, redhorse spp.) have reinvaded areas where they were previously absent. In some situations sublethal and marginal conditions continue to occur making these sensitive fish susceptible to moderate to high rates of external abnormalities. In the remaining grossly impaired areas many of the abnormalities are grotesque. Examples include even tolerant species (*e.g.*, carp, white suckers, bullheads) with no fins remaining, grossly deformed skeletal features, and eroded, deformed, and branched barbels. Although a few problem areas still exist, the geographic frequency of these situations is declining.

Maps 5-2 and 5-3 summarize stream sites in Ohio where we have observed greater than a 5% incidence of eroded fins, lesions, tumors, or deformities. This includes the areas with the highest rates of abnormalities that indicates high to extreme stress. The data illustrated on Maps 5-2 and 5-3 are also summarized in Appendix E.

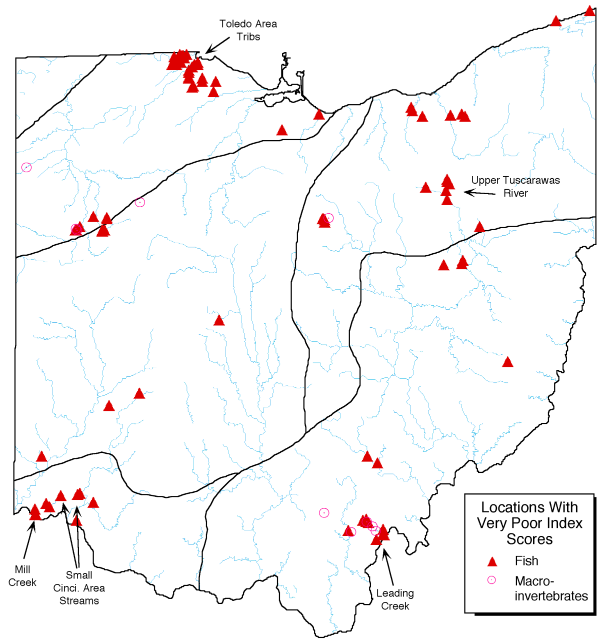
"High rates of abnormalities are also associated with very poor biological performance..."

What is apparent from Maps 5-2 and 5-3 is that the highest rates of abnormalities are found in urban areas that contain heavy industry. On these maps point size increases with percent of external abnormalities. From data collected between 1979 and 1988 (Map 5-2) the Cuyahoga River (downstream from Akron), The Tuscarawas River (Massilon), the Mahoning River (Youngstown), Nimishillen Creek (Canton), the Ottawa River (Lima), the Ottawa River (Toledo), and the Little Scioto River (Marion) have the highest rates of external abnormalities (see Appendix E). The Black Fork Mohican River near Shelby, the Great Miami River downstream from Dayton, the Scioto River downstream from Columbus, the Hocking River near Athens, and other streams scattered across Ohio had elevated, but comparatively lesser rates of external abnormalities (>1-5%). Areas that show the highest rates of external abnormalities are likely to be the areas of greatest risk to human health as well, especially where tumors, deformities, or other developmental problems indicate exposure to toxic compounds.

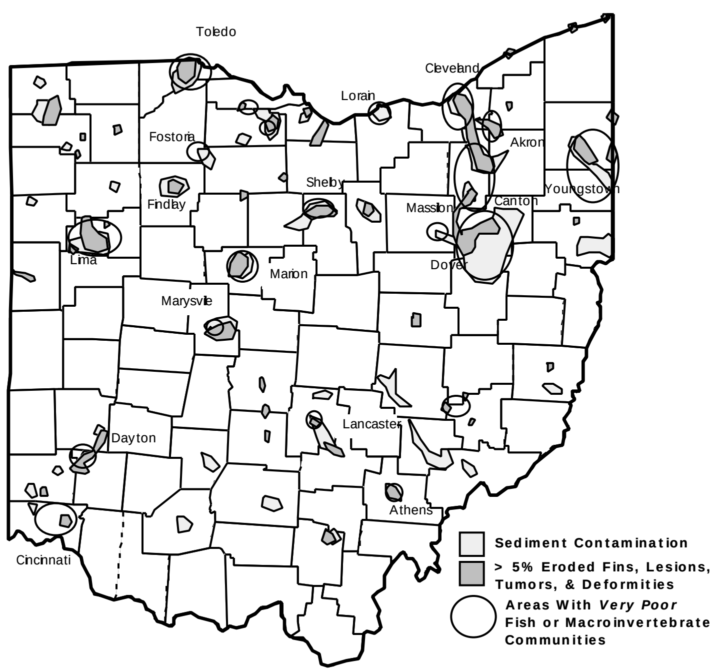
Recent surveys (1988-1991) on the Blanchard River, Scioto River, Tuscarawas River, Hocking River, Cuyahoga River, Ottawa River (Lima), Great Miami River, and some other smaller streams, show a substantial decline in the number of sites with external abnormalities >5% of fish captured (Map 5-3). Although rates have declined to <5%, they remain elevated above background levels in many of these areas. Nevertheless, the declines are additional evidence that pollution abatement efforts are working. Some of the areas that exhibited >5% (*e.g.*, Mahoning River, Maumee River, Tiffin River, Huron River, Little Scioto River) between 1979 and 1988 (Map 5-2) have not been resampled. Until these areas are resampled (in the next several years) it would be premature to conclude with certainty that a similar decline in has taken place, especially with the severity of the impairment that occurred in some of these waters (*e.g.*, Mahoning River).

High rates of abnormalities are also associated with very poor biological performance (*i.e.*, biological index results near minimum values). Map 5-4 illustrates fish and/or macroinvertebrate results that score in the very poor range. These locations are generally located in some of the same areas as the other indicators of toxic conditions (*e.g.*, elevated metals in sediment) for the reasons discussed above. This pattern includes the areas of Ohio that contain concentrations of heavy industry (*e.g.*, steel making, rubber and plastic, petroleum refineries, glass making, electroplating).

Map 5-4. River and stream sampling stations in Ohio with very poor fish and/or macroinvertebrate community performance based on data collected from 1989-1993.



Map 5-5 An overlay of the sampling locations in Ohio with highly elevated or extremely elevated concentrations of metals in sediment, > 5% deformities, eroded fins, lesions, or tumors, and very poor biological performance.



"...the areas of the greatest toxic impacts in Ohio are urban areas with a concentration of industrial point sources."

Map 5-5 is an overlay of sampling locations with highly to extremely elevated sediment metals contamination, high rates of external abnormalities on fish, and very poor biological performance (not updated since the 1992 report). This map makes it clear that the areas of the greatest toxic impacts in Ohio are urban areas with a concentration of industrial point sources. Although we are seeing substantial improvements in some of these areas, much remains to be accomplished to restore these rivers and streams to their designated use potential.

Fish Kill Information/Spills/Drinking Water Closures

"...areas of frequent spills may often identify areas with chronic toxic problems."

Fish kills can be useful indicators of waterbodies with chronic spill problems. An absence of reported fish kills alone, however, does not ensure satisfactory conditions. Streams that have infrequent or no reported fish kills may be severely impacted and have a predominance of tolerant species. Until 1991 the Ohio Division of Wildlife summarized fish kills yearly in a public document that was the source of our information for this report. Because of financial constraints this report has not been published over past several years. We are currently working with ODNR to get the fish kill reports in a computer database; with more detailed geographic descriptions in the planned database fish kill data will be of greater use in the future.

Like fish kills, areas of frequent spills may often identify areas with chronic toxic problems. The 1988 Ohio Water Resource Inventory provides a summary of spills by county from 1978 to 1987. Estenik and Clayton (1988) provide further detailed information about spills in Ohio. Information from Ohio EPA's spill database (EROS) is incorporated into EAS Technical Support Documents. Like the fish tissue database, the geographic location information in this database is being improved so that future use of the information can be more readily linked to biological assessment data.

Table 5-2. Reported drinking water intake closures related to spill incidents in Ohio from 1987–1991.

River	Date	Affected Cities	Pollutant Spilled
Ohio River	Jan. 88	East Liverpool Steubenville Toronto	Fuel Oil Spill at Pittsburgh
Sandusky River	Feb. 88	Fremont	Toluene Spill
Wills Creek	May 88	Cambridge	Raw Sewage Discharge
Little Hocking R.	Mar. 89	Nelsonville	Oil Spill
Ohio River	July 89	Steubenville	Cyanide Spill at Weirton, WV
1987, 1990-1991[a]			

[1]No closures reported.

Besides the toxic impacts discussed above other types of pollution can also affect human health. Highly elevated and extremely elevated fecal coliform bacteria counts in Ohio streams and rivers during 1987-1991 are listed by waterbody in Appendix G. Table 5-2 lists reported drinking water closures related to toxic spills from 1987 to 1991. These impacts have direct effects on the recreational uses of these waterbodies and are another indicator of problems from spills, improper treatment of sewage, uncontrolled runoff, and combined sewer overflows.

Information on water quality (*i.e.*, high fecal coliform counts) advisories at public bathing beaches during the 1990-91 period is limited to Lake Erie and state park beaches as reported by the Ohio Department of Natural Resources and the Ohio Department of Health. Recent advisories posted in 1992 and 1993 are listed in Appendix K. Postings were due to elevated levels of fecal coliform bacteria in excess of the bathing waters standard (200 ct. / 100 ml).

Ohio's Fish Tissue Contaminant Monitoring Program

Volume II of this report is the second historical summary of the various fish tissue contaminant monitoring efforts in Ohio over the past 15 years. Ohio EPA has had a variable amount of effort directed to fish tissue monitoring over this period. These efforts have varied in scope, objectives, sample size and types, and parameters analyzed. The most limiting aspect of this part of the surface water monitoring program has been laboratory capacity. It was only during the past five years that Ohio has convened an inter-agency fish consumption advisory task force. Volume II discusses the process for issuing consumption advisories in Ohio, descriptions and rationale for current advisories, and sampling plans for 1994-1995.

"PCBs were detected in 672 of 899 samples analyzed..."

A preliminary analysis of the Ohio EPA PCB and pesticide database in Volume II provides some insights into the pattern of fish tissue contamination. PCBs were detected in 672 of 899 samples analyzed and chlordane was detected in 77 of 388 samples (whole body and fillet results combined). Both parameters had most values in excess of the FDA recommended action levels than any other contaminant.

Fish Consumption and Human Body Contact Advisories in Ohio

There are presently 22 fish consumption and/or primary contact advisories (Appendix F) in Ohio waters (13 consumption only, 1 contact only, and 8 consumption/contact). Contact advisories are generally issued for locations where contact between the skin or mouth and the chemical poses an increased health or cancer risk.

Twelve of the sport fish advisories recommend that no fish of any species caught in the segment be eaten while six restrict the advisory to carp and/or channel catfish. Four others involve variations of these species: carp, channel catfish, suckers, white bass, bullhead, largemouth bass, smallmouth bass, and rockbass. Most affected segments are the result of historical releases (both point and nonpoint source in origin) and/or contaminated in-place sediments. Possible sources/causes of the release of chemicals identified in the sportfish advisories include: industrial activities and spills - 11; coke manufacturing - 2; spills - 2; landfills - 1; historical superfund site - 1; and, unknown - 5.

Section 6

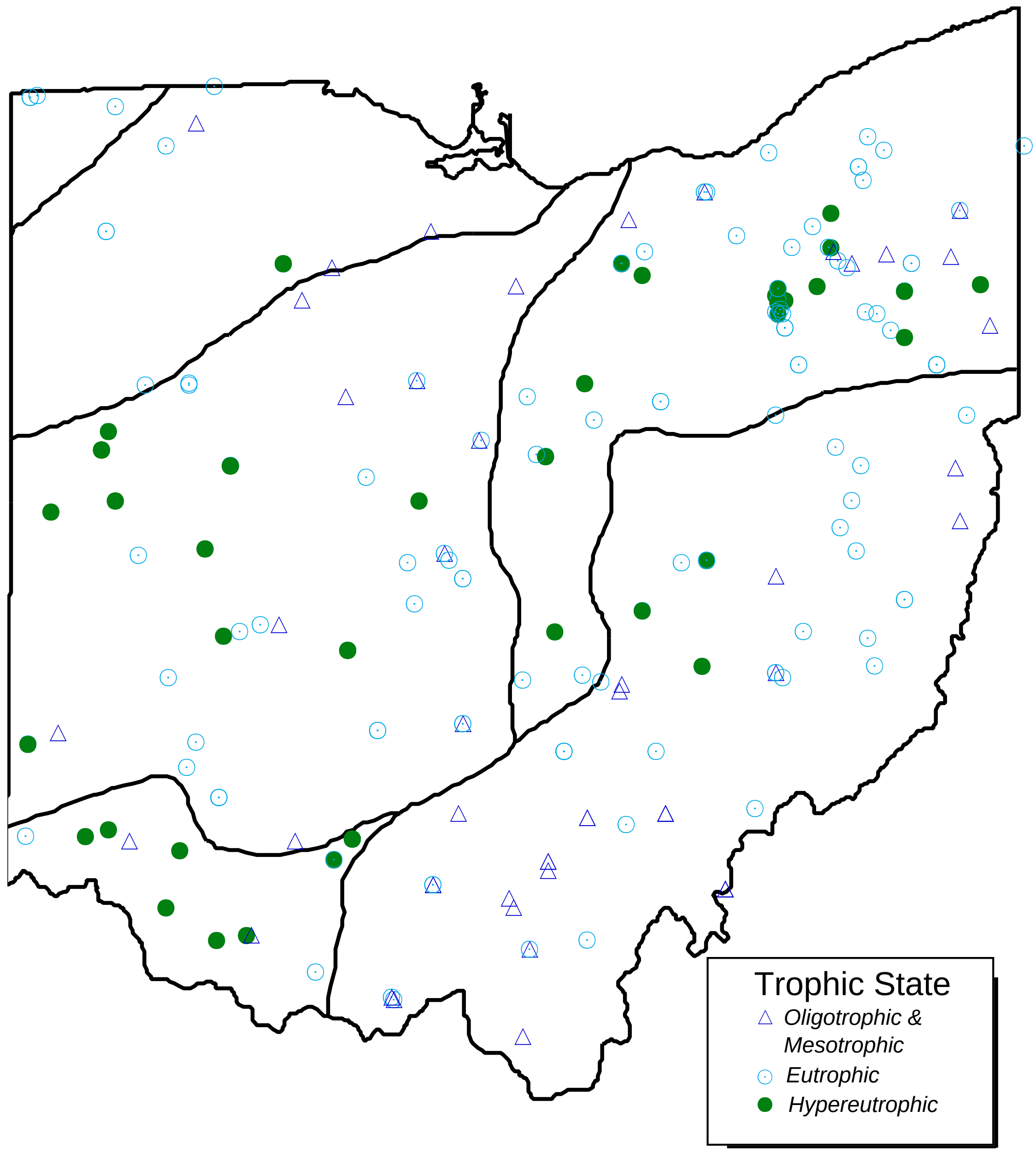
Lakes Information

Ohio has identified at least 450 lakes that are considered publicly owned. Publicly owned lakes are defined as those lakes, ponds, or reservoirs, including upground reservoirs, which are 5 acres or greater in surface area and where public access to the water is owned by a public entity, *or* that are subject to Ohio EPA regulations as a primary or secondary public drinking water supply. These lakes are further divided into a list of 305 significant public lakes which are freely open to public recreation. A detailed analysis of water quality data for Ohio's inland lakes is contained in Volume III (Davic and DeShon 1992) which is part of the 1992 Ohio Water Resource Inventory. Volume III provides an inventory of Ohio's publicly owned lakes and also information on Ohio EPA's water quality assessment process, including an updated trophic classification of Ohio's lakes (summarized here in Map 6-1), an explanation of the use of evaluated and monitored level data, a summary of current and historical lake monitoring in Ohio, lake pollution control procedures, and recommendations for future lake monitoring in Ohio. Also included are tables outlining designated use support in Ohio's lakes, an assessment of causes and sources of non-support, and identification of lake acreage in non-support due to toxics.

There is a relative paucity of comprehensive monitored data for publicly owned lakes in Ohio. Historical lake monitoring on a statewide basis has been sporadic and generally driven by the availability of federal funds. Some early efforts included the National Eutrophication Survey in the 1970s, the cooperative lake monitoring program between the Ohio EPA and the U.S. Geological Survey from 1975 to 1980, and a 1980-81 Clean Lakes Assessment grant awarded to Ohio EPA for lake classification and prioritization. Between 1981 and 1987, only a few lakes were sampled, mostly as part of comprehensive water quality surveys of major river basins. Beginning in 1987, four Clean Lakes program funded Phase I diagnostic and feasibility studies, coordinated by the Ohio EPA, have been conducted or are ongoing in Ohio (Winton Woods Lake, Indian Lake, Sippo Lake, and Dillon Reser-

"...there is a relative paucity of comprehensive monitored data for publicly owned lakes in Ohio."

Map 6-1. Trophic status of Ohio's 447 public lakes.



voir). The Winton Woods, Sippo Lake, and Indian Lake studies have been completed and funding for Phase II implementation funds for Indian Lake and Sippo Lake have been received. The Phase I report for Dillon Lake will be completed this year. These Phase I projects have been among the most comprehensive lake and watershed surveys conducted in the state, pooling resources from numerous local, state, and federal, lake consultants, and universities. Most recent statewide lake monitoring in Ohio involved water and sediment sampling of 23 lakes in 1992 and 1993 with funding provided by a Section 314 Lake Water Quality Assessment (LWQA) grant. A new LWQA grant will fund sampling of an additional 24 lakes in 1994.

Other lake monitoring activities in Ohio included a sedimentation survey of 47 lakes conducted in 1988 by the U.S. Soil Conservation Service and sampling of numerous lakes by a volunteer monitoring network established in northeast Ohio in 1988. A new volunteer lake monitoring program coordinated by the Ohio Lake Management Society (Citizen Lake Improvement Program) collected Secchi depth data at 21 lakes in 1991. Trophic state data for 19 Ohio lakes sampled in 1989 was reported by Fulmer and Cooke (1990), working at the Kent State University Institute of Limnology. Data from these sources have resulted in the reassessment of 92 (20%) of Ohio's 447 public lakes.

"...most Ohio lakes are highly productive with 78% being either eutrophic or hypereutrophic."

Based on these new data sources and the availability of historical monitored and evaluated data, approximately one-third of Ohio's publicly owned lakes have been assessed for trophic condition, Clean Water Act goal achievement (fishable and swimmable), and use designation support (Exceptional Warmwater Habitat and Public Water Supply). Trophic state analysis of 164 lakes using Carlson's Trophic State Index (TSI) indicates that most Ohio lakes are highly productive with 78% being either eutrophic or hypereutrophic. The majority of the remaining lakes are classified as mesotrophic, and fewer as oligotrophic. The 1992-1993 monitoring data evaluated 11 new lakes and reevaluated six lakes from the 1992 trophic state classification. Of the six lakes reevaluated, three went from euthrophic to oligotrophic, two went from hypereutrophic to eutrophic, and one lake went from mesotrophic to eutrophic. Goal achievement and use support were determined using the Ohio Lake Condition Index (LCI), a multi-parameter index utilizing observations and / or measurements of numerous components of the lake resource (*e.g.*, Secchi depth, volume loss due to sedimentation, total phosphorus (spring season), nuisance growths of macrophytes, priority organics, priority metals, etc.). Specified combinations of the parameters are used to determine goal achievement or use support following guidelines described in Davic and DeShon (1989) as revised in Volume III of this report. Of the lakes with sufficient data for analysis, the vast majority were either partially supporting the goals and designated uses or were fully supporting, but threatened. The most significant problems causing excessive productivity and non-attainment of goals and uses in Ohio's lakes are, 1) volume loss due to sedimentation, 2) nuisance growths of macrophytes, 3) organic and nutrient enrichment, and 4) general aesthetic condition.

"More lakes need to be sampled more frequently to determine trends in lake condition."

Efforts since 1988 by the Ohio EPA and other agencies to assess the condition of Ohio's lakes should be continued and expanded. Additional information is needed on volume loss due to sedimentation, fish tissue and sediment contamination, and health of the biological resource (*e.g.*, through development of biocriteria for fish, plankton, macrophyte communities, etc.). Besides continuing to obtain Section 314 Phase I and II grants for synoptic monitoring of specific lakes, a state funded inland lake monitoring program needs to be initiated to collect baseline and long-term chemical, physical, and biological data for all of Ohio's publicly owned lakes. More lakes need to be sampled more frequently to determine trends in lake condition. Finally, efforts of volunteer citizen monitoring programs should be continued and expanded to include a variety of lake monitoring activities such as phosphorus and chlorophyll-a.

Section 7

Nonpoint Source Program Descriptions

Ohio EPA Nonpoint Source Assessment

A comprehensive assessment of nonpoint sources and their impacts on water resources is contained in a separate report produced by Ohio EPA (1990). This was submitted to U.S. EPA separately by the Division of Water Quality Planning & Assessment (now Division of Surface Water) in fulfillment of the requirements of Section 319 of the 1987 Clean Water Act. An update to the NPSA is currently under way.

Heidelberg Water Quality Laboratory Studies

A comprehensive evaluation of the chemical and physical characteristics of nonpoint runoff in selected stream and river basins of the Lake Erie drainage has been conducted by the Heidelberg Water Quality Laboratory since the early 1970's. A detailed analysis of the findings and conclusions of this effort are found in *Lake Erie Agro-Ecosystem Program: Sediment, Nutrient, and Pesticide Export Studies* (Baker 1987). The monitoring approach of this effort fills an important gap that has existed in the evaluation of Ohio surface water quality and represents a model program for similar efforts elsewhere. The results of this program also reveal that there are significant potential and realized impacts to surface waters, particularly for non-aquatic life uses such as drinking water supplies, aesthetics, harbor maintenance (dredging), and various water quality concerns in Lake Erie. According to Baker (1987) the major nonpoint source pollutants observed in Lake Erie basin watersheds include sediment, nitrates, phosphorus, and a number of pesticides (primarily herbicides) several of which have export rates higher than national averages. Surface water uses impaired or threatened by these pollutants include surface drinking water supplies, wetlands, and aquatic life.

Ohio EPA has been implementing an expanded nonpoint assessment program that includes analysis of both chemical/physical and biological responses in surface waters. Much of this has been accomplished under the framework of the Five-year Basin Approach. A more detailed analysis of the information generated by these nonpoint studies is contained in the Ohio EPA Nonpoint Assessment (Ohio EPA 1990).

The inclusion of biological evaluations partially addresses one of the recommendations of Baker (1987). A workshop on the biological assessment of nonpoint source impacts was held at Heidelberg in May 1991 to discuss potential methods and applications. One outgrowth of this workshop is the Lake Erie Basin Tributary Biomoniotring and College Education Network (BioNet) "which has been established by Heidelberg to accomplish long term stream biomonitoring, provide experiential learning in the college curriculum, and enhance faculty proficiency in the practice of freshwater ecology" (Ken Krieger, pers. comm.).

Section 8

Ground Water Quality

Ground water quality monitoring activities for the 1992-1993 reporting period are described in Volume IV of this report. A brief overview of Ohio's ground water resources, major aquifer systems, and a general discussion of ground water program activities carried out by the Ohio EPA and other state agencies is provided. Forty percent of Ohio's population relies on ground water as their primary water source.

Ambient ground water monitoring has progressed significantly over the past two years. The Ambient network currently consists of approximately 200 selected industrial and municipal production wells at 150 sites which represent all of the major aquifer systems in the state. Most stations are sampled annually or semiannually for organic and inorganic parameters. During 1992 and 1993, a total of 295 water samples were collected from ambient monitoring stations. This is a 14.6 percent increase over the previous reporting period. Ohio EPA, Division of Drinking and Ground Waters is in the process of confirming that the Ambient wells provide representative data for the primary aquifers in the state. Currently, 65 percent of these wells are developed in the buried valley aquifers and 35 percent of the wells are producing from bedrock aquifers.

In the past two years the Ambient Data has been entered into a database system that allows temporal and spatial analysis of these data. The initial use of this ability has focused on identifying ground water quality by aquifer type. A subset of the Ambient database, with aquifer type identified, is presented in the Table A. It should be noted that these are preliminary analyses of these data and that QA/QC has not been completed yet. These data begin to illustrate trends in Ohio's water quality by aquifer type. The bedrock carbonate aquifers are high in Ca, SO_4, and TDS and the unconsolidated sand and gravel and the consolidated sandstone aquifers are high in Cl and Mn relative to the carbonate aquifers. These results are similar to water quality results reported by the USGS and the Ohio Electric Utilities Institute. Further analysis is necessary to determine the significance of these variations and to clarify water quality relative to aquifer lithology.

In addition, these data have been linked to a geographic information system. The ability to present ambient or public water system data in a geographical manner with related information (geology, aquifer type, etc.) is a major advancement for assessing the ground water quality in Ohio. This will allow significant advancement in defining background water quality, and aid in identifying impacted ground waters in special studies. Figure A, which plots the public water systems (PWS) with nitrate levels above 3 ppm superimposed on the major buried valley aquifers in Ohio, illustrates the vulnerability of the buried valley aquifers and the power of combining geologic and water quality data. Other examples of this capability of the Ohio EPA, Division of Drinking and Ground Waters are provided in Volume IV, Section 8.

Ohio's public water supply systems that rely on ground water sources have been monitored during the past two years in compliance with requirements mandated by the Safe Drinking Water Act and Ohio State Legislation. In particular, water supply testing of public systems has continued for inorganic elements, synthetic organic chemicals, volatile organic chemicals, nitrates, radionuclides, and asbestos. The water quality information requested for PWS in the USEPA Guidance for 305(b) Reports is provided for community and nontransient non-community systems. These data confirm the high quality of water provided by PWS in Ohio. To maintain the high quality of PWS, a Wellhead Protection Program has been implemented. Approximately 140 PWS have initiated WHP efforts to date.

"...biomarkers could prove to be a valuable tool in identifying causes and sources of impact..."

Inventories produced in a recent update of the ground water component of the NPS Assessment Report were used to document the sources of ground water contamination, the contaminants in Ohio, and their relative priority. As facility owners have been required to complete on-site pollution source monitoring by Federal RCRA and CERCLA legislation, the focus of Ohio EPA's Pollution Source Monitoring has shifted toward nonpoint source pollution like fertilizer and road salt application.

Significant effort was expended to improve and update the 1994 305(b) report on Ohio's ground water quality. This report reflects the progress that Ohio EPA, Division of Drinking and Ground Waters has made in computerizing databases and linking these databases to geographic information systems. This progress will continue as we apply these skills to analyzing and documenting the quality of Ohio's ground water.

Table 8-1. Preliminary ambient groundwater data in Ohio by aquifer type.

Parameter (Units)	Aquifer Type	Number Samples	Minimum	Maximum	Average
Arsenic	USG	363	< 2	74	4.9
(µg/l)	CSS	22	< 2	53	6.4
	CLS	186	< 2	18	3.7
Barium	USG	296	15	11,085	217.9
(µg/l)	CSS	18	15	192	86.2
	CLS	186	< 10	305	67.5
Calcium	USG	266	39	188	108.7
(µg/l)	CSS	13	58	145	96.3
	CLS	145	68	1410	148.2
Chloride	USG	399	< 2	267	41.3
(µg/l)	CSS	29	5	130	39.3
	CLS	160	< 2	136	22.5
Iron	USG	399	< 2	8800	1107.8
(µg/l)	CSS	29	< 2	6300	1144.1
	CLS	192	< 2	13500	1344.3
Magnesium	USG	407	3	67	28.7
(µg/l)	CSS	29	8	223	29.2
	CLS	192	< 2	102	51.3
Manganese	USG	353	< 10	2620	207.6
(µg/l)	CSS	24	< 10	363	170.2
	CLS	144	< 10	304	33.4
Sodium	USG	408	< 2	101	27.1
(µg/l)	CSS	29	4	346	48.3
	CLS	192	5	112	35.9
Sulfate	USG	395	5	280	81.6
(µg/l)	CSS	29	29	1070	100.7
	CLS	185	32	1060	295.8
TDS	USG	377	152	1176	484.6
(µg/l)	CSS	24	151	1800	467.8
	CLS	145	384	1620	745.5

Aquifer Types: USG - unconsolidated sand and gravel; CSS - consolidated sandstone; CLS - consolidated limestone and dolomite.

Section 9

Selected Program Descriptions

Unregulated Hazardous Waste Site Evaluations

Two staff in the Ecological Assessment Section (EAS) are funded and tasked by the Division of Emergency and Remedial Response (DERR) to conduct biological and water quality investigations of surface water resources that are potentially impacted not only by unregulated hazardous waste sites on the state priority list, but also Department of Energy radioactive materials sites and Superfund sites as well. These studies may include fish and macroinvertebrate community assessments, fish tissue sampling, sediment and surface water contaminant monitoring, along with evaluations of physical habitat conditions. The information collected is used in assessing environmental impacts from hazardous waste sites and as resource information for performing Natural Resource Damage Assessments. These staff members are also involved with a biomarker research project, a discussion of which follows. If this research is successful, biomarkers could prove to be a valuable tool in identifying causes and sources of impact by creating strong links to specific classes of pollutants and hence to specific sources. Along with the standard biological community and habitat information this has the potential for use in assessing situations for natural resource damage claims.

Biomarker Research Project

In 1992 and 1993 EAS staff were involved in an innovative research project with the U.S. EPA Environmental Monitoring Systems Laboratory (EMSL) in Cincinnati. The project goal is to develop indicators of subtle biochemical and physiological responses in organisms which can assist in pinpointing causes and sources of impairment, potentially serving as early warning signals, and/or predicting eventual manifestations of overt environmental damage. U.S. EPA requested Ohio EPA's participation based on Ohio's capability to collect field samples, development of biological indices, experience in applying the indices to assess a wide range of impairments, and the biological database developed from these assessments.

The research was initiated to further develop and refine a new index, the Physiological and Clinical Index (PCI), which has the potential to strengthen and confirm existing biological community evaluation methods. Emphasis was placed on producing usable tools by basing the research on samples collected from areas where Ohio EPA had existing information about environmental impacts. Ohio EPA staff have collected blood, spleen, bile, and liver samples from fish at fifty-three (53) sites across the state ranging from varying impacts from a variety of sources to least impacted reference sites.

The blood serum, bile, and liver tissue samples were shipped in liquid nitrogen of formalin to EMSL-Cincinnati where a number of immunological, histological, and blood serum enzyme analyses were performed. These samples serve as a baseline over a gradient of impacts previously demonstrated by Ohio EPA monitoring. Further work is planned for the 1994 field season. Biomarker results have been incorporated into several Ohio EPA biological and water quality reports. (e.g., Cuyahoga River TSD, Ohio EPA 1994).

Wetlands Assessment/401 Water Quality Certifications

National and Statewide Wetland Inventories

The total acreage of wetland areas in Ohio has not been quantified with any degree of accuracy, primarily because a complete inventory of the state's wetland resources does not exist. Two inventories are currently being completed for Ohio. The most complete survey is the National Wetlands Inventory (NWI) initiated by the U.S. Fish and Wildlife Service (U.S. FWS) in the late 1950s. To date all aerial photos used to produce the maps have been photointerpreted for Ohio. Maps have been produced for approximately one half of the State's land area, excluding the central

Ohio area. The inventory is scheduled for completion by summer of 1995. Field checking of previously unmapped areas will take place during 1994.

Besides the NWI, a statewide inventory of wetlands is being conducted by the Remote Sensing Program in the Ohio Department of Natural Resources (Ohio DNR), Division of Soil and Water Conservation, the Ohio DNR Division of Wildlife, and the U.S. Soil Conservation Service (SCS). Digital data from the LANDSAT Thematic Mapper have been computer classified to identify shallow marsh, shrub/scrub wetland, wet meadow, wet woodland, open water, and farmed wetland. The satellite multi-spectral data, which comes at a resolution of 30 meters by 30 meters, are being combined with digitized soils data to improve wetland identification. For example, all woodlands in Ohio were identified from the Landsat imagery; any of those occurring on hydric soils are presumed to be wet woodlands. In addition, low level aerial photographs of the glaciated counties of Ohio, provided by the SCS, were reviewed to correct gross errors and identify farmed wetlands. Non-glaciated counties were error corrected using USGS topographic maps. In mid-1994, SCS personnel finalized a review of the draft maps for each county. This will complete the first edition of the Ohio wetlands inventory. It is anticipated that maps will be updated every 5 years. The State wetland inventory will be used to help implement the Swampbuster provision of the 1985 U.S. Farm Bill. The inventory will also provide planning information in wildlife management of both game and threatened species.

Programmatic Developments Concerning Wetlands

Ohio EPA has received three wetlands program development grants from U.S. EPA to fund three major projects, including the development of a State Comprehensive Wetlands Strategy, the development of water quality standards for wetlands, and the development of performance goals for wetland mitigation projects. In addition, Ohio EPA will review programs and policies for consistency with wetland protection goals. These program developments are discussed in more detail below.

The Ohio Comprehensive Wetlands Strategy

The loss of Ohio's wetlands over the years is estimated to be greater than 90%. While in recent times significant efforts have been undertaken by the public and private sectors to conserve wetlands, there has not been a coordinated approach to wetlands preservation and management in the state. Recognizing the need to develop consensus among the involved and affected parties on the direction for state policy towards wetlands, the State of Ohio convened the Ohio Wetlands Task Force and charged the group with developing a State wetlands strategy.

The Ohio Wetlands Task Force was comprised of 35 members representing business, agricultural, environmental and conservation groups, universities, and federal, state and local government agencies. Early in the process Ohio EPA developed an agreement with the Ohio Commission on Dispute Resolution and Conflict Management (OCDRCM) to facilitate the development of the Strategy. This allowed Ohio EPA to participate in the meetings as a member without dual roles. Prior to the first Task Force meeting, OCDRCM interviewed each member of the Task Force to elicit their key issues and concerns about wetlands. Because time commitment to the process was a significant concern for most members, an endpoint of December, 1993 was established.

"The loss of Ohio's wetlands over the years is estimated to be greater than 90%."

Meetings began in December, 1992 and were held monthly to develop a broad set of recommendations concerning wetlands. At the first meeting, ground rules were identified and documented as to how the group would function. The Task Force operated by consensus, that is, while each member may not wholeheartedly support a particular recommendation, they could live with it.

Besides the 35 members selected for the Task Force, many other individuals and groups began requesting representation. To accommodate this interest without creating a cumbersome body, a Wetlands Forum was formed. The Forum was formed to involve interested parties that wanted to stay apprised of the development of the Strategy. As part of the process, the Task Force sponsored two public information meetings, open to all interested groups and individuals, and solicited their ideas concerning the emerging Strategy. The final product reflects the input from the meetings.

The goal of the Task Force was, "to provide the framework in which the State can actively preserve, protect, and enhance wetlands, their functions and values, and encourage a gain in wetlands acreage, in a manner that balances the ecological integrity of wetlands with responsible economic development." Because thirty-five members is a large group, three work groups were formed to work on issues identified by the large group. These were: 1) regulatory; 2) preservation and restoration, and 3) planning and technical assistance.

The Strategy consists of a series of recommendations on different wetland issues facing Ohio. Six primary objectives were established to guide the development of specific recommendations, including:

- develop mechanisms to improve coordination of existing federal, state, and local regulatory programs so that there is clarity, consistency, timeliness and effectiveness;

- strengthen state/local cooperation within the context of state wetlands goals and objectives;

- improve the quality and availability of information about Ohio's wetlands and wetland programs;

- educate landowners, developers, local governments and the general public about the importance of, and techniques for, preserving wetlands;

- identify, initiate, and support mechanisms for public and private preservation, restoration, and creation of wetlands.

- create consistent, adequate and flexible funding mechanisms for implementation of the above goals and objectives.

Recommendations on how to carry out these objectives were made as specific as possible. Strategies recommendations are identified as short term (1 - 2 years), intermediate term (2 - 6 years), and long term. Some of the key recommendations to state government include the following:

· a biennial report on the status and trends of Ohio's wetlands will be produced. Data will be organized by hydrologic unit and will include information on the losses and gains of wetland acreage, regulatory permit statistics, information on mitigation and restoration efforts, and tracking the implementation of other Strategy recommendations;

· development of a state wetland restoration policy goal. The Strategy proposes an interim goal of a gain of 50,000 acres of wetlands and riparian ecosystems by the year 2000, and an overall goal of 400,000 acres to be restored or created by the year 2010;

- establish a Wetlands Information Office. This would serve to coordinate the flow of information to the public, providing landowners, local governments, organizations, and citizens with a source of comprehensive information on wetlands;

- develop educational materials including a *Private Landowners Wetlands Assistance Guide: Voluntary Options for Wetlands Stewardship in Ohio*, *Wetlands and Watershed Management*, and a *Guide to Existing Wetland Regulations*;

- an array of suggestions was made to create consistent, adequate and flexible funding mechanisms to implement the recommendations of the Strategy.

The report from the Task Force recommends that the Governor adopt an Executive Order that includes the following: 1) the objectives of the Strategy; 2) requires Ohio EPA and ODNR to report on the status of implementation biannually, and 3) reconvene the Task Force on a yearly basis and authorize a smaller group to oversee progress.

The Task Force kept to the original time frame, ending in December, 1993. Keeping to the schedule was important in maintaining the integrity of the process. A few Task Force members would have preferred to have continued and consequently felt they could not sign the final document. The directors of Ohio EPA and ODNR believe that does not diminish the value of the report and plan to proceed with implementation. Plans are underway to seek funding for implementation. As part of this project, the OCDRCM will provide an analysis of the process used to develop the Strategy and will include recommendations on the use of this process as a mechanism for State policy development.

Water Quality Standards for Wetlands

"Ohio EPA is in the process of developing wetland water quality standards."

Ohio EPA protects water quality in streams, rivers, and lakes using water quality standards consisting of aquatic life use designations, numerical chemical and biological criteria, narrative criteria and an antidegradation policy. Ohio EPA currently meets some of the minimum federal requirements for wetland water quality standards by including wetlands in the definition of waters of the state and by applying the antidegradation policy to wetlands (Table 9-1).

To fully extend the protection of the Clean Water Act to wetlands, Ohio EPA is developing wetland water quality standards. Aquatic life, wetland hydrology and recreational/educational use designations have been drafted to protect the functional values of wetlands. Narrative criteria to support the uses and an antidegradation policy specifically for wetlands have also been drafted. Under the proposed antidegradation policy, wetlands will be categorized as a function of their sensitivity, rarity, irreplaceability and functional values. This categorization will be used as a means to make regulatory decisions and to set appropriate mitigation ratios. Procedures needed to implement the wetland standards are also under development.

As recommended in the Ohio Wetlands Strategy, Ohio EPA formed a Technical Advisory Committee to provide review and comment on the technical and ecological soundness of the draft standards. Several meetings of the Committee were held in the spring of 1994. Ohio EPA anticipates that the standards will be promulgated into rule in the spring of 1995.

Under the wetlands program development grants, Ohio EPA has begun discussions of a suitable monitoring program needed to support both the wetland water quality standards and the development of performance goals for mitigation projects.

Table 9-1. Development of Ohio's Wetland Water Quality Standards (March 1994).

	In Place	Under Development or Revision	Proposed for Development
Waters of the State	X		
Use Classification		X	
Narrative Biocriteria		X	
Numeric Biocriteria			X
Antidegradation Policy	X	X	

Performance Goals for Wetland Mitigation Projects

As part of Ohio EPA's long-term development of the wetlands program, performance goals for mitigation projects will be developed following the promulgation of the wetland water quality standards. Mitigation for approved wetland fills is allowed under Ohio EPA's Section 401 certification program. It is essential in authorizing this practice that wetland mitigation projects successfully replace the functional values of the impacted wetlands.

"The effectiveness of the Section 401 program in protecting wetlands is improving."

Performance goals will be used to identify the criteria that will define successful mitigation projects and allow an assessment of their performance. They can also serve as a diagnostic tool to evaluate reasons for mitigation project failure and to suggest any mid-course corrections that may be necessary.

Section 401 Water Quality Certification

The Section 401 water quality certification program administered by Ohio EPA is the major regulatory tool used to protect wetlands in Ohio. Wetlands are specifically included in the definition of waters of the state in the Ohio Revised Code and the Ohio Administrative Code and are protected by those portions of the Ohio water quality standards which apply to all surface waters.

The placement of fill material in a wetland or dredging a wetland may interfere with the existing beneficial use as designated in the water quality standards. For example, if a shallow, inundated wetland is utilized by fish as a spawning and nursery area, the deepening of the wetland through dredging may interfere with the existing aquatic life function that wetland performs.

The Ohio EPA has denied applications for Section 401 water quality certification for projects involving the dredging and the placement of fill material in wetlands. The Antidegradation Policy has also been used to reduce the scope of proposed activities in wetlands by issuing conditional water quality certifications. These conditions specify adequate establishment of mitigation areas and protection of existing wetlands from indirect impacts. Wetlands will retain their classification as State Resource Waters under the existing antidegradation scheme until the new wetland water quality standards, which include an antidegradation policy specific to wetlands, have been adopted.

Mitigation for approved wetland fills is allowed under Ohio EPA's Section 401 certification program. Wetland restoration, creation and enhancement carried out as mitigation for wetland fills are done at a 1.5 to 1.0 in-kind ratio. The conditions of the certification may require an unmaintained buffer area around both mitigation and existing wetlands. Extensive monitoring of water quality, sediment, vegetation establishment, and hydroperiod is required for a period of 5 years. (These monitoring requirements may be revised as part of the development of performance goals for mitigation wetlands). In the third year following mitigation, Ohio EPA has the opportunity to make recommendations to enhance the successful establishment of mitigation wetlands in order to maintain and improve water quality.

The Ohio EPA responds to frequent citizen complaints of unauthorized placement of fill materials into wetlands and other waters of the state. Ohio EPA investigates the complaint and generally notifies the alleged violator of their responsibilities under federal and state law. The case is then referred to the U.S. Army Corps of Engineers.

The 401 water quality certification program provides protection to wetlands through regulating projects that require a federal permit. Ohio EPA presently lacks the authority to regulate projects that impact wetlands, but do not require a federal permit (i.e., those activities that do not involve the discharge of dredged or fill materials). This limits the degree of protection which wetland resources receive. Currently, the Section 401 water quality certification program is the only mechanism other than the NPDES permit program for applying the Ohio water quality standards to wetlands and other surface waters.

The effectiveness of the Section 401 program in protecting wetlands is improving. The program has been limited by a lack of specific water quality standards for wetlands and by lack of funding for staff and field equipment. Until the spring of 1992, the Section 401 program was maintained by a full time staff of 1.5 work years. As of early 1994, three full time staff members are managing the program, with additional technical assistance from other Ohio EPA wetlands staff on an as needed basis. However, staff shortages currently limit Ohio EPA's ability to monitor compliance with the requirements of 401 permits.

Section 401 permits are required for activities affecting both streams and wetlands. Recent permit activities concerning wetland are shown in Table 9-2. Over the period 1991 - 1993, 120 acres of wetlands were impacted under a total of 47 projects in the 401 program. An estimated 195 acres were restored or created as required by compensatory mitigation projects (giving a mitigation ratio greater than 1.5:1). In balance, it appears that through the 401 program Ohio is gaining wetland acres (as is the goal of the "no-net loss" policy); while a total of 120 acres of wetlands were permitted to be filled, 352 acres were gained through restoration, creation, enhancement or the establishment of long-term management.

Table 9-2. Statistics on Section 401 Wetland Projects for 1991 through 1993.

Permit action	1991	1992	1993
Total applications	20	27	22
Approved	14	14	15
Denied	0	1	5
Withdrawn	5	6	1
Waived	1	5	0
Pending	0	1	1

Wetland Impacts	1991 + 1992	1993
Acres impacted	120	40
Acres mitigated †	195	59
Acres enhanced	43	4
Acres managed	114	966
Acres preserved through 401 denial	37	36
Total acres mitigated, enhanced, managed	352	1124

† mitigation through wetland restoration and, to a very limited extent wetland creation.

The wetland acres put under management shown in Table 9-2 indicates cases where 401 permits for wetland fills have been authorized to create dikes around Lake Erie coastal wetlands. Often, these coastal wetlands are restricted to a small strip of land between the lake and areas of upland development. When lake water levels rise, the wetlands can be drowned out or destroyed by erosive forces since they are not able to "migrate" upland as they would have done in pre-development times. Dikes are placed around these wetlands to ensure their survival (in spite of the possibility of compromising their ecological functions). The acreage protected by the creation of the dike is counted as managed wetland.

It should be noted that limitations on staff time have prevented checking compliance with permit requirements. Therefore the actual number of acres mitigated, and their degree of success, is not well-known. Ohio EPA plans to institute a monitoring protocol to track mitigation projects as part of the development of performance goals for mitigation wetlands.

The development of a Status and Trends Report on Ohio's wetlands called for in the Ohio Wetlands Strategy will be used to track 401 certifications. A computerized data base will be established to monitor wetland-related activities by hydrologic unit. This will include tracking losses and gains of wetland acreage, a chronology of application processing, information on regulatory permit statistics and information on mitigation and restoration efforts. Monitoring wetland activities through a computerized tracking system will also facilitate production of future 305(b) reports.

Lake Erie Programs

There remains a lack of recent data to re-evaluate the status of the Lake Erie nearshore. However, a number of initiatives are underway which will provide data or assessment guidelines in the future.

"There remains a lack of recent data to re-evaluate the status of the Lake Erie nearshore."

Development of a Lakewide Management Plan (LaMP) for Lake Erie has begun. The original intent of LaMPs, as cited in the Great Lakes Water Quality Agreement, is to reduce the loadings of toxic pollutants that are causing the impairment of beneficial uses in the waters of the Great Lakes. A Concept Paper, developed as an initial starting point for the Lake Erie LaMP, recommends that the Lake Erie LaMP take a much broader perspective. It is widely felt that there a number of stressors that impact the lake much more than toxics. These include habitat destruction, the invasion of exotic species, overfishing and others.

As the Lake Erie LaMP progresses, data gaps should be filled and allow a much stronger data base against which to assess the water quality of the lake. Ongoing chemical and biological assessments of direct Lake Erie dischargers need to be continued to ensure that NPDES limits are protective of the environment and public health.

Ohio EPA has begun an effort to develop biological criteria for the Lake Erie estuary, harbor and nearshore areas. These will be similar to those developed for Ohio's inland streams and rivers, but will use metrics and evaluation tools appropriate for these areas. The first year of data collection and method development has been completed. The second is underway and a third year is planned. It is expected that a fourth year will be needed to finalize the criteria.

Ohio EPA has spent considerable time during the past two years reviewing and commenting on the U.S. EPA Great Lakes Water Quality Guidance (GLWQG). The initial phase focussed on specifying numerical limits for pollutants in ambient Great Lakes waters to protect human health, aquatic life and wildlife. It also provided guidance to the Great Lakes States on minimum water quality standards, antidegradation policies and implementation procedures for the Great Lakes System. Ohio has many concerns about the current content of the GLWQG, and hopes to address many of these issues through the development of the Lake Erie LaMP.

Under the Great Lakes Governors Toxic Substances Agreement, an interagency work group has drafted a protocol for a uniform Great Lakes sport fish consumption advisory. Based on this protocol, Ohio has issued a revised fish advisory for Lake Erie. In some ways it is now more restrictive, and in often ways it is less restrictive. Either way, the advisory is now more risk based and provides a better guidance for consumers deciding when to eat their catch.

The state of Ohio has authorized an extensive fish tissue sampling program to be implemented across the state to provide better information on which to base the need for issuance of fish advisories. A number of Lake Erie tributaries are included in the sampling schedule.

Since 1988, Ohio EPA has been working toward completion of remedial action plans (RAPs) for Ohio's four Lake Erie Areas of Concern (AOCs). These include the lower Ashtabula, Cuyahoga, and Maumee rivers, and the entire Black River watershed. Also a requirement of the Great Lakes Water Quality Agreement, RAPs are to be developed through a systematic, ecosystem approach with a considerable amount of local community involvement. Considerable progress has been made on RAPs, and highlights are presented below.

Ashtabula River

The Ashtabula River RAP Advisory Council formed in March, 1988 in partnership with Ohio EPA to identify beneficial impairments, the causes and sources, and design and implement future remedial actions in the Area of Concern (AOC). The 25-member RAP group meets bimonthly. Agencies and organizations contributing to the RAP include Ohio Sea Grant, Ashtabula Soil and Water Conservation District, angler groups, marinas, industries, local government agencies, elected officials and unaffiliated citizens. A Stage 1 investigative report was approved by the IJC in 1992. Stage 2 progress is tracked via quarterly Ohio EPA reports and RAP newsletters, consistent press coverage, and annual progress reports.

The primary issue in the Ashtabula River AOC is contaminated sediments. A fish advisory issued in 1983, due to PCB's and the presence of a variety of chlorinated chemicals, still exists. A 1993 interim dredging project completed in 1993 removed an estimated 30,000 cubic yards of nontoxic, moderately polluted sediment from shoaled areas in the navigation channel.

The lower Ashtabula River is currently being considered for designation as an extension of the Fields Brook Superfund site. To avert Superfund designation and devise a plan to cleanup and restore the AOC in the most effective and efficient manner, the RAP has endorsed exploration of cleanup options under a public/private partnership. This partnership includes OEPA, U.S. EPA, the Corps of Engineers, RAP representatives, local industries (PRP and non-PRP), local governments, etc. A multi-use disposal facility to contain maintenance dredging and environmental cleanup dredging is sought. Such a partnership can also open additional avenues for funding the proposed multi-million dollar cleanup of the Ashtabula AOC.

The Corps of Engineers and U.S. EPA are currently developing a sediment transport model and associated field sampling to predict effects of scouring on the river. The object of the model is to determine the potential for contaminated sediments to be exposed by river under various remedial action scenarios.

Also in 1994, Ohio EPA is analyzing fish tissue samples from the river to determine the status of contamination in the local fishery. Ohio EPA's effort to develop baseline biocriteria for the Lake Erie harbor, estuary and nearshore areas continues. The RAP, in association with the Ashtabula County Health Department is conducting fecal coliform sampling in the river. The RAP also plans to investigate nonpoint source impacts in the upper watershed and determine possible impacts from these sources on the AOC.

Black River

The Black River RAP process was the last to begin, but is already ahead of the others. Many remedial actions have already been completed to substantially reduce discharge from point sources.

The Friends of the Black River initiated volunteer monitoring to supplement Ohio EPA stream monitoring. A 1992 Ohio EPA intensive survey indicated tributaries are impacted by nonpoint sources, but the mainstem is much improved due to advances in point source controls. The City of Elyria has undertaken an aggressive sewer rehabilitation program to reduce overflows from separate sewer outfalls. In 1992, Section 319 funds totaling $200,000 were awarded to basin farmers and applied toward equipment buy-downs, installation of buffer strips, conservation tillage, and cover crop measures. To expand conservation measures over a 20 year period, over $10 million in Ohio EPA low interest loan funds was requested. As part of the loan application process, a watershed management plan for the agricultural community was developed. In 1993, the Great Lakes National Program Office (GLNPO) awarded more than $150,000 to the Lorain Soil & Water Conservation District (SWCD) for an upper watershed agricultural wetland habitat restoration project. The Lorain SWCD published a Homeowners Guide to Water Quality about residential impacts on the environment and measures to reduce nonpoint sources. The Lorain SWCD plans to conduct a 1995 upper watershed nonpoint source identification study of Findlay Lake. More than $200,000 in USEPA funding enabled Ohio EPA to conduct Total Maximum Daily Load (TMDL) studies to determine both point and nonpoint source impacts. The RAP and Friends of the Black River are investigating and planning habitat restoration projects in the basin. Funding for these projects is currently being sought. Seventh Generation, an umbrella organization overseeing environmental activities in Lorain County, has implemented a pollution prevention program targeting local industrial point and nonpoint sources.

The Stage 1 Report for the Black River was completed in 1992 and reviewed by the IJC. Planning for Stage 2 is actively underway. Follow-up studies on the occurrence of tumors in brown bullhead indicate a substantial decrease since the removal of PAH contaminated sediments from the river. Additional fish tissue sampling is being done and hopefully will lead to the cancellation of the fish consumption and contact advisory in effect for the lower Black River since 1983. Ohio EPA continues their efforts to develop biocriteria for the lower river, harbor and nearshore area.

Cuyahoga River

The Cuyahoga River RAP process was established in 1988 by the creation of the Cuyahoga River Coordinating Committee. This group established a nonprofit organization, the Cuyahoga River Community Planning Organization (CRCPO), to support the Stage 1 process. The Stage 1 Report has been completed and approved by the IJC, and both groups are now actively involved in the Stage 2 process.

Three years of fish tissue collection supported by the Cuyahoga RAP, provided enough data to review to determine the need for issuance of a fish advisory. According to old guidelines and FDA action levels, the fish showed no levels of contaminants in exceedance. However, according to new (1993) risk-based guidance now used by Ohio, a fish consumption advisory has been issued for the Cuyahoga.

Two years of intensive water quality data collection were used to develop a water quality model for the Cuyahoga ship channel. This portion of the river has long been deferred in Ohio Water Quality Standards due to lack of sufficient documentation on what the designated use for the channel should be. The RAP was actively involved in this investigation and use designation. Results indicated the morphology of the channel itself was the primary cause of failure to meet Ohio Water Quality Standards for dissolved oxygen. The RAP and Ohio EPA are now exploring the options to re-aerate the channel.

Extensive work has been done investigating fecal coliform contamination in the river, including development of a die-off model. Many public involvement activities have been implemented and the whole Cuyahoga RAP process has been cited repeatedly across the Great Lakes Basin as a successful model of how the RAP process benefits the local community and the environment.

Habitat enhancement is a priority effort underway in the Cuyahoga AOC. A recent RAP survey identified 25 sites along the river mainstem with high erosion potential. The RAP is seeking opportunities to restore these areas. The Cuyahoga SWCD is applying a $10,000 grant toward restoration of riparian areas with willow posts. One of many topics highlighted on the “Cuyahoga Caravan,” an annual RAP-sponsored tour, is urban nonpoint source impacts. Storm drain stenciling projects are being implemented in the AOC. Eight video vignettes show homeowners how to address nonpoint source impacts. The videos, nearly 8 minutes in length, were developed with support from public television stations. Education curriculum materials were also created to be used with the videos.

Here also, Ohio EPA continues its efforts to develop biocriteria for the Lake Erie estuary, harbor and nearshore. Larval fish investigations have been implemented in the Cuyahoga River to better characterize the importance of the lower Cuyahoga River to the river and lake fish community.

Maumee River

After the Stage 1 Report was completed and approved by the IJC, the Maumee River Advisory Committee reorganized itself as the Maumee RAP Implementation Committee. It continues to focus its efforts on prioritizing and implementing recommendations developed upon completion of its Stage 1 Report. Top priorities include agricultural runoff, landfills and dumps, wetlands and habitat preservation, and urban runoff. Action groups have been formed for each issue and public participation is actively being sought. The Maumee RAP has expanded the original AOC boundaries to include several Lake Erie-direct tributaries where nonpoint source runoff, wetlands, and habitat issues are a concern. The Maumee AOC received an additional $1.2 million from USEPA to continue its investigation of landfills and stream monitoring. A third year of funding is anticipated (total funding would be $3 million). A multi-agency work group continues to actively address longterm management of dredged Toledo Harbor sediments. Implementation of BMP's throughout the watershed have been intensified to reduce sediment and the associated phosphorus and contaminant loading in the harbor. In late 1994, the Lucas County SWCD plans to initiate an urban runoff campaign and conduct storm drain stenciling.

Ohio EPA is also conducting fish tissue sampling here to better quantify impacts on the local fishery. Investigations are underway here as well to establish baseline biological criteria to better assess the Lake Erie estuary, harbor and nearshore area.

Inland Lakes, Ponds, and Reservoirs

Ohio EPA has recently updated its statewide assessment of the quality of inland lakes for inclusion in the 1994 305(b) report (Ohio EPA 1994). This partially fulfills a major requirement for the Ohio EPA to qualify for future lakes funding under section 314 of the 1987 Clean Water Act. More information about the lakes program is available in Volume III of this report.

Nonpoint Source Program

Ohio EPA, in fulfillment of the requirements of section 319 of the 1987 Clean Water Act, has updated its statewide assessment of nonpoint sources (Ohio EPA 1991b). This report was submitted in 1991 and is available from the Division of Water Quality Planning & Assessment, Nonpoint Source Management Section.

Ohio River (ORSANCO)

Ohio is an original compact state of the Ohio River Valley Sanitation Commission (ORSANCO). ORSANCO, in cooperation with the compact states, performs most the water quality monitoring and reporting for the mainstem portion of the Ohio River. This includes the production of an Ohio River 305(b) report that is produced separately (ORSANCO 1994). ORSANCO recognizes the need for more integrated, site specific assessments and the inclusion of an expanded biological monitoring effort. The Ohio EPA has completed six annual electrofishing surveys of the Ohio portion of the Ohio River during 1988 through 1993. The 1989-1993 efforts were funded by a nongame grant from the Ohio Department of Natural Resources, Division of Wildlife (Sanders 1992, 1993). The development of biocriteria for the Ohio River mainstem is an Ohio EPA priority within the next 3-5 years. Recommendation number three of the 1990 Ohio River 305(b) report (ORSANCO 1990) was a call to “Develop and carry out a program to characterize the biological community of the Ohio River.” As illustrated in Section 3, ORSANCO has initiated a biosurvey program using night electrofishing methods developed by Sanders (1990). Assessment of water quality by using chemical data alone, is a limited assessment. A characterization of the aquatic biota is needed to understand the effects of Ohio River water quality on aquatic life use attainment / non-attainment.

Economic Analyses

Ohio EPA conducts analyses of the financial capability of municipal and industrial dischargers to meet the terms and requirements of their NPDES permits. The results of an analysis may determine the need to issue a discharge specific variance from Ohio water quality standards if an entity were economically incapable of meeting discharge requirements. A summary of the process for evaluating municipal and industrial dischargers follows. The detailed procedure is described in Economic Evaluation Methodology (Ohio EPA 1991c).

Municipal Analysis

The evaluation of the financial capability of a municipal discharger is a three-part procedure; a screening review, a cursory review, and a detailed analysis. The initial screening review addresses the impact of the project on residential customers. The purpose of the screening review is to identify the obviously affordable projects, and to eliminate them from further analysis. When the cost of the project results in a household impact above the benchmark, a detailed analysis of the financial health of the municipality will be completed. This analysis determines if the project is likely to result in substantial and widespread economic and social impact. When the annual cost per residential customer is below the benchmark, a detailed analysis is generally not required. However, a cursory review of the general economic condition of the community will also be used to suggest the need for detailed analysis.

The focus of a detailed analysis is on the financial stability of the community, and on the changes projected to occur in the financial condition as a result of the project. To develop a comprehensive picture of the community, four general areas are considered: 1) socioeconomic factors; 2) financial factors; 3) debt factors; and 4) administrative factors.

Industrial Analysis

During the period covered by this report a two-part review process was in place for industrial dischargers to determine their ability to make expenditures necessary to meet effluent limitations. The initial screening review determined the impact on the industry and predicted the possibility of plant closure. The detailed analysis assessed the potential impact of a plant closure on the community. Two types of screening reviews would be completed depending on the type of financial data that was available. The analysis would be done at the plant level if information were available. If plant specific information was not available, the analysis would be at the level of the firm as a whole. Both analyses would be completed for a five year period to identify trends.

Expenditures for Water Pollution Control in Ohio 1991-1992

"The total amount expended was $827.1 million statewide"

Capital expenditures for wastewater pollution control in Ohio were compiled for the period January 1991 through December 1992. This information was obtained from Permits to Install (PTI) that were filed with the Division of Water Pollution Control during that period. No figures were available for operation and maintenance costs. The total amount expended was $827.1 million statewide. Table 9-3 provides a break-down by major basin for 1991-1992. In some cases it was not possible to determine the basin where the expenditure took place. These are included under "Overlapping Basins". Seven different types of pollution control activity were listed:

1) publicly owned treatment works (POTWs);
2) industrial treatment facilities;
3) industrial pre-treatment facilities;
4) on-site systems;
5) semi-public facilities;
6) sewers, pumps, and lift stations; and
7) other

Figures depicting the distribution of funds across these seven categories by major river basin are presented in Appendix H. Also included in Appendix H is a graph that indicates the level of total water pollution control expenditures in the years 1987-1988, 1989-1990 and 1991-1992.

Ohio EPA Toxics Strategy

The Divisions of Water Quality Planning & Assessment and Water Pollution Control (since merged into the Division of Surface Water) completed the Ohio Toxic Substance Control Strategy in 1989 (Ohio EPA 1989). This document outlines Ohio's program to control toxic substances primarily through NPDES permits. The strategy outlines specific procedures and guidelines that Ohio EPA staff have been using during the past two years in developing water quality based effluent limit recommendations. This was submitted to and approved by U.S. EPA, Region V in 1989. Copies of the document can be obtained by contacting the Division of Surface Water.

Section 10

Special State Concerns

Interagency Work Group on Fish Contaminant Advisories

An interagency work group was established in September 1987. Between the Ohio EPA, Ohio Department of Natural Resources (ODNR), Ohio Department of Health (ODH), and the Ohio Department of Agriculture (ODA) to examine fish tissue contamination problems and issue advisories. Specific issues examined include Lake Erie concerns, short-term data needs, organization of existing information, and a clear definition of each agency's authority. Laboratory capability has been a focus of the group's attention recently. Besides this group Ohio EPA, Ohio DNR, and ODH all participate in the Great Lakes Governors Task Force on Great Lakes toxics problems which was previously described under Lake Erie programs.

Exotic Species in Ohio Waters

The introduction of exotic (non-native) species in Ohio surface waters is a form of "biological pollution" that has posed a serious problem for Ohio's indigenous aquatic fauna for more than 100 years. Non-native species such as carp and goldfish are well established in Ohio waters. These species have their highest populations in areas with moderate to high degradation of habitat or water chemistry. Several recently introduced exotic species have become the focus of special concern in Lake Erie.

Zebra Mussell[1]

Zebra mussels (*Dreissena polymorpha*), which are native to southern and central Asia, are believed to have entered the Great Lakes in 1986 via the discharge of ballast water from ocean going ships. By 1989 the zebra mussel had spread throughout Lake Erie. Zebra mussels colonize quickly and have been reported at densities up to 30,000 individuals per square meter. The long term ecological effects of this species on fish and wildlife is unknown at this time. It is known to have economic impacts by fouling water intake systems in Lake Erie. This species could have beneficial effects as a food supply for certain species of fish and birds, and has apparently contributed to increased water clarity by filtering suspended particles while feeding. It may also serve as an indicator of toxic pollution via its ability to concentrate certain pollutants. The effects of its large filtering capacity and high rate of colonization on other species in Lake Erie are unclear at this time. Thus, it will be important to monitor the effects of the zebra mussel especially given the economic importance of Lake Erie to Ohio. The Ohio Division of Wildlife has funded research by the Ohio Cooperative Fishery and Wildlife Research Units to study the mussel's impact on walleye reef spawning. OSU Sea Grant has also funded a study of the feeding habits of the freshwater drum on zebra mussels. The Ohio Division of Wildlife will continue to assess the stock dynamics of walleye and yellow perch in Lake Erie, as it has in the past, which should enable the detection of significant impacts of zebra mussels (if any) on population stocks. In addition, the zebra mussel has been collected in the Ohio River which may threaten populations of native naiad mollusks in this drainage.

Round Goby and Other Exotic Species

Besides the zebra mussel, other recently introduced exotic species may be of concern in Ohio. Two recent arrivals are the spiny water flea (*Bythotrephes cederstroemi*) and the river ruffe (*Gymnocephalus cernua*). The effects of the spiny water flea could result from its foraging on daphnia, rotifers, and copepods, which themselves are forage for young fish of such species as emerald shiners (*Notropis atherinoides*). It is unclear whether this species could disrupt the trophic relationships in Lake Erie or whether they will simply replace the zooplankton consumed as forage for fish. Yellow perch and walleye have been reported to consume spiny water fleas.

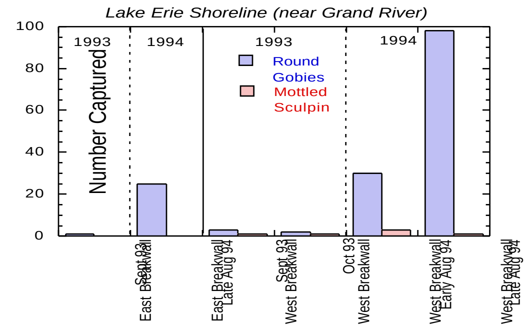


Figure 10-1. Collections of round goby and mottled sculpin at two sampling stations along the Lake Erie shoreline near the mouth of the Grand River during 1993 and 1994.

The river ruffe, like the zebra mussel, also arrived via the discharge of ballast water from ocean going ships. The concern with this species is that it could compete for forage with yellow perch. Because it reproduces earlier than yellow perch and has little or no sport or commercial significance, it would be an unsatisfactory replacement for yellow perch in Lake Erie. Because of its proportionately large spiny fins it does not seem to be a preferred food item of most large predators.

Other recent exotic invaders of the Great Lakes are the tube-nosed goby and round goby. Both had been found in the St. Clair River between Lake St. Clair and Lake Huron. In 1993 Ohio EPA staff collected round goby in Lake Erie near the mouth of the Grand River. These species have the same Asian origins as the zebra mussel. These are small bottom dwelling fish species that also arrived via ocean freighter ballast water discharges. Because of its bottom dwelling habitats, it may compete with the indigenous darter and sculpin species present in Lake Erie. Figure 10-1 summarizes the limited data to date. The spread of this species and its possible interactions with sculpins and other species will be monitored over the next few years. Because the effects of each of these exotic species are unknown they are of special concern to both the ecological and economic interests of Lake Erie.

"Because the effects of each of these exotic species are unknown they are of special concern to both the ecological and economic interests of Lake Erie."

Biocriteria in Ohio's WQS

Ohio EPA first proposed biological criteria as part of its water quality standards regulations in November 1987 and reproposed them in October 1989. Following extensive interaction with interested parties the revised WQS were adopted in February 1990 and became effective in May 1990. A three volume set entitled Biological Criteria for the Protection of Aquatic Life contains the rationale, development, and field methods for deriving and using biocriteria in Ohio (Ohio EPA 1987a,b; 1989a,b). An addendum to Volume II (Ohio EPA 1989) and a revised Volume III (Ohio EPA 1989b) were produced in 1989. In addition, a detailed rationale for the development and application of the Qualitative Habitat Evaluation Index (QHEI) was also produced (Rankin 1989). This issue has received national attention as evidenced by the first national workshop on biocriteria held December 1987. Since that initial effort U.S. EPA has produced guidance on Rapid Bioassessment (U.S. EPA 1989), national biocriteria program guidance (U.S. EPA 1990b), and a policy statement on biocriteria in April 1990. A technical guidance manual for developing and using biological criteria in wadeable streams is in progress. Efforts have also been initiated to develop biological criteria for lakes.

Policy Issues

A key policy debate involving biological criteria is the U.S. EPA policy of independent application. This policy requires that biological survey information, chemical-specific data, and bioassay results are evaluated independently with no single method being viewed as superior or preemptive of another. Others have proposed a weight-of-evidence approach in which the application of each tool is done on a more flexible case-specific basis. Ohio EPA has been much involved in this debate, particularly given the narrative language in the 1990 WQS that allows for a weight-of-evidence approach. This issue has yet to be resolved with U.S. EPA, Region V. We have suggested that the issue include a classification of the "strength" of the biological survey and underlying biological criteria development procedures as a way to regulate how much flexibility a state might be granted in the use of biological survey information (Yoder 1991a; see also Section 2, Table 2-7. pp. 31 of this volume). The real issue is not one of attempting to prove the superiority of one tool over another, but rather an issue of knowing the relative strengths of the particular assessment types for each tool and not extending the respective chemical-specific, toxicological, or biosurvey tools beyond their inherent abilities. Obviously there are biological survey techniques that have a comparatively low power of discrimination and assessment, as there are parallels for chemical-specific and bioassay techniques. We firmly believe that this concept must be part of the process, otherwise we risk basing decisions on the weakest information, jeopardizing the accuracy of decision making and the credibility of the institutions.

"...otherwise we risk basing decisions on the weakest information which jeopardizes not only the accuracy of decision making, but the credibility of the institutions as well."

Based on analyses presented in the 1990 Ohio Water Resource Inventory (Ohio EPA 1990a) and elsewhere (Yoder 1991a, 1991b), there is little doubt that the addition of biological criteria and ambient biological monitoring significantly adds to the capability to detect and manage water resource impairments. For example, Ohio EPA (1987a) illustrates several examples of problem discovery and problem amplification, none of which would have been possible without an *integrated* chemical, physical, and biological approach to surface water monitoring. Aquatic life use impairments that we have identified and characterized during the past 12 years simply would not have been detected using chemical criteria and assessment tools *alone*. The identification of the three leading causes of aquatic life use impairment described by this inventory would not have been possible without this type of approach, including the use of numerical biological criteria derived using the regional reference site approach.

A Five Year 305(b) Cycle

It is fast becoming apparent that the two-year cycle of the 305(b) report is too brief. The principal focus of the 305(b) report is to examine changes in water resource quality over time and to examine the effectiveness of water quality management programs. Two years is not only too brief of an interval to expect to detect substantial or significant changes (see Figure 4-1, Section 4), but it is also an unrealistic interval for producing a written report on an ever increasing base of ambient information. A five-year cycle coincides with Ohio's Five-year Basin Approach (and that of other states) and allows sufficient time to produce a useful and quality report. In place of the current biennial cycle the following is recommended:

(1) a five-year cycle for the detailed written report, starting in 1995 and occurring every five years thereafter (i.e., 2000, 2005, and so on)

(2) revise the submittal date from April 1 to September 30. This would allow states to incorporate data from the previous field year making the report more current. With the present April 1 date, information from the previous field season is not yet available in a readily usable form and is therefore excluded from the report (it is incorporated into the next biennial report).

(3) states would be required to upload new information to the Waterbody System (WBS) each year. In addition, a brief summary including a running tally of status could also be produced annually This will ensure that states evaluate and assess their ambient data on an annual basis.

(4) The focus of the report could be changed to be complimentary with EMAP. This has the advantage of keeping each program in focus with its own unique capabilities and not extending each beyond that which they are capable of doing. EMAP is designed to produce unbiased estimates of status and trends at a *national and regional scale*. The state produced 305(b) reports focus more on site specific assessments of water resource integrity at a finer scale than EMAP. The 305(b) process could also address results obtained via the EMAP process and vice versa.

(5) U.S. EPA needs to stress that the 305(b) process is intended to report status, trends, and results of existing state monitoring efforts that

should be integrated through all of the state water resource management efforts.

Stream Habitat Protection

It is evident from the data summarized in Section 4 that the Ohio EPA year 2000 goal of restoring water resource quality cannot be achieved by controlling point sources alone. While nonpoint sources and causes of impairment are often complex there is a physical "infrastructure" of streams and rivers that is basic and essential for the proper ecological functioning of these ecosystems. Ohio needs to work to protect and restore stream functions that support the aquatic life uses of these waters. Any approach should recognize: (1) the long-term ecological, recreational, and economic value of surface waters, and (2) the need for economic vitality in Ohio. Excepting those areas that Ohio wishes to maintain in a near pristine state for the enjoyment of future generations the challenge of stream habitat protection is to protect the environment while not unnecessarily burdening economic development. These efforts need to maximize long-term economic and ecological considerations over short-term economic gain that sometimes sacrifices environmental quality.

"...stream function is strongly keyed to the presence of intact riparian zones."

Work done near Toronto, Ontario has shown that instream ecological integrity depends on the existence of intact riparian areas and landuse (Steedman 1988). As landuse becomes more urban, ecological integrity usually declines; however, that decline can be forestalled and moderated with intact, healthy riparian areas along streams. As riparian areaa are reduced and removed, streams lose ecological integrity. Clearly, stream function is strongly keyed to the presence of intact riparian zones.

The functions provided by riparian areas include nutrient uptake and storage, erosion control and storage, habitat forming functions, shading, energy provision (i.e., leaves and woody debris), flood control, groundwater treatment (recharge) and storage, breeding and migrating bird and wildlife habitat, and recreation. These functions are discussed in more detail in Appendix B.

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Acronyms used in the 1990 305(b) report.

Acronym	Meaning
AMD	Acid mine drainage
AoC	Area of Concern (IJC)
ADV	Area of Degradation Value
BAT	Best Available Technology
BPJ	Best Professional Judgement
BPT	Best Practical Technology
BMP	Best Management Practice
CFD	Cumulative Frequency Distribution
CIV	Community Index Value
CLIP	Citizen Lake Improvement Program
CSO	Combined sewer overflow
CWA	Clean Water Act
CWH	Cold Water Habitat
DLG	Digital Line Graph
DNR	Department of Natural Resources
ECBP	Eastern Corn Belt Plains
EOLP	Erie-Ontario Lake Plain ecoregion
EPA	Environmental Protection Agency
EWH	Exceptional Warmwater Habitat
FDA	Food and Drug Administration
GLISP	Great Lakes International Surveillance Plan
HELP	Huron-Erie Lake Plain ecoregion
IBI	Index of Biotic Integrity
ICI	Invertebrate Community Index
IJC	International Joint Commission
Iwb	Index of Well-Being
IP	Interior Plateau ecoregion
LEH	Lake Erie Habitat
LRW	Limited Resource Water
MWH-I	Modified Warmwater Habitat (Impounded)
MWH-C	Modified Warmwater Habitat (Channelized)
MWH-A	Modified Warmwater Habitat (Mine Affected)
NASQAN	National Stream Quality Accounting Network
NPDES	National Pollutant Discharge Elimination System
NPSA	Nonpoint Source Assessment
NPSMP	Nonpoint Source Management Plan
OAC	Ohio Administrative Code
ODA	Ohio Department of Agriculture
ODH	Ohio Department of Health
ODNR	Ohio Department of Natural Resources
ODOT	Ohio Depart. of Transportation
ORC	Ohio Revised Code
OSUMZ	Ohio State Univ. Museum of Zool.
PAH	polynuclear aromatic hydrocarbons
PCB	polychlorinated biphenols
POTW	publicly owned treatment works
PWS	Public Water Supply
QA/QC	Quality Assurance/Quality Control
QHEI	Qualitative Habitat Evaluation Index

RAP	Remedial Action Plan
RF3	Reach File 3
SCORP	Statewide Comprehensive Outdoor Recreation Plan
SQM	Stream Quality Monitoring Program
SRW	State Resource Water
SSH	Seasonal Salmonid Habitat
TMACOG	Toledo Metropolitan Area Council of Governments
TMDL	Total Maximum Daily Load
USGS	United States Geological Survey
WAP	Western Allegheny Plateau ecoregion
WRI	Water Resource Inventory
WQA	Water Quality Act of 1987
WQS	Water quality standards
WWH	Warmwater Habitat
WWTP	Wastewater treatment plant

Glossary

Acute - Acute involves a stimulus severe enough to rapidly induce a response; in toxicity tests a response observed in 96 hours or less typically is considered acute. An acute effect is not always measured in terms of lethality; it can measure a variety of effects[1]

Acute (Chemical) Criteria - Water quality standard in Ohio designed to protect the Limited Resource Waters (Nuisance Prevention) aquatic life use; this criteria is less stringent than the chronic criteria and is designed to protect aquatic life from rapidly induced stresses.

Aquatic Life Use - A designation assigned to a waterbody in Ohio based on the *potential* aquatic life that the water can sustain given the ecoregion potential; (See EWH, WWH, CWH, LRW, Designated use).

Aquatic Life Use Attainment - Defined as the condition when a waterbody has demonstrated, through the use of ambient biological and/or chemical data, that it does not significantly violate biological or water quality criteria for that use.

Bioassay - The procedure of exposing test organisms, in a laboratory setting, to various concentrations of of suspected toxicants or dilutions of whole effluent to determine the lethality of the solution2 (See Whole Effluent Bioassay).

Biological (Biotic) Integrity - The ability of an aquatic community to support and maintain a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of the natural habitats within a region (taken from: Ohio EPA 1987; Karr et al. 1986).

Biosurvey - In field (ambient) sampling of resident biological organisms to assess biological integrity. For Ohio the accepted methods include pulsed-DC methods of electrofishing for sampling fish and, for sampling macroinvertebrates, Hester-Dendy Multiple Plate Artificial Substrate Samplers and dip nets. Other synonyms: ambient (or instream) biological sampling, biosurveillance[2].

Channelization - General term applied to stream channel modifications, usually designed to improve drainage of fields and/or prevent flooding, which include channel straightening and widening and often is associated with riparian vegetation removal; these activities almost always result in degraded biological integrity via habitat loss and trophic disturbances.

Chemical Specific Approach - Traditional water quality approach of regulating point sources by setting surrogate water quality criteria (allowable concentrations of individual chemicals in the water), that if not violated instream, should protect aquatic life and maintain aquatic life uses.

Chronic - Chronic involves a stimulus that lingers or continues for a relatively long period of time, often one-tenth of the life span or more. Chronic should be considered a relative term depending on the life span of the organism. A chronic effect can be lethality, growth, reduced reproduction, etc.

Chronic (Chemical) Criteria - Water quality standard in Ohio that is designed to protect the Warmwater and Exceptional Warmwater aquatic life uses by preventing long-term stresses to organisms that would affect growth, reproduction. etc.,; this criteria is more stringent than the acute criteria.

Clean Water Act - An act of the US Congress, first passed in 1972, which provides the legal framework for reducing pollutants to America's waters. This report is required by a section (305(b)) of that report.

Combined Sewer Overflow (CSO) - Combined sewers are sewers with sanitary wastes and storm water runoff in the same pipes; a combined sewer overflow is the location where storm water and municipal wastes are discharged to streams during rainfall events when the increased amount of flow cannot be carried by the sewer system to the WWTP.

Conventional Pollutants - Refers to pollutants commonly discharged by municipal WWTPs as by-products of the treatment process such as ammonia, nitrite, dissolved oxygen, and chlorine. These may also be constituents of urban and agricultural nonpoint runoff.

Criteria - The conditions presumed to support or protect a designated use (*e.g.*, WWH or MWH)[2].

Degradation - A lowering of the existing water quality or biological condition in Ohio's surface waters.

Designated Use - The purpose or benefit to be derived from a waterbody, *e.g.*, drinking water, aquatic life[2].

Dilution Screening - Mass-balance analysis of pollutants discharged based on point source discharge flow, the critical low flow of the stream (*e.g.*, $Q_7 10$), and the concentration of a parameter in the effluent. Predicted instream concentrations are compared to the criteria for a given value and examined for WQS exceedences.

Ecoregion - Regions of geographic similarity based on an overlay of maps of land-surface form, soils, land use, and potential natural vegetation; such regions are likely to contain similar aquatic communities.

Ecoregion Criteria - Biological index values that represent the base level of what minimally impacted communities should achieve in a particular ecoregion.

Effluent - Term given to the wastewater discharge of a WWTP or industry.

Electrofishing - Method of collecting fish by stunning them with electrical current from a gas-powered generator; the stun is temporary and fish are released unharmed after processing. Processing includes species identification, counting, weighing, and examining for external anomalies. These results are used to calculate the Index of Biotic Integrity (IBI) and the modified Index of Well-Being (Iwb).

Eutrophic - This refers to a highly "productive" body of water that has high concentrations of organic matter, nutrients, and algae.

Evaluated Data - This refers to data used in this report that originated from sources *OTHER* than intensive surveys of biological or chemical conditions;

these sources include predictive modeling, the nonpoint source survey, citizen complaints, and chemical data > 5 yrs old.

Exceptional Warmwater Habitat (EWH) - Aquatic life use designed to protect aquatic communities of exceptional diversity and biotic integrity; such communities usually have high species richness, often support rare and endangered species and/or an exceptional sport fishery.

FDA action limit - The “safety” limits for concentrations of compounds in fish flesh that above which consumption of the flesh carries some risk of cancer or other health problem.

Fecal Coliform - A bacteria group that is present in the intestines of warm-blooded animals and is evidence of the presence of human or animal wastes.

Fish Consumption Advisory - In Ohio, a notice to the public warning about specific areas with fish tissue contamination by toxic chemicals that exceed FDA action limits; advisories may be species specific or community wide. The decision to issue an advisory is based on an agreement between the Ohio EPA, Ohio Dept. of Natural Resources, the Ohio Dept. of Agriculture, and the Ohio Dept. of Health

Hester-Dendy Multiple Plate Sampler - A sampling device for macroinvertebrates which consists of a set of square hardboard plates (approximately a surface area of one square foot) separated by spacers of increasing width. Aquatic macroinvertebrates colonize or reproduce on this device which is placed instream for six weeks during the summer. Counts of individuals and species are used in calculation of the Invertebrate Community Index (ICI). (See Invertebrate Community Index).

Impacted - This refers to the situation where there is suspected impairment based on the presence of sources (*e.g.,* nonpoint source survey). In such cases there is evidence that some changes or disturbance has occurred to the stream, but there is no quantitative data to establish whether aquatic life uses are actually being impaired.

Impaired - This refers to the situation where there is monitored level data that establishes a violation of some water quality or biological criterion, and hence, an impairment of the designated use .

Index of Biotic Integrity (IBI) - An ecologically-based index that uses fish community data and summarizes them as 12 ecological metrics that can be classified into three categories: species richness, species composition, trophic composition, and fish density and condition (Karr 1981; Karr *et al.* 1986).

Index of Well-Being (Iwb) - A composite index of diversity and abundance measures (density and biomass) based on fish community data (Gammon 1976; Gammon *et al*. 1981).

Invertebrate Community Index (ICI) - An index of biological condition based on ten metrics that measure various structural and tolerance components of macroinvertebrate communities in Ohio streams (DeShon *et al*., unpublished; OhioEPA 1987).

In-Place Pollutants - Refers to pollutants deposited in the sediments of a waterbody (*i.e.*, therefore they are "in-place").

LC50 - the concentration of some tested substance in a suitable dilutant at which 50% of the organisms die in a specified period of exposure.

Limited Resource Water (LRW) - An aquatic life use assigned to those streams with very limited aquatic life potential, usually restricted to mine drainage streams or very small streams (<3 sq. mi. drainage area) in urban areas with limited or no flow during the summer

Long List - List of all impaired waterbody segments for all causes and sources pursuant to Section 304(l) of the 1987 Water Quality Act (WQA).

Major Cause or Source - The primary cause or source for a stream segment not attaining its designated use.

Mass Balance Analysis - See dilution analysis

Medium ("Mini") List - List of all stream segments impaired by toxic substances, including ammonia, chlorine, and toxicity detected by whole effluent bioassays. This a subset of the long list and is pursuant to Section 304(l) of the 1987 Water Quality Act (WQA).

Metals - Specific class of chemical elements that have unique characteristics (such as conductance); some of the metals commonly found in water or sediment as pollutants include lead, copper, cadmium, arsenic, silver, zinc, iron, mercury, and nickel.

Moderate Cause or Source - A secondary or contributing (but not primary) cause or source of impairment of a designated use.

Modified Warmwater Habitat (MWH) - Aquatic life use assigned to streams that have irretrievable, extensive, man induced modifications that preclude attainment of the Warmwater Habitat Use (WWH); such streams are characterized by species that are tolerant of poor chemical quality (fluctuating dissolved oxygen) and habitat conditions (siltation, habitat simplification) that often occur in modified streams.

Monitored Data - This refers to chemical or biological data used in this report that originated from sources such as intensive surveys of biological or chemical conditions; chemical data must be less than 5 yrs old.

Named Stream - Streams large enough to be named on USGS 71/2 minute topographic maps and listed in the Gazateer of Ohio streams; there are approximately 22,000 miles of named streams in Ohio.

Natural Conditions - Those conditions that are measured outside the influence of anthropogenic activities.

Non-conventional Pollutant - Toxic pollutants *other* than the common nitrogen compounds (ammonia, nitrite), dissolved oxygen, or chlorine; examples of non-conventional pollutants are pesticides, herbicides, other organic compounds, and heavy metals.

Nonpoint Pollution Source - Diffuse sources of pollutants such as urban storm water, construction, farms and mines that are usually delivered to waterbodies via rain runoff and water infiltration.

Point Source of Pollution - Any source of pollution that arises from a single identifiable point, such as a discharge pipe of an industry or WWTP.

Pollutant Loading - Amount (mass) of a compound discharged into a waterbody per unit of time, for example, kg/day.

Priority Pollutant - One of the 126 toxic compounds (a subset of 65 classes of toxic compounds). (See 304(l))

QHEI (Qualitative Habitat Evaluation Index) - A qualitative habitat index designed as a screening tool to help in assigning designated uses and as an aid in interpreting changes in aquatic communities.

Recreation Use - Ohio designated uses related to human body contact (*i.e.*, swimming, wading, canoeing).

Reference Site - A relative unimpacted biosurvey site that is used to define the expected or potential biological community within a region such as a ecoregion; in Ohio reference sites were used to calibrate the ICI and IBI.

Rheophilic - Organisms that are "current loving"; usually reserved for organisms that are obligate riffle dwellers.

Short List - A list of point sources that discharge one or more priority pollutants of a quantity sufficient to substantially impair the designated use(s) of the receiving waterbody segment; a subset of the medium list and is defined pursuant to Section 304(l) of the 1987 Water Quality Act (WQA)

Stream Miles - Ohio's method of indicating locations along a stream; mileage is defined as the linear distance starting from a streams terminus (*i.e.*, mouth) and moving in an upstream direction.

Storm Sewer - System to collect and remove rain runoff from communities and discharge it to nearby waterways.

Surrogate Measures of Biotic Integrity - Chemical parameters designed to protect aquatic life if they are not exceeded instream. Because they are indirect measures of aquatic community integrity, and mostly derived from laboratory toxicity tests, they are termed "surrogate" (*i.e.*, substitute) measures of biotic integrity.

Threatened Streams - These are streams that are currently meeting their designated uses but because of obvious trends (see urban encroachment) or qualitative data are thought to be declining in quality and may become degraded in the future without changes in current practices.

Toxic Substances - Any substance that can cause death, abnormalities, disease, mutations, cancer, deformities, or reproductive malfunctions in an organism.

Unnamed Stream - Small streams for which there are no names provided on USGS 71/2 minute topographic maps; there are approximately 22,000 miles of unnamed streams in Ohio.

Urban Encroachment - Increased development in a watershed, especially where it affects the floodplain, riparian zone, and runoff characteristics of a basin.

Use Designation - See “Designated Use”.

Wasteload Allocation - The portion of a streams capacity to assimilate pollutants without violating water quality standards allotted to existing (or future) point sources (*e.g.,* WWTPs)[1]; *i.e.*, the loading (kg/day) of a pollutant allowed to be discharged by a source without violating water quality standards.

Waterbody/Waterbody Segment - A length of stream, based on Ohio EPA’s mapping system (Division of Environmental Planning and Management), defined for analysis of water quality trends for this report. Each stream segment is approximately 10 miles in length; there are over 3800 stream segments currently defined for Ohio. Each lake is also a separate waterbody.

Water Quality Act of 1987 - A bill that re-authorized and amended the Clean Water Act and added some additional sections (e.g., see 304(l))

Water Quality Based Effluent Limits - Parameter by parameter effluent limits for individual point source dischargers based on water quality considerations (criteria) and not a technological approach such as mandating a specific type of technology to be used in treatment.

Water Quality Limited Segment - Any segment where it is known that water quality does not meet applicable water quality standards and is not expected to meet applicable water quality standards even after the application of “Best Practical Waste Treatment Technology” by publically owned treatment works and the application of “Best Available Technology Economically Achievable” by point sources other than publically owned treatment works[1].

Water Quality Standards - The rules set forth for establishing stream use designations and water quality criteria protective of such uses the surface waters of the state[1].

Whole Effluent Toxicity - The collective toxicity of an effluent to bioassay test organisms expressed as the LC50 and irrespective of individual chemical concentrations. The procedure includes exposing test organisms, in a laboratory setting, to dilutions of whole effluent[2] (See Whole Effluent Bioassay). For complex effluents with many compounds, whole effluent toxicity testing is a more realistic predictor of effects on the instream biota than parameter by parameter chemical testing.

305(b) - Section of the Clean Water Act that requires a biennial report to assess the progress of the Clean Water Act programs.

304(l) - Section of the Water Quality Act of 1987 that is intended to accelerate the control of toxic discharges from point sources.

307(a) - Section of the Clean Water Act that lists 126 compounds denoted as "priority" pollutants; these compounds have historically been the focus of the U. S. EPA water quality program with the reasoning that removal of these priority compounds will also remove the 65 classes of compounds (thousands of individual compounds of which the priority pollutants are a subset).

[1]Taken from : USEPA. 1987. OhioEPA User's Manual for Wasteload Allocation, Water Quality Modeling

[2] Taken from: USEPA. 1987. Report of the National Workshop on Instream Biological Monitoring and Criteria. USEPA Office