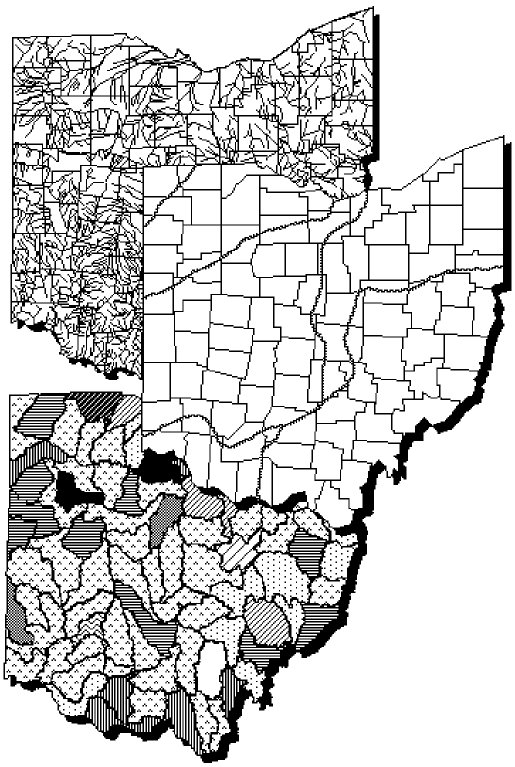
State of Ohio
Environmental Protection Agency

Monitoring and Assessment Section
Division of Surface Water



1994 Ohio Water Resource Inventory:

Summary, Conclusions, and Recommendations

Edward T. Rankin
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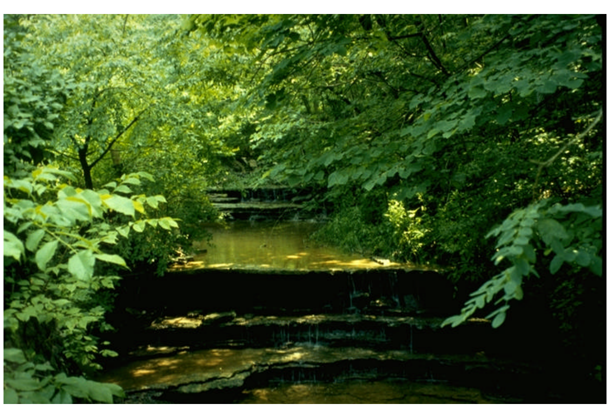
July 1, 1995



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Ohio EPA Technical Bulletin MAS/1995-7-2

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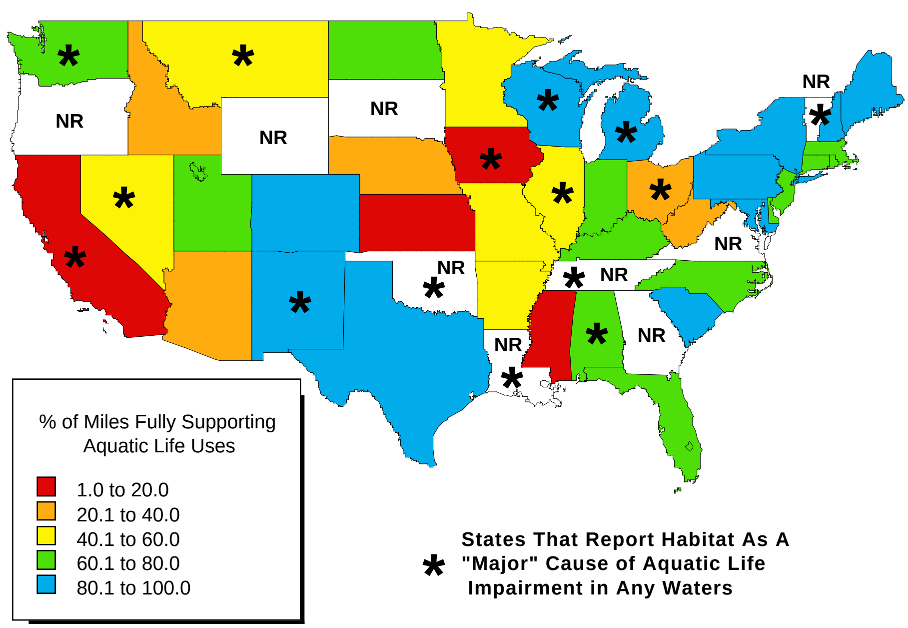
Preface: State 305(b) Reports - An Illustration of Inconsistency

One constant in a perusal of the 305(b) statistics produced by individual states for the National Water Quality Inventory (National 305[b] report; U.S. EPA 1994) is inconsistency and variability of results, methods, and databases. These differences include different types of pollution sources (*e.g.*, agricultural, industrial, urban, etc.,) and landscapes, the crucial categories of variability and inconsistency include widely different assessment approaches and water quality standards. Assessment approaches range from a principal reliance on professional opinion and simple chemical indicators to systematic, comprehensive and integrated monitoring and assessment frameworks that employ multiple indicators. State water quality standards also contribute to this inconsistency through differing classification schemes (e.g., designated uses), variation among water quality criteria, and the inclusion of biological criteria by states such as Ohio. The map of the U.S. illustrates the resultant differences and inconsistencies in the proportion of stream and river miles reported by the states as fully supporting aquatic life. States with the more integrated and robust monitoring programs and more structured and inclusive water quality standards present a more accurate and balanced accounting of the condition of their water resources. While this generally results in the increased capability to detect a broader range of problems, the ability to more accurately and realistically establish appropriate clean water goals is greatly enhanced.

If one were to drive on Interstate 80 across Pennsylvania, Ohio, Indiana, Illinois, and Iowa only gradual changes in key watershed attributes (e.g., land form, land use, population density) would be apparent. However, the variation in aquatic life support reported by each state varies widely (PA- 81%; OH - 40%; IN - 69%; IL - 44%; IA - 5%). These states also vary widely in reported habitat associated impairment (two states report none) despite observable riparian impacts and stream channel modifications in each state. Similar inconsistencies would be evident when driving between other states. The key point is that users of these statistics need to be especially careful in drawing conclusions from state 305(b) reports and must be aware of the monitoring and assessment approaches used by a state. An unfortunate result of the inconsistency between states is the erroneous impression that some states have been less successful in achieving Clean Water Act goals. Inconsistencies between states will hopefully decline over the next 10-20 years, especially if ongoing initiatives with environmental indicators, 305(b) consistency, and biological criteria are successful. More details on the inconsistencies described above can be found on pages 23-27 of this report.



Aquatic Life Use Support Reported By States in the National Water Quality Inventory. States that reported *any* aquatic life use impairment primarily caused by habitat disturbance are marked with an asterisk.

1994 Ohio Water Resource Inventory:
Summary, Conclusions, and Recommendations

FOREWORD

Ohio is a water-rich state with more than 25,000 miles of named and designated streams and rivers, a 451 mile border on the Ohio River, more than 5000 lakes, ponds, and reservoirs (>1 acre), and 236 miles of Lake Erie shoreline (Figure 1). Ohio has 10 scenic rivers comprising more than 629 river miles, the fourth largest total of any state in the nation. Ohio also has extensive, high quality ground water resources. The economic and social well-being of Ohioans is closely linked to the quantity and quality of these water resources and the goods and services each provide. Section 305(b) of the Clean Water Act requires states to submit to U.S. EPA a biennial report summarizing the status and trends in water quality of both surface and ground waters. U.S. EPA, in turn, compiles the State supplied information into a national summary that is then reported to Congress. The intent is for the 305(b) report to be a routine check on the progress that is being made toward achieving the goals of the Clean Water Act. Ideally, the 305(b) is a "report card" on the nation's water quality and water pollution control efforts. Unfortunately, the ambient monitoring data that is needed to support this process has been inconsistent, inadequate, or lacking altogether thus making national statistics unreliable or so general as to lack the necessary resolution or accuracy. This dilemma has been recognized for several years and is exemplified by former U.S. EPA

One of Ohio's highest quality waters, the Kokosing River in Knox Co.

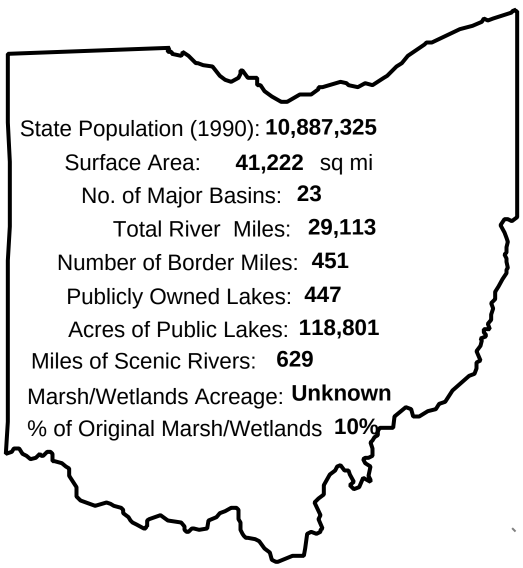


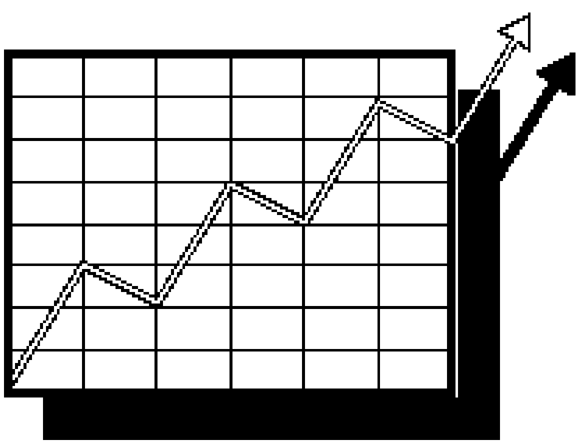
Figure 1. Atlas of Ohio statistics.

"The economic and social well-being of Ohioans is closely linked to the . . . quality of water resources and the goods and services each provides."

Administrator William Reilly's "good news/bad news" statement to Congress. The good news was that U.S. EPA and the States have accomplished much in the way of administrative activities (*e.g.,* issuing permits, awarding grants, *etc*.) since passage of the Clean Water Act in 1972; the bad news is the failure to document this with real information from the environment. Fortunately, U.S. EPA, other federal agencies, and the States have recognized the need to devote more resources to information gathering in support of the reporting and assessment process. Also implicit is the recognition that monitoring and assessment tools and evaluation criteria need to be founded on good science and be sufficiently comprehensive to detect, characterize, and rank environmental problems. Recently, the Intergovernmental Task Force on Monitoring Water Quality completed a three-year project to define the details of a comprehensive and adequate ambient monitoring framework (ITFM 1995).

Ideally, the 305(b) is a "report card" on the nation's water quality and water pollution control efforts.

Ohio EPA anticipated many of these needs in the late 1970s and has endeavored to develop ambient monitoring capabilities that will provide the type of "vital signs" information needed to accurately assess and characterize the state of Ohio's surface and ground waters. This process has been guided by the principles of good science and cost-effectiveness. The result is one of the most comprehensive databases in the nation in terms of the period of record, geographic coverage, standardization of methods, comparability of data, and the strength of the environmental indicators used. As will be seen in this summary, Ohio EPA is not only able to report on what has been accomplished in terms of real environmental results, but can anticipate the key issues which will emerge into the next century. The forecast analysis in this report (see p. 30) for streams and rivers through the year 2000 exemplifies this capability. Other waterbody types including lakes, ponds, and reservoirs, Lake Erie, and wetlands, however, presently lack the indicators and database to



adequately assess their status. Without adequate status information there can be no trend assessment for these water bodies. Further development and refinement of ambient indicators by Ohio EPA is presently underway for Lake Erie, the Ohio River, and wetlands.

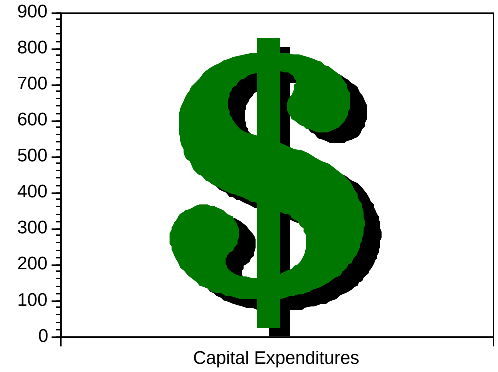


Figure 2. Capital expenditures made on municipal wastewater treatment plant construction during 1991 and

More than $6 billion of public and private funds have been spent in Ohio on the control of point sources of pollution during the past 25 years. Expenditures on municipal wastewater treatment during 1991 and 1992 alone totaled more than $825 million (Figure 2). Ohio EPA has supported an intensive and integrated surface water monitoring program over the past 16 years, thus developing an ability to document the results of these substantial economic expenditures. By maintaining a strong ambient monitoring program Ohio EPA has been able to document the effectiveness of 20+ years of intensive water pollution control efforts on site-specific, regional, and statewide scales. Since substantial follow-up monitoring has been completed since 1988 (*i.e.*, following the July 1, 1988 National Municipal Policy deadline), the 1994 Ohio Water Resource Inventory seems an appropriate vehicle to evaluate the effectiveness of pollution control programs during the past 20 years and to project where these efforts might lead in the future. Because of a principal reliance on ambient performance indicators, the success of Ohio's water resource management programs can be evaluated directly on the basis of environmental results rather than administrative accomplishments alone (*i.e.*, numbers of permits issued, grant dollars awarded, compliance rates, enforcement actions, *etc*.). In this sense, the 1994 Ohio Water Resource Inventory represents an environmental audit of Ohio's water resource management efforts, both public and private, using ambient environmental measures and indicators.

"More than $6 billion dollars . . . have been spent in Ohio on the control of point sources . . . during the past 25 years."

City of Columbus Jackson Pike wastewater treatment plant discharge to the Scioto River in Franklin Co. The flow in many Ohio streams and rivers is dominated by effluent during low flow periods.

Environmental indicator-based "305(b)" reports have been published biennially by Ohio EPA since 1988, which marked the first 305b report based on ecoregionally calibrated indicators; the first Ohio EPA 305b report was produced in 1974.

" . . . Ohio EPA established the Ohio 2000 goal of reaching 75% full attainment of beneficial uses in surface waters by the year 2000."

In 1994, the Ohio EPA established the Ohio 2000 goal of reaching 75% full attainment of beneficial uses in surface waters by the year 2000. A major feature of the 1994 report is a forecast analysis for rivers and streams. By examining what the rate of recovery (*i.e.*, changes in status from non or partial to full attainment of designated aquatic life uses) has been since 1988, a projection through the year 2000 was made to assess the likelihood of achieving the 75% goal. The results of this analysis should help guide the Ohio EPA water program and reveal what changes, if any, are needed to meet the Ohio 2000 goal.

1994 Ohio Water Resource Inventory

Section 305(b) of the Clean Water Act requires each state to submit a biennial report to U.S. EPA describing the quality of the state's waters. Accomplishing this task requires the compilation, computerization, and integration of chemical/physical and ecological information for streams, rivers, lakes, wetlands, and groundwater from numerous sources. The 1994 Ohio Water Resource Inventory is comprised of this summary and four major volumes covering; 1) inland rivers and streams, wetlands, Lake Erie, and water program descriptions, 2) fish tissue contaminants, 3) inland lakes, ponds, and reservoirs, and 4) groundwater. A separate document prepared by the Ohio River Valley Sanitation Commission (ORSANCO) provides similar information for the Ohio River mainstem. Specific information summarized by each volume includes:

Muskellunge from the Scioto R. in Franklin Co.

1) an analysis of the extent to which Ohio's surface and ground waters provide for healthy and viable aquatic communities, recreation, water supply, and fish and wildlife that are virtually free from contaminants at concentrations of concern;

2) an analysis of the extent to which previously impaired waters have improved;

3) identification of water bodies where additional actions are needed (*e.g.*, lists of impaired waterbodies as required by Sections 303[d] and 304[l] of the Clean Water Act);

4) geographic portrayals of the major surface water resource attributes, conditions, and problems throughout the state;

5) an estimate of the economic expenditures for water pollution abatement during the biennial reporting period;

6) a description of the quality of Ohio's inland rivers and streams, inland lakes, ponds, and reservoirs, wetlands, Lake Erie, and the Ohio River;

Electrofishing in the lower Cuyahoga River in Cuyahoga Co.

7) a description of the nature and extent of nonpoint sources of pollution;

8) a historical perspective of water pollution and surface water degradation in Ohio and how this affects the goals established for the Ohio EPA water programs;

9) a description of Ohio's first comprehensive fish tissue contaminant monitoring efforts and a preliminary analysis of the contaminants data base; and,

10) a forecast of the miles of streams and rivers projected to attain designated uses through the year 2000 with respect to tracking progress toward meeting the Ohio 2000 goal of 75% full attainment.

Indicators Hierarchy

A carefully conceived ambient monitoring approach, which uses cost-effective indicators comprised of ecological, chemical, toxicological, and administrative measures, can ensure that all sources are judged objectively on the basis of environmental results rather than prescriptive, administrative goals alone (*i.e.*, administrative "bean counting") in managing for water resource improvements. Such an integrated approach is outlined in Figure 3 and includes a hierarchical continuum from administrative to true environmental indicators. The six "levels" of indicators include: 1) actions by regulatory agencies (permits, enforcement, grants); 2) responses by the regulated community (treatment works, management practices); 3) changes in discharged quantities (pol-

"A carefully conceived ambient monitoring approach . . . can ensure that all sources are judged objectively on the basis of environmental results . . . in managing for water resource improvements."

lutant loadings); 4) changes in ambient conditions (water quality, habitat); 5) changes in uptake and/or assimilation (tissue contaminants, productivity, biomarkers); and, 6) changes in health, ecology (ecological indicators), or other effects. Thus the administrative activities that have predominated water pollution control efforts since the early 1970s (levels 1,2, and 3), and which have prompted the expenditure of billions of dollars, can now be tracked through to "the results" in the environment as revealed by chemical/physical and ecological indicators. This process also serves as a feedback loop taking the observations made in levels 4, 5, and 6 as environmental "cues" to effect changes and adjustments within levels 1, 2 and 3. This hierarchy is essentially in place within the Ohio EPA water programs.

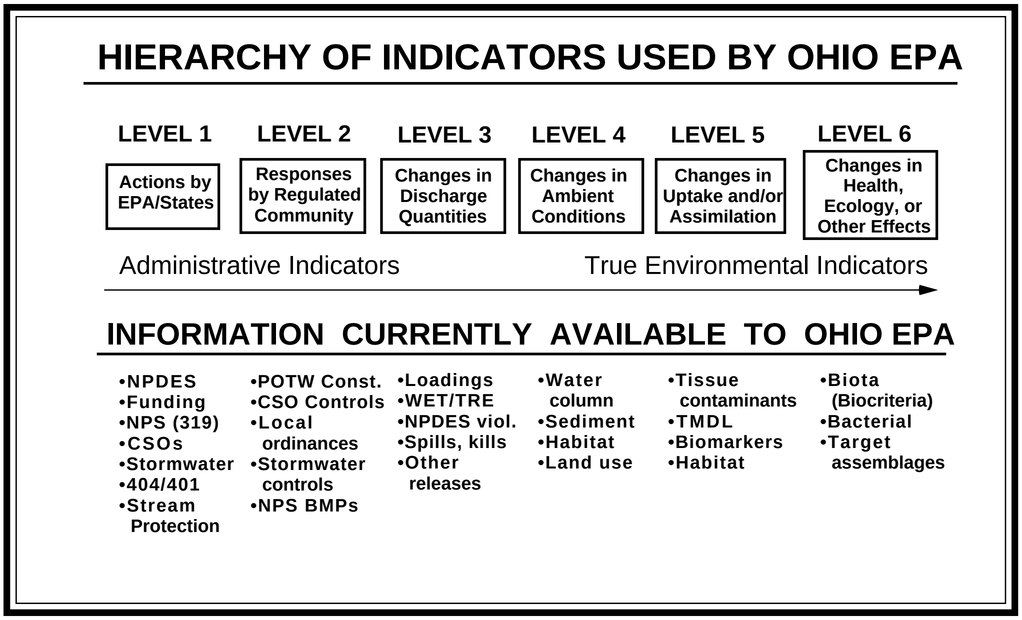


Figure 3. Hierarchy of administrative and environmental indicators used by Ohio EPA for monitoring and assessment, reporting, and evaluating program effectiveness. This is patterned after a model developed by the U.S. EPA, Office of Water.

Volunteer monitoring is an excellent tool for education and environmental awareness and can provide information of value to Ohio EPA.

Essential Technical Elements of a Watershed Approach

Ohio EPA's approach to surface water monitoring and management (Five-Year Basin Approach, see p. 21) is, from a technical assessment and indicators framework standpoint, a watershed approach. The environmental indicators used in this process are categorized as stressor, exposure, and response indicators. ***Stressor*** indicators generally include activities which impact, but do not necessarily degrade, the environment.

This can include point and nonpoint source loadings, land use changes, and other broad-scale influences generally resulting from anthropogenic activities. ***Exposure*** indicators include chemical-specific, whole effluent toxicity, tissue residues, and biomarkers, each of which suggest or provide evidence of biological exposure to stressor agents. ***Response*** indicators include the more direct measures of community and population response and are represented here by the biological indices that comprise Ohio EPA's biological criteria. The key to having a successful watershed approach is in using the different types of indicators *within the roles that are the most appropriate for each.* The inappropriate use of stressor and exposure indicators as substitutes for response indicators is at the root of the national problem of widely divergent 305(b) statistics reported between the States. Such divergent approaches have, unfortunately, led to an impression of poorer environmental quality in those states with more complete indicator frameworks. States which follow the aforementioned indicators framework are better able to detect and properly characterize a wider range of environmental problems than are States with more limited monitoring and assessment frameworks, hence the widely divergent statistics between States. This problem is explained in more detail on pp. 23-27.

KEY POINT

"The inappropriate use of stressor and exposure indicators as substitutes for response indicators is at the root of the national problem of widely divergent 305(b) statistics reported between the States."

The Ohio EPA approach to assessing surface waters relies on evidence of the attainment or non-attainment of calibrated ecological indicator criteria (*i.e.*, response indicators) which collectively express water resource integrity directly. This results in a fundamentally more accurate portrayal of environmental conditions and provides the opportunity to invest pollution abatement resources where needed the most. For example, the emergence of nonpoint source related impacts in streams that were previously impaired by wastewater treatment plants (WWTPs) during the 1970s and 1980s should prompt an increased emphasis towards certain nonpoint source abatement efforts (*e.g.*, riparian restoration).

"The Ohio EPA approach to assessing surface waters relies on evidence of the attainment . . . of calibrated indicator criteria which collectively express water resource integrity directly."

The emphasis of the 1994 Ohio Water Resource Inventory (305[b] report) is on: (1) summarizing the present quality and integrity of surface and ground waters using an array of chemical, physical, and ecological indicators and different spatial scales, (2) describing trends in the quality of Ohio's inland rivers and streams before and after 1988, and (3) forecasting the quality of inland rivers and streams through the year 2000. This latter effort provides a unique opportunity to assess the effectiveness of Ohio EPA's approach to water resource quality protection, past and present. The conclusions and recommendations of the 1994 report are the result of a continuing endeavor toward these ends. Proportionately focusing water resource management efforts on the sources most responsible for observed impairments is a continuing goal of the Ohio EPA water program. The Ohio Water Resource Inventory and the attendant data analyses should also enhance the development of a watershed-based approach.

Copies of this summary and the four major supporting volumes may be obtained by contacting:

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PART I: PRINCIPAL CONCLUSIONS AND RECOMMENDATIONS OF THE 1994 OHIO WATER RESOURCE INVENTORY

While the 1994 Ohio Water Resource Inventory includes information on all aquatic resource types and indicator frameworks, the database was sufficiently robust to support a comprehensive analysis of temporal trends and spatial patterns only for inland rivers and streams. Statistics and highlights for Lake Erie, the Ohio River, inland lakes, ponds, and reservoirs, the statewide fish contaminant monitoring program, wetlands, and ground water appear in Part III.

Big Darby Creek in Pickaway Co.

Inland Rivers and Streams

√ The overall quality (*i.e.*, integrity) of Ohio's inland streams and rivers has improved since passage of the Federal Water Pollution Control Act in 1972 as follows:

- Presently, 29% of the miles of streams and rivers fail to meet criteria for the protection of aquatic life; this is an improvement over that determined prior to 1988 (44%). This estimate is most applicable to streams and rivers with watershed areas >20 square miles.

- Results from streams and rivers that have been monitored more than once (*i.e.*, before and after the implementation of water quality-based controls) show a statistically significant improvement in biological performance indicators such as the Index of Biotic Integrity (IBI) and Invertebrate Community Index (ICI).

- Much of the observed improvements have resulted from reduced loadings of oxygen demanding substances, ammonia, and chlorine due to upgraded municipal wastewater treatment facilities. More than $4 billion has been spent on these upgrades in Ohio since 1972, most of which was prompted by the July 1, 1988 National Municipal Policy deadline.

"The overall quality of Ohio's inland streams and rivers has improved since passage of the Federal Water Pollution Control Act in 1972."

- Toxic impacts still cause locally severe impairments in selected stream and river reaches. The remaining problems are generally located in or near most of the larger urban/industrial centers, particularly those with steel making, glass making, metal finishing, chemical, and petroleum refining industries. Biological and chemical indicators of toxic impacts (*e.g.,* poor and very poor community performance, highly elevated incidence of anomalies on fish, highly elevated metals and/or organic compounds in bottom sediments, chemical residues in fish tissues, *etc*.) are geographically correlated with these areas and types of industry across the state.

External anomalies on a channel catfish from the lower Maumee R. in Lucas Co.

- The impacts from sources such as combined sewer overflows, urban storm water, siltation of substrates, and habitat degradation are becoming increasingly evident as historically more pronounced impacts from point sources (*e.g.*, municipal WWTPs, some industrial effluents) are reduced.

"The impacts from sources such as combined sewer overflows, urban storm water, siltation of substrates, and habitat degradation are becoming increasingly evident . . . "

√ Recreational use (primary and secondary contact) attainment has improved to 59%, up from 49% prior to 1988, and non-attainment has declined from 48% to 27%. The improvements in this water quality indicator are attributed to improved municipal wastewater treatment and reduced bypasses of untreated and partially treated sewage. Problems do remain, however, in areas impacted primarily by combined and sanitary sewer overflows, urban runoff, and livestock operations.

√ A forecast analysis was conducted in an attempt to evaluate the likelihood of meeting the Ohio 2000 goal of 75% full attainment of aquatic life criteria by the year 2000. The major findings of the analysis are:

- Since 1988, there has been a 56% decline in point sources as a major source of impairment in reassessed stream and river segments.

- Nonpoint sources have emerged as a major source of impairment in streams and rivers during this period, with increases ranging from 141% for agricultural sources to 208% for urbanization related nonpoint source impairments.

"Since 1988, there has been a 56% decline in point sources as a major source of impairment in reassessed streams."

- Based on the observed rate of restoration since 1988, full attainment of aquatic life criteria is projected for 56.5% of streams and rivers by the year 2000.

- The Ohio 2000 goal will not be achieved by the restoration of point source related impairments alone. Even if point source associated impairment is virtually eliminated (and assuming no new nonpoint source impacts are revealed) the result would be just over 65% of streams and rivers fully attaining aquatic life criteria by the year 2000. Given these facts, "new" successes in controlling, abating, and preventing nonpoint and other sources of impairment will be needed to reach the Ohio 2000 goal.

Riparian/land use interface along the Scioto R. in Pike Co.

√ While successes resulting from the abatement of point sources have been documented, there are other indications that impacts from nonpoint source runoff, habitat degradation, and watershed disturbances may be worsening. Siltation of substrates and habitat degradation are now the second and third leading causes of aquatic life impairment in Ohio streams and rivers, surpassing ammonia and heavy metals. These impairments are principally the result of agricultural land use, intensive urbanization, and suburban development, the latter of which is emerging as one of the most significant threats to watersheds in the 1990s. Some ecological symptoms of these lingering and emerging problems include the following:

"Siltation of substrates and habitat degradation are now the second and third leading causes of aquatic life impairment in Ohio streams and rivers."

- The status of many indigenous Ohio aquatic species, principally fish and naiad mollusks (freshwater mussels), remain in various states of imperilment. Thirty (30) percent of Ohio's fish species are classified as rare, endangered, threatened, or special status (at the state level). Based on data collected since 1978, the proportion of imperiled fish species may now be as high as 40%. At least 15 additional species (which are not presently listed in one of the aforementioned imperilment categories) appear to be declining throughout Ohio.

- These declining species are among the more intolerant forms and are dependent on permanent stream flow, clean substrates, and good quality habitat (*i.e.*, intact riparian buffer, pools, runs, riffles). Several of these species are inhabitants of headwater streams and reflect the high level of disturbance to this stream type.

River chub, a declining Ohio species.

- These emerging problems could "undo" some of the gains recently made in the restoration of point source associated impairments given the ultimate dependence of mainstem reaches on the network of headwater streams. This would constitute an unanticipated deterrent to achieving the Ohio 2000 goal.

- The restoration and maintenance of minimum width riparian buffer zones is viewed as an essential component in preventing these impacts from emerging as new threats and to increase the rate of restoration toward reaching the Ohio 2000 goal. Land use is an important factor that affects the width of a riparian buffer needed to protect aquatic ecosystems. Land use and landscape elements (*i.e.*, ecoregion characteristics) will be important characteristics to be considered and integrated with riparian protection efforts throughout Ohio.

"The restoration and maintenance of minimum width riparian buffer zones is . . . essential . . . "

PART II: A SUMMARY OF ACTIONS ON THE CONCLUSIONS AND RECOMMENDATIONS OF PREVIOUS OHIO WATER RESOURCE INVENTORIES

Major Recommendations

The 1992 Ohio Water Resource Inventory and previous years reports offered a number of recommendations pertaining to programmatic, policy, and technical needs and issues. These are summarized below with a report on the accomplishments made to date.

1) **Recommendation**: The theme of protecting and managing water *quality* should be revised to one that emphasizes the water *resource*, by focusing on an integrated ecosystem approach to water *resource* management (see Figure 4).

Accomplishments: The adoption of biocriteria and a system of tiered designated uses has provided the technical framework to implement a water resource based approach. The assessment approaches used by Ohio EPA incorporate this concept by using indicators that individually and summarily reflect the five major factors of water resource integrity (Figure 4). Ohio EPA is taking further steps in this direction by designing a watershed based system for water program operations. Ohio EPA has also begun working more closely with Ohio

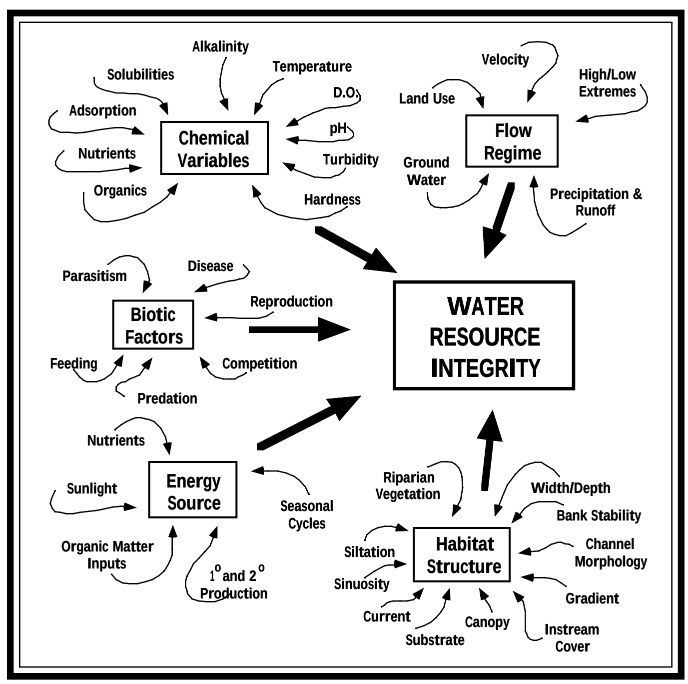


Figure 4. The five major factors which determine the integrity of the water resource.

Department of Natural Resources (ODNR) and other state, local and federal agencies. Examples include a series of cross-training workshops for Ohio EPA, ODNR, and the National Resource Conservation Service (NRCS, formerly SCS) employees that also included representatives from local soil and water agencies and the U.S. Army Corps of Engineers.

"In 1990 Ohio EPA initiated the Five-Year Basin Approach to NPDES Permit Reissuance and Monitoring . . ."

2) **Recommendation**: In 1990 Ohio EPA initiated the five-year basin approach to wastewater permit (NPDES) reissuance and monitoring (see page 22). However, less than 50% of the issues that were considered "priority needs" (*e.g.*, significant permit issues, streams never sampled, complex urban areas, 319 NPS project areas, *etc*., - see Glossary) could be addressed with the resources available. In order to more effectively utilize all water program resources, the five-year cycle of permit reissuance, under certain restrictions, should be extended to 10 years.

"Ohio EPA increased the resources devoted to . . . monitoring . . . [so that] approximately 60% of the priority needs are addressed in a five-year cycle.

Accomplishments: Ohio EPA increased the resources devoted to the monitoring and assessment component so that approximately 55-60% of the priority needs can be addressed in a five-year cycle. This was made possible, in part, by the NPDES permit fees that fund the Ohio EPA water program. While the resources to meet these demands have been increased, the demand has also been increasing steadily since 1990. Although there seems to be general agreement about the merits of a 10-year permit cycle, this will likely require a modification of the Clean Water Act to implement. Accomplishing this change would better match the administrative activities with available monitoring and assessment resources and assure that recent information would be available for most of the major issues.

3) **Recommendation**: Within the framework of the five-year basin approach, Ohio EPA should continue to conduct follow-up monitoring after pollution controls have been upgraded.

Accomplishments: Follow-up monitoring (*e.g.*, after a WWTP upgrade) is a "high priority need" (see Glossary) and this will continue during the next cycle of the five-year basin approach. Sufficient data are now available to assess before and after changes for 31 major rivers and streams. Another 25 rivers and streams are scheduled for follow-up assessments over the next 5-10 years, provided monitoring and assessment resources remain stable. Most areas are on a once-every-10-years reassessment schedule given that only 55-60% of the needs identified between 1990 and 1994 have been met.

"Sufficient data are now available to assess before and after changes for 31 major rivers and streams."

4) **Recommendation**: It was recommended that the 305(b) report be updated and revised on a five-year cycle to more closely coincide with the five-year basin approach and permit cycle.

Accomplishments: Ohio EPA has been instrumental in working with U.S. EPA to revise several 305(b) reporting conventions. While the merits of this concept are widely recognized, this too will require a modification of the Clean Water Act.

"The predominance and role of non-traditional causes of impairment (**i.e.*****, non-point sources, habitat degradation) are beginning to be widely recognized."***

5) **Recommendation**: The many non-chemical and non-toxic chemical impacts that continue to impair water resources need to be addressed. To successfully protect high quality waters and to rehabilitate waters impaired by these impacts, a much broader approach to water resource management is needed.

Accomplishments: The predominance and role of non-traditional causes of impairment (*i.e.*, nonpoint sources, habitat degradation) are beginning to be widely recognized. Ohio EPA has jurisdiction over certain activities, such as 401 certifications, construction sites, and permits to install (PTIs), that can impact habitat quality . Actions to protect

Habitat degradation caused by interceptor sewer line construction in Rapid Run (Hamilton Co.).

aquatic life from habitat destruction have been implemented in the reviews of 401s and PTIs. However, this is not a sufficiently comprehensive approach to solving the extensive problems which presently impair streams and rivers and threaten high quality waters. A reliance on education, voluntary initiatives, and financial incentives will also be needed to stem the trend toward an increasing prevalence of these types of impairments. Some initiatives are already in place including the Ohio DNR "Nature Works" stream banking program. This program will provide support in the form of Ohio Bond Issue 1 funds to protect and restore riparian habitats through long-term or permanent conservation measures. The Ohio EPA Division of Environmental and Financial Assistance (DEFA) also provides low interest loan funds to Ohio communities to abate nonpoint pollution or habitat problems, a program that should prove complementary to the Nature Works efforts.

Sugarcamp Run in Clermont Co. is an example of a high quality headwater stream in the Interior Plateau ecoregion. Such streams are threatened by severe habitat degradation caused by interceptor sewer line construction in the stream bed and corridor.

6) **Recommendation**: U.S. EPA requires states to provide a separate, annually updated list of waterbody segments impaired by toxics. It is recommended that U.S. EPA also place a similar emphasis on developing lists of stream segments impaired by habitat degradation, sedimentation, and nutrient enrichment, with all lists (including toxics) being given appropriate weight based on the extent and severity of impairment and on the proportion of waters impaired by each general cause category.

Accomplishments: Ohio EPA completed the 304(l) short list of waters impacted by priority pollutants (*i.e.*, toxics) which are discharged by point sources. Of greater need, however, is a comprehensive, agency-wide list of impaired surface waters that will address this recommendation from a much broader, environmental indicators driven perspective by encompassing all sources (*i.e.*, both point and nonpoint) and causes (*i.e.*, habitat degradation, sedimentation, nutrient enrichment in addition to toxics). This effort should also include the listing of high quality waters as a priority category for protection efforts in addition to listings of impaired waters.

7) **Recommendation**: Tools that quantify damage to aquatic ecosystems need to be used more effectively by the water programs (*e.g.*, in enforcement and environmental damage claim proceedings, establishing priorities, etc.). The Area of Degradation Value (ADV; Figure 5), developed by Ohio EPA, is one such tool that can be used for this purpose and can also be used to quantify the costs and benefits of water resource management efforts.

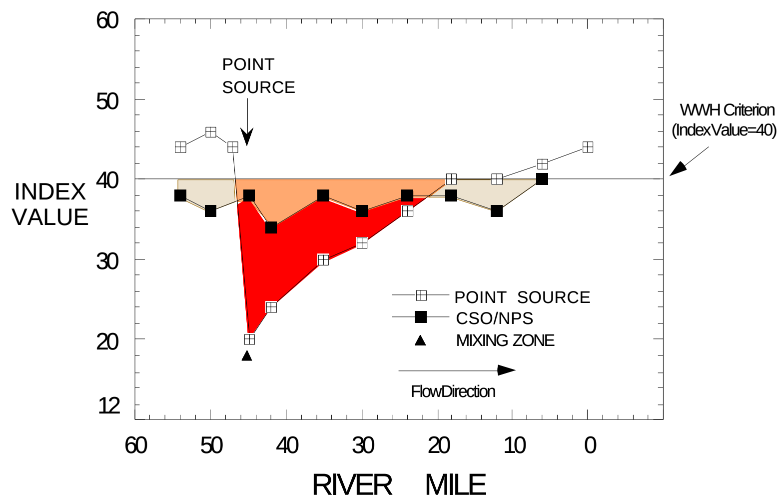
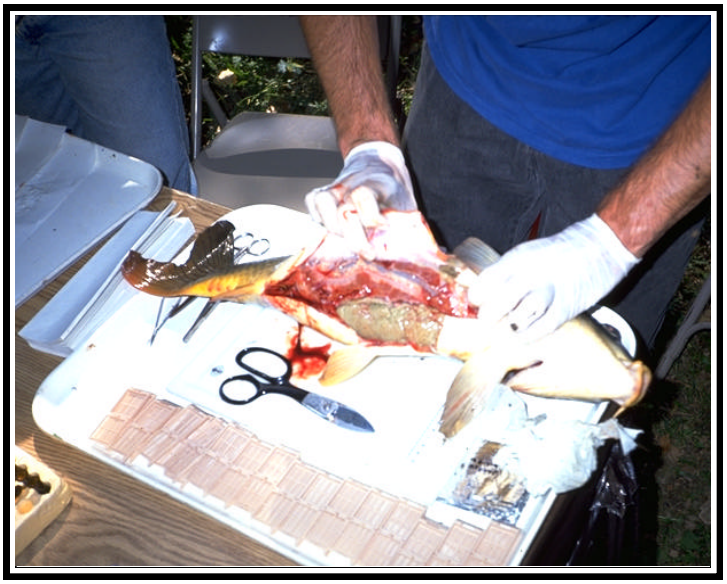


Figure 5. Graphical depiction of the Area of Degradation Value which is used by Ohio EPA to quantify the extent and severity of departures from biocriteria benchmarks (e.g., WWH criterion).

Accomplishments: The ADV is currently used to document the extent and severity of degradation for specific stream and river segments primarily to demonstrate environmental quality "before and after" the implementation of water quality-based pollution controls as part of the reporting and assessment process (see p. 50). Ohio EPA intends to broaden the application of the ADV by incorporating this tool into the enforcement and priority setting processes.

8) **Recommendation**: It is recommended that research conducted on the usefulness of biomarkers as diagnostic and assessment tools be continued over the next several years to establish a baseline over a range of impact types and at least impacted reference sites.



Collection of organ and tissue samples for biomarker analysis.

Accomplishments: Work has continued on a cooperative basis with the U.S. EPA, Environmental Monitoring and Systems Laboratory (EMSL-Cincinnati), to collect additional data for biomarkers. Obtaining sufficient data to characterize reference concentrations of selected biomarkers and develop specific markers associated with specific impact types is an important goal of this effort.

9) **Recommendation**: Some important sources of water resource impairment in Ohio have not been addressed in proportion to their occurrence and impact. Two such sources are mine drainage and silviculture.

Example of poor sivicultural practices and severe riparian zone degradation accompanied by acid mine drainage impacts to Moxahala Creek in Perry Co.

Accomplishments: No new internal activities specifically directed toward these sources are expected outside of the opportunities afforded within the five-year basin approach. A Strategic Plan and a Statement of Mutual Intent were signed by Congressional representatives, local, state, and Federal agencies, and watershed and environmental organizations in February 1995 to deal with acid mine drainage. One result of this agreement is an acid mine drainage workshop that will be held in Cincinnati in late 1995.

10) **Recommendation**: Consistent and regular monitoring of Lake Erie river mouth, near shore, and open lake areas needs to be initiated and maintained to provide an accurate and comprehensive database for the purpose of tracking status and trends, problem discovery, and resource characterization of this critically important resource.

Accomplishments: Ohio EPA initiated a project to develop biological criteria for Lake Erie river mouth, near shore, and harbor areas in 1993. This project, which is scheduled for completion in late 1996, should provide the basis to make more comprehensive assessments of these waters. This would then yield a more comprehensive and accurate picture of resource conditions and trends than is presently available. A stable and consistent ambient monitoring effort will be needed once this project is completed.

Biomarkers:

"...measurements at the molecular, biochemical, or cellular level ...that indicate that the organism has been exposed to toxic chemicals...(McCarthy and Shugart 1990)"

11) **Recommendation**: A state funded monitoring effort for publicly owned lakes, ponds, and reservoirs is needed to more consistently and comprehensively assess status and trends in this important water body type. The development of additional indicators such as biological criteria and a more detailed lake classification system are also needed to broaden and increase the accuracy of lake assessment and management throughout the state.

Accomplishments: The need for new or expanded tools to assess and classify Ohio's inland lakes and reservoirs is widely recognized. However, no formal project to develop the tools and indicators needed to achieve these goals is anticipated. U.S. EPA is currently developing technical guidance for the development of biocriteria for lakes.

"Ohio EPA initiated a project to develop biological criteria for Lake Erie river mouth, nearshore, and harbor areas in 1993."

"In 1993, Ohio EPA in cooperation with other state agencies, initiated a comprehensive, statewide fish contaminants monitoring program."

12) **Recommendation**: Although laboratory capability was recently expanded for fish contaminants monitoring, the current (*i.e.*, as of 1991) effort is providing less information than is needed to address major Ohio water bodies. Monitoring needs to occur on a more regular basis to evaluate Ohio's important fishery resources and as an additional assessment tool within the five-year basin approach.

Accomplishments: In 1993, Ohio EPA, in cooperation with other state agencies, initiated a comprehensive, statewide fish contaminants monitoring program. This expanded the monitoring program by 300% and should address the shortfalls of previous years, leading to a more comprehensive assessment in future 305(b) reports.

13) **Recommendation**: Discussions about the role of biological criteria in overall water resource management need to be continued and should include the consideration of the relative strength of the biocriteria framework and the underpinnings of the biological criteria derivation process. A proposed hierarchy of bioassessment types provides a potential framework for determining how policy restrictions should be applied to biological assessments and biological criteria. We suggest that a similar framework be developed for the different levels of chemical-specific, physical (habitat), and toxicity assessment tools.

A component of the biological criteria process - the collection of biological field data. Employing the wading electrofishing method in Kinnikinnick Creek (Ross Co.).

Accomplishments: Ohio EPA continues to cooperate with U.S. EPA in the development of policy and technical issues of biocriteria and bioassessments. The technical components (*i.e.*, hierarchy of bioassessment types, regional reference sites, multimetric indices, *etc*.) developed and used by Ohio EPA have been included in the technical products of the Intergovernmental Task Force on Monitoring Water Quality (ITFM 1992, 1993) and U.S EPA's biological criteria guidance for wadeable rivers and streams. Furthermore, U.S. EPA is further considering the approaches outlined by Ohio EPA in their biocriteria policy development and 305(b) reporting guidelines.

"Out of 13 major recommendations made in the 1992 Ohio Water Resource Inventory, substantial progress has been or is being made on nine."

Out of 13 major recommendations made in the 1992 Ohio Water Resource Inventory, substantial progress has been or is being made on nine. Two (numbers 9 and 11) cannot to be acted on without additional resources or changes in program priorities, and two others (numbers 2 and 4) require changes in the Clean Water Act. Specific areas on which further progress is needed include fully implementing a watershed approach, increasing the numbers of streams, rivers, and issues assessed under the five-year basin approach, more fully integrating ambient information in priority setting, focusing more on habitat protection, and finding satisfactory resolutions to the outstanding biocriteria and bioassessment policy issues.

A new recommendation relates to the integration of administrative and environmental indicators within the Ohio EPA water program. This involves linking administrative measures of activity (*i.e.*, permits issued, grants awarded, enforcement actions taken, dollars spent on controls, *etc*.) with environmental exposure, stressor, and response indicators already used by the agency in the environmental assessment process. Ohio EPA is presently involved in two pilot projects with U.S. EPA to test the effectiveness of selected administrative and environmental indicators. Establishing linkages between these indicator levels is a prerequisite to having an effective and comprehensive watershed based approach within the Ohio EPA water program.

PART III. OVERVIEW OF SURFACE AND GROUND WATER CONDITIONS

Introduction

Ohio EPA and other water resource agencies are faced with an increasingly complex array of different, subtle, and diffuse water pollution problems. Thus the need for a robust, comprehensive, and integrated assessment process quickly becomes apparent. A continued reliance on prescriptive, technology-based (*i.e.*, "end-of-pipe"), and even some water quality-based approaches will be inadequate for resolving the remaining environmental problems and in preventing new ones.

"Ohio EPA and other water resource agencies are faced with an increasingly complex array of different, increasingly subtle, and diffuse water pollution problems."

Water resource management efforts are maturing beyond a sole reliance on worst-case, dilution-based techniques for load allocations and surface water assessments. Integrated ambient monitoring including chemical/physical and ecological indicators comprises an integral component of the information and feedback that is needed to more effectively manage water resource restoration and protection efforts. We can no longer afford to regard ambient monitoring of this type as an optional “luxury” if these efforts are to truly succeed. Integrated monitoring and assessment will also play an important role in the emerging watershed and ecosystem approaches as it not only provides evidence of present impairments, but critical baseline information as well.

The 1988 Ohio Water Resource Inventory (Ohio EPA 1988) was the first Ohio 305b report based entirely on an integrated, comprehensive, and standardized chemical/physical and ecological assessment for determining the status of Ohio's aquatic resources. The 1988 report also identified the causes and sources associated with impairments of individual waterbody segments. This information was then aggregated to yield the statewide statistics which are reported to U.S. EPA. The 1990 and 1992 reports also utilized this approach and the 1994 report is the latest update.

Monitoring and Design Issues

The integrated water quality management framework being developed by Ohio EPA includes: 1) comprehensive ambient monitoring utilizing multiple chemical/physical and ecological indicators; 2) an ecoregion based landscape partitioning framework; 3) tiered aquatic life and non-aquatic life use designations; 4) a triad of chemical/physical, toxicological, and ecological criteria (including biological criteria); and, 5) a sequential hierarchy of administrative and environmental indicators (see Fig. 3). This process was developed through the early and mid-1980s and, since 1988, has provided Ohio EPA with a comprehensive, standardized, scientifically sound, and cost-effective assessment of the status of Ohio's water resources. Some of the most useful aspects of this framework include basing clean water goals and management actions on realistically attainable expectations for ecological, chemical, and physical performance indicators, the discovery and improved understanding of previously unknown or poorly understood problems, and a watershed focus in ranking and addressing water quality problems.

Preparing automatic water samplers - part of the ambient chemical/physical assessments performed by Ohio EPA as part of the Five-Year Basin Approach.

Inconsistencies in State 305(b) Statistics

One constant in a perusal of the summary statistics produced by individual states for the National Water Quality Inventory (National 305[b] report; U.S. EPA 1994) is inconsistency and variability. Adjoining states and those with similar types and levels of water quality impacts may report widely divergent stories about the status of their respective surface waters. Some examples that are evident in the national 305(b) statistics include: 1) full attainment of aquatic

Another important component of biological criteria and biological monitoring - setting artificial substrates for the collection of macroinvertebrates.

life uses among the states ranged from a low of zero (0) to a high of 98%; 2) 13 states did not report on aquatic life uses, but instead reported on a much broader category of overall use support; 3) the proportion of assessed waters among states ranged from a low of 5% to a high of 100%; and, 4) twenty-five (25) states reported zero miles as impaired by habitat impacts. Another area of inconsistency is with the extrapolation of assessment results. Some states extrapolate the results of single, fixed monitoring stations to entire drainage basins whereas other states take a much more conservative approach. The result is the impression of a much higher proportion of waters assessed by the former compared to the latter.

"Most apparent in these statistics is the inappropriate reliance . . . on stressor and exposure indicators (*e.g.*, source information, loadings, chemical assessments) as substitutes for response indicators (*e.g.*, direct biological assessments) . . ."

The aforementioned variability and inconsistency is attributable to different frameworks for reporting, monitoring, assessment, and using indicators. Most apparent in these statistics is the inappropriate reliance by many states on stressor and exposure indicators (*e.g.*, source information, loadings, chemical assessments) as substitutes for response indicators (*e.g.*, direct biological assessments) in their assessments of aquatic life use attainment. While this approach was sufficient to detect the gross water pollution problems of previous decades, it now commonly results in the gross under-reporting of problems (*e.g.,* the 25 states that reported no habitat impaired waters) or an overstatement of problems in some instances (*e.g.,* the reporting of zero miles in full attainment by one state). Individual states are essentially free to approach surface water monitoring and assessment quite differently; the result is an uneven "playing field" nationally. An unfortunate result of this national inconsistency is the erroneous impression that some states have been less successful than their peers in achieving Clean Water Act goals.

It needs to be more widely recognized that this is the result of incomplete monitoring, assessment, and indicator frameworks. One remedy would be to even the "playing field" by requiring a complete framework. The greatest deficiency is with the lack of appropriate response indicators.

For aquatic life uses, this means direct assessments of biological communities using biological criteria. At least 30 states have used *some* type of biological indicator data (*e.g.*, fish, algae, and/or macroinvertebrates) in their 305(b) reporting (U.S. EPA 1995). However, only 12 states have sufficiently developed the assessment criteria needed to properly use this indicator (U.S. EPA 1995). Even fewer states have progressed to the point of developing formal biological criteria (exceptions include Ohio, North Carolina, and Maine), but 22 states have the underlying research and development efforts in progress.

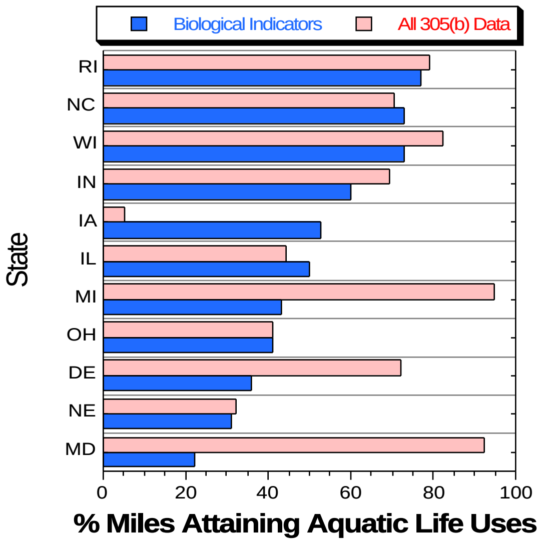


Figure 6. Percent miles attaining aquatic life uses as reported in the National 305(b) report in 1992 and the subset of these statsitics for assessments made with biological indicators. States are those that have assessed > 10% of their waters and have used biological indicators to assess some of their waters.

Another deficiency is that some states have only one generic aquatic life use (in contrast to Ohio's multiple, tiered aquatic life uses) which also contributes to the likelihood of underestimating impacts to high quality waters and overestimating impacts to low quality waters. Figure 6 shows the aquatic life use statistics reported in the 1992 national 305(b) report (U.S. EPA 1994) by selected states (which were based on the prevailing assessment framework employed by the individual state) and for a subset based only on biological indicators (termed the biological integrity indicator by U.S. EPA) as extracted from individual state 305(b) reports by U.S. EPA. For some states, the two statistics are either identical (*e.g.*, Ohio) or very close. For other states (*e.g.*, Michigan, Delaware, Maryland, Iowa) the aquatic life use and biological integrity statistics are widely divergent. The key point illustrated here is that *there is a tendency for states to overestimate the quality of their aquatic resources when biological indicators are not used* to drive the determination of aquatic life use attainment statistics, even though the basic biological data may be available. The statistics for Michigan (43%) and Ohio (42%) were very similar based on the biological integrity indicator, but very different based

KEY POINT

"...there is a tendency for states to overestimate the quality of their aquatic resources when biological indicators are not used..."

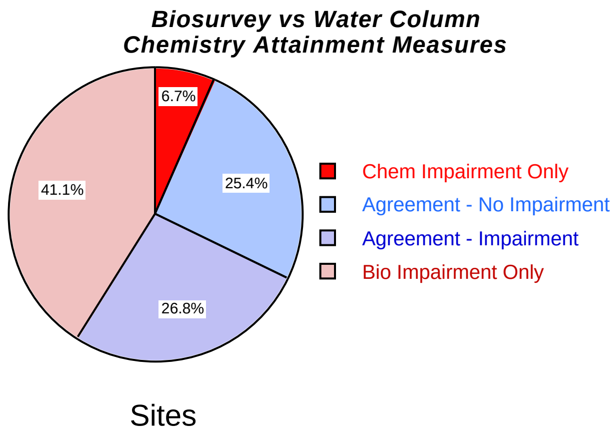


Figure 7. Detection of aquatic life impairment between biosurvey-based monitoring efforts (including water chemistry data) and water chemistry data alone in Ohio (n = 2543 sites).

on the statistics reported in the 1994 national 305(b) report (96% compared to 42%).

The quality and power of the data that states use in developing 305(b) statistics range from gross estimates based on opinion, complaints, visual impressions, data collected by volunteers, and chemical grab sampling to watershed-level biological surveys. The unfortunate tendency to equate these very different types of assessments in the national 305(b) report results in the highly skewed statistics between states. Recent efforts by U.S. EPA to improve consistency, particularly the development of better environmental indicator frameworks, biological criteria, and improved 305(b) guidelines should improve the situation. While it will take several years to fully correct these deficiencies, we can now distinguish the reasons behind the widely divergent state reported 305(b) statistics.

"Ohio's low national ranking for aquatic life use attainment . . . in the national 305(b) report is an artifact of methodological differences."

Ohio's low national ranking for aquatic life use attainment, compared to nearby states in the national 305(b) report, is an artifact of methodological differences. Figure 7 illustrates the increased power of a biological based assessment framework (which includes stressor and exposure indicators in appropriate roles) compared to a water chemistry only approach. This example illustrates that *41% of the impairment now detected with a response indicator driven framework would have been overlooked with a water chemistry only approach.* There is a high likelihood of seriously underestimating the extent of impairment to aquatic life with an exclusive reliance on chemical-based exposure indicators. The states that report a high percentage of full aquatic life use at-

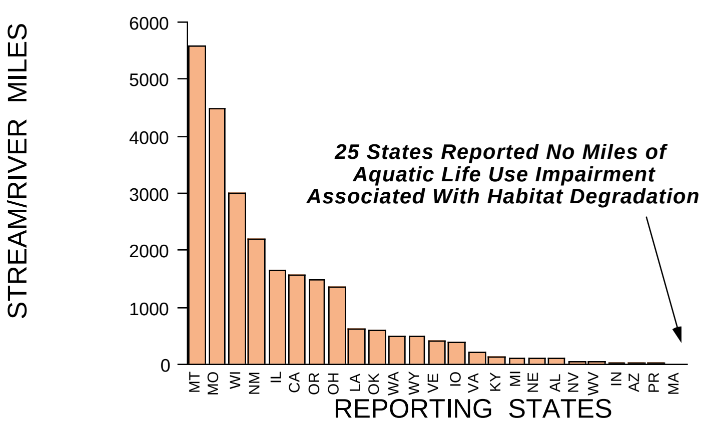


Figure 8. Reported miles of habitat related impairment of aquatic life by state (data from the 1994 National Water Quality Inventory [1994]).

tainment and therefore rank well ahead of Ohio in this category generally employ water chemistry driven assessments. This is further supported by the lack of habitat related impairment reported in the national 305(b) report (Figure 8). Aquatic habitat degradation was recognized as a widespread and serious national problem in a recent report sponsored by the prestigious National Academy of Sciences (U.S. National Research Council 1992).

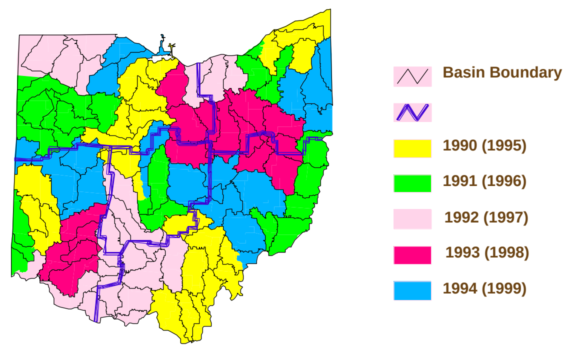


Figure 9. Five-Year Basin Approach map showing the distribution of major subbasin aggregations by biosurvey year. Biosurveys are conducted within each basin area with water quality standards rulemakings and NPDES permit reissuance following in succeeding years.

Five-Year Basin Approach: A Summary of Progress

Ohio EPA initiated the five-year basin approach to NPDES permit reissuance and monitoring beginning with the 1990 field season (Figure 9). The completion of field work in 1994 marked completion of the first five-year cycle. An assessment of issues addressed versus identified needs revealed some significant shortfalls in terms of addressing high priority issues once every five years:

- Of the more than 2300 sites targeted for monitoring between 1990 and 1994, over 1300 (56%) were sampled. Of the 237 NPDES discharges targeted, monitoring was conducted at 145 (61%). At this rate we are essentially reassessing once every 10 years, with some flexibility for addressing selected high priority issues on a five-year rotation. However, the volume of high priority needs has increased steadily through this period and has outpaced the increases gained in monitoring and assessment resources.

Limestone bedrock substrate is typical of many small, headwater streams in the Interior Plateau ecoregion of southwest Ohio. This site typifies the reference condition of the headwater streams within this ecoregion.

- Reference sites are being resampled at a 41% rate (179 out of 440 sites have been resampled through 1994). This represents a 9% shortfall from the once-every-ten-years goal of resampling all reference sites as suggested by the Ohio EPA biological criteria protocols.

"Of the more than 2300 sites targeted for monitoring between 1990 and 1994, over 1300 (56%) were sampled."

Ohio EPA's 16+ years of experience has demonstrated that in larger watersheds, more sampling sites are needed to accurately characterize resource conditions over space and time. This is especially true of concentrated, diverse, and interactive impacts to streams and rivers within urban areas. This is also applicable to the evaluation of significant point sources located on larger mainstem streams and rivers. Here it is important to accurately characterize the longitudinal response of the chemical, physical, and ecological indicators to detect all of the major impacts and accurately assess the extent and severity of any impairments. Most of the larger streams and rivers have been assessed at least once since 1978.

Inland Rivers and Streams

This section includes: 1) descriptions of the condition of inland streams and rivers through the 1992 data year; 2) a summary of changes in aquatic life use attainment status since 1988; 3) forecasts of changes in use attainment status through the year 2000; and, 4) a discussion about possible programmatic changes (*e.g.*, new initiatives, shifts in emphasis) which are needed to make progress towards achieving the Ohio 2000 goal of 75% of Ohio's streams and rivers fully supporting healthy populations of aquatic life, recreational opportunities, and other beneficial uses by the year 2000. In keeping with the pattern established by the 1988, 1990, and 1992 305(b) reports, the 1994 report emphasizes monitored level information and as-

Streams and rivers are the most frequently sampled water body type in Ohio. There are approximately 25,000 miles of named designated streams and rivers in Ohio.

sessment results (*i.e.*, biosurvey data <5 years old). A separate Ohio EPA document, the Ohio Nonpoint Source Assessment (Ohio EPA 1990a), includes evaluated and opinion/survey level information, much of which was obtained via questionnaires distributed to more than 200 state, local, and federal agencies regarding suspected sources of nonpoint source pollution.

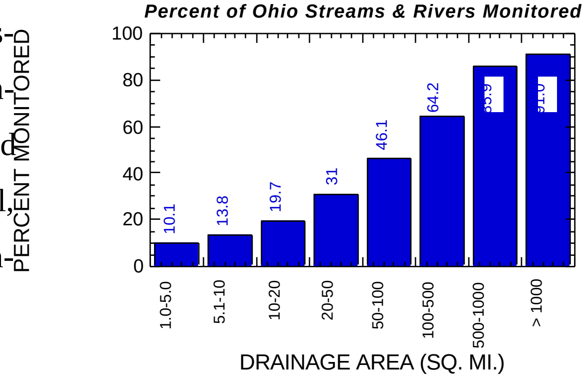


Figure 10. Proportion of Ohio's named and designated streams and rivers which have been monitored at least once with monitored level data since 1978.

Approximately 8300 river miles have been assessed with monitored level data since the late 1970s. There are approximately 25,000 stream and river miles that have been named and designated for uses in the Ohio water quality standards by Ohio EPA, thus more than one-third of these waters have been assessed. When stream and river size is considered, Ohio EPA has assessed 91% of the miles of rivers with drainage areas >1000 square miles, 71% of stream and river miles >100 square miles, and 50% of streams >20 square miles (Figure 10). The largest proportion of unassessed waters consists of headwater streams (<20 square miles) where 14% of the named and designated stream miles have been assessed. More than 2700 stream and river miles have been assessed two or more times during the past 16 years and just over 1670 miles have been reassessed since the 1992 305b report.

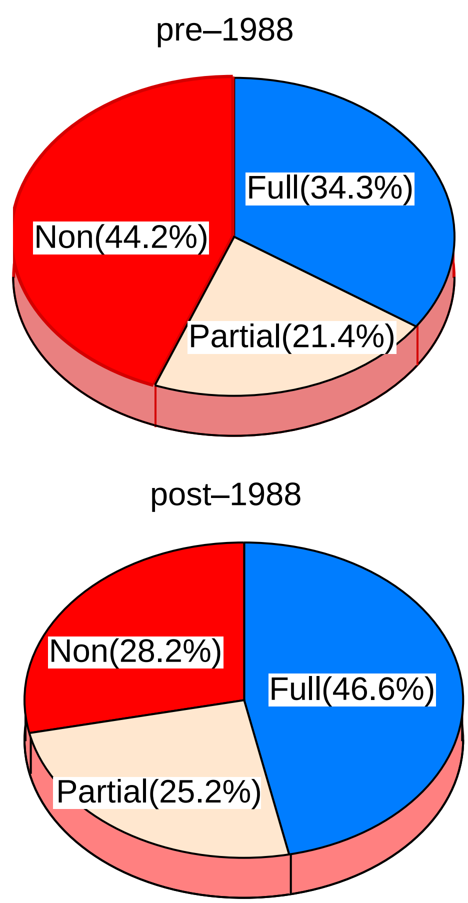


Figure 11. Proportion of stream and river miles which fully attain, partially attain, and which fail to attain aquatic life uses between the pre-1988 and post-1988 305(b) assessment cycles. These results are applicable to monitored level data.

Data collected since 1988 gives the best picture of recent conditions and the effectiveness of past water pollution abatement efforts, many of which were made to meet the July 1, 1988 National Municipal Policy deadline. This information indicates that 46.6 percent (1729 miles) are fully attaining their applicable aquatic life use designations (*i.e.*, all criteria are met), 25.2 percent (932 miles) are partially attaining (*i.e.*, some criteria are met, others are not), and 28.2 percent (1,043 miles) are in non-attainment (*i.e.*, none of the criteria are met; Figure 11; lower). This represents a substantial improvement compared to data collected prior to 1988 (Figure 11; upper). These changes signify a substantial improvement in the aquatic life use attainment status of Ohio's surface waters, much of which is the result of reduced pollution from municipal point source discharges. The coverage of the Ohio EPA monitoring program has emphasized the larger streams and rivers, these are where most of the direct use benefits are derived by Ohioans. However, this potential bias should not be construed as diminishing the value of headwater streams since their aggregate integrity indirectly influences that of the larger waterbodies.

"Approximately 8300 river miles have been assessed . . . for aquatic life use attainment status by Ohio EPA since the late 1970s."

Organic enrichment (includes both nutrient and dissolved oxygen related problems) is by far the major cause associated with aquatic life use impairment in Ohio's streams and rivers (2217 miles; Figure 12). Other significant causes of impairment include silt and sedimentation (832 miles), habitat modification (772 miles), heavy metals (495 miles), ammonia (472 miles), flow alterations (416), low pH (318 miles), unknown (217 miles), and priority organics (principally cyanide and PAHs; 104 miles). The major sources of impairment are point sources (2058 miles), habitat modification (817 miles), agriculture (712 miles), mining (595 miles), urban runoff (184 miles), in-place contaminants and other miscellaneous sources (464 miles), and on-site septic systems, landfills, and hazardous waste sites (139 miles). The predominance of organic enrichment, silt and sedimentation, and habitat as the major causes of impairment reflects the nature and extent of problems that have yet to be adequately addressed in Ohio.

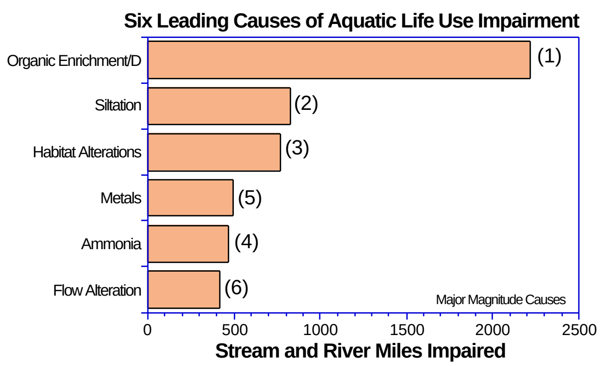


Figure 12 The six leading causes of aquatic life impairment in Ohio streams and rivers based on data from the 1994 assessment cycle. Rankings from the 1992 assessment cycle are shown in parentheses.

"Organic enrichment . . . is by far the major cause associated with aquatic life use impairment in streams and rivers."

The proportion of non-attainment also varied according to stream and river size (Figure 13). Large rivers appear more resilient to the effects of point source discharges compared to smaller rivers and streams, while headwater streams are the most susceptible to the direct effects of nonpoint sources (*e.g.*, hydromodification, runoff) and general watershed modifications. Where nearly 50% of headwater stream miles were in bonafide non-attainment, only 18% of large rivers were fully impaired (Figure 13). However, full use attainment varied little between river and stream size, indicating that a higher proportion of large rivers are partially impaired.

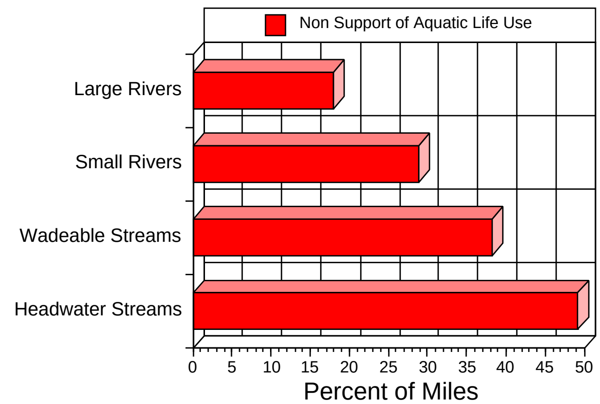


Figure 13. Non-attainment of aquatic life criteria in Ohio by watershed size: headwaters ≤ 20 sq. mi.; wadeable streams >20-200 sq. mi.; small rivers, >200-1000 sq. mi.; and, large rivers, ≥ 1,000 sq. mi. (based on information from the 1994 assessment). cycle).

Use Attainment by Ohio EPA District

Regional examination of aquatic life use attainment status enables Ohio EPA to further refine the use attainment forecast and better develop strategies to restore and protect rivers and streams. Aquatic life use attainment stratified by Ohio EPA district (which roughly approximates an ecoregion-based breakdown) illustrates some key regional differences in water resource quality. The lowest percentage of fully attaining waters occurred within the Northwest District (26.7%; Figure 14), which is mostly within the extensively impacted Huron/Erie Lake Plain (HELP) ecoregion. This contrasts with the higher percentage of full attainment (51%) in the Southeast District which essentially lies within the relatively intact Western Allegheny Plateau (WAP) ecoregion. However, the high proportion of acid mine affected waters results in the Southeast District falling second to the Central District (which occupies parts of the E. Corn Belt Plains, Erie/Ontario Lake Plain, and WAP ecoregions in central Ohio) for the lowest percentage of impaired miles.

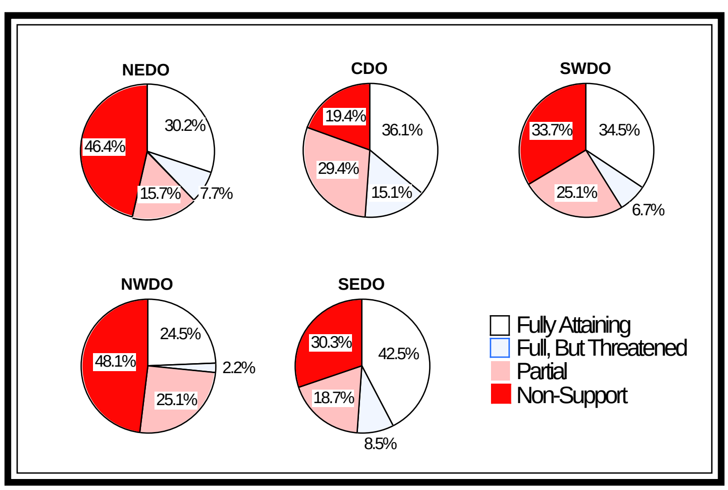


Figure 14. Aquatic life use attainment status based on Ohio EPA district boundaries.

Forecasting Trends in Use Attainment Status

A major challenge facing the Ohio EPA water program is the goal of achieving full attainment of aquatic life use criteria in 75% of streams and rivers by the year 2000. To determine the likelihood of achieving this goal, an attempt was made to look forward based on what has been observed in the recent past.

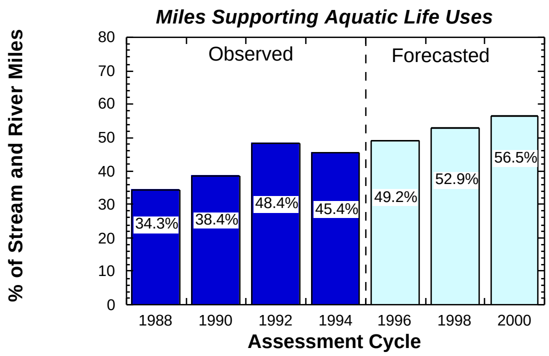


Figure 15. Measured improvement of aquatic life use attainment from the 1988 to the 1994 assessment cycles and forecast to the year 2000.

Sufficient stream and river segments have been reassessed since 1988 to enable a forecast of the possible future rate of restoration (Figures 15 and 16). This analysis provides the basis to evaluate whether the Ohio 2000 goal of 75% full attainment is likely with current water resource management and regulatory programs. This analysis revealed the following:

√ Extrapolating changes in use attainment status observed between 1988 and 1994 indicates that <u>aquatic life uses have been restored in more than 1000 miles of streams and rivers</u>.

√ The predominant factor in this restoration has been municipal wastewater treatment plant (WWTP) upgrades. An analysis of reassessed segments shows that approximately 50% of the previous WWTP associated impairment is abated by the time a segment is reassessed. Thus, it is likely that at least 50% of the 1140 miles of streams and rivers that are awaiting reassessment (and are still listed as impaired) have been restored. If the rate of restoration of point sources increases to 90%, the remaining miles of impairment associated with point sources will be less than 50 miles of monitored streams and rivers by the year 2000.

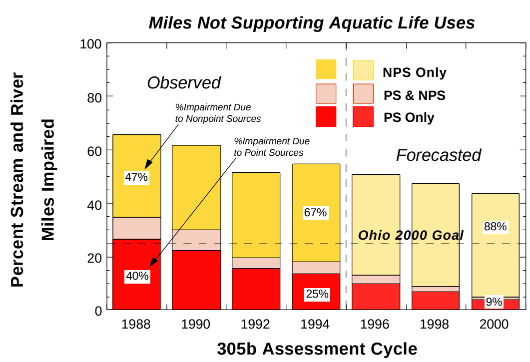


Figure 16. Change in total percent impairment of aquatic life uses (by assessment cycle) between 1988 and 1994 and forecasted to the year 2000 based on the observed restoration rate. The proportion of impairment attributed to point sources as a major source is represented by the darker (lower) portion of each column.

The current rate of improvement, projected from the reassessment results observed between 1988 and 1994 (Figure 15), is an accumulated addition of 1-2% restored miles per year (Figure 16). The major conclusions of the forecast analysis are:

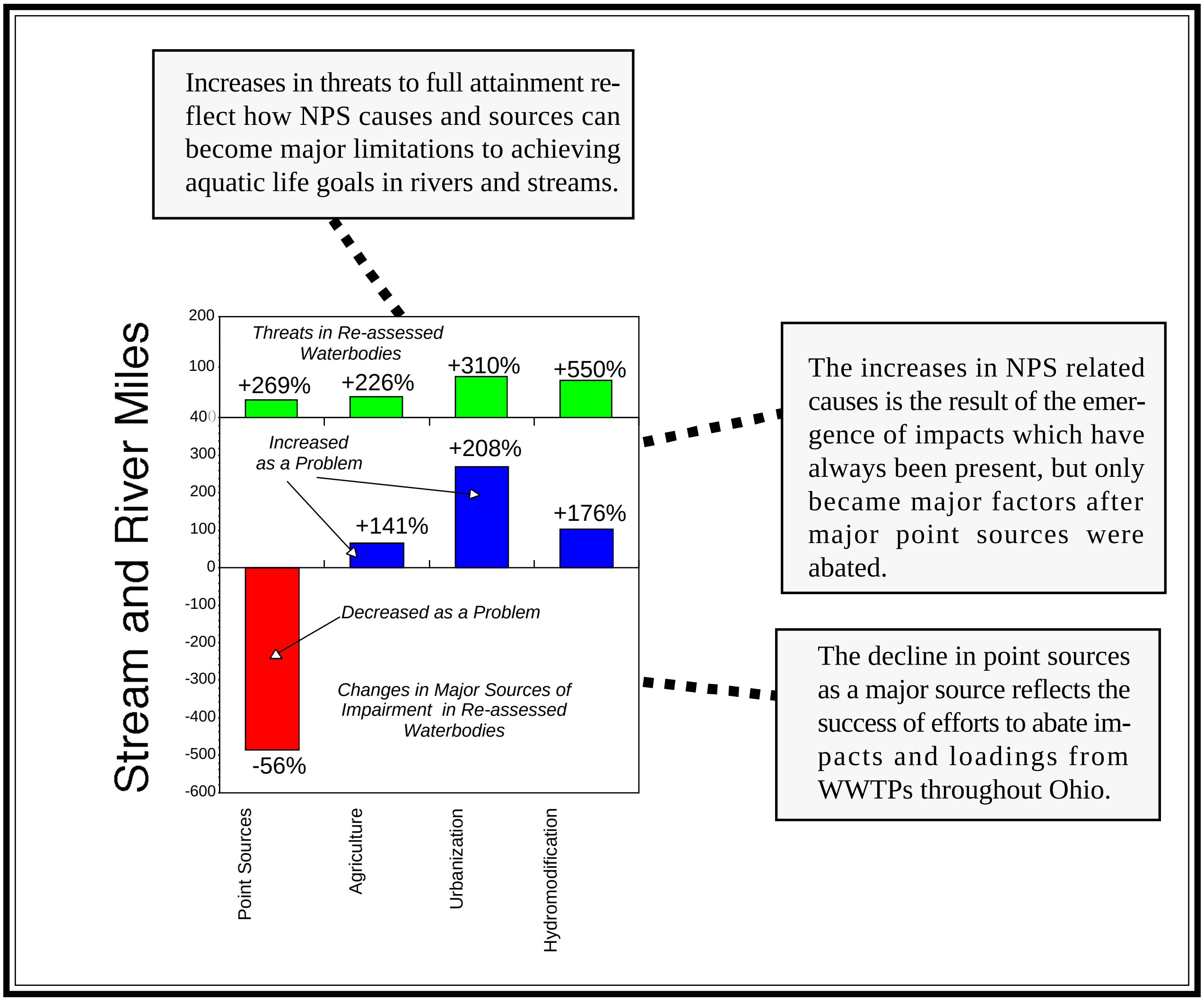


Figure 17. Change in the sources of threats to rivers and streams which exhibit full attainment of aquatic life criteria (top panel), and declines (increase in miles; middle panel) or improvements (reduction in miles) among the major sources of aquatic life impairment between the 1988 and 1994 assessment cycles for waters that have been reassessed since the 1988 cycle.

√ Over the past 10 to 15 years, there has been a 56% decline in point sources as a major source of impairment in reassessed streams (Figure 17, lower panel). Based on the observed rate of restoration, aquatic life use criteria will be fully attained in 56.5% (5450 miles) of streams and rivers by the year 2000 (Figure 15).

√ To meet the Ohio 2000 goal of 75% of streams and rivers fully supporting aquatic life uses, a gain of an additional 18.5% over that forecasted will need to be achieved during the next six years.

Forecast Analysis Summary: Inland Streams & Rivers

Designated Use Class.	1994 305(b)	Year 2000
Aquatic Life	47%	57%
Recreation	60%	70%

√ Nonpoint sources have emerged as a major source of impairment in streams and rivers during this period, with increases ranging from 141% for agricultural sources to 208% for urbanization related nonpoint sources (Figure 17, middle panel). The proportional increase in nonpoint sources as a major source of impairment is due largely to the emergence of pre-existing problems that were masked by the historically more severe point source impairments.

"Nonpoint sources are major threats to segments that fully attain designated aquatic life use criteria."

√ Nonpoint sources are major threats to segments that fully attain designated aquatic life use criteria. The principal threats are urbanization and hydromodification, which have increased by 310% and 550%, respectively, since 1988 (Figure 17, upper panel).

One of the most important findings of this analysis is that the quality of Ohio's aquatic resources are improving steadily with time. However, achieving the magnitude of improvement needed to attain the Ohio 2000 goal with existing program emphases (*i.e.,* primarily on point sources) is unlikely because point sources are declining as major causes of impairment both proportionately and in absolute terms (darker, lower portion of Figure 16). The pattern observed during the past six years (1988-1994) has been one of: 1) a gradual lessening of point source associated impairment; and 2) an emergence in the predominance of nonpoint source associated impairments (Figure 18). The emergence of nonpoint source associated impairments is largely the result of an "unmasking" of these sources as a major effect (as the formerly more prevalent and locally severe point source associated impairments are abated) rather than any substantial net increases in nonpoint associated impairments. Thus, as point source problems are abated, underlying problems are becoming increasingly apparent. A comparison of the major causes and sources of aquatic life impairment between the pre- and post-1988 assessment cycles illustrates the character of these changes (Figures 18).

"The emergence of nonpoint source associated impairments is largely the result of an "unmasking" of these sources . . . "

Strategies To Increase the Rate of Restoration

Given that the current rate of restoration will increase the full attainment fraction of streams and rivers to less than 60% by the year 2000, what actions could Ohio EPA take to accelerate restoration to meet the Ohio 2000 goal? Accelerating the rate of point source restoration alone will not achieve the 75% goal by 2000 or soon thereafter. Even if the rate of point source related restoration is accelerated to the virtual elimination of point source associated impairments (darker portion in Figure 16), and no new nonpoint source impacts are unmasked, this will result in just over 65% of streams and rivers fully attaining aquatic life criteria.

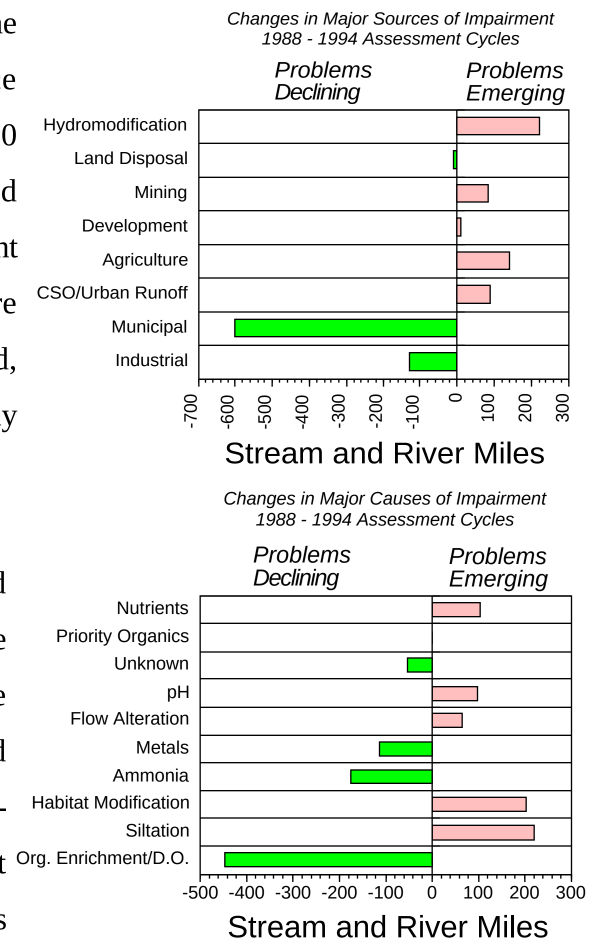


Figure 18. Reduction (decrease in impaired miles) and emergence (increase in impaired miles) of major sources (upper) and causes (lower) of aquatic life impairment between the 1988 and 1994 assessment cycles.

The projected restoration rates also need to be tempered with an understanding of the role of threats to aquatic life use attainment. The most rapidly increasing threats are those associated with suburban development, watershed level modifications (*e.g.*, wetland losses), and hydromodification (Figure 17). As the monitoring and assessment of Ohio's surface waters continues, the threats to waters that are currently attaining aquatic life use criteria will become increasingly evident. More than 600 miles of streams and rivers which presently attain their applicable aquatic life uses are considered threatened by impacts which, if not controlled, could emerge as impairments in the near future. The leading threats are habitat degradation (238 miles), silt and sedimentation (222 miles), and organic enrichment/dissolved oxygen (131 miles). Organic enrichment (includes nutrients), habitat, and sedimentation are likely to have the most rapid increases in the future because of wastewater treatment plant expansions, the increasing development of once rural watersheds, and the lack of an overall process to adequately control these impacts. Major sources of threats include hydromodification (154 miles), agriculture (169 miles), mining (105 miles), point sources (95 miles), and urban runoff (27 miles). Many of the threatened surface waters include streams and rivers designated as Exceptional Warmwater Habitat (EWH) or Warmwater Habitat (WWH) that perform well above the minimum criteria (*e.g.,* those WWH streams presently classified as State Resource Waters).

"The most rapidly increasing threats are . . . suburban development, watershed level modifications (wetland loss), and hydromodification."

Based on these statistics, it is clear that new strategies in controlling, abating, and preventing other sources of impairment will be needed to reach the Ohio 2000 goal. Any new or increased impacts from either point or nonpoint sources could erode gains made through point source abatement since 1988 and/or result in further slowing of the overall rate of restoration. This would be a deterrent to achieving the Ohio 2000 goal.

In an attempt to address some of these issues, some efforts in Ohio EPA have been expended to directly address two of the leading impacts to surface water quality, nonpoint source runoff and hydromodification. A summary of the technical justification and supporting material regarding these types of impairments follows:

"Functionally healthy and intact riparian zones . . . are essential for the attainment of the clean water goals embodied by the Ohio Water Quality Standards (WQS)."

- The land and terrestrial vegetation immediately adjacent to the stream channel (*i.e.,* riparian zone) are an integral part of stream and river ecosystems. Functionally healthy and intact riparian zones perform several important functions that are essential for the attainment of the clean water goals embodied by the Ohio Water Quality Standards (WQS). The National Academy of Sciences (U.S. National Research Council 1992) established a goal of restoring riparian buffer zones to 400,000 miles of streams and rivers nationally over the next 20 years.

- Minimum riparian widths specified by other states, federal agencies, local jurisdictions, and the technical literature range from 50 to more than 100 feet. A riparian width ranging between 50 feet and 120 feet for waters designated as Warmwater Habitat (WWH), Exceptional

Warmwater Habitat (EWH), and other high quality waters (*e.g.*, proposed Superior High Quality Waters classification) would substantially help

Wide angle view of riparian degradation caused by mature tree removal along the Scioto River at Circleville in Pickaway Co.

protect and restore Ohio's rivers and streams. This is not a totally "hands-off" zone, but rather an area within which special precautions would need to be taken to protect the structural and functional integrity of aquatic ecosystems.

". . . the maintenance of minimum width riparian buffer zones is the linchpin to attaining and maintaining clean water goals."

- Riparian zones have been documented as providing the following ecosystem services: assimilation and removal of nutrients from both surface and subsurface waters, sediment retention and removal, temperature moderation, shading, and the principal source of raw energy (*e.g.*, tree leaves).

- The mature tree component of a riparian buffer zone provides bank stabilization, instream habitat formation (source of woody debris necessary for habitat formation), water retention, nutrient uptake and assimilation, raw energy source, and shading. *Grass filter strips alone do not provide equivalent ecosystem functions and services.*

• Big Darby Creek and other high quality Ohio streams and rivers have largely intact riparian buffer zones and are tangible evidence of the natural resource benefits that result from retaining and restoring the riparian attributes described above.

The lower Little Miami R. in Warren Co. exemplifies an intact riparian zone.

• The status and condition of mainstem streams and rivers (*i.e.*, 4th order and larger) appears to be linked to the aggregate condition of the headwater streams (*i.e.*, 1st through 3rd order) in a watershed. Direct degradation of headwater streams by activities that encroach on riparian zones and by gross habitat modification will eventually become manifest in the subpar performance of the ecological indicators used to assess the condition of mainstem streams and rivers. This could, over time, erode some gains recently made via point source controls.

• Riparian buffer zones have been identified as a critical component together with land use types (Steedman 1988) in determining the ability of streams and rivers to attain the aquatic life use criteria codified in the Ohio WQS. Attainment of indicator performance values compatible with these criteria is dependent on a balanced combination of urban land use and minimum riparian buffer zone widths.

High quality Ohio headwater stream - Sugarcamp Run in the Interior Plateau ecoregion (Clermont Co.). These streams are vulnerable to activities which fracture or destroy the bedrock substrates.

• Given that land use is the more difficult of the two factors to predetermine or control, *the maintenance of minimum width riparian buffer zones is essential to attaining and maintaining clean water goals*. Failure to adequately maintain, establish, and protect riparian buffer zones will result in cumulative degradation on a watershed scale. These effects could eventually be reflected by an *increase* in stream and river miles failing to attain clean water goals specified by the Ohio WQS.

An eventual result of riparian zone degradation and land use encroachment - severe bank erosion along the Scioto R. in Pickaway Co. This contributes to siltation and embeddedness of substrates downstream.

Trends in Selected Ohio Rivers and Streams

An analysis of biological monitoring results from streams and rivers with multiple years of data indicate that the greatest improvements have occurred where organic enrichment and dissolved oxygen were the predominant impact types. This reflects the past emphasis of regulatory and financial assistance efforts towards municipal wastewater treatment. Impairments associated with a combination of complex toxic and organic enrichment impacts have also improved, but to a lesser degree, reflecting the greater difficulties in dealing with these issues and the longer recovery periods. However, no major stream or river segment with significant historical impairments has completely recovered to the point where full attainment of the applicable aquatic life uses has been restored in virtually 100% of the formerly impaired miles.

". . . the greatest improvements have occurred where organic enrichment and dissolved oxygen were the predominant impact types."

A description of the extent and direction of these changes in selected Ohio streams and rivers appears in Tables 1 and 2. Along with Figure 16, these provide information intended to illustrate the general status and trends in principal Ohio rivers and streams. Tables 1 and 2 have been updated from the 1992 Ohio Water Resource Inventory and indicate the years of monitoring, the trend indicated by the latest year of monitoring, a qualitative indication of the strength of the trend, and a narrative description of the principal attributes and point or nonpoint source problems. Major portions of 32 rivers and streams have been reassessed since the initial biosurveys of the late 1970s and 1980s. Of these, at least portions or all of 13 show consistent improvements (*i.e.*, many sites now fully attain aquatic life use criteria), six show modest or partial improvements, eight show no improvement, and nine have exhibited declines. In many of the latter, the declines were usually due to the worsening of an already impaired status. Assessments of trends in a minimum of 26 additional rivers and streams will occur during the next 5-10 years, provided monitoring resources remain stable.

"Assessments of trends in a minimum of 26 additional rivers and streams will occur during the next 5-10 years, provided monitoring resources remain stable."

A key parameter of Ohio's biocriteria, the Index of Biotic Integrity (IBI), was used to accomplish a ranking of major streams and rivers. IBI data for 99 streams and rivers with drainage areas >50 and <6000 square miles were plotted in an attempt to demonstrate existing quality and statewide and regional patterns (Figure 19). Streams and rivers were ranked in order of median IBI values (50th %ile) according to the results of box-and-whisker plots showing the median , upper quartile (75th %ile), lower quartile (25th %ile), maximum, minimum, and outlier (*i.e.*, values >2 interquartile ranges above the median) values. Data from multiple years were combined when no between year differences were evident; however, if differences were evident, data from the most recent monitoring year was used. Some streams and rivers showed little variation between the minimum and maximum IBI values which is an indication of uniform conditions throughout the segment or subbasin. Others exhibited wide variations that reflect variable quality owing to differences between relatively unimpacted upstream sites and severely impacted sites near problem sources. Thus while some streams and rivers may have been characterized as marginal, fair, or poor in terms of the median IBI value, this does not necessarily reflect the performance of all sites nor the potential for recovery to a higher status. Nevertheless, considering these caveats, Figure 19 represents a comparative accounting of the current condition of Ohio's major streams and rivers.

Table 1. Summary of aquatic community status and trends for the principal rivers and streams monitored by Ohio EPA between 1979 and 1993 in the Lake Erie drainage basin. For study areas where before and after surveys have been performed, an indication of any significant change as greatly improved (▲▲), improved (▲), decline (▼), or no change (↔) was made under the Trends column (some areas are described as simultaneously improving, declining, etc. which reflects conditions in different segments of the study area). The year (e.g. 1995) indicates the next opportunity for a follow up survey within the Five-Year Basin Approach schedule. A qualitative description of the nonpoint source and habitat conditions, and general highlights of major events in the study are also noted.

River/ Stream	**Earliest/ Latest Yr.**	**Trends**	**Nonpoint Status**	**Habitat Status**	**Comments/Observations**
Lake Erie Drainage Basins					
Grand River	1987	1995	Good	Good	Upgraded to EWH; chromate lagoon impacts.
Maumee River	1984/93	↔	Poor	Good-Fair	NPS background impacts; WWTP/CSO impacts.
Auglaize R.	1985/91	▲	Fair-Poor	Good-Fair	1985 agency enforcement Farm Services, Inc.
St. Marys R.	1991	1996	Fair-Poor	Fair-Poor	Silt/habitat impacts; HELP ecoregion effect.
Tiffin River	1984	▲	Fair	Fair	Significant NPS; some habitat recovery.
Blanchard R.	1983/91	▲	Fair	Fair	Findlay WWTP upgrade; CSO abatement eval.
Ottawa R.	1985/91	▼↔▲	Good-Fair	Good-Fair	Historically improved; fish anomalies remain.
Sandusky River	1979/90	▼▲	Fair-Poor	Good	WWTP upgrades; NPS impacts worsened.
Ashtabula River	1989	1995	Good	Good	Good quality ust. Ashtabula; toxics in harbor area.
Huron River	1982/84	1993	Good	Good	Generally good quality; local WWTP impacts.
Rocky River	1981/1992	▼↔▲	Good	Good	Many WWTP upgrades since 1981.
Chagrin River	1986/1991	1996	Good	Good	Industrial impacts evident in 1986 & 1991.
Portage River	1985	1994	Good-Poor	Good-Poor	NPS impacts; CSO impacts severe in E. Branch.
Cuyahoga River	1984/91	▲▲	Good-Fair	Excell.-Fair	WWTP upgrades, pretreatment; CSO impacts.
Black River	1982/1992	▼↔▲	Fair/Poor	Good-Fair	WWTP/CSO, industrial; NPS worsening
Vermilion River	1987	1997	Good-Fair	Excell.-Good	High quality in areas; NPS impacts in upper basin.

Table 2. Summary of aquatic community status and trends for the principal rivers and streams monitored by Ohio EPA between 1979 and 1993 in the Ohio River drainage basin. For study areas where before and after surveys have been performed, an indication of any significant change as greatly improved (▲▲), improved (▲), decline (▼), or no change (↔) was made under the Trends column (some areas are described as simultaneously improving, declining, etc. which reflects conditions in different segments of the study area). The year (e.g. 1995) indicates the next opportunity for a follow up survey within the Five-Year Basin Approach schedule. A qualitative description of the nonpoint source and habitat conditions, and general highlights of major events in the study are also noted.

River/ Stream	Earliest/ Latest Yr.	Trends	Nonpoint Status	Habitat Status	Comments/Observations
Ohio River Drainage Basins					
Hocking River	1982/1990	▲▲	Poor	Good-Poor	Lancaster WWTP upgraded; serious bank erosion.
Scioto River	1979/1993	▲▲	Fair	Good	WWTP upgrades; CSO, siltation impact remains.
Paint Cr	1989	1997	Fair-Poor	Excell.-Fair	Upgraded to EWH; NPS problems upstream.
Olentangy R.	1989	1996	Good	Excell.-Good	Upgraded to EWH; WWTP problems remain.
Big Darby Cr	1979/1992	↔	Good	Excellent	High quality waters; NPS impacts in upper basin.
Mill Creek	1978/1990	▼	Good-Fair	Excell.-Good	Declining despite WWTP upgrade; pesticides.

Table 2. (continued).

River/Stream	Earliest/ Latest Yr.	Trends	Nonpoint Status	Habitat Status	Comments/Observations
Central Ohio R. Tribs.					
Yellow Cr.	1983/1991	↔	Good-Poor	Good	Locally severe acid mine impacts.
Cross Cr.	1983	1996	Good-Poor	Good	Locally severe acid mine impacts.
Captina Cr.	1983/1991	↔	Good	Excellent	High quality (EWH); improvements in tribs.
McMahon Cr.	1983/1991	▲	Good-Poor	Good	Locally improved; acid mine impacts in tribs.
Sunfish Cr.	1983/1991	↔	Excell.-Good	Excellent	High quality (EWH).
L. Muskingum	1983/1991	↔	Good-Fair	Excell.-Good	High quality (EWH); some local NPS impacts.
Little Beaver Cr.	1985	1994	Excellent	Excellent	High quality (EWH).
Middle Fork	1985	1994	Good	Good	Fish tissue advisory; Nease Chem. site.
West Fork	1984	1994	Excellent	Excellent	Consistent EWH attainment.
Southeast Ohio R. Tribs.					
Symmes Cr.	1990	1995	Good-Fair	Excell.-Good	NPS sediment impacts from surface mining.
LeadingCr.	1990/1993	▼▼	Good-Fair	Excell.-Good	Recovering from Meigs Mine #31 discharge.
Raccoon Cr.	1990	1995	Good-Poor	Good-Fair	NPS sedimentation impacts from surface mining.
L. Scioto R.	1990	1995	Good-Fair	Good	NPS sediment and oil & gas well impacts.
Southwest Ohio R. Tribs.					
Ohio Brush Cr.	1987	1997	Good	Excell.-Good	High qual. (EWH); WWTP impacts to tribs.
Whiteoak Cr.	1987	1997	Good	Excellent	High qual. (EWH); some NPS in upper basin.
Little Miami R.	1983/1993	▼↔▲	Good-Fair	Excell.-Good	WWTP impacts still evident; NPS in upper basin.
E. Fk. L. Miami	1982/1993	▼↔▲	Good-Fair	Excell.-Good	High quality (EWH); NPS impacts upper basin.
Great Miami River	1980/1989	▲	Good	Excell.-Fair	Some improvements; WWTP impacts remain.
Twin Cr	1986	1995	Good	Excellent	High quality (EWH); NPS threats in upper basin.
Stillwater River	1982/1990	▲	Good-Fair	Excell.-Good	Improved since 1982; NPS impacts in upper basin.
Greenville Cr	1982/1990	▲	Good	Excellent	Improvements due to WWTP upgrade.
Mad River	1984	1994	Good	Good	WWTP upgrades since 1984.
Muskingum R	1988	1994	Good-Fair	Good-Fair	Lower part impounded; thermal impacts remain.
Upper Tusc	1983/1989	↔	Good-Fair	Good-Poor	Extensive channel mod., in-place contaminants.
Lower Tusc.	1983/1988	▲▲	Good	Excell.-Good	Upgraded to EWH due to PS improvements.
Nimishillen Cr.	1985	1993	Good-Fair	Excell.-Fair	Extensive industrial, WWTP, and CSO impacts.
E.Br. Nimishillen	1985/93	▼↔	Fair-Poor	Poor	Industrial, toxics; NPS worsening in headwaters
Killbuck Cr.	1981/85	1993	Good-Fair	Good-Fair	WWTP, NPS impacts, channel mod., wetlands.
Rocky Fork	1979/1993	▼↔▲	Good	Excell.-Good	Industrial, toxics worsened; WWTP improved.
Black Fork	1984/1989	▼	Good-Fair	Fair-Poor	Decline due to worsening industrial impacts.
Kokosing R.	1987	1993	Excellent	Excellent	High quality (EWH); few impacts noted.
Licking River	1981/1993	▲▲	Good	Excell.-Good	WWTP impacts abated since 1981.
S.Fk. Licking	1984/1993	▲▲	Good	Excell.-Good	WWTP impacts abated since 1984.
Wills Creek	1984	1994	Fair-Poor	Fair-Poor	Extensive sedimentation due to mine runoff.
Mahoning River	1980	1994	Good-Fair	Good-Fair	Historically very degraded by industry, WWTPs.
Mill Creek	1988/1992	↔	Poor	Fair-Poor	Extensive channel mod., CSOs, urban, toxics.

". . . the highest quality streams (are) distributed principally between the W. Allegheny Plateau (WAP), the E. Corn Belt Plains (ECBP), and the Interior Plateau (IP) ecoregions."

Ecoregional influences were apparent with the highest quality streams distributed principally among the Western Allegheny Plateau (WAP), the E. Corn Belt Plains (ECBP), and the Interior Plateau (IP) ecoregions. These include some of the better known high quality stream and river resources such as Big Darby Creek, Little Darby Creek, Ohio Brush Creek, Stillwater River, and Salt Creek, but also include less well known, but equally exceptional resources, such as Captina Creek, West Fork of Little Beaver Creek, Kokosing River, and Twin Creek. Others, such as the Scioto River and Licking River, are well along in the recovery process with each ranking in the very good and exceptional ranges. The highest ranking stream or river located mostly within the Huron/Erie Lake Plain (HELP) ecoregion was the Tiffin River (55th out of 99). Rush Creek (WAP ecoregion), which has severe acid mine drainage problems, scored the lowest of all 99 streams.

". . . watersheds with extensive and intensive hydromodification and nonpoint sources (Auglaize R., Tiffin R., L. Auglaize R., Chippewa Cr.) scored primarily in the fair, fair-poor, or poor ranges."

A narrative rating scale similar to that which is linked to the biocriteria index score ranges was also included along with a description of the cultural and watershed influences and characteristics associated with each stream or river. For example, watersheds with extensive and intensive hydromodification and nonpoint source impacts (*e.g.*, Auglaize River, Tiffin River, Little Auglaize River, Chippewa Creek) scored primarily in the fair, fair-poor, or poor ranges and consistently ranked in the lower one-half of streams and rivers. Streams and rivers impacted by multiple urban and industrial impacts generally scored in the fair-poor, poor, or very poor ranges and several ranked in the lower one-fourth of streams and rivers.

Figure 20 demonstrates one of the methods used to graphically portray results from individual sampling locations in a river segment. This example depicts the Index of Biotic Integrity (IBI) for the Scioto River within and downstream from Columbus, Ohio. The results of two different sampling years, before and after the imposition of water quality-based effluent limits at the major municipal wastewater treatment plants, are shown for a 40-mile segment. This permits the visualization of departures from the ecoregional biocriteria and any changes over space and time. Here the reductions in loadings of sewage constituents (oxygen demanding wastes, ammonia, chlorine) have resulted in a positive response from the fish community.

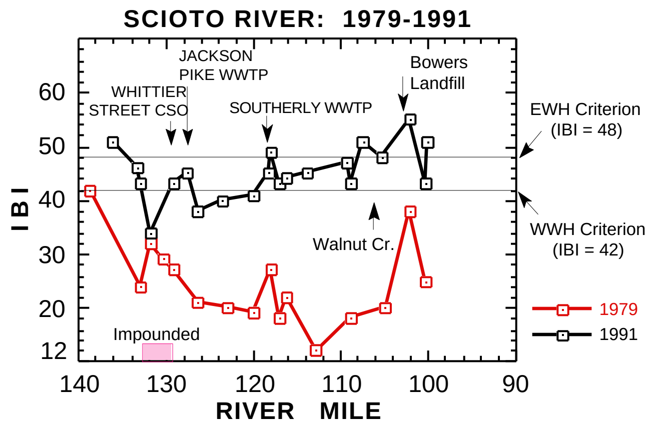


Figure 20. Longitudinal and temporal trend of the Index of Biotic Integrity in the middle Scioto River in and downstream from Columbus, Ohio. The improvement towards attainment of the IBI criterion for the Warmwater Habitat use is a result of improvements made at the two municipal wastewater treatment facilities.

Recreational Uses

The principal measurement for assessing whether waters are suitable for human body contact (*i.e.*, swimming, canoeing, or wading as specified by the Primary Contact Recreation and Secondary Contact Recreation uses) are fecal bacteria counts. A total of 5,513 miles of rivers and streams have been assessed since 1978 with 1,842 miles assessed since 1988. Of this latter figure, 616 miles were new assessments and 1226 miles were reassessments. The observed improvements in recreation use attainment (Figure 21) are attributed to improved municipal wastewater treatment, particularly reductions in bypasses of raw or partially treated sewage. The remaining non-attainment is the result of: 1) urban runoff and combined sewer overflows; 2) unresolved WWTP treatment problems (bypassing); and, 3) livestock and agricultural runoff. At the observed rate of improvement reflected in Figure 18, 70% of stream and river miles should fully attain designated recreational uses by the year 2000.

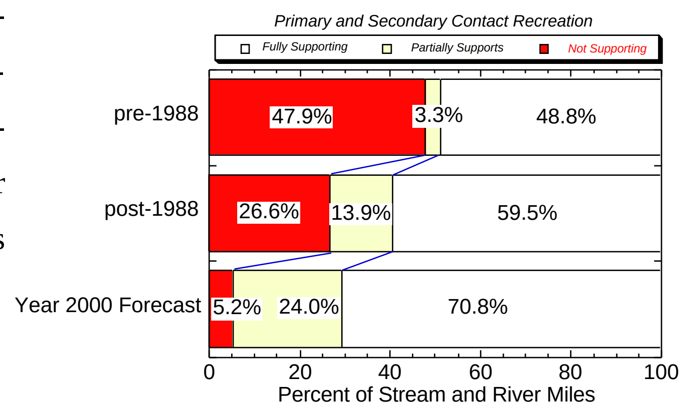


Figure 21. Miles of rivers and streams fully attaining, partially attaining, or not attaining recreational uses (primary or secondary contact) between the pre-1988 and post-1988 305[b] assessment cycles.

Inland Lakes, Ponds, and Reservoirs

Monitoring of inland lakes, ponds, and reservoirs has historically been less intensive than for rivers and streams, but the recent Lake Water Quality Assessments (LWQAs) and Citizen Lakes Initiative Program (CLIP) have helped to close the gap. The information presented here was collected primarily during the past six years as part of the LWQA program and from a Lake Condition Index questionnaire completed by managers of publicly owned lakes. Davic and DeShon (1990) devised a Lake Condition Index (LCI) which aggregates a wide range of lake indicators such as secchi disk depth, presence of contaminants, and trophic state to assess lake water quality conditions and to track the progress of lake restoration activities. The paucity of long-term monitoring data limits our analysis to the present status of the publicly owned lakes that have been recently monitored.

Ohio has an aggregate total of 118,801 acres among 447 public lakes, ponds, and reservoirs greater than five acres in surface area. Of this acreage, 54,905 acres (46.2%) were assessed for aquatic life use support, 23,679 acres (19.9%) were assessed for fish tissue contaminants, 55,126 acres (46.4%) were assessed for public water supply uses, and 55,127 acres (46.4%) were assessed for recreational uses. For aquatic life uses, there was full attainment in 23,499 acres (19.9%), partial attainment in 41,110 acres (74.9%), and non-attainment in 2,613 acres (0.5%; Figure 22). However, nearly all (99.8%) of the fully attaining lake acres were considered threatened. For fish consumption, 23,499 acres fully attained this use (none were considered threatened), 180 acres were partially attaining (due to advisories in two small lakes in northeast Ohio), and no lakes were considered in non-attainment of this use. For the public water supply use, 7,867 acres fully attained, but all except 321 acres were considered threatened (95.9%); 42,106 acres were partially attaining, and 4,832 acres were in non-attainment. For recreational uses, 1,864 acres fully attained (655 acres were considered threat-

Most of Ohio's lakes are artificially created, although a good number of natural lakes exist in the northeast and west central parts of Ohio.

ened), 23,957 acres were partially attaining, and 28,651 acres were in non-attainment.

For the most part, Ohio's publicly owned lakes, ponds, and reservoirs (recreation, public water supply, and aquatic life) were at least in partial attainment. The assessment methodology, based on the Ohio Lake Condition Index (LCI), includes multiple metrics and a classification of partial attainment may indicate a minor problem in only one or two (*e.g.*, low hypolimnetic dissolved oxygen during the summer months) with the remainder indicating acceptable conditions. The LCI is most useful for assisting lake managers in identifying water resource problems and actions that will improve overall lake quality. It is also useful for classifying outstanding and high quality lakes that meet all of the criteria of the LCI. Thus, partial attainment should be used only to indicate the partial presence of specific problems, not as an indication of complete impairment. The non-attainment category is the most reliable indicator of lake impairment and should be used exclusively in statewide or national reporting statistics. Recreational use was the only major category where most Ohio lake acres are in bonafide non-attainment.

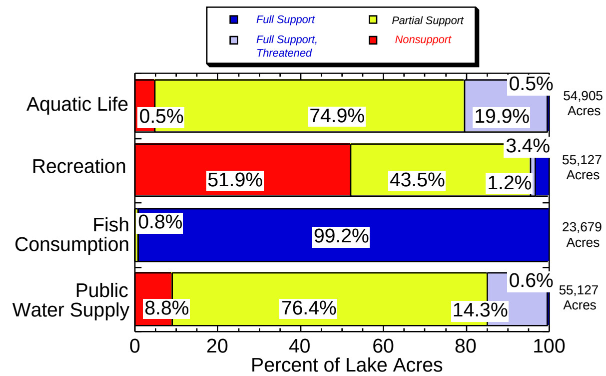


Figure 22. Designated use and fish consumption status for acres of lakes, ponds, and reservoirs in Ohio.

Major magnitude sources associated with partial and non-attainment were (in order of acreage affected): agricultural nonpoint sources (29,713 acres), on-lot septic systems (15,016 acres), point sources (1,518 acres), habitat modifications (1,094 acres), and urban runoff (740 acres). Major magnitude causes were identified as turbidity (15,629 acres), algal/nutrients (16,631 acres), siltation (15,444 acres), and habitat (12,700 acres). Similar to Ohio's streams and rivers, abatement of nonpoint sources is a key for improving and maintaining lake conditions.

"The non-attainment category is the most reliable indicator of lake impairment . . ."

Lake Erie

Lake Erie was similarly evaluated for aquatic life use attainment status, but neither recent nor comprehensive information is available. Thus, much of the assessment is based on older data primarily from Lake Erie river mouth and harbor areas. None of the open lake was considered to fully attain the Exceptional Warmwater Habitat (EWH) use designation (based on chemical criteria exceedences alone). The entire 231 shoreline miles of the near shore were considered in partial attainment of EWH, which is based primarily on a lake-wide fish consumption advisory for carp and channel catfish, and exceedences of chemical water quality criteria for copper and cadmium in the water column. Associated sources (major and moderate influence) included point sources (69%), nonpoint sources (19%), in-place pollutants (3.5%), and other (8.5%). Associated causes include toxics (mostly heavy metals, 77%), organic enrichment/D.O. (14%), and pH (9%). *The lack of a comprehensive set of ecological indicators for Lake Erie makes these estimates of use attainment/non-attainment tenuous.*

The George B. Garrett, shown here in the lower Maumee R. (Lucas Co.), has expanded Ohio EPA's ability to conduct ambient monitoring in Lake Erie nearshore, river mouth, and harbor areas.

"Ohio EPA is presently working to develop numerical biological criteria for the nearshore, river mouth, and harbor areas of Lake Erie."

Ohio EPA is presently working to develop numerical biological criteria for the nearshore, river mouth, and harbor areas of Lake Erie. This effort will be similar in scope to that accomplished for Ohio’s inland streams and rivers in the late 1980s. However, the specific metrics and evaluation tools will be appropriately developed and calibrated for applicability to 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 anticipated that a fourth year will be needed to finalize the biocriteria. Hopefully, the availability of these criteria and the attendant monitoring and assessment tools will improve the present situation.


Shoreline development along Lake Erie in Erie Co.

The development of a Lakewide Management Plan (LaMP) for Lake Erie has also been initiated. A concept paper, developed as an initial starting point for the LaMP, recommends that a much broader approach be taken than the present emphasis on toxic compounds alone. It is widely recognized that multiple stressors impact the lake, some more so than toxics. These include habitat destruction, wetlands losses, exotic species introductions, overfishing, and nutrient enrichment.

Remedial Action Plans (RAPs)

Since 1988, Ohio EPA has been working toward completion of remedial action plans (RAPs) for Ohio's four Areas of Concern. These include the lower Ashtabula, Cuyahoga, and Maumee rivers, and the entire Black River watershed. A provision of the Great Lakes Water Quality Agreement, RAPs are to be developed through a systematic, ecosystem approach with a considerable amount of local community and stakeholder involvement. Important highlights from the RAPs are further summarized in Volume I.

" . . . RAPs are . . .developed through a systematic, ecosystem approach with . . . local community and stakeholder involvement."

Ohio River

The assessment of the Ohio River focused on the status of multiple designated uses (Warmwater Habitat, Public Water Supply, Recreation) and fish consumption performed by the Ohio River Valley Sanitation Commission (ORSANCO) and summarized in their 1994 305(b) report (ORSANCO 1994). Unlike the procedures used by Ohio EPA for inland rivers and streams, use attainment status is based on a combination of chemical-specific and qualitative biological information. For the Warmwater Habitat aquatic life use (Ohio boundary waters only), 293.4 mainstem miles (65.3%) were in full attainment, partial attainment occurred in 61.3 miles (13.6 %), and non-attainment occurred in 95.1 miles (21.1%). For fish consumption, all Ohio mainstem miles (449.8) were in partial attainment due primarily to a fish consumption advisory for selected species. For the public water supply use, which has major application in the Ohio River, all 449.8 miles (100%) were in full attainment. No miles (0%) fully attained the primary contact recreation use, 372.3 miles (82.8%) were in partial attainment, and 77.5 miles (17.2%) were impaired (non-attainment due to elevated bacteria levels).

The Ohio River mainstem near Martins Ferry in Belmont Co.

The principal causes associated with aquatic life use impairment in the Ohio River were heavy metals, particularly chemical criteria exceedences of copper and lead. However, fish community data collected by Ohio EPA and ORSANCO generally show good to exceptional community performance, which is at odds with the status and condition of the mainstem based solely on ambient water column chemistry results. Metals in the water column are likely not present in their most toxic forms, thus an assessment based on chemical criteria violations alone may be misleading. The

Biological sampling in large water bodies requires the use of boat mounted methods. This photo shows boat electrofishing in a Lake Erie river mouth area. A similar method is used on the Ohio River.

two metals showing criteria exceedences, copper and lead, are prone to this type of phenomenon. However, lacking more formal biological assessment criteria currently precludes "overruling" the chemical criteria exceedences in deciding use attainment status. Work is underway to develop formal biological criteria that may help to resolve this situation in the future.

" . . . fish community data collected by the Ohio EPA and ORSANCO generally shows good to exceptional community performance."

Ohio's Fish Tissue Contaminant Monitoring Program

Ohio lacked a formal and comprehensive fish tissue monitoring program until recently. Besides serving as a human health risk indicator, contaminated tissue is a useful indicator for identifying lakes, streams, and rivers that have been affected by hydrophobic toxic substances and for tracking the success of pollution abatement efforts. Until 1993, Ohio's fish tissue sampling program had been small in scope (approximately 50 sites/year) and the results presented herein reflect that effort. In 1993, Ohio EPA, in cooperation with Ohio Department of Natural Resources (Ohio DNR), the Ohio Department of Health, and Ohio Department of Agriculture, initiated a comprehensive, statewide monitoring effort for fish tissue contaminants. Future 305b reports will reflect this increased level of sampling. Data collected from 1978 to 1992, analyzed herein, provide a baseline for evaluating future results. Volume II of this report discusses the procedures for issuing fish consumption and contact advisories in Ohio, provides a list of existing advisories, and the projected sampling for 1994 and 1995.

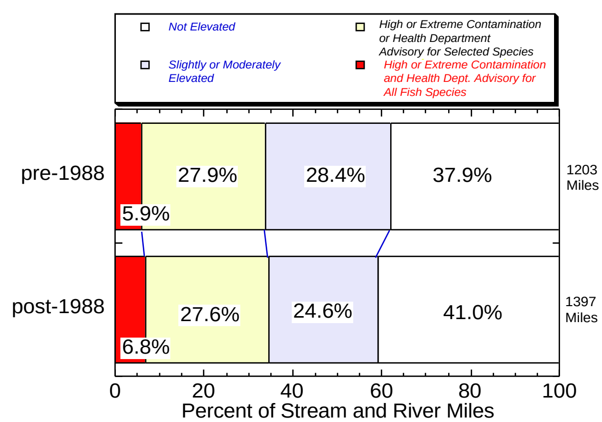


Figure 23. Miles of streams and rivers with fish tissue samples which exhibited no contamination, slightly or moderately elevated contamination, highly or extremely elevated contamination, or highly or extremely elevated contamination <u>in segments</u> with a State or local health advisory, during pre-1988 and post-1988 assessment cycles.

More than 40% of fish tissue samples analyzed from monitored streams and rivers were essentially free from elevated concentrations of PCBs, pesticides, metals, or other organic compounds. Levels of these contaminants that are considered slightly or moderately elevated were observed in 24.6% of monitored stream and river miles. Highly or extremely elevated levels of contaminants occurred in 27.6% of the total miles. State and/or local consumption advisories for selected species have been issued for only a fraction of these latter miles. Comprehensive health advisories covering all species have been issued for 6.9% of the miles monitored for fish tissue contaminants. There has been a slight decline in the miles of streams and rivers with historically high levels of contamination (Figure 23). A more thorough assessment of trends will be generated by the more intensive data collection efforts planned over the next several years.

"More than 40% of fish tissue samples analyzed . . . were essentially free from elevated concentrations of PCBs, pesticides, metals, or other organic compounds."

Biological Criteria in the Ohio Water Quality Standards

Biological criteria (biocriteria) are narrative or numerical expressions that reflect the overall quality of the aquatic life which inhabit the aquatic environment (*i.e.,* direct measures of fish and macroinvertebrate population and community characteristics). As such they represent a method for directly measuring whether a stream or river is attaining a designated aquatic life use. Biological criteria are fundamentally different from chemical-specific criteria in that the latter, being based on laboratory studies of representative aquatic species, serve as surrogates for what biocriteria are designed to measure directly. Biocriteria function within a monitoring and assessment effort as response indicators whereas chemical-specific criteria function as exposure indicators. Chemical-specific criteria also serve as design endpoints for determining water quality based limitations whereas biocriteria serve as an ambient aquatic life goal assessment tool. U.S. EPA has demonstrated their interest and support of biocriteria by producing bioassessment guidance (Plafkin *et al.* 1989), national biocriteria program guidance (U.S. EPA 1990), a policy statement on biocriteria (April 1990), and a technical guidance manual for developing biocriteria in wadeable streams (U.S. EPA 1995). Similar efforts are in various stages of development for lake, wetland, and large river biocriteria.

"Biocriteria function within a monitoring and assessment effort as response indicators . . ."

Ohio EPA adopted numerical biological criteria for rivers and streams in February 1990. A regional reference site approach was used to derive these criteria (Figure 24). Within this framework, numerical biological community performance expectations are based on what the least impacted reference sites within a given geographic region demonstrate as being attainable. This process includes consideration of background factors that influence and determine the inherent character of watersheds (*i.e.*, land use, geology, soils, *etc*.), stream and river size, and inherent biological characteristics and attributes. As such, biocriteria should provide a more accurate reflection of both the existing and restorable condition of aquatic resources that should lead to a better identification of critical issues, appropriate designated uses, and the formulation of abatement strategies which are inherently more cost-effective and environmentally effective.

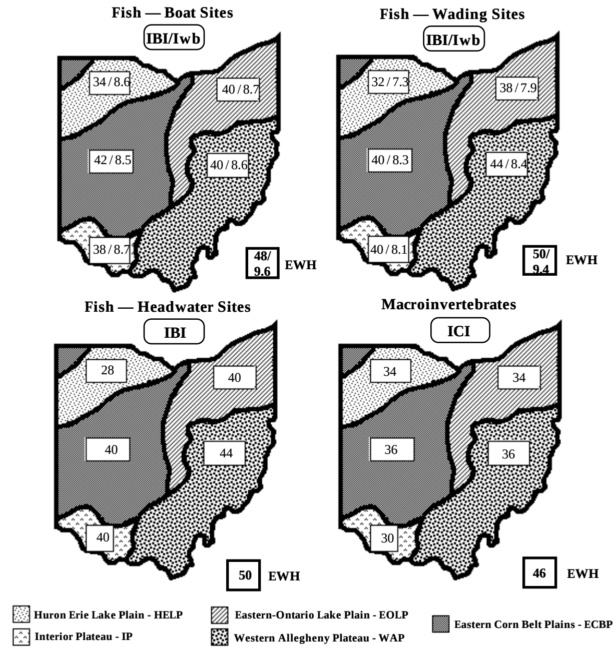


Figure 24. Numerical biological criteria codified in the Ohio Water Quality Standards shown by index, site type, and ecoregion for the Warmwater Habitat and Exceptional Warmwater Habitat use designations.

A key policy issue facing states is the U.S. EPA policy of independent application. This policy requires that biological criteria, chemical-specific criteria, and whole effluent toxicity test results be evaluated independently with no one indicator being viewed as preemptive of another. Others (including most states) have advocated a weight-of-evidence approach in which the application of each indicator is done on a more flexible, case-specific basis. Most states already employ a weight-of-evidence approach in their ambient bioassessments. Ohio EPA has recently advocated consideration of a hierarchical process in which the strength of the biological survey and underlying biological criteria development process be used to determine how much flexibility might be granted in the regulatory usage of biological criteria.

". . . biological criteria . . . significantly adds to the capability to detect, characterize, and more effectively manage water resource impairments.

Based on analyses presented in the 1990 Ohio Water Resource Inventory (Ohio EPA 1990b) and elsewhere (Yoder 1991a, 1991b, 1995; Yoder and Rankin 1995a), there is little doubt that the addition of biological criteria and ambient biological monitoring and assessment significantly adds to the capability to detect, characterize, and more effectively manage water resource impairments.

Because it represents a direct and tangible product of the environment, biological criteria and assessment provides a meaningful way to demonstrate the benefits that expenditures on pollution controls have achieved. Furthermore, the information bases that are accumulated as a consequence of the ambient monitoring and assessment process has led to a more informed and cost-beneficial expenditure of both public and private funds. Problem discovery and comprehension would not be nearly as effective without an integrated chemical, physical, and biological approach to surface water monitoring and assessment. Aquatic life use impairments that we have identified and characterized during the past 15 years simply would not have been understood or even detected using chemical criteria and assessment tools alone. Identification of the three leading causes of aquatic life use impairment reported by this inventory would not have been possible without this type of integrated approach, including the use of numerical biological criteria derived within a regional reference site framework. While these biocriteria are restricted to rivers and streams, the development of biocriteria for Lake Erie river mouth, harbor, and nearshore areas, the Ohio River, and wetlands are either underway or under consideration.

Biological criteria for wetlands are in the developmental stage. Biocriteria differ from chemical criteria in that they measure ecological attributes directly.

Ohio EPA continues to incorporate the concepts and information produced from having biological criteria integrated into water resource management. Two recent innovations that are being explored include using the Area of Degradation Value (ADV; Yoder and Rankin 1995b) to assist in making and prioritizing water program decisions and in evaluating the benefits derived from pollution control expenditures in Ohio. These efforts will generally follow a process similar to that previously used to set priorities for funding in the former construction grants and present State Revolving Loan Fund programs.

Economic Assessment

The Ohio EPA economic assessment for point sources is detailed in Volume I of this report. An analysis of incremental wastewater treatment expenditures for Publicly Owned Treatment Works (POTW) showed that more than $6 billion was spent between 1970 and 1992 to meet water quality-based effluent limitations at publicly owned treatment works. More than $0.8 billion was spent on point source pollution controls between December 1991 and January 1992. The total spending on pollution controls for all point sources is even higher when industrial and other treatment facilities are included. An effort to compare the environmental improvements derived from these expenditures has recently been initiated.

". . . an effort to compare the environmental improvements derived from these expenditures has been initiated."

Wetlands

The total acreage of wetlands remaining in Ohio has not been quantified because a comprehensive inventory of the state's wetland resources does not yet exist. The most complete survey is the National Wetlands Inventory initiated by the U.S. Fish and Wildlife Service (U.S. FWS) in the late 1950s. An inventory currently underway is scheduled for completion by the summer of 1995. This 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, Division of Wildlife, and the National Resource Conservation Service (NRCS). The wetland inventory is needed to implement the swampbuster provision of the 1985 Farm Bill. The inventory also will provide planning information beneficial to the management of both game and non-game species.

"The historic loss of Ohio's wetland resources is estimated to exceed 90%."

Ohio EPA has received 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 (including biological criteria) for wetlands, and the development of performance goals for wetland mitigation projects. The historic loss of Ohio's wetland resources is estimated to exceed 90%. While recent 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 a consensus among all affected parties on the policy direction toward wetlands, the State of Ohio convened the Ohio Wetlands Task Force and charged the group with developing a State wetlands strategy. The Strategy that emerged from this group proposed an interim goal of restoring 50,000 acres of wetlands *and* riparian ecosystems by the year 2000, and a goal of 400,000 acres restored or created by the year 2010. In order to more fully extend the protection of the Clean Water Act to wetlands, Ohio EPA is in the process of developing wetland water quality standards (WQS). The results of the Ohio Wetlands Task Force and progress in developing wetlands WQS are more fully summarized in Volume I.

High quality wetland habitat in Columbiana Co. While not all wetlands exhibit surface water, specialized types of vegetation and hydric soils are generally present.

". . . the ecological consequences of projects involving the degradation of lotic habitat can be predicted."

401 Water Quality Certifications

The 401 water quality certification program provides protection to wetlands and surface waters through regulating projects which require a federal dredge and fill permit (Sec. 404 of the CWA). The Section 401 water quality certification program is the only mechanism other than the NPDES permit program for applying the Ohio Water Quality Standards (Ohio WQS) to wetlands and other surface waters. The effectiveness of the Section 401 program in protecting wetlands is improving and should improve further as water quality criteria for wetlands are developed.

More success has been evident in applying 401 certifications to streams and rivers. This is attributable to the use of biological and habitat assessment tools in the review of selected 401 certification applications. These have included stream channelization projects, surface mining, hydromodification (dam construction), and damage assessments for unauthorized activities. The biological criteria are useful in this process since habitat is a predominant factor in determining the ability of a stream or river to attain the use designations prescribed by the Ohio WQS. Furthermore, by using the results of the work that supported the development of the Qualitative Habitat Evaluation Index (QHEI; Rankin 1989, 1995), the ecological consequences of projects involving the degradation of lotic habitat can be predicted. This allows Ohio EPA to prevent unnecessary degradation of aquatic resources where such authority exists.

The loss of wetland habitat is frequently at issue in Section 401 certifications.

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 threat to Ohio's indigenous aquatic fauna for more than 100 years. Non-native species such as carp and goldfish are well established in Ohio waters and are now an accepted part of the fauna. However, these two species have their highest populations in areas with moderate to high degradation of habitat and/or water quality (see Volume I of this report). Recently introduced exotic species have become the focus of concern in Lake Erie, however, their impacts are presently unknown. An increasing number of these species have been introduced as a result of shipping. This makes controlling and preventing future introductions difficult. Zebra mussels *(Dreissena polymorpha)*, which are native to southern and central Asia, are the best known of these introductions. It is believed that their entry into the Great Lakes occurred in 1986 via the discharge of ballast water from ocean going ships. By 1989, the zebra mussel had spread throughout Lake Erie. It has already had significant economic impacts by fouling water intake sys-

"The introduction of exotic (non-native) species in Ohio surface waters is a form of biological pollution . . . "

Round goby collected from Lake Erie by the Ohio EPA near the Grand River (Lake Co.), 1994.

". . . zebra mussels recently have been collected in the Ohio River and some larger tributaries . . ."

tems. The environmental effects of its high filtering capacity and rapid rate of colonization in Lake Erie remain unclear. Thus, it will be important to monitor the effects of the zebra mussel introduction, especially given the economic and recreational importance of Lake Erie to Ohio. More recently, zebra mussels have been collected in the Ohio River and some larger tributaries which may pose a threat to populations of native naiad mollusks in this drainage basin.

Zebra mussels attached to a (native) pimpleback mussel from the Ohio River downstream of the Little Miami River confluence (1994).

Although less well known than the zebra mussel, other more recently introduced exotic species are also of concern in Ohio. Two other recent invaders in the Great Lakes are the spiny water flea *(Bythotrephes cederstroemi)* and the river ruffe *(Gymnocephalus cernua)*. It is unclear if the spiny water flea has the potential to affect trophic relationships in Lake Erie or whether it will simply replace the zooplankton consumed as forage by fish. Other exotic invaders of the Great Lakes are the tube-nosed goby and round goby. In 1993 Ohio EPA collected round gobies in the nearshore of Lake Erie near the mouth of the Grand River. These are small, bottom-dwelling fish species that also arrived via ocean-going freighter ballast water discharges. Because of their bottom-dwelling habits, the gobies may compete with indigenous darter and sculpin species (such as the deepwater sculpin, *Myoxocephalus thompsoni*, designated a "special concern" species by Ohio DNR) present in Lake Erie. All of these exotic species have the same Eurasian origins as the zebra mussel.

"Ambient ground water monitoring has progressed significantly over the past two years . . . "

Ground Water Quality

Ambient ground water monitoring has progressed significantly over the past two years in Ohio. 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 semi-annually for organic and inorganic parameters. During 1992 and 1993, a total of 295 water samples were collected. A significant effort was made to improve and update the 1994 305(b) report on Ohio's ground water quality. This report reflects the progress that the 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 these skills are applied to analyzing and documenting the quality of Ohio's ground water.

Many Ohio communities depend wholly or in part on groundwater. Well-head protection measures ensure the quality of these public water supplies.

In the past two years, the ambient data has been entered into a database which will allow temporal and spatial analysis of the 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 Volume IV of this report. It should be noted that these are preliminary analyses and that a quality assurance review has yet to be completed. These data begin to illustrate trends in Ohio's ground water quality by aquifer type. In addition, the data have been linked to a geographic information system. The ability to present ambient or public water system data in a geographical information format (geology, aquifer type, *etc*.) is a major improvement in assessing ground water quality. This will foster advancements in defining background water quality and in identifying impacted ground waters through special studies.

"The ability to present ambient or public water system data in a geographical information format (geology, aquifer type,* etc.*) is a major improvement in assessing ground water quality."

Ohio's public water supply systems which rely on ground water sources have been monitored during the past two years in compliance with requirements mandated by the federal Safe Drinking Water Act and Ohio state legislation. In particular, testing of public water supply systems has continued for inorganic parameters, synthetic organic chemicals, volatile organic chemicals, nitrates, radionuclides, and asbestos. The water quality information requested for public water systems in the U.S. EPA Guidance for 305(b) reports is provided for community and non-transient, non-community systems. These data confirm the high quality of water provided by public water systems. To maintain this quality, a wellhead protection program has been implemented. Approximately 140 public water systems have initiated wellhead protection efforts to date.

A recent update of the ground water component of the Ohio Nonpoint Source Assessment was used to document sources of ground water contamination, specific contaminants, and their relative priority. As facility owners have been required to complete on-site pollution source monitoring by the federal Resource Conservation and Recovery Act (RCRA) and the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) legislation, the focus of Ohio EPA's pollution source monitoring has shifted toward nonpoint source pollution such as fertilizer usage and road salt application.

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GLOSSARY

Aquatic Life Use – A designation assigned to a waterbody based on the *potential* aquatic assemblage that can be sustained given the ecoregion potential; (*e.g.*, EWH, WWH, CWH, LRW, designated uses).

Aquatic Life Use Attainment – 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 the designated aquatic life use.

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.

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

Biomarkers – "Biological markers are measurements at the molecular, biochemical, or cellular level in either wild populations from contaminated habitats or in organisms experimentally exposed to pollutants that indicate that the organism has been exposed to toxic chemicals, and the magnitude of the organism's response to the contaminant (McCarthy and Shigart 1990)."

Channelization – A term applied to stream channel modifications designed to improve sub-surface drainage of agricultural fields and/or to prevent surface flooding. This includes channel straightening and widening and includes riparian vegetation removal. These activities almost always result in degraded biological quality via habitat loss and trophic (energy pathways) disruptions.

Chemical-Specific Approach – Traditional water quality approach of regulating point sources by using water quality criteria as surrogates for assessing biological goals. The criteria consist of safe concentrations of individual chemicals in the water which, if not exceeded instream, are presumed to protect aquatic life and maintain designated aquatic life uses.

Clean Water Act (CWA) – An act of the U.S. Congress, first passed in 1972 as the Federal Water Pollution Control Act, which provides the legal framework for reducing pollutants to America’s waters and protecting and restoring chemical, physical, and biological integrity. This report is required by a section (305[b]) of the CWA.

Combined Sewer Overflow (CSO) – Combined sewers are pipes within which both sanitary wastes and storm water run together. A combined sewer overflow is the location where the mixed storm water and sanitary wastes are discharged to a water body during rainfall events because the increased amount of flow cannot be carried by the sewer to the municipal wastewater treatment plant (WWTP).

Conventional Pollutants – Pollutants commonly discharged by municipal WWTPs as by-products of the treatment process and include parameters such as ammonia, nutrients (phosphorus and nitrates), dissolved oxygen, suspended solids, and chlorine. These are also constituents of urban and agricultural non-point source runoff.

Criteria – The chemical, physical, or biological conditions demonstrated or presumed to support or protect a designated use (*e.g.,* WWH, MWH, *etc*.).

Degradation – A lowering of the existing water, habitat, or biological quality of surface or ground waters.

Designated Use – The general purpose(s) or benefit(s) to be derived from a waterbody, *e.g.*, drinking water, aquatic life, swimming, fishing, *etc*.

Ecoregion – Regions of geographic homogeneity based on an overlay of maps of land–surface form, soils, land use, and potential natural vegetation. Such regions are likely to contain similar watershed characteristics and, hence, similar water quality, habitat, and aquatic communities.

Ecoregional Biocriteria – Biological index values which represent the base level of what minimally impacted communities should achieve in a particular ecoregion and waters of a given designated use and respective of stream size.

Effluent – The wastewater discharge of a WWTP or industry. This term is most commonly associated with point sources.

Electrofishing – A method of collecting fish using an electrical field designed to non-lethally stun and immobilize fish for capture and observation. Electrical power is provided by a gas–powered generator or battery. Captured fish are released after processing which includes species identification, counting, weighing, and an examination for external anomalies. These results are used to calculate the Index of Biotic Integrity (IBI) and the modified Index of Well–Being (MIwb), two of the indices which comprise the Ohio biocriteria.

Eutrophic – A highly "productive" body of water that has elevated concentrations of organic matter, nutrients, and algae. The trophic state index (TSI) is used to determine the degree of eutrophication.

Evaluated Level Data – Data which originated from sources *OTHER* than intensive surveys of biological or chemical conditions and which follow Ohio EPA protocols. These sources may include predictive modeling, the Ohio nonpoint source survey, citizen complaints, and chemical data less than5 yrs old.

Exceptional Warmwater Habitat (EWH) – The aquatic life use designed to protect aquatic communities of exceptional diversity and biotic integrity. Such communities typically have a high species richness, often include strong populations of rare, endangered, threatened, and declining 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. These limits were determined by the U. S. Food and Drug Administration (FDA).

Fecal Coliform – A bacteria group which is present in the intestines of warm–blooded animals and is evidence of the presence of human or animal wastes. Fecal coliform bacteria criteria are the principal means of assessing attainment of the recreational use designations in the Ohio WQS.

Fish Consumption Advisory – An official notification of the public about specific areas where fish tissue samples have been found to be contaminated by toxic chemicals which exceed FDA action limits or other accepted guidelines. 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, with the latter agency having the authority to issue such advisories.

Hester–Dendy Multiple Plate Sampler (also known as an artificial substrate) – A device for sampling macroinvertebrates which consists of a set of square hardboard plates (approximating an aggregate surface area of one square foot) separated by spacers of increasing width. Aquatic macroinvertebrates colonize or reproduce on this device which is placed in the water body for a six week colonization period during the summer months. Counts of individuals and taxa are used in the calculation of the Invertebrate Community Index (ICI) which is part of the Ohio biocriteria. (see Invertebrate Community Index).

Impacted – The situation where there is a suspected impairment based on the presence of sources (*e.g.,* nonpoint source survey). In such cases there is anecdotal evidence that some changes or disturbance may have occurred, but corroborating instream data to establish the status of a designated use is lacking.

Impaired – The situation where monitored level data 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 which utilizes fish community data and aggregates results across 12 ecological metrics that can be classified into four categories: species richness, species composition, trophic composition, and fish density and condition. Developed by Karr (1981), further explained in Karr *et al.* (1986), and modified for application to Ohio by Ohio EPA. This comprises part of the Ohio biocriteria.

Index of Well–Being (Iwb) – A composite index of diversity and abundance measures (density and biomass) based on fish community data. The Iwb was originally developed by Gammon (1976), further explained by Gammon *et al.* (1981), and modified for application in Ohio by Ohio EPA. This comprises part of the Ohio biocriteria.

Invertebrate Community Index (ICI) – An index of biological condition based on ten metrics which measure various structural and tolerance components of macroinvertebrate communities. This index was developed by Ohio EPA (DeShon 1995). This comprises part of the Ohio biocriteria.

In–Place Pollutants – Chemical pollutants deposited in the sediments of a waterbody (*i.e., they* are "in–place").

Limited Resource Water (LRW) – An aquatic life use assigned to streams with a very limited aquatic life potential, usually restricted to highly acidic mine drainage streams or highly modified small streams (<3 sq. mi. drainage area) in urban or agricultural areas with little or no water during the summer months.

Major Cause or Source – The primary cause or source of partial or non-attainment of a given designated use.

Metals – A specific class of chemical elements that have unique characteristics (such as conductance). Some of the metals commonly found in water or sediment as pollutants in Ohio include lead, copper, cadmium, arsenic, zinc, iron, mercury, and nickel.

Moderate Cause or Source – A secondary or contributing (but not primary) cause or source of partial or non-attainment of a given 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, but which harbor the semblance of an aquatic community. Such waters are characterized by species that are tolerant of poor chemical quality (low and fluctuating dissolved oxygen) and degraded habitat conditions (siltation, habitat simplification) that are characteristic of modified streams.

Monitored Level Data – Chemical or biological data used in this report that originated from sources such as intensive surveys of biological or chemical conditions and which follow Ohio EPA protocols. Chemical data less than 5 years old also qualifies.

Named Stream – Streams large enough to be named on USGS 71/2 minute topographic maps and/or listed in the Gazetteer of Ohio streams. There are approximately 25,000 miles of named streams in Ohio out of 61,000 miles of streams listed by the U.S. EPA RF3 database.

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

Non–conventional Pollutant – Toxic pollutants *other* than the common nitrogen compounds (ammonia, nitrates), phosphorus, 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 precipitation runoff and ground water infiltration.

Point Source of Pollution – Any source of pollution that emanates 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, e.g., kg/day.

Priority Monitoring Needs– Streams where any of following information is needed for management decisions:

1) areas previously sampled 8-12 years ago and where new pollution controls have been implemented;
2) areas that have never been sampled or that lack adequate coverage;
3) priority nonpoint source projects where Section 319 and related projects are planned or underway;
4) potential use designation issues, particularly EWH and MWH potential;
5) existing SRW designated segments that will require an evaluation for the anticipated Superior High Quality Waters (SHQW) classification under the revised anti-degradation rule;
6) complex urban/industrial centers;
7) rapidly developing suburban areas;
8) discharges with recurring chronic or acute toxicity;
9) discharges with a history of non-compliance, spills, and unauthorized releases;
10) potential coordination with DERR sites.

Priority Pollutant – One of the 126 toxic compounds (a subset of 65 classes of toxic compounds) listed by U.S. EPA under Section 307[a] of the CWA.

QHEI (Qualitative Habitat Evaluation Index) – A qualitative habitat index designed as a screening tool to assist 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 relatively unimpacted site which is used to define the expected or potential biological community or water quality within a region such as a ecoregion; in Ohio reference sites were used to calibrate the ICI and IBI and to establish background water quality levels.

Stream Mile (also River Mile) – A method used by Ohio EPA to identify locations along a stream or river. Mileage is defined as the lineal distance from the downstream terminus (*i.e.*, mouth) and moving in an upstream direction.

Storm Sewer – A sewer system designed to collect and remove precipitation runoff from land areas and discharge to nearby water bodies.

Threatened – The state in which a water body is currently meeting the designated use, but because of trends in land use (see urban encroachment) or other information are threatened with a future decline in quality and which may become degraded in the future without precautionary measures or changes in current practices.

Toxic Substances – Any substance which can cause death, 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 36,000 miles of unnamed streams in Ohio.

Urban Encroachment – Increased development in a watershed, especially where the quality of the floodplain, riparian zone, and runoff characteristics of a watershed is adversely affected to the point where designated uses are threatened or not attained.

Use Designation – See "Designated Use".

Wasteload Allocation – The portion of the capacity of a water body to assimilate pollutants without exceeding a water quality criterion which is allotted to existing (or future) discharges (*e.g.*, WWTPs), *i.e.*, the loading (kg/day) of a pollutant allowed to be discharged by a source without violating water quality standards.

Waterbody Segment – A lake, wetland, or length of stream or river, based on an Ohio EPA mapping system and which is defined for analysis of water quality trends for this report. Each water body stream or river segment is approximately 10 miles in length. More than 3800 water body stream and river segments have been delineated. Individual lakes and reservoirs are separate waterbodies.

Water Quality Based Effluent Limits – Parameter specific limitations calculated for individual point source discharges based on water quality considerations (criteria) as opposed to a technological approach in which a specific type of treatment technology is mandated by the CWA or U.S. EPA guidelines.

Water Quality Standards – The administrative rules which set forth use designations and criteria protective of such uses. These apply to all surface waters of the State.

Whole Effluent Toxicity – The collective toxicity of an effluent to bioassay test organisms expressed as the LC_{50} and irrespective of individual chemical concentrations. The procedure includes exposing test organisms, in a laboratory setting, to varying dilutions (*i.e.*, strengths) of effluent. For complex effluents containing numerous compounds, whole effluent toxicity testing is a more realistic predictor of the true effects on the resident biota than parameter by parameter chemical characterizations.

305(b) – The section of the Clean Water Act requiring States to submit a biennial report to U.S. EPA and Congress for the purpose of reporting on the progress of Clean Water Act programs.