Measurable Parameters of Ecosystem Health: Introduction and Concepts

Clean Water Act Goal: Restoration of Degraded Waters

- Chemical, physical, and biological integrity
- Fishable/swimmable - **designated uses**
- "Where attainable"- **use attainability analysis**

Detecting Environmental Problems With Ambient Bioassessment Tools

We cannot address problems about which we are not aware.

- Traditional "administrative" approaches do not capture all significant impairments.
- Environmental monitoring needs to be comprehensive enough to detect problems.
- Choice of ambient indicators strongly influences overall effectiveness.
- Ambient background influences need to be understood and accounted for up front.

Environmental Indicator

". . a measurable feature which singly or in combination provides managerially and scientifically useful evidence of ecosystem quality, or reliable evidence of trends in quality."

ITFM Indicators

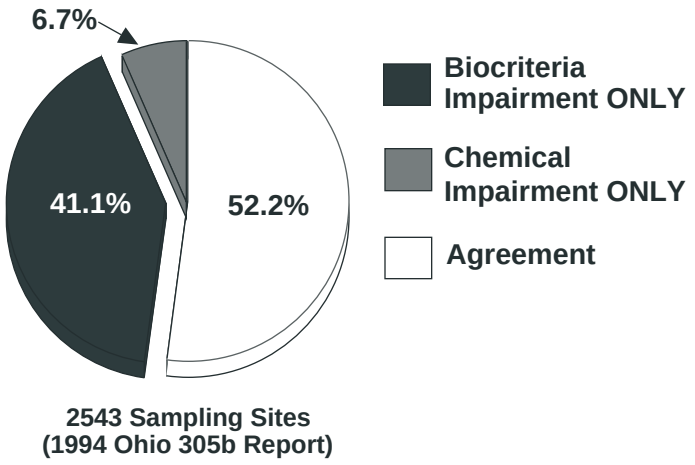
Major Classes and Types of Environmental Indicators: Problem Statement

1. Stressor Indicators (e.g., loadings, land use, habitat)
2. Exposure Indicators (e.g., chemical-specific, biomarkers, toxicity)
3. Response Indicators (e.g., biological community condition)

The problem nationally has been with the inappropriate use of stressor and exposure indicators as response indicators.

Chemical vs. Biological Indicators of Aquatic Life Impairment:

Relative performance of chemical water quality criteria compared with biological criteria in detecting aquatic life impairments:



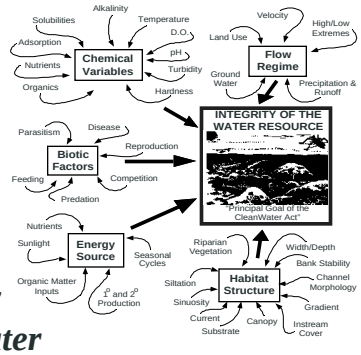
Measurable Parameters of Watershed Health: Introduction & Concepts

An Integrated Approach to Water Quality Management

Water Quality Based
- Parameter specific criteria
- Surrogate assessment
- Pollutant focused
- Partial coverage
- Bottom up approach
- Individual effects
- Stress/exposure indicator
- Design criteria

Bioassessment Based
- Biological criteria
- Direct assessment
- Resource focused
- Complete coverage
- Top down approach
- Cumulative effects
- Response indicator
- Impact assessment criteria

Integrated and complimentary use of bioassessment, chemical/physical assessment, and attendant tools, each within their most appropriate roles, is needed to successfully restore and protect water resources.



Making Ambient Indicators Relevant to Water Quality Management

- Indicators must measure or extend to the key elements of the 5 factors that influence water resource integrity.
- Indicators fundamentals - stressor, exposure, response - each used within the most appropritate role.
- National inconsistency results from using indicators outside of their most appropriate role.
- Using the indicators hierarchy framework will lead to a well-rounded WQ management program.
- Integration of programmatic needs (*e.g.*, tiered uses) with logistical and structural needs must occur.

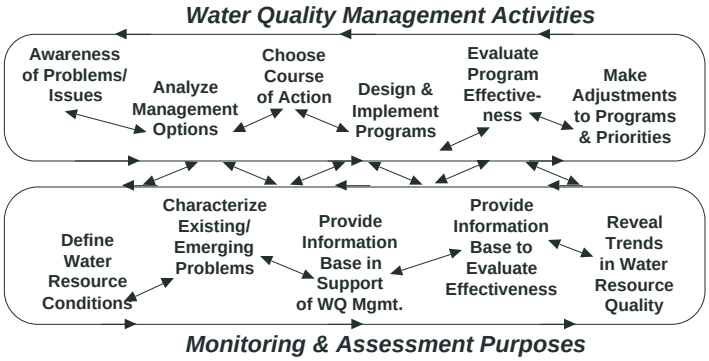
Measurable Parameters of Watershed Health: Introduction & Concepts

Monitoring & Assessment Should Be a Determinant in How WQ is Managed

- Problem identification and characterization.
- Policy/program and legislation development.
- Criteria development and application.
- Demonstrate WQ management program effectiveness, *i.e.*, manage for environmental results.

Develop monitoring & assessment as an overall function of WQ management, not on a piecemeal basis.

The Relationship Between WQ Management and the Purposes of Monitoring & Assessment



Source: ITFM (1995)

Important Considerations for Using Monitoring and Assessment to Support WQ Management

- Indicators and methods
- Data quality & management
- Assessment techniques
- Variability
- Regional stratfication
- Levels of protection & restoration
- Design considerations
- Reporting
- Role in management & policy

Measurable Parameters of Watershed Health: Introduction & Concepts

Important Concepts and Elements of an Adequate State Watershed Monitoring and Assessment Program

August 16, 1998

BETTER BETTER

"Monitoring to Support WQ Management"

Steps Towards an Adequate State Watershed Monitoring & Assessment Program

- Use environmental indicators that are relevant to WQ management goals and WQS.
- Assess at all relevant scales and for all aquatic resource types.
- Link compliance and ambient monitoring & assessment (re: Hierarchy of Indicators).
- Produce data & assessments of sufficient quality and power.
- Responsive data & information management and reporting.
- Promotion of incentives and elimination of disincentives.

Incentives/Disincentives

Incentives - better M&A in exchange for:

- Policy & program flexibility.
- Improved WQS - stratified & refined use designations.
- More accurate national statistics.
- Stratified approaches to TMDLs.
- Rewards via EnPPA process.

Disincentives - deterrents to better M&A:

- Listings - too many waters, problems (303d).
- Makes things look worse - impact on 305b stats.
- Legislation, mandates, distractions.
- IA policy.

Five-Year Basin Monitoring

Where

- Historical emphasis on inland rivers & streams
- Extended to Lake Erie nearshore
- Developmental work in the Ohio R. mainstem

What

- Watershed scale, synoptic design
- Fish, macroinvertebrates, physical habitat
- Sediments, water quality, fish contaminants
- Biomarkers at selected sites

Why

- Support all water quality management programs
- Integrate traditional water quality management tools with real world measures
- Determine status of Ohio's aquatic resources in relation to agency mission and objectives

CORE INDICATORS

• Fish Assemblage • Macroinvertebrates • Periphyton

(Use Community Level Data From At Least Two)

Physical Habitat Indicators

- Channel morphology
- Flow
- Substrate Quality
- Riparian

Chemical Quality Indicators

- pH
- Temperature
- Conductivity
- Dissolved O_2

For Specific Designated Uses Add the Following:

AQUATIC LIFE

Base List:

- Ionic strength
- Nutrients, sediment

Supplemental List:

- Metals (water/sediment)
- Organics (water/sediment)

RECREATIONAL

Base List:

- Fecal bacteria
- Ionic strength

Supplemental List:

- Other pathogens
- Organics (water/sediment)

WATER SUPPLY

Base List:

- Fecal bacteria
- Ionic strength
- Nutrients, sediment

Supplemental List:

- Metals (water/sediment)
- Organics (water/sediment)
- Other pathogens

HUMAN/WILDLIFE CONSUMPTION

Base List:

- Metals (in tissues)
- Organics (in tissues)

Why Use Fish & Invertebrates?

- Inhabit the receiving waters continuously.
- Integrate past events, both long and short-term.
- Reasonable response and recovery rates.
- Many species have long life-spans (>3-10 yrs.).
- Not directly dependent on dilution dynamics.
- Portray program results in direct terms.
- Minimal use of adjustment or uncertainty factors.

Fish Assemblage Assessment: Ohio EPA Approach

- Standardized & Representative Sampling - stratified pulsed D.C. electrofishing methods, mid-June to mid-October.
- Relative Abundance - numbers and weight (biomass) per unit distance (effort).
- Data Quality Objectives - genus/species based on regional ichthyology keys and AFS nomenclature.
- Key Component of Biocriteria - IBI, MIwb, and component metrics.
- Basin/Sub-basin Sampling Design - longitudinal and watershed scale interpretation of results.
- Watershed Scale Considerations - headwaters, wading, and boat sites; metric calibration accomplished for each strata.
- Experienced Biologists - regional fauna, natural history, response signatures, impact types.

Macroinvertebrate Assemblage Assessment: Ohio EPA Approach

- Standardized & Representative Sampling - artificial substrates & qualitative dip-net/handpick methods, mid-June to late-September.
- Taxa Richness & Relative Abundance - counts and numbers per unit area (sq. ft.).
- Data Quality Objectives - lowest taxonomic level practicable for common orders/families (genus or species), standard keys.
- Key Component of Biocriteria - ICI and component metrics
- Basin/Sub-basin Sampling Design - longitudinal and watershed scale interpretation of results.
- Watershed Scale Considerations - ICI metrics are calibrated against stream and river size.
- Experienced Biologists - detailed familiarity with regional fauna, natural history, response signatures, impact types.

Fundamental Objectives of Adequate Monitoring and Assessment Approaches

Function: Surface Water Assessment

- Collect and analyze baseline information.
- Establish cause/effect (causal associations).
- Compare results to criteria and goals (use attainment).
- Publish results - statewide, regional, site-specific.

Function: WQ Management/Pollution Abatement

- Attainability analyses and criteria development (maintain WQS).
- Formulate and revise abatement strategies (TMDL development).
- Assess effectiveness of programs (WQ Management).

Function: Compliance Evaluation

- Monitor to determine compliance.
- Monitor to support enforcement.

after 40CFR Part 35 (deleted in 1990?)

Essential Principles of Adequate Monitoring and Assessment Approaches

- **Data Quality Objectives**: need to produce data and information at a sufficient level of resolution so as to assure accuracy and precision.
- **Watershed Scale Assessment**: essential to encompass the full gradient of response and exposure to multiple stressors and influences.
- **Comprehensive Assessments**: integrated and careful analysis of multiple indicators adhering to a disciplined approach (Hierarchy of Indicators).
- **Learn by Doing**: gain new knowledge and insights by iterative assessment and observing responses to management actions (what works?).

State of Ohio
Environmental Protection Agency

BIOCRITERIA TRAINING/ CERTIFICATION

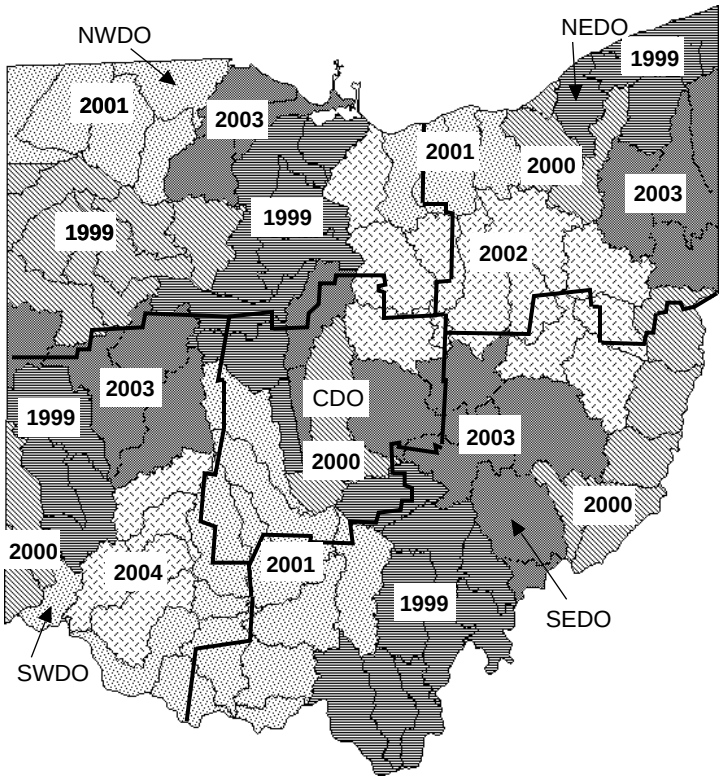
August 28 -
September 1,
2000

Measurable Parameters of Ecosystem Health: Five-Year Basin Monitoring and Assessment

Measurable Parameters of Watershed Health: 5-Year Basin Approach

Ohio EPA 5-Year Basin Approach for Monitoring & Assessment

- Rotating basin approach for determining annual monitoring activities.
- Correlated with NPDES permit schedule.
- Supports annual WQS use designation rule-making.
- Aligned with 15 year TMDL schedule.



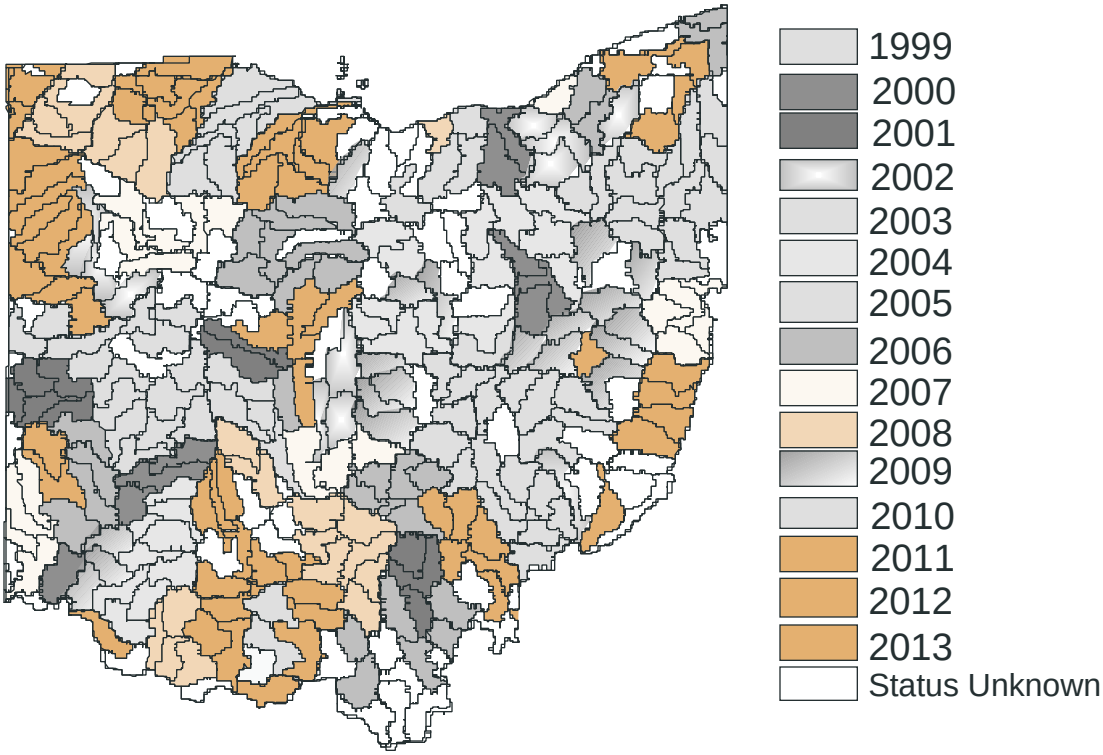
Five-Year Basin Project Selection Criteria & Priorities

- Previously sampled areas with new controls.
- Watersheds targeted for TMDL development.**
- Areas that have remaining "high profile" problems.
- Inadequately or unassessed areas.
- Priority NPS project or problem areas.
- Use designation issues (priority for non-WWH uses).
- Segments requiring re-evaluation under antidegradation rule.
- Complex urban/industrial areas.
- Rapidly developing or changing watersheds.
- Areas with chronic spills, kills, exceedences.
- Coordination with remedial activities.

** - new in 1998.

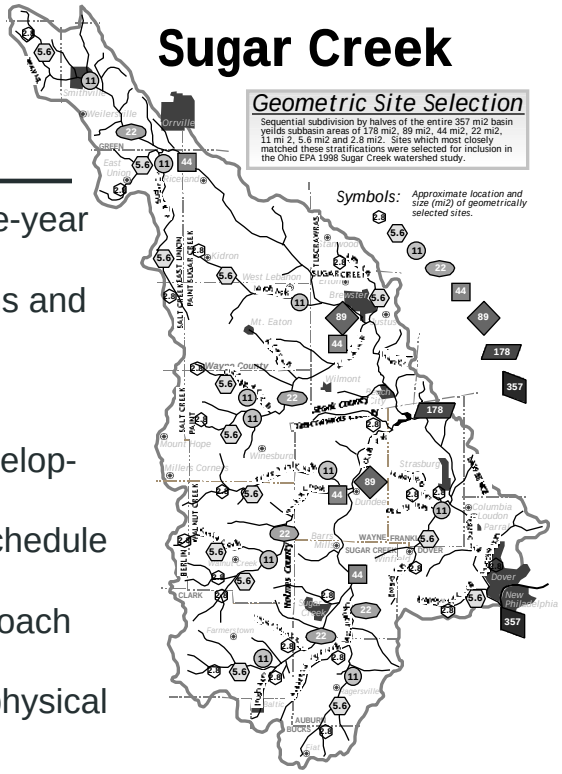
Measurable Parameters of Watershed Health: 5-Year Basin Approach

TMDL DEVELOPMENT SCHEDULE: 1999 - 2013

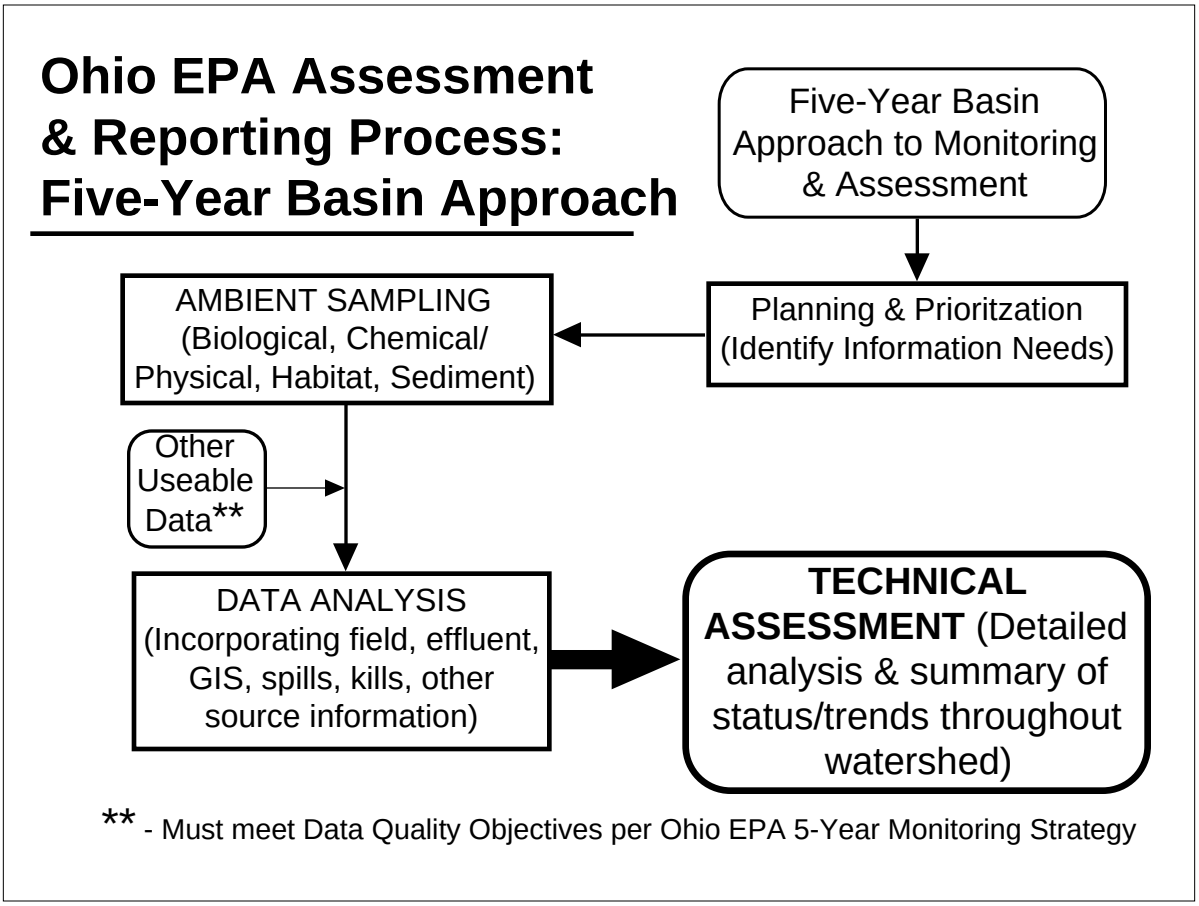


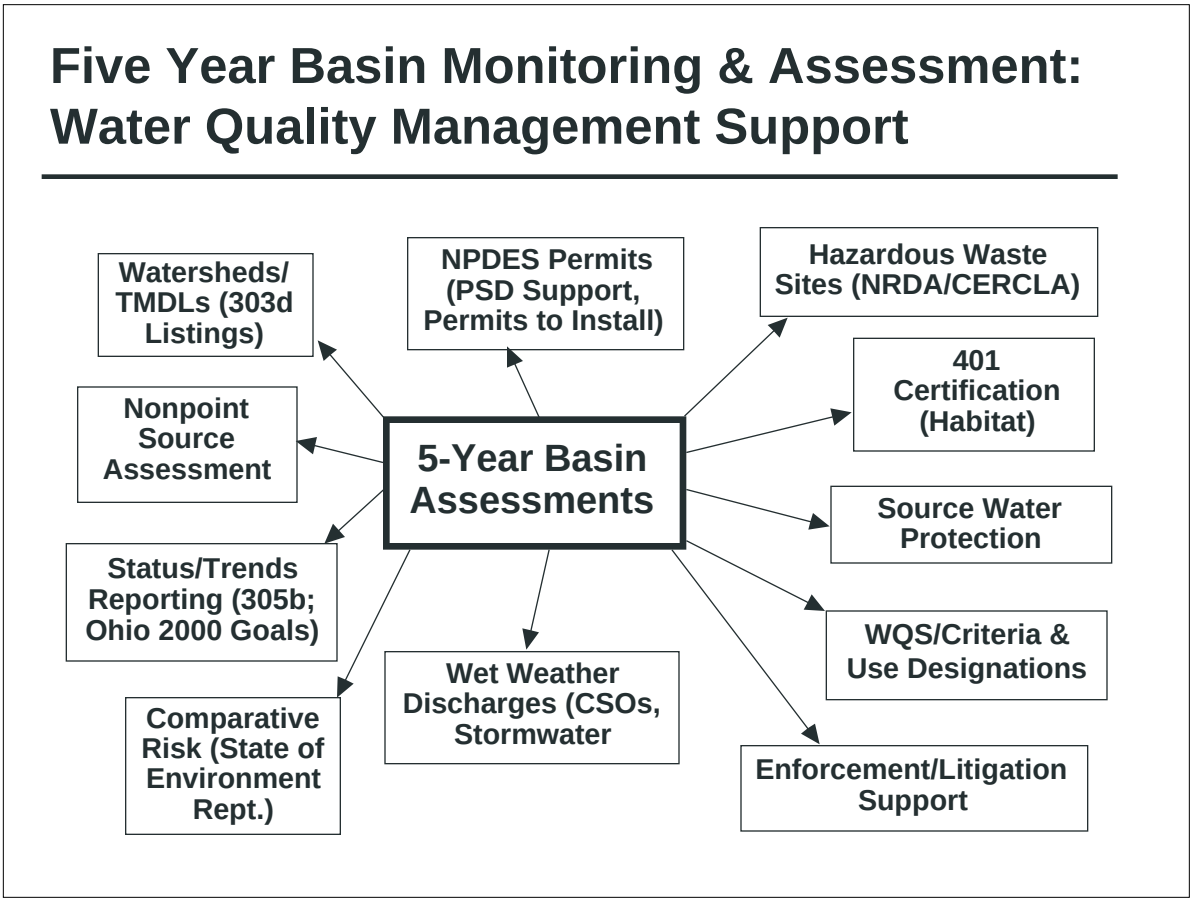
Sugar Creek Subbasin: Example of Geometric Site Selection Process

- Used in TMDL development and five-year basin watersheds
- Increased miles of assessed streams and rivers annually
- Resolve undesignated streams
- Close 305b/303d listing gaps
- Generate broader database for development of improved tools and criteria
- Part of 15 yr. TMDL development schedule beginning in 1998
- Augmented by five -year basin approach process (1980-1997)
- Standardized biological, chemical, physical tools and indicators



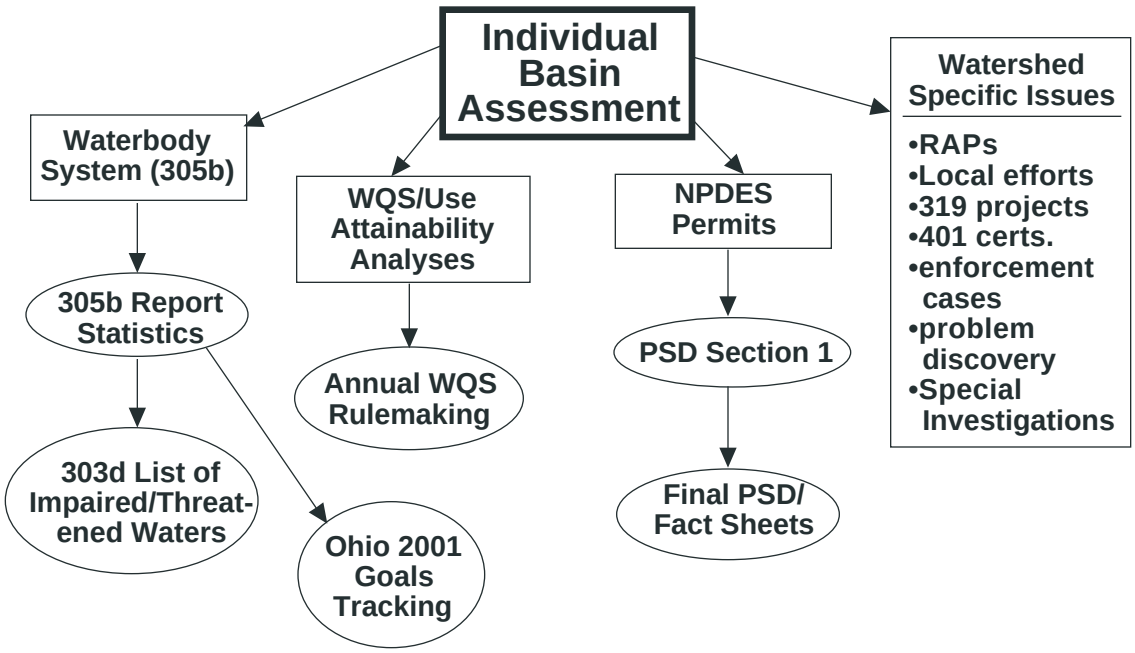
Measurable Parameters of Watershed Health: 5-Year Basin Approach



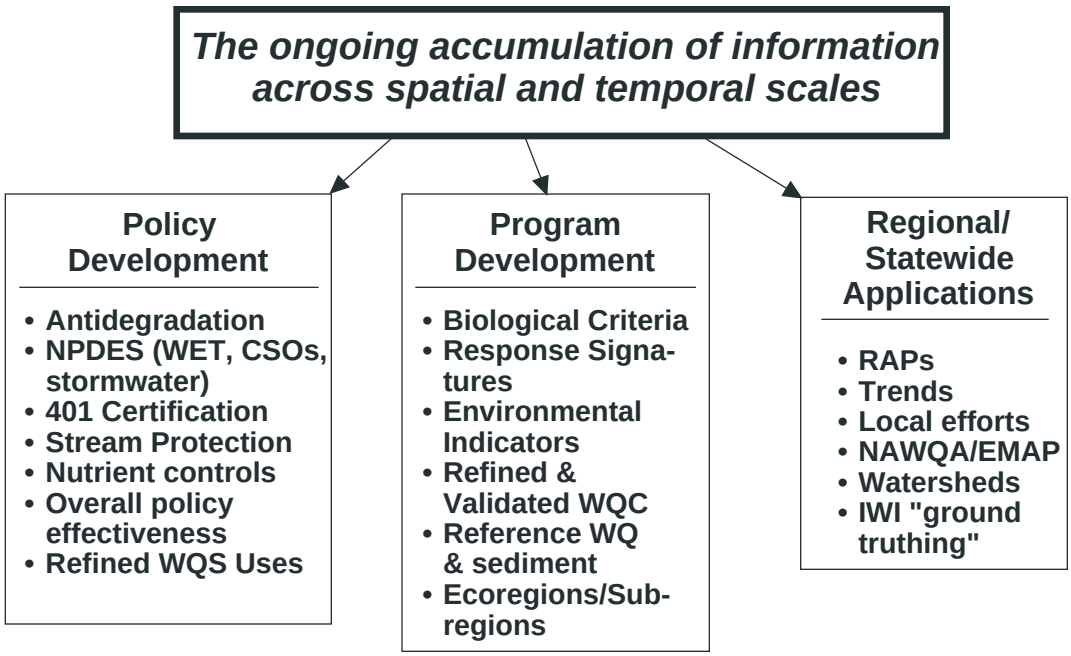


Measurable Parameters of Watershed Health: 5-Year Basin Approach

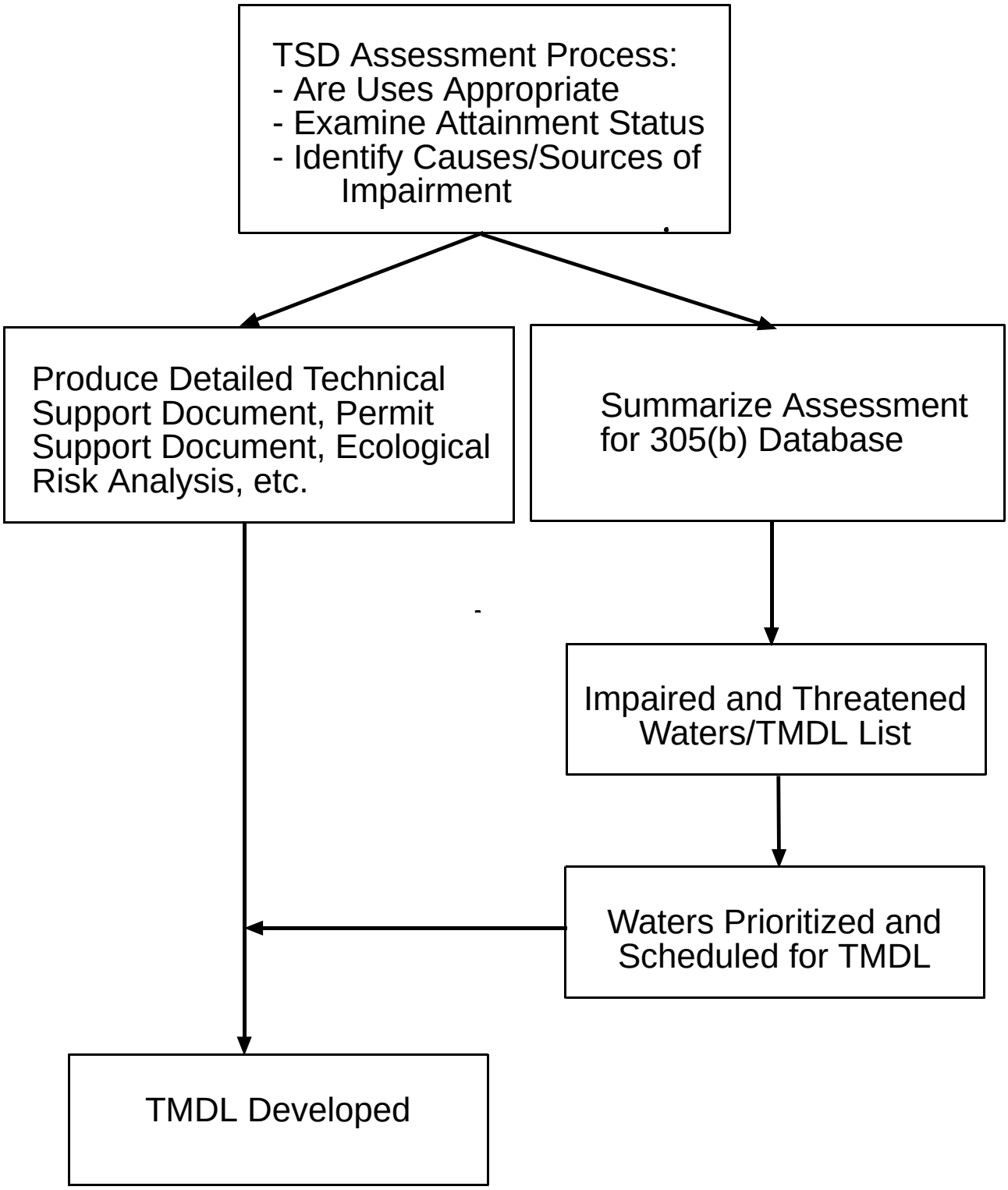
Functional Support Provided by Individual Basin Assessments



Strategic Support Provided Collectively by Basin Assessments



Ohio EPA 305(b)/303(d) Link



The Role of Biocriteria & Biosurveys in NPDES Permits

Use Designations:
- Use designation determines which chemical critetia apply

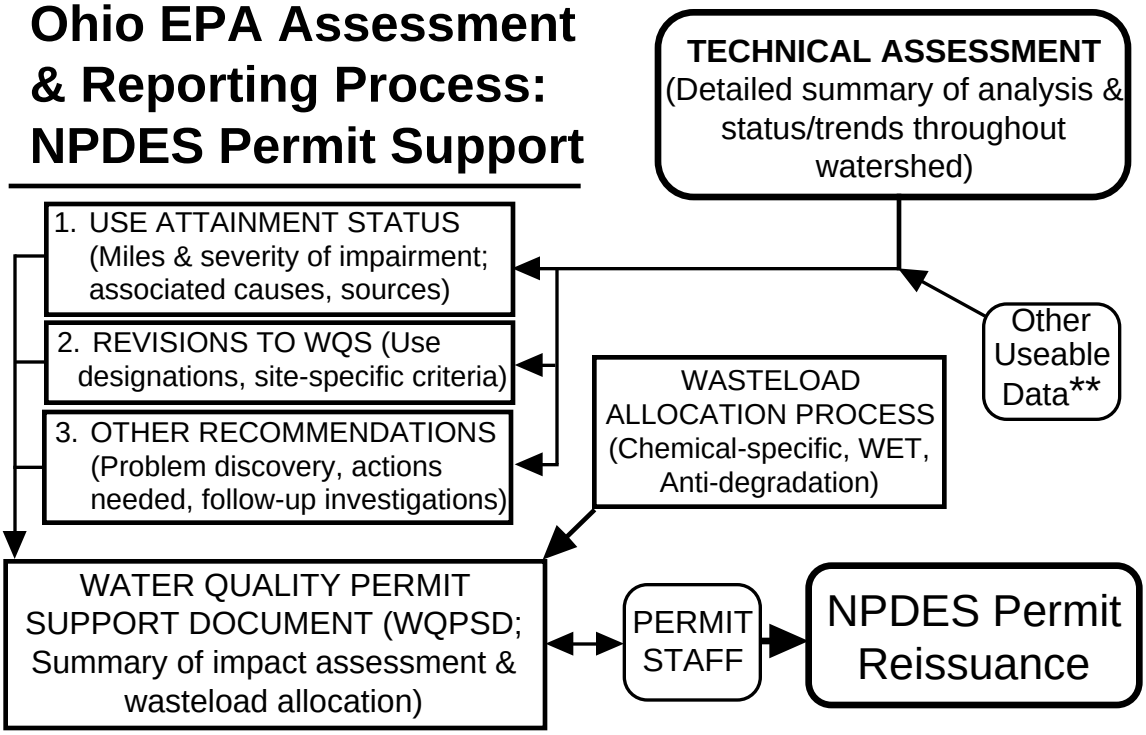
Mixing Zones/WET Requirements:
- Near and far-field impacts help determine WET category

Characterization of Impact:
- Descibes extent and severity of impacts
- Biological response signatures

Compliance Success/Failure:
- Determine adequacy & success of abatement efforts

Enforcement Support:
- Basic information about extent of environmental damage

Ohio EPA Assessment & Reporting Process: NPDES Permit Support



** - Must meet Data Quality Objectives per Ohio EPA 5-Year Monitoring Strategy

Measurable Parameters of Ecosystem Health: Water Quality Standards/Designated Uses

Water Quality Standards: The Basis for Water Quality Management

- **Basis for implementing controls under CWA**
- **Consist of uses and criteria**
- **Focus of water quality planning/implementation**
- **Benchmarks for evaluating effectiveness of controls, funding, permits, BMPS, etc.**

States are the principal custodians of WQS and associated use designations and criteria

Ohio WQS: Use Designations

Aquatic Life Use Designations

- Tiered system of use classifications.
- Principal uses: EWH, WWH, CWH, SSH, MWH, LRW.
- Chemical criteria: pollutant specific.
- Whole toxicity criteria: lab bioassay end-points.
- Biological criteria: indigenous community based.

Non-aquatic Life Use Designations

- Recreation uses: primarily bacteriological criteria.
- Consumption based uses: water supply uses.

Measurable Parameters of Watershed Health: Water Quality Standards

Aquatic Life Use

Definition:

A designation (classification) assigned to a waterbody based on the potential aquatic community that can realistically be sustained given the ecoregion potential and the level of protection afforded by the applicable criteria.

(1990 305b Report, Volume I)

Aquatic Life Designated Uses

Ohio Water Quality Standards

- Uses defined as narratives;
- Chemical and biological criteria are assigned to each use in accordance with the attributes ascribed by the narrative definition.

Uses Are Based on Demonstrated Potential

- Attainment of biological criteria; or,
- Physical habitat assessment demonstrates potential to support use;
- Attainment of uses are tracked in 305b report.

Aquatic Life Use Designations: Ohio WQS

Based on Biological Community Attributes

√ **Exceptional Warmwater Habitat (EWH)**: preserve & maintain exisitng high quality.

√ **Warmwater Habitat (WWH):** basic restoration goal for most streams.

√ **Modified Warmwater Habitat (MWH):** attainable condition for streams under drainage maintenance or other essentially permanent hydromodifications (*e.g.*, impoundments).

√ **Limited Resource Waters (LRW):** essentially irretrievable, human induced (*e.g.*, widespread watershed modififcations) or naturally occurring conditions (*e.g.*, ephemeral flow).

Warmwater Habitat (WWH)

Characterized by aquatic communities with a diversity and functional organization comparable to the typical habitats of the region; such habitats represent the "least disturbed" conditions typical of an ecoregion.

Exceptional Warmwater Habitat (EWH)

Characterized by aquatic communities of exceptional diversity and biotic integrity; such communities usually have high species richness, often support significant populations of rare, threatened, endangered, or declining species and/or support exceptional sport fisheries.

Modified Warmwater Habitat (MWH)

Aquatic life use assigned to streams subjected to essentially irretrievable, extensive, anthropogenic modifications that preclude attainment of the Warmwater Habitat (WWH) use; such streams are characterized by species that are tolerant of poor chemical quality (e.g. low D.O.) and habitat conditions (silt, habitat simplification).

Limited Resource Waters (LRW)

An aquatic life use assigned to streams with a very limited aquatic life potential due to irretrievable, human-induced conditions; usually restricted to very small streams (<3 sq. mi. drainage area) with severe habitat restrictions and/or no or limited water during the summer, or severe acid mine drainage affected streams (pH < 4 S.U.).

Measurable Parameters of Ecosystem Health: Biological Criteria Concepts & Derivation

The Utility of Bioassessments and Biological Criteria

The ability of a water body to sustain a balanced, integrated, adaptive assemblage of aquatic organisms is one of the best overall indications of the suitability of that water body for many other beneficial uses.

(after Karr 1991)

Minimum Criteria That Biological Assessment and Criteria Programs Should Meet

1. The measures must be biological.
2. The measures must be interpretable at or extend to several trophic levels.
3. The measures must be sufficiently sensitive to the environmental conditions being assessed.
4. The response range (sensitivity) must be suitable for the intended purpose.
5. The measures must be reproducible and sufficiently precise.
6. The variability of the measures must be low.

After Herricks and Shaeffer (1985)

Biological Criteria: I

- Narrative ratings or numerical values which are based on the numbers and kinds of aquatic organisms (i.e., assemblage) which are found to inhabit a particular stream or river sampling location.

Biological Criteria: II

- Biological criteria are indexed to the reference assemblage of aquatic organisms within a particular geographical region (i.e., ecoregion) and with respect to stream and river size.

Biological Criteria: III

- Biological criteria represent a calibrated assessment tool which fosters an organized goal setting process in an effort to reconcile human impacts and guide restoration efforts.

Biological Integrity: Operational Definition

"The ability of an aquatic community to support and maintain a structural and functional performance comparable to the natural habitats of a region."

(Core of each aquatic life designation definition in the Ohio WQS)

paraphrased from Karr and Dudley (1981)

Biological Integrity: Putting Theory Into Practice

Essential Elements of the Regional Reference Site Approach

- **Biological Performance** - need ways to measure (e.g. IBI, ICI, MIwb, BI, etc.).
- **Natural Habitats** - come to grips with the attainability issue (e.g. "least impacted" reference sites).
- **Region** - need to stratify and account for natural variability (e.g. ecoregions and tiered uses).
- Reference site "re-sampling" to account for broad scale, long-term changes in attainable conditions.

Index of Biotic Integrity (Karr 1981)

12 Metrics

- Species richness
- #Darter species
- #Sunfish species
- #Sucker species
- %Intolerant species
- %Green sunfish
- %Omnivores
- %Insectivores
- %Top Carnivores
- %Hybrids
- %Diseased individuals
- Number of Fish

Community Composition

Environmental Tolerance

Community Function

Community Condition

- 5,3,1 metric scoring categories.
- 12 to 60 scoring range.
- Calibrated on a regional basis.
- Scoring adjustments needed for very low numbers.

INDEX OF BIOTIC INTEGRITY (IBI) MODIFIED FOR USE IN OHIO STREAMS AND RIVERS

OHIO EPA MODIFIED IBI METRICs	HEADWATER SITE TYPE (<20 SQ. MI.)	WADEABLE SITE TYPE (20-300 MI.^{2})	BOATABLE SITE TYPE (200-6000 MI.^{2})
1. Total Native Species	X	X	X
2. #Darter Species		X	
#Darters + Sculpins	X*		
%Round-bodied Suckers			X*
3. #Sunfish Species		X	X
#Headwater Species	X*		
%Pioneering Species	X*		
4. #Sucker Species		X	X
#Minnow Species	X*		
5. #Intolerant Species		X	X
#Sensitive Species	X*		
6. %Tolerant Species	X	X	X
7. %Omnivores	X	X	X
8. %Insectivores	X	X	X
9. %Top Carnivores		X	X
10. %Simple Lithophils	X*	X*	X*
11. %DELT Anomalies	X	X	X
12. Number of Individuals	X	X	X

*- Substitute for original IBI metric described by Karr (1981) and Fausch et al. (1984)

Invertebrate Community Index (Ohio EPA 1987; DeShon 1995)

- Taxa Richness
- #Mayfly taxa
- #Caddisfly taxa
- #Dipteran taxa
- %Mayflies
- %Caddisflies
- %Tanytarsini Midges
- %Other Diptera/Non-Insects
- %Tolerant taxa
- Qualitative EPT taxa

- 6,4,2,0 metric scoring categories.
- 0 to 60 scoring range.
- Calibrated on regional basis.
- Scoring adjustments needed for very low numbers of specific taxa.

Modified Index of Well-Being (MIwb): Computational Formula

Modified Index of Well-Being (MIwb)

$$\mathbf{MIwb = 0.5Ln\ N + 0.5Ln\ B + \overline{H}\ (no.) + \overline{H}\ (wt.)}$$

where:

N = relative numbers of all species except Hybrids, exotics, and those designated as highly tolerant.

B = relative weight (kg) of all species except Hybrids, exotics, and those designated as highly tolerant.

$\overline{H}$ = Shannon diversity index based on numbers[1]

$\overline{H}$ = Shannon diversity index based on numbers[1]

[1] based on $\log_e$ version; all species including tolerants and exotics are included in the calculation of $\overline{H}$.

The Regional Reference Site Approach: The Role of Stratification

Recognizing the relative importance of landscape, geographic, physical, and socioeconomic factors in deriving regionally relevant benchmarks or criteria

Inter-Regional Factors:

- Ecoregions - overall synthesis of taxonomy, biogeography, diversity, ecological function, and attainability.
- Water Quality Standards - define goals and criteria.

Intra-Regional Factors:

- Site-Specific Stratification - stream size (drainage area, width), gradient, temperature, elevation, latitude etc.

Reference and Control Sites

Regional Reference Sites

- A collection of sites within a homogenous regional area which represent the best attainable condition (unimpaired) for all waters with similar physical dimensions for that particular region.

Control Site

- A single site usually located on the waterbody under study which represents the best or most appropriate attainable condition for that waterbody whether it is impaired or not.

Coping With Biological Data Variability

- **Compress Variability**: use multi-metric measures (e.g. IBI, ICI, etc.).
- **Stratify Variability**: use ecoregions (or subsets) and tiered aquatic life use classification system.
- **Control Variability**: select efficient sampling methods that yield informative and consistent results.

Ecoregion Definition and Delineation

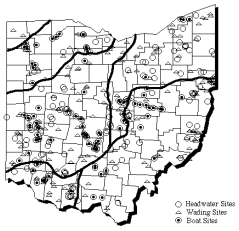
A more or less homogeneous area that differs from other areas.

- Within region variability < between region variability
- Ecoregion driving factors:
  - land surface form
  - soil type
  - land use
  - potential natural vegetation
- Regionalization helps organize and present ambient information and enhances communication

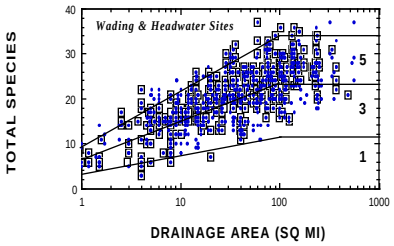
Ecoregions and Subregions: Policy & Program Uses

- **Ecosystem Characteristics** - stratified biological, physical, and chemical assessment end-points for rivers and streams.
- **Water Quality Management Objectives** - stratify background conditions across landscapes and watersheds (e.g., biological criteria, nutrients).
- **Stream Protection Efforts** - use ecoregions and subregions to stratify policy applications.
- **Best Management Practices** - provides a ready framework to determine where specific BMPs are most effective.

Measurable Parameters of Watershed Health: Biological Criteria



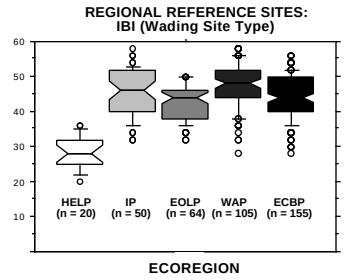
I.Select & sample reference sites



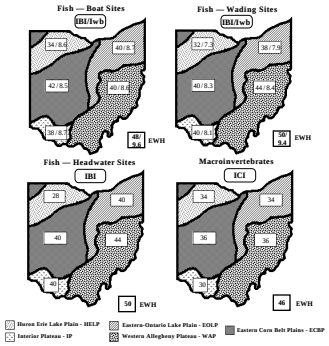
II. Calibration of IBI metrics

Metric	5	3	1
Number of Species	Varies x Drainage Area		
No. of Darter Spp.	Varies x Drainage Area		
No. of Sunfish Spp.	>3	2-3	<2
No. of Sucker Spp.	Varies x Drainage Area		
Intolerant Species			
>100 sq. mi.	>5	3-5	<3
<100 sq. mi.	Varies x Drainage Area		
%Tolerant Species	Varies x Drainage Area		
%Omnivores	<19	19-34	>34
%Insectivores			
<30 sq. mi.	Varies x Drainage Area		
>30 sq. mi.	>55	26-55	<26
%Top Carnivores	>5	1-5	<1
%Simple Lithophils	Varies x Drainage Area		
%DELT Anomalies	>1.3	0.5-1.3	<0.5
Relative Abundance	>750	200-750	<200

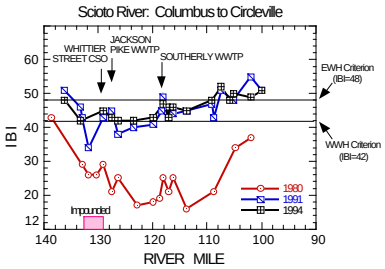
III.Calibrated IBI modified for Ohio waters



IV. Establish ecoregional patterns/expectations

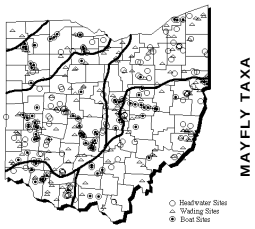


V. Derive numeric bio-criteria: Codify in WQS

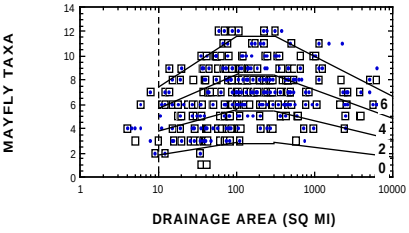


VI. Numeric biocriteria are used in bioassessments

BIOLOGICAL CRITERIA CALIBRATION & DERIVATION PROCESS: INVERTEBRATE COMMUNITY INDEX (ICI)



I. Select & sample reference sites

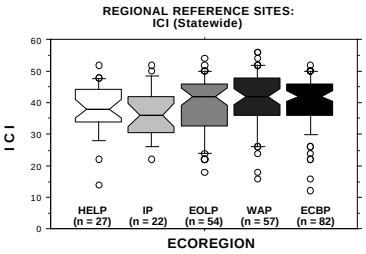


II. Calibration of ICI metrics

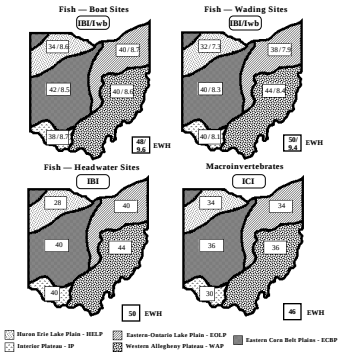
Metric	0	2	4	6
Number of Taxa				
No. of Mayfly Taxa				
No. of Caddisfly Taxa				
No. of Dipteran Taxa				
%Mayfly Composition				
%Caddisfly Composition				
%Tribe Tanytarsini				
%Other Dipteran & Non-insect Composition				
%Tolerant Organisms				
%Total Qual. EPT Taxa				

All ICI Metrics Vary With Drainage Area

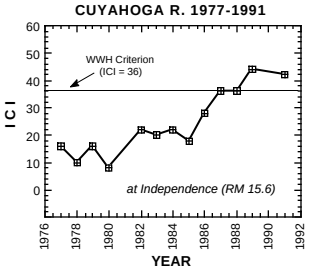
III. Calibrated ICI applicable to Ohio waters



IV. Establish ecoregional patterns/expectations



V. Derive numeric bio-criteria/codify in WQS

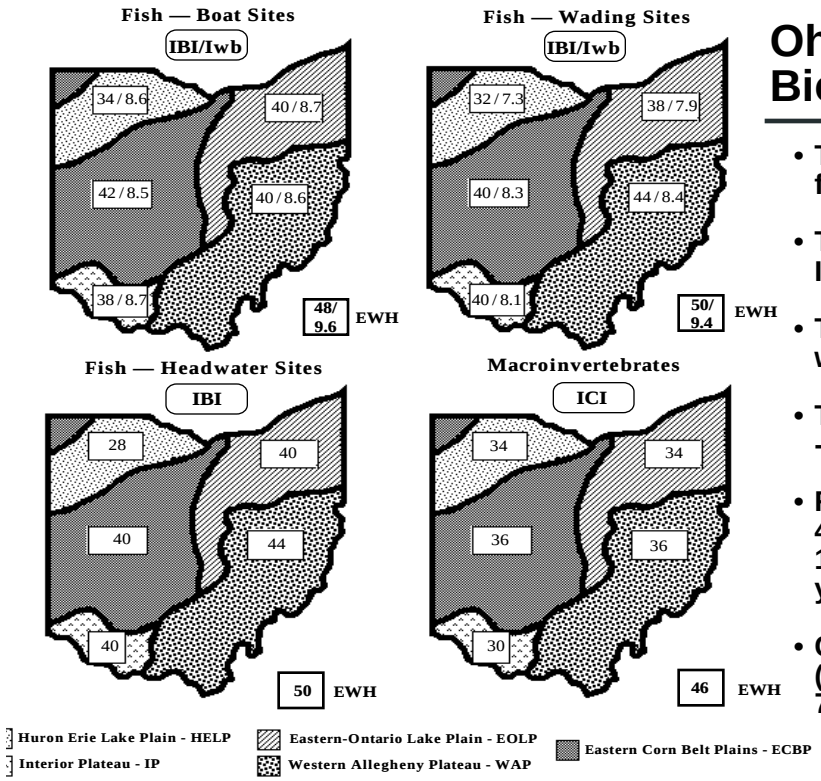


VI. Numeric biocriteria used in assessments

Measurable Parameters of Watershed Health: Biological Criteria

Biocriteria in the Ohio Water Quality Standards (OAC 3745-1-07; Table 7-14)

INDEX Site Type ECOREGION	Modified Warmwater Habitat Channel Modified	Mine Affected	Impounded	Warmwater Habitat	Exceptional Warmwater Habitat
I. INDEX OF BIOTIC INTEGRITY (IBI)					
A. Wading Sites					
HELP	22	--	--	32	50
IP	24	--	--	40	50
EOLP	24	--	--	38	50
WAP	24	24	--	44	50
ECBP	24	--	--	40	50
II. INVERTEBRATE COMMUNIY INDEX (ICI)					
A. Artificial Substrate Samplers (Statewide)					
HELP	22	--	--	34	46
IP	22	--	--	30	46
EOLP	22	--	--	34	46
WAP	22	30	--	36	46
ECBP	22	--	--	36	46



Ohio Numerical Biological Criteria

- Two organism groups - fish & invertebrates
- Three indices - IBI, MIwb, ICI
- Three site types - head-water, wadable, boat
- Three use designations - WWH, EWH, MWH
- Reference sites number 400 (sampled 1981- 1989); 10% are resampled each year
- Codified in WQS in 1990 (OAC 3745-1-07; Table 7-14)

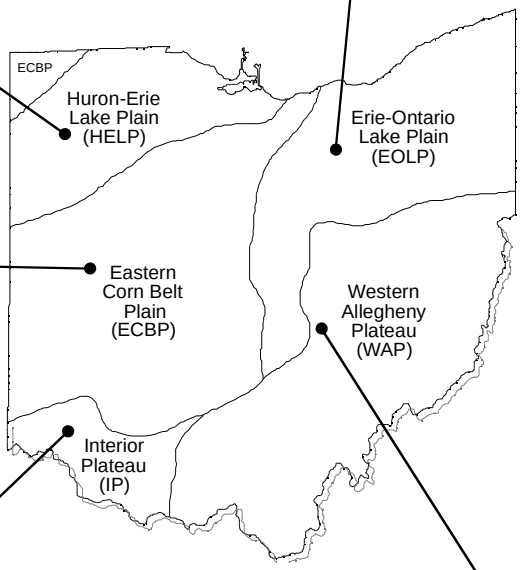
Numerical Biological Criteria: Ohio Water Quality Standards (OAC 3745-1-07; Table 7-14) Adopted May, 1990

Huron Erie Lake Plain (HELP)

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

Erie Ontario Lake Plain (EOLP)

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



Eastern Corn Belt Plains (ECBP)

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

Interior Plateau (IP)

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

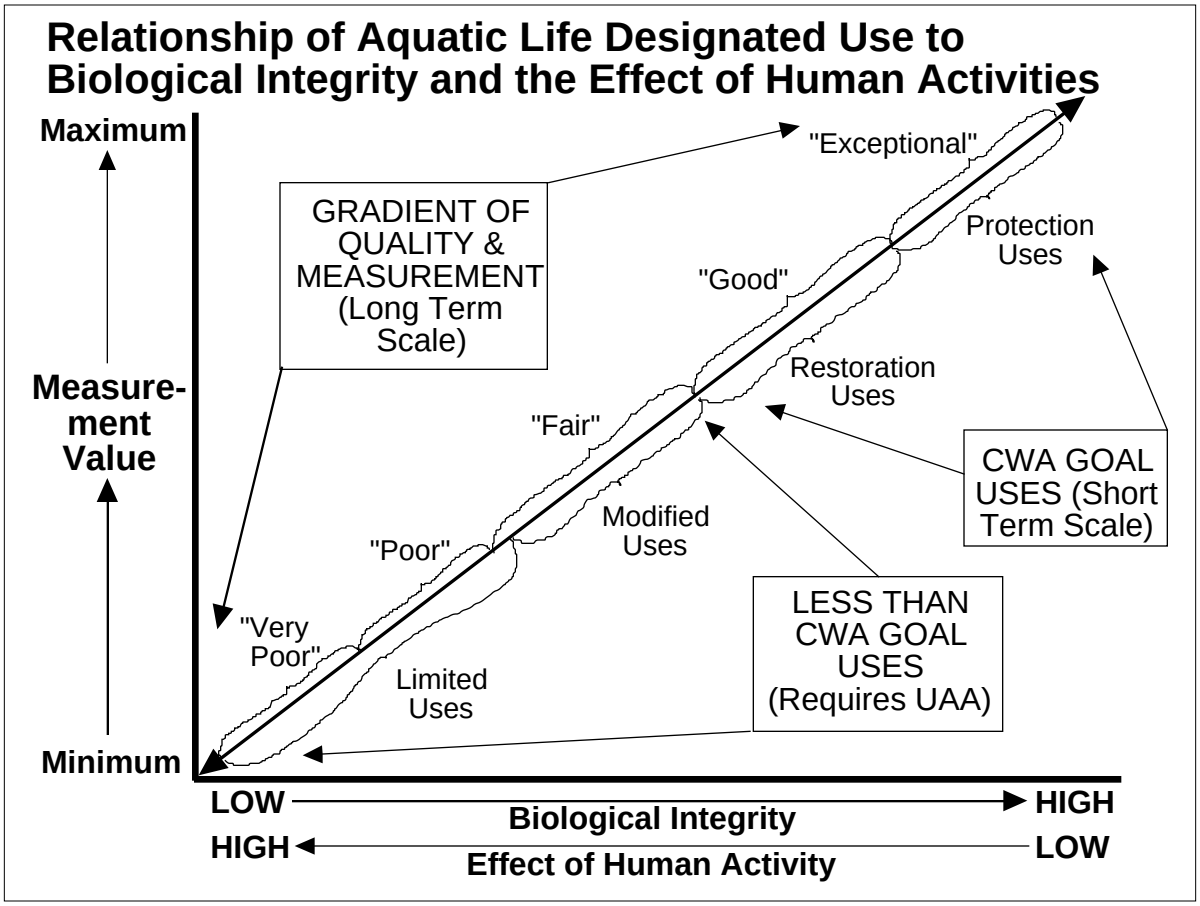
Western Allegheny Plateau (WAP)

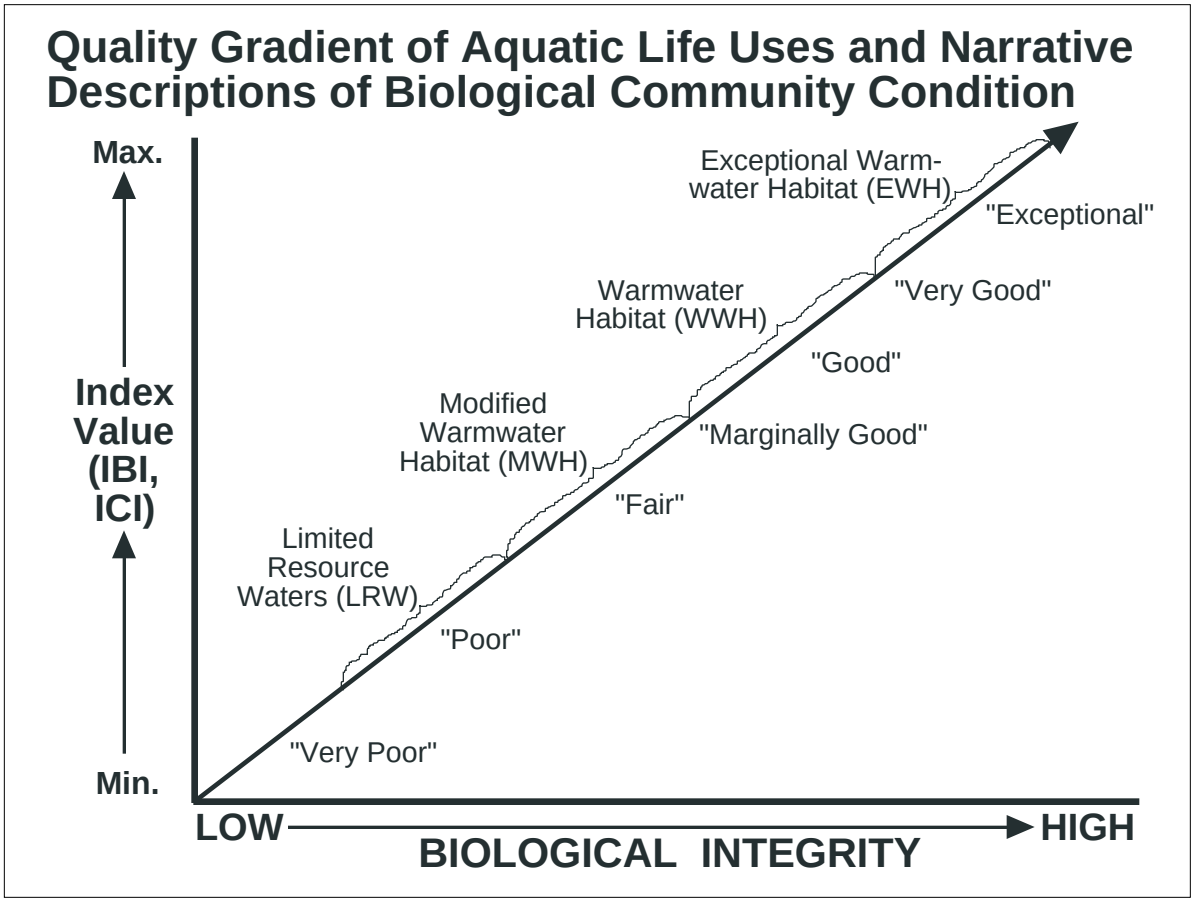
Use	Size	IBI	MIwb	ICI
WWH	H	44	NA	36
	W	44	8.4	36
	B	40	8.6	36
MWH-C	H	24	NA	22
	W	24	6.2	22
	B	24	5.8	22
MWH-A	H	24	NA	30
	W	24	5.5	30
	B	24	5.5	30
MWH-I	B	30	6.6	NA

Statewide Exceptional Criteria

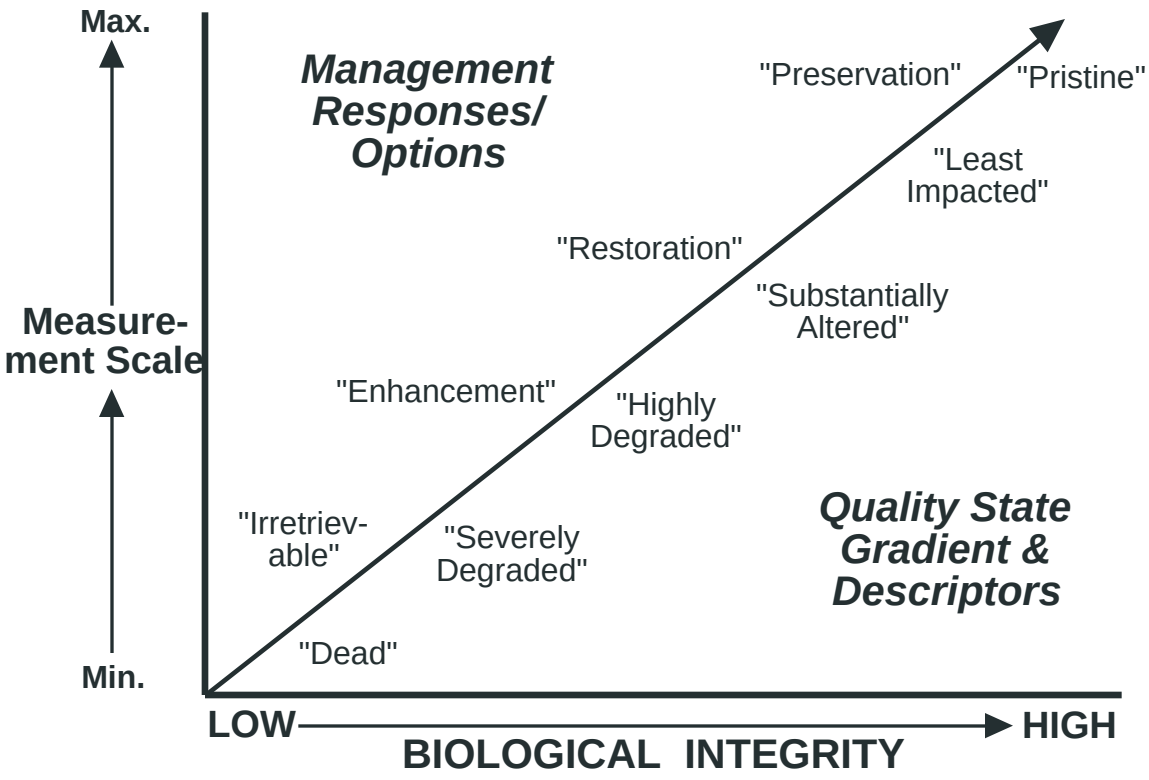
Use	Size	IBI	MIwb	ICI
EWH	H	50	NA	46
	W	50	9.4	46
	B	48	9.6	46

Measurable Parameters of Watershed Health: Biological Criteria





Measurable Parameters of Watershed Health: Biological Criteria

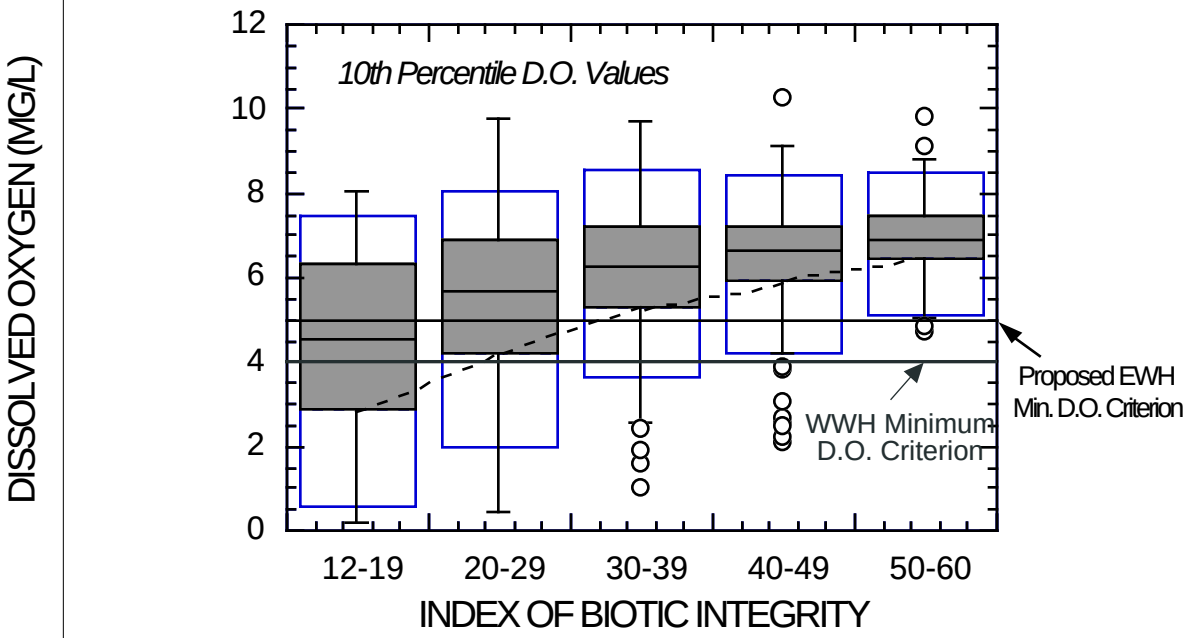


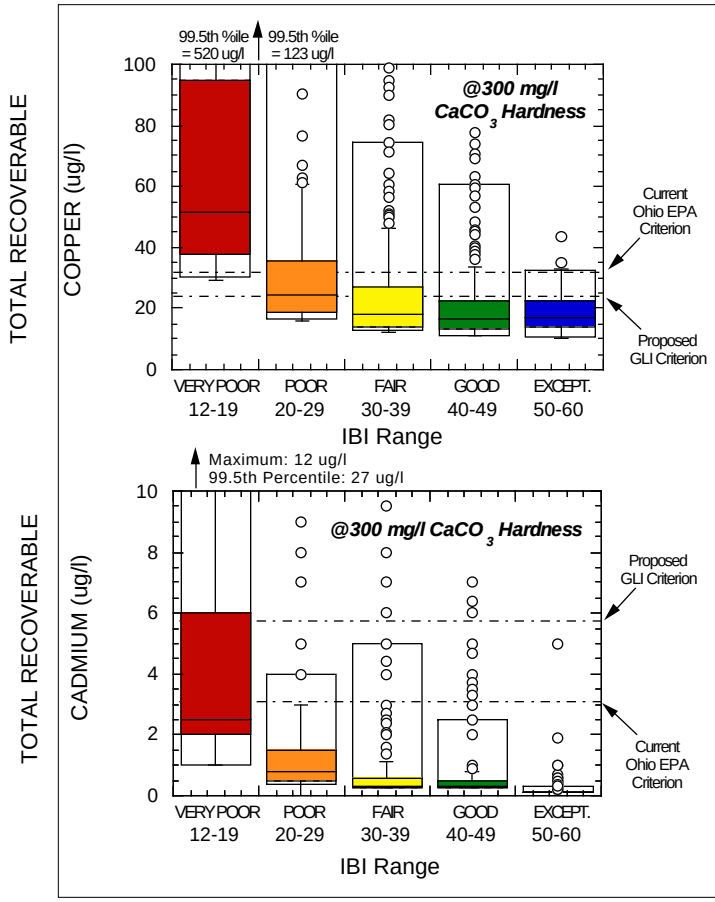
Designated Uses: Principal Water Quality Management Objectives

- **Restoration -** applies to most 303d listed waters in Ohio (i.e., do not attain baseline CWA goals); most common for *WWH*.
- **Preservation -** applies to high quality waters above CWA baselines; most common for *EWH* and higher antidegradation tiers.
- **Enhancement -** the best we can do where CWA restoration is precluded; applies to less than CWA uses (*MWH*, *LRW*).

Measurable Parameters of Watershed Health: Biological Criteria

Correspondence of Biocriteria to Environmental Gradients: Dissolved O_2



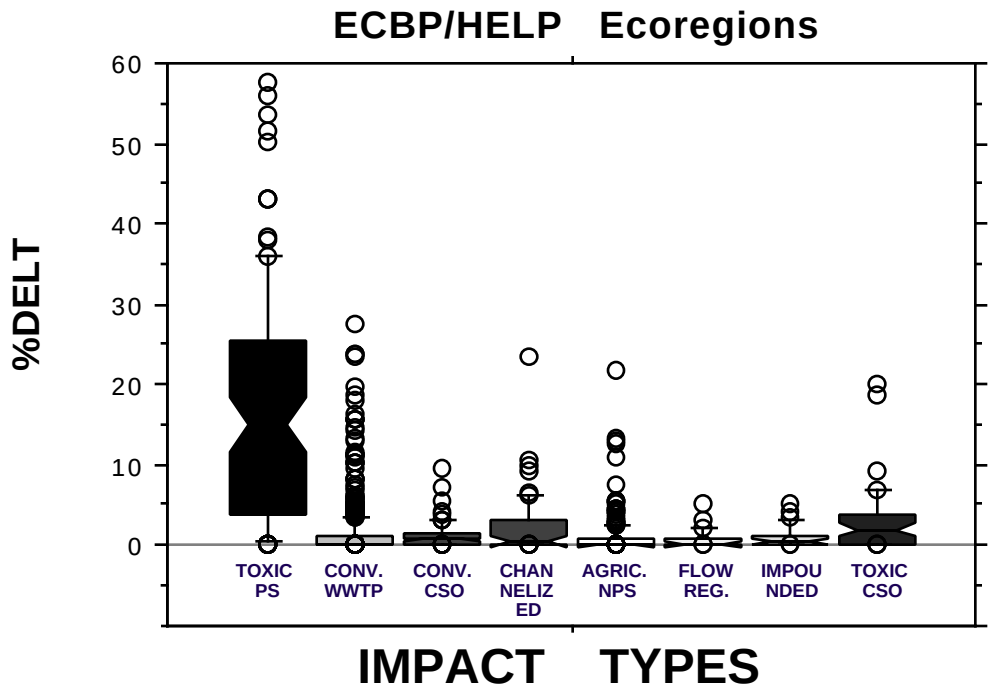


Biocriteria Can Be Used to Validate the Accuracy of Chemical Water Quality Criteria: Metals

- The Ohio EPA statewide database was used to correlate ranges of biological quality with heavy metals concentrations.
- Proposed criteria changes for copper, cadium, zinc, and lead were evaluated.
- The results were used to develop biologically-based application guidelines for the use of dissolved metals in calculating wasteload allocations for point sources.

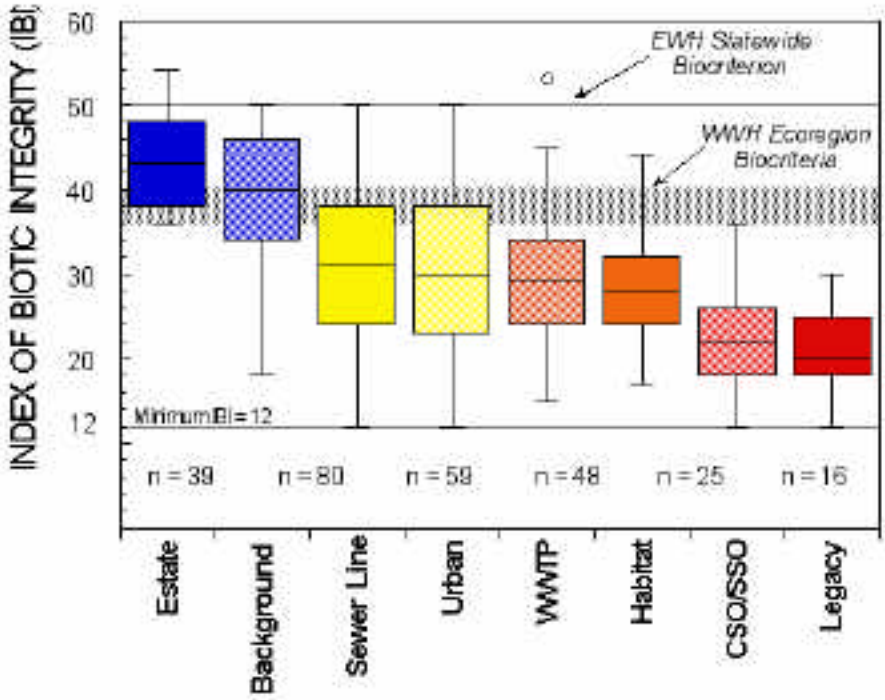
Measurable Parameters of Watershed Health: Biological Criteria

Biocriteria Metrics Can Aid in Distinguishing Different Types of Impacts: Anomalies on Fish



after Yoder and Rankin (1995)

BIOLOGICAL QUALITY OF SELECTED OHIO URBAN/SUBURBAN WATERSHEDS (<100 mi.²): IMPACT TYPES



Measurable Parameters of Ecosystem Health: Biological Assessment Concepts and Uses

Overall Framework For Using Biological Criteria in Assessments

- **Goal** - protect/restore biological integrity.
- **Standards** - Use designations and criteria.
- **Operational Measures** - biological criteria based on key indicator assemblages.
- **Tool of Measurement** - ambient biological sampling (survey).

Definitions of Impaired and Impacted

Impaired:

Monitored level data establishes a violation of the biological criteria, and hence, an impairment of the aquatic life designated use.

Impacted:

Evidence based on the presence of stressors suggests that there *may* be an impairment; quantitative, monitored level data is needed to *confirm* an impairment.

(Ohio Water Resource Inventory 305b Report)

Measurable Parameters of Watershed Health: Biological Assessment

Aquatic Life Use Attainment

Definition:

The condition when a waterbody has demonstrated, through use of ambient biological and/or chemical data, that it does not significantly violate biological or water quality criteria for that use.

(1990 305b Report, Volume I)

Determining Use Attainment Status With Biocriteria

FULL ATTAINMENT

- **ALL** biological indices are at or within non- significant departure of the applicable biocriterion

PARTIAL ATTAINMENT

- A **MIX** of biological index scores at or within non-significant departure **and** below the applicable biocriterion

NON-ATTAINMENT

- **NONE** of the biological indices are at or within non-significant departure of the applicable biocriterion **OR** one organism group reflect poor or very poor quality

Determining Aquatic Life Use Attainment Status With Biocriteria

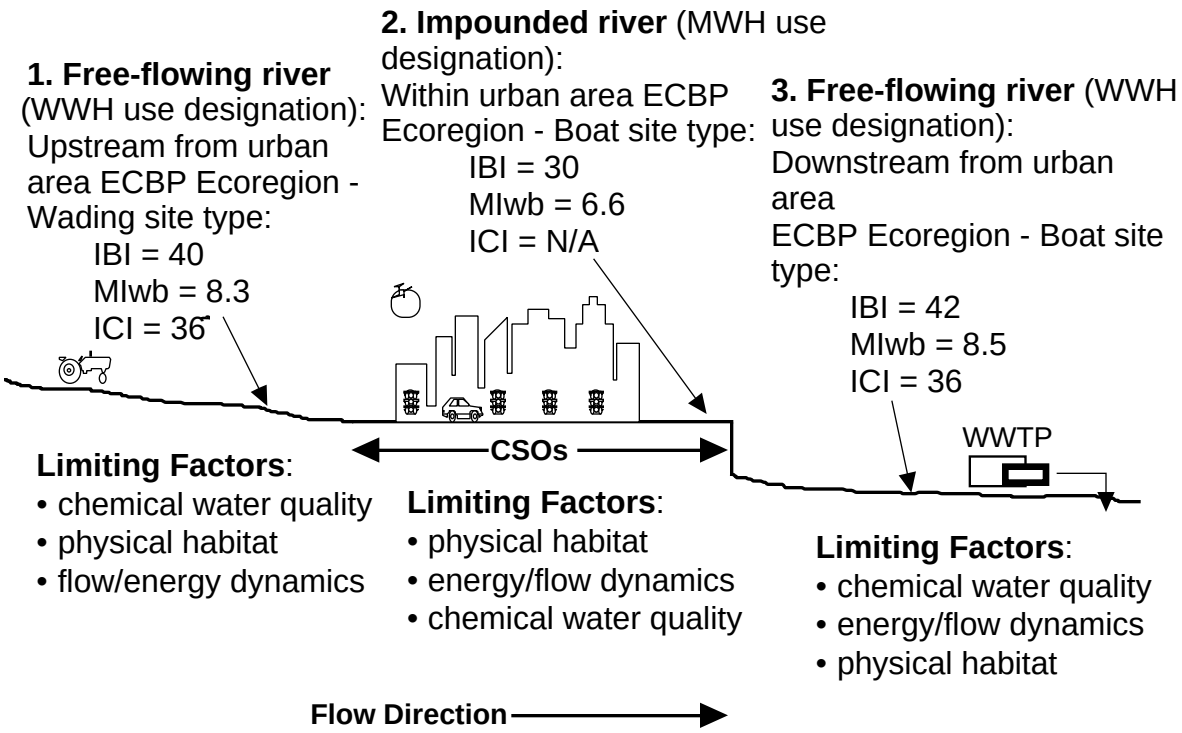
Aquatic Life Use Attainment Table Format:

River Mile	IBI	MIwb	ICI	QHEI	Attainment Status-WWH	Comment
20.2/20.0	44	8.9	40	68	**FULL**	Ust. Anyplace WWTP
19.5/19.7	30*	8.0[ns]	34[ns]	60	**PARTIAL**	WWTP Mixing Zone
17.0/16.8	22*	6.3*	8*	62	**NON**	Dst. Anyplace WWTP
12.6/12.3	36[ns]	8.4	32*	70	**PARTIAL**	Recovery zone
9.5/9.0	40	8.8	42	56	**FULL**	Full Recovery
5.2/5.7	42	9.2	44	75	**FULL**	
0.5/ -	32*	7.6*	--	45	**[NON]**	Impoundment effect

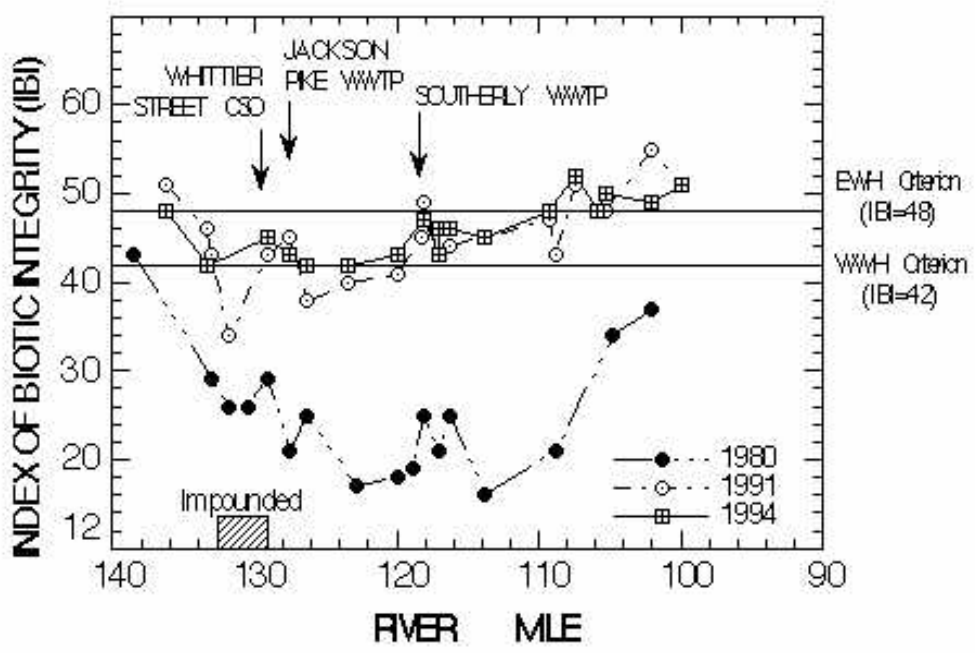
* - significant departure from ecoregion biocriteria; poor and very poor performing values are underlined.
[ns]- insignificant departure from ecoregion biocriteria (4 IBI or ICI units; 0.5 MIwb units).

Measurable Parameters of Watershed Health: Biological Assessment

Application of Biocriteria in Complex Settings



USING BIOLOGICAL CRITERIA & ASSESSMENT TO EVALUATE TRENDS IN QUALITY: SCIOTO RIVER



Measurable Parameters of Watershed Health: Biological Assessment

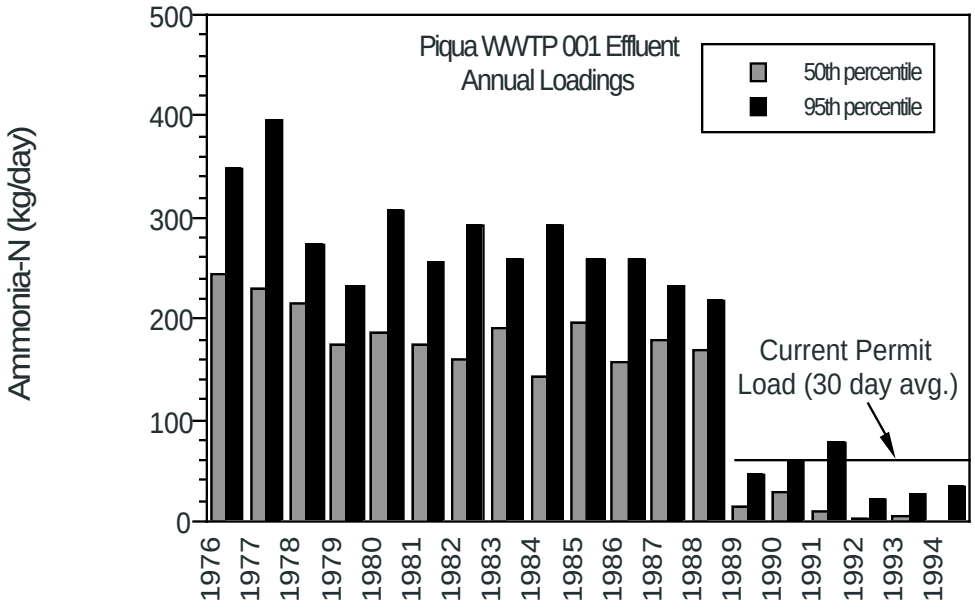
Hierarchy of Environmental Indicators for Surface Waters

- Pilot indicators project tested hierarchy and selected indicators.
- Each indicator was used within the most appropriate role.
- Two case studies: Scioto R. (Columbus, OH) and Ottawa R. (Lima, OH).

Administrative → True Environmental

LEVEL 1	**Actions by EPA and States**	• NPDES Permit Issuance • Compliance/Enforcement • Pretreatment Program • Actual Funding • CSO Requirements • Storm Water Permits • 319 NPS Projects • 404/401 Certification • Stream/Riparian Protection
LEVEL 2	**Responses by the Regulated Communitiy**	• POTW Construction • Local Limits • Storm Water Controls • BMPs for NPS Control • Pollution Prevention Measures
LEVEL 3	**Changes in Discharge Quantities**	• Point Source Loadings - Effluent & Influent • Whole Effluent Toxicity (WET) • NPDES Violations • Toxic Release Inventory • Spills & Other Releases • Fish Kills
LEVEL 4	**Changes in Ambient Conditions**	• Water Column Chemistry • Sediment Chemistry • Habitat Quality • Flow Regime
LEVEL 5	**Changes in Uptake and/or Assimilation**	• Assimilative Capacity - TMDL/WLA • Biomarkers • Tissue Contamination
LEVEL 6	**Changes in Health and Ecology, or Other Effects**	• Biota (Biocriteria) • Bacterial Contamination • Target Assemblages (RT&E, Declining Species)

Upper Great Miami River: Piqua WWTP Effluent Loadings 1976-1994 (Level 3 Indicator)



Demonstrating Linkages Between Indicators: Scioto River Case Study

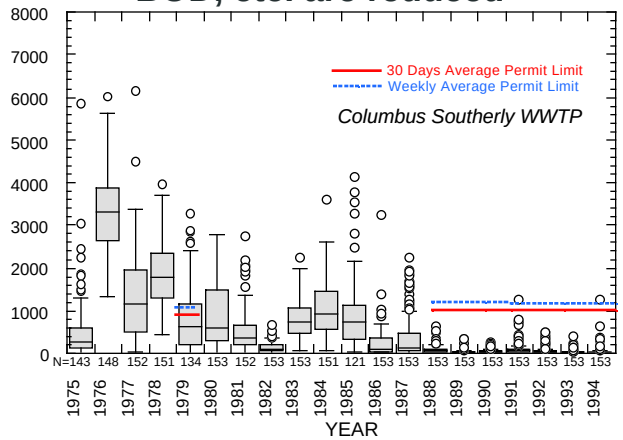
ADMINISTRATIVE INDICATORS

LEVEL 1:
Ohio EPA issues WQ based permits & awards funds for Columbus WWTPs

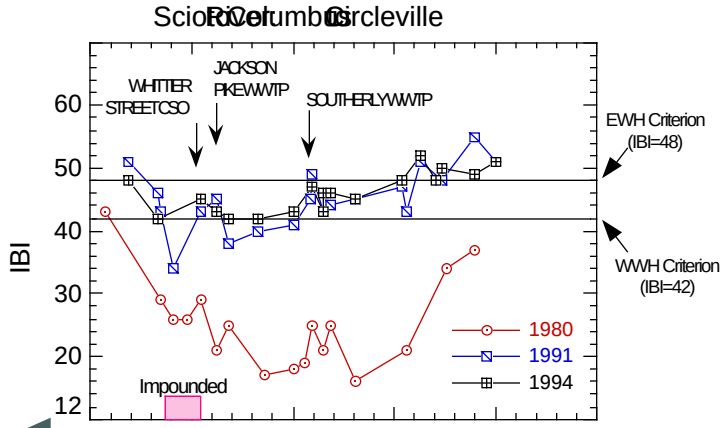
LEVEL 2:
Columbus constructs AWT by July 1, 1988; permit conditions attained

STRESSORS

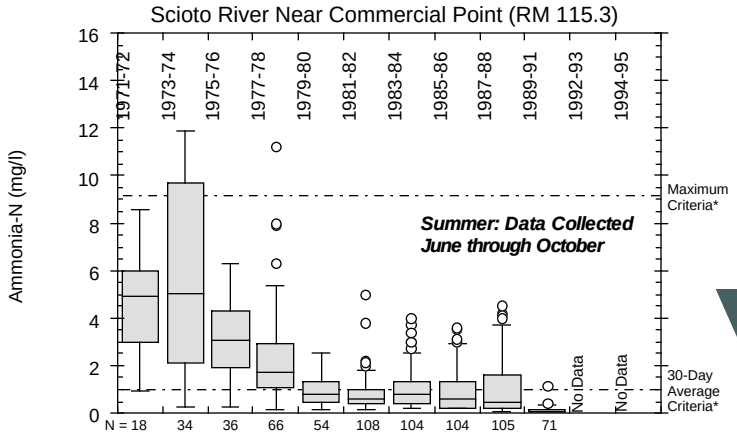
LEVEL 3: Loadings of ammonia, BOD, etc. are reduced



LEVEL 6: Biological recovery evidenced in biocriteria; 3 yrs. post AWT



LEVELS 4&5: Reduced instream pollutant levels; enhanced assimilation



RESPONSE

EXPOSURE

Demonstrating Linkages Between Indicators: Ottawa River Case Study

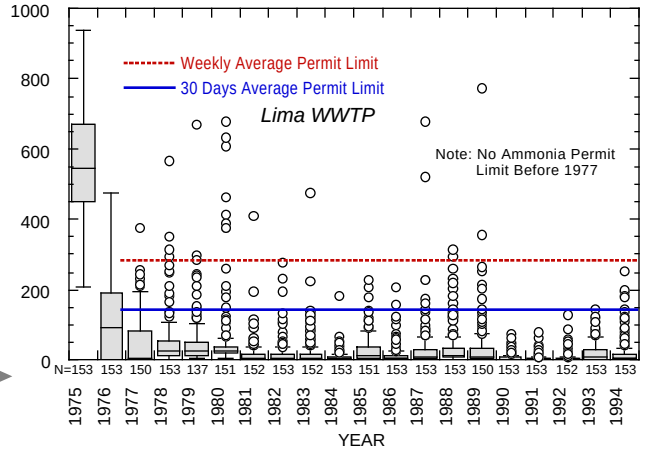
ADMINISTRATIVE INDICATORS

LEVEL 1:
Ohio EPA issues WQ based permits & awards funds for the Lima WWTP

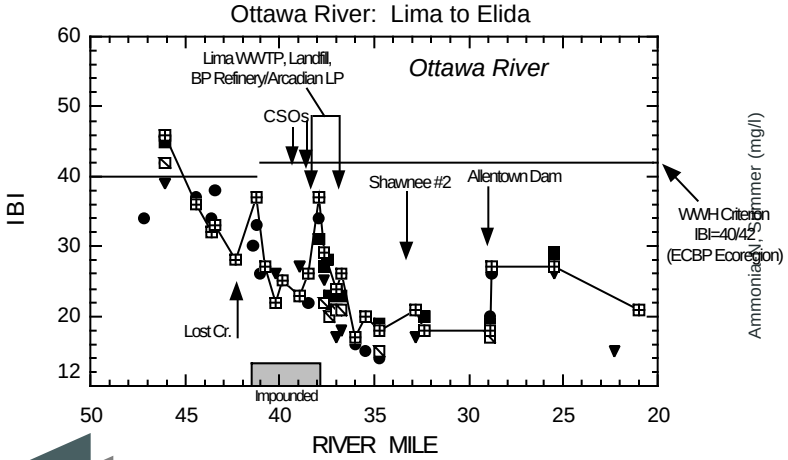
LEVEL 2:
Lima constructs AWT by mid 1980s; permit conditions attained by 1990

STRESSORS

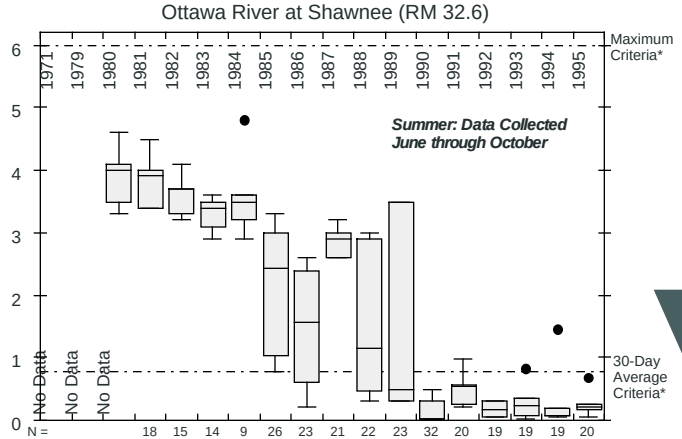
LEVEL 3: Loadings of ammonia, BOD, were reduced; other sources present



LEVEL 6: Biological recovery incomplete 6-8 yrs. post AWT; toxic response signatures



LEVELS 4&5: Reduced instream pollutant levels; toxics in sediment



RESPONSE

EXPOSURE

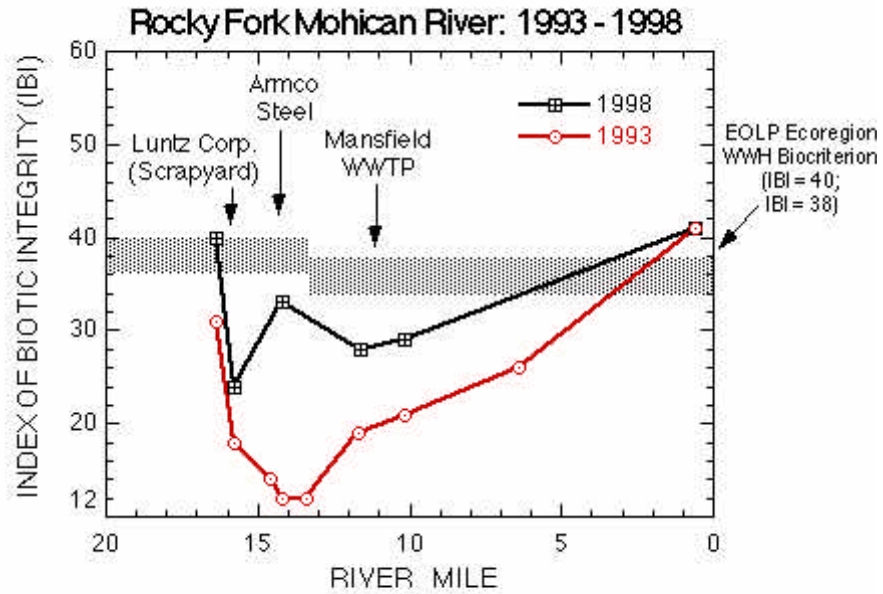
Using Indicators to Evaluate Causal Associations & Trends

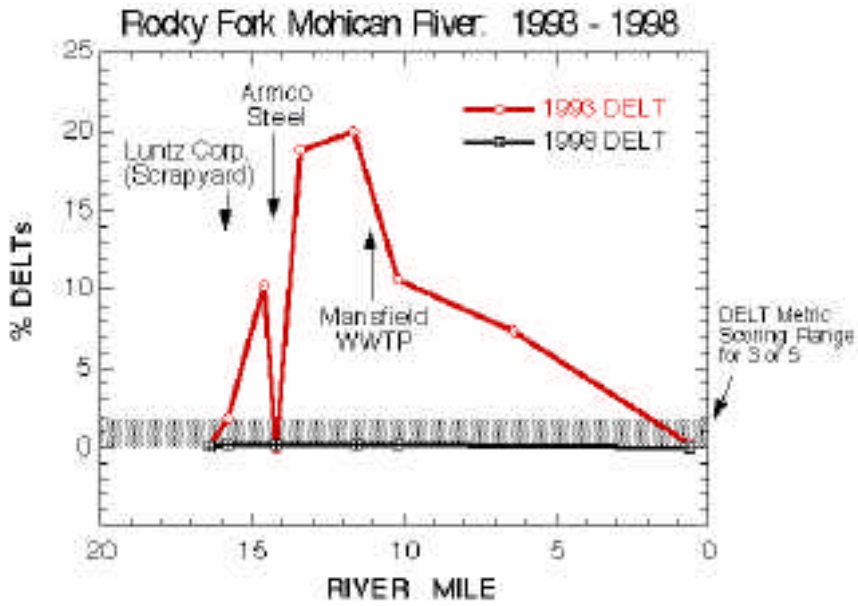
Rocky Fork Mohican River:
WWH Use (existing)

Major Point Sources:
Mansfield WWTP
[Industrial Pretreatment]
Armco Steel

Other Stressors:
Luntz Corp. Scrapyard
Channelization

Key Indicators: (Levels 4&6)
Biological Response Signatures
[IBI, DELT Anomalies]
Chemical (Sediment Chemistry)





Indicator Case Examples in Ohio

Documentation of Permit Program Effectiveness:

- Good "success stories" limited to point sources.
- Scioto River type of results repeated at approximately 20-25 other municipalities statewide.
- Ottawa River type results in fewer, but historically industrialized areas of Ohio.

Documentation of Other WQ Management Successes:

- Evidence of nonpoint source abatement emerging.
- Clear Creek watershed - 50% reduction in soil loss.
- Response observed in IBI 10-12 later.

Recent Indicators Publications

1. ***As Used in Water Quality Management***

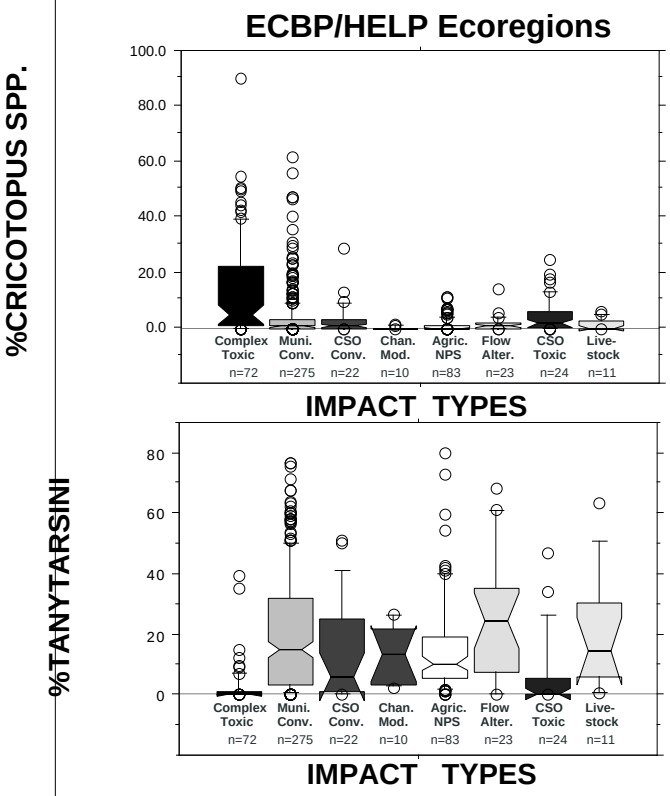
   The role of biological indicators in a state water quality management process. J. Env. Mon. Assess. 51: 61-88.

   Biological criteria for water resource management, pp. 227-254. in P. Sculze (ed.). Measures of Environmental Performance and Ecosystem Condition, National Academy Press, Washington, D.C. [www.nap.edu/books/0309054419/html/227.html]

2. ***As Used in Monitoring & Assessment Programs***

   Important elements and concepts of an adequate State watershed monitoring and assessment program. [www.epa.state.oh.us/dsw/document_index/docindex.html]

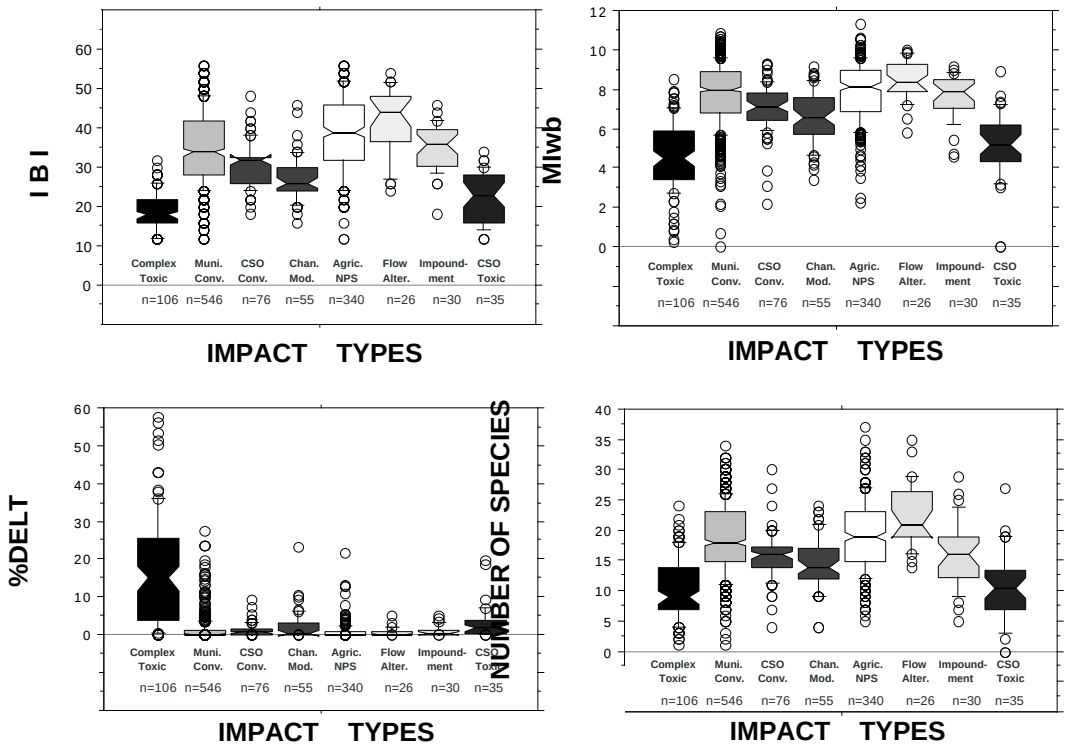
Measurable Parameters of Watershed Health: Biological Assessment



Biocriteria Metrics and Attributes Aid in Distinguishing Different Types of Impacts

- Two aggregations of the midge family Chironomidae show starkly differing responses to different stressors.
- %Tanytarsini midges are indicators of good water quality and serve as a metric of the ICI.
- %Cricotopus midges are indicators of toxic conditions and poor water quality.
- Genus level taxonomic resolution is required ***at a minumum*** to benefit from macroinvertebrate data in this manner.

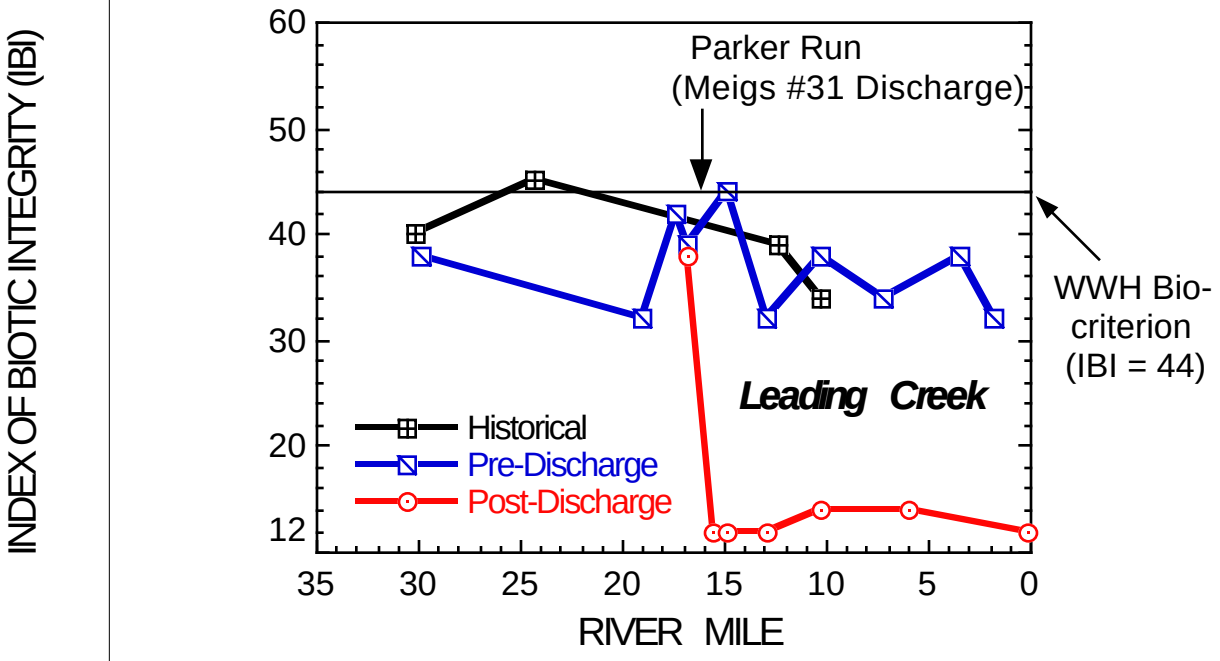
Biocriteria Indices and Metrics Show Varying Quality and Aid in Determining Types of Impacts

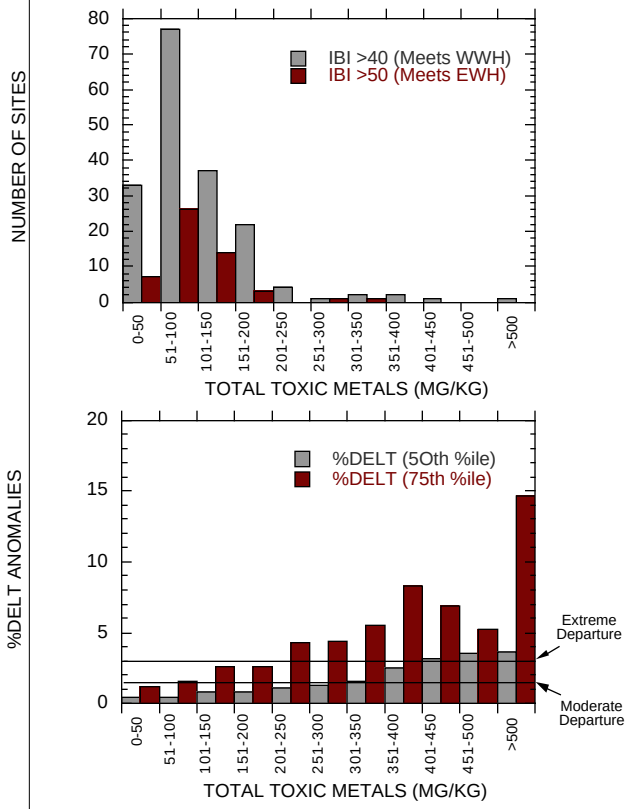


after Yoder and Rankin (1995)

Measurable Parameters of Watershed Health: Biological Assessment

Using Biocriteria to Evaluate Impacts of Toxic Releases: Leading Creek (SOCCo Mine Spill)



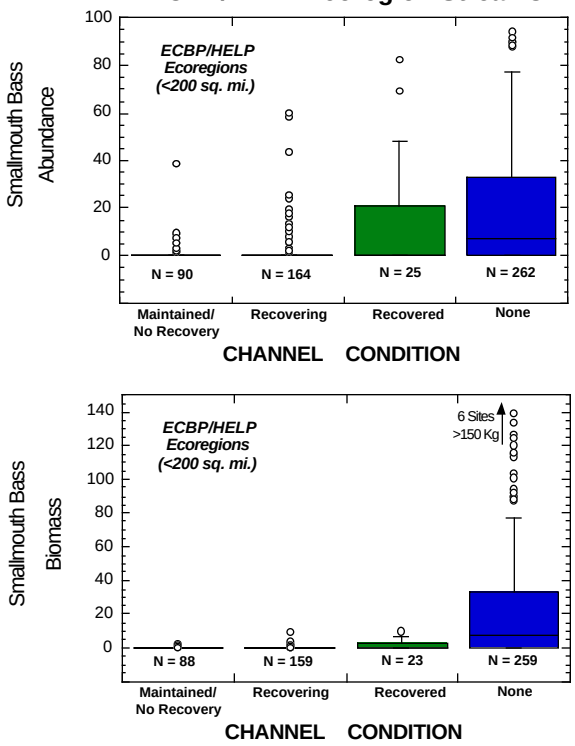


Using Biocriteria to Evaluate Chemical Contaminant Thresholds: Metals in Sediment

- Direct correlation of heavy metals in sediment with the IBI and %DELT anomalies state-wide.
- Determine highest concentrations at which biocriteria are attained, thus evaluating protectiveness of threshold concentrations.
- Does not rule out adverse effects at lower concentrations - other test data needed.
- Can be used to evaluate the risk of toxic contamination in bottom sediments to aquatic life.

Measurable Parameters of Watershed Health: Biological Assessment

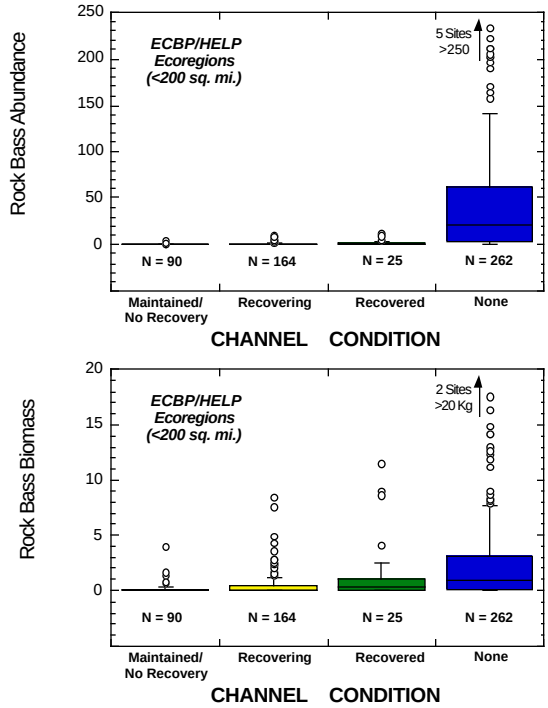
Smallmouth Bass Abundance and Biomass by Channel Condition: ECBP/HELP Ecoregion Streams



Channel Condition Affects the Abundance and Size of Small-mouth Bass in Ohio Streams & Rivers

- Smallmouth bass are one of the most popular and wide-spread game fish in Ohio and are a sentinel species for WWH and EWH streams and rivers.
- Adverse effects of channel modification to smallmouth bass include loss of cover, loss of pools, degradation of substrates, and food web alterations.

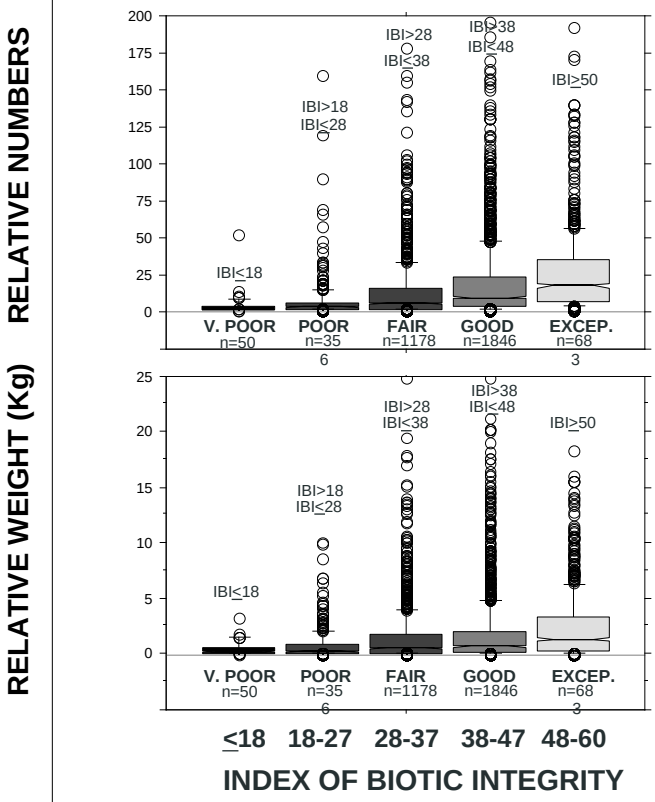
Rock Bass Abundance and Biomass by Channel Condition: ECBP/HELP Ecoregion Streams



Channel Condition Affects the Abundance and Size of Rock Bass in Ohio Streams

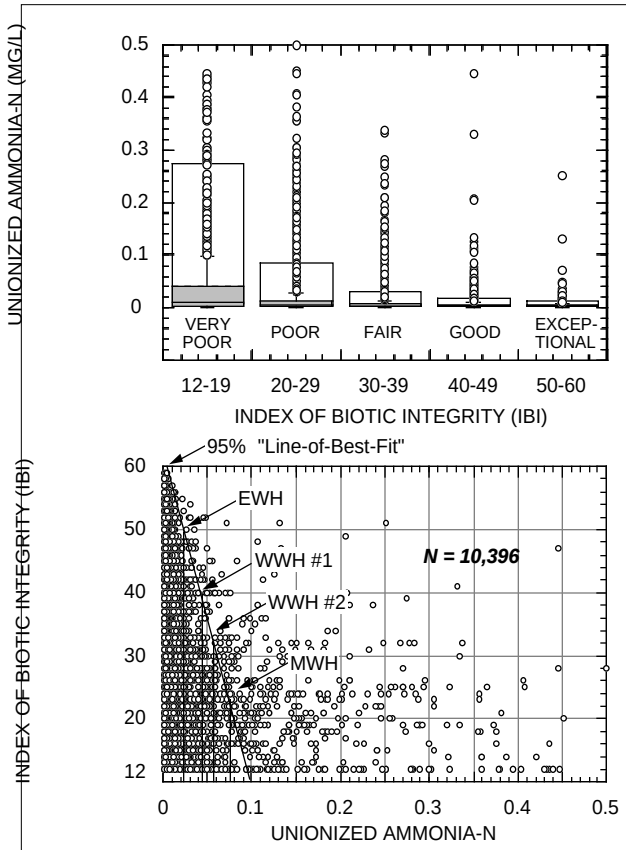
- Rock bass are a popular and widespread pan fish in Ohio and are a sentinel species for small WWH and EWH streams.
- Adverse effects of channel modification to rock bass include loss of cover, loss of pools, degradation of sub-strates, and food web alterations.

Measurable Parameters of Watershed Health: Biological Assessment



The Abundance and Size of Smallmouth Bass Corresponds to the IBI in Ohio Streams & Rivers

- Smallmouth bass are one of the most popular and wide-spread game fish in Ohio and achieve their highest numbers and size in streams and rivers which attain WWH and EWH.
- As a top carnivore, small-mouth bass abundance and size decrease as overall aquatic community condition and health declines.



Using Biocriteria to Validate and Evaluate Water Quality Criteria: Ammonia

- Direct correlation of ambient ammonia results with the IBI statewide.
- Determine upper concentrations at which biocriteria are attained, thus evaluating protectiveness of a criterion.
- Does not rule out adverse effects at lower concentrations - toxicity test data needed.
- Can be used to set tiered chemical criteria for different designated uses.

Measurable Parameters of Ecosystem Health: Ohio Water Resource Inventory (305b Report)

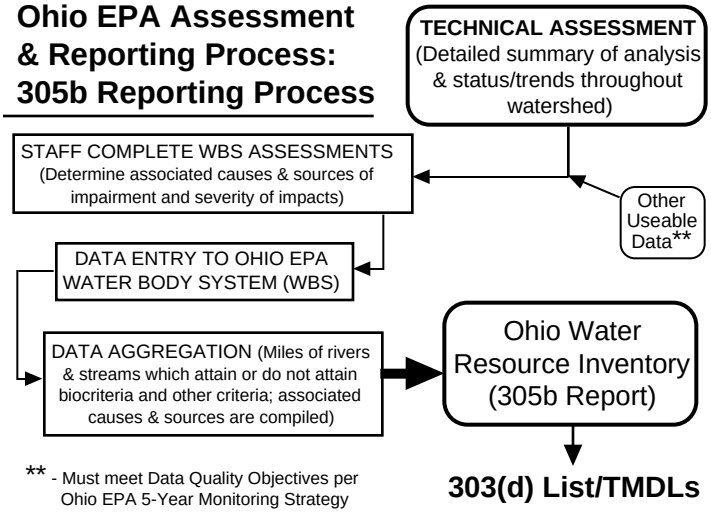
Measurable Parameters of Watershed Health: 305[b] Reporting

Ohio Water Resource Inventory (305[b] Report)

Required by Sec. 305b of the Clean Water Act

- √ Reports on status of designated uses of Ohio's rivers, streams, lakes, reservoirs, Lake Erie, Ohio River, wetlands, and ground water.
- √ Causes and sources of impairment determined using multiple indicators and "lines of evidence" approach.
- √ Tracks progress in restoring water resources.
- √ Provides rankings of different types of problems.
- √ Baseline for future comparisons.

Ohio EPA Assessment & Reporting Process: 305b Reporting Process



** - Must meet Data Quality Objectives per Ohio EPA 5-Year Monitoring Strategy

Causes and Sources of Impairment

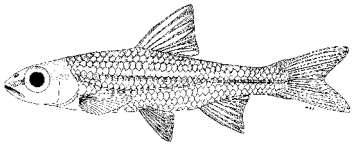
Causes

- Agents such as pollutants and stressors such as habitat alterations

Sources

- Activities that produce the agents such as point source discharges or land use activities

Year 2000
Ohio Water Resource Inventory



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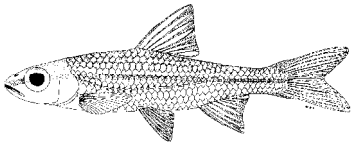
Sept 11, 2000

Appendices to the Year 2000 Ohio Water Resource Inventory



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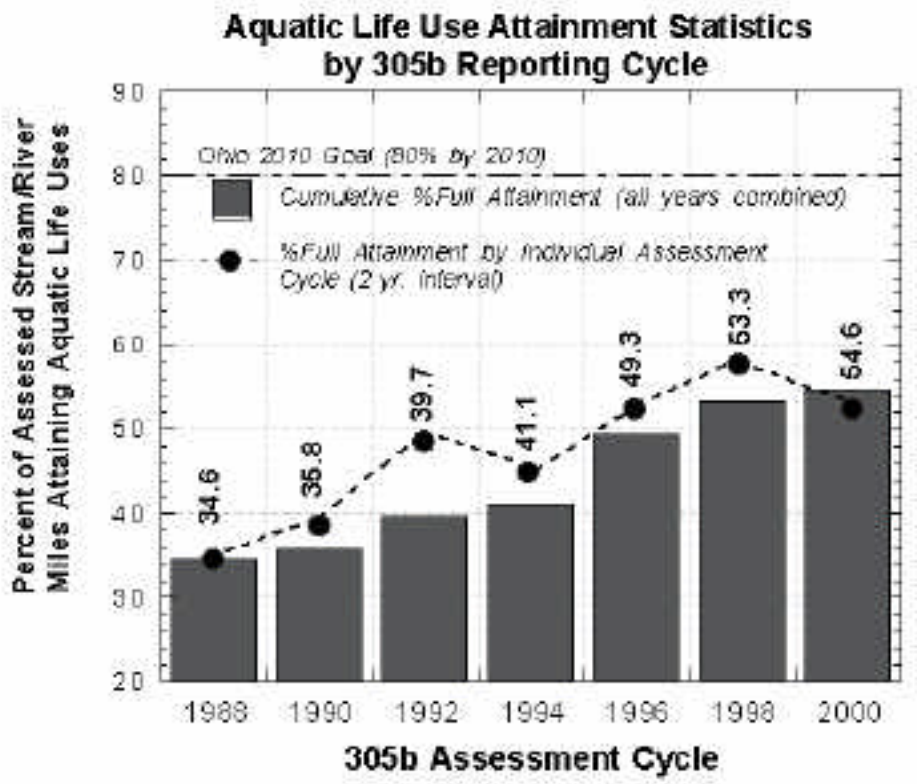
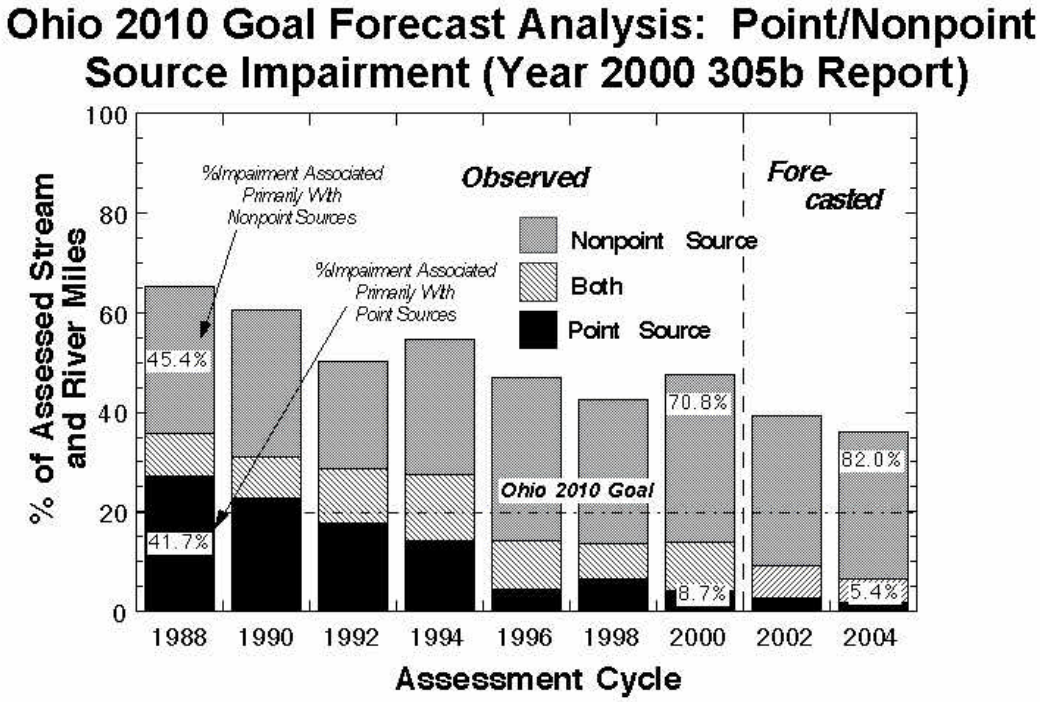
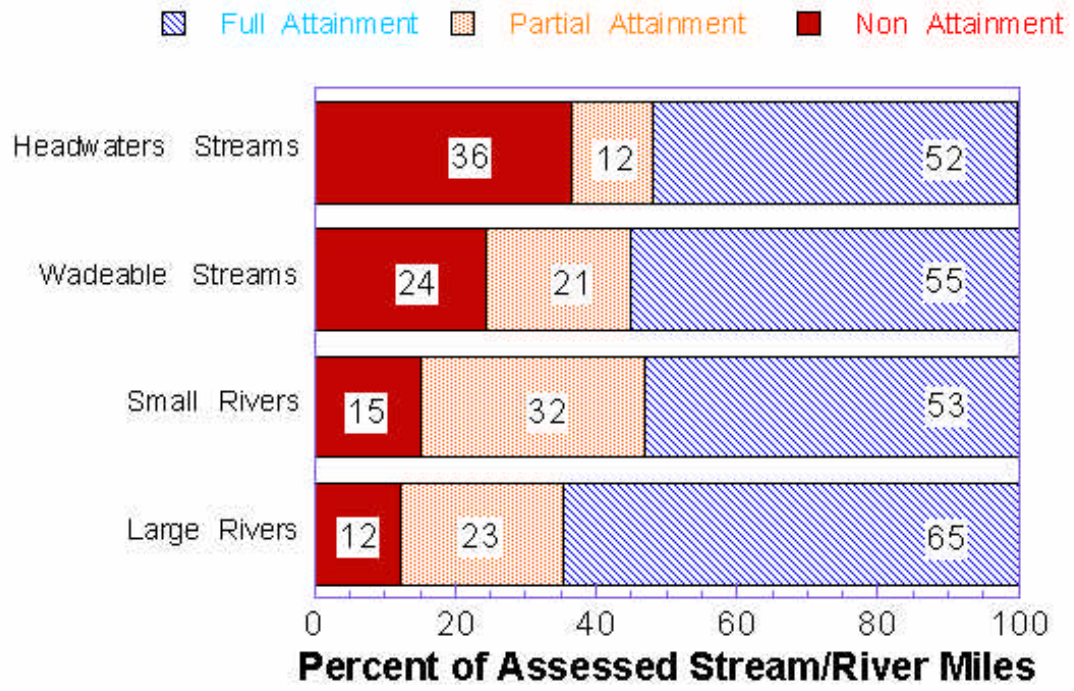
Measurable Parameters of Watershed Health: 305[b] Reporting



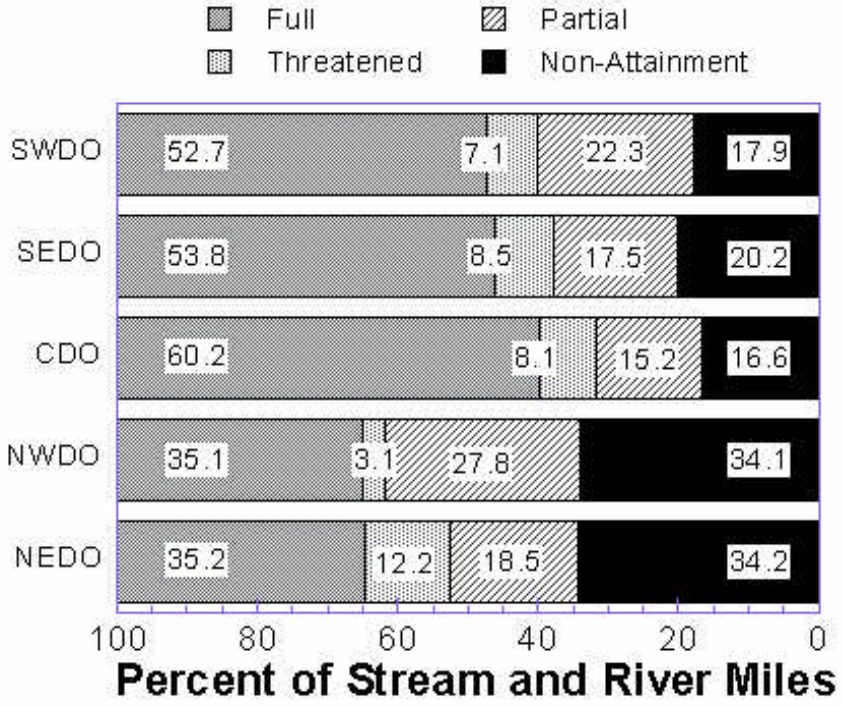


Measurable Parameters of Watershed Health: 305[b] Reporting

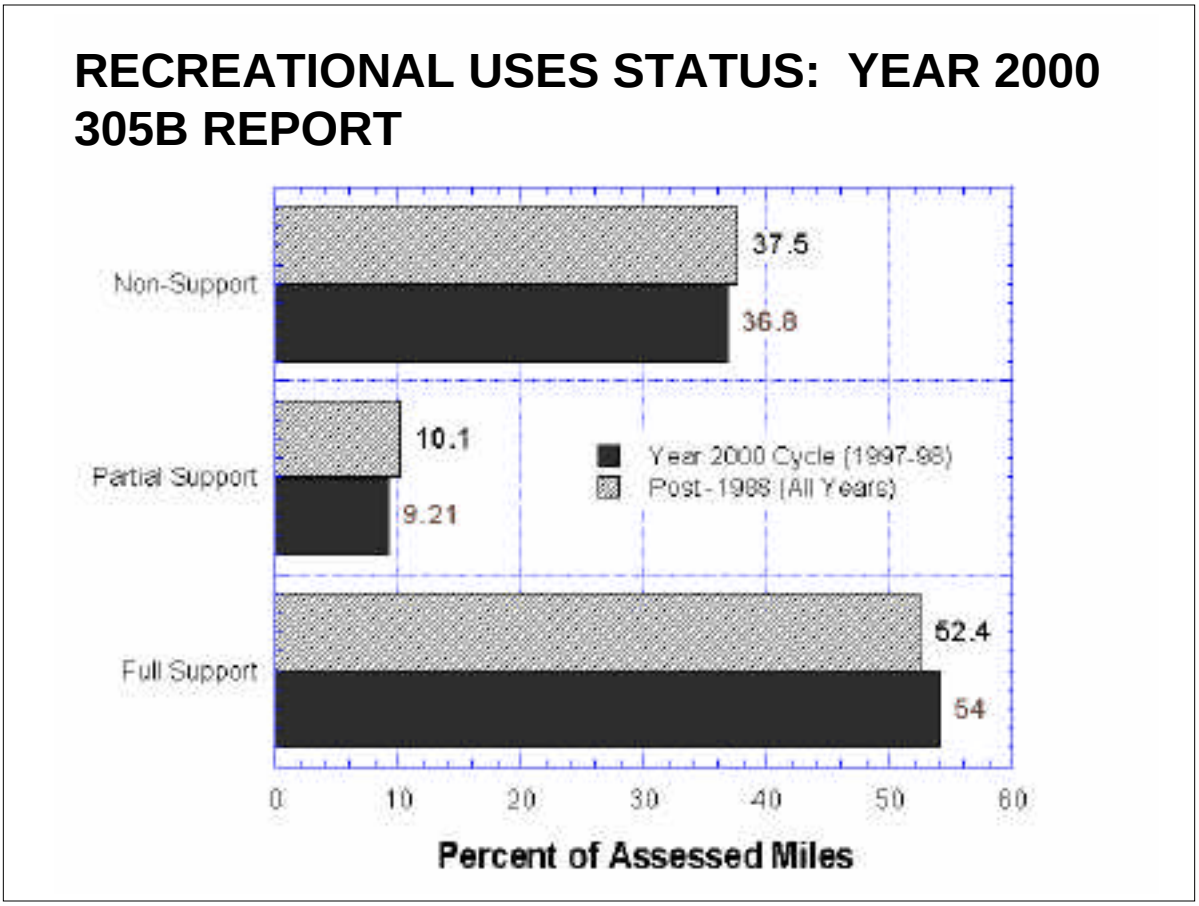
Attainment Status by Stream/River Size: Year 2000 305b Report

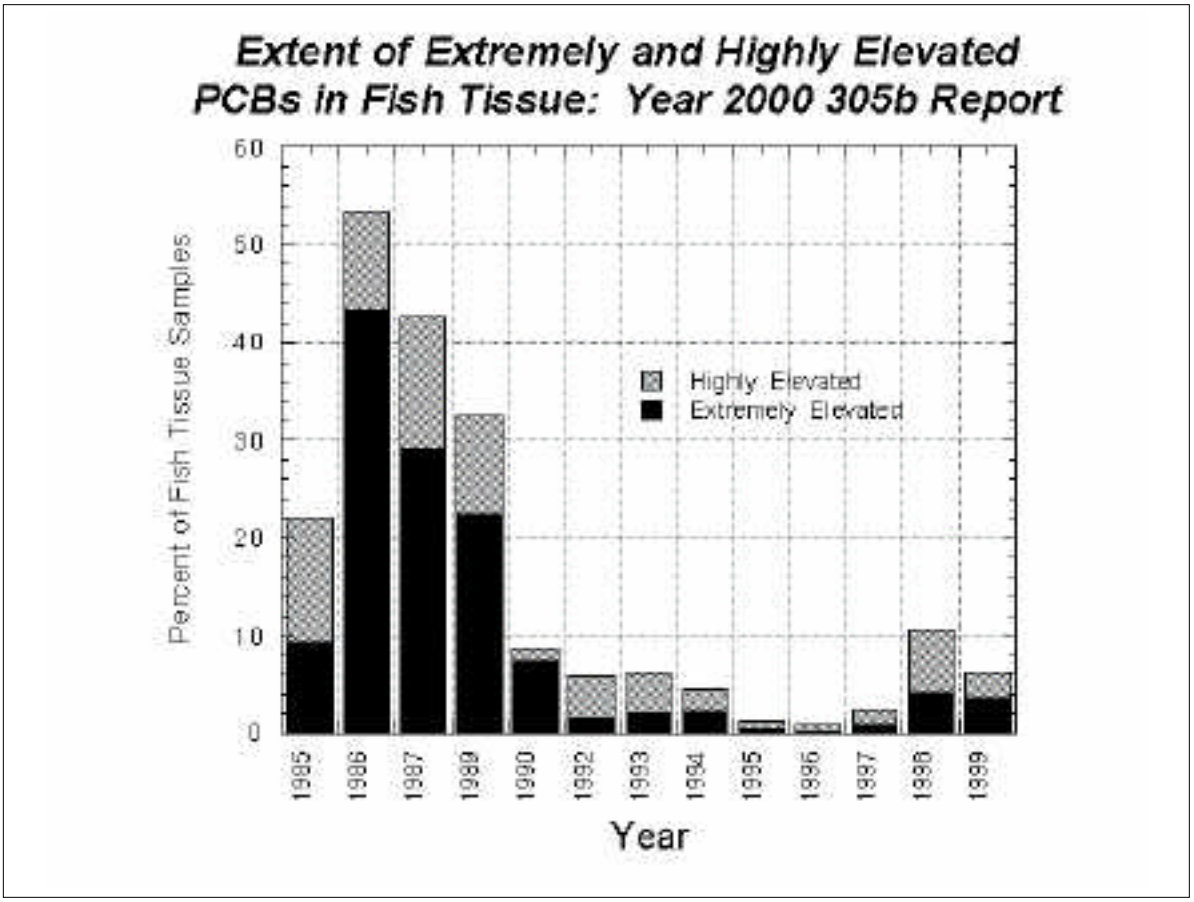


Aquatic Life Use Attainment Status by Ohio EPA District: Year 2000 305b Report



Measurable Parameters of Watershed Health: 305[b] Reporting





Waterbody System Segment Coding Worksheet

River Code: 20-001 River Segment: Black River, RM 15.65 to mouth

Waterbody ID#: OH86 2 URM: 15.65 LRM: 0.00 Length: 15.65 * Initials: RJM

Aquatic Life Use: WWH Date of Assessment: (MM/YY): 04/99

Dates of Data Collection: (MM/YY) 07/97 to 10/97

TYPES OF DATA AVAILABLE: FISH: X BUG: X CHEM: X

Assessment Types: ☐ 7Q10 Other:

Uses:	Recommended Use Change? (Y/N)	Supported	Threatened	Miles: Partial Support	Non-Support	Not Attainable	Unassessed
Aquatic Life:		3.7		4.2	7.7		
Recreation:							

Biological Integrity Narrative:	Excellent	Good:	Fair:	Poor:	Very Poor:
		3.7	4.2	0.9	6.8

Significant Aquatic Contamination:

Causes (w/Magnitude) of Partial or Non Support:

Cause/Mag - Miles	Cause/Mag - Miles	Cause/Mag - Miles	Cause/Mag - Miles	Cause/Mag - Miles
0900 H 7.7	1200 H 11.9	2400 M 6.0		

Sources (w/Magnitude) of Partial or Non Support:

	Source/Mag - Miles	Source/Mag - Miles	Source/Mag - Miles	Source/Mag - Miles	Source/Mag - Miles
Major Categ.	0000 H 11.9	0000 M 6.0			
Subcategory	0210 H 7.7	0210 M 6.0			
Subcategory	0400 H 11.9	0110 M 6.0			
Subcategory		0400 M 6.0			

Toxic Parameters Measured (That May Not Be Electonically Accessible at EAU)

Code:	Pollutant
☒ 4	*Organics (Effluent)*
☐ 8	*Pesticides (Effluent)*
☒ 12	*Metals (Effluent)*
☐ 14	*Oth. Inorganics (Effluent)*
☒ 15	*Toxicity Testing (Water Column)*
☒ 16	*Toxicity Testing (Sediment)*
☐ 17	*Toxicity Testing (Effluent)*

Estimate of Miles of Segment Covered by Toxic Monitoring: 5.0

TSD Planned or in Progress(Y/N): Y Estimated Completion Date: (MM/YY): 04/99

Data Compiled for this Assessment Includes:

- ☒ Use Attainment Table
- ☒ OHEI Matrix
- ☒ WQS Use Designation Matrix w/Rec. Use Changes
- ☒ Chemical Criteria Exceedence Table
- ☒ Chemical Data Summary
- ☒ Sediment Chemistry Table
- ☒ Spill Summary
- ☒ Fish Kill
- ☒ Fish Sampling Results Summary
- ☒ Macroinvertebrate Results Summary
- ☐ Other (Specify)
- ☒ PSD

Date Printed:03/31/99

Front Side

Narrative Summary/Additional Information

Are you recommending an Aquatic Life Use change? ☐ -YES ☒ - NO

New Use LRW MWH WWH EWH

Other:_____

If a portion of the segment is currently meeting its use, but you feel that this use is threatened, briefly describe this threat:

Is any of the impact observed caused by priority organic pollutants? ☒ - YES ☐ - NO

If so briefly describe the source of these pollutants and the extent of the problem:

Historic and residual PAH contamination from coking facilities in the lower river

Trend in the segment (more than one year of data)

Improving Stable Declining

Does this site need future monitoring?

☒ -YES ☐ - NO

Was data from outside of Ohio EPA used?

☒ -YES ☐ - NO

List Sources:

Dr. Paul Bauman, USGS/OSU
Dr. Allan Burton, Wright State U

Significant Point Sources Present in Segment:

NPDES	Name
3PD00034	City of Elyria WWTP
3ID00028	USS/Kobe Steel
3PE00005	City of Lorain Eastside WWTTP

Significant Nonpoint Sources in Segment:

Name	Description
USS Kobe	Slag Piles
D2	Landfill

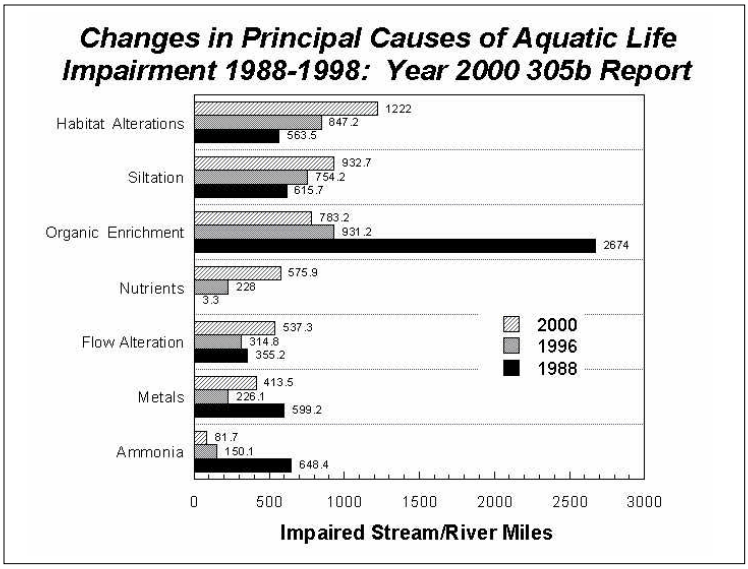
Summary Narrative Description of Status/Causes/Sources in Segment [If you can't fit it in this box, then you've written too much!]

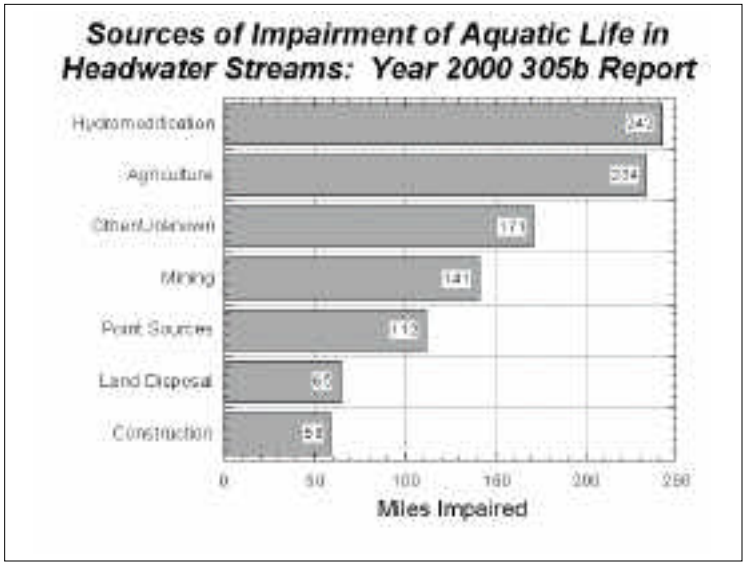
Pollutant loadings in the lacustrine portion of the river contribute to anoxia. Residual and current sources of toxics including metals and PAHs continue to impair aquatic life in the Black River.

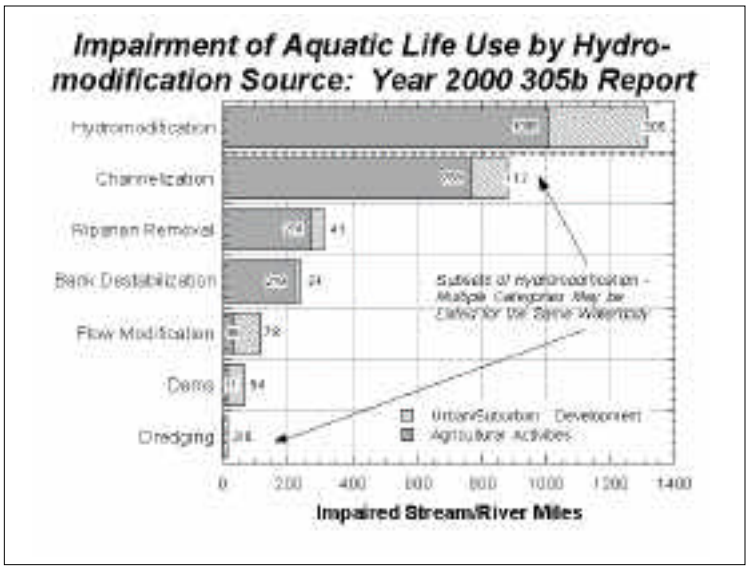
CSOs and SSOs in Elyria contribute to the impairment in the free flowing section of the mainstem, as well as contribute organic loading to the lacustrine portion.

Back Side

Measurable Parameters of Watershed Health: 305[b] Reporting







Ohio is a water-rich state with more than 25,000 miles of named and designated streams and rivers and a 451-mile border on the Ohio River. The suitability of these waters for beneficial uses (e.g., recreation and drinking water) and to maintain healthy ecological conditions or "biological integrity" (a key goal of the Clean Water Act) is important to Ohio's economy and standard of living.

Ohio EPA uses multiple chemical, physical, and biological measures to assess the health and integrity of surface water resources. The biological measures are emphasized because the fish and invertebrates that comprise this measure serve as living indicators of the health and well-being of Ohio's waterways. They also serve as a direct measure of the biological integrity goal of the Clean Water Act. These organisms are sensitive indicators of water pollution because they inhabit the water all of the time and all aspects of their life cycles are dependent on water. A healthy fish or invertebrate community is also associated with high quality recreational opportunities (e.g., fishing, swimming, canoeing, etc.).

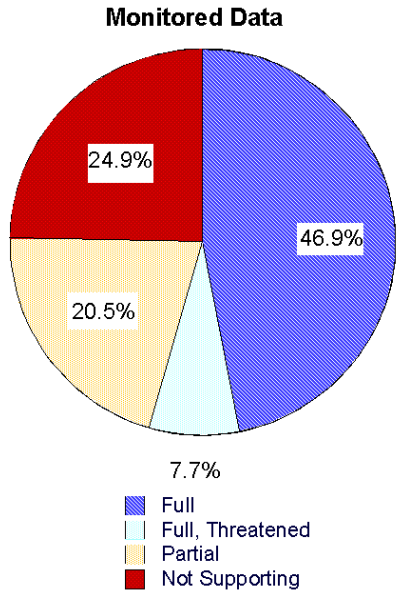


Figure 1. This pie chart summarizes the current cumulative aquatic life use attainment status for monitored-level data from the 1988-2000 assessment cycles.

Ohio's goal is for 80% of stream and river miles to fully meet the applicable aquatic life goals and standards (called "uses") by the year 2010. Progress towards this goal is tracked by this report. The statistics reported here indicate that just over one-half (54.6%) of the streams and rivers that have been monitored and data is considered current by Ohio EPA are fully supporting their applicable aquatic life use designation (Figure 1). This means that more than one-half of Ohio's streams and rivers harbor good or exceptional quality assemblages of aquatic life. Statistics for the most recent two-year reporting cycle alone (representing data collected in 1997-98) showed 52.3% of streams and rivers meeting uses (dotted line on Figure 2) which is a break in the trend of increasing attainment that has been observed since 1994. There are multiple factors that are responsible for this change. Almost all of the improvement noted in these statistics since 1988 (Figure 2) is the result of the abatement of the point source impacts dating from before the 1970s and 1980s that were the original impetus for the Clean Water Act. Reducing the effects of these sources was amenable to the type of permitting and funding assistance that was widely available in the 1980s. The remaining point and nonpoint source impacts present greater challenges and thus a leveling off of the comparatively rapid rate of restoration seen between 1988 and 1998 was

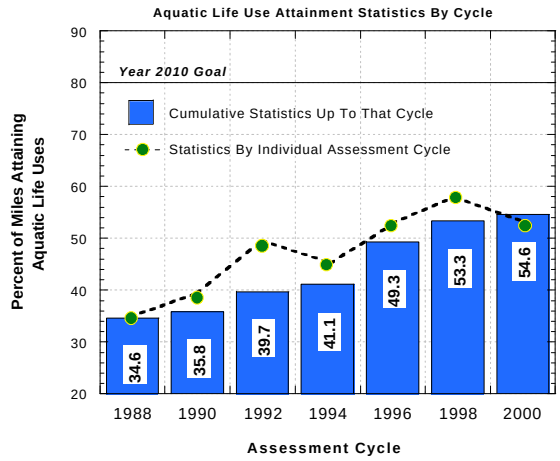


Figure 2. This bar chart summarizes the aquatic life use attainment statistics cumulatively up to each two-year cycle from 1988 to 2000. Statistics for each assessment cycle alone are illustrated by the dotted line. The individual 2000 cycle reflects data collected in 1997 and 1998, the 1998 cycle data collected from 1995 and 1996, etc.

TMDL Program

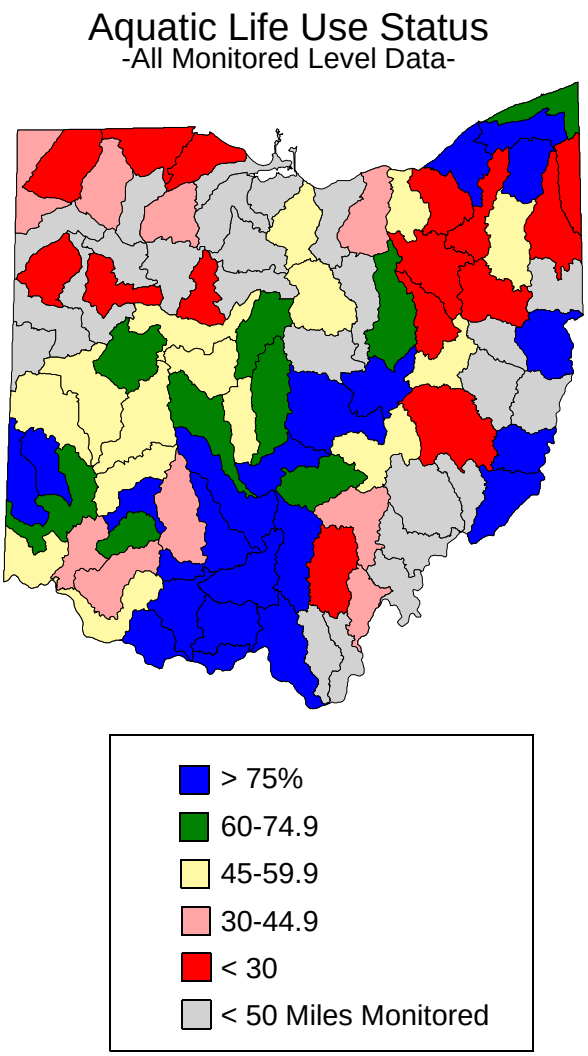
The TMDL process will be used as a starting point to restore impaired waters. This includes nonpoint (NPS) impairments as well as the remaining point source related impacts. TMDL stands for "Total Maximum Daily Load" and is mandated by the Clean Water Act. The objective of a TMDL is to derive the loadings of pollutants that a water body can receive and maintain "water quality standards" (i.e., that needed to protect and restore aquatic life and other uses). The data and statistics presented here are the basis for Ohio's list of impaired waters that need restoration and/or protection to meet and maintain standards. The analysis involved in developing a TMDL represents a key component of the strategic focus that is needed to restore degraded waters and make progress towards the goal of 80% full attainment by 2010.

expected. An increasingly greater proportion of the remaining impairment is associated with nonpoint sources, which includes polluted runoff (such as sediment, nutrients, and toxic chemicals), habitat modification and destruction, and alteration of flow regimes, that have always been present during the past 20 years, but in which there has been comparatively little progress in abating. Other factors contributing to the decline includes a shift to monitoring a larger number of small streams, spatial bias in where monitoring is conducted each year, and formerly attaining streams and rivers which have since become impaired. Small, headwater streams are the most common stream type in Ohio (80% of streams drain <20 sq. mi.) and are the primary interface between nonpoint source pollutants and watersheds. These streams tend to be proportionately more impaired than larger streams and rivers.

Addressing the impairments in these streams will be crucial to the success of the TMDL program (see inset). More detailed analysis of this information is available in a companion fact sheet (Fact Sheet FS-3-EAS-2000).

Map 1 illustrates the variation in attainment of aquatic life uses in Ohio streams and rivers across the state. Some subbasins (central, south-central, far northeast) are approaching or have exceeded 75% of assessed miles in full attainment while others are far below that threshold (much of northwest Ohio, most urban subbasins).

The list of impaired waters generated by the 305b report and the assignment of causes and sources associated with the impairments will be the basis for developing restoration requirements over the next 10-15 years (see TMDL process sidebar). Ohio EPA's monitoring and assessment program, supplemented by newly developed tools, will provide a method for determining whether pollution abatement strategies are working and whether public or private dollars are having the intended effect.



Map 1. Map illustrating aquatic life use attainment status in Ohio subbasins based on monitor-level data (data that is considered current and meets QA/QC standards).

As such this process serves as a feedback loop which documents the efficacy of our combined efforts, provides information about new or emerging problems, and ensures that the progress made over the past 20 years continues.

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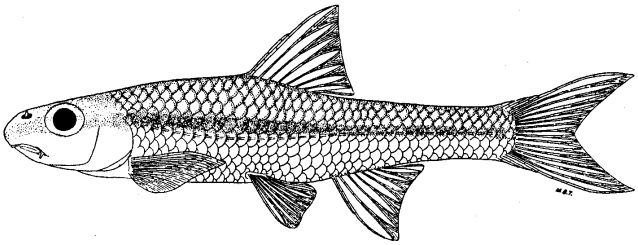
This and other publications are available on the Division of Surface Water Web Site:

http://chagrin.epa.state.oh.us/



Bigeye chub - a species sensitive to NPS pollutants such as sediment

Ohio's streams and rivers have substantially improved in quality over the past 10-15 years. The majority of this improvement has been the result of improvements in the quality of municipal waste-water treatment discharges across Ohio.

Ohio EPA uses multiple chemical, physical, and biological measures to assess the health and integrity of surface water resources. The biological measures are emphasized because the fish and invertebrates that comprise this measure serve as living indicators of the health and well-being of Ohio's waterways. They also serve as a direct measure of the biological integrity goal of the Clean Water Act. These organisms are sensitive indicators of water pollution because they inhabit the water all of the time and all aspects of their life cycles are dependent on water. A healthy fish or invertebrate community is also associated with high quality recreational opportunities (e.g., fishing, swimming, canoeing, etc.).

Causes of impairment are the "agents" that actually damage or impair the aquatic life in a stream, such as the toxic effects of heavy metals or acidic water. **Sources** of impairment are the origin of the agent. For example, an industry may discharge a heavy metal, a farm may erode topsoil, or a coal mine may be the source of acid water leaching into a stream.

In addition to biological data, Ohio EPA also collects information on the chemical quality of the water, sediment and effluents; data on the contaminants in fish flesh; and data on the physical nature of streams (*i.e.*, aquatic habitat, siltation). This data is essential to identify the factors that are limiting or impair aquatic life and which constitute threats to human health.

Describing the causes and sources associated with the impairments revealed by the biological data and linking this with pollution sources involves an interpretation of multiple lines of evidence including water and sediment chemistry data, habitat data, effluent data, biomonitoring results, land use data, and response signatures within the biological data itself. The assignment of *principal* causes and sources of impairment represents the association of impairments (defined by the biological response) with stressor and exposure indicators (e.g., chemical and physical data).

Leading Causes

The leading causes of impairment in Ohio streams and rivers are listed in Figure 1. Although the leading cause had been organic enrichment

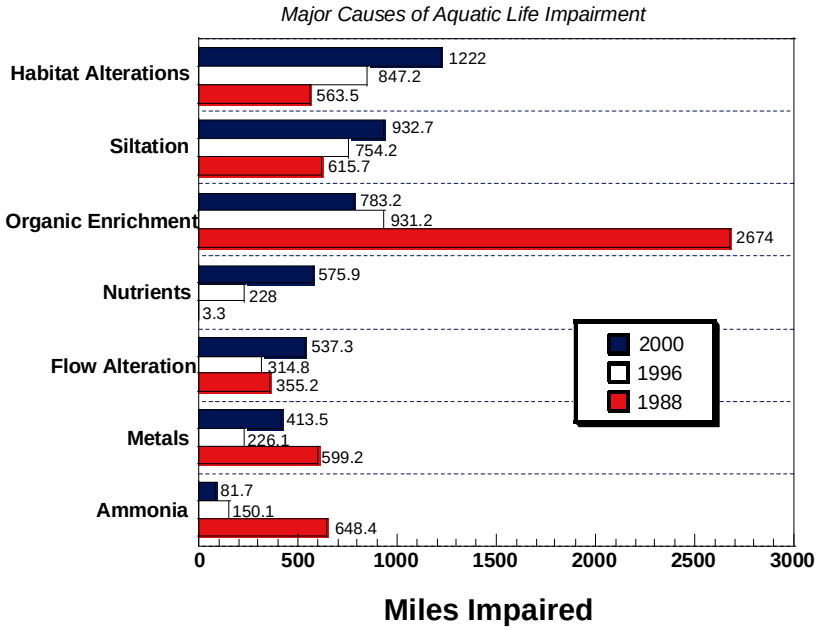


Figure 1. Changes in major causes of aquatic life use impairment in Ohio streams and rivers over the past three 305(b) assessment cycles: 1988, 1996, and 2000. These represent the water years 1980-87, 1993-94, and 1997-98.

and low dissolved oxygen up until 1996, habitat degradation and sedimentation are now the leading causes of impairment. Habitat refers to the physical character of a stream or river which is necessary to supporting aquatic life. Many human activities can directly or indirectly degrade habitat, thus making it less suitable for aquatic life. Aquatic life is especially dependent on intact instream habitat and the adjacent vegetated riparian habitat as are many other forms of wildlife. Ohio is not unique in this regard. The National Academy of Sciences (National Research Council 1992) recognized the devastation of riparian and instream habitats and recommended that 400,000 miles of river-riparian ecosystems be restored over the next 20 years. The mosaic of intact instream and riparian habitats is also critical to a stream or watershed maintaining the capacity to intercept and assimilate nonpoint source runoff, particularly nutrients and sediment. This ensures that high quality water and biological resources are "exported" to downstream reaches and larger receiving water bodies.

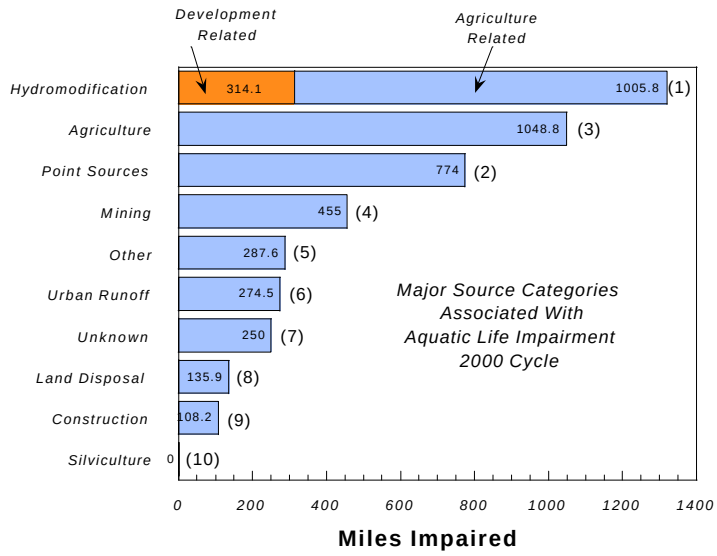


Figure 2. Major sources associated with aquatic life use impairment in Ohio streams and rivers and considered current for the 2000 assessment cycle (data collected as of 1998). Numbers in parentheses are ranks from the 1998 assessment cycle.

Point Sources

Impairments from organic enrichment and low dissolved oxygen largely originated from the inadequate treatment of municipal wastewater (a "point source"). These have been the most rapidly declining causes of impairment since 1988. In 2000 point sources, as a principal source of impairment, declined to 8.7% of impaired stream miles from 41.7% in 1988 (Fact Sheet FS-3-EAS-2000).

Point source-related *causes* of impairment have also declined since 1988. Ammonia, a toxic component of municipal wastewater and the second leading cause of impairment in 1988 (responsible for 648 miles of impairment), dropped to tenth in 2000 (82 miles; Figure 1). This dramatic improvement resulted from the construction of new and upgraded sewage treatment facilities in the 1980s at a cost of approximately $6 billion across Ohio. Heavy metals as a principal cause of impairment showed a less dramatic decline since 1988 (Figure 1).

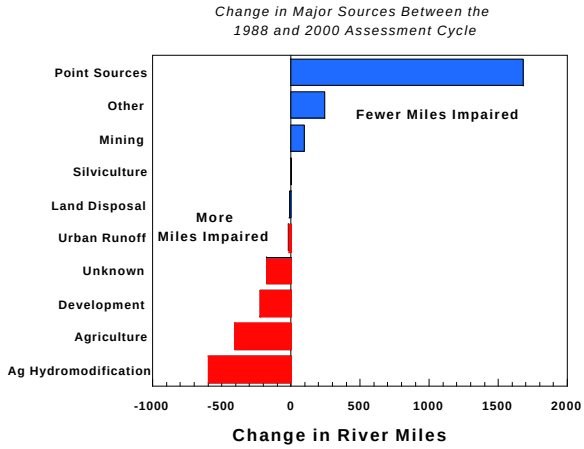


Figure 3. Change in major source categories associated with aquatic life use impairment in Ohio streams and rivers between the 1988 and the 2000 assessment cycles.

Nonpoint Sources: Leading Sources of Impairment in Ohio

The major sources of aquatic life impairment are illustrated in Figure 2. Hydromodification is now the leading source of impairment and is the origin of habitat degradation and sedimentation problems that are now the top two leading *causes* of impairment. These are termed "nonpoint sources" because they do not emanate from pipes or other discrete conveyances, but instead are the result of land disturbance activities or direct modifications of stream ecosystems. In 2000 we initiated a more detailed analysis of hydromodification by more precisely delineating the origin (e.g., associated with development or agricultural activities, etc.). Urban and suburban development associated hydromodification was responsible for 23.8% of the impairment attributed to hydromodification (Figure 2). Combined with the construction category, development is the fifth ranked source of impairment behind mining. Development-related activities are also the highest

ranked threat to fully attaining streams and rivers.

Point sources of impairment have declined the most since 1988 when we began tracking it in this manner. At that time point sources were a major source in 2,453 miles of rivers and streams versus 777 miles in 2000. Figure 3 summarizes these changes for the leading source categories. Increases in agriculture and related hydromodification does not mean that these sources have worsened, rather they were previously overshadowed by now corrected point source impacts. It is these remaining nonpoint source impacts that will provide the primary restoration challenge for the TMDL process.

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Citation

National Research Council. 1992. Restoration of aquatic ecosystems: science, technology, and public policy. Committee on Restoration of Aquatic Ecosystems: Science, Technology, and Public Policy. National Academy Press, Washington, D.C.

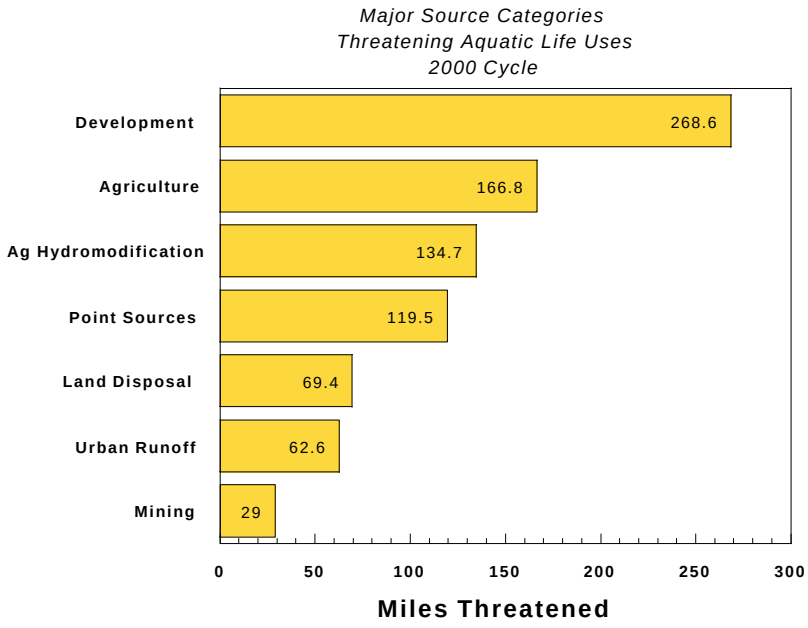
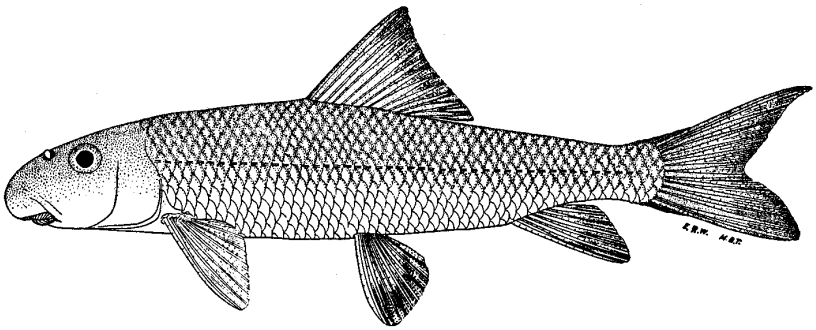
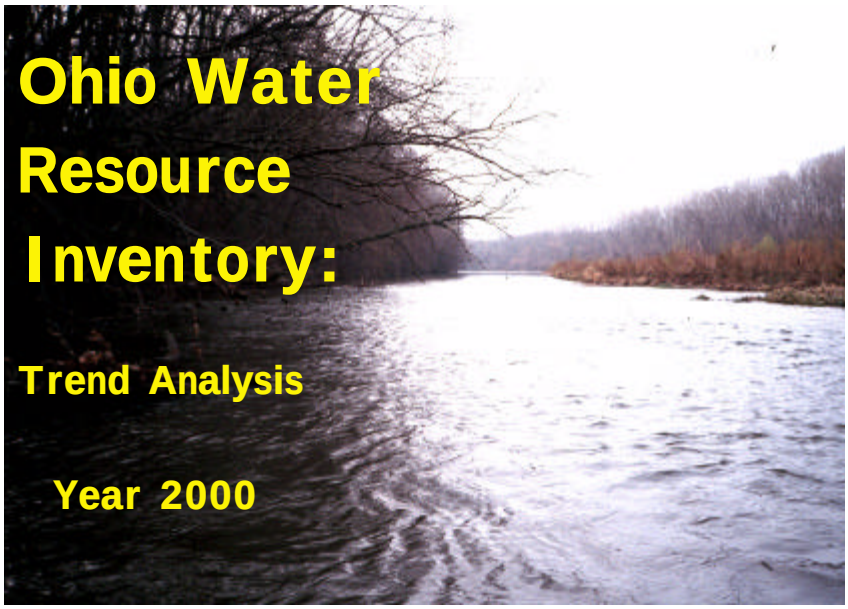


Figure 4. Major sources threatening aquatic life use attainment in Ohio streams and rivers and considered current for the 2000 assessment cycle (data collected as of 1998).



Black Redhorse - Moxostoma duquesnei (Lesueur)
An intolerant species found in medium to large streams and rivers that feeds on insects and invertebrates and is sensitive to the causes of impairment that predominate in Ohio waters (e.g., sedimentation, habitat destruction, nutrient enrichment)



Ohio EPA has been assessing the quality of rivers and streams for nearly 25 years. Each river or stream in Ohio has one of four aquatic life use goals (termed "uses") that vary with the ecological potential of that waterway. Monitoring and assessment results are used to track attainment of these goals and this is detailed in the Ohio Water Resource Inventory. The results of the year 2000 report are summarized in this and two companion fact sheets.

Numerous Ohio stream and river segments have been reassessed following the implementation of point source controls to meet water quality standards in the 1970s and 1980s. One benefit of the monitoring approach employed by Ohio EPA is the ability to forecast potential water quality changes into the future. A major challenge facing the Ohio EPA water programs is the goal of achieving full support of aquatic life uses in 80% of Ohio's streams and rivers by the year 2010 (Ohio 2010 Goal). In order to determine if existing programs are likely to achieve this goal, we attempted to look ahead based on past trends in the process of restoring impaired waters. The first of these forecast analyses was accomplished in 1994, and updated biennially thereafter The rate of restoration based on results observed between 1988 and 1998 (Figure 1) was 2.2% impaired miles restored per year (range: 0.9-3.8% per year). This has largely been the product of point source abatement efforts that took place in the 1970s and 1980s (see Figure 3). The results of the 2000 forecast analysis indicate a slowing in the rate of restoration to less than 2% (Figure 1). This was not entirely unexpected since the proportion of point source related impairments has been declining, presently comprising less than 10% of impaired waters. It is likely that the trend over the next several biennial assessment cycles will continue to level off until additional progress is realized in abating nonpoint sources of impairment, which comprise more than 80% of the current impairment. Even if immediate progress is made in dealing with these sources, the inherently longer recovery time from nonpoint source impacts will result in the slowing of the rate of restoration in the future.

Ohio 2010 Goals:	
Aquatic Life Uses	
2010 Goal:	80%
2010 Forecast:[1]	60.0%
2000 Forecast:	61.7%
2000 Actual:[2]	52.3%

[1] Assuming Asymptotic Trend
[2] 97/98 Water Years

Slowing Rate of Restoration

It is important to understand the basis for the trend assessment and to recognize what in the forecast analysis is real and how much is statistical "noise". The data used in the trend and forecast analyses are generated by the watershed assessments that comprise the five-year basin approach. This effort employs a targeted, intensive watershed survey design. While it is driven by the need to provide site-specific information for a variety of water quality management purposes (e.g., is a

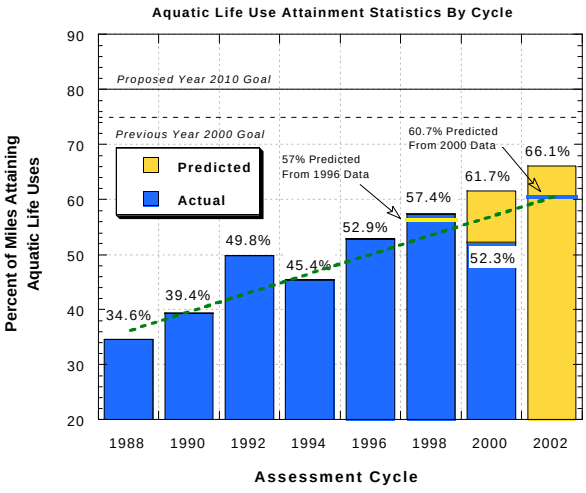


Figure 1. Aquatic life use attainment trend prediction based on 1988-1998 assessment cycles.

particular treatment plant effective? is the designated aquatic life use appropriate? should we commit abatement resources to this water body? *etc.*), it also provides a growing database from which aggregate statistics like those featured in this report can be derived. Comparisons of this approach to a statistically random stream sampling design (1996 REMAP project) validate its ability to provide reliable statewide estimates of quality and trends in quality. As such, it provides a reasonable estimate of the condition of all of Ohio's rivers and streams using a subsample of assessed streams and rivers.

Potential Factors: Stream Size, Declines in Attainment, and Spatial Bias

The 2000 results for the data years 1997 and 1998 showed that 52.3% of the assessed miles were in full attainment. This was 5.1% less than the 57.4% result reported in 1998 (data years 1995 and 1996). It also represented a break in the trend of steadily increasing full attainment observed since 1988 and was significantly different from that predicted by the 1998 forecast analysis (Figure 1). A major question raised by these results is whether the observed change in the rate of restoration can be attributed to real changes in environment quality, whether it is within or outside of the range of expected deviation, or some combination of these factors. Several factors were examined to determine the extent of their influence on the changes in the rate of restoration and the forecast analysis. Several factors, in addition to an anticipated leveling off of the restoration rate, were identified as potentially being responsible for the 5.1% difference between the 1998 and 2000 two-year results. *It is important to understand that we are concerned with changes in recent trends, recognizing that the aggregate database (1988-2000) showed an overall improvement.*

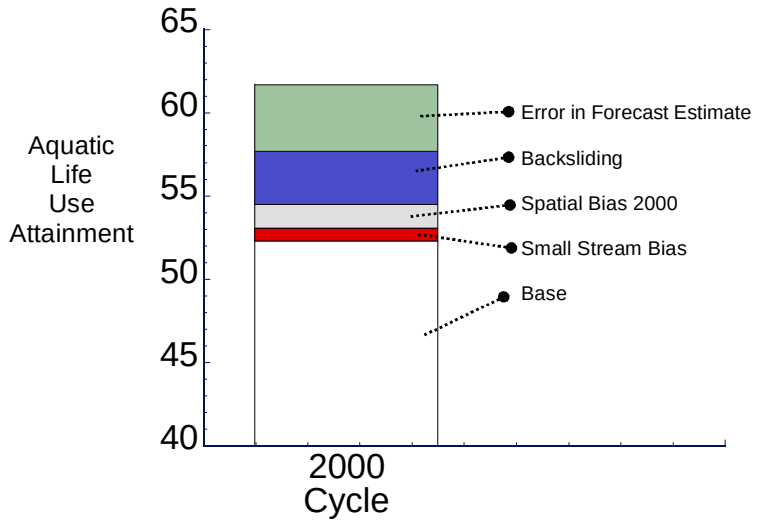


Figure 2. The attainment statistics for the 2000 assessment cycle and the estimated apportioning of deviation from the projected trend based on the 1988-1998 assessment data.

Stream Size

The inclusion of proportionately more small streams in our basin assessments beginning in 1998 was identified as one factor potentially affecting the 2000 results. When the 2000 statistics are stratified by stream size ranges, the inclusion of more small streams had only a minor effect on the overall statistics and were similar to the 1998 results for small streams. The contribution of this factor was less than 1% (Figure 2).

Spatial Bias: Postponing Selected Basin Assessments

The five-year basin approach intends that watersheds will be regularly assessed and reassessed on a 5-10 year cycle. The resulting database forms the basis for the biennial 305b statistics and the forecast analysis. In 1998, the TMDL development commitment resulted in some

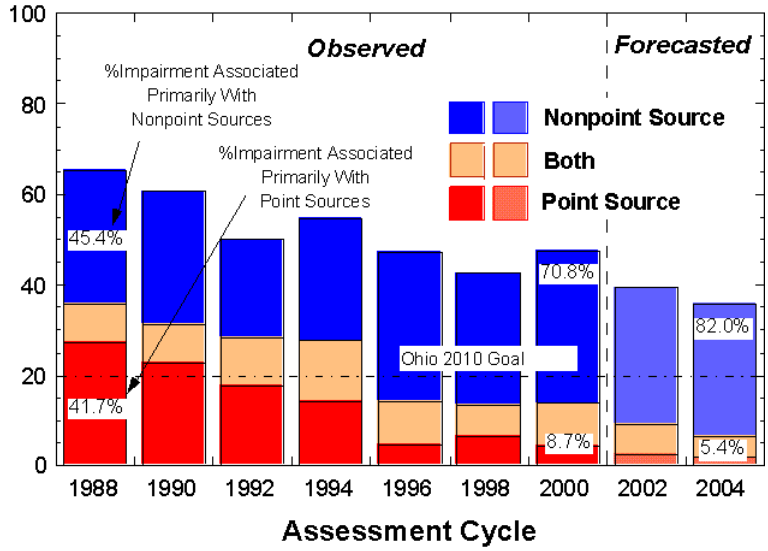


Figure 3. Trend in non-attainment of aquatic life uses in Ohio streams and rivers and illustrating the percent of non-attainment due to point sources, nonpoint sources, or a combination of point and nonpoint sources.

previously scheduled watershed reassessments being postponed. This shift towards monitoring TMDL targeted watersheds could potentially induce a spatial bias to the biennial results by: 1) providing proportionately more data from impaired watersheds; and, 2) not including data from watersheds with proportionately higher levels of full attainment.

Map 1 illustrates the 2000 cycle aquatic life attainment statistics by subbasin where at least 25 stream and river miles were assessed. Three high quality subbasins (Big Darby Creek, Kokosing River, Salt Creek) scheduled for reassessment in 1997 and 1998 were bypassed for the aforementioned reasons. In order to examine the potential effect of this on the 2000 statistics, the previous assessment results were carried forward and used to recalculate the 2000 attainment statistics. The addition of this information added 1.4% to the 2000 cycle aquatic life attainment statistics, which is approximately one-fourth of the 5.1% change from 1998 to 2000 (Figure 2).

Declining Attainment

On average, in reaches where we have sampled during a previous assessment cycle there has been a trend of improving attainment statistics when the earliest versus latest data were compared. Generally this entails comparison of pre-1988 surveys with post-1988 results, which comprises the information for the Ohio 2010 goal tracking and the forecast analysis. The 1988 year is an important threshold as it represents the deadline for municipal wastewater treatment plants being in compliance with water quality-based permit limitations. Increasingly, data is available to compare the results of assessments and reassessments conducted since 1988, thus assessing the maintenance of the post-1988 gains in full attainment. Approximately 16% of these resampled reaches in 1997 and 1998 showed declines in miles attaining and an increases in miles impaired. The total miles that declined (105.3 miles) contributed 3.2% to the 5.1% change between 1998 and 2000 (nearly two-thirds) and was the greatest of the factors examined (Figure 2). Most of the decline in formerly attaining waters occurred in the Little Miami River and East Fork Little Miami River, both EWH designated rivers. It will be important in the future to determine if similar high quality rivers with major point sources and a relatively high proportion of effluent flow show similar results.

Conclusions

All of the factors examined had measurable effects on the 2000 results and the changes noted from 1998. Of these, declines in attainment status associated with point sources was the largest factor, followed by spatial bias in watershed selection, and stream size. However, these factors combined accounted for just over one-half of difference between the 2000 results and the forecast analysis of 1998. The most reasonable interpretation of the data presented here is that the trend of consistent linear increase over the past decade is in reality leveling off and that the progress made in abating point source pollution the 1970s and 1980s has essentially been accounted for in the 305b database. This conclusion is supported by examining the changes in impairment where point sources are the sole problem (Figure 3). The trend in these statistics leveled off between the 1996 and 2000 assessment cycles compared to the greater improvements noted in the 1988 to 1994 cycles. It seems likely that the attainment statistics will level off between 55-60% until the remaining sources of impairment are addressed and those results become evident in the statistics. The TMDL process and other management and funding programs will assume much significance over the next decade if we are to resume the trend of restoration we observed during the 1980s.

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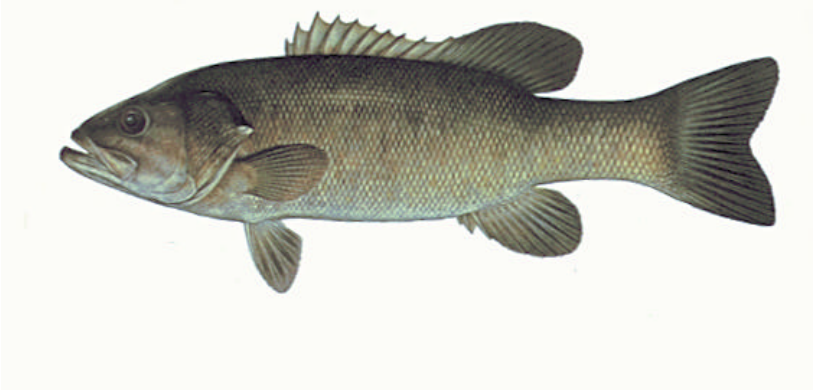


Populations of smallmouth bass, a premier sport fish in Ohio rivers and streams, would benefit from the abatement of nonpoint causes of impairment such as habitat, sediment, and nutrients identified in the Ohio Water Resource Inventory.

Measurable Parameters of Ecosystem Health: Habitat Assessment/Use Attainability Analysis

The Qualitative Habitat Evaluation Index (QHEI)

QHEI Includes Six Major Categories of Macrohabitat

- Substrate - types, origin, quality, embeddedness
- Instream Cover - types and amounts
- Channel Quality - sinuosity, development, stability
- Riparian/Bank Stability - width, quality, bank erosion
- Pool/Riffle/Run - max. depth, current types, morphology, substrate embeddedness
- Gradient - local gradient (varies by drainage area)

Source: The Qualitative Habitat Evaluation Index (Rankin 1989)

QHEI: Qualititave Habitat Evaluation Index

- Visual method of measuring habitat quality
- Aid in designating aquatic life uses
- Aid in assessing causes of impacts
- Correlated with biological integrity
- Depends on standardized definitions of habitat types (training is very important)
- Reach-level habitat conditions also important (*i.e.*, “covariate” to QHEI)

Qualitative Habitat Evaluation Index Field Sheet QHEI Score: ____

River Code:_____RM: _____ Stream_____

Date_____ Location_____

Scorers Initials:_____ Comments_____

1] SUBSTRATE (Check *ONLY* Two Substrate *TYPE BOXES; Estimate % present*);

TYPE	POOL	RIFFLE	TYPE	POOL	RIFFLE
❒ ❒-BLDR /SLBS[10]	____	____	❒ ❒-GRAVEL [7]	____	____
❒ ❒-BOULDER [9]	____	____	❒ ❒-SAND [6]	____	____
❒ ❒-COBBLE [8]	____	____	❒ ❒-BEDROCK[5]	____	____
❒ ❒-HARDPAN [4]	____	____	❒ ❒-DETRITUS[3]	____	____
❒ ❒-MUCK [2]	____	____	❒ ❒-ARTIFICIAL[0]	____	____
❒ ❒-SILT [2]	____	____			

NOTE: (Ignores sludge originating from point-sources; score on natural substrates)

NUMBER OF SUBSTRATE TYPES: ❒-5 or More [2] ❒-4 or Less [0]

SUBSTRATE ORIGIN Check ONE (OR 2 & AVERAGE)

❒ -LIMESTONE [1]
❒ -TILLS [1]
❒ -WETLANDS[0]
❒ -HARDPAN [0]
❒ -SANDSTONE [0]
❒ -RIP/RAP [0]
❒ -LACUSTRINE [0]
❒ -SHALE [-1]
❒-COAL FINES [-2]

SUBSTRATE QUALITY Check ONE (OR 2 & AVERAGE)

SILT:
❒ -***SILT HEAVY [-2]***
❒ -SILT MODERATE [-1]
❒ -SILT NORMAL [0]
❒ -SILT FREE [1]

EMBEDDEDNESS:
❒ -EXTENSIVE [-2]
❒ -MODERATE [-1]
❒ -NORMAL [0]
❒ -NONE [1]

Substrate ____ Max 20

COMMENTS_____

2] INSTREAM COVER (see back for instructions for additional cover scoring method)

TYPE: **(Check *All* That Apply)**

❒ ___UNDERCUT BANKS [1]
❒ ___OVERHANGING VEGETATION [1]
❒ ___SHALLOWS (IN SLOW WATER) [1]
❒ ___ROOTMATS [1]
❒ ___POOLS> 70 cm [2]
❒ ___ROOTWADS [1]
❒ ___BOULDERS [1]
❒ ___OXBOWS, BACKWATERS [1]
❒ ___AQUATIC MACROPHYTES [1]
❒ ___LOGS OR WOODY DEBRIS [1]

COMMENTS:_____

AMOUNT: **(Check *ONLY* One or check 2 and *AVERAGE*)**

❒ - EXTENSIVE > 75% [11]
❒ - MODERATE 25-75% [7]
❒ - SPARSE 5-25% [3]
❒ - NEARLY ABSENT < 5%[1]

Cover ____ Max 20

3] CHANNEL MORPHOLOGY: (Check *ONLY* One PER Category OR check 2 and *AVERAGE*)

SINUOSITY	DEVELOPMENT	CHANNELIZATION	STABILITY	MODIFICATIONS/OTHER	
❒ - HIGH [4]	❒ - EXCELLENT [7]	❒ - NONE [6]	❒ - HIGH [3]	❒ - SNAGGING	❒ - IMPOUND.
❒ - MODERATE [3]	❒ - GOOD [5]	❒ - RECOVERED [4]	❒ - MODERATE [2]	❒ - RELOCATION	❒ - ISLANDS
❒ - LOW [2]	❒ - FAIR [3]	❒ - RECOVERING [3]	❒ - LOW [1]	❒ - CANOPY REMOVAL	❒ - LEVEED
❒ - NONE [1]	❒ - POOR [1]	❒ - RECENT OR NO RECOVERY [1]		❒ - DREDGING	❒ - BANK SHAPING
				❒ - ONE SIDE CHANNEL MODIFICATIONS	

Channel ____ Max 20

COMMENTS:_____

4]. RIPARIAN ZONE AND BANK EROSION-(check ONE box per bank or check 2 and AVERAGE per bank) ★River Right Looking Downstream★

RIPARIAN WIDTH — L R **(Per Bank)**
❒ ❒ -WIDE > 50m [4]
❒ ❒ - MODERATE 10-50m [3]
❒ ❒ -NARROW 5-10 m [2]
❒ ❒ - VERY NARROW <5 m[1]
❒ ❒ - NONE [0]

FLOOD PLAIN QUALITY (*PAST 100 Meter RIPARIAN*) — L R **(Most Predominant Per Bank)**
❒ ❒-FOREST, SWAMP [3]
❒ ❒-SHRUB OR OLD FIELD [2]
❒ ❒-RESIDENTIAL,PARK,NEW FIELD [1]
❒ ❒ -FENCED PASTURE [1]
❒ ❒-CONSERVATION TILLAGE [1]
❒ ❒ -URBAN OR INDUSTRIAL [0]
❒ ❒ -OPEN PASTURE,ROWCROP [0]
❒ ❒ -MINING/CONSTRUCTION [0]

BANK EROSION — L R **(Per Bank)**
❒ ❒ -NONE/LITTLE [3]
❒ ❒ -MODERATE [2]
❒ ❒ -HEAVY/SEVERE[1]

Riparian ____ Max 10

COMMENTS:_____

5.]POOL/GLIDE AND RIFFLE/RUN QUALITY

MAX. DEPTH **(Check 1 ONLY!)**
❒ - >1m [6]
❒ - 0.7-1m [4]
❒ - 0.4-0.7m [2]
❒ - 0.2- 0.4m [1]
❒ - < 0.2m [POOL=0]

MORPHOLOGY **(Check 1 or 2 & AVERAGE)**
❒ -POOL WIDTH > RIFFLE WIDTH [2]
❒ -POOL WIDTH = RIFFLE WIDTH [1]
❒ -POOL WIDTH< RIFFLE W. [0]

CURRENT VELOCITY [**POOLS & RIFFLES!**] **(Check *All* That Apply)**
❒ -EDDIES[1]
❒ -FAST[1]
❒ -MODERATE [1]
❒ -SLOW [1]
❒ -TORRENTIAL[-1]
❒ -INTERSTITIAL[-1]
❒ -INTERMITTENT[-2]

Pool/Current ____ Max 12

COMMENTS:_____

CHECK ONE OR CHECK 2 AND AVERAGE

RIFFLE DEPTH
❒ -*Best Areas >10 cm [2]
❒ - Best Areas 5-10 cm[1]
❒ - Best Areas < 5 cm [RIFFLE=0]

RUN DEPTH
❒ - MAX > 50 [2]
❒ - MAX < 50[1]

RIFFLE/RUN SUBSTRATE
❒-STABLE (e.g.,Cobble, Boulder) [2]
❒-MOD. STABLE (e.g.,Large Gravel) [1]
❒-UNSTABLE (Fine Gravel,Sand) [0]

RIFFLE/RUN EMBEDDEDNESS
❒ - NONE [2]
❒ - LOW [1]
❒ - MODERATE [0]
❒ - EXTENSIVE [-1]

Riffle/Run ____ Max 8

COMMENTS:_____ ❒ - NO RIFFLE [Metric=0]

Gradient ____ Max 10

6] GRADIENT (ft/mi): _____ **DRAINAGE AREA (sq.mi.)**:_____

%POOL: ____ %GLIDE: ____
%RIFFLE: ____ %RUN: ____

*Best areas must be large enough to support a population of riffle-obligate fish species.

Is Sampling Reach Representative of the Stream (Y/N)___ If Not, Explain: _____

_____

_____

_____

_____

Major Suspected Sources of Impacts (Check All That Apply):

- None ❒
- Industrial ❒
- WWTP ❒
- Ag ❒
- Livestock ❒
- Silviculture ❒
- Construction ❒
- Urban Runoff ❒
- CSOs ❒
- Suburban Impacts ❒
- Mining ❒
- Channelization ❒
- Riparian Removal ❒
- Landfills ❒
- Natural ❒
- Dams ❒
- Other Flow Alteration ❒
- Other:_____ ❒

	Gear:	Distance:	Water Clarity:	Water Stage:	Canopy -% Open
First Sampling Pass	_____	_____	_____	_____	_____

Subjective Rating (1-10)

Aesthetic Rating (1-10)

Gradient:
❒ - Low, ❒ - Moderate, ❒ -High

Stream Measurements:

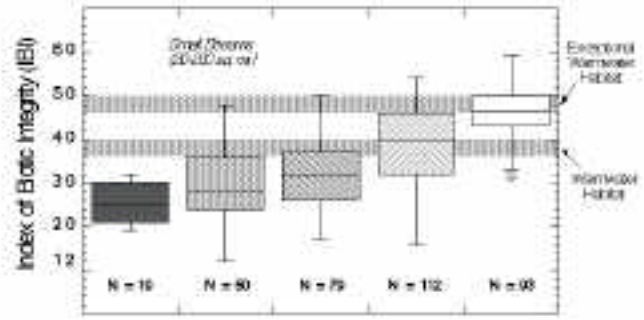
Average Width	Average Depth	Maximum Depth	Av. Bankfull Width	Bankfull Mean Depth	W/D Ratio	Bankfull Max Depth	Floodprone Area Width	Entrench. Ratio

Stream Drawing:

Instructions for Scoring the Alternate Cover Metric: Each Cover Type Should Receive a Score of Between 0 and 3, Where: 0 - Cover type absent; 1 - Cover type present in very small amounts or if more common of marginal quality; 2 - Cover type present in moderate amounts, but not of highest quality or in small amounts of highest quality; 3 - Cover type of highest quality in moderate or greater amounts. Examples of highest quality cover include very large boulders in deep or fast water, large diameter logs that are stable, well developed rootwads in deep/fast water, or deep, well-defined, functional pools.

Measurable Parameters of Watershed Health: Habitat/UAA

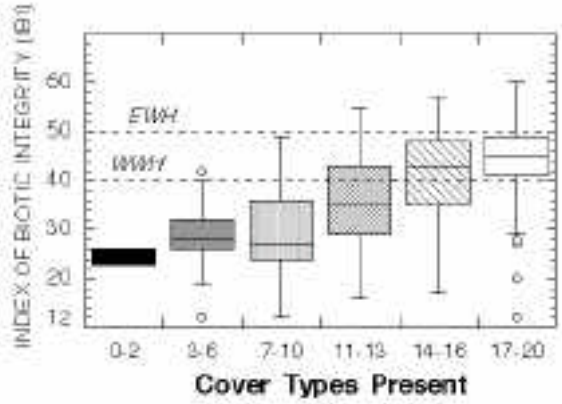
BIOLOGICAL CONDITION IS CORRELATED WITH HABITAT QUALITY: IBI



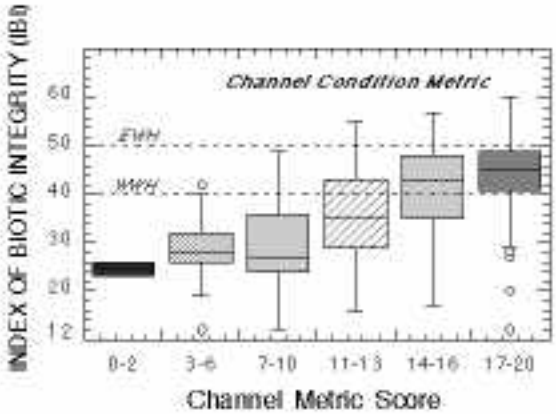
<30	30-44	45-59	60-74	>75
(V. Poor)	(Poor)	(Fair-Good)	(Good)	(Excellent)

Q H E I

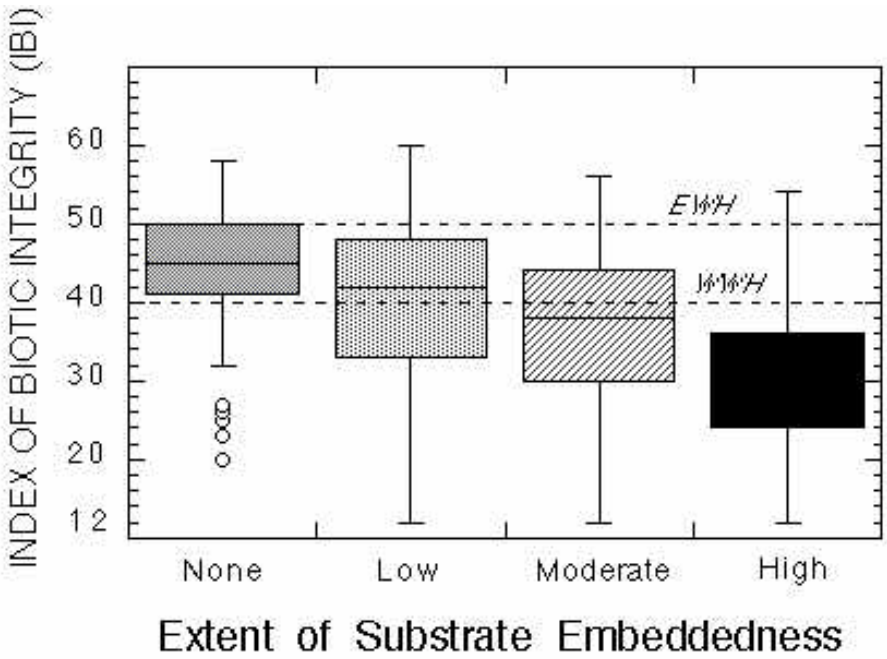
Abundance of Cover Types Affects the Ability to Meet Designated Uses



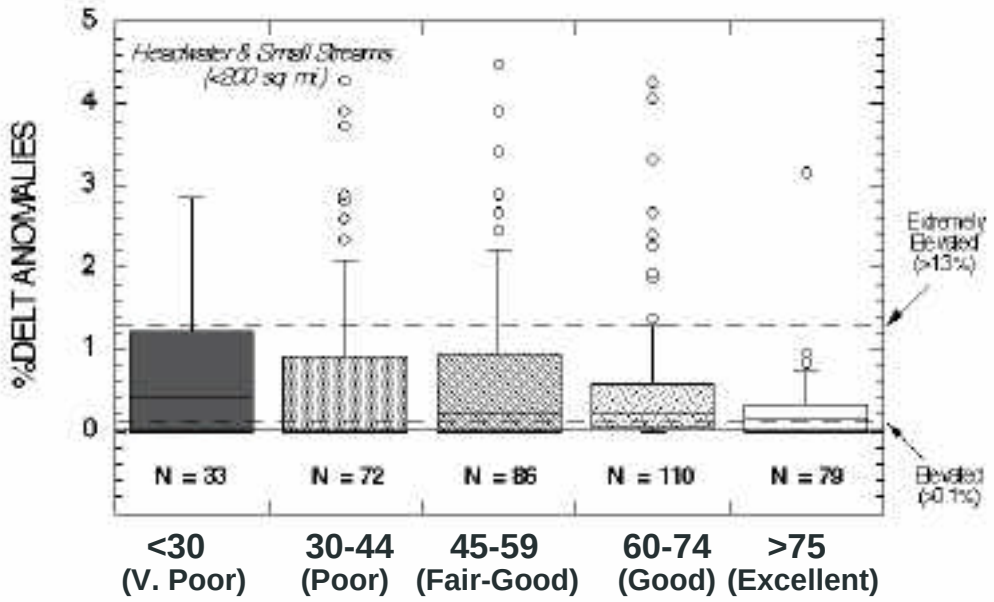
Channel Condition Affects the Ability to Meet Designated Uses



Substrate Condition Affects the Ability to Meet Designated Uses



BIOLOGICAL CONDITION IS CORRELATED WITH HABITAT QUALITY: DELT Anomalies



Key QHEI Components

			WWH Attributes											MWH Attributes																		
														High Influence					*Moderate Influence*													
River Mile	QHEI	Gradient (ft/mile)	No Channelization or Recovered	Boulder/Cobble/Gravel Substrates	Silt Free Substrates	Good/Excellent Substrates	Moderate/High Sinuosity	Extensive/Moderate Cover	Fast Current/Eddies	Low-Normal Overall Embeddedness	Max Depth > 40 cm	Low-Normal Riffle Embeddedness	**Total WWH Attributes**	Channelized or No Recovery	Silt/Muck Substrates	No Sinuosity	Sparse/No Cover	Max Depth < 40 cm (WD, HW)	**Total HI. MWH Attributes**	Recovering Channel	Heavy/Moderate Silt Cover	Sand Substrates (Boat)	Hardpan Substrate Origin	Fair/Poor Development	Low Sinuosity	Only 1-2 Cover Types	Intermittent and Poor Pools	No Fast Current	High/Mod. Overall Embeddedness	High/Mod. Riffle Embeddedness	No Riffle	**Total MI. MWH Attributes**	**(MWH HI.+1)/(WWH+1) Ratio**	**(MWH MI.+1)/(WWH+1) Ratio**
(04-130) Little Auglaize River																																		
Year: 1983																																		
41.1	**22.0**	2.23									■		1		●		●		2	▲	▲		▲	▲	▲	▲		▲	▲		▲	9	1.50	6.00
37.4	**22.0**	1.48					■				■		2	●	●		●		3		▲			▲				▲	▲		▲	5	1.33	3.00
34.2	**29.0**	1.36					■				■		2		●		●		2	▲	▲			▲		▲		▲	▲		▲	7	1.00	3.33
29.5	**22.0**	1.06											0		●		●	●	3	▲	▲			▲	▲	▲		▲	▲		▲	8	4.00	*.**
18.8	**37.0**	3.23		■						■	■		3		●		●		2	▲	▲			▲	▲	▲		▲			▲	7	0.75	2.50
17.6	**36.0**	3.50		■				■					2	●			●	●	3		▲			▲	▲	▲		▲	▲	▲	▲	8	1.33	4.00
14.2	**37.0**	1.71		■			■						2				●	●	2	▲	▲			▲		▲		▲	▲		▲	7	1.00	3.33
7.8	**40.0**	2.66		■									1				●	●	2	▲	▲			▲	▲	▲		▲	▲		▲	8	1.50	5.50
2.0	**26.0**	0.10					■				■		2	●	●		●		3		▲			▲		▲		▲	▲		▲	6	1.33	3.33
(14-500) Twin Creek																																		
Year: 1986																																		
35.5	**84.5**	9.26	■	■	■	■	■	■	■	■	■	■	10						0													0	0.09	0.09
35.0	**92.0**	9.26	■	■		■	■	■	■	■	■	■	9						0													0	0.10	0.10
31.7	**71.0**	5.56	■	■		■	■	■	■		■	■	8						0									▲	▲			2	0.11	0.33
27.0	**88.0**	9.62	■	■		■	■	■	■	■	■	■	9						0													0	0.10	0.10
26.7	**80.0**	8.55	■	■		■	■	■	■	■	■		8						0												▲	1	0.11	0.22
23.9	**88.5**	13.70	■	■	■	■	■	■	■	■	■	■	10						0													0	0.09	0.09
19.2	**90.5**	8.00	■	■	■	■	■	■	■	■	■	■	10						0													0	0.09	0.09
18.3	**89.5**	8.00	■	■	■	■	■	■	■	■	■	■	10						0													0	0.09	0.09
16.9	**73.0**	5.21	■	■		■	■	■	■	■	■	■	9				●		1													0	0.20	0.20
9.8	**90.5**	4.93	■	■	■	■	■	■	■	■	■	■	10						0													0	0.09	0.09
0.2	**73.5**	13.16	■	■		■	■	■			■		6						0			▲						▲	▲		▲	4	0.14	0.71

Use Attainability Analysis I: Are CWA Goal Uses Attainable?

U.S. EPA regulations allow lower than CWA goal uses where precluded by:

- naturally occuring pollutant levels;
- natural flow conditions (i.e., ephemeral)**;
- human-induced conditions which cannot be remediated
- hydrological modififcations (dams, diversions, channel modifications) which cannot be operated in a manner consistent with the CWA goal use;
- natural physical features (substrate, flow, depth);
- controls to attain use would cause widespread, socioeconomic impacts.

**** - does not apply when flow is augmented by an.effluent discharge.**
Source: 40 CFR Part 131.10 (g)(1-6)

Use Attainability Analysis II: Process and Information Requirements**

Use attainability analysis requires the following information and knowledge:

- existing status of waterbody based on biocriteria;
- habitat assessment to evaluate potential;
- reasonable relationship between impaired state and precluding activity based on assessment of multiple indicators used in appropriate roles;
- recommendation subject to WQS ruelmaking process
- reviewable every three years - a "temporary" designation.

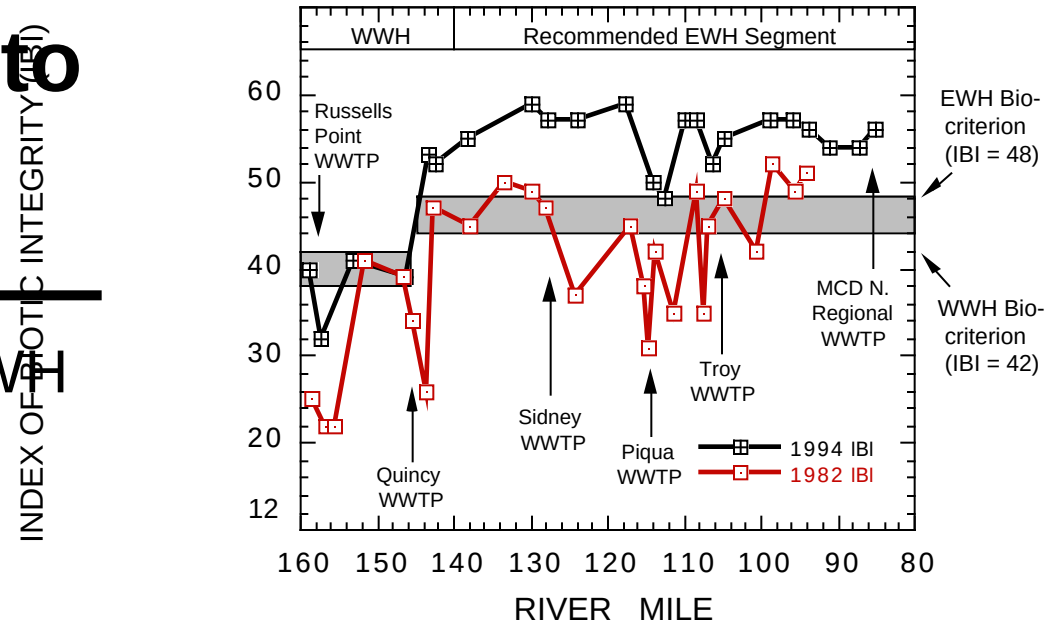
**** - All data collection and analysis must conform to Ohio WQS and Five-Year Monitoring Strategy data and design quality objectives.**

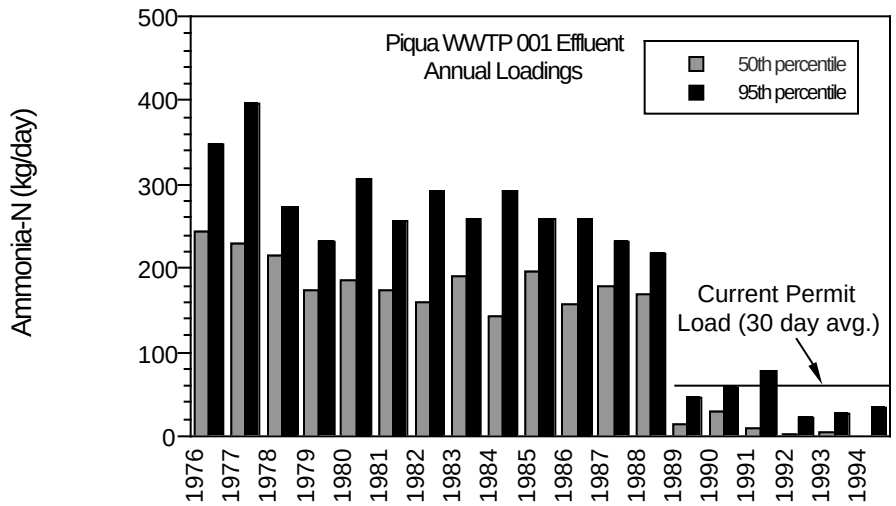
Using Indicators to Demonstrate Improvements

Great Miami River: WWH Use (existing)
EWH Use (recommended)

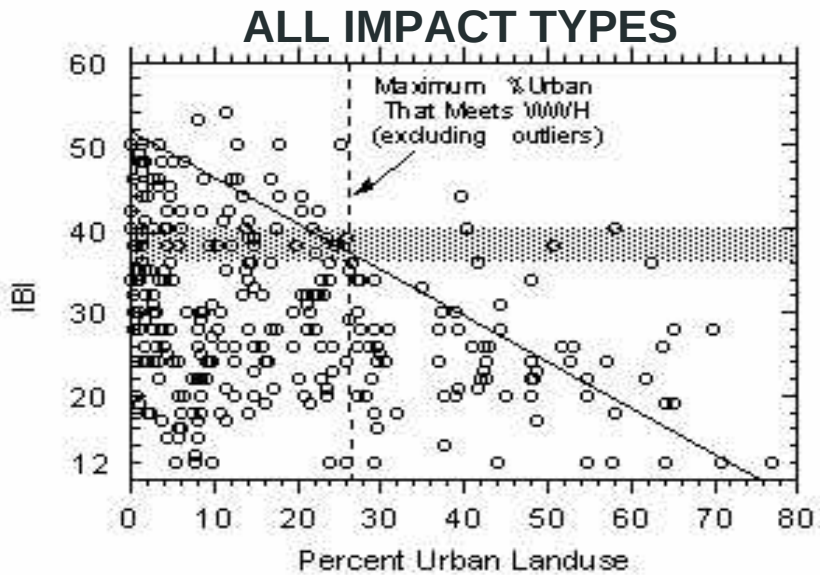
Major Point Sources:
Sidney WWTP
Piqua WWTP
Troy WWTP
MCD N. Regional WWTP

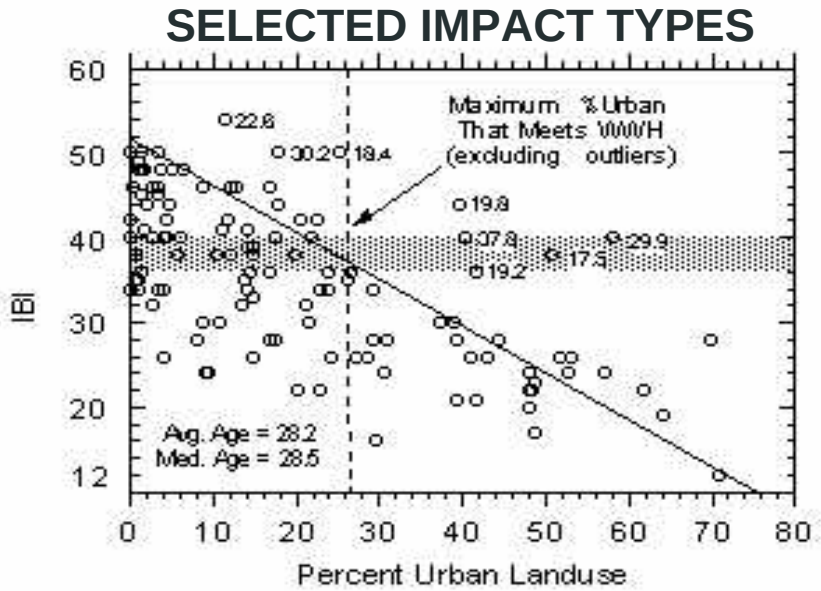
Key Indicators: (Levels 3&6) Biological [IBI, ICI]
WWTP Loadings [Ammonia-N]



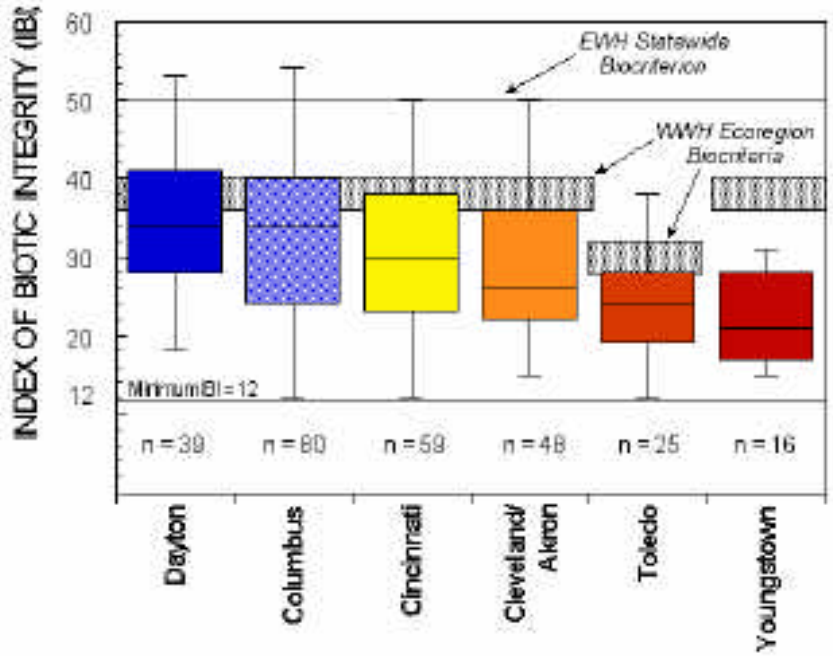


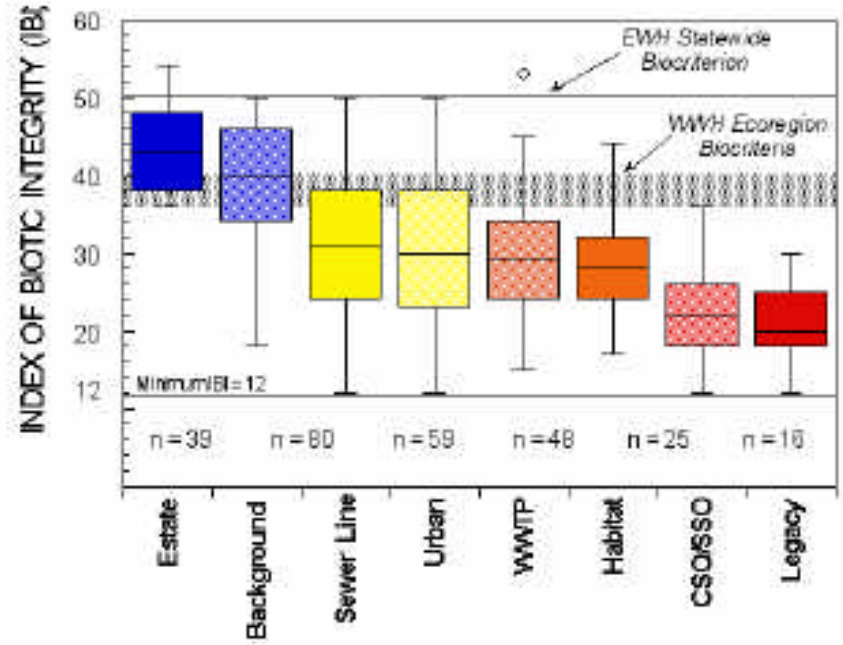
IBI vs. % Urban Land Use





- **Typical threshold for WWH attainment at 25-30% urban land use.**
- **No attainment at >60% urban land use.**
- **Attainment "outliers" occur at 40-60% urban land use.**
- **Characteristics common to outliers are good riparian, sustained flow, or <20 years of urban development.**
- **Removal of habitat, sewer overflow, and legacy impacts helped clarify IBI/urban land use relationship.**



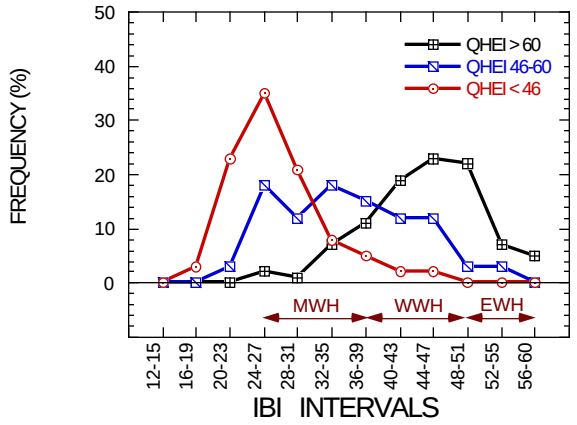


Using Biocriteria to Assess Small Urban Streams in Ohio

- Data from statewide Ohio EPA database at urban and suburban sites <100 mi^2 drainage area.
- No more than 35-40% of sites in any major municipal area attained the WWH IBI criterion.
- The additive effect of multiple stressors in urban watersheds was evident in consistently lower IBI scores.

Measurable Parameters of Watershed Health: Habitat/UAA

HABITAT THRESHOLDS FOR DESIGNATED USE ATTAINMENT

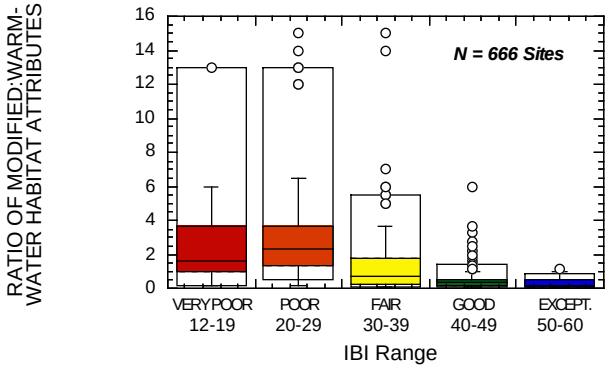


Habitat Attributes of Warmwater and Modified Streams

Warmwater Streams	Modified Streams
1. No channel mod./recovered	Recent channel mod./recovered
2. Boulder/cobble/gravel substrtates	Silt/muck Substrates
3. Silt Free or Silt Normal	Heavy/moderate Silt Covering
4. Good/Excellent Development	Fair/Poor Development
5. Moderate/High Sinuosity	Low/No Sinuosity
6. Extensive/moderate Cover	Only 1-2 Cover Types
7. Fast Current w/Eddies	No Fast Current
8. Low/Normal Embeddedness	High Embeddedness
9. Maximum Depth >40 cm	Maximum Depth <40 cm
10.	Intermittent/interstitial Flow

Source: The Qualitative Habitat Evaluation Index (Rankin 1989)

Influence of Modified Habitat Attributes on the IBI and Biological Integrity



Measurable Parameters of Ecosystem Health: Program Management Concepts

Two Paths to Watershed Management

	PROGRAM BASED APPROACH	RESOURCE BASED APPROACH
Goal:	**Program Performance**	**Environmental Performance**
Measures:	**Administrative Actions** (Permits, Funding, Rules)	**Indicator End-points** (Biological, Chemical, Physical)
Results:	**Improve Programs** (Reduce backlogs, improve timeliness)	**Programs are Tools to Improve the Environment** (Admin. actions followed by positive changes in indicators)

Two Approaches to Water Quality Management

Pollutant Driven

- Dilution scenarios - critical design conditions
- Do not exceed the "speed limit".
- Limited toolbox - limited accuracy.

Resource Driven

- Chemical, physical, biological attributes
- What are the critical relationships?
- What is to be restored, enhanced, preserved?
- Indicators used determines accuracy.

TMDL: CWA Section 303[d]

Total Maximum Daily Loads (TMDL)

"Letter of the Law"

- PS Pollutants + NPS Pollutants + Safety Margin = TMDL

Pollutant Focused Approach

"Spirit of the Law"

- Restoration of impaired waters based on attainment of designated uses

Resource Focused Approach

Essential Technical Elements of a Watershed Approach

Three major classes of environmental indicators:

- Stressor Indicators (e.g., loadings, land use, habitat)
- Exposure Indicators (e.g., chemical-specific, biomarkers, toxicity)
- Response Indicators (e.g., biological community condition)

Landscape partitioning framework:

- Ecoregions and/or subecoregions (other than hydrologic units).

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What Biocriteria Can Bring to Watershed Management

Incorporating Biocriteria Can Result in the Following:

- Watershed Approach to Monitoring, Assessment, and Management
- Integrated Point, Nonpoint, and Habitat Assessment and Management
- Cumulative Effects
- Biodiversity Concerns
- Interdisciplinary Focus
- Sound Science

The Role of Biological Assessments and Criteria in the TMDL Process: I

Biocriteria and allied tools serve the following functions in the 303d process:

- as a principal arbiter of attainment status (303d listing).
- key tool for determining the appropriate designated use.
- biological data provides information to describe causes and sources of impairments.
- key effectiveness end-point for assessment of TMDL implementation.
- important vector for development of "new" criteria for TMDL modeling outputs.

The Role of Biological Assessments and Criteria in the TMDL Process: II

Using Biocriteria Indices as an end-point for TMDL development can:

- incorporate the cumulative effect of all chemical, physical, and biological stressors in a watershed as opposed to a focus on individual pollutants alone.
- appropriately integrate factors that influence the fate of pollutants (e.g., habitat and nutrients).
- provide a more direct link between the TMDL process and attainment of designated uses.