

# **Guidelines for Preparation of the Comprehensive State Water Quality Assessments (305(b) Reports) and Electronic Updates:**

## **Supplement**

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**ACRONYM LIST**

ADEQ	Arizona Department of Environmental Quality
ADWR	Arizona Department of Water Resources
ALUS	Aquatic life use support
ASTM	American Society for Testing Materials
AWQMN	Ambient Water Quality Monitoring Network
BMP	Best management practice
BPJ	Best professional judgement
CAFO	Concentrated animal feeding operation
CCC	Criteria continuous concentration
CLPMS	Clean Lakes Program Management System
CMC	Criteria maximum concentration
CSO	Combined sewer overflows
CU	USGS watershed cataloging unit
CWA	Clean Water Act
CZARA	Coastal Zone Act Reauthorization Amendments
DNREC	Delaware Department of Natural Resources and Environmental
Conservation	
DLG	Digital line graph (database)
DO	Dissolved oxygen
DOE	Washington State Department of Ecology
DQO	Data quality objective
DWFG	305(b) Drinking Water Focus Group
EMAP	Environmental Monitoring and Assessment Program
EPA	U.S. Environmental Protection Agency
FDA	U.S. Food and Drug Administration
FIPS	Federal Information Processing Standard
FWS	U.S. Fish and Wildlife Service
GIS	Geographic information system
GPS	Global positioning satellite system
GRIS	Grants Reporting and Tracking System
HUC	Hydrologic Unit Code



**ACRONYM LIST** (continued)

ITFM	Intergovernmental Task Force on Monitoring Water Quality
IWI	Index of Watershed Indicators
LAN	Local Area Network
LWQA	Lake Water Quality Assessment
MCL	Maximum contaminant level
MDL	Method detection limit
NAS	National Academy of Science
NAWQA	National Ambient Water Quality Assessment Program
NBS	National Biological Service
NHD	National Hydrographic Dataset
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NPS	Nonpoint source
NRCS	Natural Resources Conservation Service
NSTP	NOAA's National Status and Trends Program
NWQMC	National Water Quality Monitoring Council (formerly ITFM)
OGWDW	Office of Ground Water and Drinking Water
OPPE	EPA Office of Policy, Planning, and Evaluation
ORD	EPA Office of Research and Development
OST	Office of Science and Technology
OW	EPA Office of Water
OWM	EPA Office of Wastewater Management
OWOW	EPA Office of Wetlands, Oceans, and Watersheds
PACE	Annual Census Bureau Survey of Pollution Abatement Costs and Expenditures
PCB	Polychlorinated biphenyl
PCS	EPA Permit Compliance System
POTW	Publicly owned treatment works
PPA	Performance Partnership Agreements
PS	Point source
PSP	Paralytic shellfish poisoning
PWS	Public water supply

**ACRONYM LIST (continued)**

QA	Quality assurance
QC	Quality control
RBP	Rapid bioassessment protocol
REMAP	Regional Environmental Monitoring and Assessment Program
RF3	EPA Reach File Version 3
RTI	Research Triangle Institute
SCRF1	Waterbody System Screenfile 1
SCS	Soil Conservation Service
SDWA	Safe Drinking Water Act
SOC	Semi-volatile organic compound
SOP	Standard operating procedure
STORET	EPA STORage and RETrieval system
TDS	Total dissolved solids
TMDL	Total maximum daily load
TVA	Tennessee Valley Authority
UAA	Use attainability analysis
USACE	U.S. Army Corps of Engineers
USDA	U.S. Department of Agriculture
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
VOC	Volatile organic compound
WBS	EPA Waterbody System
WQC	Water quality criteria
WET	Whole effluent toxicity
WLA	Waste load allocation
WQL	Water quality limited
WQS	Water quality standard
WRC	Water Resource Council

### SECTION 1

#### WATER QUALITY ASSESSMENTS UNDER SECTION 305(b)

This section describes the basic components of a water quality assessment including degree of use support, causes (pollutants and other stressors), and sources of impairment. It also explains several concepts that may have resulted in inconsistencies in the past, such as the fully supporting but threatened category, presumed assessments, and natural sources.

##### 1.1 What is an Assessment?

In setting their water quality standards, States assign one or more designated uses to each individual waterbody. Designated uses are beneficial uses that States want their waters to support. Examples are aquatic life support, fish consumption, swimming, and drinking water supply. Under Section 305(b), assessment of an individual waterbody (e.g., a stream segment or lake) means analyzing biological, habitat, physical/chemical, and/or toxicity data and other information to determine

- C The degree of designated use support of the waterbody (fully supporting, fully supporting but threatened, partially supporting, or not supporting)
- C If designated uses are impaired, the causes (pollutants or other stressors) and sources of the problem
- C Degree of achievement of biological integrity using State biological criteria or other measures.
- C Descriptive information such as the type and quality of data used in the assessment.

Figure 1-1 illustrates how monitoring, assessment, and reporting are related for an individual waterbody. Figure 1-2 shows actual assessment results for a waterbody.

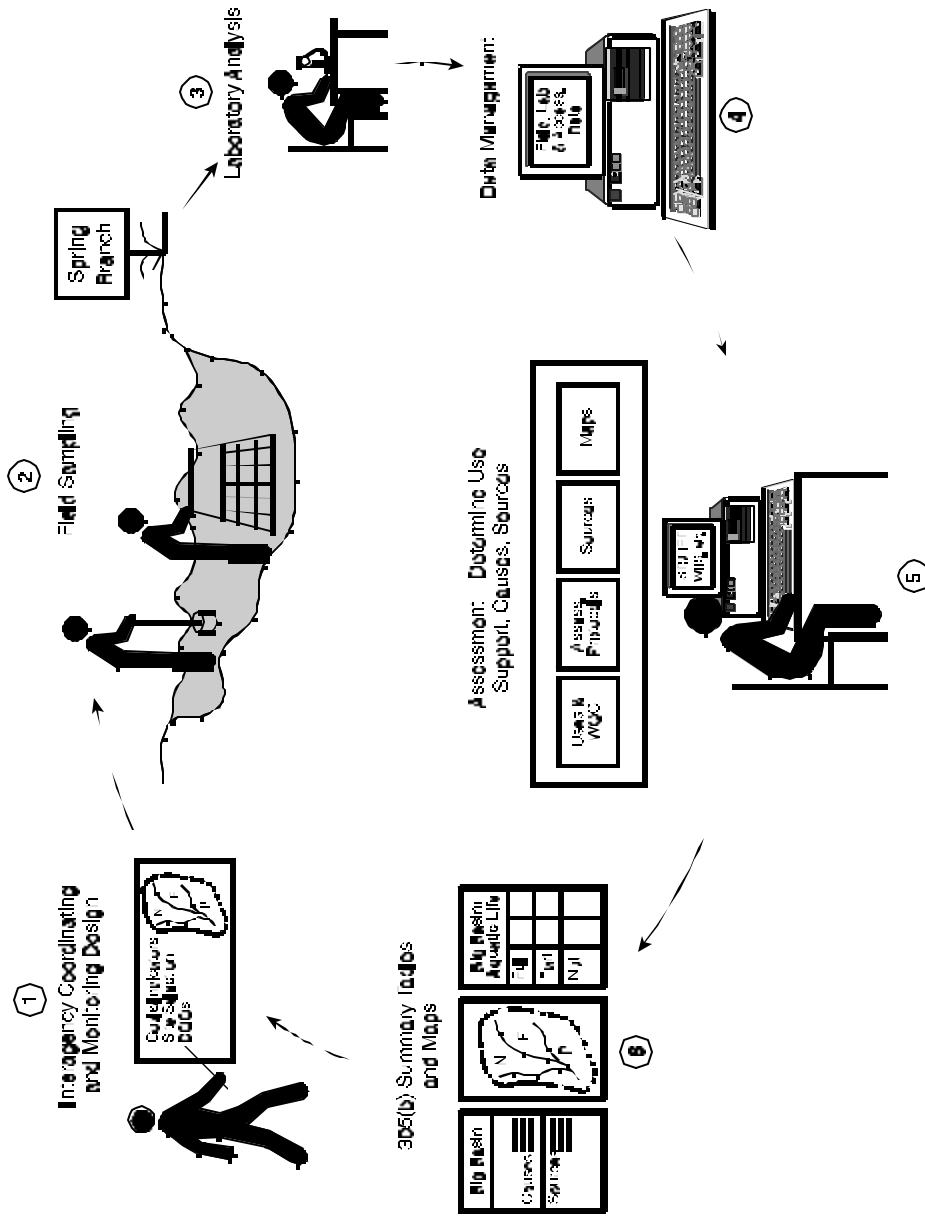


Figure 1-1. Monitoring, assessment and 305(b) reporting as an interrelated process

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## 1. WATER QUALITY ASSESSMENTS UNDER SECTION 305(b)

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## 1. WATER QUALITY ASSESSMENTS UNDER SECTION 305(b)

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Figure 1-2. Waterbody System printout summarizing assessment results for a waterbody

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## 1. WATER QUALITY ASSESSMENTS UNDER SECTION 305(b)

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### 1.2 Degree of Use Support

Each designated use has its own requirements for a finding of fully supporting, fully supporting but threatened, partially supporting, or not supporting. **Section 3 of this *Guidelines Supplement* gives EPA's detailed recommendations for determining the degree of use support for various designated uses.**

Throughout these *Guidelines*, the term "impairment" means either partially supporting or not supporting a designated use.

The category "fully supporting but threatened" requires further explanation. A waterbody is fully supporting but threatened for a particular designated use when it fully supports that use now but may not in the future unless pollution prevention or control action is taken because of anticipated sources or adverse pollution trends. Such waters are treated as a separate category from waters fully supporting uses. States should use this category to describe waters for which actual monitoring or evaluative data indicate an apparent declining water quality trend (i.e., water quality conditions have deteriorated, compared to earlier assessments, but the waters still support uses). States may also choose to include waters for which monitoring or evaluative data indicate potential water quality problems requiring additional data or verification.

Fully supporting but threatened is not appropriate during temporary impairment of designated uses (e.g., due to a construction project in a watershed). The threatened category may be appropriate prior to anticipated impairment, but while actual impairment is occurring, partial support or nonsupport should be reported.

#### Summarizing Assessment Results in the Report to Congress

EPA uses the following descriptive terms in graphical presentations of degree of designated use support:

Good Water Quality	=	Fully Supporting or Fully Supporting but Threatened
Fair Water Quality	=	Partially Supporting
Poor Water Quality	=	Not Supporting

Note: Impaired means Partially Supporting or Not Supporting (Fair or Poor)

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## 1. WATER QUALITY ASSESSMENTS UNDER SECTION 305(b)

### 1.3 Types of Assessment Information

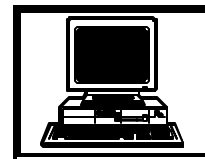
Each State reports assessments of those waterbodies for which use support decisions can be based on reliable water quality information. Such assessments are not limited to waters that have been directly monitored -- it is appropriate in many cases to make judgments based on other information (see Section 1.4). Waterbodies assessed prior to the current reporting period can be included in 305(b) reports if the State has the technical basis to conclude that the assessment results are still valid.

**It is not appropriate, however, to claim that waterbodies are fully supporting uses by default in the absence of sufficient information to make an assessment (see also Section 1.5).**

If statistical survey (probability) designs are used, the results can be reported relative to the entire resource (e.g., headwater streams in an ecoregion), not just those waterbodies actually monitored.

Table 1-1 lists categories of information for assessments. These Assessment Type Codes are from the EPA Waterbody System (WBS). They provide a wealth of information about the basis for individual assessments.

**Assessment Database Managers**—For 1997 and beyond, EPA is strongly encouraging the use of Assessment Type Codes in WBS and other State assessment data systems. They are important data elements for annual electronic updates (see Section 6 of the main *Guidelines* volume).



### 1.4 Monitored and Evaluated Waters

EPA asks the States to distinguish between assessments based on monitoring and assessments based on other information.

- C "Evaluated waters" are those waterbodies for which the use support decision is based on information other than current site-specific ambient data, such as data on land use, location of sources, predictive modeling using estimated input variables, and some questionnaire surveys of fish and game biologists. *As a general guide*, if an assessment is based on older ambient data (e.g., older than five years), the State should also consider it "evaluated."



## 1. WATER QUALITY ASSESSMENTS UNDER SECTION 305(b)

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Table 1-1. Assessment Type Codes from the Waterbody System

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<b>100</b>	<b>Qualitative (evaluated) assessment--unspecified<sup>a</sup></b>
110	Information from local residents
120	Surveys of fish and game biologists/other professionals
130	Land use information and location of sources
140	Incidence of spills, fish kills, or abnormalities
150	Monitoring data that are more than 5 years old
175	Occurrence of conditions judged to cause impairment (e.g., channelization, dredging, severe bank erosion)
180	Screening models (desktop models; models are not calibrated or verified)
190	Biological/habitat data extrapolated from upstream or downstream waterbody
191	Physical/chemical data extrapolated from upstream or downstream waterbody
<b>200</b>	<b>Physical/chemical monitoring<sup>b</sup></b>
210	Fixed-station physical/chemical monitoring, conventional pollutants only
211	Highest quality fixed-station physical/chemical monitoring, conventional pollutants; frequency and coverage sufficient to capture acute and chronic events, key periods, high and low flows
220	Non-fixed-station physical/chemical monitoring, conventional pollutants only
222	Non-fixed-station monitoring, conventional, during key seasons and flows
230	Fixed-station physical/chemical monitoring, conventional plus toxic pollutants
231	Highest quality fixed-station physical/chemical monitoring, conventional plus toxicants; frequency and coverage sufficient to capture acute and chronic events, key periods, high and low flows
240	Non-fixed-station physical/chemical monitoring, conventional plus toxic pollutants
242	Non-fixed-station physical/chemical monitoring, conventional plus toxicants, during key seasons and flows
250	Chemical monitoring of sediments
260	Fish tissue analysis
270	Community water supply chemical monitoring (ambient water)
275	Community water supply chemical monitoring (finished water)
<b>300</b>	<b>Biological monitoring<sup>b</sup></b>
310	Ecological/habitat surveys
315	Regional reference site approach
320	Benthic macroinvertebrate surveys
321	RBP III or equivalent benthos surveys
322	RBP I or II or equivalent benthos surveys
330	Fish surveys
331	RBP V or equivalent fish surveys
340	Primary producer surveys (phytoplankton, periphyton, and/or macrophyton)
350	Fixed-station biological monitoring

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## 1. WATER QUALITY ASSESSMENTS UNDER SECTION 305(b)

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Table 1-1 (continued)

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### 360 **Habitat assessment**

- 365 Visual observation, usually at road crossings; professional not required
- 370 Visual observation, use of land use maps, reference conditions, professional not required
- 375 Visual observation, may quantify some parameters; single season typically; by professional
- 380 Quantitative measurements of instream parameters, channel morphology, floodplain; one or two seasons; by professional

### 400 **Pathogen monitoring<sup>b</sup>**

- 410 Shellfish surveys
- 420 Water column surveys (e.g., fecal coliform)
- 430 Sediment analysis
- 440 Community water supply pathogen monitoring (ambient water)
- 450 Community water supply pathogen monitoring (finished water)

### 500 **Toxicity testing<sup>b</sup>**

- 510 Effluent toxicity testing, acute
- 520 Effluent toxicity testing, chronic
- 530 Ambient toxicity testing, acute
- 540 Ambient toxicity testing, chronic
- 550 Toxicity testing of sediments

### 600 **Modeling<sup>c</sup>**

- 610 Calibrated models (calibration data are less than five years old)

### 700 **Integrated intensive survey<sup>b</sup>** (field work exceeds one 24-hour period and multiple media are sampled)

- 710 Combined sampling of water column, sediment, and biota for chemical analysis
- 720 Biosurveys of multiple taxonomic groups (e.g., fish, invertebrates, algae)

### **Assessments Based on Data from Other Sources**

### 800 **Assessments based on data from other sources<sup>c</sup>**

- 810 Chemical/physical monitoring data by quality-assured volunteer program
  - 820 Benthic macroinvertebrate surveys by quality-assured volunteer program
  - 830 Bacteriological water column sampling by quality-assured volunteer program
  - 840 Discharger self-monitoring data (effluent)
  - 850 Discharger self-monitoring data (ambient)
  - 860 Monitoring data collected by other agencies or organizations (use the assessment comment field to list other agencies)
  - 870 Drinking water supply closures or advisories (source-water quality based)
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## 1. WATER QUALITY ASSESSMENTS UNDER SECTION 305(b)

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Table 1-1 (continued)

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### Discrepancy in Aquatic Life Assessment Results<sup>d</sup>

**900 Discrepancy in Aquatic Life Assessment Results**

- 910 Discrepancy among different data types; aquatic life assessment is based on physical/chemical data
- 920 Discrepancy among different data types; aquatic life assessment is based on biological data
- 925 Discrepancy among different data types; aquatic life assessment is based on habitat data
- 930 Discrepancy among different data types; aquatic life assessment is based on toxicity testing data
- 940 Discrepancy among different data types; aquatic life assessment is based on qualitative (evaluated) assessment data
- 

[Note: New codes have been added to include information types in Tables 3-2 and 3-3.]

- <sup>a</sup> Generally considered to be evaluated assessment types.
- <sup>b</sup> Generally considered to be monitored assessment types.
- <sup>c</sup> Considered to be monitored or evaluated assessment types depending on data quality and State assessment protocols.
- <sup>d</sup> States are requested to use these codes to identify cases when biological, habitat, toxicity, and/or physical/chemical data show different assessment results.

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## 1. WATER QUALITY ASSESSMENTS UNDER SECTION 305(b)

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- C "Monitored waters" are those waterbodies for which the use support decision is principally based on current, site-specific, ambient monitoring data believed to accurately portray water quality conditions. Waters with data from biosurveys should be included in this category along with waters monitored by fixed-station chemical/physical monitoring or toxicity testing. To be considered "monitored" based on fixed-station chemical/physical monitoring, waters generally should be sampled quarterly or more frequently. For specifics on biological monitoring, see Section 3.

States may use some flexibility in applying these guidelines. For example:

- C For the 800 series of codes in Table 1-1, if State-approved quality assurance/quality control procedures have been applied to volunteer monitoring programs, waters sampled under these programs could be considered monitored. However, a State may use its discretion in making an Assessment Category determination of evaluated vs. monitored. The State may wish to conduct a comparison to determine the sensitivity or power of the volunteer method compared to the State's methods (e.g., volunteer data may prove more useful for identifying severe impacts than for determining full support). Note: EPA has developed *The Volunteer Monitor's Guide to Quality Assurance Project Plans*. To obtain a copy, contact the Monitoring Branch at (202) 260-7018.
- C If older ambient data exist for high-quality waters located in remote areas with no known pollutant sources, and if those data are believed to accurately portray water quality conditions, those waters could be considered monitored.

EPA and States have been working together to better define the kinds of data upon which assessment decisions are made. See Tables 3-1 through 3-4.

### 1.5 Presumed Assessments

The 305(b) Consistency Workgroup determined that presumed assessments are unacceptable. Examples of presumed assessments are

- C Assuming that waterbodies are fully supporting by default unless there is information to the contrary
- C Extrapolating assessments from one waterbody or watershed to others unless they have very similar characteristics

## 1. WATER QUALITY ASSESSMENTS UNDER SECTION 305(b)

- C Extrapolating the "percentage of assessed stream miles that are fully supporting" to all streams in the State without adequate scientific basis such as probability-based monitoring design.

Note: If waterbodies are monitored using survey designs, results can be extrapolated.

EPA encourages States to report on all waters for which there is a reasonable technical basis for evaluation. A reasonable basis could include a judgment that a stream is not supporting uses based on channelization, a highly disturbed watershed, or data from nearby streams with similar characteristics.

In addition, EPA recommends that data from a single monitoring station not be used to generate a monitored assessment of an entire watershed. Rather, a monitoring station can be considered representative of a waterbody for that distance upstream and/or downstream in which there are no significant influences to the waterbody that might tend to change water quality within the zone represented by the monitoring station. See Section 2.1.

### 1.6 Causes of Impairment (Pollutants and Other Stressors)

Causes of impairment are those pollutants and other stressors that contribute to the impairment of designated uses in a waterbody. In the remainder of these *Guidelines* the term "cause/stressor" is used. Table 1-2 lists cause/stressor codes from the WBS. States can also add their own codes to WBS to track additional causes. At the States' request, EPA has added new subcategories under Code 0500 and Code 0900 to track specific metals and nutrients.

#### How to Avoid Double-counting of Causes/Stressors

**WBS Users**—If you use the new subcategories for metals/nutrients or add cause/stressor codes to WBS, you must enter a total size for each major category of causes/stressors (the **bold categories** in Table 1-2; e.g., **0500--Metals** or **0200--Pesticides**) for each waterbody. This is necessary because there may be overlap among the subcategories of causes/stressors.

**Non-WBS Users**—Like WBS, most customized waterbody-level databases must also track a total size for each major category of causes/stressors (the **bold categories** in Table 1-2) in order to avoid overlap among subcategories.



## 1. WATER QUALITY ASSESSMENTS UNDER SECTION 305(b)

**Table 1-2. Cause/Stressor Codes from the Waterbody System**

<b>0000</b>	<b>Cause Unknown</b>	<b>1000</b>	<b>pH</b>
<b>0100</b>	<b>Unknown Toxicity</b>	<b>1100</b>	<b>Siltation</b>
<b>0200</b>	<b>Pesticides</b>	<b>1200</b>	<b>Organic</b>
<b>0300</b>	<b>Priority Organics</b>		<b>Enrichment\Low</b>
<b>0400</b>	<b>Nonpriority Organics</b>		<b>Dissolved Oxygen</b>
<b>0410</b>	<b>PCBs</b>	<b>1300</b>	<b>Salinity/Total Dissolved</b>
<b>0420</b>	<b>Dioxins</b>		<b>Solids/Chlorides/Sulfates</b>
<b>0500</b>	<b>Metals</b>	<b>1400</b>	<b>Thermal Modifications</b>
	0510 Arsenic	<b>1500</b>	<b>Flow Alterations</b>
	0520 Cadmium	<b>1600</b>	<b>Habitat Alterations (other</b>
	0530 Copper		<b>than flow)</b>
	0540 Chromium	<b>1700</b>	<b>Pathogens</b>
	0550 Lead	<b>1800</b>	<b>Radiation</b>
	0560 Mercury	<b>1900</b>	<b>Oil and Grease</b>
	0570 Selenium	<b>2000</b>	<b>Taste and Odor</b>
	0580 Zinc	<b>2100</b>	<b>Suspended Solids</b>
<b>0600</b>	<b>Ammonia (un-ionized)</b>	<b>2200</b>	<b>Noxious Aquatic Plants</b>
<b>0700</b>	<b>Chlorine</b>		<b>(native macrophytes)<sup>a</sup></b>
<b>0720</b>	<b>Cyanide</b>	<b>2210</b>	<b>Excessive Algal Growth/</b>
<b>0750</b>	<b>Sulfates</b>		<b>Chlorophyll a</b>
<b>0800</b>	<b>Other Inorganics</b>	<b>2400</b>	<b>Total Toxics</b>
<b>0900</b>	<b>Nutrients</b>	<b>2500</b>	<b>Turbidity</b>
	0910 Phosphorus	<b>2600</b>	<b>Exotic Species</b>
	0920 Nitrogen		
	0990 Other		

NOTES: In addition to the above, WBS users can enter their own customized cause codes. See WBS Users Guide.

Codes 0200 through 0800 are toxicants for purposes of WBS reports.

Filling and draining is considered a source (Source Code 7800) and no longer appears in the above table.

Bold type indicates a major cause category; regular type indicates a subcategory.

<sup>a</sup>Non-native plants should be handled under Category 2600.

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## 1. WATER QUALITY ASSESSMENTS UNDER SECTION 305(b)

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## 1. WATER QUALITY ASSESSMENTS UNDER SECTION 305(b)

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In Table 1-2, bold type indicates a major cause/stressor category and regular type indicates a subcategory. **See the highlight box entitled “How to Avoid Double-counting of Causes/Stressors” regarding the importance of storing size data for major cause/stressor categories, not just subcategories.**

### 1.7 Sources of Impairment

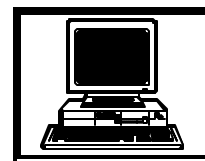
Sources are the activities, facilities, or conditions that contribute pollutants or stressors resulting in impairment of designated uses in a waterbody. Table 1-3 lists source codes from the WBS. States can also add their own source codes to the WBS. Appendix G provides definitions of selected source categories.

In Table 1-3, bold type indicates a major source category and regular type indicates a subcategory of that major category. **See the highlight box entitled “How to Avoid Double-counting of Sources” regarding the importance of storing size data for all applicable major source categories, not just subcategories.**

Determining the sources of designated use impairment can be a difficult process. Ambient monitoring data can give good evidence of the causes of impairment. In some cases, field observations can provide information on obvious, nearby problems; e.g., land use, substrate, and habitat may provide a basis for identifying sources. This is especially the case for “hydromodification” sources.

In most cases, additional information is needed--watershed land use inventories, records of permit compliance, locations of areas with highly erodible soils, areas with poor best management practice (BMP) implementation, measurements of in-place contaminants, or loadings from atmospheric transport or ground water.

**Assessment Database Managers**—Agriculture is the only source category with three tiers of codes (see Table 1-3). EPA asks States to track size data for the “1000—Agriculture” code and at least the next tier (“1050—Crop-related Sources”, etc.)





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## 1. WATER QUALITY ASSESSMENTS UNDER SECTION 305(b)

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Table 1-3. Source Categories (with National Codes from the Waterbody System)

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<b>0100</b>	<b>Industrial Point Sources</b>
0110	Major Industrial Point Sources
0120	Minor Industrial Point Sources
<b>0200</b>	<b>Municipal Point Sources</b>
0210	Major Municipal Point Sources—dry and/or wet weather discharges
0212	Major Municipal Point Sources—dry weather discharges*
0214	Major Municipal Point Sources—wet weather discharges*
0220	Minor Municipal Point Sources—dry and/or wet weather discharges
0222	Minor Municipal Point Sources—dry weather discharges*
0224	Minor Municipal Point Sources—wet weather discharges*
0230	Package Plants (Small Flows)
<b>0400</b>	<b>Combined Sewer Overflow</b>
<b>0500</b>	<b>Collection System Failure*</b>
<b>0900</b>	<b>Domestic Wastewater Lagoon</b>
<b>1000</b>	<b>Agriculture**</b>
<b>1050</b>	<b>Crop-related Sources*</b>
1100	Nonirrigated Crop Production
1200	Irrigated Crop Production
1300	Specialty Crop Production (e.g., horticulture, citrus, nuts, fruits)
<b>1350</b>	<b>Grazing-related Sources*</b>
1400	Pasture grazing—Riparian and/or Upland
1410	Pasture Grazing--Riparian*
1420	Pasture Grazing--Upland*
1500	Range Grazing—Riparian and/or Upland
1510	Range Grazing--Riparian*
1520	Range Grazing--Upland*
<b>1600</b>	<b>Intensive Animal Feeding Operations*</b>
1620	Concentrated Animal Feeding Operations (CAFOs; permitted, PS)
1640	Confined Animal Feeding Operations (NPS)
1700	Aquaculture
<b>2000</b>	<b>Silviculture</b>
2100	Harvesting, Restoration, Residue Management
2200	Forest Management (e.g., pumped drainage, fertilization, pesticide application)
2300	Logging Road Construction/Maintenance
2400	Silvicultural Point Sources

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## 1. WATER QUALITY ASSESSMENTS UNDER SECTION 305(b)

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Table 1-3 (continued)

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<b>3000</b>	<b>Construction</b>
3100	Highway/Road/Bridge Construction
3200	Land Development
<b>4000</b>	<b>Urban Runoff/Storm Sewers</b>
4100	Nonindustrial Permitted
4200	Industrial Permitted
4300	Other Urban Runoff
4400	Illicit connections/Illegal hook-ups/dry weather flows*
4500	Highway/Road/Bridge Runoff*
4600	Erosion and Sedimentation*
<b>5000</b>	<b>Resource Extraction</b>
5100	Surface Mining
5200	Subsurface Mining
5300	Placer Mining
5400	Dredge Mining
5500	Petroleum Activities
5600	Mill Tailings
5700	Mine Tailings
5800	Acid Mine Drainage
5900	Abandoned mining*
5950	Inactive mining*
<b>6000</b>	<b>Land Disposal</b>
6100	Sludge
6200	Wastewater
6300	Landfills
6350	Inappropriate Waste Disposal/Wildcat Dumping*
6400	Industrial Land Treatment
6500	Onsite Wastewater Systems (Septic Tanks)
6600	Hazardous Waste
6700	Septage Disposal
<b>7000</b>	<b>Hydromodification</b>
7100	Channelization
7200	Dredging
7300	Dam Construction
7350	Upstream Impoundment
7400	Flow Regulations/Modification

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## 1. WATER QUALITY ASSESSMENTS UNDER SECTION 305(b)

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Table 1-3 (continued)

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<b>7550</b>	<b>Habitat Modification (other than Hydromodification)</b>
7600	Removal of Riparian Vegetation
7700	Bank or Shoreline Modification/Destabilization
7800	Drainage/Filling of Wetlands
<b>7900</b>	<b>Marinas and Recreational Boating*</b>
7910	In-water releases*
7920	On-land releases*
<b>8050</b>	<b>Erosion from derelict land*</b>
<b>8100</b>	<b>Atmospheric Deposition</b>
<b>8200</b>	<b>Waste Storage/Storage Tank Leaks (above ground)</b>
<b>8250</b>	<b>Leaking underground storage tanks*</b>
<b>8300</b>	<b>Highway Maintenance and Runoff</b>
<b>8400</b>	<b>Spills (Accidental)</b>
<b>8500</b>	<b>Contaminated Sediments</b>
<b>8520</b>	<b>Debris and bottom deposits*</b>
<b>8530</b>	<b>Internal nutrient cycling (primarily lakes)*</b>
<b>8540</b>	<b>Sediment resuspension*</b>
<b>8600</b>	<b>Natural Sources</b>
<b>8700</b>	<b>Recreation and Tourism Activities (other than Boating; see 7900)</b>
8710	Golf courses*
<b>8900</b>	<b>Salt Storage Sites</b>
<b>8910</b>	<b>Groundwater Loadings</b>
<b>8920</b>	<b>Groundwater Withdrawal</b>
<b>8950</b>	<b>Other</b>
<b>9000</b>	<b>Unknown Source</b>
<b>9050</b>	<b>Sources outside State Jurisdiction or Borders*</b>

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Notes:

**Bold type indicates a major source category;** regular type indicates a subcategory.

In addition to the above codes, WBS users can enter their own customized source codes.

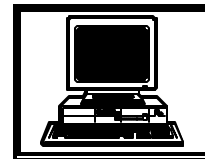
Code 8000 for "Other" has been deleted because it resulted in significant loss of detail nationwide.

See Appendix G for definitions of selected source categories.

\* Codes changed or added since 1996 Guidelines.

\*\* Agriculture is the only major source category with three tiers of codes (such as codes 1000, 1050, and 1100). EPA asks States to report size data for the "1000—Agriculture" code plus one or both of the other two tiers.

### How to Avoid Double-Counting of Sources



**WBS Users**—WBS can be used to generate the 305(b) summary report, "Total Sizes of Waters Impaired by Various Source Categories." *However, to use the WBS to generate this table, enter a total size for each major category of sources (i.e., the **bold categories** in Table 1-3 such as **1000--Agriculture** and **2000--Silviculture**).* This is necessary because there may be overlap among the subcategories of sources.

**Non-WBS Users**—Your customized database must also track major source categories (the **bold categories** in Table 1-3) at the waterbody level.

A modeling framework can be helpful, especially where a variety of sources could be involved. Even a simple annual average export-coefficient screening model can help determine if particular source categories are significant contributors to impairment. A well-rounded assessment process, therefore, might involve monitoring, an inventory of land uses and point source contributions for a watershed, and, where appropriate, a screening-level model to rank and prioritize the relative impacts of different source categories.

Appendix H lists types of information that can be used to determine sources of water quality impairment.

### Natural Sources

The Natural Sources category should be reserved for waterbodies impaired due to naturally occurring conditions (i.e., not caused by, or otherwise related to, past or present human activity) or due to catastrophic conditions. In the past, some States have used natural sources as a catch-all category for unknown sources. This gives an inaccurate picture of the extent of natural sources at both State and national levels. States should use the natural sources category only for clearly defined cases, including:

- C Saline water due to natural mineral salt deposits
- C Metals due to naturally occurring deposits
- C Low dissolved oxygen (DO) or pH caused by poor aeration or natural organic materials, where no human-related sources are present or where impairment would occur even in the absence of human activity

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## 1. WATER QUALITY ASSESSMENTS UNDER SECTION 305(b)

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- C Excessive siltation due to glacial till or turbidity due to glacial flour, where such siltation is not caused by human activity or where impairment would occur even in the absence of human activity
- C Habitat loss or pollutant loads due to catastrophic floods that are excluded from water quality standards or other regulations
- C High temperature, low DO, or high concentrations of pollutants due to catastrophic droughts with flows less than design flows in water quality standards.

The Natural Sources category does **not** include, for example, low flows due to diversions resulting in low DO; drainage from abandoned mines resulting in low pH; stormwater runoff resulting in habitat destruction, high temperatures, or other impacts except under catastrophic conditions; or atmospheric deposition of heavy metals where human-induced emissions are a factor.

In many cases, State water quality standards already take into account natural conditions (e.g., a "fish and wildlife/swamp waters" classification in the Southeast where naturally-occurring low DO is allowed). In such cases, the waterbody is not reported as impaired. In other cases where standards do not allow for natural conditions, impairment by a natural source may still be beyond a State's capability to correct for technical or economic reasons. A use attainability analysis (UAA) should be done to determine if designated uses are attainable or if other uses are more appropriate for a waterbody. Regional Water Quality Standards Coordinators can provide information on conducting UAAs. In the absence of a UAA, EPA recognizes that States should report impairment due to natural sources even in cases where standards could be overly restrictive or in need of revision.

### 1.8 Cause/Source Linkage

States are requested to link causes/stressors with sources for waterbodies in their assessment databases where possible. A special cause/source link field is provided in WBS for this purpose. Linked cause/source data are important for answering State resource management questions. For example, the question "Which waterbodies are impaired due to nutrients from agricultural runoff?" cannot be answered if the cause/source link is not used.

The following chart illustrates what happens when causes and sources are not linked. Although valuable information is stored, one cannot tell which sources are associated with which pollutants or stressors:

## 1. WATER QUALITY ASSESSMENTS UNDER SECTION 305(b)

### Causes and Sources Not Linked

Waterbody	Causes (pollutants/stressors)	Sources (not linked with causes)
WBID = XX-012 Mill Creek above Brook Branch	Nutrients, siltation, thermal modification	Urban runoff, removal of riparian vegetation, municipal point sources

The following chart shows how the same causes and sources can be associated with each other using the WBS link variable:

### Causes and Sources Linked

Waterbody	Causes (pollutants/stressors)	Sources (linked with causes)
WBID = XX-012 Mill Creek above Brook Branch	Nutrients	Urban runoff
	Nutrients	Municipal point sources
	Siltation	Removal of riparian vegetation
	Thermal modification	Urban runoff
	Thermal modification	Removal of riparian vegetation

For help in accomplishing this link, WBS users and non-WBS users are urged to contact WBS Technical Support at the number on page ii for more information.

### 1.9 Major/Moderate/Minor Contribution to Impairment

Section 4 of the main *Guidelines* volume requests determination of the relative contribution to impairment of causes and sources of pollution.

The definitions of major/moderate/minor contributions in these *Guidelines* now reflect the severity of impairment rather than the number of sources contributing. The 1994 definitions, for example, required that a source be labeled "major" if it is the only source of impairment on a waterbody, regardless of the severity of impairment. The current definitions are:

- C Major contribution: A cause/stressor or source makes a major contribution to impairment if it is the only one responsible for *nonsupport* of any designated use or it predominates over other causes/sources.

## 1. WATER QUALITY ASSESSMENTS UNDER SECTION 305(b)

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- C Moderate contribution: A cause/stressor or source is the only one responsible for partial support of any use, predominates over other causes/sources of partial support, or is one of multiple causes/sources of nonsupport that have a significant impact on designated use attainment.
  
- C Minor contribution: A cause/source is one of multiple causes/sources responsible for nonsupport or partial support and is judged to contribute relatively little to this nonattainment.

The major/moderate/minor designations are difficult to quantify and will continue to reflect the best professional judgment of the data analyst. For example, multiple minor causes/stressors or sources or multiple moderate causes/sources could be interpreted to add up to nonsupport. States are asked to clarify how they use magnitude codes in their annual electronic reporting data dictionaries.

### SECTION 2

#### DESIGNING ASSESSMENTS AND MANAGING INFORMATION

This section discusses several topics related to the overall operation of State water quality assessment programs:

- C The extent of individual assessments
- C Comprehensively characterizing waters of the State through a combination of targeted and probabilistic monitoring designs
- C Delineating waterbodies and watersheds
- C Managing assessment data

#### 2.1 Extent of Individual Assessments

The extent or size of a waterbody that is represented by a given monitoring station is important because it affects the quality of assessment results. For example, low assessment quality can result when a large segment of stream or a large lake is assessed based on a single monitoring site. The 305(b) Consistency Workgroup discussed this topic in 1994 and concluded that only general guidance can be given at this time, as follows.

Because of the importance of site-specific considerations,

A monitoring station can be considered representative of a stream waterbody for a distance upstream and downstream that has no significant influences that might tend to change water quality or habitat quality. A significant influence can be

- C A point or nonpoint source input to the waterbody or its tributaries
- C A change in watershed characteristics such as land use
- C A change in riparian vegetation, stream banks, substrate, slope, or channel morphology
- C A large tributary or diversion
- C A hydrologic modification such as channelization or a dam.



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## 2. DESIGNING ASSESSMENTS AND MANAGING INFORMATION

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EPA discourages the use of uniform default values for the size of waterbody represented by a single monitoring site. For streams, States should consider the upstream and downstream characteristics of each monitoring station and its watershed in arriving at an extent of assessment. A single site should not be used to assess an entire watershed unless land use, sources, and habitat are relatively homogeneous (e.g., as is sometimes the case in undeveloped areas) and the observed stressor is consistent with watershed-wide impacts.

In general, a wadable stream station probably should represent no more than five to 10 miles of stream. For large rivers, EPA believes that 25 miles is a reasonable upper limit for a single station unless stream-specific data demonstrate otherwise. However, some large western rivers may have no significant influences for more than 25 miles, as is the case in New Mexico where a few stations on large rivers are believed to represent 50 to 75 miles each.

For lakes, the factors that affect the number of monitoring sites needed per lake are complex. They include purpose of the sampling, lake size, stratification, morphometry, flow regime, and tributaries. No simple guideline for size assessed per station can be given. Reckhow and Chapra (1983) discuss monitoring design for lakes and the potential problems associated with sampling only a single site. Similarly, no specific guidelines are available for the extent of assessment of estuarine monitoring sites. The Washington Department of Ecology (DOE) has used a GIS to draw circles around each monitoring site; the site is considered to represent the area within its circle. Open water stations represent an area within a 4-mile radius, most bay stations represent an area within a 2-mile radius, and highly sheltered bay sites represent an area within a 0.5-mile radius. DOE uses circles in part to emphasize the uncertainty associated with the extent of assessment for estuarine sites.

EPA asks States to provide information in the Assessment Methodology Sections of their 1998 305(b) reports on how they determine extent of waterbody represented by a single assessment or monitoring site.

### 2.2 Comprehensive Statewide Assessment

EPA, States and Tribes are moving toward a goal of **comprehensively characterizing waters** of the States and Tribes using a variety of monitoring techniques based on the condition of, and goals for, the waters. Achieving this goal would mean a significant increase in the percentage of waters assessed throughout the Nation. For example, in their 1996 305(b) reports, the States assessed approximately 19 percent of the Nation's total stream miles (including intermittent streams, canals,

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## 2. DESIGNING ASSESSMENTS AND MANAGING INFORMATION

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and ditches); this amounted to less than half of the Nation's perennial stream miles. Achieving the goal of comprehensive coverage will require a combination of monitoring approaches including both targeted and probability-based monitoring as well as aggregation of acceptable data from a variety of agencies and sources. Figure 2-1 shows several aspects of monitoring, assessment, and reporting that will be important to realizing the goal.

The traditional means used by EPA to meet the 305(b) requirements has been to compile information from individual States, Territories, Tribes, and interstate basin commissions. In general, such data come from a diverse set of monitoring programs, each of which is based on its own valid purpose. One of the difficulties that arises from this process is differences in overall objectives. On the one hand, EPA is required to report on the condition of the Nation's aquatic resources as a whole, implying either a national census of the resource or a sample survey from which inferences about the entire resource can be drawn. On the other hand, States often select monitoring locations with specific, local purposes in mind. A compilation of such data for regional or national assessments is subject to question about the representativeness of these locations for making comprehensive assessments; i.e., to what extent might the resultant assessment be biased by the non-random selection of monitoring locations as well as the incomplete coverage of the State or Tribal lands?

**Comprehensive Assessment:** An evaluation of resources that provides complete spatial coverage of the geographic area or resource being studied; it provides information on assessment value (condition of the resource), spatial and temporal trends in resource condition, causes/stressors and sources of pollution, and locational information.

**Sample Survey (Probability-Based) Design:** A sampling design based on selection of sites or sample locations using some aspect of randomization; allows statistically-valid inferences to be drawn on a population as a whole.

**Conventional or Targeted Design:** Targeted site selection is used to answer specific questions regarding the condition of a site or area.

**Judgmental (Sample Survey) Design:** Non-random selection of sampling sites with the intent of using assessment results for drawing inferences on a population as a whole.

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## 2. DESIGNING ASSESSMENTS AND MANAGING INFORMATION

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Figure 2-1 not available in electronic form

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### 2.2.1 General Types of Monitoring Designs

The section is intended to expand upon these fundamental differences in general objectives; to describe the types of questions each of the monitoring approaches is intended to address and some of the strengths and weaknesses of the approaches; and to provide some initial recommendations toward more comprehensive assessments. The term “sample survey” is used to describe monitoring designs for producing representative data for regional (statewide, basinwide, ecoregional) or national assessments. The term “conventional or targeted” is used to describe monitoring designs that are more local in scope and that tend to focus on a particular problem, or on sites that are selected for a specific local issue. A “judgmental” monitoring design refers to selecting sites for assessing a broader geographic area and assuming that they are representative of that area (non-random selection). EPA recognizes that most States would need to make programmatic or design adjustments in their monitoring efforts to meet national-, regional-, or State-scale objectives as well as more site-specific data needs.

**Sample surveys** are intended to produce snapshots of the condition of an entire resource when that resource cannot be subject to a census (monitoring of every waterbody). Sample surveys rely on the selection of monitoring sites that are representative of the resource. Randomization in the site selection process is one way to ensure that the sites represent the resource of interest. These surveys are often called **probability-based** or statistical sample surveys.

#### *Examples of Monitoring Questions*

Site Specific: What is the biological condition of Jamster Creek? (targeted monitoring design most often used)

Regional: What is the biological condition of lakes in the mid-Atlantic coastal plain? (requires probability-based monitoring design or defensible judgmental design in the absence of a census)

An alternative is to select sites **judgmentally**, based on some criterion other than randomness. Judgmental selection of sites is based on the judgment of the monitoring agency that the sites are representative of the target resource. Such judgmentally-based sample surveys require strong defense regarding the representativeness of the sites so selected, and it may not be possible to estimate the uncertainty with which inferences are made as it is when using probability-based sample surveys.

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## 2. DESIGNING ASSESSMENTS AND MANAGING INFORMATION

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**Targeted designs** allow questions to be addressed that are focused on site-specific problems, and the aggregation of these site-specific results to make comprehensive assessments is open to question regarding the representativeness of those sites to the resource as a whole. State monitoring programs that combine aspects of the two general approaches (survey designs and targeted designs) may be necessary to provide data and assessments useful at multiple geographic scales from site-specific to national. Appendix I provides some of the advantages and disadvantages of probability-based, targeted, and judgmental monitoring and also examples of the types of questions that can be addressed by each.

### 2.2.2 Planning Process for Probability-based Sampling in a Rotating Basin Design

Considerable planning is required to define the particular classes of waterbodies of interest, but the end result can be a cost-effective, defensible and rigorous process for making inferences about all waterbodies in an area.

The initial step in random selection is definition of the target population (e.g., all lakes over 10 acres or all streams of the State). To characterize all streams of a State, basin, or watershed, the agency would do a simple random selection of locations from within the appropriate boundaries (Figure 2-2).

However, stream segments could be stratified based on watershed, stream sizes (e.g., first, second, or third-order), ecoregion, or even predominant land use/land cover.

Random selection of stream locations for sampling then occurs within each grouping.

Figure 2-3 represents

the stratification of streams into three classes. Techniques are available to ensure even distribution of sampling sites among the classes or strata and across the resource (or State or basin). The selection process would depend on geographic scale or monitoring questions and objectives. Such a probability-based design can provide assessment data that are useful not only for each class of streams individually, but that can be aggregated into a broader-scale resource assessment. It would also allow

**Target Population (Stratum):** A group of potential sampling locations (or assessment units) that is some subset of the total population of sampling units.

**Geographic Scale:** Spatial breadth or size; can be based on political unit (e.g., state, county, or municipality), basin or watershed (e.g., the Anacostia River Watershed, the Columbia River Basin), region (e.g., the Huron-Erie Lake Plain ecoregion, the Pacific coastal Mountain ecoregion), or resource (e.g., the Okefenokee Swamp, the Everglades).

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extrapolation of sources and causes/stressors to broader geographic scales.

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Figure 2-1. Universe of streams from which to draw a random sample

Figure 2-3. Stratification of streams into three classes

(figures not available in electronic form)

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## 2. DESIGNING ASSESSMENTS AND MANAGING INFORMATION

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### 2.2.3 Stratified Probability in a Rotating Basin Design

(text box showing schedule not available in electronic form)

Incorporating stratified probability design into a monitoring program could enable a more efficient and effective sampling of all of a State's major basins. If a State is willing to select its order of rotating basins randomly, the State could potentially obtain results, even in the early year(s), that are meaningful and valid for statewide assessment. To apply such a design, begin with a random selection of three to four basins to be sampled in each year (Figure 2-4a). The sampling schedule in the text box above is an example of the results for a State with 16 basins. Randomized selection of basins is not necessary, and the State can select the order of basins on a priority basis.

The second phase of site selection is random selection of stream reaches from within each of the basins. For example, there are 16 stream segments in Basin 6 (Figure 2-4b). Random selection of a subset of stream segments from within Basin 6 allows aggregation of assessment results into a statistically-valid basinwide assessment.

Referring to the above schedule box, following the 1997 sampling season, there would be four basin assessments to aggregate for a statewide assessment; after 1999, there would be 10 basin assessments to aggregate for a statewide assessment, and so forth. With each subsequent year, the confidence associated with statewide assessments increases. In the first year of the second cycle (2002 in this example), the basin rotation would begin again.

A stratified design can be used to focus on a class of waterbodies for which there has been little previous data collection. For example, larger rivers and streams of some States are well-represented by historical, fixed-station sampling networks, while only a small percentage of headwater streams are assessed. Maryland has applied stratified random design to first- through third-order streams to greatly increase the percentage of its total miles assessed. Delaware selects sampling from all points where roads cross streams.



Figure 2-4a. Random selection of basins

Figure 2-4b. Random selection of streams within a basin

(figures not available in electronic form)

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Note: The above is one approach to incorporating probability-based sampling into rotating basin monitoring. Another approach is to use a repeated statewide survey yearly, complimented by targeted monitoring and assessment according to the State's rotating-basin schedule.

EPA/ORD Corvallis is available to provide technical support in designing probability-based rotating basin surveys through coordination with the Regional 305(b) Coordinator. EPA's Environmental Monitoring and Assessment Program (EMAP) has developed expertise in the area of probability surveys and in establishing a mechanism to help States investigate and implement probability-based designs for their specific needs.

### 2.2.4 Case Studies of Different Types of Monitoring Designs

#### Probability-based Sample Survey Design: State of Delaware

A probability-based sampling design was developed to assess the ecological condition of Delaware's nontidal streams by the Department of Natural Resources and Environmental Conservation (DNREC). The results were used to produce unbiased estimates of biological and physical habitat condition for the State's 305(b) reports. The area of the State containing nontidal streams was estimated from National Wetlands Inventory data on the State's 35 major watersheds. A list of 3,200 locations where roadways cross a nontidal stream was produced using a GIS. Sampling sites were then selected randomly from this list and sampled during the Fall of 1993. The design was selected to reduce the time necessary to reach specific locations on nontidal streams. The underlying assumption is that road crossings are an accurate representation of nontidal stream resources in Delaware. This assumption is currently being tested.

Ninety-six sites were selected in the northern two counties using this approach; benthic macroinvertebrate and habitat data were collected at all locations. Results of the habitat assessment were presented in Delaware's 1994 305(b) report. The majority of the 1357 miles of nontidal streams in the two counties had impaired physical habitat; 65% were severely impaired (i.e., 'poor') and 22% were moderately impaired (i.e., 'fair'). The habitat results were also reported as three strata within the two counties: one stratum comprising all of Kent County (32 sites); another, the piedmont region of New Castle County (26 sites); and the third, the coastal plain of New Castle County (38 sites). Thus, the probability design allowed reporting of results at two geographic scales: 1) the two counties aggregated, and 2) the two counties individually and separated by physiographic region or topography.

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The above description of the Delaware program is taken directly from "The use of a probability-based sampling design to assess the ecological condition of Delaware streams" (Maxted, 1996).

### Judgmental Sample Survey Design: State of Washington

This approach is referred to as the 'representative sampling approach' by the staff of the State of Washington, Department of Ecology. They reviewed all existing monitoring stations to determine why existing sampling locations were selected. If stations were selected because they were judged to be representative of the type of water within a watershed, they will be used in the sampling network and aggregated to a statewide assessment. Alternatively, if stations were selected because of their position relative to a known problem, such as those downstream of a specific discharge, they will not be used as part of a statewide assessment. Data from the latter sites will continue to be used strictly for site-specific assessments; the former will provide site-specific assessments that can be aggregated into a regional (statewide, ecoregional) assessment.

All sites determined as appropriate for the statewide assessment will be initially stratified by ecoregion and waterbody type under the assumption that collectively these sites are representative of all waters within their particular stratum. This assumption will be tested by direct comparison to results provided by the strictly probabilistic design of EPA Region 10 REMAP. Although one concern may be that the selection process could be biased against selecting problem sites, preliminary results show an increased percentage of stations exhibiting impairment compared to a strict probability design.

The Washington Department of Ecology provided background material for the above description of their program.

### Combined Probability-based Sample Survey and Conventional Designs: Prince George's County, Maryland

The Prince George's County Department of Environmental Resources (DER) recently designed and piloted a county-wide biological monitoring program. The County is located in the middle Atlantic coastal plain region and has flowing surface waters that drain into the Patuxent and Potomac Rivers, which themselves drain into the Chesapeake Bay. The County wants to answer questions at various geographic scales including stream-specific, watershed-wide, and county-wide and to have sampled all watersheds over a 5-year period. It was necessary to be able to have

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valid county-wide assessments from the first year of the program and to be able to address problems from known point sources.

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### NPS Monitoring and Evaluation Guide

A nonpoint source (NPS) pollution monitoring and evaluation (M&E) guide is available for use by those who fund and approve M&E plans and those who perform the monitoring. The guide discusses the various objectives of NPS pollution M&E, biological monitoring for NPS pollution, and quality assurance/quality control aspects, and includes an extensive chapter on statistical methods for the evaluation of NPS pollution monitoring data. Appendices contain abstracts and content listings of over 40 guidance documents related to monitoring both point and nonpoint source pollution programs.

Federal, State and regional agencies that support M&E activities might use the guide to assess the technical merit of proposed plans. Those agencies, private groups, and university personnel that perform M&E might use the guide to formulate their plans. The guide is in no way intended to supersede proven NPS pollution M&E plans currently in use, but it is intended as both a check against existing plans and an outline for developing new NPS pollution M&E plans. To obtain a copy contact the NPS Branch at (202) 260-7110.

The unit of assessment was defined as a channel segment of a wadable, nontidal river or stream into which no tributary flows. The number of assessment units within the County was determined from maps to be approximately 1000. This target population was prestratified (subdivided or grouped) by the following: northern and southern parts of the County, watershed, and order (first through fourth). Step 1 was to randomly select four to five watersheds (alternating between north and south) until about 25 percent of the total population, or 200 stream segments, had accumulated. Then, from within each watershed, approximately 25 percent from each of the groups of first, second, and third order segments were randomly selected. Fourth order segments, if they were represented in a particular watershed, were automatically selected since their occurrence was so rare within the County. This process resulted in a rotating basin design where, over a 6-year period, a total of 254 probability sites would be sampled per index period. Each of the 41 watersheds would have 25 percent of its first order streams sampled, 25 percent of its second order, and 25 percent of its third order.

Twenty to 25 specific streams with known problems or special projects would also be sampled and would be used for evaluating the effectiveness of stream restoration projects, remediation of stormwater outfalls, implementation of BMPs, or the effects of specific discharges.

### 2.2.5 Improving Monitoring Designs through Modeling

Calibrated empirical and process models hold the potential to estimate in-stream quality based on landscape and other stressor factors. This active area of research links landscape ecology with instream indicators of

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biological, habitat and chemical quality (e.g., correlating the Index of Biological Integrity with land use and other factors). While probability-based monitoring gives reliable estimates of condition over wide areas, models can provide comprehensive screening for potential problem areas that should be sampled to confirm problems. That is, calibrated empirical and/or process models relating landscape and other stresses to instream condition can potentially provide reliable estimates of where additional problems are likely to be found and thus can result in better targeted monitoring approaches. Statisticians refer to this approach as “model-based inferences.” These models may be an additional tool for States in their efforts to use all available monitoring network approaches to answer key questions such as: “what is the desired condition, where are our problems, and are we making progress over wide areas over time?” A potential synergy among approaches is that data from probability-based efforts could be used to construct the models needed for better screening and targeting. References regarding linking landscape ecology with instream indicators of biological habitat and chemical quality include Zucker and White (1996), Roth et al. (1996), Jones et al. (1996), and U.S. Department of Agriculture, 1996.

### 2.3 Watershed and Waterbody Delineation

The waterbody is the basic unit-of-record for water quality assessment information. That is, most States assess individual waterbodies and store assessment results at this level--results such as degree of use support, causes/stressors, sources, and type of monitoring. The States have defined waterbodies in various ways, from short stream segments and individual lakes to entire watersheds.

The paragraphs below describe features of watersheds and waterbodies and common approaches to their delineation. One goal of this section is to help States make the best decisions about watershed and waterbody delineation, thereby avoiding their need to repeat the process later. Another goal is to ensure that whatever process is selected, it will result in data that can be related to standard watersheds such as USGS Cataloging Units and Natural Resources Conservation Service (NRCS) watersheds to allow data aggregation at various scales. **The proper delineation of individual waterbodies is time-consuming but critically important to a State's 305(b) program. Many States have found it necessary to re-delineate waterbodies after only a few years based on previously unrecognized data needs. EPA urges any State that is considering re-delineating its waterbodies to contact the National 305(b) Coordinator for information about approaches and the experience of other States.**

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### USGS Hydrologic Units

The Hydrologic Unit Code (HUC) is a system developed by the USGS and adopted as a national standard. This system divides the United States into four levels of hydrologic units for purposes of water resources planning and data management:

- 0 Region (2-digit code)
- 0 Subregion (4-digit code)
- 0 Accounting Unit (6-digit code)
- 0 Cataloging Unit (8-digit code)

Note: NRCS has added two additional levels of watersheds. Figure 1-3 shows an 8-digit USGS Cataloging Unit and a 14-digit NRCS small watershed.

The following illustrations show how the hydrologic unit classification is applied to a portion of the State of South Carolina.

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### South Atlantic - Gulf Region 03

Figure not available in electronic form

**Regions** - The Region is the largest unit that USGS uses for comprehensive planning. For example, the South Atlantic-Gulf Region 03 extends from the coastline to the Blue Ridge, and from southern Virginia through the Southeast to New Orleans, Louisiana. There are 18 regions in the conterminous United States, with a national total of 21 (including Alaska, Hawaii, and Puerto Rico and the Virgin Islands).

**Subregions and Accounting Units** - Subregions are defined by major river basins. For instance, in South Carolina, subregion 0305 includes the Saluda, Broad, and Santee Rivers and the Edisto system. Accounting Units are aggregations of Cataloging Units used by USGS to organize water resource data into manageable units. The South Carolina data in Subregion 0305 are organized into 030501--the Santee, Saluda, Broad Rivers accounting unit--and 030502--the Edisto River accounting unit.

**Cataloging Units (CUs)** - The CU is the lowest level of hydrologic classification by USGS for planning and data management. There are 2,111 CUs in the continental United States. The 8-digit HUC number designates each individual CU. In the previous graphic, the lines within Accounting Unit 030501 are CU boundaries and each CU has a unique 8-digit HUC.

The HUC has been adopted as a Federal Information Processing Standard (FIPS); i.e., the HUC is a mandatory standard for Federal agencies describing hydrologic data. The HUC classification is well accepted by



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professional planners and hydrologists at all levels of government and in the private sector.

Figure not available in electronic form

### **NRCS Watersheds**

Years ago, the Soil Conservation Service (now the Natural Resources Conservation Service) subdivided the CUs into watersheds, appending three digits to the eight digit HUC (CU + 3). The designations were made by each State Conservationist to create smaller units for planning activities. There were some consistency problems with the earlier designations, with inharmonious sizes from State to State and a lack of common standards for base maps. Now NRCS Headquarters, working with USGS, EPA, and others, is aggressively pursuing better coherence in the nationwide delineation and standardizing use of the 11-digit watershed code. NRCS is in the process of subdividing States into 14-digit small watersheds (CU + 3 + 3) for planning and analysis at an even finer scale. For example, NRCS in North Carolina worked closely with State environmental agencies to delineate 1,640 14-digit watersheds averaging about 19,000 acres each (see Figure 2-5).

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Figure 2-5 not available in electronic form

### NRCS 11-Digit Watersheds in Cataloging Unit 03050109

Figure not available in electronic form

#### **NRCS Watersheds as a Common Watershed Base**

Many States are seeking to establish common watersheds for use by all State agencies, an approach EPA endorses. The watershed level that seems to offer the most advantages, and is the most frequently chosen by the States, is the NRCS watershed. Use of these watershed boundaries allows easy access to NRCS data and improves coordination of nonpoint source assessments with other agencies.

South Carolina was the first State to index its waterbodies to RF3 and it used the NRCS watershed as the basis for waterbody designation. At first, use support, cause/stressor, and source information was tracked only at the watershed level, but this proved too generalized for use in some specific State decisions. The State then went back and identified use support, causes/stressors, and sources for individual stream segments, which proved to be a useful level of resolution. One goal in any delineation scheme is to assemble data at a resolution sufficient to answer the questions that are important for management, without spending more resources than necessary to obtain data.

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South Carolina, on the basis of information developed in its first GIS effort, also developed some important locational information at significantly higher resolution. They used global positioning system (GPS) technology to accurately identify the location of discharges. They are proceeding basin by basin throughout the State. Their GIS now has obvious value as a tool for management.

This type of functionality will become increasingly important as tools such as ArcView become available.\* These tools, together with the GIS coverages produced by EPA's Reach Indexing project, will allow States to analyze their waterbody and stream reach data spatially. The WBS route system data model (RTI, 1994) allows the State to geographically identify specific use support classifications down to the reach segment level. The EPA contact for georeferencing waterbodies to RF3 is given on page ii.

### **Waterbody Delineation**

Waterbodies have been defined on a wide range of criteria--from individual RF2 reaches, frequently used from 1986 to 1988, to NRCS watersheds or other groupings conforming to administrative boundaries. Tracking of individual RF3 reaches for the 305(b) report gives detailed resolution to waterbody data but can complicate workload management. On the other hand, watershed-scale waterbodies may fail to give sufficient detail for mapping and management decisions unless they identify the actual locations of use support classifications and causes/stressors and sources of impairment.

EPA recommends that States delineate waterbodies to be compatible with NRCS 11- or 14-digit watersheds. "Compatible" can mean for example that multiple stream and lake waterbodies lie entirely within the watershed's boundaries but can be mapped individually (i.e., do not cross NRCS watershed boundaries). Where 14-digit watersheds will be delineated in the near future, a State might consider waiting for these boundaries before redelineating waterbodies. Figure 2-5 shows some of the 14-digit watersheds agreed upon by NRCS and the State of North Carolina.

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\* Mention of trade names in this document does not constitute endorsement. ArcView is a program that enables nonprogrammers to utilize ARC/INFO coverages to do mapping and spatial analysis. ARC/INFO and ArcView (Environmental Systems Research Institute, Inc., ESRI) are the only GIS packages currently in wide use by EPA and State water agencies.

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Table 2-1 describes an approach to delineating waterbodies that is consistent with aggregating data at the watershed level. A cornerstone of any approach should be flexible data management. That is, the level of detail of assessment data can vary from watershed to watershed depending on the unique causes/stressors and sources in each watershed. **EPA urges any State that is considering re-delineating its waterbodies to contact the National 305(b) Coordinator for more information about options and experiences of other States.**

### **Aggregating Assessment Data at Watershed, Basin, and Ecoregion Levels**

EPA recommends that States store assessment data at the most detailed level of resolution they can manage—generally at the level of stream segment, individual lake, or very small homogeneous watershed. EPA encourages States to develop the **capability** to aggregate their waterbody-level assessment data to the watershed, basin, and ecoregion levels. EPA is not asking States to present aggregated assessment data by NRCS watershed, USGS HUC or ecoregion in the 305(b) report, but rather to develop the capability to do so by including appropriate locational data. However, if States prepare basin management plans, States are encouraged to begin reporting aggregated data in them (see Appendix E).

Using CUs or NRCS watersheds as basic units for aggregating water quality assessment data will aid in data integration and in making other agencies' data available to the States. Sufficient locational information should be included to allow aggregation of detail at a minimum at the CU level. CU numbers can be stored, for example, in WBS SCRF1 or SCRF2 files. At a minimum, WBS or other State 305(b) databases should contain watershed identification numbers for each waterbody and, to the extent possible, waterbodies should not cross NRCS or CU watershed boundaries. Assessments can also be aggregated by ecoregion if ecoregion codes are stored in WBS for each waterbody, or in combination with a GIS coverage of ecoregions. Note: If waterbodies are georeferenced to RF3, and a GIS is available, aggregation of assessments to watersheds and ecoregions can be done with the GIS.

### **Reach Indexing Waterbodies to RF3**

Reach indexing or georeferencing is the process of electronically linking a State's waterbodies and other water quality information to the EPA Reach File. Within the next year, RF3 will be incorporated into a new National Hydrography Dataset (NHD), with increased flexibility, accuracy, and GIS compatibility. The NHD will become the official hydrologic database for USGS, EPA, and other agencies. The main product of reach

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indexing is a GIS coverage containing locations of waterbodies, stream networks and



Table 2-1. Approaches for Delineating Waterbodies

Approach	Description	Advantages, Disadvantages, Comments
<p>Waterbodies include individual stream segments, stream networks, and lakes</p>	<p>Several States use a mix of waterbodies:</p> <ul style="list-style-type: none"> <li>c mainstem stream segments</li> <li>c individual tributaries or segments</li> <li>c individual lakes</li> <li>c stream networks--tributaries in a small homogeneous watershed can make up one waterbody</li> <li>c lakes in a small watershed can make up one waterbody</li> <li>c individual estuaries or portions of estuaries (polygons)</li> </ul> <p>Waterbodies do not cross CU or NRCS watershed boundaries</p>	<p>Provides flexibility in the number of waterbodies and in level of detail State wants to track</p> <p>ARC/INFO route systems and dynamic segmentation can be used to add greater detail for selected waterbodies if needed.</p> <p>States can learn from other States' experiences</p> <p>Ideally, the number of waterbodies should be in a tractable range--recommend keeping the total below 2,000 to 4,000 waterbodies depending on the size of the State</p> <p>With georeferencing to RF3, this approach is powerful in its ability to interface with GIS and EPA databases. For tracking and reporting by watershed, watershed boundaries can be overlaid on these waterbodies using a GIS, or watershed ID numbers can be stored in WBS</p>

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flows, and other information. This gives the State powerful mapping and spatial analysis capabilities. In 1996, at least a dozen States incorporated color maps of uses support, causes and sources into their 305(b) reports and other documents such as basin plans. The reaction to this mapping capability has been very positive. Assessment results displayed in map form are much easier for managers and the public to understand than the traditional tabular or printout form.

### 2.4 Managing Assessment Data

The EPA Waterbody System (WBS) is a PC system of water quality assessment information used by nearly half of the States with 305(b) databases. Most other States have developed and maintain their own customized systems. WBS was developed by EPA for States and other entities specifically for tracking and reporting assessments under 305(b). It provides a standard format for water quality assessment information and includes a software program for adding and editing data, linking to other water databases, generating reports, and transferring data between the PC and GISs.

WBS has four main functions:

- C To reduce the burden of preparing reports required under Sections 305(b), 303(d), 314, and 319 of the Clean Water Act
- C To improve the quality and consistency of water quality reporting among the States
- C To provide data for national level assessments and for analyzing water quality issues outside of 305(b)
- C To be a useful water quality management tool for State agencies.

These 305(b) *Guidelines* and user requests determine the features of the WBS. The *Guidelines* require States to track dozens of data types for each waterbody (each State has from several hundred to several thousand waterbodies) in order to generate the summary tables required in Section 4 of the main volume of these *Guidelines*. Although most WBS features result from the 305(b) *Guidelines*, WBS also contains some data elements that States have requested for internal management purposes (e.g., georeferencing fields and memo fields).

WBS contains over 100 data elements in such categories as:

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- C Descriptors — waterbody name, number, description, type (stream, lake, etc.), size
- C Locational data elements — Reach File coordinates, basin and watershed identifiers
- C Assessment data — degree of use support for each use, size impaired, causes/stressors and sources, type of monitoring, type of assessment, assessment confidence.

For detailed information about the WBS, see the *WBS Users Guide*. EPA also provides ongoing technical support to WBS users. Between January and August 1996, EPA provided consultations to more than 30 agencies, including States, Territories, Tribes, and Interstate Commissions, on the use of WBS and RF3 for 305(b) programs. Contact WBS Technical Support at the telephone number on page ii.

### Data Management Options for Aggregating Data by Watershed

At least three options are available for aggregating assessment data by watershed for basin management plans and other purposes. These options are compatible with WBS and the approaches described in Table 4-1.

1. Entirely within WBS or other State assessment database. If waterbody records contain CU or NRCS watershed numbers, the database can aggregate data to that level automatically.
2. WBS or other State assessment database in combination with a GIS program. WBS can be used to store assessment data in combination with GIS programs such as ARC/INFO or ArcView, which enable users to analyze spatial data and prepare maps. ArcView runs on personal computers and users do not need to learn the ARC/INFO programming language. It uses standard ARC/INFO data coverages (e.g., reach-indexed waterbodies or STORET monitoring stations). (See previous note regarding mention of trade names.)
3. Entirely within the GIS environment. States with full GIS capability (e.g., having access to ARC/INFO programmers and workstations) can manage assessment data within the GIS environment and export results to WBS or other programs for reporting.

### SECTION 3

#### MAKING USE SUPPORT DETERMINATIONS

This section presents EPA's recommended approaches to making use support decisions. Designated uses are assigned to individual waterbodies in a state's water quality standards. Types of designated uses include: aquatic life, fish consumption, recreational uses such as swimming, and drinking water. This guidance is drafted for wadeable streams and rivers. However, the approach is applicable to other types of waterbodies, as well.

#### 3.1 ITFM Recommendations for Monitoring

The Intergovernmental Task Force on Monitoring Water Quality (ITFM) was formed in 1992 to develop recommendations on monitoring to achieve more comparable and scientifically defensible information, interpretations, and evaluations of water-quality conditions across the nation. The ITFM comprised both Federal and State agencies responsible for monitoring and assessment programs as well as an associated advisory committee including municipalities, academia, industry, etc. (ITFM 1995). The ITFM subsequently developed a model for stream monitoring for different types of designated uses based on a combination of biological, physical, and chemical monitoring (Figure 3-1). The model defines the relationship between parameters that directly measure the condition of the biotic community and its response over time to stressors, such as fish and benthic macroinvertebrate indices, and parameters that measure either stressors or exposure of organisms to stressors, such as levels of pH, nutrients, and toxicants. For streams, EPA recommends that States incorporate ITFM's suite of parameters in their monitoring programs for evaluating attainment of designated uses. These are general recommendations to consider when developing and revising monitoring programs. For example, monitoring for aquatic life use would include the base monitoring program parameters in the box--community level biological data from at least two assemblages, habitat, and physical/chemical field parameters—plus ionic strength, nutrients, and toxicants in water and sediment.

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The ITFM in May 1997 became a permanent National Water Quality Monitoring Council to facilitate, among other tasks, the development and implementation of the recommendations on specific methods for measuring

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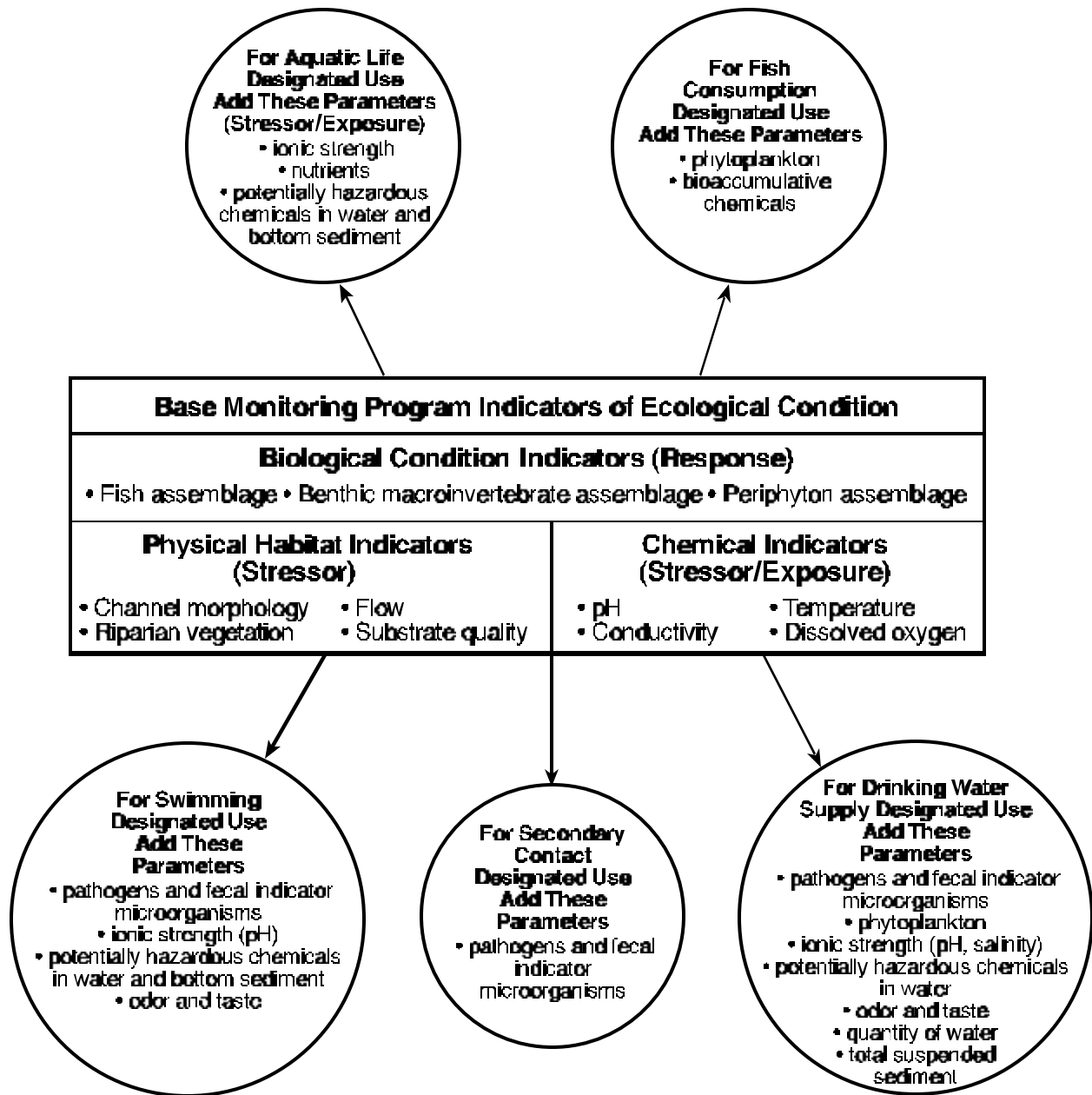


Figure 3-1. ITFM Model for Stream Monitoring: Monitoring for different designated uses based on a combination of biological, physical, and chemical measures

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the parameters shown in Figure 3-1. Standard methods for measuring the chemical parameters and conducting toxicity tests are well established among the States, but methods for biological and habitat assessments are not standardized for all types of waterbodies. Recent work by the Ohio EPA suggests that bioassessment methods differ widely in their accuracy and discriminatory power for aquatic life use determinations (Yoder et al., 1994). Ohio evaluated a hierarchy of bioassessment approaches relevant to differing levels of rigor and confidence. In their State, Ohio EPA found that less intensive bioassessment approaches tend to be accurate **in detecting impairment**, but may give a false indication of full support in reaches where the methods are not rigorous enough to detect subtle problems.

ITFM (1995) recommends that to combine data for assessment, monitoring data produced by different organizations should be comparable, of known quality, available for integration with information from a variety of sources, and easily aggregated spatially and temporally. This is important at a variety of scales, up to and including national assessments. If different methods are similar with respect to the quality of data each produces, then data from those methods may be used interchangeably or together (Diamond et al. 1996). As data quality (i.e., precision, sensitivity) increases, the confidence in the assessment increases. Data quality objectives should be defined for each method so that assessments can be validated by imposing a known level of confidence in the results.

#### *Monitoring Design*

Any monitoring and assessment program begins with setting goals and a monitoring design that can meet those goals. The history of water quality monitoring is replete with programs that could not answer key questions. Examples include:

- C A watershed study where the monitoring organization assumes that flow data can be obtained after the fact based on "reference point" measurements from bridges, only to learn later that many streams lack the channel morphometry to develop a stage-discharge relationship;
- C An intensive survey where the laboratory's detection levels for metals prove inadequate to detect even concentrations above water quality standards;
- C A basin survey where management or the legislature poses the question "What is the statistical trend in biological condition of our streams?" too late to be incorporated into the monitoring design.

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As discussed in Section 2, EPA has a goal of comprehensively characterizing the Nation's streams, rivers, lakes, wetlands, estuaries, and shorelines. These assessments will include monitored and evaluated assessments and may involve probability-based as well as targeted monitoring. To achieve this goal, EPA encourages States to incorporate a formal process of goal setting and monitoring design while meeting their own State-specific goals. ITFM provides general guidelines for the topics to consider in monitoring design in a technical appendix of its final report (ITFM, 1995), and EPA's Section 106/604(b) monitoring guidance tailors the ITFM guidelines to the 106/305(b) process.

The Data Quality Objectives (DQO) process developed by EPA's Quality Assurance Management Staff is a specific approach to monitoring design that has been applied to monitoring programs in all media. The DQO process involves the stakeholders in the program in the design. Stakeholders itemize and clarify the questions being asked of a monitoring program, including the required level of accuracy in the answers. Generally, these questions are stated in quantitative terms ("What are the index of biotic integrity [IBI] and invertebrate community index [ICI] values for wadable streams in Big River Basin, and what is the trend in IBI across the basin, with 80 percent certainty?"), and statistical methods may be recommended for selecting sites or sampling frequency. For information about DQOs for water quality monitoring contact the Assessment and Watershed Protection Division at (202) 260-7023.

To date, States have taken three main approaches to monitoring a large portion of their waterbodies:

- C Fixed-station networks with hundreds or thousands of sites (most large networks have been reduced in the past 10 years)
- C Rotating basin surveys with a large number of monitoring sites covering thousands of miles of waters (Ohio EPA's bioassessment program)
- C Rotating basin surveys with a probabilistic monitoring design; a statistically valid set of sites are selected for sampling in each basin (Delaware's benthic macroinvertebrate program).

The National Water Quality Monitoring Council may make recommendations about monitoring design; in the meantime, however, EPA encourages States to consider existing approaches such as Ohio's and Delaware's. In particular, EPA urges States to take advantage of monitoring data provided by other agencies such as USGS, NOAA, or the U.S. Fish and Wildlife Service (USFWS). See Section 2 for more



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information about comprehensive assessments using different monitoring designs.

#### 3.2 Aquatic Life Use Support (ALUS)

The EPA/State 305(b) Consistency Workgroup has begun to implement the ITFM recommendations including how to integrate the results of biological, habitat, chemical and toxicological assessments in making a determination of aquatic life use support (ALUS). This approach includes consideration of assessment quality as indicated by levels of information of the different data types in evaluating the degree of impairment (partial support vs nonsupport) when there are differences in assessment results. Level of information is discussed below and described for each data type in Sections 3.2.1 through 3.2.4, Tables 3-1 through 3-4. Guidance on making assessments of ALUS for each individual data type is included in Sections 3.2.1 through 3.2.4. Guidance and case studies on integration of the assessment results from different data types, including consideration of level of information and site specific conditions, are presented in Section 3.2.5.

##### *Level of Information*

In 1994, the 305(b) Consistency Workgroup concluded that descriptive information characterizing the level of information, or rigor, in the method is needed to more fully define an assessment of use support. Documenting this information is important because users often need to know the basis of the underlying information. The Workgroup recommends that assessment quality information become a part of State assessment data bases. Consequently, the Workgroup has developed guidance for evaluating the level of information of methods used in making ALUS.

Data types are grouped into four categories: biological (Table 3-1), habitat (Table 3-2), toxicological (Table 3-3) and physical/chemical (Table 3-4). A hierarchy of methods corresponding to each data type and ordered by level of information is summarized in the tables. The rigor of a method within each data type is dictated by its technical components, spatial/temporal coverage, and data quality (precision and sensitivity). In the data type tables, Level 4 data are of highest quality for a data type and provide relatively high level of certainty. Level 1 data represent less rigorous approaches and thus provide a level of information with greater degree of uncertainty. However, in situations where severe conditions exist, a lower level of assessment quality will be adequate. For example, a severely degraded site can be characterized as impaired with a high level of confidence based on a cursory survey of biota or habitat, as in

### **3. MAKING USE SUPPORT DETERMINATIONS**

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the case of repeated fish kills or severe sedimentation from mining. Data in Levels 1 through 4 vary in strengths and limitations, and, along with site-specific conditions, should be evaluated carefully for use in assessments. Data not adequate for ALUS determinations should be excluded from the assessment.

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**Table 3-1. Hierarchy of Bioassessment Approaches for Evaluation of Aquatic Life Use Attainment Based on Resident Assemblages**

Level of Info <sup>a</sup>	Technical Components	Spatial/ Temporal Coverage	Data Quality <sup>b</sup>	WBS Codes <sup>c</sup>
1	Visual observation of biota; reference conditions not used; simple documentation	Limited monitoring; extrapolations from other sites	Unknown or low precision and sensitivity; professional biologist not required	310, 320, 350, 322
2	One assemblage (usually invertebrates); reference conditions pre-established by professional biologist; biotic index or narrative evaluation of historical records	Limited to a single sampling; limited sampling for site-specific studies	Low to moderate precision and sensitivity; professional biologist may provide oversight	310, 320, 322, 350
3	Single assemblage usually the norm; reference condition may be site-specific, or composite of sites (e.g., regional); biotic index (interpretation may be supplemented by narrative evaluation of historical records)	Monitoring of targeted sites during a single season; may be limited sampling for site-specific studies; may include limited spatial coverage for watershed-level assessments	Moderate precision and sensitivity; professional biologist performs survey or provides training for sampling; professional biologist performs assessment.	310, 315, 320, 321, 330, 331, 350
4	Generally two assemblages, but may be one if high data quality; regional (usually based on sites) reference conditions used; biotic index (single dimension or multimetric index)	Monitoring during 1-2 sampling seasons; broad coverage of sites for either site-specific or watershed assessments; conducive to regional assessments using targeted or probabilistic design	High precision and sensitivity; professional biologist performs survey and assessment	310, 315, 320, 321, 330, 331, 340, 350

NOTE: Table is based on use in lotic systems. With some modification, these approaches would apply to other waterbody types.

<sup>a</sup> Level of information refers to rigor of bioassessment, where 1 = lowest and 4 = highest.

<sup>b</sup> Refers to ability of the ecological endpoints to detect impairment or to differentiate along a gradient of environmental conditions.

<sup>c</sup> WBS Assessment Type Codes from Table 1-1.

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**Table 3-2. Hierarchy of Habitat Assessment Approaches for Evaluation of Aquatic Life Use Attainment**

Level Of Info <sup>a</sup>	Technical Components	Spatial/ Temporal Coverage	Data Quality <sup>b</sup>	WBS Codes <sup>c</sup>
1	Visual observation of habitat characteristics; no true assessment; documentation of readily discernable land use characteristics that might alter habitat quality; no reference conditions	Sporadic visits; sites are mostly from road crossings or other easy access	Unknown or low precision and sensitivity; professional scientist (biologist, hydrologist) not required	365
2	Visual observation of habitat characteristics and simple assessment; use of land use maps for characterizing watershed condition; reference condition pre-established by professional scientist	Limited to annual visits and non-specific to season; generally easy access; limited spatial coverage and/or site-specific studies	Low precision and sensitivity; professional biologist or hydrologist not involved or only correspondence	370
3	Visual-based habitat assessment using standard operating procedures (SOPs); may be supplemented with quantitative measurements of selected parameters; conducted with bioassessment; data on land use compiled and used to supplement assessment; reference condition used as a basis for assessment	Assessment during a single season usually the norm; spatial coverage may be limited or broad and commensurate with biological sampling; assessment may be regional or site-specific	Moderate precision and sensitivity; professional biologist or hydrologist performs survey or provides oversight and training	375
4	Assessment of habitat based on quantitative measurements of instream parameters, channel morphology, and floodplain characteristics; conducted with bioassessment; data on land use compiled and used to supplement assessment; reference condition used as a basis for assessment	Assessment during 1-2 seasons; spatial coverage usually broad and commensurate with biological sampling; assessment may be regional or site-specific	High precision and sensitivity; professional biologist or hydrologist performs survey and assessment	380

NOTE: Table is based on use in lotic systems. With some modification, these approaches would apply to other waterbody types.

<sup>a</sup> Level of information refers to rigor of habitat assessment, where 1 = lowest and 4 = highest.

<sup>b</sup> Refers to ability of the habitat endpoints to detect impairment or to differentiate along a gradient of environmental conditions.

<sup>c</sup> WBS Assessment Type Codes from Table 1-1.

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**Table 3-3. Hierarchy of Toxicological Approaches and Levels for Evaluation of Aquatic Life Use Attainment**

Level of Info <sup>a</sup>	Technical Components	Spatial/ Temporal Coverage	Data Quality <sup>b</sup>	WBS Codes <sup>c</sup>
1	Any <u>one</u> of the following: C Acute or chronic WET C Acute ambient C Acute sediment	1-2 WET tests/yr or 1 ambient or sediment sample tested in a segment or site	Unknown/low; minimal replication used; laboratory quality or expertise unknown	510, 520, 530, 550
2	Any of the following: C Acute <u>or</u> chronic ambient C Acute sediment C Acute <u>and</u> chronic WET for effluent-dominated system	3-4 WET tests/yr or 2 ambient or sediment samples tested in a segment or site at different times	Low/moderate—little replication used within a site; laboratory quality or expertise unknown or low	510, 520, 530, 540, 550
3	Any of the following: C Acute and chronic WET for effluent-dominated system C Chronic ambient <u>or</u> acute or chronic sediment	Monthly WET tests or total of 3 tests based on samples collected in a segment at 3 different times	Moderate/high—replication used; trained personnel and good laboratory quality	510, 520, 540, 550
4	Both of the following: C Acute and chronic ambient and C Acute <u>or</u> chronic sediment	\$ 4 tests in total based on samples collected in a segment at 4 different times including low flow conditions	High—replication used; trained personnel and good laboratory quality	530, 540, 550

<sup>a</sup> Level of information refers to rigor of toxicity testing, where 1 = lowest and 4 = highest

<sup>b</sup> Refers to ability of the toxicity testing endpoints to detect impairment or to differentiate along a gradient of environmental conditions

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c WBS Assessment Type Codes from Table 1-1.

### 3. MAKING USE SUPPORT DETERMINATIONS

**Table 3-4. Hierarchy of Physical/chemical Data Levels for Evaluation of Aquatic Life Use Attainment**

Level of Info <sup>a</sup>	Technical Components	Spatial/Temporal Coverage	Data Quality <sup>c</sup>	WBS Codes <sup>d</sup>
1	Any <u>one</u> of the following: <ul style="list-style-type: none"> <li>C Water quality monitoring using grab water sampling</li> <li>C Water data extrapolated from an upstream or downstream station where homogeneous conditions are expected</li> <li>C Monitoring data &gt; 5 years old without further validation</li> <li>C Best professional judgment based on land use data, source locations</li> </ul>	Low spatial and temporal coverage: <ul style="list-style-type: none"> <li>C Quarterly or less frequent sampling with limited period of record (e.g., 1 day)</li> <li>C Limited data during key periods or at high or low flows (critical hydrological regimes)<sup>b</sup>.</li> </ul>	Unknown/ Low	210, 220, 230, 240, 850, 150, 130
2	Any <u>one</u> of the following: <ul style="list-style-type: none"> <li>C Water quality monitoring using grab water sampling</li> <li>C Rotating basin surveys involving multiple visits or automatic sampling</li> <li>C Synthesis of existing or historical information on fish contamination levels</li> <li>C Screening models based on loadings data (not calibrated or verified).</li> </ul>	Moderate spatial and temporal coverage: <ul style="list-style-type: none"> <li>C Bimonthly or quarterly sampling during key periods (e.g., spring/ summer months)</li> <li>C Fish spawning seasons, including limited water quality data at high and low flows</li> <li>C Short period of record over a period of days or multiple visits during a year or season.</li> </ul>	Low/ Moderate	210, 220, 222, 230, 240, 242, 260, 810, 180
3	Any <u>one</u> of the following: <ul style="list-style-type: none"> <li>C Composite or a series of grab water sampling used (diurnal coverage as appropriate)</li> <li>C Calibrated models (calibration data &lt; 5 years old).</li> </ul>	Broad spatial and temporal (long-term, e.g., > 3 years) coverage of site with sufficient frequency and coverage to capture acute events: <ul style="list-style-type: none"> <li>C Typically, monthly sampling during key periods (e.g., spring/ summer months, fish spawning seasons), multiple samples at high and low flows</li> <li>C Lengthy period of record (sampling over a period of months).</li> </ul>	Moderate/ High	211, 222, 242, 250, 610
4	All of the following: <ul style="list-style-type: none"> <li>C Water quality monitoring using composite or series or grab samples (diurnal coverage as appropriate)</li> <li>C Limited sediment quality sampling and fish tissue analyses at sites with high probability of contamination.</li> </ul>	Broad spatial (several sites) and temporal (long-term, e.g., > 3 years) coverage of site with sufficient frequency and parametric coverage to capture acute events, chronic conditions, and all other potential P/C impacts <ul style="list-style-type: none"> <li>C Monthly sampling during key periods (e.g., spring/summer months)</li> <li>C Fish spawning seasons) including multiple samples at high and low flows</li> <li>C Continuous monitoring.</li> </ul>	High	231, 242, 250

NOTE: Physical refers to physical water parameters (e.g., temperature, pH, dissolved oxygen, turbidity, color, conductivity)

<sup>a</sup> Level of information refers to rigor of physical/chemical sampling and analysis, where 1 = lowest and 4 = highest.

<sup>b</sup> Even a short period of record can indicate a high confidence of *impairment* based on P/C data; 3 years of data are not required to demonstrate impairment.

For example, a single visit to a stream with severe acid mine drainage impacts (high metals, low pH) can result in high confidence of nonsupport. However, long-term

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monitoring may be needed to establish full support.

<sup>c</sup> Refers to ability of the physical/chemical endpoints to detect impairment or to differentiate along a gradient of environmental conditions.

<sup>d</sup> WBS Assessment Type Codes from Table 1-1.



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At the Workgroup's recommendation, EPA is applying levels of information to wadable streams and rivers where EPA's Rapid Bioassessment Protocols or other comparable methods can be applied. This is because, at this time, monitoring methods for wadable streams and rivers are better documented and standardized (Gibson et al. 1996, Plafkin et al., 1989) than for other surface water resources such as lakes and estuaries.

EPA asks States to document the level of information that characterizes their methods for biological, habitat, toxicological, and chemical evaluations. The approach may be extended to ALUS determinations in other types of waterbodies as well as other designated uses in future 305(b) cycles based on the experience with ALUS in streams and rivers and as methods for other waterbody types are standardized. The Waterbody System will contain fields to track level of information for each data type (first columns of Tables 3-1 through 3-4).

EPA encourages States to store and provide this information for each river and stream assessment in addition to WBS Assessment Type Codes. See Section 6, especially Table 6-1, of the main *Guidelines* volume regarding data elements for annual electronic reporting.

#### 3.2.1 Bioassessment

Biological survey methods are desirable for ALUS determinations, because they measure ecosystem health and integrity more directly than surrogate techniques and serve as response indicators to a variety of stressors. Certain biological survey and assessment techniques are useful for screening; i.e., they are intended to be sufficient for detecting problems and may not be as rigorous as techniques used to assess the degree of use support or prioritize sites for further study or some mitigation action. However, simple biological screening techniques are usually sufficient to identify severely degraded or the other extreme (i.e., excellent) biological conditions. A hierarchy of biological approaches can be developed that incorporates certain technical considerations and are relevant to various levels of information (Table 3-1). The data quality elements emphasize a determination of precision (i.e., measurement error at a site as evidenced by the reproducibility of metric values or bioassessment scores for a given site during the same index period) and sensitivity (i.e., the ability to detect impairment relative to the reference condition).

Based on considerable information already available, EPA strongly endorses the regional reference approach for State bioassessment programs for streams (Gibson et al. 1996), which is a level 3 or 4 assessment in Table 3-1. If States choose not to implement a reference

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site approach, they are still encouraged to monitor two organism assemblages (level 4), with detailed taxonomy, a multimetric approach, and habitat evaluation. In calling for two assemblages, EPA seeks to include critical groups in the food chain that may react to different ecosystem stressors or differently to the same stressor. EPA recognizes that the use of two assemblages or the regional reference approach may not be feasible in certain cases (e.g., streams in the arid west due to naturally occurring conditions such as extreme temperatures and lack of flow). EPA also recognizes that some State bioassessment programs are in their early stages and may not yet have the capability to use a regional reference site approach or to monitor more than one assemblage.

Many States (Davis et al. 1996) are currently assessing a single assemblage, benthic macroinvertebrates, with detailed taxonomy, a multimetric approach, and habitat evaluation (Level 2 or 3 assessment in Table 3-1). These States are monitoring a critical assemblage that often gives the greatest information about ecosystem health for the available resources. For fish sampling, some rely on their fish and game agencies, which are mainly oriented to game fish. As resources permit, EPA encourages State water quality agencies to develop the capability for fish assemblage monitoring themselves or work with the fish and game staff to develop the needed capabilities.

#### ALUS Determination Based on Biological Assessment Data

- A. Fully Supporting: Reliable data indicate functioning, sustainable biological assemblages (e.g., fish, macroinvertebrates, or algae) none of which has been modified significantly beyond the natural range of the reference condition.
- B. Partially Supporting: At least one assemblage (e.g., fish, macroinvertebrates, or algae) indicates moderate modification of the biological community compared to the reference condition.
- C. Not Supporting: At least one assemblage indicates nonsupport. Data clearly indicate severe modification of the biological community compared to the reference condition.

The interpretation of the terms "modified significantly," "moderate modification," and "severe modification" is State-specific and depends on the State's monitoring and water quality standards programs. For example, Ohio EPA reports nonattainment (not supporting) if none of its 3 indices (2 for fish and 1 for macroinvertebrates) meet ecoregion criteria or if one assemblage indicates severe toxic impact (Ohio's poor or very poor category), even if the other assemblage indicates attainment. Partial

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support exists if 1 of 2 or 2 of 3 indices do not meet ecoregion criteria and are in the poor or very poor category.

#### *Additional Considerations for Lakes*

State lake managers should address more than one biological assemblage in making lake ALUS decisions. Many parameters of these assemblages may not have specific criteria (e.g., algal blooms, growth of nuisance weeds) but have important effects on lake uses. Many are also response indicators of the level of lake eutrophication.

Lake resources vary regionally, even within States, due to variations in geology, vegetation, hydrology, and land use. Therefore, regional patterns of lake water quality, morphometry (physical characteristics such as size, shape, and depth), and watershed characteristics should ideally be defined based on comparison to natural conditions using an ecoregion approach. The State can then set reasonable goals and criteria for a variety of parameters. These regional patterns currently apply to natural lakes, but are being evaluated for use with reservoirs.

EPA is developing guidance on bioassessment protocols and biological criteria development for lakes and reservoirs (*Guidance on Lake and Reservoir Bioassessment and Biocriteria*, draft, U.S. EPA, 1996). Draft guidance is currently being revised to address a review of comments by EPA's Science Advisory Board. Notice of availability for public review and comment in the *Federal Register* is planned for 1997.

#### **3.2.2. Habitat Assessment**

Assessment of the physical habitat structure is necessary for aquatic life support evaluations because the condition and/or potential of the biological community is dependent upon supportive habitat. Aquatic fauna often have very specific habitat requirements, independent of water quality (Barbour et al. 1996a). The technique of habitat assessment has evolved substantially over the last decade to provide adequate information on the quality of the habitat. Numerous State and Tribal agencies are well-versed in habitat assessment and have incorporated appropriate techniques into their monitoring programs. Results from nonpoint-source assessments suggest that habitat alteration is a major source of perturbation of the Nation's surface waters. The strengths of habitat assessment are: (1) enhances interpretation of biological data; (2) provides information on non-chemical stressors, and (3) leads to informed decisions regarding problem identification and restoration.

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Most often, habitat assessment is conducted in conjunction with bioassessment. A general habitat assessment incorporates physical attributes from microhabitat features such as substrate, velocity, depth, to channel morphology features such as width, sinuosity, flow or volume, to riparian and bank structure features. All of these features are stressor indicators. The approach also can integrate habitat information into an index or summary of overall habitat condition.

The rigor of the habitat assessment ranges from a visual-based characterization (Level 1), which documents specific characteristics without placing a value, to a true assessment (Levels 2 through 4), which places a value on the quality of the physical habitat structure (Table 3-2). Habitat assessments may be visual-based (e.g., RBPs), patterned after Ohio EPA (1987), Plafkin et al. (1989), Florida DEP (1994), and Idaho DEQ (1995), or more quantitative as suggested by the Environmental Monitoring and Assessment Program (EMAP). The data quality associated with habitat assessment is more difficult to define than with bioassessment, but can be done by a comparison among investigators.

#### ALUS Determination Based on Habitat Assessment Data.

- A. Fully Supporting: Reliable data indicate natural channel morphology, substrate composition, bank/riparian structure, and flow regime of region. Riparian vegetation of natural types and of relatively full standing crop biomass (i.e., minimal grazing or disruptive pressure).
- B. Partially Supporting: Modification of habitat slight to moderate usually due to road crossings, limited riparian zones because of encroaching land use patterns, and some watershed erosion. Channel modification slight to moderate.
- C. Not Supporting: Moderate to severe habitat alteration by channelization and dredging activities, removal of riparian vegetation, bank failure, heavy watershed erosion or alteration of flow regime.

Habitat assessment is mostly conducted in conjunction with bioassessment. However, degradation of habitat associated with aquatic resources is a primary stressor limiting the attainment of aquatic life use support in many regions of the country. Land use patterns involving urban development and impervious surface, agriculture and ranching, silviculture, mining, and flood control/regulation are generally the principal factors in habitat degradation.

#### 3.2.3. Aquatic and Sediment Toxicity Methods

EPA recommends that information from toxicity tests be separated from the physical/chemical data. Although chemical criteria are based on toxicity tests, actual testing done to evaluate an aquatic life use should be treated as an additional ecological indicator.

Toxicity tests are a well-established tool for examining effects of both point and nonpoint sources of chemicals or effluents in surface waters (i.e., stressor and exposure indicators). Most States require whole effluent toxicity (WET) testing of waste water dischargers under the NPDES program. For ALUS, ambient water column and whole sediment toxicity tests may be most relevant, particularly if the early life stages of test organisms and sublethal (chronic) endpoints are used (Table 3-3). Ambient tests use samples that are collected from sites and that are typically used whole (i.e., no dilution). Toxicity tests, like chemical analyses, use temporally discrete samples which, in the case of water column tests, typically have short holding times (< 36 hours according to EPA guidance). Sediment samples may be held for longer periods (2 to 8 weeks) prior to testing if stored properly. Samples used in aquatic toxicity testing are usually collected over no more than a 24-hour period. Sediment samples, by their very nature, are grab samples which are also collected over a short time period (hours) at any one site. As a result, all toxicity tests, even those involving prolonged chronic exposures (such as EPA 7-day chronic tests or 28-day chronic sediment tests), yield data that are a "snapshot" in time. The longer the period of time over which site water or sediment samples are collected and used in testing, the longer the "snapshot" and the higher confidence that the test result is representative of prevailing water or sediment quality conditions at that time. The strengths of ambient toxicity tests are:

- C They aid in identifying point and nonpoint source water-quality impairments that may otherwise be undetectable using other monitoring tools;
- C They are used for confirming that observed impairment is not due to chemical or toxicity-related sources. Ohio EPA and the North Carolina Division of Water Quality, for example, used toxicity tests to demonstrate that habitat or physical stressors were the major causes of impairment in some systems and not point-source toxicity as previously assumed;
- C They integrate biological effects of most chemical stressors present, thereby giving a more accurate estimate of the actual water or sediment quality as compared to chemical concentration

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measurements; this has been shown to be particularly true for certain water column metals, bulk sediment chemical measurements that do not take into account total organic carbon or acid volatile sulfide concentrations (for nonpolar organics and metals, respectively), and for sites in which potential pollutants were unmeasured or unknown.

WET tests are potentially useful for ALUS at sites in which an effluent contributes the major flow instream (i.e., effluent-dominated or effluent-dependent systems). These tests are well standardized and relatively easy to interpret, however, their relationship to ALUS is dependent on many factors that may or may not be identifiable for the system of interest (Waller et al. 1996; LaPoint et al. 1996).

Sediment toxicity tests are especially useful for ALUS since sediments can be prominent sources as well as sinks. For this reason, sediment samples may represent a somewhat longer "snapshot" in time than water column samples. Also, because sediment samples can be stored for longer periods than water samples, they are more convenient to use in testing. Collection of sediment pore water or elutriates further enhances the use of sediments in ALUS because these fractions may contain most of the bioavailable pollutants present and because these fractions are amenable to standard aquatic toxicity test methods. Combined with bioassessments and sediment chemical analyses, sediment toxicity is a powerful tool to evaluate and identify causes of impairment. Whole sediment testing, using the more standardized 10-day acute tests, may be most appropriate for ALUS. These are the least labor-intensive and costly tests and are also easiest to interpret. The more recently developed EPA chronic sediment test methods (which should be available by the end of 1997) are also promising tools for ALUS. Sediment testing is most relevant if there are appropriate reference site sediments available with which to compare different site samples. Usually, such reference sites are available, but in some instances are defined by trial and error. The use of clean laboratory-formulated reference sediments as a means of comparison is also a viable option, particularly if factors such as sediment particle size are similar to that observed at the site of interest.

Concerns with sediment tests are: (1) for representativeness, many sediment samples may need to be composited at a site to overcome physical and chemical heterogeneity; (2) storage and manipulation of samples prior to testing may change the chemical characteristics and toxicity of a sample in unknown ways; and (3) for some species, physical characteristics of the sediment (e.g., particle size or TOC) may be suboptimal for the test species resulting in a false positive or apparently toxic conditions when there are none. This may necessitate the use of two or more different test species for a given sediment sample.

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Several EPA, American Society for Testing Materials (ASTM), and State agency toxicity test methods exist, both for saltwater and freshwater aquatic and sediment toxicity tests, ranging from short-term acute or lethality tests (usually 48 to 96h in length for aquatic and pore water or elutriate tests and 10d for whole sediments) to longer term early life stage (7 day for pore water and elutriates and 28 day for whole sediments) and full life-cycle (> 21 day for aquatic tests) chronic tests that measure sublethal endpoints. Some sublethal tests such as those for saltwater bivalve embryo-larval development or echinoderm fertilization, may be much shorter in duration (48 and 1.5 hour, respectively). Appropriate sample collection is critical to ensure representative and accurate results. In addition, chemically inert sampling equipment must be used and depth and/or width integrated composite samples should be considered for ALUS determination.

#### ALUS Determinations Based on Aquatic and/or Sediment Toxicity Data

- A. Fully Supporting: No toxicity noted in either acute or chronic tests compared to controls or reference conditions.
- B. Partially Supporting: No toxicity noted in acute tests, but may be present in chronic tests in either slight amounts and/or infrequently within an annual cycle.
- C. Not Supporting: Toxicity noted in many tests and occurs frequently.

#### *Other Considerations*

For certain species such as planktonic ones, ambient aquatic samples may appear more or less toxic due to the presence of certain natural water quality conditions or eutrophication effects. Ambient tests are a "snapshot" in time and may be unrepresentative of other times, seasons, or flows. Non-toxic conditions include naturally high dissolved solids, hardness, or conductivity, or naturally low alkalinity and hardness. Appropriate reference site or control samples for comparison may not be readily available in some systems resulting in a certain amount of uncertainty in extrapolating laboratory control or simulated reference conditions to actual natural conditions at a site. WET tests are best incorporated into the NPDES program; for ALUS, the results obtained using tools in the 305(b) process such as bioassessment, ambient aquatic and sediment toxicity tests, and chemical monitoring are more appropriate.

#### 3.2.4 Physical/Chemical Methods

The use of physical/chemical data as stressor and exposure indicators for determining ALUS has long been a basis of State monitoring programs. Established criteria exist for many chemical parameters and standard sampling and analysis protocols have been developed for ensuring consistency and quality control. These data are separated into categories of toxicants (priority pollutants, chlorine, and ammonia), conventionals (dissolved oxygen, pH, temperature) in reference to the physical constituents of water quality, and metals. Although SOPs exist for physical/chemical parameters, States still differ in their design and implementation of chemical sampling and analysis (Table 3-4). Sampling frequency and intensity vary among states. The number of parameters sampled and analyzed also varies among programs which influences comparability in assessments.

Analyses of chemical concentrations in fish tissues are included in Table 3-4. Though not a traditional or required measure of ALUS, fish tissue concentrations are useful for evaluating the potential impacts to wildlife that depend on aquatic systems for food and/or habitat.

#### ALUS Determinations Based on Physical/Chemical Assessment Data

EPA recognizes that many States may not always collect a broad spectrum of chemical data for every waterbody. Therefore, States are expected to apply the following guidance to whatever data are available and to use a "worst case" approach where multiple types of data are available. If, for example, chemical data indicate full support but temperature data indicate impairment, the waterbody is considered impaired.

#### Conventionals (dissolved oxygen, pH, temperature)

- A. Fully Supporting: For any one pollutant or stressor, criteria exceeded in #10 percent of measurements. In the case of dissolved oxygen (DO), national ambient water quality criteria specify the recommended acceptable daily average and 7-day average minimums and the acceptable 7-day and 30-day averages. States should document the DO criteria being used for the assessment and should discuss any biases that may be introduced by the sampling program (e.g., grab sampling in waterbodies with considerable diurnal variation).



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- B. Partially Supporting: For any one pollutant, criteria exceeded in 11 to 25 percent of measurements. For DO, the above considerations apply.
- C. Not Supporting: For any one pollutant, criteria exceeded in > 25 percent of measurements. For DO, the above considerations apply.

#### *Special Considerations for Lakes*

For lakes, States should discuss their interpretation of DO, pH, and temperature standards for both epilimnetic and hypolimnetic waters. In addition, States should consider turbidity and lake bottom siltation.

#### Toxicants (priority pollutants, metals, chlorine, and ammonia)

- A. Fully Supporting: For any one pollutant, no more than 1 exceedance of acute criteria (EPA's criteria maximum concentration or applicable State/Tribal criteria) within a 3-year period based on grab or composite samples and no more than 1 exceedance of chronic criteria (EPA's criteria continuous concentration or applicable State/Tribal criteria) within a 3-year period based on grab or composite samples.
- B. Partially Supporting: For any one pollutant, acute or chronic criteria exceeded more than once within a 3-year period, but in  $\leq 10$  percent of samples.
- C. Not Supporting: For any one pollutant, acute or chronic criteria exceeded in > 10 percent of samples.

Note: The above assumes at least 10 samples over a 3-year period. If fewer than 10 samples are available, the State should use discretion and consider other factors such as the number of pollutants having a single violation and the magnitude of the exceedance(s).

#### *Other Considerations Regarding Toxicant Data*

- C. EPA maintains that chronic criteria should be met in a waterbody that fully supports its uses. Few States and Tribes, if any, are obtaining composite data over a 4-day sampling period for comparison to chronic criteria. EPA believes that 4-day composites are not an absolute requirement for evaluating whether chronic criteria are being met. Grab and composite samples (including 1-day composites) can be used in water quality assessments if taken during stable conditions.

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This should give States more flexibility in utilizing chronic criteria for assessments.

- C States should document their sampling frequency. Sampling frequency should be based on potential variability in toxicant concentrations. In general, waters should have at least quarterly data to be considered monitored; monthly or more frequent data are considered abundant. More than 3 years of data may be used, although the once-in-3-years consideration still applies (i.e., two violations are allowed in 6 years of abundant data).
- C The once-in-3-years goal is not intended to include spurious violations resulting from lack of precision in analytical tests. Therefore, using documented quality assurance/quality control (QA/QC) assessments, States may consider the effect of laboratory imprecision on the observed frequency of violations.
- C If the duration and frequency specifications of EPA criteria change in the future, these recommendations should be changed accordingly.
- C Samples should be taken outside of designated mixing zones or zones of initial dilution.

#### *Special Considerations Regarding Metals*

The implementation and application of metals criteria is complex due to the site-specific nature of metals toxicity. EPA's policy is for States to adopt and use the dissolved metal fraction to set and measure compliance with water quality standards, because dissolved metal more closely approximates the bioavailable fraction of metal in the water column than does total recoverable metal. One reason is that a primary mechanism for water column toxicity is adsorption at the gill surface which requires metals to be in the dissolved form. Table 3-5 provides guidance for calculating EPA dissolved criteria from the published total recoverable criteria. The dissolved metal criteria, expressed as percentage, are presented as recommended values and ranges. If a State is collecting dissolved metal data but does not yet have dissolved criteria, Table 3-5 might be useful for estimating screening values. Also, if total recoverable metal concentrations are less than the estimated dissolved metal criteria calculated from Table 3-5, the State could be relatively certain that toxic concentrations are not present.

Some States have already developed and are using dissolved metals criteria and should continue to do so. In the absence of dissolved metals data and State criteria, States should continue to apply total recoverable

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metals criteria to total recoverable metals data because this is more conservative and thus protective of aquatic life. In some situations, a State may choose to use total recoverable metals criteria when there are indications that total metal loadings could be a stress to the ecosystem. The ambient water quality criteria are neither designed nor intended to address the fate and effect of metals in an ecosystem, e.g., protect sediments, prevent effects due to food webs containing organisms that dwell in the sediments and those that dwell in the water column and filter or ingest suspended particles. However, since consideration of sediments or bioaccumulative impacts is not incorporated into the criteria methodology, the appropriateness and degree of conservatism inherent in the total recoverable approach is unknown.

Historical metals data should be used with care. Concern about the reliability of the data are greatest below about 5 to 10 ppb due to the possibility of contamination problems during sample collection and analysis. EPA believes that most historical metals concentrations above this level are valid if collected with appropriate quality assurance and quality control.

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**Table 3-5. Recommended Factors for Converting Total Recoverable Metal Criteria to Dissolved Metal Criteria**

Metal	Recommended Conversion Factors	
	CMC <sup>a</sup>	CCC <sup>a</sup>
Arsenic (III)	1.000	1.000
Cadmium <sup>b</sup>		
Hardness = 50 mg/L	0.973	0.938
Hardness = 100 mg/L	0.944	0.909
Hardness = 200 mg/L	0.915	0.880
Chromium (III)	0.316	0.860 <sup>c</sup>
Chromium (VI)	0.982	0.962
Copper	0.960	0.960
Lead <sup>b</sup>		
Hardness = 50 mg/L	0.892	0.892
Hardness = 100 mg/L	0.791	0.791
Hardness = 200 mg/L	0.690	0.690
Nickel	0.998	0.997
Selenium	0.922	0.922
Zinc	0.978	0.986

<sup>a</sup> CMC = Criterion Maximum Concentration  
 CCC = Criterion Continuous Concentration

<sup>b</sup> The recommended conversion factors (CFs) for any hardness can be calculated using the following equations:

Cadmium

$$\text{CMC: CF} = 1.136672 - [(\ln \text{ hardness}) (0.041838)]$$

$$\text{CCC: CF} = 1.101672 - [(\ln \text{ hardness}) (0.041838)]$$

$$\text{Lead (CMC and CCC): CF} = 1.46203 - [(\ln \text{ hardness}) (0.145712)]$$

where:

(ln hardness) = natural logarithm of the hardness. The recommended CFs are given to three decimal places because they are intermediate values in the calculation of dissolved criteria.

<sup>c</sup> This CF applies only if the CCC is based on the test by Stevens and Chapman (1984). If the CCC is based on other chronic tests, it is likely that the CF should be 0.590, 0.376, or the average of these two values.

Source: Stephen, C. E. 1995. *Derivation of Conversion Factors for the Calculation of Dissolved Freshwater Aquatic Life Criteria for Metals*. U.S. EPA, Environmental Research Laboratory, Duluth.

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#### 3.2.5 Integration of Different Data Types in Making an ALUS Determination

The following guidelines apply to ALUS determinations for wadable streams and rivers when biological, habitat, chemical, and/or toxicity data types are available (Figure 3-2, Table 3-6). These guidelines strongly emphasize the use of biological data for the assessment of ALUS specific to wadeable streams and rivers. However, the basic principles are applicable to other waterbody types. This guidance has undergone external peer-review (Dickson et al. 1996) and has been revised to address the principle peer-review recommendations to improve the guidance. In addition, peer review recommendations were made to expand the guidance to (1) develop a confidence icon for the overall assessment and (2) develop guidelines that consider the results from biological, chemical and physical assessments in relation to their role as response, stressor or exposure indicators. The peer review specifically recommended that EPA develop a weighting algorithm for biological results (as response indicator) in relation to results from physical/chemical, habitat, and toxicological assessments (as stressor/exposure indicators). These latter recommendations will be evaluated for future guidelines. EPA considers the current guidelines, particularly consideration of level of information, as providing the initial basis for addressing these additional peer review recommendations.

EPA recommends consideration of the level of information of the different data types in evaluating degree of impairment (partial support vs nonsupport). Case studies follow that demonstrate how ALUS determinations could be made based on types of data, level of information, and site specific information and conditions, and are not intended to cover all possible situations but to highlight commonly encountered scenarios. These case studies are based on actual State examples that represent a State's decision process in making an ALUS determination, and are presented in a uniform manner for illustration. Different states use different ordinal scales for assessment.

Generally, assessments based on data with high levels of information should be weighted more heavily than those based on data with low levels of information, and biological data should be weighted more heavily than other data types. In particular, it is recommended that the results of biological assessments, especially those with high levels of information, be the basis for the overall ALUS determination if the data indicate impairment. This is because the biological data provide a direct measure of the status of the aquatic biota and detect the cumulative impact of multiple stressors on the aquatic community, including new or previously undetected stressors. This approach is consistent with EPA's

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Policy on Independent Application while incorporating a weight of evidence approach in determining the degree of impairment (partial or nonsupport). The Policy does not allow for a



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Table 3-6. Determination of ALUS Using More Than One Data Type

ALUS Attainment	
A. Fully Supporting:	No impairment indicated by all data types
B. Fully Supporting but Threatened:	No impairment indicated by all data types; one or more categories indicate an apparent decline in ecological quality over time or potential water quality problems requiring additional data or verification, or  Other information suggests a threatened determination (see Section 3.2)
ALUS Non-attainment	
C. *Partially Supporting:	Impairment indicated by one or more data types and no impairment indicated by others.
D. *Not Supporting:	Impairment indicated by all data types
* A determination of <i>partially supporting</i> or <i>not supporting</i> could be made based on the nature and rigor of the data and site-specific conditions in the results of the data types. If bioassessment (usually Level 3 or 4) indicates impairment, then a determination of not supporting should be made. See case studies that follow.	



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Case studies (3 pages)--see separate file "V2, CHAP 3--CASE STUDIES"

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determination of full support when there are differences in assessment results when at least one assessment indicates impairment. For example, it is possible to arrive at an overall assessment of partial support where biological data indicate full support and other data types indicate some level of impairment.

#### 3.2.6 Additional Information on Biological Assessment of ALUS for Wadable Streams and Rivers

The following information may be useful to States in making ALUS determinations based on biological and associated habitat data. Biological assessments are evaluations of the biological condition of waterbodies using biological surveys and other direct measurements of resident biota in surface waters and comparing results to the established biological criteria. They are done by qualified professional staff trained in biological methods and data interpretation. The utility of biological measures has been demonstrated in assessing impairment of receiving waterbodies, particularly that caused by nonpoint sources and nontraditional water quality problems such as habitat degradation. Biological assessments are key to determining whether functional, sustainable communities are present and whether any of these communities have been modified beyond the natural range of the reference condition. Functional and sustainable implies that communities at each trophic level have species composition, population density, tolerance to stressors, and healthy individuals within the range of the reference condition and that the entire aquatic system is capable of maintaining its levels of diversity and natural processes in the future (see Angermeier and Karr, 1994).

The techniques for biosurveys are still evolving, but there have been significant improvements in the last decade. Appropriate methods have been established by EPA (e.g., Plafkin et al., 1989), State agencies (e.g., Ohio EPA, 1987; Massachusetts DEP, 1996; Florida DEP, 1994; Idaho DEQ, 1995), and other investigators assessing the condition of the biota (e.g., Karr et al., 1986). Guidance for development of biocriteria-based programs is provided in the *Biological Criteria: National Program Guidance for Surface Waters* (U.S. EPA, 1990) and *Biological Criteria: Technical Guidance for Streams and Small Rivers* (Gibson et al., 1996). As biosurvey techniques continue to improve, several technical considerations apply:

- C *The identification of the REFERENCE CONDITION is basic to any assessment of impairment or attainment of aquatic life use and to the establishment of biological criteria.*

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Reference conditions are described from an aggregate of data best acquired from multiple sites with similar physical dimensions, represent minimally impaired conditions, and provide an estimate of natural variability in biological condition and habitat quality. For determining reference condition, alternative approaches to selection of reference sites include use of historical data, paleoecological data for lakes, experimental laboratory data for select cases, quantitative models, and best professional judgment (Hughes 1995).

Reference conditions must be stratified (i.e., put into homogenous waterbody classes) to account for much of the natural physical and climatic variability that affects the geographic distribution of biological communities. The Ecoregion Concept (Omernik, 1987) recognizes geographic patterns of similarity among ecosystems, grouped on the basis of environmental variables such as climate, soil type, physiography, and vegetation. Currently, efforts are under way in several parts of the country to refine these ecoregions into a more useful framework to classify waterbodies. Procedures have begun in several ecoregions and subcoregions to identify reference conditions within those particular units. In essence, these studies are developing reference databases to define biological potential and physical habitat expectations within ecoregions. The concept of reference conditions for bioassessment and biocriteria is discussed further below.

In developing community bioassessment protocols, reference conditions against which to compare test sites and to judge impairment are needed. Ideally, reference conditions represent the highest biological conditions found in waterbodies unimpacted by human pollution and disturbance. That is, the regional reference site concept is meant to accommodate natural variations in biological communities due to bedrock, soils, and other natural physicochemical differences. Recognizing that pristine habitats are rare (even remote lakes and streams are subject to atmospheric deposition), resource managers must decide on an acceptable level of disturbance to represent an achievable or existing reference condition. Acceptable reference conditions will differ among geographic regions and States and will depend on the aquatic life use designations incorporated into State water quality standards.

Characterization of reference conditions depends heavily on classification of natural resources. The purpose of a classification is to explain the natural biological condition of a natural resource from the physical characteristics. Waterbodies vary widely in size and ecological characteristics, and a single reference condition that applies to all systems would be misleading. A classification system that

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organizes waterbodies into groups with similar ecological characteristics is required to develop meaningful reference conditions.

The best approach to classifying and characterizing regional reference conditions is determined by the estimated quality of potential reference sites that are available in the region. If a sufficient number of relatively undisturbed waterbodies exist (e.g., primarily forested watersheds), then it is possible to define watershed conditions that are acceptable for reference sites. If no reference sites exist, then reference conditions can be characterized based on an extrapolation of the biological attributes representative of the aquatic biota expected to be found in the region (see Gibson et al., 1996) or through other quantitative models (Hughes 1995). EPA sees the use of a regional reference condition as an important component and goal of State biological programs. The Agency also recognizes that other approaches, such as upstream/downstream sampling, may be necessary (U.S. EPA, 1990).

The Ohio Environmental Protection Agency has been very active in the development of biocriteria based on reference conditions. Ohio's experiences and methods may be useful to other States in developing their biological monitoring and biocriteria programs (see, for example, Ohio EPA, 1987, 1990). Florida DEP has developed a similar approach for defining reference conditions (Barbour et al., 1996); Arizona DEQ has oriented its reference condition by elevation (Spindler, 1996); and Maine DEC uses a statistically derived-decision model technique that is based on a knowledge of the ecology and expectations in the response to perturbation of the biological attributes to classify and assess its streams (Davis et al., 1993). For further information on the development and implementation of biological criteria and assessments, States should consult *Biological Criteria: National Program Guidance for Surface Waters* (U.S. EPA, 1990), *Rapid Bioassessment Protocols for Use in Streams and Rivers: Benthic Macroinvertebrates and Fish* (Plafkin et al., 1989), and *Biological Criteria: Technical Guidance for Streams and Small Rivers* (Gibson et al., 1996).

- C *A MULTIMETRIC APPROACH TO BIOASSESSMENT is recommended to strengthen data interpretation and reduce error in judgment based solely on population indices and measures.*

The accurate assessment of biological integrity requires a method that integrates biotic responses through an examination of patterns and processes from individual to ecosystem levels (Karr et al., 1986). The early conventional approach to using individual population measures

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has been to select some biological parameter that refers to a narrow range of changes or conditions and evaluate that parameter (e.g., species distributions, abundance trends, standing crop, or production estimates). Parameters are interpreted separately with a summary statement about the overall health. This approach is limited in that the key parameters emphasized may not be reflective of overall ecological health. The preferred approach is to define an array of metrics that individually provide information on each biological parameter and, when integrated, function as an overall indicator of biological condition. The strength of such a multimetric approach, when the component metrics are calibrated for a particular stream class, is its ability to integrate information from individual, population, assemblage, and zoogeographic levels into a single, ecologically-based index of water resource quality (Karr et al., 1986). The development of metrics for use in the biocriteria process can be partitioned into two phases (Barbour et al., 1995). First, an evaluation of candidate metrics is necessary to eliminate nonresponsive metrics and to address various technical issues (i.e., associated with methods, sampling habitat and frequency, etc.). Second, calibration of the metrics determines the discriminatory power of each metric and identifies thresholds for discriminating between "good" and "poor" sites. Known impaired sites are used to provide a test of discriminatory power. This process defines a suite of metrics that are optimal candidates for inclusion in bioassessments. Subsequently, a procedure for aggregating metrics to provide an integrative index is needed. For a metric to be useful, it must be (1) relevant to the biological community under study and to the specified program objectives; (2) sensitive to stressors; (3) able to provide a response that can be discriminated from natural variation; (4) environmentally benign to measure in the aquatic environment; and (5) cost-effective to sample. A number of metrics have been developed and subsequently tested in field surveys of benthic macroinvertebrate and fish assemblage (Barbour et al., 1995).

- C *Assessment of HABITAT STRUCTURE as an element of the biosurvey is critical to assessment of biological response.*

Interpretation of biological data in the context of habitat quality provides a mechanism for discerning the effects of physical habitat structure on biota from those of chemical toxicants. If habitat is of poor or somewhat degraded condition, expected biological values are lowered; conversely, if habitat is in good condition (relative to regional expectations), high biological condition values are expected. Poor habitat structure will prevent the attainment of the expected biological condition, even as water quality problems are ameliorated.

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If lowered biological values are indicated simultaneously with good habitat assessment rating scores, toxic or conventional contaminants in the system may have caused a suppression of community development. Additional chemical data may be needed to further define the probable causes (stressors). On the other hand, high biological metric scores in poor habitat could indicate a temporary response to organic enrichment, natural variation in colonization/mortality, change in predation pressures, change in food source/abundance, or other factors.

- C *A standardized INDEX PERIOD is important for consistent and effective monitoring.*

The intent of a statewide bioassessment program is to evaluate overall biological conditions. The capacity of the aquatic community to reflect integrated environmental effects over time can be used as a foundation for developing bioassessment strategies (Plafkin et al., 1989). An index period is a time frame for sampling the condition of the community that is a cost-effective alternative to sampling on a year-round basis. Ideally, the optimal index period will correspond to recruitment cycles of the organisms (based on reproduction, emergence, and migration patterns). In some instances, an index period would be oriented to maximize impact of a particular pollutant source (e.g., high-temperature/low-flow period for point sources). Sampling during an index period can (1) minimize between-year variability due to natural events, (2) optimize accessibility of the target assemblages, and (3) maximize efficiency of sampling gear.

- C *STANDARD OPERATING PROCEDURES and an effective QUALITY ASSURANCE PROGRAM are established to support the integrity of the data.*

The validity of the ecological study and resultant conclusions are dependent upon an effective QA Plan. An effective QA Plan at the onset of a study provides guidance to staff in several areas: objectives and milestones for achieving objectives throughout the study; lines of responsibility; accountability of staff for data quality objectives; and accountability for ensuring precision, accuracy, completeness of data collection activities, and documentation of sample custody procedures. Documented SOPs for developing study plans, maintenance and application of field sampling gear, performance of laboratory activities, and data analyses are integral quality control components of QA that can provide significant control of potential error sources.



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- C *A determination of PERFORMANCE CHARACTERISTICS of the bioassessment provides an understanding of the data quality for the assessment.*

Perhaps the most important component in making bioassessments useful to water resource programs is the data quality of different assessment methods currently in use and the level of comparability among methods in performing an assessment. The comparability of methods should be judged by the degree of similarity in their performance characteristics (i.e., a performance-based approach) rather than by direct comparison of their respective scores or metric values (ITFM 1995, Diamond et al. 1996). To enable a sharing of data and results from various techniques that might be used by different agencies or other groups, some level of confidence in making an assessment must be established for each method based on the quality of data. This performance characteristic is precision, which is dependent upon the sampling methodology and the range in natural variation of the reference condition (note -- use of stream classification will increase precision).

The ability to detect impairment also depends on the sensitivity of the method. In some cases, the desirable sensitivity level depends on how severe or subtle the impairment. For example, it does not require a very rigorous method to detect impairment following an extensive fish kill or algal bloom. It is the subtle impact areas that require some level of rigor that minimizes Type I and Type II errors in a judgment of condition.

Based on preliminary information obtained from bioassessments conducted in Florida (Barbour et al. 1996a, Diamond et al. 1996), Ohio (Stribling et al. 1996), and New Hampshire (Stribling et al. 1994), quantitative criteria for precision and sensitivity can be set conservatively at "high" being less or equal to 20%, "moderate" being between 21 and 49%, and "low" being more or equal to 50%. High precision is equated to having low measurement error (coefficient of variation < 20%) and sensitivity is the ability to detect small differences (< 20% difference) between reference and the site being assessed.

- C *AN IDENTIFICATION OF THE APPROPRIATE NUMBER OF SAMPLING SITES that are representative of a waterbody is an important consideration in evaluating biological condition.*

The spatial array of sampling sites in any given watershed or region and the extrapolation of biological condition and water quality to

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areas beyond the exact sampling point must be established in any type of assessment. Two primary guidelines can be identified for extrapolating biological assessment data to whole watersheds. First, the structure of aquatic communities in lotic (flowing water) systems changes naturally with an increase in size of the stream. Thresholds in this continuum of change can be established through an analysis of regional databases. The biological condition at any particular site can only be used to represent upstream and downstream areas of the same physical dimensions and flow characteristics. Likewise, lake size will influence the number of sites needed to adequately characterize a lake or area of a lake. In small lakes, one site will generally be sufficient. In large lakes with multiple basins or in reservoirs with various zones (inflow, midsection, outflow), a site representative of each basin or zone may be needed.

A second consideration for site identification is the change in land use patterns along a stream gradient or lake shoreline. Changes from agricultural land use to urban centers, forested parkland, etc., would warrant different representative sampling sites. A waterbody with multiple dischargers may also require numerous sampling sites to characterize the overall biological condition of the waterbody.

#### Technical Support Literature

The Peer Review Team for ALUS recommended several technical papers to be used in support of specific technical issues associated with bioassessment. Information from these and other relevant literature will be incorporated into the revision of this chapter, pending comments and guidance from the Technical Experts Panel. The technical papers recommended by the ALUS Peer Review Team are as follows:

Cummins, K. W. 1988. Rapid bioassessment using functional analysis of running water invertebrates. In: T. P. Simon, L. L. Holst and L. J. Shepard (eds.). EPA -905-9-89-003. Proceedings of the First National Workshop on Biological Criteria. U.S. Environmental Protection Agency, Chicago.

Cummins, K. W. and M. A. Wilzbach. 1985. Field procedures for analysis of functional feeding groups of stream macroinvertebrates. Contribution 1611. Appalachian Environmental Research Laboratory, University of Maryland, Frostburg, Maryland.

Davis, W. S. and T. P. Simon (eds). 1995. Biological assessment and criteria: tools for water resource planning and decision making. Lewis Publishers, Boca Raton, Florida.

Hauer, F. R. and G. A. Lamberti (eds). 1996. Methods in Stream Ecology. Academic Press, San Diego.

Rosenberg, D. M. and V. H. Resh. 1993. Freshwater Biomonitoring and Benthic Macroinvertebrates. Chapman and Hall, New York.

### 3.3 Primary Contact Recreation Use

All States have recreational waterbodies with bathing areas, as well as less heavily used waterbodies with a designated use of swimming. In some States, nearly all waters are designated for swimming, although the great majority of waters are not used heavily for this purpose. States are asked to first target their assessments of primary contact recreation use to high-use swimming areas such as bathing beaches, a risk-based approach to targeting resources to protect human health.

#### 3.3.1 Bathing Area Closure Data

States should acquire data on bathing area closures from State and local health departments and analyze them as follows.

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- A. Fully Supporting: No bathing area closures or restrictions in effect during reporting period.
- B. Partially Supporting: On average, one bathing area closure per year of less than 1 week's duration.
- C. Not Supporting: On average, one bathing area closure per year of greater than 1 week's duration, or more than one bathing area closure per year.

Some bathing areas are subject to administrative closures such as automatic closures after storm events of a certain intensity. Such closures should be reported along with other types of closures in the 305(b) report and used in making use support determinations if they are associated with violation of water quality standards.

#### 3.3.2 Bacteria

States should base use support determinations on their own State criteria for bacteriological indicators.

EPA encourages States to adopt bacteriological indicator criteria for the protection of primary contact recreation uses consistent with those recommended in *Ambient Water Quality Criteria for Bacteria—1986* (EPA 440/5-84-002). This document recommends criteria for enterococci and *E. coli* bacteria (for both fresh and marine waters) consisting of:

- C Criterion 1 = A geometric mean of the samples taken should not be exceeded, **and**
- C Criterion 2 = Single sample maximum allowable density.

Many State criteria for the protection of the primary contact recreation use are based on fecal coliform bacteria as previously recommended by EPA (*Quality Criteria for Water—1976*). The previous criteria were:

- C Criterion 1 = The geometric mean of the fecal coliform bacteria level should not exceed 200 per 100 mL based on at least five samples in a 30-day period, **and**
- C Criterion 2 = Not more than 10 percent of the total samples taken during any 30-day period should have a density that exceeds 400 per 100 mL.

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If State criteria are based on either of EPA's criteria recommendations outlined above (based on the 1976 or 1986 criteria), States should use the following approach in determining primary contact recreational use support:

- A. Fully Supporting: Criterion 1 and Criterion 2 met.
- B. Partially Supporting:
  - C For *E. coli* or enterococci: Geometric mean met; single-sample criterion exceeded during the recreational season, **or**
  - C For fecal coliform: Geometric mean met; more than 10 percent of samples exceed 400 per 100 mL.
- C. Not Supporting: Geometric mean not met.

This guidance establishes a minimum baseline approach; should States have more restrictive criteria, these may be used in place of EPA's criteria. Please indicate when this is the case.

#### 3.3.3 Other Parameters

In addition to pathogens, some States have criteria for other pollutants or stressors for Primary Contact Recreation. As noted by the ITFM, potentially hazardous chemicals in water and bottom sediment, ionic strength, turbidity, algae, aesthetics, and taste and odor can be important indicators for recreational use support determinations. The following guidelines apply where appropriate (i.e., where States have water quality standards for other parameters).

- A. Fully Supporting: For any one pollutant or stressor, criteria exceeded in #10 percent of measurements.
- B. Partially Supporting: For any one pollutant, criteria exceeded in 11 to 25 percent of measurements.
- C. Not Supporting: For any one pollutant, criteria exceeded in > 25 percent of measurements.

#### 3.3.4 Special Considerations for Lakes

Trophic Status—

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Trophic status is traditionally measured using data on total phosphorus, chlorophyll *a*, and Secchi transparency. As mentioned above, comparison of trophic conditions to natural, ecoregion-specific standards allows the best use of this measure.

In this context, user perception surveys can be a useful adjunct to trophic status measures in defining recreational use support. Smeltzer and Heiskary (1990) offer a basis for linking trophic status measures with user perception information. This can provide a basis for categorizing use support based on trophic status data. If user perception data are not collected in the State, extrapolations using data from another State, i.e., best professional judgment, might provide the opportunity to characterize recreational use support in a similar fashion.

#### Pathogens—

States should consider pathogen data in determining support of recreational uses. Guidelines above also apply to lakes.

#### Additional Parameters—

In addition to trophic status and pathogens, States should consider the following parameters in determining support of recreational uses:

- C Frequency/extent of algal blooms, surface scums and mats, or periphyton growth
- C Turbidity (reduction of water clarity due to suspended solids)
- C Lake bottom siltation (reduction of water depth)
- C Extent of nuisance macrophyte growth (noxious aquatic plants)
- C Aesthetics.

### 3.4 Fish/Shellfish Consumption Use

#### **Fish/Shellfish Consumption Advisory Data**

- A. Fully Supporting: No fish/shellfish restrictions or bans are in effect.
- B. Partially Supporting: "Restricted consumption" of fish in effect (restricted consumption is defined as limits on the number of meals or size of meals consumed per unit time for one or more fish/shellfish)

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### 3. MAKING USE SUPPORT DETERMINATIONS

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species); or a fish or shellfish ban in effect for a subpopulation that could be at potentially greater risk, for one or more fish/shellfish species.

- C. Not Supporting: "No consumption" of fish or shellfish ban in effect for general population for one more fish/shellfish species; or commercial fishing/shellfishing ban in effect.

In addition, the ITFM recommended specific indicators for assessing fish and shellfish consumption risks: levels of bioaccumulative chemicals in fish and shellfish tissue for fish and shellfish consumption, and, for shellfish only, paralytic shellfish poisoning (PSP)-type phytoplankton and microbial pathogens.

In areas where shellfish are collected for commercial or private purposes and removed to cleaner waters for depuration, the originating waterbodies should be considered Partially Supporting for Shellfish Consumption use.

#### 3.5 Drinking Water Use

The following guidelines provide a framework for assessment of drinking water use support. These guidelines were developed by EPA in conjunction with the 305(b) Drinking Water Focus Group (DWFG), which consists of interested State and EPA personnel. EPA and States participating in the DWFG made it their goal to develop a workable set of guidelines that would serve to elevate the awareness of drinking water as a designated use within the 305(b) program, increase the percentage of waters assessed for drinking water use support, and enhance the accuracy and value of the assessments.

It was agreed by all parties involved in the development of these drinking water guidelines that no single template is suitable for every reporting State. The guidelines must incorporate flexibility and rely heavily on the judgment of the professional staff of each State's public water supply supervision program to meet the challenges of assessing source waters for drinking water use support.

For purposes of the 1998 305(b) Water Quality Reports, States are asked to focus their assessments on water resources that support significant drinking water supplies. It is generally assumed that most States will initially focus their assessments on surface water resources; however, these guidelines are non-resource-specific and the framework may be applied to any waters within a State that are designated for drinking water use.

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### 3. MAKING USE SUPPORT DETERMINATIONS

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EPA and States participating in the DWFG discussed at length the issues and difficulties involved in assessing source waters for drinking water use support. EPA and these States recognize and fully accept that there will be significant variability in the information that States are able to provide in the 1998 305(b) reporting cycle. However, EPA expects that the direction of future reporting cycles will be evident, and that States will begin to develop plans and mechanisms to improve the overall accuracy and value of the assessments.

Key features of these guidelines include:

- C assessment of State's water resources in phases over two 305(b) reporting cycles
- C flexibility to perform assessments using a tiered approach
- C identification of multiple data sources that may be used in the assessments
- C assessment of water resources using a target list of contaminants reflecting the interests and goals of the State, and
- C interpretation of data.

#### 3.5.1 Prioritization and Phases of Source Water Assessment

EPA and the DWFG recognize that assessment of source waters for drinking water use support within the framework of the following guidelines is revised to achieve the key features listed above. EPA and the DWFG also recognize that assessment of the entire State's water resources for drinking water use support is a monumental task. To ease the burden, States may choose to perform drinking water use support assessments using a phased approach.

States may consider prioritizing their water resources and performing drinking water use support assessments for a limited percentage of their water resources. States are encouraged to expand their drinking water assessment efforts to include additional waters each subsequent reporting cycle. In this way, an increasingly greater percentage of waters will be assessed. Furthermore, this phased approach provides States with the opportunity to develop and implement plans and mechanisms for compilation, organization, and evaluation of drinking water data for improved reporting. EPA encourages States to set a goal of assessing drinking water use support for most of the State (approximately 75 percent of the waterbodies used for drinking water) by the year 2000.



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### 3. MAKING USE SUPPORT DETERMINATIONS

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For 1998, States are encouraged to set a priority for reporting results for waters of greatest drinking water demand. For these waters, States may elect to further prioritize with respect to vulnerability or other State-priority factors.

Identifying the presence of “treatment beyond conventional means” is one example of a technique that may be used to screen water resources for potential vulnerability and aid in prioritization of source waters for drinking water assessments. If “treatment beyond conventional means” is present (i.e., treatment beyond coagulation, sedimentation, disinfection, and conventional filtration), it may signify that the source water has been impacted to some degree and warrants more detailed investigation; however, it should be recognized that this information is generally not explicit, and therefore, neither the presence nor the absence of “treatment beyond conventional means” can be positively correlated to drinking water designated use support without additional investigation.

Prioritization of water resources for assessment may best be achieved in coordination with State professionals responsible for collecting and maintaining water quality data for sources of drinking water. It is generally these professionals that are most familiar with the data needed to assess drinking water designated use support and the conditions under which that data were collected. Their insight is integral to assuring the accuracy and value of these assessments.

#### 3.5.2 Tiered Approach for Source Water Assessments

In addition to assessing only a limited percentage of State waters for drinking water use support, EPA and the DWFG encourage States to consider using a tiered approach in the assessments. A tiered approach accommodates the different types of data currently available to States with which to make an assessment and allows for differing levels of assessment.

Initially, States may use the most readily available information such as regional data, agency files, or other existing records or reports to conduct a preliminary assessment. As State programs develop and become more sophisticated, the preliminary assessments can be progressively upgraded through the incorporation of more detailed data (e.g., monitoring data). For 1998, EPA encourages States to provide a short narrative explaining how their assessments were performed and the level of detail incorporated into each assessment.

#### 3.5.3 Data Sources

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### 3. MAKING USE SUPPORT DETERMINATIONS

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By instituting the tiered approach to conducting drinking water designated use assessments, EPA and the DWFG are acknowledging that data collection and organization varies among the States, and that a single data source for assessing drinking water designated use does not exist for purposes of the 1998 305(b) reports. EPA encourages States to use available data that they believe best reflect the quality of the resource. EPA is not asking States to conduct additional monitoring that does not fit in with other State priorities.

It is generally accepted that for purposes of the 1998 305(b) reports, States may need to be resourceful to acquire the data necessary to conduct preliminary assessments of source waters for drinking water designated use. States noted during the previous 1996 305(b) reporting cycle that the *Guidelines* placed heavy emphasis on the use of ambient water quality data. Frequently these data were not available and States defaulted to the use of finished water quality data. It was noted by many States that the default to finished water quality data might yield a jaded view of the source water quality.

EPA and the DWFG concur that the use of finished water quality data is not the best possible source of data for assessing source water quality; however, EPA and the DWFG also recognize the difficulties in obtaining data for use in drinking water assessments. By encouraging States to prioritize their water resources and perform drinking water use support assessments in a phased approach over two 305(b) cycles, EPA hopes that acquiring the necessary data will continue to become less difficult in time.

Within the numerous 1996 Amendments to the Safe Drinking Water Act (SDWA), the States are encouraged to use the Source Water Assessment Program (SWAP) to promote assessment of drinking water sources. EPA's August 1997 guidance suggests that States complete source water delineations and source inventory/susceptibility analyses for the public water supplies in the State within two years after EPA approval of the program. These assessments, when completed by the States, are an additional source of data for evaluating drinking water designated use and should contribute considerably to the assessment of drinking water quality.

For the 1998 305(b) reporting cycle, EPA is encouraging States to be resourceful in acquiring and using available data. EPA is not asking States to perform additional monitoring.

EPA and the DWFG identified several potential data sources that States might consider using in their 1998 assessments, including:

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### 3. MAKING USE SUPPORT DETERMINATIONS

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- C Available ambient water quality data
- C Untreated water quality data from public water supply (PWS) wells and/or surface water intakes<sup>1</sup>
- C PWS drinking water use restrictions
- C STORET database
- C Independent water suppliers databases
- C Source water assessments (SDWA 1996 Amendments)
- C U.S. Geological Survey NAWQA studies
- C Private water association studies
- C Independent studies
- C Other 305(b) use support impairments (e.g., aquatic life impairments).

States that have access to other data sources that can be used to assess source water quality for drinking water purposes are encouraged to use them if, in the judgment of the drinking water professionals, the data have undergone sufficient quality assurance/quality control checks.

Ideally, one or several of the above data sources will be available for States to use in assessing drinking water use support. However, lacking any of the above, States may have no choice but to default to the PWS compliance monitoring data required under the SDWA (i.e., finished water quality data). These data should only be used if the distinct source water can be identified (i.e., mixed systems do not qualify). Information on contamination-based drinking water use restrictions imposed on a source water may also be considered.

#### 3.5.4 Contaminants Used in the Assessment

In many cases, the source of the data will determine the contaminants used in the assessment. For example, if a State has access to ambient

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<sup>1</sup>States that designate for drinking water use only at the point of intake should assess an appropriate area of the source water for drinking water use support. This may require assigning an appropriate area around or distance upstream of the point of intake.

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### 3. MAKING USE SUPPORT DETERMINATIONS

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monitoring data, the assessment is limited to the monitored contaminants.

Each State should develop a target list of contaminants that best represents the State's assessment goals; this list may be based on monitoring or other sources of data. EPA and the DWFG recommend that States use the contaminants regulated under the SDWA as a starting point in developing their target list of contaminants (a list of the contaminants regulated under the SDWA and their associated maximum contaminant levels is provided in Appendix O). States are not expected to include all of the contaminants regulated under the SDWA as part of their target list.

EPA and the DWFG acknowledge that there are no specific guidelines or hierarchical structure to follow for developing a target list of contaminants for use in drinking water assessments and States must use their best professional judgment in the decision-making process. Important considerations include the availability and quality of data and the level of assessment States are prepared to make. To assist States in reducing the comprehensive list of contaminants regulated under the SDWA to a final, more manageable, grouping of contaminants, EPA and the DWFG recommend that States consider any of the following:

- C MCL violations
- C detections greater than the action trigger limits
- C vulnerability studies
- C occurrence data
- C chemical waivers
- C contamination-based drinking water use restrictions
- C treatment beyond conventional means
- C treatment objectives
- C treatment processes
- C treatment technique violations, and/or
- C ambient turbidity levels.

EPA and the DWFG realize that the list of contaminants regulated under the SDWA is not an all-inclusive list and States may decide to add contaminants to their target group based on their best professional judgment. For example, States may choose to add contaminants that are not regulated under the SDWA but are of special interest or concern within the State (e.g., pesticides, herbicides, algae, phosphates).

#### 3.5.5 Data Interpretation

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### 3. MAKING USE SUPPORT DETERMINATIONS

EPA and the DWFG developed a framework to assist States in assigning use support categories based on data availability. As shown in Table 3-7, assessments can be based on actual monitoring data that are compared to water quality criteria (e.g., State-specific water quality standards or National Primary Drinking Water Regulations). If States do not have actual monitoring data available, finished water quality data and/or drinking water use restrictions could be used to infer source water quality. Use restrictions include:

- C closures of source waters that are used for drinking water supply
- C contamination-based drinking water supply advisories lasting more than 30 days per year
- C PWSs requiring more than conventional treatment (i.e., other than coagulation, sedimentation, disinfection, and conventional filtration) due to known or suspected source water quality problems
- C PWSs requiring increased monitoring due to confirmed detections of one or more contaminants (excluding cases with minimum detection limit issues).

#### 3.5.6 Conclusion

Relatively few source waters have been adequately characterized for drinking water use support during the past 305(b) reporting cycles. EPA and States worked to develop a workable set of *Guidelines* that would serve to elevate the awareness of drinking water as a designated use within the 305(b) program, increase the percentage of waters assessed for drinking water use support, and enhance the accuracy and value of the assessments. These Guidelines provide a flexible framework for assessing drinking water designated use support. Using this framework is expected to result in better, more comprehensive assessments of source waters.

### 3. MAKING USE SUPPORT DETERMINATIONS

**Table 3-7. Assessment Framework for Determining Degree of Drinking Water Use Support**

Classification	Monitoring Data		Use Support Restrictions
Full Support	Contaminants do not exceed water quality criteria <sup>a</sup>	and/or	Drinking water use restrictions are not in effect.
Full Support but Threatened	Contaminants are detected but do not exceed water quality criteria <sup>a</sup>	and/or	Some drinking water use restrictions have occurred and/or the potential for adverse impacts to source water quality exists.
Partial Support	Contaminants exceed water quality criteria <sup>a</sup> intermittently	and/or	Drinking water use restrictions resulted in the need for more than conventional treatment with associated increases in cost.
Nonsupport	Contaminants exceed water quality criteria <sup>a</sup> consistently	and/or	Drinking water use restrictions resulted in closures.
Unassessed	Source water quality has not been assessed for contaminants used or potentially present.		

<sup>a</sup> For purposes of this assessment, EPA encourages States to use the maximum contaminant levels (MCLs) defined under the SDWA. However, if State-specific water quality standards exist, and constituent concentrations are at least as stringent as the MCL levels defined under the SDWA, State-specific water quality criteria can be used for assessment purposes.

### 3. MAKING USE SUPPORT DETERMINATIONS

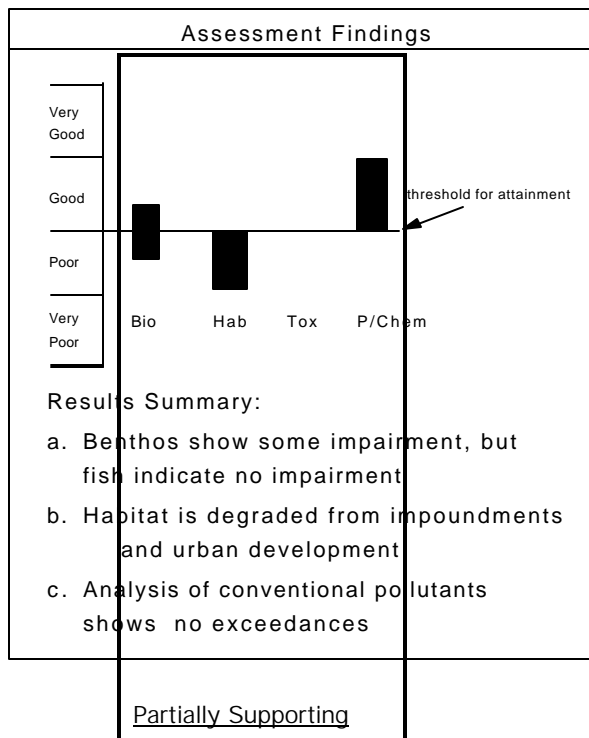
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### 3. MAKING USE SUPPORT DETERMINATIONS

Ten Mile River, MA—Site TM01 Dec. 1991

Waterbody Description
ALUS: Class B, warm water fishery Reach Size: 0.8 miles, Headwaters to Bacon Street, Plainville, site upstream of electroplating facility Drainage Area: ? Stressors: urban development, impoundment Number of sites monitored: 1

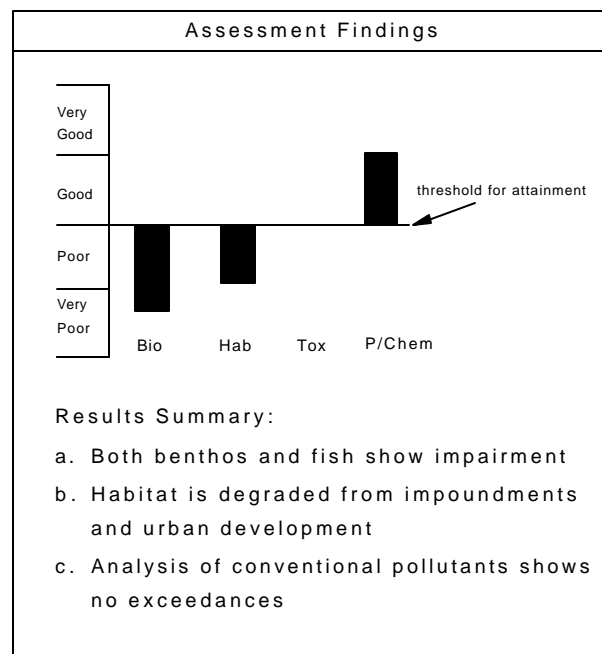
Assessment Quality					
Data Type	Level				Description
	1	2	3	4	
Biological			T		<ul style="list-style-type: none"> <li>• RBP (Benthic and Fish) survey, 1990</li> <li>• Vis.-based RBP</li> <li>• None</li> <li>• Conventionals, no metals</li> </ul>
Habitat			T		
Toxicity					
P/Chemical		T			



Ten Mile River, MA—Site TM02 Dec. 1991

Waterbody Description
ALUS: Class B, warm water fishery Reach Size: 0.1 miles, Bacon Street, Plainville, site downstream of electroplating facility Drainage Area: ? Stressors: urban development, impoundment Number of sites monitored: 1

Assessment Quality					
Data Type	Level				Description
	1	2	3	4	
Biological			T		<ul style="list-style-type: none"> <li>• RBP (Benthic and Fish) survey, 1990</li> <li>• Vis.-based RBP</li> <li>• None</li> <li>• Conventionals, no metals</li> </ul>
Habitat			T		
Toxicity					
P/Chemical		T			



Result =

Not Supporting

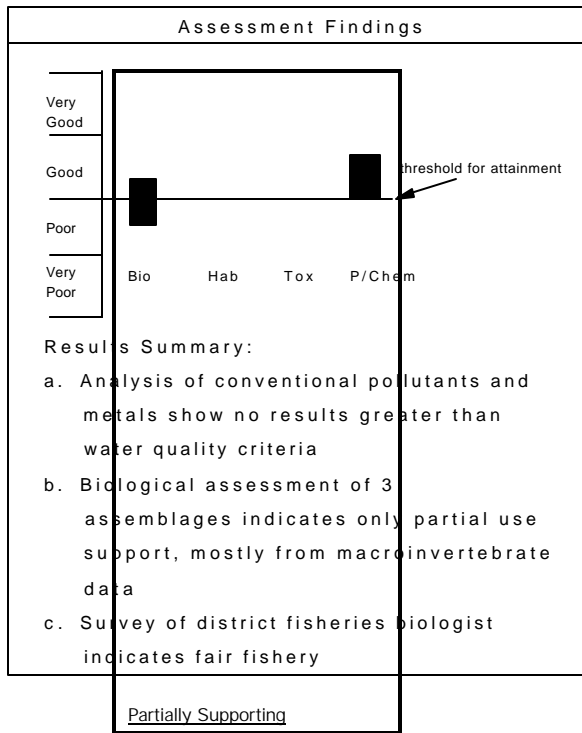


### 3. MAKING USE SUPPORT DETERMINATIONS

#### Little River, Kentucky, 1994-95

Waterbody Description	
ALUS:	Warmwater Aquatic Life
Reach Size:	37.4 mi
Drainage Area:	250 mi <sup>2</sup>
Stressors:	Municipal WWTPs, agriculture
Number of sites monitored:	1

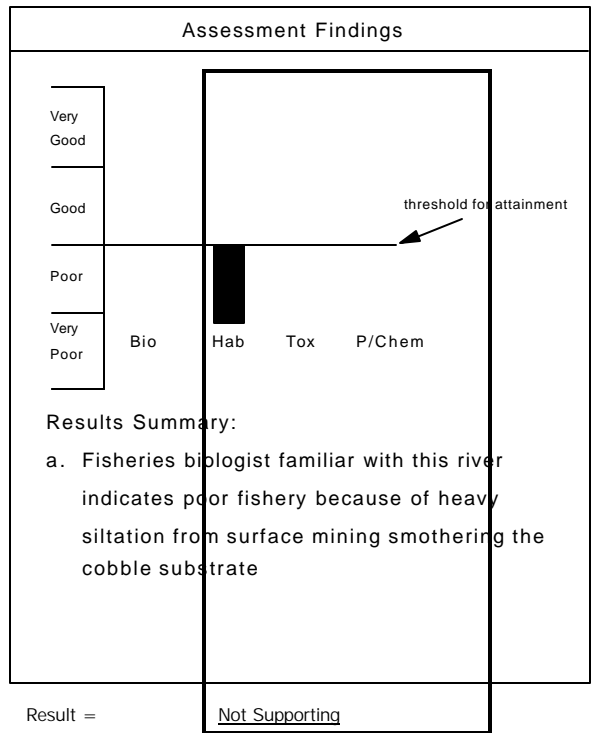
Assessment Quality					
Data Type	Level				Description
	1	2	3	4	
•Biological	T			T	<ul style="list-style-type: none"> <li>Fish, macroinvertebrates (Level 4), algae survey by division biologists; survey form submitted by regional fisheries biologist</li> <li>Monthly ambient monitoring network station</li> </ul>
•Habitat •Toxicity •P/Chemical			T		



#### Middle Fork Kentucky River, Kentucky, 1995

Waterbody Description	
ALUS:	Warmwater Aquatic Life
Reach Size:	27.1 mi
Drainage Area:	205 mi <sup>2</sup>
Stressors:	Coal mining
Number of sites monitored:	None; assessment is visual observation and general knowledge of quality of fishery

Assessment Quality					
Data Type	Level				Description
	1	2	3	4	
•Biological •Habitat	T				<ul style="list-style-type: none"> <li>Survey submitted by regional fisheries biologist</li> </ul>
•Toxicity •P/Chemical					

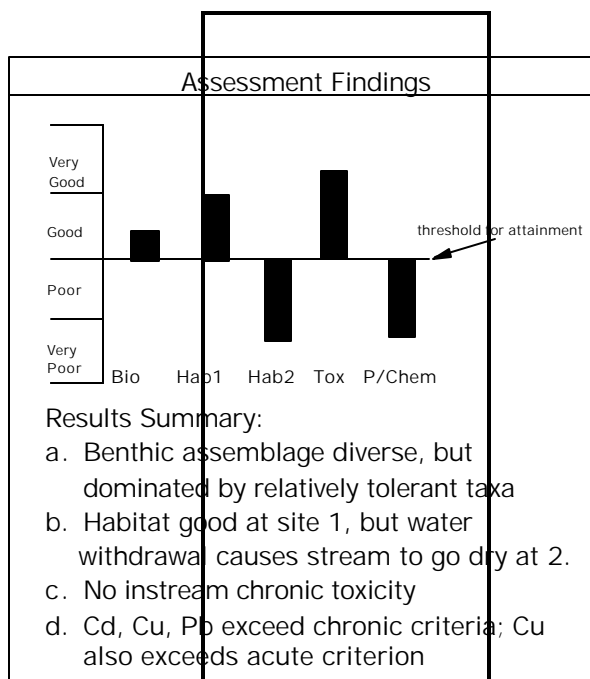


### 3. MAKING USE SUPPORT DETERMINATIONS

#### Blackstone River, MS 62-06, Massachusetts, 1994

Waterbody Description	
ALUS:	Class B, Warmwater Fishery
Reach Size:	3.7 mi
Drainage Area:	?
Stressors:	WWTP treating industrial center of Blackstone, urban runoff, contaminated sediments
Number of sites monitored:	1

Assessment Quality					
Data Type	Level				Description
	1	2	3	4	
•Biological			T		• RBP (Benthic) Survey
•Habitat			T		• Visual-based done at 2 sites
•Toxicity		T			• Instream chronic test
•P/Chemical		T			• Toxics (water column and sediments)



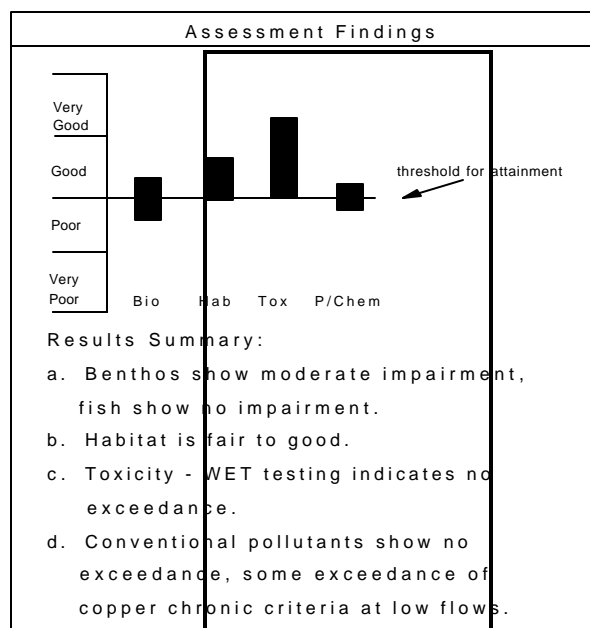
Result =

Partially Supporting

#### Naugatuck River CT 6900, Connecticut, 1996

Waterbody Description	
ALUS:	Fish and Wildlife Habitat
Reach Size:	19 miles Torrington to Waterbury
Drainage Area:	155 mi <sup>2</sup>
Stressors:	2 POTWS, 3 metal finishers, urban runoff
Number of sites monitored:	4 biol., 1 chem., long term sites

Assessment Quality					
Data Type	Level				Description
	1	2	3	4	
•Biological				T	• RBP III Benthos • RBP IV Fish
•Habitat			T		• RBP Visual obs.
•Toxicity	T				• WET acute
•P/Chemical			T		• Conventional, metals, longterm fish tissue



Result =

Partially Supporting

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## 4. MEASURING AND REPORTING THE BIOLOGICAL INTEGRITY INDICATOR

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### SECTION 4

#### MEASURING AND REPORTING THE BIOLOGICAL INTEGRITY INDICATOR

##### 4.1 Voluntary Pilot Biological Integrity Indicator

EPA is considering the addition of a new item to the 305(b) report, the biological integrity indicator. EPA has previously presented its concept of how this indicator would be assessed to States, both through its 305(b) Consistency Workgroup and in earlier drafts of these Guidelines, which were distributed to States for comment. Some States have supported the inclusion of biological integrity as a separate indicator while others have questioned its usefulness given that biological integrity is already considered in the assessment of aquatic life use support (ALUS). EPA believes that while much of the field work to assess biological integrity is already performed by States in their assessment of ALUS, a separate biological integrity indicator would add useful information to the 305(b) report (see box).

EPA is currently preparing to submit this indicator to the Office of Management and Budget (OMB) for approval under the Paperwork Reduction Act. As part of this process, States will be given a formal opportunity to comment to both EPA and OMB on the practical utility of this indicator, the additional burden associated with assessing it, and any other concerns they may have regarding its inclusion in the report. EPA is aware that some States are already preparing to

##### **The Biological Integrity Indicator**

The biological integrity indicator describes the condition of the biota and habitat in an ecosystem having minimal influence from human activities. The indicator measures the degree to which an ecosystem approaches this condition. Many States with biomonitoring programs can already measure some form of this indicator.

The traditional aquatic life use support (ALUS) assessment takes into account socioeconomic factors in State water quality standards. It can also be based on chemical data alone. The biological integrity indicator, on the other hand, must be based on biological and habitat monitoring and on comparison to reference conditions.

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#### 4. MEASURING AND REPORTING THE BIOLOGICAL INTEGRITY INDICATOR

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assess biological integrity as part of their 1988 305(b) reports. EPA would welcome submission of these assessments and will use them in its ongoing evaluation of this item for possible inclusion in future 305(b) reports. States are not required to include assessments of biological integrity in their 1988 reports, although of course they should continue to consider biological and habitat monitoring in their assessment of ALUS.

For the benefit of those States that wish to submit with their 1988 reports the results of any biological integrity assessments they are already conducting, as well as to further inform subsequent comment on the inclusion of this indicator in future reports, EPA is providing these guidelines.

Biological integrity is “the ability of an aquatic ecosystem to support and maintain a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of the natural habitat of a region” (Karr and Dudley, 1981; see also Angermeier and Karr, 1994). The State members of the 305(b) Consistency Workgroup asked that the biological integrity indicator be reported electronically rather than in their hard-copy 305(b) reports. This will avoid presenting assessments of aquatic life use support and biological integrity in the same State document, which might confuse the public. The voluntary pilot biological integrity indicator is thus included in the list of data elements in Section 6 of the main *Guidelines* volume.

The recommended approach for developing and reporting on the indicator is presented in Section 4.2 as three phases:

- C Develop reference conditions, the framework for making judgements of biological impairment
- C Design the monitoring network, including both historical sampling locations and new ones
- C Implement the monitoring program.

The information to develop a biological integrity indicator is described in detail below. This approach is compatible with biological and habitat assessment levels 3 and 4 in Tables 3-1 and 3-2 as well as the case studies for making ALUS determinations in Section 3. States may develop alternative approaches for measuring the biological integrity indicator, provided such approaches are compatible with levels 3 or 4 in Tables 3-1 and 3-2. Note that a good monitoring program should integrate biological monitoring with water column sampling; habitat,

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## 4. MEASURING AND REPORTING THE BIOLOGICAL INTEGRITY INDICATOR

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sediment and tissue monitoring; and other monitoring. Biosurvey monitoring should not be a separate program or done in a vacuum without other important types of monitoring.

The following outline of the three phases is **not** intended to be a complete description of the process for developing the biological integrity indicator. More complete technical guidance is available for many of the biological monitoring concepts and procedures described in this section. See *Biological Criteria: Technical Guidance for Streams and Rivers* (Gibson et al., 1996; EPA 822-B-96-001) and *Rapid Bioassessment Protocols for Use in Streams and Rivers* (Plafkin et al., 1989, EPA /440/4-89-001). For additional information, contact the EPA/OWOW Monitoring Branch at the number given on page ii.

The approach below has been applied to streams and rivers. Protocols for the measurement of biological integrity in lakes and estuaries are not fully developed. When these protocols are completed, reporting of biological integrity will expand into these waterbody types. In the interim, the States that have developed such protocols are encouraged to report biological integrity for as many waterbody types as possible.

### 4.2 Phases and Steps in Developing the Indicator

Although the steps in these phases are presented in a linear fashion below, the overall process is quite iterative, with some of the later steps providing information that allows testing of previous steps and refinement of the process.

#### **Phase 1 - Develop Reference Conditions**

The majority of the tools necessary for routine data analysis and site assessment are developed during this phase of the process. The approach presented here involves the use of reference sites; EPA recognizes that States may have other approaches for developing reference conditions.

**a. Classify Natural Landscape and Waterbody Types Contained within Region of Interest.**

- T** Partition the landscape on maps based on, for example, ecoregions, subcoregions, physiographic regions, watershed size, waterbody type, vegetation types, elevation, etc. Categories will serve as **preliminary** site classes.

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**b. Select Reference Sites.**

T Identify multiple sites per site class that exhibit minimal physical or chemical degradation and meet specified reference site criteria.

**c. Select Stressor Sites.**

T Identify multiple sites per site class with various degrees of known and documented physical and/or chemical degradation.

**d. Sample Reference and Stressor Sites.**

T Using appropriate biological methods, sample sites.

**e. Test Site Classification; Select and Calibrate Metrics** (assumes a multimetric approach).

T Calculate all potential metrics, indicate probable direction of change in presence of stressors

T Exclude metrics that have no ecological meaning

T Compare individual metric value ranges (from multiple reference sites) within and among preliminary site classes

- If value ranges cannot be separated, combine 2 or more site classes and aggregate reference site data from combined classes

- If metric values are highly variable within classes, examine alternative site classifications

- Test final classification with analytical methods such as discriminant analysis, MANOVA, or ordination

T Compare metric value ranges of reference sites vs. stressor sites within new site classes (i.e., test ability of each metric to discriminate between impaired and non-impaired)

- Exclude metrics that fail to respond to stressors within a site class and lack discriminatory power (use statistical tests, if necessary).

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#### 4. MEASURING AND REPORTING THE BIOLOGICAL INTEGRITY INDICATOR

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**f. Develop Performance Characteristics of Calculated Values.**

T Need to know precision and uncertainty of index and metric estimates (preliminary estimates can be developed with single year of data).

T Final determination requires repeated (replicate) samples, multiple year samples, and knowledge of site class variability.

**g. Develop Metric Scoring Criteria.**

T After metrics have been selected, choose threshold for determining impairment (depending on direction of change in presence of stressor) as some percentile of reference value distribution. Divide remainder of range into successively lower scoring categories.

**h. Determine Assessment (Index) Rating Scales**

T States use different approaches to continuous rating scales, typically using three, four and five categories. Currently, EPA is recommending a five-category scale such as excellent, good, fair, poor, and very poor (where *excellent* would be considered minimally impaired, that is, achieving biological integrity).

### **Phase 2 - Develop Monitoring Network Design**

**a. Determine Types and Geographic Scale(s) of Questions to be Addressed (Site-Specific, Watershed-wide, or Region-wide)**

T Determine appropriate approach for site selection (random selection), special (targeted selection), or combined approach.

**b. Determine Acceptable Data Quality Objectives (DQOs) for Assessment Results.**

T Base on *estimates of precision and uncertainty* of metrics and index (developed in Phase 1), as well as on availability of resources.

**c. Select Sampling Sites.**

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#### 4. MEASURING AND REPORTING THE BIOLOGICAL INTEGRITY INDICATOR

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- T Select sampling sites using probability design, targeted design, or combined approach. Take advantage of historical sampling sites where feasible.

### **Phase 3 - Implement Monitoring Program**

This is the routine monitoring program that will be performed regularly over specified time intervals, depending on the program. During Phases 1 and 2:

- " Metrics have been selected and calibrated; scoring criteria already developed
  - " Sampling locations have been selected based on monitoring objectives
  - " Field sampling and laboratory methods have been defined
  - " Index period has been defined
  - " Data management system has been defined and
  - " DQOs have been defined
- a. **Schedule field teams to complete sampling within index period.**
  - b. **Complete all sampling (as well as field taxonomy for fish) within defined time period; take duplicate samples (complete) at approximately 10% of sites.**
  - c. **Perform laboratory sorting and subsampling (benthos and periphyton, only).**
  - d. **Perform laboratory taxonomy (fish, where necessary; benthos; and periphyton) using a standard level of effort (i.e., consistent taxonomic levels for different organisms).**
  - e. **Using raw data from laboratory results, calculate selected *metrics* (selected during Phase I) for each sample.**
  - f. **Normalize metric values into unitless scores by comparison to *scoring criteria* (developed during Phase I).**
  - g. **Sum all metric scores for each sample.**



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- h. Compare summed metric total to *assessment rating scale* developed during Phase I.
  - T this step provides the site assessment of “excellent, very good, good, fair, or poor” (or other narrative rating terms)
- i. Compare precision and uncertainty values to the *DQOs* (developed in Phase I).

### 4.3 Reporting the Biological Integrity Indicator: Case Study

This section presents an example of metric calculation, index scoring, and judgement of impairment using actual data for a site. This is performed following the selection of reference sites and metrics, determination of final site classes, and development of reference conditions (i.e., scoring criteria). (Note: alternative methods are acceptable providing they are compatible with level 3 or 4 assessments in Tables 3-1 and 3-2). This example uses a benthic macroinvertebrate sample taken from a low gradient stream in the eastern United States and compares the laboratory results to the appropriate reference conditions. The text box on Page 4-7 presents definitions of the final metrics that were selected (Phase 1/step e above), the reference conditions used as the basis for scoring calculated metric values (Phase 1/step g above) and categories used for translating total bioassessment scores to narrative ratings (Phase 1/step h above).

Following sampling using appropriate methods for the stream type and region under study, the benthic macroinvertebrate sample is returned to the laboratory for sorting and taxonomic identification. An example of what results from laboratory processing of a single sample is shown in Table 4-1 and is a list of taxa, the number of individuals of each taxon, and their tolerance values and functional feeding group designations. This set of raw data represents Step 1 of the site assessment process.

Using the data produced in Table 4-1, the selected metrics are calculated, resulting in a set of metric values (Table 4-2). Each metric value is compared to the metric scoring criteria that were previously developed and normalized to scores, resulting in a list of metric scores (Table 4-2). For example, the site used for this example had a calculated value of 19.4 for the metric ‘% EPT (metric 3)’. Comparing that value to the scoring criteria, this site receives a ‘3’ for this metric. This comparison, or scoring, once done for all seven metrics, results in a list of metric values (Table 4-2) that can then be summed for a total bioassessment score. Comparing total bioassessment, or index, score to the narrative rating categories allows translation to a narrative assessment--**in this case, a Biological Integrity Indicator rating of “good” (Table 4-2). The State’s**

#### **4. MEASURING AND REPORTING THE BIOLOGICAL INTEGRITY INDICATOR**

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electronic database (WBS or other) would then be updated to show this rating for the appropriate number of miles of this waterbody (e.g., 5 miles = "good").

The exact sampling methods, reference site selection criteria, metrics, scoring criteria, and narrative rating categories will vary according to the waterbody type and region, sampling index period, and sample handling procedures.

## 4. MEASURING AND REPORTING THE BIOLOGICAL INTEGRITY INDICATOR

### Tools Developed During the Phase 1 Process that are Used During Bioassessment

#### Metric Definitions

1. Taxa Richness - the number of distinct taxa in the sample.
2. EPT Taxa - the number of distinct Ephemeroptera (mayflies), Plecoptera (stoneflies), and Trichoptera (caddisflies) taxa in the sample.
3. Percent EPT - the number of EPT individuals as a proportion of the total sample.
4. Percent Chironomidae - the number of chironomid individuals as a proportion of the total sample.
5. Number of Trichoptera Taxa - the number of distinct Trichoptera taxa in the sample.
6. Hilsenhoff Biotic Index - measures the abundance of tolerant and intolerant individuals in a sample by the following formula, where  $x_i$  is the number of individuals in the  $i$ th species,  $t_i$  is the tolerance value of the  $i$ th species, and  $n$  is the total number of species in the sample:

$$HBI' = \frac{\sum x_i t_i}{n}$$

7. Percent Collector-Filterers - the number of individuals that are members of the Functional Feeding Groups Collector or Filterer as a proportion of the total sample.

#### Reference Conditions

Metrics	Scoring Criteria		
	5	3	1
1. Total Taxa	\$23	22-12	11-1
2. EPT Taxa	\$8	7-4	3-0
3. %EPT	\$22.3	22.3-11.2	11.16-0
4. %Chironomidae	#33.6	33.6-67.3	> 67.3
5. No. Trichoptera Taxa	\$6	5-3	2-0
6. HBI	#5.5	5.5-7.8	> 7.8
7. %Collector-Filterers	\$57.2	57.2-28.1	28.1-12

#### Narrative Rating Categories

Narrative Rating	Total Bioassessment Score
very good	\$31
good	25-30
poor	18-24
very poor	< 18

#### 4. MEASURING AND REPORTING THE BIOLOGICAL INTEGRITY INDICATOR

Table 4-1. An example of laboratory results from sorting and identification of a single benthic macroinvertebrate sample.

Taxon	No.	TV	FFG
DIPTERA	2	-	-
CHIRONOMIDAE	19	5	-
Tanypodinae	52	5	-
Orthoclaadiinae	7	5	-
Chironominae	1	5	-
<i>Tipula</i>	4	4	SHR
<i>Dixella</i>	1	1	COL
<i>Limnophila</i>	1	4	PRE
<i>Chrysops</i>	2	7	PRE
<i>Pseudolimnophila</i>	2	2	PRE
<i>Hexatoma</i>	1	3	PRE
<i>Simulium</i>	7	6	FIL
<i>Culicoides</i>	2	10	PRE
<i>Bezzia/Palpomya</i>	2	6	PRE
<i>Mallochohelea</i>	5	-	-
<i>Phylocentropus</i>	1	5	FIL
<i>Hydatophylax</i>	4	2	SHR
<i>Pycnopsyche</i>	7	4	SHR
<i>Ptilostomis</i>	1	4	SHR
<i>Isonychia</i>	12	3	SHR
<i>Cheumatopsyche</i>	2	5	FIL
<i>Paranemoura</i>	7	2	SHR
<i>Leptophlebia</i>	3	4	SHR
<i>Centroptilum</i>	2	2	COL
<i>Baetis</i>	2	6	COL
<i>Boyeria</i>	1	2	PRE
<i>Calopteryx</i>	2	5	PRE
<i>Neohermes</i>	1	2	PRE
<i>Gammarus</i>	23	6	COL
<i>Caecidotea</i>	6	6	COL
<i>Crangonyx</i>	5	4	COL
OLIGOCHAETA	7	10	COL
<i>Pisidium</i>	16	5	FIL
<i>Pseudosuccinea</i>	1	6	COL
<b>Total No. Individuals</b>	<b>211</b>		

**Abbreviations:** FFG-functional feeding group, TV-tolerance value, SCR-scrappers, PRE -predators, SHR -shredders, FIL-filterers, COL-collectors.

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#### 4. MEASURING AND REPORTING THE BIOLOGICAL INTEGRITY INDICATOR

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**Table 4-2. Determining the biological integrity indicator for the waterbody\*.**

Note: Each of the seven metrics are calculated using raw data resulting from laboratory analysis. Metric values are normalized by comparison to scoring criteria, allowing them to be summed to a total index, or bioassessment, score. Comparing the total index score to narrative rating categories results in the a condition narrative .

Metric	Value	Score
TotTax	32	5
EPT Tax	10	5
%EPT	19.4	3
%Chir	37.4	3
TrichTax	6	5
HBI	5.2	5
%ColFil	12.3	1
Total Index Score		27

<b>BIOLOGICAL INTEGRITY INDICATOR:</b>
Good

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\* See previous box entitled "Metric Definitions." As noted in Section 4.1, other approaches to achieving biological assessment and habitat levels 3 or 4 (Tables 3-1 and 3-2) can be used to

#### **4. MEASURING AND REPORTING THE BIOLOGICAL INTEGRITY INDICATOR**

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determine the biological integrity for a waterbody. See also example case studies for ALUS assessments in Section 3 for more information about assessment quality.

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