California's Surface Water Ambient Monitoring Program
Clean Water Team

WHAT ARE BIOASSESSMENTS ?

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CLEAN WATER TEAM

CALIFORNIA Water Boards

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What Is Biological Integrity?

Integrity implies an unimpaired condition, or the quality or state of being complete or undivided.

The goal of biological integrity, unlike fishable and swimmable goals, encompasses all factors affecting the ecosystem. Karr and Dudley (1981; following Frey [1975]) define biological integrity as **"the capability of supporting and maintaining a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of the natural habitat of the region."** That is, a site with high biological integrity will have had little or no influence from human society.

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What Is Implied Within the Definition of Biological Integrity?

Inherent in the previously given definition is that:

(1) living systems act over a variety of scales from individuals to landscapes;

(2) a fully functioning living system includes items one can count (the elements of biodiversity) plus the processes that generate and maintain them; and

(3) living systems are embedded in dynamic evolutionary and biogeographic contexts that influence and are influenced by their physical and chemical environments

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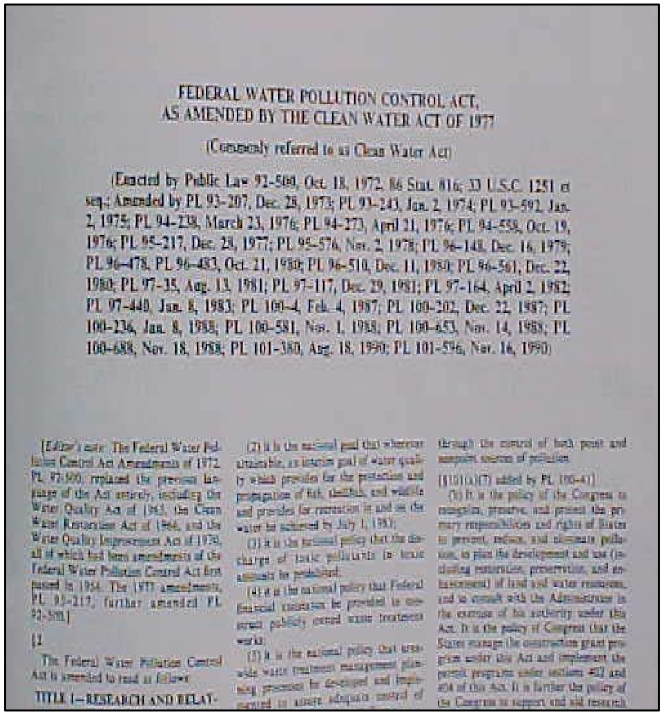
Biological Integrity & the Clean Water Act

Clean Water Act Section 101(a)
……..restore and maintain the chemical, physical and biological integrity of the nation's waters

Biological integrity was first explicitly included in water resource legislation in the Water Pollution Control Act Amendments of 1972 (Pub. L. 92-500); and the concept, which was retained in subsequent revisions of that act, is now an integral component of water resource programs at state and federal levels (U.S. Environ. Prot. Agency, 1990).

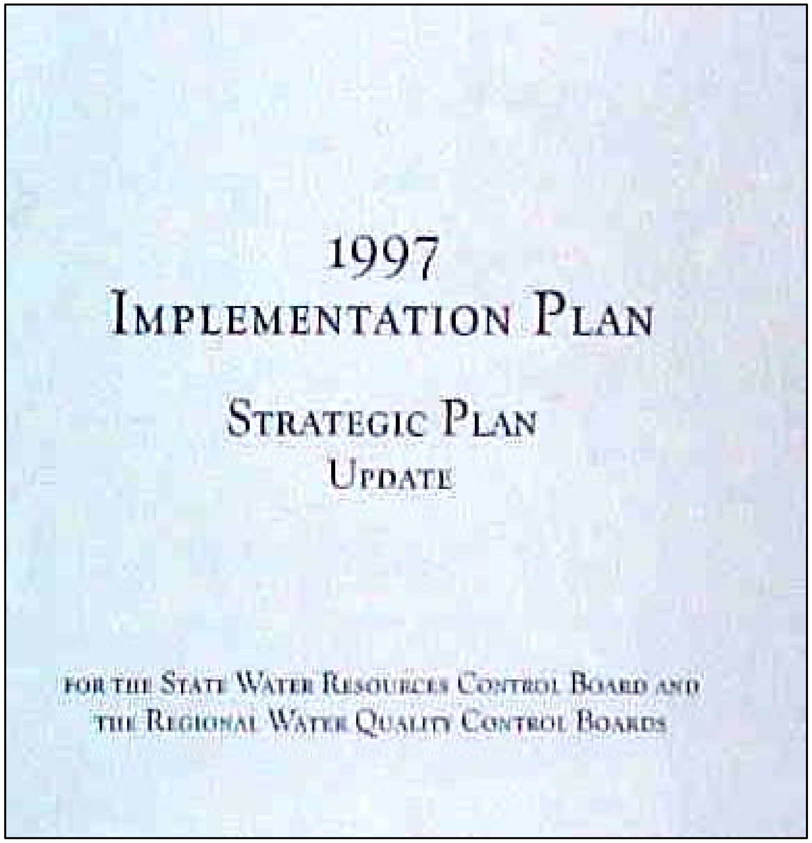


FEDERAL WATER POLLUTION CONTROL ACT,
AS AMENDED BY THE CLEAN WATER ACT OF 1977

(Commonly referred to as Clean Water Act)

(Enacted by Public Law 92-500, Oct. 18, 1972, 86 Stat. 816; 33 U.S.C. 1251 et seq.; Amended by PL 93-207, Dec. 28, 1973; PL 93-243, Jan. 2, 1974; PL 93-592, Jan. 2, 1975; PL 94-238, March 23, 1976; PL 94-273, April 21, 1976; PL 94-558, Oct. 19, 1976; PL 95-217, Dec. 28, 1977; PL 95-576, Nov. 2, 1978; PL 96-148, Dec. 16, 1979; PL 96-478, PL 96-483, Oct. 21, 1980; PL 96-510, Dec. 11, 1980; PL 96-561, Dec. 22, 1980; PL 97-35, Aug. 13, 1981; PL 97-117, Dec. 29, 1981; PL 97-164, April 2, 1982; PL 97-440, Jan. 8, 1983; PL 100-4, Feb. 4, 1987; PL 100-202, Dec. 22, 1987; PL 100-236, Jan. 8, 1988; PL 100-581, Nov. 1, 1988; PL 100-653, Nov. 14, 1988; PL 100-688, Nov. 18, 1988; PL 101-380, Aug. 18, 1990; PL 101-596, Nov. 16, 1990)

Why bioassessment?



1997

IMPLEMENTATION PLAN

STRATEGIC PLAN

UPDATE

FOR THE STATE WATER RESOURCES CONTROL BOARD AND
THE REGIONAL WATER QUALITY CONTROL BOARDS

SWRCB Strategic Plan
calls for a

" bioassessment monitoring
program"

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BIOLOGICAL vs CHEMICAL MONITORING

Chemical monitoring measures the health of a stream at a specific point in time. It also gives us a view of the biological potential for that given stream.

Biological monitoring allows the direct assessment of the streams biota and directly measures the streams biological condition.

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EPA's "Where We Want to Be" With Bioassessment/Biocriteria

The Goal **:**

- **All States use bioassessments to evaluate the health of aquatic life in all waterbodies**
- **Bioassessment data are used to better define aquatic life uses**
- **Quantifiable biocriteria are in all State/Tribal water quality standards**
- **Biocriteria is used in ongoing regulatory programs**
- **Bioassessment data and biocriteria are used to better communicate the health of the Nation's waters**

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Degradation of Biological Integrity

Degradation of water resources comes from pollution, which is defined in the Clean Water Act of 1987 as "manmade or man-induced alteration of the chemical, physical, biological, or radiological integrity of water" (U.S. Gov. Print. Off. 1988).

This comprehensive definition does not limit societal concern to chemical contamination. It includes any human action or result of human action that degrades water resources. Humans may degrade or pollute water resources by chemical contamination or by altering aquatic habitats; they may pollute by withdrawing water for irrigation, by over harvesting fish, or by introducing exotic species that alter the resident aquatic biota. The biota of streams, rivers, lakes, and estuaries, unlike other attributes of the water resource (e.g., water chemistry or flow characteristics), are sensitive to all forms of pollution. Thus, the development of biological criteria is essential to protect the integrity of water resources

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Biological Indicators

What Are Biological Indicators?

After much careful study, environmental scientists have determined that the presence, condition, and numbers of the types of fish, insects, algae, and plants can provide accurate information about the health of a specific river, stream, lake, wetland, or estuary. These types of plants and animals are called biological indicators.

An indicator is a sign or signal that relays a complex message, potentially from numerous sources, in a simplified and useful manner. An ecological indicator is defined here as a measure, an index of measures, or a model that characterizes an ecosystem or one of its critical components.

An indicator may reflect biological, chemical or physical attributes of ecological condition. The primary uses of an indicator are to characterize current status and to track or predict significant change. With a foundation of diagnostic research, an ecological indicator may also be used to identify major ecosystem stress

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Current EMAP/CEMAP Indicators (2007)

- **Physical Habitat**
- **Biological**
  - **Macroinvertebrate**
  - Fish community
  - Algae (Chla and AFDW)
- Chemical
  - TSS, turbidity, color, pH, conductivity
  - Major ions (Al, Ca, Cl, K, Mg, S04)
  - Nutrients (N, P, Si)
  - Organic Carbon (DOC, DIC)

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Biological Criteria

Biological criteria are narrative descriptions or numerical values that are used to describe the reference condition of aquatic biota inhabiting waters of a designated aquatic life use. They are developed by biologists and other natural resource specialists as measures to directly assess the overall condition of an aquatic community in surface waters such as streams, rivers, lakes, estuaries and wetlands. Based on appropriate reference conditions and using an array of scientific assessments and stream surveys, scientists use these criteria to determine if waters are affected by chemical pollution or other factors.

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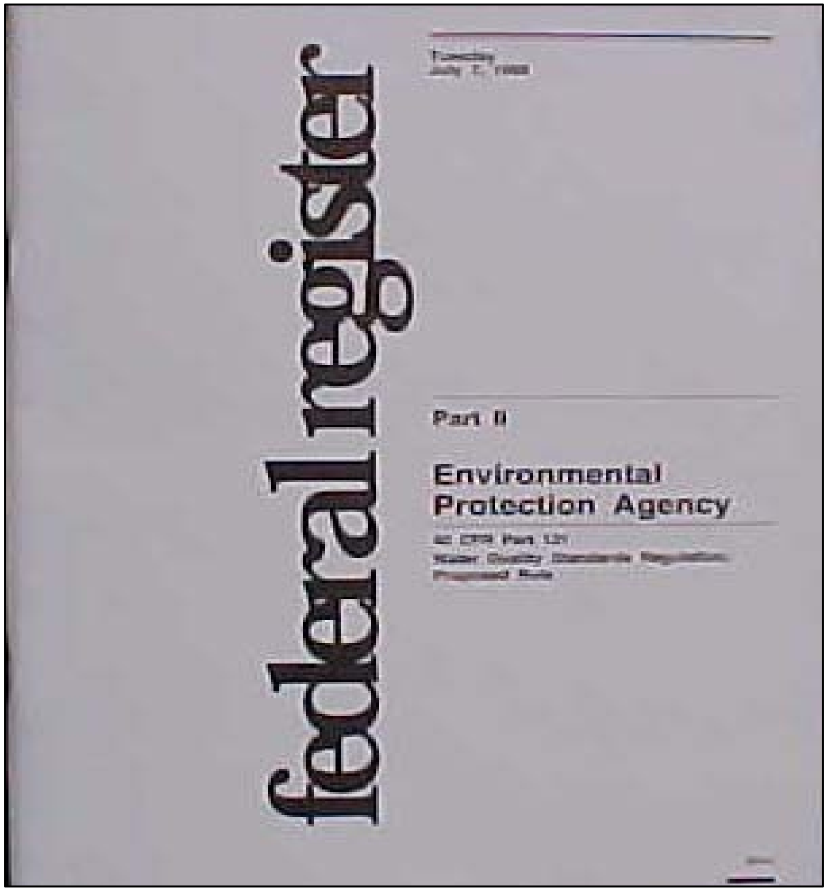
Biological Criteria
EPA



Federal Register Volume 63, No. 129

"Biological Criteria"

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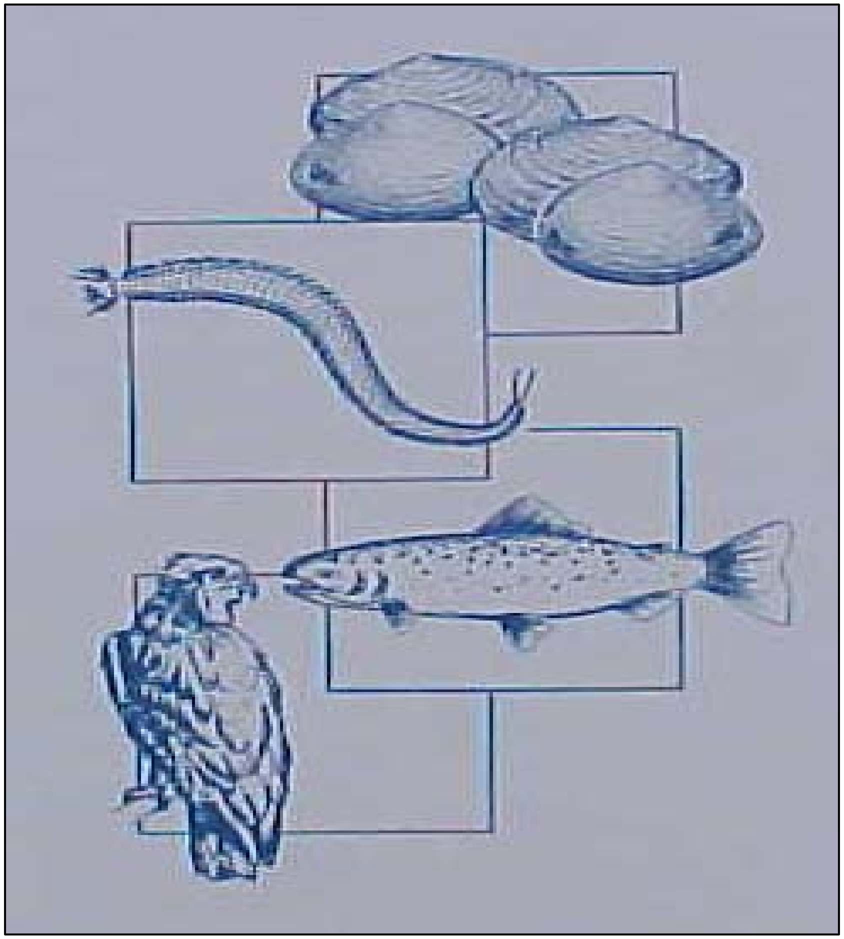
Biomonitoring



Use of a biological entity as a detector and its response as a measure to determine environmental conditions

(Includes: toxicity tests, tissue chemistry, bioassessment surveys, etc.)

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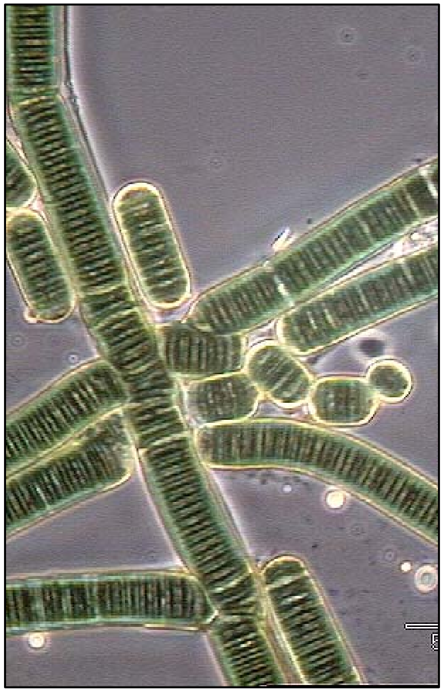
Bioassessment

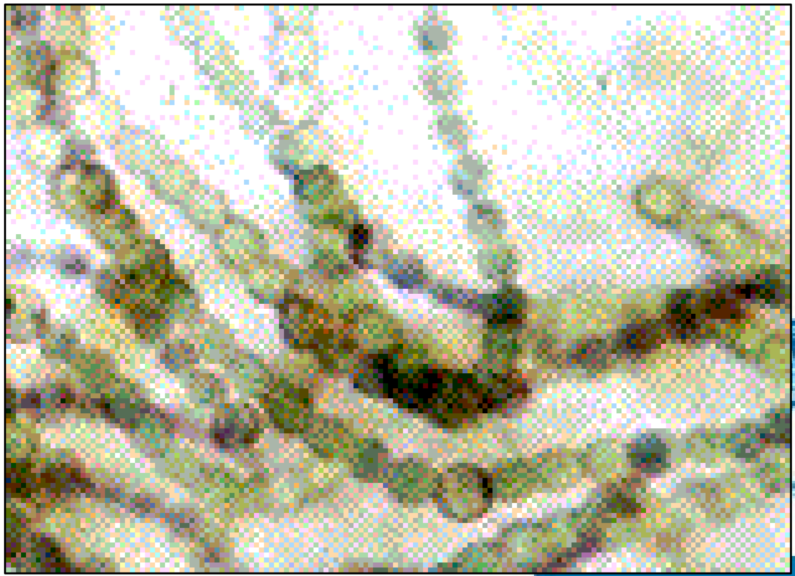


An evaluation of the biological condition of a waterbody that uses biological surveys and other direct measurements of resident biota in surface waters

Why Bioassessment?

- direct measure of integrity of aquatic life uses

- integrates water quality over time



Bioassessment typically looks at “assemblages”:

- periphyton (i.e., algae)
- benthic macroinvertebrates
- fish
- amphibians
- reptiles
- birds
- vegetation

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WHY STUDY BENTHIC MACRO INVERTEBRATES

Different groups of invertebrates have different tolerances to pollution. This makes them useful indicators of water quality

- They live in the water for all or most of their life.
- They are an important part of the streams ecology.
- They provide information about a streams health over a long period of time.
- They are easy to collect.
- Can be identified.
- Relatively inexpensive

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Metrics

Metrics are used to analyze and interpret biological data by condensing lists of organisms into relevant biological information. In order to be useful, metrics must be proven to respond in predictable ways to various types and intensities of stream impacts. Most stream ecologist recommend using a **multimetric** approach that combines several metrics into an overall score

Metrics

When conducting biological assessments, measurements are taken in the field or lab. Metrics (or biological attributes) for each assemblage sample (e.g., benthic invertebrates, fish, periphyton, macrophytes) are calculated from these measurements

Each metric is then assigned a score which is related to its deviation from the reference (or expected) site values. In more complicated studies, multimetric indices can be calculated, which is the sum of all the metric scores within each biological assemblage

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Table of Metrics

Metric	Response to Stress
No. of taxa.	Reduced
Mean number of individuals per taxon.	Substantially lower or higher.
% contribution of dominant taxon.	Elevated
Shannon-Wiener diversity.	Reduced
% intolerant species.	Reduced
% oligochaetes.	Elevated under organic enrichment.
ETO taxa (ephemeroptera, trichoptera, odonates).	Reduced under enrichment, DO, stress.
% non-insects.	Reduced
Crustacean + mollusc taxa.	Reduced under acid stress.
% crustaceans and molluscs.	Reduced under acid stress.
Tolerance indices (e.g., HBI [Hilsenhoff 1987]; Hulbert's Lake Condition Index [LCI] [Frydenborg et al. 1995]).	Reduced
% suspension feeders.	Reduced
% shredders.	Reduced under enrichment or in very large lakes.

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Metrics

Taxonomic Richness - The total number of unique taxa in the sample. Metric values decrease as water quality and habitat quality decrease. Values have no limits.

EPT Richness - The total number of unique taxa in the Ephemeroptera, Plecoptera, and Trichoptera orders. Metric values decrease as water quality and habitat quality decrease. Values have no limits.

% EPT Abundance - The percent of the organisms in the sample that are EPTs. Metric values decrease as water quality and habitat quality decrease. Values range from 0 to 100.

% Chironomidae - The percent of the organisms in the sample that are in the family Chironomidae. Metric values increase as water quality and habitat quality decrease. Organic pollution results in a loss of EPTs and an increase in the abundance of these organisms. Values range from 0 to 100.

% Dominant Taxon - The percent of the total abundance that is a single taxon. Metric values increase as water quality and habitat quality decrease. A community dominated by a single taxon is indicative of anthropogenic stress. Values range from 0 to 100.

% Non-Insect - The percent of the organisms in the sample which are not insects. Assemblage dominated by snails, worms, leeches, water mites, and other non-insects are generally more pollution tolerant than assemblage dominated by insects. Used principally to assess severe impairment. Values range from 0-100.

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Other Metrics

Number of EPT Taxa-The combined number of mayfly (E), stonefly (P) and caddisfly (T) taxa found in the sample.

Percent of Tolerant- The number of taxa in the sample that are in the 5-10% of the most tolerant taxa in a region or that have a pollution tolerance value of greater than a certain number.

Biotic Index:-Pollution tolerance values (based on the scale of 1-10) are assigned to each family. An overall pollution tolerance value is determined for the sample.

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Biological Response Signatures

Biological indicators are both accurate and sensitive measures of the health of waterways and they can also be used to diagnose sources and causes of pollution. Definite patterns exist in the responses of biological communities to stress (pollution), and finding these patterns can show what types of pollution are present, and sometimes the source of those problems.

When the response patterns of the various metrics and components of IBIs (Indices of Biotic Integrity) are identified, these unique combinations of biological community characteristics that aid in distinguishing one impact type over another are referred to as "Biological Response Signatures."

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What Is a Multimetric Index?

The Index of Biological Integrity (IBI) consists of multiple metrics such as species richness, species composition and trophic structures. They are developed for specific geographic areas and for specific sampling protocols/methodologies.

An index of biological integrity (IBI) is a synthesis of diverse biological information which numerically depicts associations between human influence and biological attributes. It is composed of several biological attributes or 'metrics' that are sensitive to changes in biological integrity cased by human activities. Metrics are based on either taxa richness (the number of taxa found at a study site) or the percentage of individual organisms which share common biological characteristics that increase or decrease along the gradient of human influence.

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Using the IBI

To determine an IBI for a stream, metric values from the stream are compared with values expected for a relatively undisturbed stream of similar size in the same geographic region. Each metric is assigned a value of 5, 3, or 1 depending on whether the condition is comparable to, deviates somewhat from, or deviates strongly from the "undisturbed" reference condition. Metric scores are then summed to yield an index (based on 9 metrics for western streams) that ranges from a low of 9 to a high of 45 for faunas equivalent to those in pristine or relatively undisturbed areas

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Current applications

- Baseline & trend monitoring
- Evaluate effectiveness of:
  - BMP implementation
  - restoration projects
  - permit requirements
  - remediation efforts
- Establish biological targets for TMDLs
- Establish reference conditions

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Future Applications

- Beneficial use attainment:
  - listing (i.e., “303[d] list”)
  - de-listing
  - reporting (i.e., “305[b] report”)
- Biocriteria ??

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