May 5, 1997

EPA-SAB-EPEC-LTR-97-007

Honorable Carol M. Browner
Administrator
U.S. Environmental Protection Agency
401 M Street, S.W.
Washington, DC 20460

Subject: Review of the Draft Guidance for Lakes and Reservoir Bioassessment and Biocriteria

Dear Ms. Browner:

The Lakes Biocriteria Subcommittee of the Ecological Processes and Effects Committee (EPEC) of the Science Advisory Board met on April 22-23, 1996 in Washington, D.C. to review the Agency's draft document, *Lake and Reservoir Bioassessment and Biocriteria: Technical Guidance Document* (dated May 1995). The document is intended to offer guidance to states on biological monitoring approaches, including the development and implementation of biological criteria, defined as numeric values or narrative expressions that describe the reference biological integrity of aquatic communities for a given aquatic life use. Biocriteria, based on multi-metric indices that incorporate information on a variety of biological assemblages (e.g., macro-invertebrates, fish, and aquatic plants), are intended to supplement, rather than replace, physical/chemical measures of environmental condition. The charge to the Subcommittee was to review the following components of the draft guidance document for scientific adequacy and pertinence:

a) The selection and treatment of biotic parameters used to evaluate lake and reservoir resource quality in the guidance;

b) The selection and treatment of habitat characteristics used to classify and to assess these lakes and reservoirs;

c) The sampling design recommended to gather the above information for biological criteria development; and

d) The analytical techniques discussed in the guidance to determine significant deviations from the criteria which would prompt remedial action.

In this letter, we include our thoughts on the broader aspects of the development and use of biocriteria, as well as specific technical comments in response to the charge questions.

1. <u>Rationale and Context for Biocriteria</u>:

The Subcommittee fully supports the Agency's efforts to develop meaningful measures of the health of biological communities and believes the lake/reservoir biocriteria document compliments the on-going efforts of the Agency. In 1993, another subcommittee of EPEC reviewed the Agency's draft guidance for developing biocriteria for streams and small rivers and found it to be an important contribution to the development of scientifically credible methods for biological assessment (SAB, 1993). At that time, the Committee offered to review future biocriteria guidance documents, including guidance for lakes and reservoirs, which is the focus of this letter.

There are a number of general advantages to using biological measures of environmental condition as a supplement to physical/chemical measures. These include their ability to integrate the effects of exposures over time from a variety of sources and to assess directly the resource to be protected. Some states, however, may view biological assessment as an additional technical and financial burden on already overextended state monitoring programs. In this regard, the draft guidance document fails to present a compelling rationale for the need for and benefits of biocriteria. Thus, we recommend that the opening chapters of the draft guidance document be revised to provide a more eloquent and succinct discussion of the benefits to be gained from employing biological measures, not in terms of better reporting to EPA but in terms of the information they provide that cannot be obtained from water and sediment quality measures alone. For example, the document should emphasize that, for any sampling period, biological measures represent a time-integrated measure of lake/reservoir quality as opposed to a snapshot view of exposure provided by one-time chemical analyses.

In addition, as suggested by the SAB for the streams biocriteria document, the Subcommittee strongly recommends that the opening chapters of the document more clearly describe the relationship between the development of biocriteria and the ecological risk assessment process outlined in the Agency's *Framework for Ecological Risk Assessment* (EPA/630/R-92/001) and *Proposed Guidelines for Ecological Risk Assessment* (EPA/630/R-95/002B). Application of the ecorisk framework to the lakes and reservoir biocriteria development process would include, for example, discussion of the coupling between stressors (both natural and anthropogenic) and ecological responses or condition, as characterized by the metrics associated with the biocriteria. The ecorisk framework also highlights the opportunities for policy or regulatory inputs into the problem formulation process (e.g., definition of regulatory goals for lakes and reservoirs), the development of a conceptual model of ecological condition (i.e., the reference condition and other benchmarks), and the connectivity of the scientific process with the risk management, monitoring, and feedback process. We are aware that the Agency, in a separate effort, is developing guidance and case studies on the application of the ecorisk framework in watersheds, and we agree that it will address many of these issues. Nonetheless,

we strongly recommend that the biocriteria guidance documents themselves describe the development of biocriteria explicitly in the ecorisk assessment context.

2. <u>The Role of Science in Lake and Reservoir Assessment and Management</u>:

The guidance document describes the process of developing biocriteria as containing the following steps: regionalization/classification of lakes; definition of reference conditions for each class (including survey of physical and biological characteristics); development of a multimetric index that integrates information on a number of biological and habitat attributes; and development of biocriteria that describe the desired condition for an area (taking into account multiple uses and not necessarily the same as reference condition). Implementation then involves monitoring and assessment of lakes, calculation of multimetric indices, and comparison against the biocriteria.

Central to this process is the definition of reference condition. The distinction between biologically attainable condition vs. societally/economically feasible condition was not always clear in the guidance document. Ultimately, biocriteria are placed within the regulatory context of water quality standards and designated uses. While recognizing that considerations other than scientific ones play a role in such decisions, the Subcommittee has the following thoughts about the role of science in this process.

"Use designations" for lakes and reservoirs, established at the state level, reflect societal values and goals for water resource uses. Clearly, there are no methods inherent to science by which those value decisions can be made. However, science is a powerful way of acquiring new knowledge and, as such, science can assist decision-makers to establish or revise use designations. Science can also guide management as actions are implemented to achieve the water quality goals (in the sense of Averett and Marzolf, 1987; Marzolf, 1991) associated with specific uses. Specifically, in the field of water resource assessment and management, science, including biocriteria, can:

a) assess and document the status of aquatic ecosystems and evaluate trends of change in that status through time (e.g., resource inventory and monitoring);

b) develop understanding of the mechanisms by which aquatic ecosysems are maintained or vary through time and in space, including understanding the degrees to which variation (or stability) is expected;

c) suggest management actions to achieve water quality goals or target conditions, including evaluation of feasibility, schedules, and compatability with pre-existing goals; and

d) predict the outcome of natural events or management actions beforehand, assess the result of management actions once implemented, and provide warning of the need for mid-course corrections in a management plan.

These areas of scientific inquiry, when integrated with management, provide illumination for policy choices, **but they cannot make the human value judgments about what is good or bad, useful or impaired**. The Subcommittee recommends, therefore, that the guidance document more clearly distinguish between the aspects of the biocriteria process that derive from science and those that represent societal choices for desired condition.

3. <u>Defining Reference and Benchmark Conditions</u>:

As in the 1993 review, much of the Subcommittee discussion related to the concept of reference condition, how it should be defined in practice, and the related issue of resource classification. Based on review of the draft guidance document and presentations by state agencies at the review meeting, the Subcommittee noted some confusion on what constitutes reference conditions in practice, varying from selecting the least-impacted lakes in Vermont based on watershed development criteria (though not based on the ecological condition of the lakes), to the development by the Tennessee Valley Authority (TVA) of hypothetical reference reservoirs that are defined by composite characteristics not tied to any single water body. The Subcommittee recommends, therefore, the following consistent guidance to states in the development of biocriteria:

First, we recommend that hypothetical reference <u>conditions</u> be established using information from actual sites, historical data, empirical models, and expert opinion, rather than the identification of a particular actual lake or reservoir as the reference system. The use of an ideal lake for a given class of lake types avoids the problem of a selected reference lake changing over time (which all lakes do), and it avoids the problem of having an impacted water body as a reference site (which would limit the goal to attainment of only best current conditions). The reference condition concept, by contrast, would be defined by an expert judgment process to constitute an idealized water body characterized by specific biological and physical-chemical conditions that may or may not actually exist at present. Ecological models are often useful in this expert judgment process, and should not be dismissed out of hand, as they are in section 4.2.5 of the draft document. Biocriteria developed to describe such a reference condition would then reflect a condition that is the best attainable or the highest ecological quality that existed prior to changes caused by human activities. Obviously, such reference biocriteria can only be defined for a particular class of water body (see discussion of classification issues below).

In addition to a reference condition that describes the highest attainable condition for a water body of a specified class, the Subcommittee recommends development of biocriteria to describe other states of ecological condition. Conceptually, a water body may have a broad range of ecological characteristics that could be distributed along a continuum or gradient of ecological health, ranging from most impaired by human activities to least impaired. Indeed, the bounds of

this ecological health continuum are complete impairment at one end and the reference conditions, which may be theoretical only, at the other end. Between the two extremes may exist an infinite array of ecological conditions defined in terms of the parameters used for the reference condition. The critical import of the biocriteria process, then, is to articulate the particular ecological characteristics for various locations along this ecohealth continuum that relate to the regulatorily determined, societally relevant goals or uses defined for water bodies (see Figure 1).

If the Agency wishes to reserve the term "biocriteria" for descriptions of ecological condition that pertain only to aquatic life use designations, then another term such as "benchmark biocriteria," might be used to refer to points along the continuum of ecological condition associated with other designated uses. Benchmark biocriteria would be developed to provide the ecological characterization appropriate for the lower, upper, and median conditions within a designated regulatory category or water body use. This scheme would allow specific comparisons to be made between the health of a particular water body and the range of conditions for that class of water bodies, between the same water body at different points in time in order to detect trends, and between regulatory categories, such as to demonstrate improvement in a water body sufficiently to advance it to a higher use category.

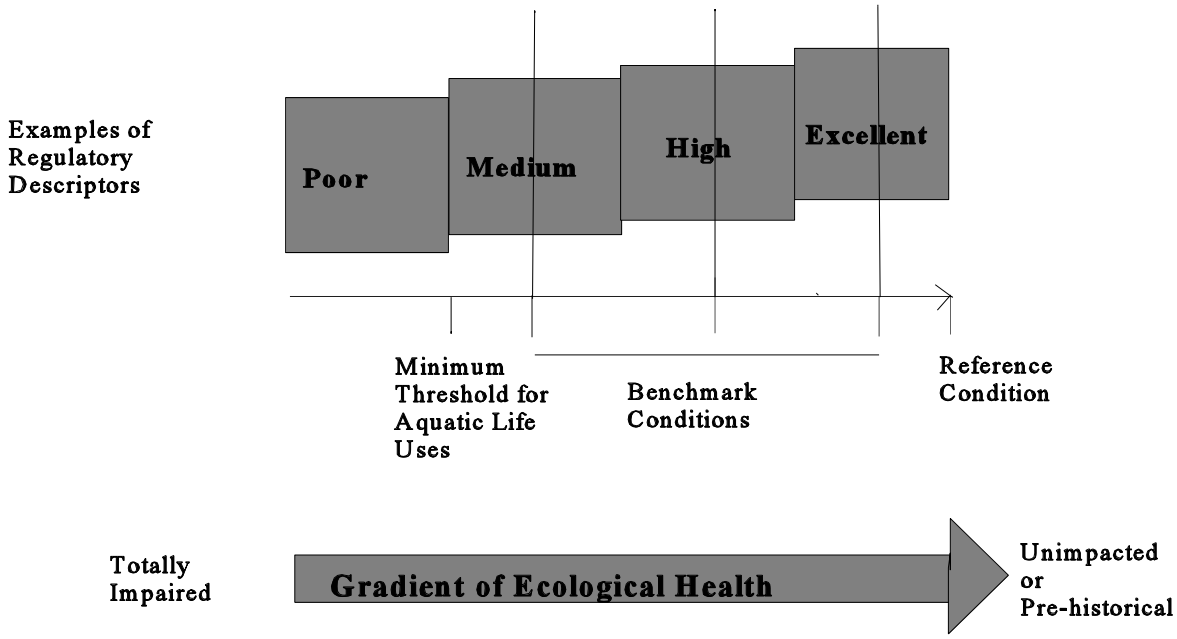
Using such a scheme, a state would have a scientific basis for evaluating the status and trends of environmental health of its water bodies defined in terms reflecting ecological condition, not stressor state. In ecological risk assessment terminology, the biocriteria process then is the mechanism for translating regulatory endpoints into ecological endpoints, and for developing appropriate success criteria to evaluate the progression of a restoration process in ecological terms, using the parameters selected to define the idealized reference conditions of an unimpaired system. It is clear that the distinction must be maintained between the societal goals-setting process and the scientific process of characterizing ecological condition. The proposed conceptual basis thus provides a structure to link those two aspects, ensuring the scientific criteria are relevant to the policy process.

4. <u>Classification/Regionalization</u>:

An essential first step in lake/reservoir bioassessment is to develop classification subsets of a state's lakes and reservoirs. Subsequently, reference conditions are defined for each subset, as previously described, recognizing that reference conditions among subsets can be naturally variable (see, for example, Heiskary et al., 1987). As stated in the draft guidance document, geographic regionalization schemes such as that developed by Omernik (1987) have demonstrated applicability to surface water characterization. However, other regionalization schemes, including the U.S. Geological Survey Hydrologic Units (USDOI, 1980) and the U.S. Department of Agriculture Land Resource Regions and Major Land Resource Areas (USDA, 1981), might also be applicable, and should be mentioned in the guidance document.

It should be noted as well that regionalization is not the only possible means for classification, and in some states may not be the most desirable means. Mountainous states, for

Figure 1. Relationship between regulatory descriptions of lake/reservoir quality and ecological condition.



example, might classify their lakes based on an elevational gradient that is not regional (e.g., high mountain lakes, intermountain basin lakes). Arid states might classify their lakes along a gradient of water salinity. Although several alternative classification schemes are described in the guidance document as a means of stratifying within ecoregions (i.e., watershed characteristics, lake basin characteristics, lake hydrology, and characteristic water quality), there may be instances where these alternative schemes are preferable to regional classification schemes. If geographic regionalization is the basis for classification, then reference conditions should be developed for each region within a state, independent of the others.

5. Special Considerations for Reservoirs:

The Subcommittee agrees with the acknowledgement in the draft document that river impoundments/reservoirs have unique features that influence water quality assessment and that these unique features have implications for the design of a sampling program for reservoirs. Nevertheless, the treatment of reservoirs in the document was not without some logical problems that might confuse the interpretation of monitoring and inventory data.

The underlying question is whether reservoirs are "lakes with special features" or "altered rivers?" While this may sound like a philosophical point, the application of biocriteria will be different depending upon the answer. In the case of reservoirs, the concept of "designated uses" is complicated by the fact that the dams that resulted in formation of the reservoirs were constructed for purposes other than designated aquatic life uses. In fact, dam/reservoir uses often were designated by Congress in its authorization and appropriation to the U.S. Army Corps of Engineers, Bureau of Reclamation, or the Tennessee Valley Authority for dam construction. The design specifications for the dam necessarily focused on the authorized purposes, e.g., flood control; water storage (conservation) for irrigation or domestic supply; navigation; and hydropower generation. Virtually all major rivers in the United States have been impounded for one or more of these purposes.

The Subcommittee suggests, therefore, that reservoirs may be more logically treated under the assessment guidelines for streams and rivers. Since the streams and rivers guidance is completed and in the hands of the states, however, this option probably is not feasible. As an alternative, the Subcommittee recommends that the treatment of reservoirs in the current guidance document be strengthened by: a) adding a separate section that specifically discusses the special case of reservoirs, and b) more fully addressing reservoir-specific considerations in each subsection of the document.

Regardless of how this question is resolved, the guidance should distinguish between the use of biocriteria to assess changes in rivers as a result of reservoir formation vs. change in reservoirs themselves. In this regard, additional treatment of the hydrologic and historic context of impounded rivers is needed. Furthermore, the document should give greater attention to the time dimension of change in rivers/reservoirs, both the changes associated with dam construction itself and the longer term changes that result from impoundment. Some description of the nature

and pace of these changes should help interpretive thought by the states. For example, there are a number of immediate changes to a river upon impoundment: channel cross-sections are wider and deeper, flow velocity is slower, and sediment distribution and the fluxes of dissolved and particulate materials are changed. These new features create an environment which continues to change and evolve on longer time scales; e.g., migration and dispersion of floral and faunal components of the river ecosystem are compromised so that riverine biota are changed and changing further; the new sedimentary regime due to impoundment alters the success (survival and reproductive performance) of benthic organisms; and the low current velocities increase the successful establishment of invading planktonic forms. Finally, but by no means less significant, is the fact that the creation of a lake-like environment is often followed by the decision to introduce exotic sport fishes to the system.

In short, in most cases the system itself has been dramatically changed and, with such change, the processes that historically mediated water quality in rivers have been altered. Whether the ecosystem components and the attendant processes that are replacing them in reservoirs will yield similar water qualities for human uses is not known. The rate at which various changes occurred and are occurring is different, of course, but there is more reason to expect continued change rather than new, stable equilibria. Some additional considerations for reservoir biological assessment include:

a) The hydrologic regimes of reservoirs, being tied to large rivers, are likely to exhibit significant year-to-year variation, including variation resulting from major episodic events. Sampling design and data analysis should accommodate this expected temporal variation. (The expectation of spatial variation is well covered in the draft document.)

b) The river below the reservoir is also altered, experiencing, for example: altered temperatures; periodically lower dissolved oxygen concentrations; lower sediment loads; and consequently, altered benthic habitat and altered biota from species introductions and invasions.

c) Reservoir bioassessment should take advantage of existing monitoring records. Dam operation records often include extraordinary data sets of flow, temperature, dissolved oxygen, and conductivity. These may span the entire history of the reservoir, but in any case represent a greater fraction of the reservoir's life than is available for Pleistocene lakes.

d) Reservoir management efforts should take advantage of the operational options of dams to achieve management objectives, both for water quality and water quantity, in the reservoir and in the tailwaters. For example, the discharge magnitude and schedule can influence lake level and retention time, each of which has potential secondary effects on productivity, spawning, insect emergence, anoxia, heat budgets, tailwater flows, and so forth. The range of possible dam operations is

almost always broader than that required to achieve the dam's original purpose and may be manipulated to allow water quality objectives to be met.

6. <u>Response to Specific Charge Questions</u>:

In response to the charge, the Subcommittee has the following additional comments regarding the scientific adequacy and pertinence of various aspects of the draft document:

a) <u>Selection and treatment of biotic parameters</u>

The Subcommittee believes that the draft document's discussion of the selection and treatment of biotic parameters used to complement physical/chemical evaluation of lake and reservoir resource quality are pertinent and, for the most part, adequate. We recommend, however, that EPA consider including macrophytes and relevant aquatic-related wildlife, including shorebirds, waterfowl, and fish-eating birds, as potential populations that could be evaluated and used to develop lake and reservoir biocriteria. Macrophyte metrics should not be excluded merely because lake macrophytes are not "entirely in the water"; for example, emergent macrophytes that usually grow in lake beds (such as wild rice and hard-stemmed bulrush) should be considered for measurement. The use of macrophyte metrics will become even more important as the Agency develops biocriteria for wetlands and estuaries.

Further, in order to determine if the national goal of "protection and propagation of fish, shellfish, *and wildlife*" [Clean Water Act section 101(a)(2), emphasis added] is being met, it is essential to include wildlife metrics in the biological sampling. Those species that are most dependent on lake and reservoir food webs, such as diving ducks, shorebirds, and otters, would be the most logical candidates because water impairment would have the most direct effects on them. Species that live in and around lakes, but which do not rely on lake-based food webs, might also be considered. Appropriate metrics might include presence/absence, abundance, or reproductive/nest success (see, for example, Schemnitz, 1980). The discussion of "Indicators" and "Sampling Design" in the National Research Council's (1994) review of the Environmental Monitoring and Assessment Program (EMAP) surface waters monitoring component also should be consulted.

An additional concern with the draft document is that insufficient data are presented on the precision that results when the recommended parameters are measured. States planning to utilize biocriteria must first decide what level of precision is required or is generally considered acceptable for decision making purposes. Sufficient precision should be obtained using the recommended procedures to be able to discriminate differences between lakes or reservoirs along a given index continuum or between a reference lake (or reference condition) and a non-reference lake. The degree of precision provided by the recommended procedures has to be sufficient to identify statistical differences in biological condition between various lakes or reservoirs in order to apply appropriate management techniques with confidence or to decide whether or not use attainability is being achieved.

b) Selection and treatment of habitat characteristics

The Subcommittee believes that Geographic Information Systems (GIS) are a potentially useful tool for making habitat measurements, doing desktop screening, and selecting and characterizing reference conditions. The guidance document should include additional discussion of this capability, along with a listing of relevant GIS databases that are generally available (e.g., Topographically Integrated Geographic Encoding and Referencing [TIGER] files, a digital database developed for the Census Bureau's Decennial Census showing streets, water bodies, roads, and other features; USGS Digital Line Graph [DLG] files; and USGS Land Use Land Cover [LULC]). In addition, remote sensing is a scientifically defensible means of making certain biotic measurements, especially at lower sampling tiers, and should be described as a possible measurement technique. Example applications are the use of color aerial photography to quantify the extent of macrophyte beds and the use of aerial videography to quantify chlorophyll *a* concentrations in surface waters.

c) Sampling design issues

The Subcommittee believes that the existing guidance document does not provide sufficient information to judge the adequacy of the sampling design for gathering data to derive statistically defensible biocriteria. We recommend that additional guidance be provided on methods for determining the number of samples that should be collected and analyzed both for single visits and multiple visits to a given lake or reservoir. It is important that a sufficient number of samples be collected for each metric of interest to be able to discriminate appropriately along the ecological health continuum or between a given lake or reservoir and a reference lake and/or reservoir. The guidance should refer to standard approaches for determining the number of samples needed to obtain a given precision with a specified Type I and Type II error (e.g., Elliott, 1977). Case studies can be used in a retrospective manner to help derive a "generic" number of samples that should be collected for each metric of interest. Ultimately, this is best done with data from a given ecoregion. This retrospective analysis approach can be used to evaluate whether or not the error associated with some measurements is so large as to suggest that the data are not meaningful and to identify the metrics that can be taken with the greatest precision at the best cost-benefit ratio. Since all metrics are not equally diagnostic, the relative weighting of different classes of measurements should be carefully considered.

The guidance should also discuss the sampling design considerations for intermittent lakes and drawdown zones, which experience extreme variability in biotic conditions. Biologic sampling of these areas must be timed to correspond with the occurrence of lake-associated biota at these locations. This situation is analogous to the sampling of intermittent streams (see, for example, Brown and Matthews, 1995).

d) Analytical techniques to determine significant deviations from the criteria

The Subcommittee agrees that the techniques described in the guidance document are the appropriate techniques for deriving biocriteria in a defensible manner. However, as stated above, the current guidance document does not provide sufficient information to judge the discriminating ability of this approach. It is not known, for example, what level of change in a biocriteria index would be required before it could be concluded that a significant change had occurred or whether or not the biocriteria are statistically different from the reference condition.

We hope that these comments will be helpful to you and the Office of Water as the Agency revises the draft technical guidance for lakes/reservoirs bioassessment, and we look forward to a response from Mr. Robert Perciasepe, Assistant Administator for Water. We look forward to continuing the dialogue over the appropriate development and application of biological assessment and biocriteria approaches, particularly as the Agency turns its efforts toward estuarine and wetland systems.

Sincerely,

Genevieve M. Matanoski

Dr. Genevieve M. Matanoski, Chair
Executive Committee

Mark A. Harwell

Dr. Mark A. Harwell, Chair
Ecological Processes and
Effects Committee

/signed/

Dr. Kenneth W. Cummins, Chair
Lakes Biocriteria Subcommittee

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U.S. Environmental Protection Agency

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