North American Lake Management Society

Water Quality Standards for Lakes

A Survey

Preliminary Report

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Prepared by

A Special Task Force

appointed by

the Board of Directors

North American Lake Management Society

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Contents

Executive Summary

To evaluate the current use of and perceived need for water quality standards for lakes, the North American Lake Management Society conducted a survey of State water program administrators. Forty-seven States responded. The survey posed four main questions:

- Are lake water quality standards needed?
- How are such standards used now or how would they be used if adopted?
- What data is needed for developing lake water quality standards?
- Should lake-specific criteria be included in standards for toxic pollutants?

Are Lake Water Quality Standards Needed?

A large majority of States (71 percent) believe that existing water quality standards are adequate for lake protection. Twenty-four of the responding States have lake water quality standards.

About half the States have standards specifically dealing with eutrophication, with most of these in narrative form. Few of the States that lack such standards have attempted to develop them. Whether or not they have such standards, the majority of States consider their antidegradation statement effective for protecting high-quality lakes. An overwhelming majority of States oppose any EPA requirement that they adopt trophic standards for lakes.

How Are Standards Being Used Now or How Would They Be Used If Adopted?

In those States that have them, standards are used primarily for enforcement purposes. These include setting point source permit limits, siting new facilities, and certifying discharges subject to Federal permits or licenses.

A number of States have effectively applied their standards to support controls on wastewater discharges. Similarly, the majority of enforcement actions taken in relation to lake water quality standards violations have involved wastewater discharges.

What Data are Needed for Developing Lake Water Quality Standards?

Of the 24 States that have lake water quality standards, most include criteria for total phosphorus; a smaller number also include chlorophyll *a* and Secchi transparency. These standards have largely been derived from literature values and professional judgment with a lesser reliance on monitoring data.

Most States are dissatisfied with their ability to judge the quality of their lake waters. In some cases, this is due to the number and diversity of lakes; in many States, it is due to the absence of a routine lake monitoring program. Many States pointed out that they have insufficient funds for lake monitoring.

Should Lake-Specific Criteria be Included in Standards for Toxic Pollutants?

A large majority of the responding States have water quality standards for toxic pollutants in lakes, but only a few have toxic criteria different from those that apply in streams. Almost two-thirds have known or suspected lake toxicity problems.

While over half the respondents monitor their lakes for toxic pollutants, many of these monitor only fish tissue. Less than a third monitor water, sediment, and fish for toxics.

States are interested in getting more technical assistance from EPA in the development of water quality standards for toxic pollutants specific to lakes.

Introduction

Under section 303 of the Federal Clean Water Act, States are required to adopt water quality standards consistent with Federal regulations. The U.S. Environmental Protection Agency (EPA) regulations for water quality standards direct States to specify a use designation for each body of water and to set pollutant criteria that would be needed to achieve those uses. The use designation and criteria, taken together, constitute the water quality standards.

While all States have adopted (and periodically have revised) their water quality standards, most of the standards were developed for streams where constant mixing usually occurs. Many are not readily transferable to lakes and reservoirs, where conditions are vastly different because of depth, stratification, and retention times. Moreover, there has been some debate about whether uniform lake standards are valid or whether lake- and reservoir-specific standards are necessary. Generally, universally accepted, technically satisfactory standards have not been developed for lake waters.

For the past two years, the North American Lake Management Society (NALMS) has been evaluating the pros and cons of water quality standards for lakes and reservoirs. The process was initiated in November 1986, when a paper entitled "Numerical Standards for Managing Lake and Reservoir Water Quality" was requested by the president of NALMS and presented to kick off the society's 1986 annual symposium. A panel of respondents, including State, industry, and environmental group interests, spoke at the opening plenary, offering their opinions on the issue. Appendix A to this report includes the paper and responses. The response was varied and ranged from no support for lake standards to complete support for an enforceable regulatory process that included strict standards for lakes.

The lack of consensus led the NALMS Board to conclude that it would be desirable to survey State water pollution control administrators on the issue. A 16-member task force was established by the Society to conduct the survey. Chaired by the Tennessee Valley Authority, it included representation from 12 States and EPA. A list of the task force members is included as Appendix B to this report.

The survey of State opinion on lake water quality standards was conducted through a questionnaire developed by the task force and mailed to each State water pollution control agency in July 1987. This survey, consisting of 46 questions, was designed to (1) determine the views of State officials regarding the need for lake/reservoir-specific standards, and (2)gather information about existing lake/reservoir water quality standards.

The task force received 47 State responses to the questionnaire. The States of Georgia, Mississippi, and Colorado did not respond, and Hawaii indicated they had no lake resources. Appendix C presents an annotated composite summary of complete survey results. The actual questionnaires are on file at the headquarters office of NALMS, 1000 Connecticut Avenue, NW, Suite 300, Washington, D.C. 20036.

The remainder of this report presents an analysis of the results of the questionnaire. The report is structured in the same format as the questionnaire and includes four sections:

- Are lake water quality standards needed?
- How are standards used now or how would they be used if adopted?
- What data is needed for developing lake water quality standards?
- Should lake-specific criteria be included in standards for toxic pollutants?

An IBM PC LOTUS program was used to assist analysis and help establish differences among States grouped by EPA region. The task force agreed that no policy positions, opinions, or recommendations would be included in each section.

Results

The States were asked to provide three general responses in addition to filling out the questionnaire: (1) the priority lake issues in their State; (2) how lake issues rank in comparison to other water quality management issues; and (3) what help is needed from the Federal level to deal with identified lake problems.

There were 33 State responses to the first point, 34 to the second, and 33 to the last. A range of opinion was expressed by the States on the three topics, but for the most part, the following can be considered general conclusions with no apparent trend in the responses that would signify a regional effect.

With regard to priority issues, the States most frequently stress problems with overdevelopment around lake shorelines and in watersheds leading to excessive nonpoint source pollution in the form of sediment, nutrients, and bacteria. Toxic pollution to lakes is identified by some as a growing concern. Many States indicate that water quality data are needed to perform an adequate assessment of the lake issues within the State. Monitoring programs currently employed are not adequate to provide a strong information base.

As compared to other water quality issues, most States rate lake issues as low to middle priority. Most States are candid that lake issues swing with public interest and generally revolve around problems with a specific lake and the amount of money available to address the particular problem.

Finally, all but a few States indicate that money is the greatest need from the Federal government. A significant number also note a strong need for technical assistance and guidance in developing adequate programs to cope with lake problems. The needed assistance ranges from the development of adequate standards to protect lakes to the production of technology to control pollution of lakes and restore them to suitable quality.

I. Are Lake Quality Standards Needed?

Introduction

The first section of the questionnaire consists of 19 questions designed to gather information on existing water quality standards applicable to lakes and reservoirs; it also asks opinions on future needs. A summary of responses to each question is included in Appendix C along with answers to the narrative questions and any annotated remarks. Because of the mixed nature of responses to several important questions, comparisons are made with data collected as part of the 1983 NALMS State Lake Survey. These data have been summarized by NALMS[1] and have been reported in the peer-reviewed literature.[2] This comparison seems to clarify the existing situation with regard to current use of standards in managing lake water quality.

Adequacy of Existing Standards

By a large margin (71 to 29 percent), States respond that existing water quality standards are adequate to protect lake water quality. On the issue of standards for addressing eutrophication, State responses are divided. Only about half (52 percent) indicate that the State has adopted water quality standards specifically dealing with eutrophication. Thirteen States which answer that their existing standards are adequate respond that no standard exists to address eutrophication.

For States indicating that they have adopted standards related to eutrophication, about one half (52 percent) have been in existence for at least five years. Most responding (75 percent) indicate that their standards are narrative in nature, and virtually all of them are "flexible." About 60 percent of the States indicate that some numerical criteria are also applicable. When asked what form these numerical standards take, not all States responded. Of those that did, eight indicate one standard applies for the entire State, one indicates regional standards, eight indicate standards are based on lake use classifications, and three indicate standards are lake-specific. With only 11 of the responding 46 States noting specific standards based on lake use classifications or site-specific conditions, a low percentage of States seem to have these specific standards programs.

Several questions were asked regarding the use of antidegradation policies adopted by States. For those indicating that specific standards exist to address eutrophication, the majority (70 percent) respond that the antidegradation statement is successfully used to prevent degradation of water quality down to standards. When asked whether "degrade down to" situations are a potential problem with lake standards, the States are evenly divided. Some of the reasons behind their response to this question (No. 7b) are listed in Appendix C. All but one of the States responding "no" to question 7b answered "yes" that the antidegradation statement is successfully being used. A majority (63 percent) of States answering "no" to having eutrophication-specific lake standards also respond that their State's antidegradation policy is successfully used to protect high-quality lakes.

The team preparing the questionnaire was interested in whether States without eutrophication-specific lake standards feel there would be support within the State for adopting such standards. About 68 percent of States feel there would be support among public interest groups, 55 percent feel their agency would support such rulemaking, and only 36 percent believe that the State legislature would be supportive. Of significance is

1. North American Lake Management Society, 1983. 1983 State Lake Survey–Summary Report. Washington, D.C.

2. Duda, Alfred M. and Robert J. Johnson, 1984. Lakes are losing the battle in clean water programs. Journal Water Pollution Control Federation (56) pp. 815-822.

the fact that a large majority (81 percent) of responding States say there have not been previous attempts to develop such standards.

With regard to other broad programs or policies that could be used to protect lake water quality, many States (72 percent) indicate that such broad programs exist. Appendix C outlines some of the programs; outright bans on point source discharges to lakes represent one of these broad programs. In addition, about half of the responding States say they have used classifications to protect special lakes. What is unclear is whether, through a standards process, specific criteria exist to enforce these classifications. Only 3 out of 18 States that say they have special use classifications indicate in question No. 5 that they have standards based on lake use.

Future Needs

The States were asked what type of needs they foresee for better lake management. With regard to the need for standards, criteria, or policies (for example discharge bans), State responses are outlined in Table I.1.

Table I.1.—Number of States responding to particular needs

Standards	Criteria	Policy
27 States YES	22 States YES	34 States YES
17 states NO	21 States NO	9 States NO

States are evenly divided on the need for additional criteria, a majority favor additional standards, and an overwhelming majority see a need for developing policies. In response to whether the States would like EPA to provide more assistance and support for developing standards, 52 percent answer "no" and 48 percent answer "yes." When asked whether EPA should impose requirements for States to adopt lake trophic standards/criteria, an overwhelming majority (76 percent) respond "no." Evidently, States favor enactment of policies rather than criteria. They do not wish EPA to specify requirements for them, and they are mixed on the issue of more assistance support from EPA. When asked what type of assistance would be most useful, the most common response is "funding from EPA."

Nonpoint sources represent the largest loadings of pollutants to the Nation's lakes and reservoirs. All States responding to the NALMS 1983 State Lake Survey, except Georgia, felt that nonpoint sources are seriously affecting lakes/reservoirs. The 1987 survey also contains several questions regarding nonpoint sources. Many States (65 percent) respond that enforcement of standards does not include nonpoint sources. A similar percentage of States (66 percent) indicate that certain nonpoint sources are exempt from enforcement under State lake or other water quality standards. There are 17 States with these exemptions from enforcement. Agricultural activities are most commonly cited as being exempted from State water quality standards.

Table I.2 summarizes the number of States responding to the question "In what ways are lake shorelands regulated in your State to protect water quality?" Of the 47 total responses to the survey, only 4 report State regulation of stormwater discharges; 6 indicate that development is controlled by State law; and 8 respond there is no regulation at all.

When asked whether these shoreland regulations are based on lake water quality standards or criteria, a large majority of States (75 percent) indicate that the regulations are not based on criteria or standards. The question was asked whether improved lake water quality standards would promote or enhance shoreland regulation. The response was about evenly divided, with two more States answering "no" than answering "yes." Question No. 19 requested general comments on strengths and weaknesses of existing

State water quality standards and additional needs. Appendix C includes the gist of the responses.

Table I.2.—Number of States reporting different types of lake shoreland regulation

Number of States	Type of Regulation
8	None
34	Local ordinances to control development
6	Development controlled by State shoreland law
21	Requirements for more stringent onsite wastewater disposal
4	State regulation of stormwater discharges

Apparent Inconsistencies

As this section indicates, there are apparent inconsistencies, not the least of which is that an overwhelming number of States believe their existing water quality standards are adequate, when in fact thousands of lakes are reported to be experiencing serious water quality problems. A breakdown of State responses into the 10 EPA regions was conducted to examine regional differences. As Figure I-1 shows, all responding States in EPA Region III (mid-Atlantic) and Region VII believe their standards are adequate to protect lakes/reservoirs, while all States in Region X (Pacific Northwest) feel that standards are not adequate. With regard to standards dealing with eutrophication, Region X once again is the only region where all States acknowledge that such standards do not exist (Figure I-2). All but one State in Regions II, III, and VII acknowledge that eutrophication-specific standards do not exist.

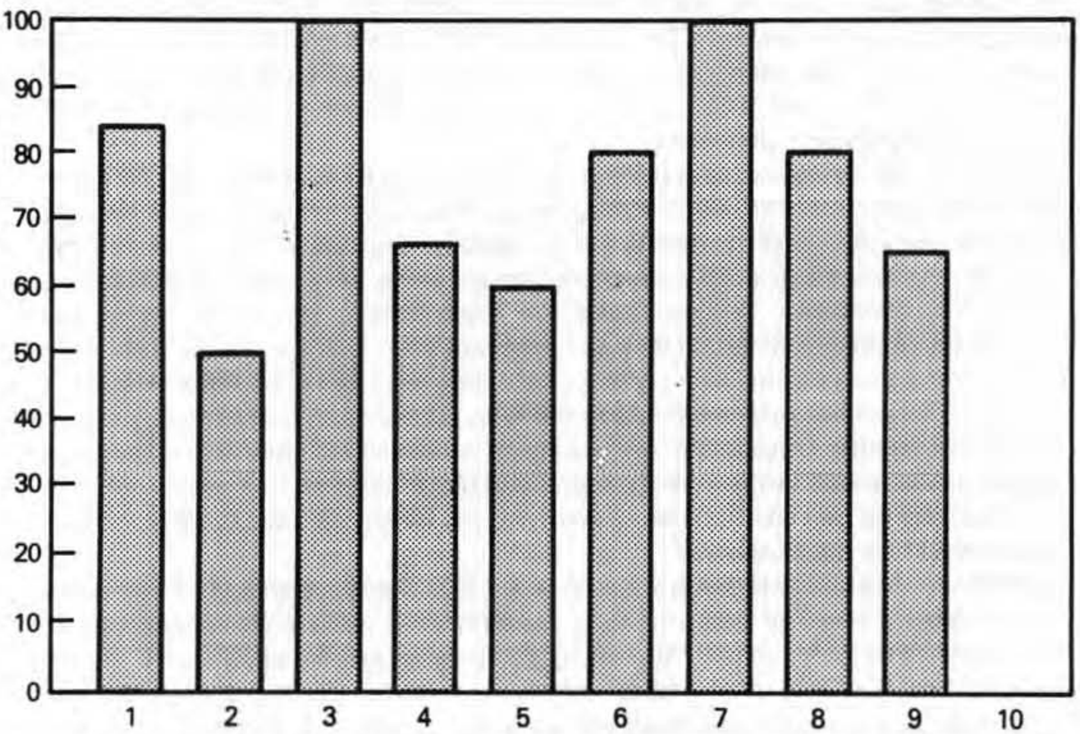

Figure I-1. Percent of responding States in each EPA region indicating adequacy of water quality standards to protect lakes

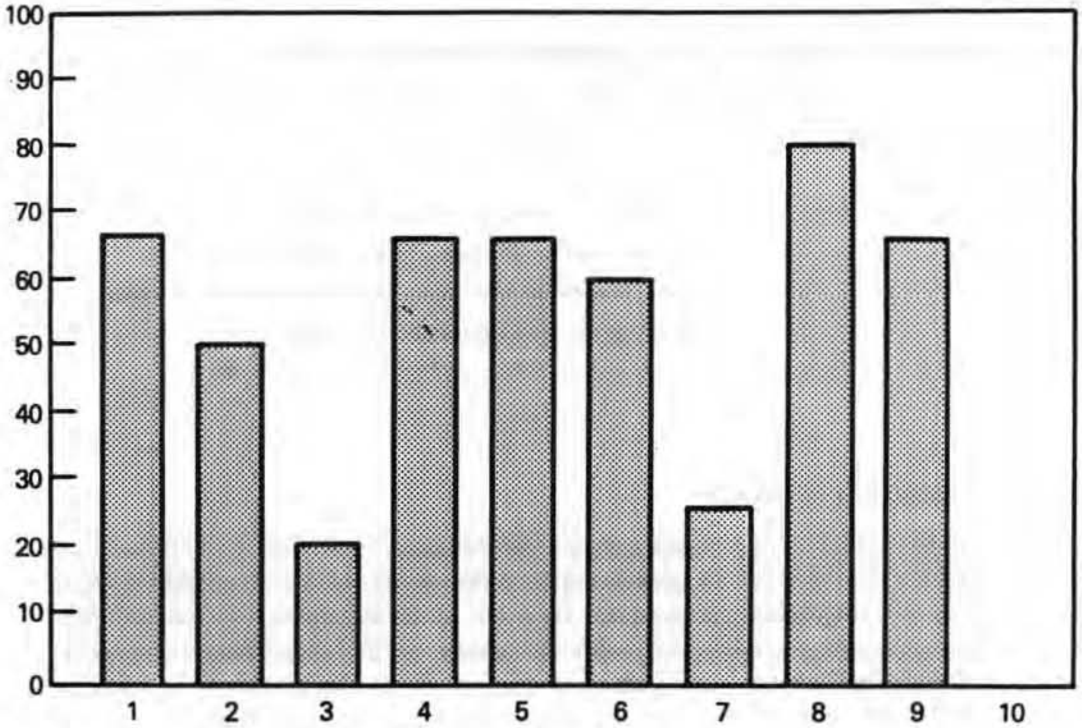

Figure I-2. Percent of responding States in each EPA region indicating their standards protect against lake eutrophication

On the question of the need for developing lake-specific standards, all responding States in Regions X and V (Midwest) believe a need exists for lake-specific standards (Figure I-3). On the other hand, Region III States are unanimous in not seeing a need for developing lake-specific standards. On the issue of EPA providing increased assistance, only Region X (more than 66 percent of States) strongly favors more assistance. Only Region V (at least 50 percent of States) favors EPA requiring States to adopt standards related to eutrophication or trophic state.

The 1983 NALMS survey results show nonpoint pollution to be the primary water quality problem facing lakes/reservoirs. Of the 25 States reporting in 1983 that at least 50 percent of their lakes/reservoirs are seriously affected by nonpoint sources, 17 of them note in the 1987 survey that their water quality standards are adequate for protecting lake quality. Only Wisconsin, Tennessee, Oregon, Oklahoma, North Dakota, Minnesota, Idaho, and Florida (of the 25 States) believe that their standards are not adequate. Question No. 11 in the 1987 Survey covers a form of nonpoint source control shoreland regulation. Figure I-4 apportions the responses (whether lake standards would enhance shoreland regulation) into the 10 EPA regions. Once again, only Region X unanimously believes that improved lake standards would help in this type of nonpoint source abatement. Regions IV and V are the only other regions that have at least 50 percent of the States responding that improved standards would help this abatement.

The 1983 NALMS survey identified States that had 1971 data which could be compared with 1983's data. Of nine key States in this group, only three with significant acreages of lake impairment responded in 1987 that existing standards are not adequate to protect lake/reservoir quality. The other States, which also report significant water quality problems in lakes, say existing standards are adequate. Of 10 States that have more than 100 lakes with excessive nutrient levels as identified in 1983, only 3 States (Wisconsin,

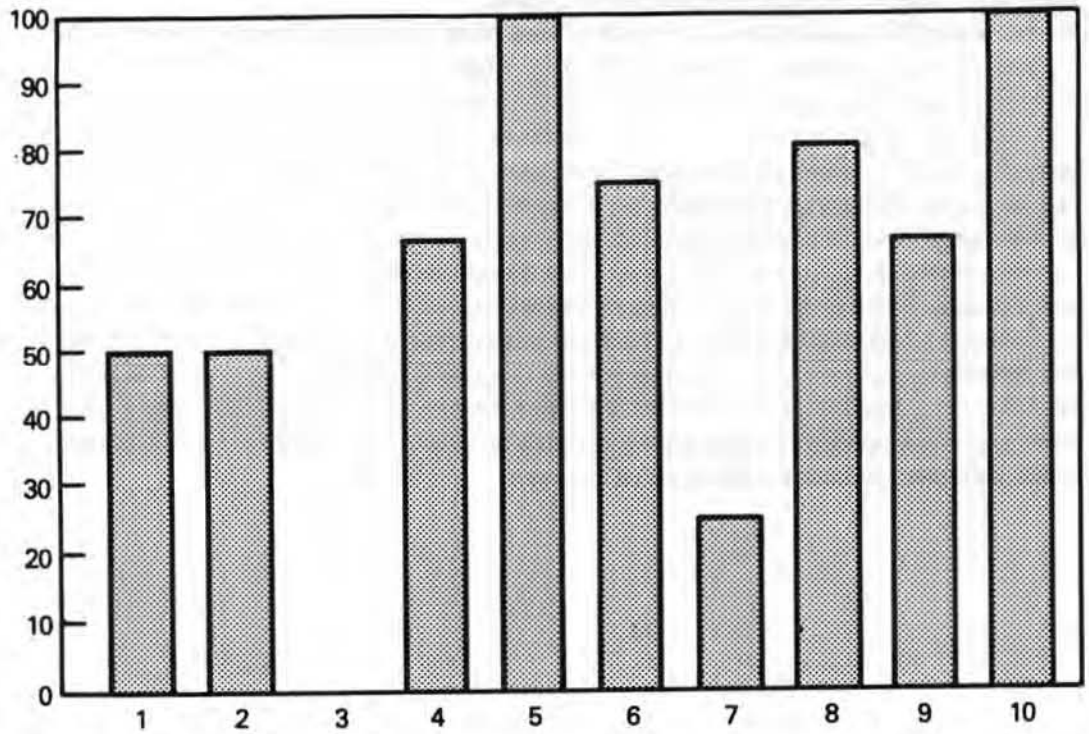

Figure I-3. Percent of responding States in each region indicating a need for lake-specific standards in each EPA region

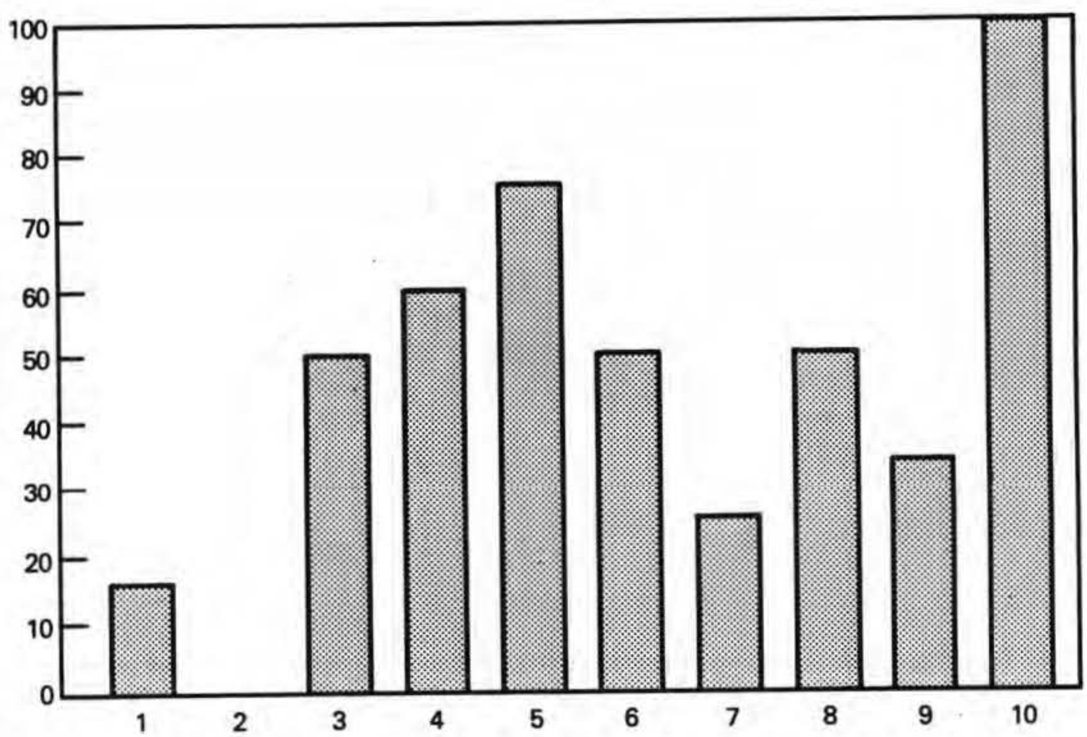

Figure I-4. Percent of responding States indicating lake water quality standards which promote or enhance shoreland regulation

North Dakota, and Minnesota) respond that existing standards are inadequate and that no eutrophication-specific standards have been adopted.

This section of the survey clearly shows inconsistency of answers among questions by many of the States. This may indicate the difficulty States are having with developing adequate water quality standards as the best means of controlling complex eutrophication problems. Or, on the other hand, they may feel more comfortable in establishing and applying policy controls, such as detergent bans, as a means of problem correction. And, then again, some States may be answering the question of standards adequacy strictly in terms of the point source control programs. And finally, some States may believe as (or if) their surface monitoring programs become more comprehensive, their existing standards will be adequate. Regardless of the reasons, the responses to this questionnaire, coupled with knowledge of wide-spread lake and reservoir eutrophication, suggest that nationally we should take a new look at (1) the role of water quality standards programs specific to lake and reservoir quality; (2) the need for other programs to complement and support the definition and enforcement of water quality objectives; and (3) the effectiveness of funding for existing lake/reservoir management institutions.

II. How Are Standards Used Now or How Would They Be Used if Adopted?

Introduction

Section II of the survey addressed the purpose(s) of lake standards, if lake standards have been effective (specifically, in upgrading water quality use classifications and in slowing or reversing eutrophication), and how they have been used in enforcement actions.

Discussion

Each State was given a list of 12 possible uses which they were asked to designate as an existing or potential standards use. There were three main types of uses: water quality planning, pollution control implementation, and regulatory procedures. Fifteen States indicate there is no existing use of standards.

The planning-type uses include setting priorities, establishing goals, watershed planning, and allocation of lake restoration funds. Out of the 47 States which answered the survey, 17 currently use lake standards for setting priorities while 23 thought it was a potential use. Fourteen States now use lake standards for establishing goals, and 22 States agree that it is a potential use. Fourteen States also said they use the standards for watershed planning, with 28 seeing it as a potential use. Only 7 States currently use the standards for the allocation of lake restoration funds while 31 believe it is a potential use (Figure II-1).

The implementation-type uses include managing cumulative impacts and evaluating the attainment of water quality goals of the Clean Water Act for the 305(b) report. Twelve States currently use lake standards to manage cumulative impacts, and 28 States agree

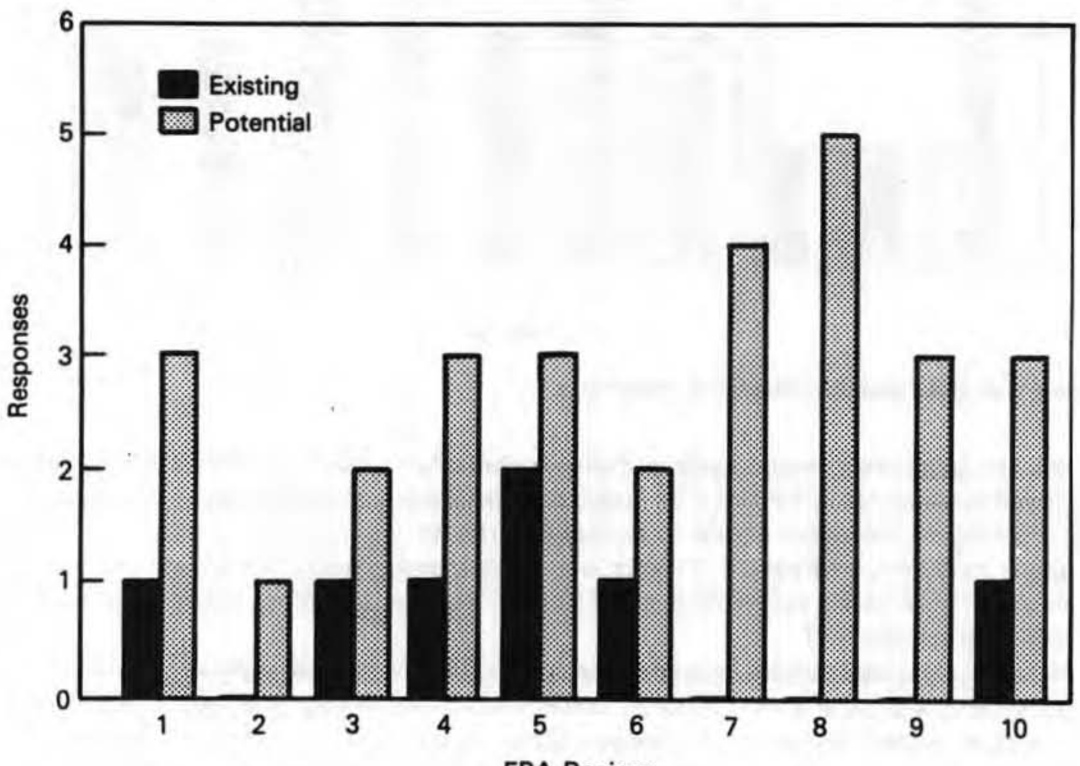

Figure II-1. Lake standard uses: allocation of lake restoration funds

that it is a potential use. Twenty States use lake standards to evaluate the attainment of the water quality goals of the Clean Water Act, and 20 thought this could be a potential use.

The regulatory-type uses reviewed by the States included the following: enforcement, permitting (NPDES), certifications under section 401 of the Clean Water Act, siting new discharges, and nonpoint regulatory controls. Twenty-five States currently use lake standards for enforcement, and 13 see it as a potential use (Figure II-2). Twenty-seven States use the standards for NPDES permitting and 15 agree that it is a potential use. Twenty responses show current use of the standards for 401 certifications, while 11 see it as a potential use. Twenty-three States use them for siting new discharges and 15 see them as potential uses. Ten States use lake standards for nonpoint regulatory controls and 30 see this as a potential use.

The States were asked whether any water quality standards had been upgraded to reflect higher use classifications resulting from the implementation of pollution controls under a Clean Lakes Phase II project or other lake restoration projects. Only two States

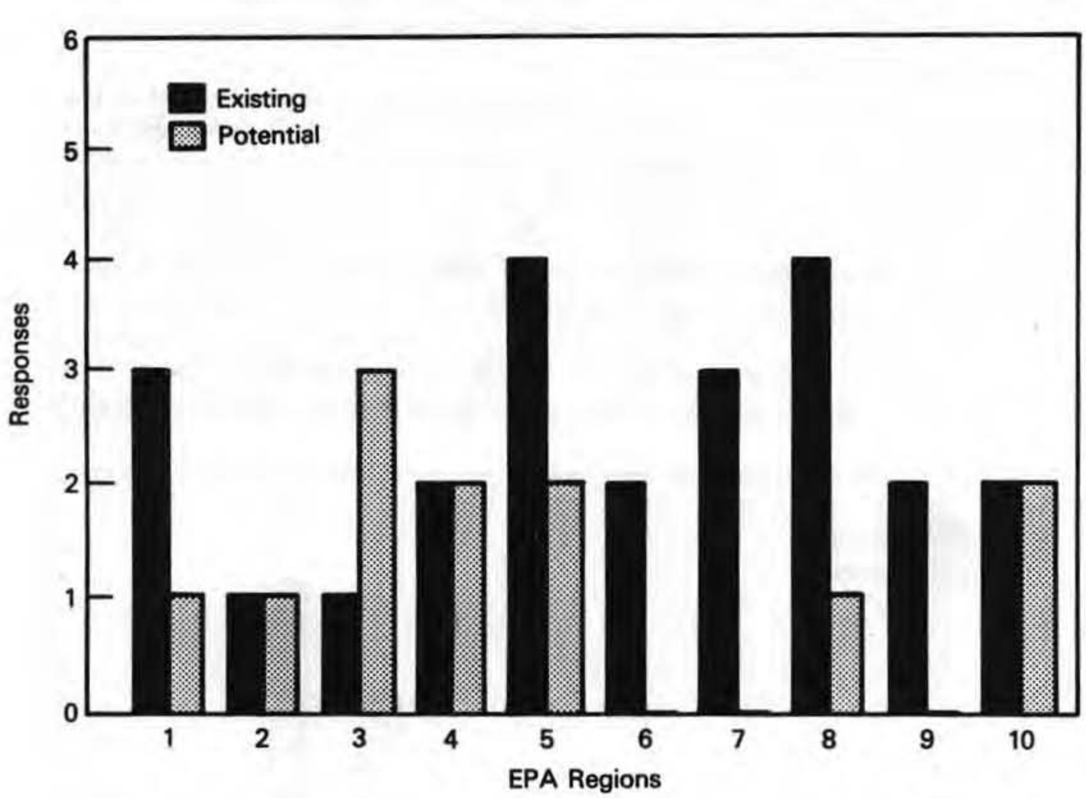

Figure II-2. Lake standard uses: enforcement

(Maine and Oklahoma), have upgraded their standards thus far. Forty-four States have not upgraded any standards. Of these, 20 States have no cases occurring where a higher use was achieved. In the "other" category, six States report no participation in the Clean Lakes Program, nine have no Phase II projects, and three States already met higher use classifications. Three States report no applicable water quality standards. These results are summarized in Figure II-3.

The States give examples where lake standards have been successfully used in reversing or slowing eutrophication. Of the 23 States responding to this question, 16 use lake standards to control wastewater discharges. Other uses include: (1) no new discharges or expansion; (2) control of toxic discharges; (3) control of lake development; and (4) banning of phosphorus detergents.

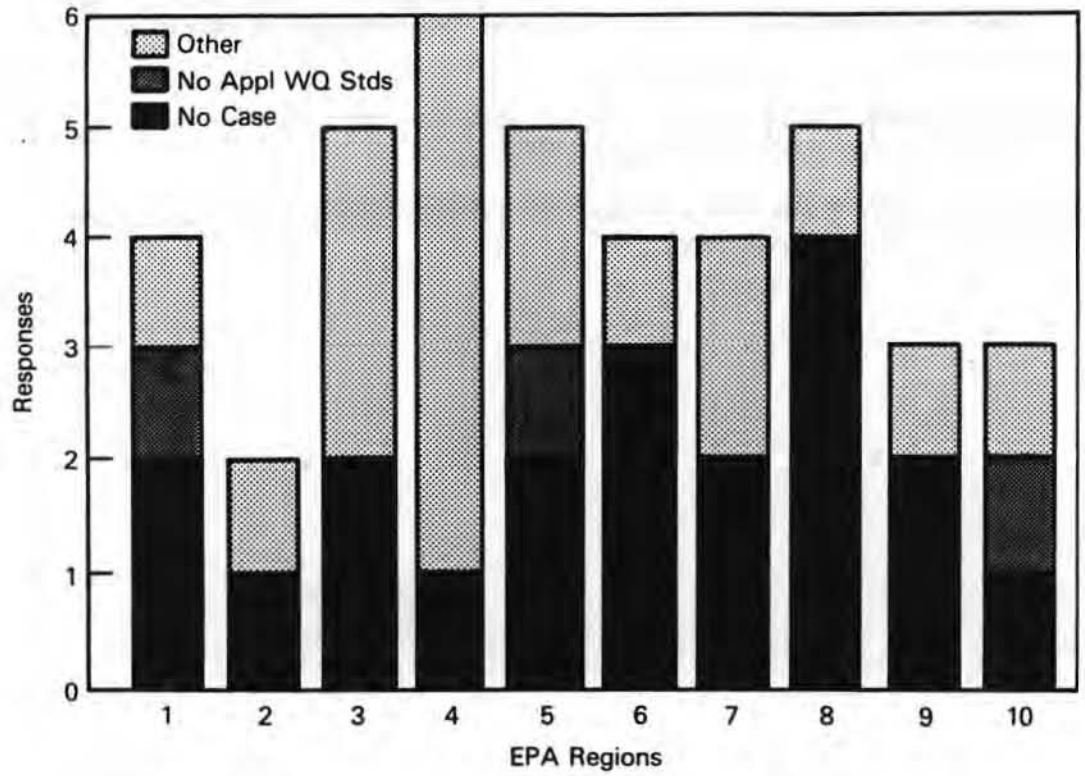

Figure II-3. Why States have not upgraded water quality standards to reflect higher use classification

In only one or two of the examples cited were statewide numerical P standards used to control eutrophication, or in enforcement actions. These cases involve limiting wastewater discharges. Judging by the examples given, eutrophication is more often controlled by lake-specific P criteria developed under narrative, antidegradation, or special use classification standards, or by policies such as outright prohibition of discharges.

Finally, the States give examples of enforcement actions taken based on violations of lake standards. Eighteen States responded to this question.

Lake standards are used to take action against wastewater discharge violations (7 States), septic system violations (2 States), and toxic discharge violations (1 State). Lake standards are also used to take action against turbidity problems caused by construction (1 State), oil spills (1 State), and dissolved oxygen problems caused by hydro projects (1 State). Other actions include controlling nonpoint sources of phosphorus (1 State), banning phosphorus detergents (1 State), and complying with a chlorophyll *a* standard (1 State).

Summary

The following is a summary of the results of Section II.

1. For those States with lake standards, the primary existing use of lake standards is for regulatory-type uses such as: (a) enforcement, (b)NPDES permitting, (c) 401 certification, and (d) siting new discharges.

2. While a few States currently use lake standards for planning and implementation activities, the majority see them as potential uses.

3. Only two States have upgraded their water quality standards to reflect a higher use classification achieved as a result of a Clean Lakes Phase II project or other lake restoration project.

4. Control of wastewater discharges is the most common example of the successful use of lake standards to reverse or slow eutrophication.

5. For those States taking enforcement action based on lake standards, the majority deal with wastewater discharge violations.

III. Data Needs for Lake Standards Development and Use

Introduction

In this section of the survey, some of the technical aspects of setting lake standards are assessed. Responses were sought both from States which have lake standards and those which do not. This type of information allows States to see how existing standards are set and what other States may consider important to include in the standard-setting process. Also sought was information on the current status of knowledge of lakes for States in each region and if this knowledge would aid (or lack of knowledge hinder) the standard-setting process. Lastly, any specific information was sought which could link user perception of water quality with numerical measures.

Discussion

The discussion of the results will follow the format used on the questionnaire and is organized as follows: (1) for States with numerical standards—the type of trophic parameters addressed, the type of information used to establish standards, and enforcement of the standards are reviewed; (2) for all States—approaches to be taken in the development of standards are evaluated; (3) the State's current knowledge of the water quality of their lakes in terms of percent of lakes is assessed; (4) current lake monitoring programs and their usefulness for detecting trends in water quality are reviewed; and finally (5) any specific information which may be used to link user perception of lake water quality with numerical measures is investigated.

The first question sought to identify the parameters most commonly cited in State standards. Each EPA region except Region VII has at least one State with lake standards. Among those States with lake standards (24), total phosphorus is most frequently addressed in their standards (58 percent), while Chlorophyll *a* and Secchi transparency are cited in 25 percent of the responses (Figure III-1). Total phosphorus is addressed in State lake standards in at least one State in each region with the exceptions of Regions VII and X. The other parameters most frequently addressed in State lake standards include dissolved oxygen, total nitrogen, bacteria, and turbidity.

Professional judgment and literature values (79 and 63 percent, respectively) are most frequently used to derive these standards (Figure III-2). Actual monitoring data is also used (50 percent). In contrast, public opinion is seldom used (8 percent). Among the other sources of information deemed valuable are EPA guidance and detailed evaluation of lake data sets. Analysis of available State water quality data is important in standard-setting in 17 percent of the States, of some importance in 50 percent, of minimal use in 25 percent, and not used in 8 percent of the States.

Lake standards are enforced in 92 percent of the States. The standards are most frequently enforced by means of effluent limitations and actual data collection (79 and 58 percent, respectively, Figure III-3). Lake and watershed modeling are used less frequently (29 and 13 percent, respectively). Of the States which have used modeling, only two (Maine and Michigan) have successfully used modeling to defend their standards in court.

The next area of the questionnaire focuses on the approaches the States feel are appropriate for developing lake standards and whether they believe there is a sufficient information base available to develop standards. Of the States without lake standards, about 65 percent believe that there is not a sufficient information base for developing them.

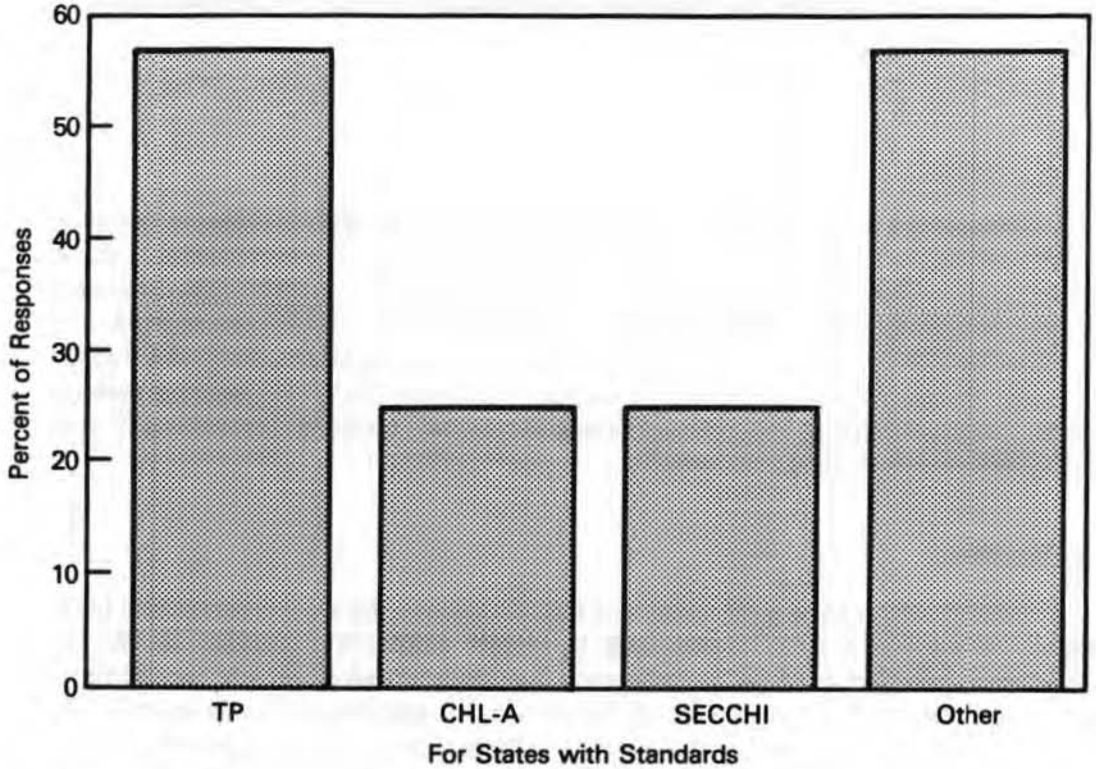

Figure III-1. Parameters used for establishing lake standards

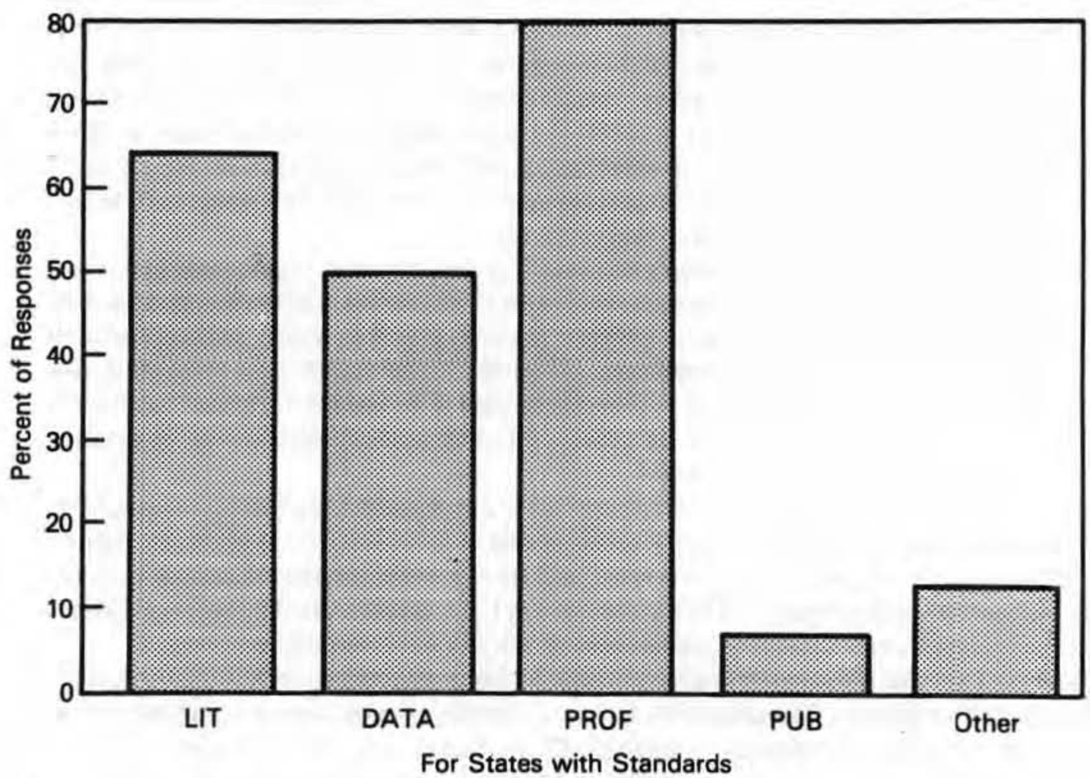

Figure III-2. Information source used to develop standards

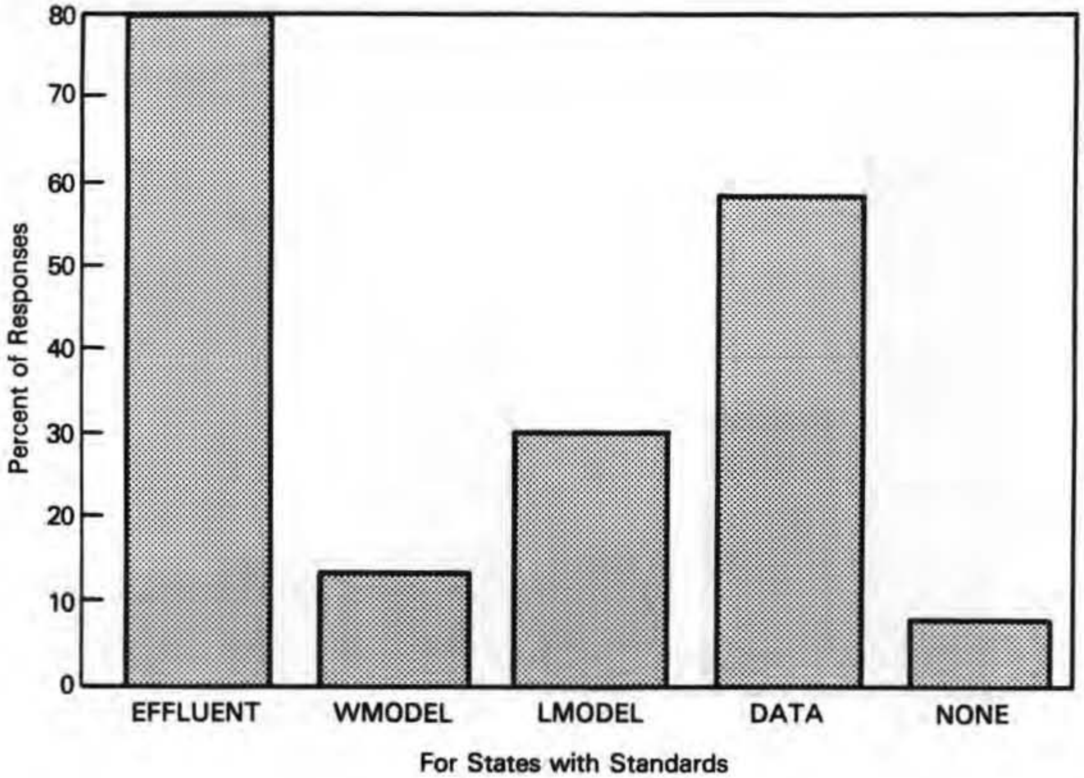

Figure III-3. How lake standards are enforced

Special use classifications (e.g., nutrient-sensitive waters, drinking water, coldwater fishery) appear as the most popular choices among the States (70 percent, Figure III-4) as a means for developing categories for lake standards. Morphometric considerations and ecoregion comparisons are also believed to be valid approaches by many States. Only a small percent of the respondents believe that urban influences or no categories (e.g., treat all lakes similarly) are valid approaches. Among some of the other approaches suggested by the States are (1) consider each lake individually (i.e., site specific), (2) glaciated vs. nonglaciated lakes, and (3) more widespread use of nondegradation statutes.

In terms of criteria to be included in standards, chemical constituents are noted most frequently (87 percent) followed by aquatic biota (64 percent) and other (43 percent). The chemical constituents noted most frequently are total phosphorus and total nitrogen. Other chemical constituents noted are total suspended solids, pH, chloride, metals, and organic hydrocarbons. Among the aquatic biota considerations, chlorophyll *a* is noted most frequently, followed by macrophytes (nuisance species), loss of fish species, and self-sustaining coldwater fishes. Other considerations include transparency, chlorophyll exceedance, dissolved oxygen depletion, and substances which bioconcentrate.

A variety of responses were received with respect to a standard for sedimentation of lake bays. These responses fall into three general categories. The first category focuses on the suspended solids load of incoming rivers and includes such tests or parameters as settled volume test, total suspended solids load, and instream turbidity. The next category focuses on the impacts to aquatic life, e.g., loss of gamefish habitat or harm to benthic life. The last category is "no standard"; these respondents believe sedimentation is a land-use issue rather than a water quality issue. These States indicate that effective watershed management plans or sediment control laws are more appropriate.

The question regarding a standard for macrophytes also elicited a wide range of responses. These responses fit into four general categories with no clear consensus. One

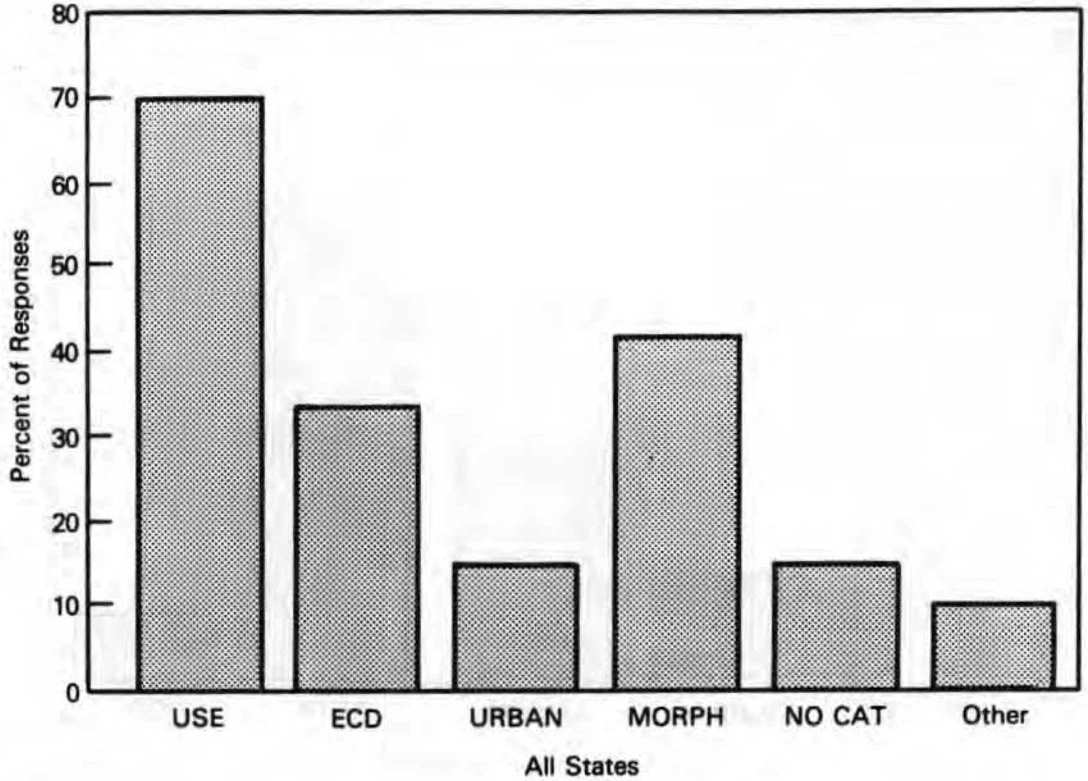

Figure III-4. Potential categories for developing lake standards

group feels this was not a standards issue but rather a lake management or local policy issue. A second focuses on species composition of macrophytes, suggesting a balance between beneficial and nuisance species. A third notes percent coverage of macrophytes and/or distance from shore. Lastly, other considerations include narrative statements, biostimulatory substances, and aesthetics.

The next series of questions focused on the States' ability to monitor their lakes and a description of their current lake monitoring programs. Only 21 percent of the 47 States responding characterize their ability to monitor the trophic status of all the lakes in their State as "good." In comparison, 53 percent characterize their ability to monitor all lakes as "poor." States in Regions IV, V, and X most typically feel their ability to monitor all their lakes is poor, while States in Regions I, III, and VI appear to be more confident in their ability to monitor all lakes. This does not reflect a lack of concern by States in Region IV, V, VIII, and X, but rather the large number of lakes in these regions (Figure III-5). For instance, the States of Minnesota or Wisconsin have more lakes individually than the States in all regions except for Region X, which includes Alaska. Alaska contains so many lakes that it cannot be graphed on the same scale as the other regions.

Extrapolating from the estimates provided by the States, the regions with the highest percentage of assessed lakes are Region VI and I, at 69 and 52 percent, respectively (Table III.1). Those with the lowest percentage of assessed lakes are Regions II, IV, V, VIII, IX, and X with percentages ranging from 13 to 15. However, in terms of the number of lakes assessed, Regions V, VI, and I have assessed the most lakes at approximately 6,700, 5,200, and 3,700, respectively. Regions with the lowest number of assessed lakes include Regions VII, III, and VIII with approximately 220, 260, and 590 assessed lakes, respectively.

About 50 percent of the States indicate that they have some form of statewide lake monitoring programs. A variety of programs is described. The general types of programs include: lay monitoring programs, intensive surveys or special requests, ambient or

Table III-1. Number of lakes and number of lakes assessed by EPA region. Based on survey responses.

EPA Region	Total Lakes	Total Lakes Assessed	Percent Lakes Assessed
I	7,171	3,740	52
II	8,728	1,148	13
III	775	263	34
IV	8,290	1,231	15
V	46,801	6,724	34
VI	7,603	5,231	69
VII	687	224	33
VIII	4,500	585	13
IX	5,085	720	14
X	9,599	1,247	13*

Number of assessed lakes estimated as midpoint of response interval for question 34 as follows:

1-25% = 13%
25-50% = 37%
50-75% = 62%
75-100% = 87%

*Alaska was omitted from this summary--they estimate only 25 percent of their 3,000,000 lakes have been assessed.

routine monitoring, Clean Lakes or lake classification studies, fishery surveys, and toxics monitoring.

About 58 percent of 41 States believe that their monitoring programs can detect changes in trophic status. Some States note, however, that only gross changes in trophic status would be noted or changes would only be noted on "important" lakes where there is more intensive monitoring. Other States cite lack of good routine programs with adequate sample frequency as a reason for not detecting trends. Some States focus their efforts on

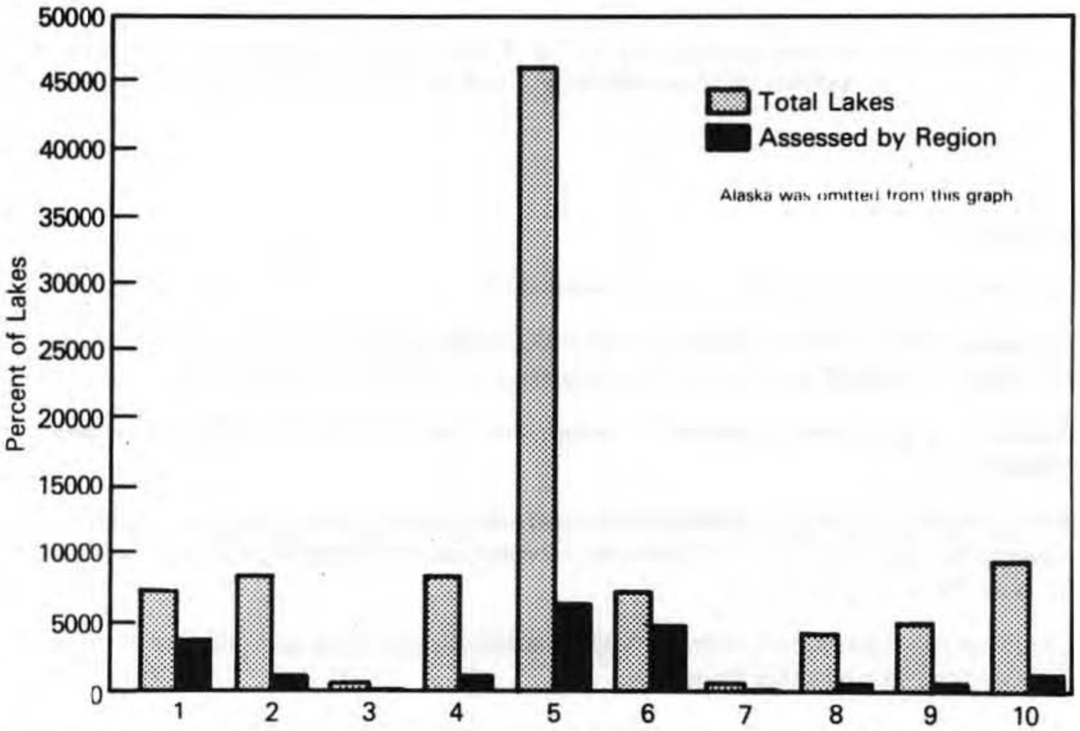

Figure III-5. Comparison of the reported number of lakes and lakes assessed by EPA region. Estimated from responses

toxics and thus are unable to detect changes in trophic status. Inadequate funding for routine programs appears to be a common problem.

A high percentage of the States (66 percent) with monitoring programs note that they have detected changes in lake trophic status. Twenty six States offer descriptions. The following general categories of change in trophic status are noted: improved trophic state with diversion or treatment of a point source; a general decline in trophic state in many waters as characterized by increased phosphorus concentrations, algae blooms, and increased macrophyte density; and citizen observations and complaints regarding a decline in water quality.

The last two questions in this section sought any information States may have which link particular numerical values with impaired uses of lakes and "threshold" concentrations above which significant changes in algal assemblage may occur.

Only 10 States had information linking particular numerical values with user perception of water quality and only 11 had information regarding threshold values. Frequently, this information was included in State lake classification reports (e.g., Illinois and Massachusetts) or other State documents.

Few specific examples are noted by the States, however. New Hampshire, for example, notes that they use a 4-foot Secchi as the lower limit for recreationally acceptable water. New Mexico notes that they have a quantitative description of algal blooms and have further pertinent information in their water quality standards. Other pertinent citations are as follows:

Kansas	Arruda, J.A. 1985. The ability of routine lake monitoring data to index use impairments. Lake and Reservoir Manage. 1:74-77.
Louisiana	Malone, R.F., and D. G. Burden. 1985. A condition index system for Louisiana lakes and reservoirs. Dept. of Civil Eng. Louisiana State University. Prep. for Louisiana Water Reservoir. Water Pollutant Cont. Div. 197 p.
Minnesota	Heiskary, S.A. and W. W. Walker. 1988. Developing phosphorus criteria for Minnesota lakes. Lake and Reservoir Manage. 4:1-9.

Summary

The following is a summary of the results in section III.

1. For those States with lake standards, total phosphorus is most frequently addressed. However, chlorophyll *a* and Secchi transparency are commonly cited as well.

2. Professional judgment and literature values are most frequently used to derive these standards.

3. A vast majority of the States feel that special use classifications are a valid means for developing categories for lake standards. Morphometric and ecoregion considerations are also frequently cited.

4. Chemical constituents, in particular total phosphorus and total nitrogen, are most frequently cited as a basis for standards.

5. A variety of responses is offered with respect to standards to deal with sedimentation of bays or excess macrophytes. Many respondents note that these are not amenable to standards but rather are watershed control or local policy issues.

6. Few States characterize their ability to assess the trophic condition of all their lakes as good. A typical reason in a given State is the very large and diverse lake resource, as in Minnesota and Wisconsin. Another reason is a lack of statewide lake monitoring programs, as with a number of States in Regions III, VIII, and X. Inadequate funding for routine lake monitoring programs appears to be a common problem in all regions.

7. There appears to be little information which links user perceptions with quantitative measures of lake conditions.

[illegible] ability to assess the biological condition of all waterbodies [illegible] in the very large [illegible] (the [illegible]), as [illegible]. Another reason is a lack of consistent data monitoring [illegible] in Regions III, VI and X [illegible] to a consistent [illegible].

[illegible]

IV. What About Lake Standards for Toxic Substances?

Introduction

For toxic substances, the concentration of pollutants in receiving waters must be maintained at levels equal to or below criteria to adequately protect the uses. As noted in the Introduction to the report, the criteria and use designation, together comprise the water quality standards. Each State has to have narrative water quality standards prohibiting discharges of "toxics in toxic amounts" and containing other general conditions. CWA section 307 allows EPA to develop a list of toxic pollutants and establish technology-based effluent guidelines.

In general, there are two types of toxicity associated with water resource management—acute and chronic. There are specific procedures to test for types of toxicity using aquatic organisms. Toxicity is also measured by the potential threat a pollutant poses to human health. This threat is a function of the amount present in the environment, paths to human exposure, and likelihood of exposure.

Discussion

Eighty-five percent of the respondents indicate they have water quality standards for toxic substances for lakes. The type of standard—numeric criteria, narrative, or a combination—is not specified. Only 1 percent of the respondents indicates its lake toxic standards are different from stream water quality standards. It is not known whether the toxic water quality standards take into account bioaccumulation and additivity.

Seventy-three percent of the respondents feel a need for toxic water quality standards. Two of those who believe see a need for lake water quality standards indicate lake toxic water quality standards should be different from stream water quality standards and one indicates that, in this State, they were different.

There are fewer respondents who believe there is a need for toxic lake WQS than there are respondents reporting that they already have toxic standards applicable for lakes. This difference could be caused by the way the question was worded.

Slightly more than half the respondents indicate their State has a statewide lake-monitoring program for toxic substances. Forty percent of these programs for toxics consist of one component, usually fish. The survey indicates that, in addition to water, sediment, and fish, some States use macrophytes and invertebrates for assessing toxics. Figure IV-1 shows the frequency of various components of the States' lake toxics monitoring programs.

Forty-two percent of the respondents who indicate they have toxic standards applicable to lakes have no statewide monitoring program for toxic substances in lakes. While these 17 respondents indicate they have appropriate water quality standards, they have no established program to determine if water quality standards are being met.

Seventy-two percent of the respondents indicate they know of or suspect lake toxicity problems within their State. This is considerably higher than the number of States indicating they have statewide monitoring programs for toxics (i.e., slightly more than one-half of the respondents). Sixty-three percent of those States that have suspected lake toxic problems have statewide toxics monitoring programs; 20 percent of those with known problems do not have monitoring programs. Sixty-one percent of those reporting no problems with toxics in lakes have no statewide toxics monitoring program for lakes.

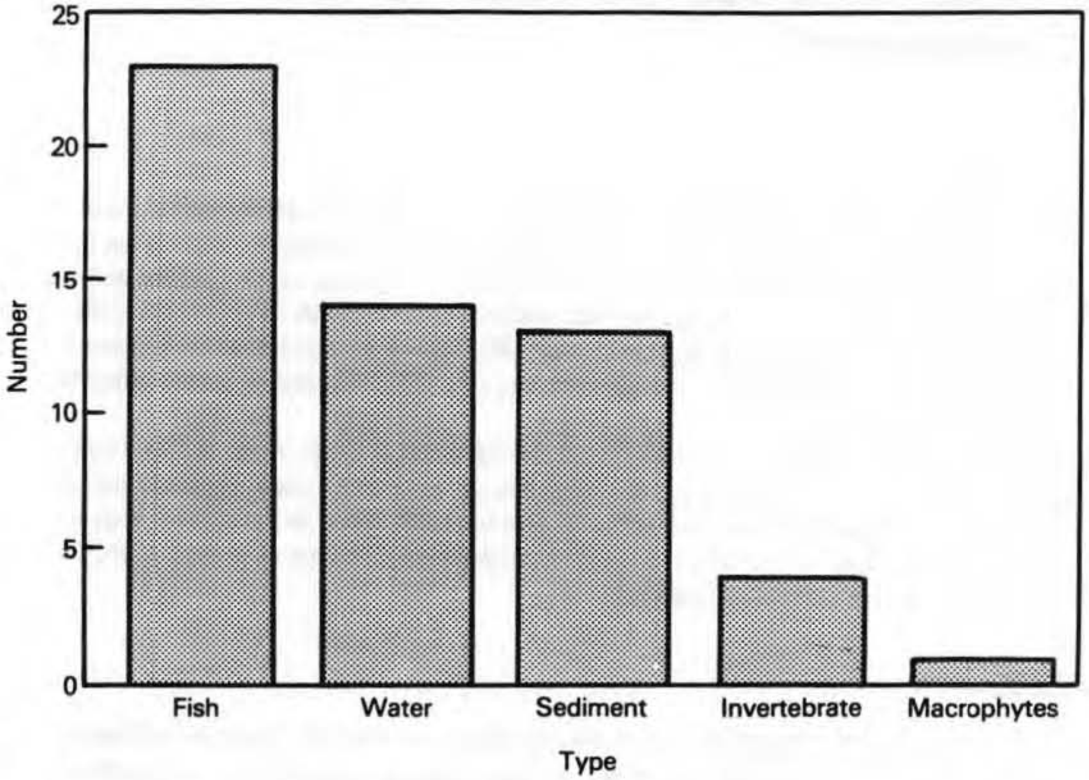

Figure IV-1. Number of States by type of monitoring

Slightly less than half the respondents indicate they would like to see more EPA assistance for the development of standards for toxic substances. The survey did not ask the States' reasons for not wanting additional assistance or whether they feel the present level of assistance is adequate.

Summary

The following is a summary of the results of section IV

1. States' monitoring programs do not comprehensively address toxic substance contamination in terms of types or scope of monitoring; therefore, the extent of toxic contamination in lakes is largely unknown.

2. While lakes and streams support different ecosystems and pollutants tend to accumulate in lakes, over 70 percent of the respondents indicate that, in their States, there is no difference between stream and lake water quality standards for toxic substances.

3. Almost one-half of the States who indicate they have toxic water quality standards applicable to lakes indicate they do not have established programs to determine if these standards were met.

Acknowledgements

The task force wishes to thank the 47 States tor taking an interest in this project and taking the time to complete the questionnaire. It demonstrates a desire on the part of the States to contribute to a better understanding of this complex issue. We wish to thank the Association of State and Interstate Water Pollution Control Administrators for assisting in condensing and distributing the questionnaire. We appreciate the support provided by the Tennessee Valley Authority (TVA) through the provision of staff time, telephone resources, and typing support. A particular note of thanks goes to Leigh Ann Wells of TVA for developing the IBM PC program and entering the data from the questionnaires, to Janet Brummitt and Sue Massingill of TVA for typing the report and assisting with a multitude of tasks in scheduling and sending correspondence to the task force members, and to Richard Green for editing the document. Finally, we appreciate the assistance of Judy Taggart of NALMS and her staff in all phases of the effort—from questionnaire development to preparing the document for final publication.

Appendix A

Numerical Standards for Managing Land and Reservoir Water Quality

Numerical Standards for Managing Lake and Reservoir Water Quality

NUMERICAL STANDARDS FOR MANAGING LAKE AND RESERVOIR WATER QUALITY*

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ABSTRACT

Even as attention to our nation's lake resources has sharpened in the past decade, water quality surveys repeatedly indicate deteriorating lake water quality. Several recent surveys indicate that the percentage of lake and reservoir waters impaired or threatened by pollution is higher than that of streams, rivers, estuaries, or groundwaters. This paper was prepared to stimulate debate on the need for specific numerical standards for managing water quality in lakes and reservoirs, and argues for them. A panel of reviewers representing different interest groups debated the issues presented in this paper at a plenary session at the 1986 Conference of the North American Lake Management Society; comments from the debate and additional opinions follow the paper. The principal authors also worked with contributors from a wide variety of institutions in writing this paper. This brought viewpoints ranging from engineering and agricultural perspectives in the university community to local, state, and federal government organizations. After reviewing the status of water quality in U.S. lakes and reservoirs and discussing innovative, comprehensive approaches for achieving point and nonpoint source pollution reduction, the authors conclude that degradation of our lake resources is a very serious national problem, one that does not appear to be adequately addressed by existing institutions. The paper addresses alternative lake protections approaches — from technology-based point and nonpoint control standards, to lake inflow or in-lake water quality standards and innovative watershed-based practices — the advantages and limitations of using simulation modeling to establish standards, and the importance of biological monitoring in establishing ecologically-based standards. Case studies illustrate the utility and limits of the various approaches. The paper particularly emphasizes a case study of watershed-based, point/nonpoint pollution reduction tradeoffs in Colorado, and a watershed-based, special classification system and nonpoint source control cost-sharing program for eutrophic reservoirs in North Carolina. The authors suggest possible federal and state approaches for using specific, numerical or ecologically-based standards to restore and protect lake and reservoir water quality.

* The opinions expressed in this paper are those of the authors and do not necessarily reflect official policy of either EPA or TVA. Comments on the debate reflect opinions of the writers alone; they do not necessarily respond to the panel paper point by point, but they do contribute to the free discussion on settling water quality standards.

INTRODUCTION

More than 99 percent of U.S. citizens live within a one-hour drive of a publicly-owned lake or reservoir. Nearly a third live within five miles of these lakes. With about 100,000 lakes greater than 100 acres scattered across the nation, it is clear that lake resources are an essential resource not only for their natural functions but also for water supply, flood control, recreation, and wastewater disposal – functions providing billions of dollars in annual benefits to our economy each year.

While the attention focused on lake quality over the last decade has increased, surveys of water quality repeatedly show that the resource is in trouble. The percentage of lake and reservoir waters impaired or threatened by pollution is greater than for streams, rivers, estuaries, or groundwaters – largely because of nonpoint source pollution. Programs employed to address lake pollution, such as the Section 314 Clean Lakes Program, are annually proposed for elimination.

Degradation of our fragile lake resources is a serious national problem that should be more effectively addressed by environmental agencies. As with the pollution problem facing Chesapeake Bay, citizens are becoming more concerned about the effectiveness of water quality management programs across the nation and what can be done to strengthen them. This paper is aimed at the institutional and policy shortcomings in managing our lake resources. Federal guidance, national minimum requirements, and state adoption of specific numerical and ecologically-based standards for lake quality appear to be needed if the nation is to achieve Clean Water Act goals in our lakes and reservoirs. As part of a basinwide, systematic approach to managing lakes and their watersheds, integrated control of both point and nonpoint pollution sources is also needed to cost-effectively attain these standards.

IMPAIRMENTS TO LAKE AND RESERVOIR WATER QUALITY

In a succession of recent national surveys, state officials report that the nation is losing the battle to clean our lakes and keep them clean. Cooperative local, state, and federal efforts to restore good quality water to degraded lakes need to be strengthened.

During the summer of 1983, the North American Lake Management Society (NALMS) asked state water pollution control administrators to respond to a questionnaire about lake quality. Duda and Johnson (1984) summarized the responses from 38 states. The administrators estimated that 120 lakes were contaminated with toxic substances and 12,000 lakes had noxious growths of weeds and algae. In a similar 1971 survey conducted by Ketelle and Uttormark, only 7 toxic and 425 problem lakes were identified nationwide, indicating that either the problem is growing worse or public awareness of it has increased. About 4,200 lakes and reservoirs were identified by the responding states in the 1983 survey as having impaired use (defined as interference with designated uses). Florida, Idaho, Illinois, Minnesota, Oklahoma, South Dakota, Tennessee, Utah, and Wisconsin each reported more than 125,000 surface acres of lakes with impaired uses. Every responding state except Georgia indicated that nonpoint source pollution seriously affected lake quality. Figure 1 displays the proportion of lakes seriously affected by nonpoint source pollution in each state. Two-thirds of the states indicated that at least half their lake and reservoir waters were seriously affected by nonpoint source pollution.

Two recent surveys conducted by the Association of State and Interstate Water Pollution Control Administrators (1984,1985) underscore the pollution problems being faced by our nation's lakes and reservoirs. The 1984 survey assessed water pollution control progress from 1972 to 1982. Four times more lakes (1,650,000 acres) were estimated to have degraded than to have improved in quality (390,000 acres) during the decade. More alarming were the 1985 survey results: 4.4 million lakes and reservoir surface acres impaired by nonpoint pollution, another 3.7 million acres threatened (Ass. State Interstate Water Pollut. Control Admin., 1985). The results imply that in 1986, 14 years after Congress passed the Clean Water Act, 53 percent of assessed U.S. lakes and reservoirs are adversely affected by nonpoint source pollution.

Some regions of the nation are particularly hard hit. For example, EPA's Region V states (Illinois, Indiana, Michigan, Minnesota, Ohio, and Wisconsin) have done a good job of evaluating lake water quality. Table 1 presents information on nonpoint pollution for three states in EPA Region V, as reported by ASIWPCA (1985), and for Region V as a whole. Table 1 presents evidence that at least 75 percent of assessed lakes and reservoirs in the three states and fully 80 percent of all waters in Region V are impaired – a situation of national importance. These surveys did not specifically address the problems of the Great Lakes, where water quality problems related to toxic substances in biotic communities and bottom sediments continue to cause concern.

A similar situation exists in the South. TVA recently conducted an assessment of environmental quality in the 7-state, 201-county area served by the Tennessee Valley Authority (1986). According to the assessment, 22 of the 32 major TVA reservoirs have

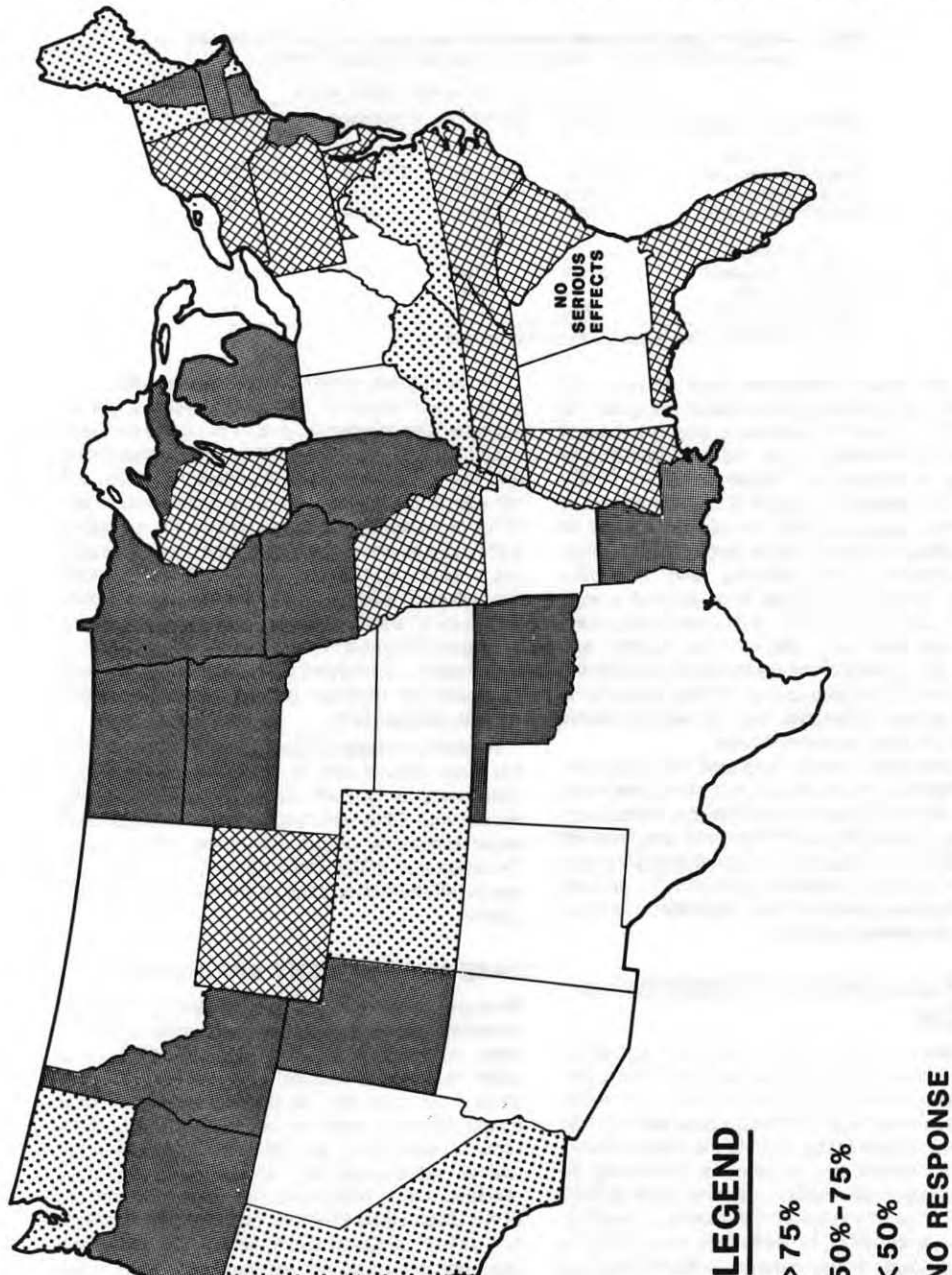

Figure 1.–Proportion of lakes and reservoirs seriously affected by nonpoint sources of pollution as reported by state water pollution control administrators in the 1983 NALMS State Lake Survey (Duda and Johnson, 1984).

Table 1.—Impaired and threatened waters from nonpoint pollution in selected states of EPA Region V as a percentage of assessed waters*.

	SELECTED STATE/EPA REGION V			
WATERBODY/IMPAIRMENT	ILLINOIS	MINNESOTA	WISCONSIN	ENTIRE REGION V
Lakes/Reservoirs				
Total acres assessed	160,619	770,226	973,000	2,020,216
Percent impaired	85%	81%	75%	80%
Percent threatened	10%	16%	18%	2%
Rivers/Streams				
Total miles assessed	9,193	7,336	43,600	65,478
Percent impaired	67%	68%	31%	40%
Percent threatened	6%	?	6%	4%

*Source: (ASIWPCA, 1985) for States and Region V EPA for total

some form of use impairment that prevents the reservoirs from meeting Clean Water Act goals. Of the 21 major non-TVA reservoirs and one natural lake in the 201-county region, states report 16 to be impaired or threatened. These degraded waterbodies are outlined in Figure 2. The impairments range from accumulations of toxic substances to low dissolved oxygen, siltation, bacterial contamination, excessive weed growths, and taste/odor problems in water supplies from excessive algal growth (eutrophication). In 10 TVA reservoirs, toxic substances adversely affect water quality and aquatic life. Several of the reservoirs have declining or imbalanced fish populations. Fishing is banned in some Alabama, Kentucky, and Tennessee waters because of accumulated toxicants.

It is clear that existing programs have not been fully effective in protecting or improving lake water quality. Tens of thousands of lakes are seriously affected by pollutants; many thousands are impaired for specific uses. The situation jeopardizes billions of dollars in potential economic benefits. To address these concerns, lakes and their watersheds must be managed as linked systems.

LAKES AND THEIR WATERSHEDS AS SYSTEMS

While streams and rivers can flush pollutants downstream and can often respond relatively quickly to waste discharge reductions, lakes and reservoirs are more ecologically fragile because they trap pollutants, accumulating them in the water column, bottom sediments, and aquatic life. Depending on their physical characteristics, different types of lakes and reservoirs vary in sensitivity to pollution loading. Because lakes tend to assimilate less pollution without damage, simply reducing pollutant loadings is not sufficient protection for many lakes; these lakes need further treatment and restoration measures.

To be effective, efforts to restore and protect lake quality must consider pollution sources upstream from the lake or reservoir and in the entire drainage basin. The physical characteristics of the waterbody and its watershed, the mix of pollution sources, and the uses of the lake also must be considered. Traditional technology-based approaches for managing point sources under the Clean Water Act will usually not be effective in managing lakes affected by complex mixes of nonpoint and point source pollutants. Determining whether specific lake quality problems are caused by point or nonpoint source pollution — and therefore, identifying possible remedies — must be based on regional, and in many cases lake-specific, assessments.

Regional, ecologically-based approaches appear the most rational way to address lakes and their watersheds as systems. Some states, such as Minnesota and Ohio, are beginning to manage their water resources on an ecological region basis. Developed at EPA's Corvallis laboratory, this approach delineates regions of similar attainable lake quality.

LAKE MANAGEMENT APPROACHES

Because of their sensitivity to pollutants, lakes and reservoirs, as well as bays and estuaries, require a more intensive level of management than other water resources. Despite point source controls, these resources have diminished in quality over recent decades, while rivers have improved. EPA recently established an Office of Marine and Estuarine Protection to focus agency concerns on that resource. Lakes should receive the same attention. EPA's Clean Lakes Program, established under Section 314 of the Clean Water Act, already too small, has been proposed for elimination annually since 1980. Consequently, protection and improvement of lakes and reservoirs often rests on river-oriented

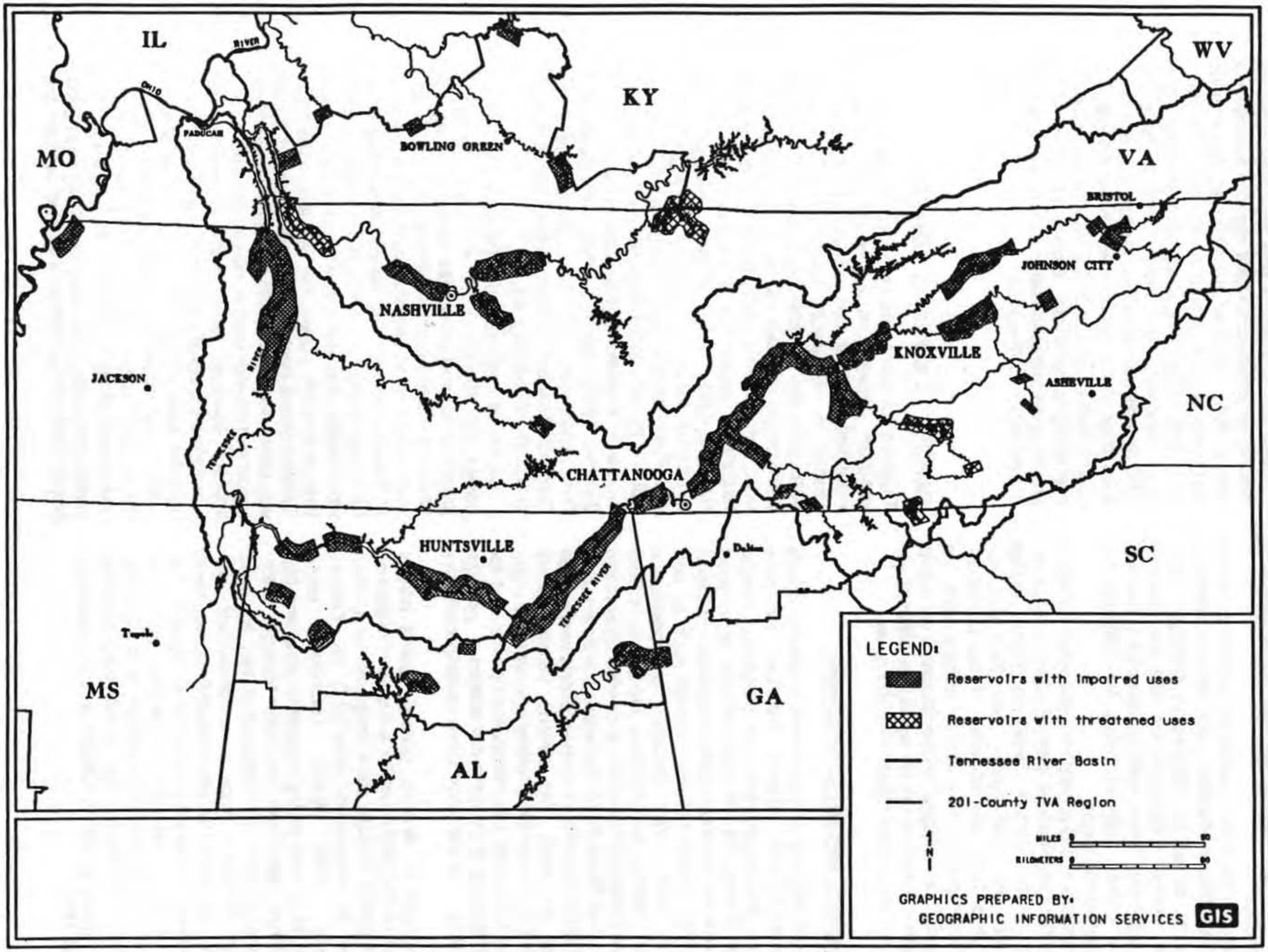

Figure 2.—Reservoirs with impaired or threatened State- designated uses because of poor water quality in the 201-county region served by the Tennessee Valley Authority (1986).

water quality programs that may not be sufficiently protective.

Despite the lack of emphasis on lakes, several federally-funded research, pilot, and demonstration projects, as well as initiatives by individual states, have national implications for lake and reservoir management. These initiatives can help in developing a uniform national policy for restoring and protecting lake quality.

Restoration and protection approaches fall under six major classifications: general source control, targeted source control, in-lake standards, in-flow criteria, use classification, and innovative approaches. These are discussed in their logical sequence regarding lake quality management, the numerical or ecological in-lake standards serving as triggering mechanisms for using the different approaches to achieve Clean Water Act goals.

GENERAL SOURCE CONTROL

General pollution source control programs include technology-based effluent limitations for point source discharges; voluntary programs planned under Section 208 with requirements for nonpoint pollution control; and scattered regulatory programs involving specific pollution sources such as coal mining, septic tank installation, or construction erosion control. Requirements are largely uniform across states and the nation, and, while lakes fit into the overall Clean Water Act water quality management process, perhaps more emphasis needs to be placed on them. The general source control programs have certainly helped prevent some pollution of lakes, and success stories do exist. But for every success story there are dozens – perhaps hundreds – of degraded lakes awaiting corrective action.

Examples of existing general source control programs that might not be adequately protecting water quality include state programs for erosion control on construction sites (N.C. Div. Environ. Manage., 1978; W.N.C. Tomorrow, 1984), federal/state coal mining regulatory programs (Ky. Div. Water, 1986; Tenn. Div. Water Manage., 1986), and the pollution of Chesapeake Bay by point source discharges. Lack of a coordinated, systematic approach to environmental management can cause interstate concerns, as evidenced on a large scale by the Chesapeake Bay, and on a smaller scale by the sediment from North Carolina mountain urbanization that is adversely affecting water quality in South Carolina's Lake Jocassee (Dysart, 1986).

Many states seem to lack legislative authority, funding, or other institutional capacity to protect or restore lakes. Because of limiting legislation, some states may be able to impose only national minimum requirements for point source control. Other states (e.g., Tennessee and North Carolina) have significant pollution sources (agriculture) exempted from state water quality laws. While this general source control approach may be less controversial and costly to administer, it does not appear to be providing the protection lakes and reservoirs require to meet water quality goals.

TARGETED SOURCE CONTROL

Targeted source control programs focus on priority pollution problems in a defined area. Specific resources or pollution abatement actions are directed to site-specific situations so that clean water goals can be achieved. Examples of such targeted programs, many stemming from federal initiatives, include EPA's Clean Lakes Program and the Nationwide Urban Runoff Program (NURP); the Massachusetts Clean Lakes Program; the EPA/USDA Model Implementation Program (MIP) and Rural Clean Water Program (RCWP); the USDA's PL 566 Small Watersheds Program (566 Program); Wisconsin's Nonpoint Source Program (Konrad, 1985); Florida's urban NPS Stormwater Rule (Livingston and Cox, 1985); and North Carolina's Nutrient Sensitive Waters (NSW) agricultural cost-sharing program.

The Model Implementation Program and the National Urban Runoff Program were one-time federal programs focused on specific problems – agricultural and urban nonpoint pollution control – and were conducted to demonstrate the implementation of Section 208 planning efforts. While they could have been used to achieve significantly improved water quality, they were limited by objectives, scope, time, or conflicting goals. For example, in the South Carolina Model Implementation Program at Broadway Lake, much of the $363,001 spent on cost sharing for farmers was used to develop farm ponds and improve pastures rather than implement best management practices (BMPs) focused on reducing nonpoint source export to surface waters. The mix of BMPs cost-shared in the Broadway Lake program did not differ substantially from either the mix in the county outside the project area during the program period or the mix in the entire county preceding the project. Little or no difference existed between the sediment load in control and treated watersheds (Ray and Dysart, 1982), and apparently, phosphorus loading to Broadway Lake did not decrease (Atkins and Dysart, 1981). Thus water quality did not improve despite the water quality goal intended for this institutional arrangement (Ranson and Dysart, 1982).

Targeted source control programs should be an integral part of an overall strategy to restore and protect lake resources. These approaches do have institutional advantages. Many of them have been conducted in a climate of state and local autonomy, and their voluntary nature — especially with government monetary incentives — is popular with landowners, politically palatable, and does not threaten established working relationships or special interests.

However, past targeted source control programs have required governnment funds as well as a federal presence. The major program disadvantage is the targeting to one particular type of pollution source with little or no authority over other pollution that might degrade lake quality. Consequently, water quality improvements may not achieve Clean Water Act goals. For example, an expensive municipal advanced wastewater treatment plant was built in northern Virginia to protect the Occoquan Reservoir, but subsequent investigations found nonpoint sources contribute most of the pollutants of concern (Randall et al. 1978). Other shortcomings that appear to hamper progress include an inability to handle large reservoirs routinely; differences in local goals/objectives; temptations to treat symptoms rather than causes; lack of adequate participation because of the voluntary nature; and shifting of project focus beyond the program's limited resources. For example, North Carolina's Nutrient Sensitive Waters cost-sharing program (as described in a subsequent case study) has been a nationally significant, targeted program, but now that it has been expanded to cover a much larger geographic area, its effectiveness may be questioned.

Some of these shortcomings have been overcome under EPA's Clean Lakes Program, a targeted program under Section 314. Although the program has its roots in the need to clean up degraded lakes, the enabling legislation recognized the need to control pollution inputs as well as to avoid short-lived improvements resulting from symptomatic treatments. After many years of delay following passage of the Clean Water Act in 1972, implementing regulations (40 CFR 35.1600) promulgated in 1980 allowed the Clean Lakes Program to give the states a tool for meeting Clean Water Act goals. This watershed-based approach to lake management required that all contributing point source pollution be adequately treated or planned for under Sections 201 and 402 of the Act before EPA could award a grant to control nonpoint sources in the lake watershed and apply in-lake restoration measures.

Some states, such as Wisconsin and Massachusetts, have established strong programs in response to Section 314. In particular, the Massachusetts program can serve as a model for the nation. The state devotes $3 million in bond funds annually to lake cleanup over the 10-year initial period of the Massachusetts program.

Battelle Columbus recently completed an evaluation of the Clean Lakes Program (U.S. Environ. Prot. Agency, 1985), finding many productive and effective demonstrations. With uncertainty in funding over the last seven years, however, many states have not enacted full-scale lake management programs. Consequently, the Clean Lakes Program has not achieved its original goals. The program has also suffered from lack of focus in implementation, the ad hoc nature of projects, and the lack of quantifiable standards (including in-lake standards) for driving project participation and assessing project success.

IN-LAKE STANDARDS

Our use of the term *in-lake standards* refers to water quality standards, as defined by EPA (40 CFR Parts 35, 120, and 131) in 1983, pursuant to Section 303 of the Clean Water Act, where standards consist of a designated use or uses for waters and water quality criteria exist to protect the uses.

Much has been said over the years about the role of water quality standards in pollution control. Twenty years ago, at a National Symposium on Quality Standards for Natural Waters in Ann Arbor, Michigan, participants examined the need for water quality standards for pollution cleanup as part of the Water Quality Act of 1965 (Wolf, 1966). By 1972, however, Congress became disenchanted with the slow progress in pollution control and changed the nation's water quality program in PL 92-500 to emphasize establishment of effluent limitations based on uniform national technology for point source discharges. As a backup tool, EPA was required to develop water quality-based criteria for states to incorporate into standards.

In the late 1970's, EPA chose a single-numbered approach based on worst-case conditions. This approach drew much criticism (Lee et al. 1982). In response, EPA revised the regulations in 1983 to allow states to develop site-specific water quality criteria for incorporation into state water quality standards. The site-specific criteria are to be developed following an intensive survey (a use attainability study) to give states flexibility in managing water quality.

In the extensive literature regarding advantages and disadvantages of water quality standards and the use of conservative criteria, scientific uncertainty, adverse impacts on the economy, and inadequate technical bases have been identified as problems (Lee et al. 1982). Hodson (1980) has commented on difficulties in developing criteria as well as problems in applying criteria and standards. Standards for protecting human health appear to be especially fraught with uncertainties and inadequate science, according to Davis (1980).

In-lake water quality standards have been successfully used in several instances. The Great Lakes Program and the state of Maine have developed in-lake phosphorus criteria. TVA has recommended in-lake phosphorus criteria based on modeling for Tellico Reservoir in Tennessee. Colorado has done the same for Cherry Creek and Dillon Reservoirs. Criteria for protecting lake ecosystems from suspended solids or turbidity related to reductions in productivity (compensation point) have been recommended by the National Academy of Sciences and The Great Lakes Water Quality Control Board (U.S. Environ. Prot. Agency, 1972). In-lake numerical objectives for certain toxic substances have also been recommended and are being evaluated for the Great Lakes.

It is scientifically difficult and expensive to establish numerical criteria to protect designated uses of lakes and reservoirs. Initially, the most likely and feasible candidates are criteria that limit nutrients such as phosphorus and nitrogen or toxic substances. A considerable body of empirical evidence exists relating various measures of lake conditions to phosphorus and nitrogen, including primary production, algal biomass (chlorophyll a), lake clarity (Secchi depth), fish production, and oxygen depletion. Conceptually, in-lake concentrations of these nutrients could be used to establish criteria. However, setting uniform national criteria for lake nutrient levels may not be practical because desirable and attainable lake quality conditions vary by geographic region. Approaches based on ecological regions seem the most appropriate.

While establishing criteria for toxics based on simulation modeling and bioassays will always be subject to considerable debate, standard techniques exist for making the determinations and are being considered for the Great Lakes. Federal assistance and guidance in developing these numerical or ecological standards may be required. Federal resources may also be required for establishing specific durations and frequencies of exposure to protect lake and reservoir aquatic life from toxicity. EPA has developed such criteria for rivers and streams. Its documents state that the one hour average concentrations should not exceed the acute criterion more than once every three years on the average, and the four-day average concentration should not exceed the chronic criterion more than once every three years on the average (U.S. Environ. Prot. Agency, 1985). With the pollutant trapping capability of lakes and longer recovery times for lake biota, more conservative criteria for various types of lakes and reservoirs would seem appropriate.

Adoption of criteria to protect aquatic life from toxicity associated with accumulated pollutants in sediments and humans from consumption of fish tainted with bioaccumulated pollutants may also be appropriate. While in-lake criteria could be back-calculated from permissible levels of pollutants accumulated in fish and bottom sediments, it would be wise to include an ample margin of safety. In these times of declining research funding for water-related needs, development of such criteria seems to be a priority research need.

Setting in-lake standards is an essential management tool for several compelling reasons. The ultimate goal of a lake standard is the condition of the lake itself. It seems logical, therefore, to define the standard relative to the end-point of concern – by actual measures of desired end or by surrogates such as phosphorus concentrations or trophic state indices, which may represent the desired trophic condition. A similar argument can be made for establishing desired conditions for water supply reservoirs or bioassay-related standards for biological integrity.

Standards are enforceable provisions of state and federal laws; they provide a triggering mechanism for determining when and where more stringent water quality management is required without waiting for development of use impairments that are costly to remedy. Standards can provide a margin of safety for protecting human health and environmental quality, a target for pollution reduction programs, and a measure of progress. In particular, ecologically-based standards may be suitable for protecting aquatic life from siltation effects or from toxic impacts. Toxic substance body burdens, chronic or acute bioassay measures, or toxicity tests for accumulations of chemicals in bottom materials may all be appropriate for use as in-lake standards.

LAKE INFLOW CRITERIA APPROACH

Once an in-lake water quality standard has been contravened or a condition of threatened impairment identified, remedial actions need to be specified. These may involve reductions in point source discharges, reductions in nonpoint inputs, or treatment of in-place pollutants (such as accumulations of sediment, toxic substances, or internally cycled phosphorus). The inflow criteria approach involves determining the level of loading reduction from the county, municipalities, local industries, the POTWs, EPA, Colorado Department of Health, and the Denver Water Board.

The management strategy for Dillon Reservoir has several elements. A water quality standard was set at Dillon's 1982 phosphorus level of 7.4 μg/L. Careful modeling indicated the level of controls necessary to attain this water quality standard. Future development was required to apply state-of-the-art phosphorus control to resulting nonpoint sources. To earn credits compensating for increased wastewater discharge resulting from new development, old nonpoint sources of phosphorus (existing prior to 1984) were required to be reduced. These "trades" between point and nonpoint sources are documented in an NPDES permit which assigns the phosphorus credit to the discharger controlling the nonpoint source. A local organization, the Summit Water Quality Committee, operates the trading and monitoring program on a daily basis, with state and federal oversight.

The result of Dillon's management strategy and its integration of point and nonpoint sources is that the reservoir's quality is being maintained, with an annual expected savings of $750,000 in treatment costs (51 percent in 1983 dollars). The success of Dillon's management plan is attributable, in part, to cooperation among all interested parties and governmental entities during its development and implementation. Equally important was a specific water quality target for management techniques.

Cherry Creek Reservoir is located southeast of Denver, in one of Colorado's primary recreation areas. The Cherry Creek drainage faces rapid urbanization (200,000 population increase between 1990 and 2010). The reservoir is presently eutrophic. Phosphorous is the limiting pollutant, and basinwide phosphorus loads are dominated by urban nonpoint sources, which comprise over 75 percent of the total phosphorus load.

Area residents instituted a management plan to protect the reservoir from water quality degradation resulting from increasing urbanization. The resulting strategy called for setting the reservoir's phosphorus standard at 0.035 mg/L. To achieve and maintain the standard, a minimum 50 percent control of all nonpoint sources of phosphorus, as well as strict limits upon standard point sources, was required. Prior to the masterplan's development, no nonpoint source controls had been required. With anticipated future growth and urban development, uncontrolled nonpoint phosphorus loadings would accelerate deterioration of the reservoir, violating the water quality standard of 0.035 mg/L before 1990.

In 1985, the Denver Regional Council of Governments completed and approved a master plan and waste load allocation for the basin designed to achieve and maintain the 0.035 mg/L water quality standards for phosphorus in the reservoir. Besides calling for a 50 percent reduction as a minimum basinwide objective for all annual nonpoint phosphorus loadings, the plan's point source component requires strict control on 12 publically-owned treatment works, three of which will be constructed between 1985 and 1990. The phosphorus allocations for the treatment plants were based on design permit limits of 0.1 mg/L or lower, with land application of the discharge effluent. Under the masterplan, a municipality or district can earn credit on its phosphorus allocation if it installs a nonpoint source pollution control device which achieves greater than 50 percent phosphorus removal. Basinwide credits can also be earned for publically-owned treatment works if control of nonpoint sources within the basin exceeds 50 percent. These credits represent point/nonpoint source trades, which increase treatment plant phosphorus allocations and allow additional population growth without requiring stricter point source treatment levels.

Integration of point and nonpoint source controls in Cherry Creek's master plan allows the reservoir's water quality standards to be met at lower cost than reliance upon point source controls alone. As at Dillon Reservoir, the master plan was based on specific water quality standards to develop reservoir protection strategies (see Elmore et al. 1985).

POLICY IMPLICATIONS

This discussion of lake water quality has raised several policy concerns, at least three of which are addressed by the case studies. These are (1) the need to integrate control of point and nonpoint sources, (2) the need for unprecedented degrees of intergovernmental coordination for such protection to be effective, and (3) the need for quantified targets or goals to drive such coordination and achieve lake water quality.

Both point and nonpoint sources contribute to lake water quality degradation. The Clean Water Act has emphasized control of point sources through elaborate permit systems, detailed effluent guidelines, and multilayered provisions for enforcement of point source NPDES obligations by EPA and States. The Act is largely silent on required control of nonpoint sources, and depends largely on local efforts for their control. Many of the Nation's remaining water quality problems result from nonpoint sources:

controlling these problems is often more effective and less expensive than additional point source upgrading. Despite interrelationships between point and nonpoint sources, the two are rarely addressed by a coordinated program.

Coordination among federal, state, and local organizations is critical to devising meaningful, systematic approaches to the problem. As EPA's Report to Congress on Nonpoint Source Pollution notes, flexible, site- and source-specific decisionmaking is the key to effectively controlling nonpoint source pollution (U.S. Environ. Prot. Agency, 1984). While local decisionmaking may be the key, intergovernmental cooperation and active public participation remain essential, as does an active federal presence to ensure that cooperation occurs. In all the case studies, federal, state, and local organizations worked together in developing plans to restore and protect lake quality. Where successes occurred, a federal/state/local partnership and federal funding played a major role in addressing the problem.

The case studies illustrate promising strategies that are not currently being used widely as part of State water quality management programs. North Carolina used watershed management requirements triggered by in-lake standards and a special use classification, while St. Albans Bay relied upon water quality objectives targeted to standards for nonpoint sources. In contrast, Dillon and Cherry Creek developed innovative lake quality management strategies, working from a numerical ambient water quality standard. The common denominator for all cases is that the standard provided a quantifiable goal or target for measuring progress. Once the goal was selected, modeling methods such as those used in the Great Lakes or the Occoquan in Northern Virginia were available to help develop programs for achieving desired goals. Representatives from several case study organizations have stressed that without quantifiable objectives, they would still be in the developmental phase of their lake quality management plans. With a concrete in-lake standard, lake water quality protection activities progressed more rapidly from the planning to the implementation phase.

The adoption of lake-specific standards, however, should not be allowed to encourage degradation of water quality down towards minimum criteria levels. Antidegradation provisions of the Clean Water Act require protection of existing water quality that exceeds minimum standards. Application of this provision is quite controversial in practice and is subject to extensive policy debate. It is clear, though, that in-lake standards must be tied to rules that prohibit deterioration of water quality as well as requiring minimum standards. Adoption of ecologically-based water quality standards on a regional basis may assist in this effort to prevent significant degradation of lakes and reservoirs.

CONCLUSIONS

The quality of our nation's lakes is threatened. Despite more than a decade of impressive progress in reducing point source discharges, lakes and reservoirs continue to accumulate pollutants from nonpoint pollution sources that have gone essentially unregulated. Fledgling programs in lake restoration and protection are not receiving the attention and support many feel they deserve. Recent surveys suggest that over half of our nation's lakes and reservoirs are impaired or threatened by insufficient water quality caused in significant part by nonpoint sources. The problem is growing worse some 15 years after passage of the Clean Water Act. Changes appear to be necessary at the national and State level to reverse this trend in declining lake quality.

The traditional permit-by-permit approach for point source control and delegation of responsibility to states for nonpoint controls (referred to in this paper as general source control approaches) have not adequately addressed this national need. Nevertheless, examples of federal and state initiatives that suggest solutions exist. The six categories of lake management approaches identified must be integrated to achieve Clean Water Act goals. In-lake numerical or ecologically based water quality standards (perhaps on a regional basis) can serve as the cornerstone for an integrated, basin-wide approach. The standards would trigger more stringent water quality management programs as needed. They would establish definable, enforceable goals and provide a means of measuring progress and assuring accountability of any new programs.

Simulation modeling has advanced to the point that a reasonable predictive capability exists for managing lakes. Point and nonpoint pollution loading reductions needed to meet in-lake standards can be established and translated into inflow criteria protecting water quality. Adoption of special designated use classifications as part of state water quality standards can serve as an institutional mechanism for targeting programs for pollution abatement so that these inflow criteria will be achieved. These plans should identify pollution control measures needed to restore or protect the waterbody and should establish schedules and responsibilities for implementation among federal, state, and local jurisdictions. This integrated approach, formalized as part of a water quality needed to achieve the desired in-lake water quality, partitioning the reduction among pollution sources, and establishing compliance schedules for control implementation. Predictive modeling techniques are often used to establish the needed reduction.

The best example of this approach is the Great Lakes' phosphorus control strategy. Load reductions of 30 percent are mandated through nonpoint source control, sewage treatment plant upgrades, and phosphate detergent bans. A similar approach is being used in North Carolina (N.C. Div. Environ. Manage. 1983), and in Cherry Creek and Dillon Reservoirs in Colorado. These are discussed more fully as case studies later in the paper.

Widespread adoption of the inflow criteria approach has been limited by the lack of loading data, costs of data collection, and uncertainties associated with modeling needed to specify the degree of reduction required. Sufficient state funding needed to develop these data has not been available. Nevertheless, the last decade has seen progress in applying modeling techniques and more widespread adoption of these techniques is possible and expected.

The advantages of using lake inflow criteria are many. Risks in making bad decisions are lessened because up-to-date scientific techniques can be used in making predictions. Cost-effective solutions are more easily identified because site-specific conditions are considered, and accountability can be promoted and ensured through compliance schedules and specific objectives.

USE CLASSIFICATION APPROACH

Special use classifications can be incorporated into state water quality standards to achieve target loading reductions needed to protect lake ecosystems. The adoption of special designated use classes for lakes and reservoirs with different criteria (in-lake standards) and appropriate authorities can achieve the protection some particularly sensitive or degraded lakes need to meet Clean Water Act goals.

An example of this approach is the Outstanding Florida Waters (OFW) special classification rule described by Swihart et al. (1986). The rule enables special attention to be given to waterbodies of unusual significance; preservation of ambient water quality by requiring high levels of pollution control; and avoidance of polluting activities. This approach protects good quality waters, but does not help restore poor quality waters because it applies only to new pollution sources.

Wisconsin is considering adopting a hybrid classification approach for addressing lake trophic status (Schrank et al. 1983). Two classes of lakes would be established: lakes needing special phosphorus controls to preserve good water quality, and all other lakes. The second category would have two sub-classes: impaired lakes needing water quality management and other lakes of less priority. The approach fits well with EPA's initiative at the Corvallis laboratory regarding the determination of attainable lake trophic states. The use classification approach is being embodied in a guidance manual for lake restoration. The State of Minnesota is considering adopting this attainable lake trophic states approach (Heiskary et al., this vol.).

The use classification approach could be unpopular in states where protection of lakes and reservoirs is not a priority. It adds uncertainties to point source permitting activities and requires extensive technical evaluations, additional expense, and public participation. However, the advantages of its employment are numerous and can more than offset the added expense. Water quality protection is tailored to individual waterbodies, and pollution sources from entire lake watersheds are considered in an integrated/systematic manner designed to develop cost-effective solutions. Classifications can be incorporated in state rules conferring authority to address specific pollution sources. Moreover, such a tool represents a flexible institutional mechanism for dealing with future, unaddressed, often unidentified lake and reservoir pollution problems.

INNOVATIVE APPROACHES

The term innovation connotes a new or different approach to problemsolving. As applied to lake management, innovative approaches have a number of common elements. First, most have been developed by state and local governments to solve specific lake environmental problems. While the innovations were case or site-specific in their applications, the concepts might be more broadly applied. Applying them to different circumstances has yielded experience in assessing their general applicability.

One example is an innovation called Pollution Reduction Trading (PRT) which began at Dillon Reservoir, was later applied at Cherry Creek Reservoir in Colorado, and is now being tested in a number of different circumstances (Jaksch and Niedzialkowski, 1985). PRT allows a point source (for example, a publicly-owned treatment works (POTWs)) to obtain pollution reduction credits by controlling nonpoint source pollution rather than upgrading point source controls beyond the technology-based requirements of best available technology/best practicable control technology (BAT/BPCT) treatment. It is employed where technology-based controls are not sufficient to meet water quality-based requirements and more must be done. What is innovative about PRT is that it puts the burden of controlling nonpoint source pollution on point source dischargers, which then have the option of either upgrading or controlling nonpoint sources. Thus nonpoint sources are voluntarily controlled, without a new regulatory program. Dischargers who opt for nonpoint source control take credit for the degree of control in their discharge permit, which is modified to contain two sets of limits: one with trading and a more stringent limit without trading. If the discharger does not achieve the required level of nonpoint source control, its allocated load and permit level automatically revert to the more stringent limits. The permit ensures the point source is and remains responsible for the installation and effective operation and maintenance of the nonpoint source pollution controls. PRT works where further point source control is more expensive at higher treatment levels when compared to nonpoint source control.

Another innovative approach is Florida's watershed management approach, which integrates control of point and nonpoint sources. Florida's explosive development has created many demands on the natural and financial resources of the State and local governments. The state's water resources and ability to provide necessary infrastructure to meet the demands of new residents have been severely strained. Florida's Department of Environmental Regulation has implemented an extensive permitting system to regulate and minimize adverse development impacts, but this has not been enough to protect Florida's water resources, particularly its lakes. Therefore a comprehensive watershed management/WLA approach, including stormwater management, has been developed by Florida as a supplement to the existing regulatory program, enhancing ability to cost-effectively manage lake resources. This approach allows integrated point and nonpoint source management strategies and facilitates the long-term retrofitting of stormwater systems built before the adoption of the state's stormwater rule. The approach promotes establishment of regional stormwater facilities, development of master stormwater management plans, creation of stormwater utilities to generate money for funding projects, and closer coordination of growth management with natural and financial resources management (Livingston, this vol.).

Simulation Modeling

Mathematical simulation is valuable for relating in-lake criteria to pollution sources, linking economic and development activity at the source to off-site effects in surface waters and reservoirs, and guiding land-use decisions. Considerable modeling, monitoring, and assessment efforts in the past two decades have dealt with various components of the overall system such as pollutant mobilization, overland transport to surface waters, transport of pollutants to surface waters, and impact on lakes and reservoirs.

A systems modeling context must be used if rational decisions are to be made on numerical standards, selection of appropriate control measures, and expenditure levels. A systems approach to modeling should include the ability to (1) track pollutants from the various source areas through surface streams to lakes and reservoirs; (2) determine potential impacts or use impairments under different economic development and control scenarios; (3) identify opportunities for source reduction, end-of-pipe treatment, mitigation, and rehabilitation; (4) produce information on estimated costs and impacts for various levels of control; and (5) model land-disturbing or other pollutant producing activities, during the development, post-development, and recovery phases.

Modeling technology has progressed substantially over the past two decades. Mathematical modeling and simulation tools are now widely available and accepted for addressing lake management needs. Modeling is an integral part of water quality management in the Great Lakes, in particular, a PCB model for Saginaw Bay and general models for each of the Great Lakes. The models are being used to help identify new pollution sources and to evaluate various source reduction strategy effects over time on toxic substances in water, sediment, and fish. Models have also been developed to simulate the transport, accumulation, and loss of toxic chemicals in tributaries, embayments, and open waters. These models, along with others now under development, will be used in conjunction with a lake mass balance approach for toxics, allowing screening of new and existing chemicals. The results will be used to establish priorities for environmental monitoring, laboratory testing, water quality criteria development, and effluent regulation.

CASE STUDIES

The following case studies report successful use of several different approaches. They show that federal, state, and local agencies can cooperate to protect lake water quality, and indicate a clear need for numerical standards to facilitate lake and reservoir water quality.

Targeted Source Control Approach — St. Albans Bay, Vermont

St. Albans Bay Project on Lake Champlain is funded by EPA and USDA under the experimental Rural

Clean Water Program. The project is aimed at reducing phosphorus-caused eutrophic conditions from POTWs (76 percent) and intensive dairy activity (24 percent). The project quickly determined that reduction of phosphorus from both agricultural and point sources would be necessary to bring the Bay to a trophic state comparable with the rest of Lake Champlain, and that extensive hydrologic modeling was needed to determine required reductions from each source.

Sewage treatment plant upgrades were initiated and critical dairy operations identified for improved waste management. Examination of the present dairy manure management practices identified critical nonpoint source areas and their priority to the water resource.

Based on circulation and inflow–outflow patterns, the project estimated acceptable phosphorus loadings to the Bay. These loadings then became the basis for nonpoint and point source control programs governing the extent of dairy farm manure treatment and the level of treatment plant upgrades. By early 1986, treatment plant upgrades were completed, and 87 percent of the identified critical dairies were under water quality contracts with most work already completed. The St. Albans Bay Program is a prime example of a situation where a management plan for part of a lake is necessary because of its size and the intensive activity within it. The nonpoint abatement program used a targeted source control approach to pollutant reduction.

In several respects St. Albans Bay is typical of agricultural nonpoint source control programs, which have traditionally been incentive-based rather than regulatory. Participation is voluntary in the Agricultural Conservation Program special water quality projects, the Rural Clean Water Program, and other agricultural nonpoint source pollution control programs. The way St. Albans Bay integrated these tools with comprehensive management approaches, however, proved unusually effective. Significant federal funding definitely helped in controlling the agricultural pollution as well as in constructing the sewage treatment plant upgrades.

In-Lake Standards/Inflow Criteria Approaches — The Great Lakes

The Great Lakes phosphorus control strategy provides a national model for establishing in-lake water quality standards, determining needed reductions in pollutants flowing into the lakes, and adopting compliance schedules to achieve water quality goals. Based on extensive data analyses and waterbody sensitivity to eutrophication, an in-lake maximum acceptable ambient level of phosphorus was specified for eight portions of the lakes (ranging from 0.005-0.015 mg/L of total phosphorus). These target concentrations serve as water quality standards because they have the force of law under the Great Lakes Water Quality Agreement of 1978. Target inflow reductions of 30 percent of nonpoint source loads, implementation of phosphate detergent bans, and effluent limitations of 1 mg/L total phosphorus from municipal sewage treatment plants discharging more than 1 million gallons per day are specified in the strategy. These inflow reduction criteria serve as the base for targeted pollution control programs.

As described by Sonzogni and Heidtke (1986), the detergent phosphorus ban seems to be successful in the five States which have enacted bans. Estimated annual savings in treatment costs range from $3-27 million and phosphorus influent concentrations to sewage treatment plants have been significantly reduced (by 1.5 mg P/L). Three other Great Lakes States (Ohio, Illinois, and Pennsylvania) have not enacted detergent bans, which may be limiting the effectiveness of the total effort.

In another example, a phosphate ban in Maryland to limit phosphorus additions to the Chesapeake Bay has recently been reported to be effective and to yield major public cost savings (Jones and Hubbard, 1986). But debate is likely to continue on the effectiveness of the Maryland ban, and some studies have indicated that detergent bans alone may not be sufficient to improve water quality for some lakes (Lee and Jones, 1986). However, laundry detergent phosphorus bans appear to be attractive as part of an integrated point/nonpoint pollution control program to achieve inflow criteria reductions for lakes and reservoirs.

About $9 billion in U.S. funding has been spent in the Great Lakes basin to construct municipal sewage treatment facilities. Good progress has been made in achieving the 1 mg/L phosphorus discharge limitations for municipal facilities. Major federal resources for nonpoint pollution control demonstration projects were also made available, but success has not been as great because state-level institutional mechanisms to deal with nonpoint sources are lacking. One reason the Great Lakes phosphorus control strategy has been a success is the International Joint Commission treaty with Canada and the resulting massive influx of U.S. federal funding. More progress still appears needed for toxic substance control, however. One possibility is a phosphorus-type control program for toxics. Another, perhaps more environmentally cost-effective, approach is to determine and regulate the toxic pollutants of concern directly. The EPA Great Lakes Program Office is developing this approach; when approved, it should become a part of the regulatory programs of the Great Lakes States.

Use Classification Approach – North Carolina NSW Classification

North Carolina has developed a watershed-based special classification system for nutrient-sensitive waters (NSW) and a special nonpoint source control cost-sharing program targeted to these sensitive watersheds. The state views its large number of major reservoirs as a cornerstone for accommodating its rapid growth. To date, two major reservoir watersheds (Jordan and Falls Reservoirs) and one coastal river basin (the Chowan River) covering approximately 2.7 million acres have been designated nutrient-sensitive waters under this program.

In the late 1970's, North Carolina adopted a chlorophyll a criterion of 40 µg/L for warm waters and 10 µg/L for cold waters as a part of its water quality standards. Exceedance of these criteria triggers an investigation of whether the waterbody and its entire watershed should be classified nutrient-sensitive, with special requirements for nutrient control. Duda and Johnson (1983) described the approach in depth. The State has determined that all new wastewater treatment plants and some existing POTWs must meet a total phosphorus effluent limitation of 1.0 mg/L to provide necessary pollutant inflow reductions to the two reservoirs. The rest of North Carolina has no treatment plant phosphorus standard.

Two other features of this use classification approach also relate to agricultural and urban nonpoint sources in the watersheds upstream of the two reservoirs. First, since 1983, the state legislature has appropriated over $6 million of cost sharing funds for agricultural nonpoint pollution reduction in identified nutrient sensitive watersheds. The targeted program provides a 75 percent cost share. It has been enthusiastically received by the agricultural community, and in 1986 was expanded to 20 coastal counties. Unfortunately, this spreads the cost-share funding over such a large area that the targeted watersheds may not receive sufficient emphasis. Thus this nationally significant targeted effort may be in danger of becoming another first-come, first-served program lacking real water quality impact.

Second, to control urban nonpoint sources to the North Carolina nutrient-sensitive reservoirs, the State issued developmental (land use) guidelines to counties and municipalities in the reservoir watersheds for controlling pollutants associated with new development. Local ordinances were encouraged to

- Designate all areas within one mile of the reservoir as a critical area where impervious cover is limited to 6 percent (one dwelling per two acres), and practices are installed to control the first half inch of runoff.
- Require a 12 percent impervious surface (one dwelling per acre) limit for the rest of the watershed (30 percent if served by sewer).
- Require a fifty foot buffer zone on all streams and rivers in the watershed.
- Bar hazardous wastes within the one-mile critical area.

Although adoption of these guidelines by counties and municipalities is currently voluntary, local governments in the most critical areas of the watershed are passing ordinances that incorporate the guidelines. This land-use-based approach is similar to the 5-acre minimum lot size governing critical upstream areas of Northern Virginia's Occoquan Reservoir. Additional authority to require retrofitting of controls in existing urban areas may be needed to achieve water quality goals in North Carolina. With existing resource limitations, unfortunately, other eutrophic waters in North Carolina are not being addressed. The use classification approach and special authorities, under State law, however, could serve as a national model for restoring and protecting lake quality. In addition, the initial targeted approach for the agricultural cost-sharing program to control nutrients could also serve as a national model for nonpoint pollution control in lake watersheds.

Innovative Approach-Point-Nonpoint Source Trading – at Dillon and Cherry Creek Reservoirs, Colorado

Dillon Reservoir's use of point-nonpoint source trading was the first of its type in the nation. The management approach at Dillon allows POTWs to use low-technology treatment systems on runoff (nonpoint) pollution in lieu of expensive upgrades of their already advanced treatment equipment.

The comprehensive reservoir management system was developed when a 1983 Clean Lakes Study found that continued focus on point sources would not prevent Dillon from becoming eutrophic. Even if the four POTWs on Dillon (already controlling to advanced treatment levels) were reduced to zero discharge by complex and expensive methods, nonpoint phosphorus loading from development would cause continued algae growth. Control of nonpoint sources was necessary to avoid a sewer tap moratorium that would effectively freeze growth and severely restrict Summit County's booming economy. In light of this situation, a committee was established to design a phosphorus control strategy. The committee was comprised of officials management plan for individual lakes or regional groups of lakes, seems possible under existing legislative authority.

If this national problem warrants an in-lake standards approach, and the legislative/technical framework is already available to implement that approach, why is it not being done? Simply put, such a change would likely require a major shift in water policy, guidance, and financial resources at all government levels. A federal presence would be needed to effect the change and ensure its successful adoption and implementation on the basin-wide levels at which effective lake management must occur.

EPA appears to have sufficient legislative authority under Section 303 of the Clean Water Act to employ a water quality standards approach for lake restoration and protection. In response to a policy directive, EPA's water quality management regulations could be reissued to target lakes and reservoirs as priority waterbodies deserving special attention under those regulations. In meeting Section 303(e) requirements, states could upgrade their continuing water quality management process by developing and applying in-lake standards as the institutional mechanism for triggering more comprehensive, systemwide pollution control for reservoir and lake watersheds. Under Section 106, Clean Water Act resources could then be directed toward states with lake/reservoir watersheds that substantially depart from these water quality standards. EPA guidance in setting priorities for lake restoration and protection as well as for more comprehensive water quality management could follow.

A redirected EPA effort focusing on these new priorities would call for additional research on methods for improving lake management and applying restoration techniques. Finally, states could be required to include in their 305(b) water quality reports a list of all lakes that do not meet standards, the causes of their impairment, and actions taken to correct the impairments. Guidance could make 305(b) reports more consistent and useful for setting priorities and for judging accountability.

More complete disclosure of lake water quality information would allow better public review and encourage informed involvement in the decisionmaking process. If lake water quality continues to degrade, the public disclosure would form the basis for holding government accountable in the same manner as for other statutes which protect natural resources. Perhaps this is the new approach to restoration and protection of lake water quality to which Dr. Fritz Bartsch alluded when he addressed the 1980 International Symposium on Restoration of Lakes in Portland, Maine. There he expressed disappointment that nothing new had been offered from 1967 to 1980 to enhance the arsenal of techniques to protect and upgrade lake quality. It may take such a major change in national program direction to make a difference.

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Panelists' Responses

Panelists received an advance draft of the plenary paper. These responses are extracted from their answering papers, which were presented at NALMS's 6th Annual International Symposium. While panelists did debate issues brought up in the foregoing plenary paper, their comments encompass additional facets of the numerical standards issue. Their opinions are presented as given, as befits an open and honest exchange of opinion.

THE DESIRABILITY OF NUMERICAL STANDARDS

For Numerical Standards:

BRUCE BAKER

As a manager of water resources programs for the State of Wisconsin, I will be the first to say that lake management has not received the attention that it deserves. There is no question in my mind that the point source programs developed in the Clean Water Act of 1972 were both necessary and successful. Unfortunately, the cleanup efforts of the 1970's did not recognize the need to develop necessary and effective nonpoint source and lake management programs.

I'm not sure how important it is to determine exactly why these areas still lack proper attention on national and state levels. It seems that it is probably due to a combination of things including the lack of a lake constituency, a less developed state-of-the-art for management techniques, a less visible problem, and regional lake resource differences. Again, the point is not to lay blame but to make sure that this lack of attention is corrected. Lakes need to be given a higher priority on the list of environmental cleanup and protection programs.

I think the paper provides compelling arguments regarding the need for lake water quality standards and I strongly agree that we need them. I don't believe we should be uneasy with the technical difficulties that will confront the establishment of standards. I would argue that we need to make our best scientific judgments just as we are forced to for stream standards. We will never have all the knowledge and data that is desired. The numerical standards should be supplemented with narrative standards such as antidegradation and nonproliferation.

ROBERT C. BAUM

The paper has presented a good case for numerical standards for managing lake and reservoir water quality supported by federal guidance and state adoption of specific standards. I agree with their conclusion concerning the "need for integrating control of point and nonpoint source pollution."

Against Numerical Standards:

D.B. PORCELLA

The water quality of a lake or reservoir is judged by criteria related to what results from the natural situation or to its uses. In more water-enriched climates, nature seems to be the arbiter of the water quality; that is, desirable water quality must result only from the natural conditions that prevail in the lake's ecosystem (geology, hydrology, climate, soil, etc.). In water-short climates, water quality is good if it can meet its uses. When water quality is not suitable, management decisions are made to change some condition or practice to provide proper water quality. The question is how to institutionalize or implement management decisions.

A management perspective is the key to maintaining water quality – and quantity – in lakes and reservoirs. Duda et al. (1986) argue that numerical standards are needed, and that these should be implemented by the U.S. EPA, to achieve the socially and economically significant goal of controlling and restoring the water quality of our nation's lakes. They suggest that these standards could be formulated on an eco-regional basis (Heiskary et al. 1986), but these standards were to be promulgated by U.S. EPA.

In my opinion, such a procedure might be useful to some individual lake systems, but in general will work against management by providing arbitrary objectives.

WATER QUALITY STANDARDS

The major questions are how to control or maintain existing good quality lakes and how to restore the quality of degraded lakes. Duda et al. argue that the key element in managing lakes is with water quality standards.

The use of water quality objectives at a specific lake or a group of lakes with common limnological characteristics is a useful tool. Such objectives serve as a trigger for action, a baseline for comparison of the effectiveness of alternatives, or for a reference point to evaluate management performance.

However, national water quality standards in lakes, even if regionally applied, often fail to reflect differences in local circumstances.

The type of standard also could create problems. For example, a dissolved oxygen standard would not protect against toxicity. A nutrient standard could be adequate in one lake, but because of other morphometric factors not provide adequate protection in a neighboring lake. Thus, arbitrary setting of standards to protect all uses does not appear possible.

Finally, such standards, by the nature of standards, would not reflect the morphometric, hydrologic and other ecological factors that cause lakes to be unique. Why is it important that uniqueness be preserved in lakes and reservoirs? The primary reason is to protect their uses, which range through domestic, industrial, and agricultural water supply to navigation and flood control, to recreation and the appreciation of pristine beauty. In this respect, lakes differ from standard analytical methods where we require uniformity so that we know what someone is measuring (Standard Methods, 1985), or from drinking water standards which protect the overall health of society.

MARK VAN PUTTEN

The National Wildlife Federation agrees that the nation's lakes, in particular the Great Lakes, are not being adequately protected by existing water pollution control programs. In part, this results from the orientation of the Clean Water Act towards controlling point sources of pollution and, in that process, considering only pollution impacts immediately downstream of the point of discharge. However, this is not to say that the Clean Water Act and existing state laws fail entirely to provide the necessary legal authority to protect lakes. Rather, the problem is a failure of political will and an absence of creative thinking on the part of responsible agencies.

IN-LAKE WATER QUALITY STANDARDS

For In-Lake Water Quality Standards:

MARK VAN PUTTEN

We agree with the paper's central thesis that specific, numerical standards for open-lake water quality are needed. Moreover, our reading of the decision by the United States Court of

Appeals for the Seventh Circuit in *Scott* v. *Hammond* is that EPA must require that states develop such standards and that, if the states fail to do so, EPA must develop and enforce these standards.

The paper does not go far enough, however, in discussing some of the important issues implicated by the development of open-lake water quality standards, particularly for an ecosystem as large and complex as the Great Lakes. These issues include: (1) the relationship of water quality standards with other indicators of environmental pollution such as fish consumption advisories; (2) consideration of pollutant interactions in developing standards; (3) the appropriate use (if any) of "mixing zones," especially for persistent toxic substances; and (4) the protection of existing water quality which *exceeds* open-lake water quality standards (i.e., "anti-degradation" and "anti-backsliding" rules).

Concurrent exposure to environmental contaminants. Generally, water quality standards and water quality-based pollutant limits are developed with no consideration of the overall risks to human health and the environment posed by the presence of many pollutants in water or biota. There are a few exceptions, such as Michigan and Minnesota's assumption that the effects of metals are additive. Aside from these rare cases, the impacts of combinations of pollutants on human health and the environment are often overlooked. As a result, developing open-lake numerical water quality standards on a pollutant-by-pollutant basis is inadequate. Some method of predicting the impacts of concurrent exposure to several pollutants present in a lake and its biota must be used in the development of these standards.

Merely saying that data on pollutant combinations or mixtures will be considered where it exists is also inadequate. Few data exist and there are an infinite number of possible, site-specific combinations. Rather, regulatory agencies must develop policy assumptions to be used about concurrent exposures to several pollutants. For example, they should assume, at a minimum, that the risks are additive. This approach has been recommended for carcinogens by the National Research Council and the Royal Academy of Canada, *The Great Lakes Water Quality Agreement, supra* at 65, and by U.S. EPA. In its recently-issued "Guidelines for Carcinogen Risk Assessment," EPA recommended:

In characterizing the risk due to concurrent exposure to several carcinogens, the risks are combined on the basis of additivity unless there is specific information to the contrary. 51 Fed. Reg. 33992, 33999 (Sept. 24, 1986).

Continued progress towards eliminating pollutant discharges. In adopting the 1972 Clean Water Act, Congress rejected the use of water quality standards as the primary means of water pollution control. Instead, the Act calls for the elimination of or continued reduction in pollutant discharges to the extent technologically or economically feasible. Water quality standards serve only as interim goals to be achieved and as benchmarks of our progress towards "zero discharge" of pollutants. The reality of ever actually achieving "zero discharge" is not relevant here – the point is that where water quality better than required by minimum standards **can** be achieved, it **must** be achieved.

The danger in developing numerical, open-lake water quality standards is that they will be used to argue for **increased** pollution of our lakes whenever current concentrations are less than the standard. Similar arguments were unsuccessfully made in 1985 by pulp and paper mills discharging into Wisconsin's Fox River. When one mill closed down, its share of the river's assimilative capacity was unused and dissolved oxygen concentrations in the river exceeded (according to the model) the 5 parts-per-million standard. The remaining mills argued that the unused assimilative capacity should be re-allocated to them, even though they were able to comply with existing permit limits. The National Wildlife Federation filed a formal administrative challenge to these proposed permit modifications and a veto of the proposed permit modifications by EPA Region V finally prevented this "innovation" from occurring.

The stakes for large lakes like the Great Lakes are significant. Concentration-based water quality standards, particularly if the effects of concurrent exposures are ignored, may support an argument that more pollution is acceptable. To counter this argument, and to comply with the Clean Water Act and the Great Lakes Water Quality Agreement of 1978, development of these standards can only occur **simultaneously** with the adoption of stringent "anti-degradation" and "anti-backsliding" rules by the jurisdictions involved. These rules must protect existing water quality which exceeds minimum standards and must prohibit the relaxation of existing permit limits with a few, well-defined exceptions.

Open-lake water quality standards are an important tool for protecting and enhancing water quality. Current federal law authorizes and requires that states develop such standards under the supervision of EPA. However, the development of these standards is not a panacea for protecting and enhancing water quality in lakes. In fact, unless implemented with adequate protection, these standards may actually result in more pollution.

IS FEDERAL, STATE, OR LOCAL CONTROL PREFERABLE?

For Federal Control

BRUCE BAKER

The best way to accomplish the establishment of lake standards is with some national leadership and technical development. The EPA should provide the best available information on standards criteria that then can be used for state standard development.

It must be recognized that standards are only one important element of a comprehensive lake management program. Standards programs must be complemented by monitoring strategies, funding mechanisms, information and education activities, regulatory mechanisms, planning, the establishment of management agencies, nonpoint source programs and further research. There is no question that inlake management techniques need to be combined with land management efforts. Each state will need to develop the proper combination and emphasis to match its problems and lake resources. But, anything less than a comprehensive approach will not be successful and will not be proper resource management. In order to accomplish these things I would propose that the EPA develop a national lake management strategy with assistance from the states and input from interested parties. Such a strategy would be the basis for refining other related environmental programs, the development of state and local programs, and the identification of needed funding and legislation.

For Federal Funding

ROBERT C. BAUM

The National Association of Conservation Districts gives special attention to nonpoint pollution recognizing the relation between nonpoint source pollution and soil erosion. The Association supported continuing the federal funding of $5 million for the Clean Lakes Program. Our position in testimony before the House Agriculture Committee on October 2, regarding the conservation title of the 1985 Farm Bill, was that "the most obvious resource concern facing us is water quality and the effects of nonpoint source pollution. Conservation districts will play a vital role in the implementation of future water quality programs. Current conservation programs go a long way towards reducing soil erosion, which in turn will increase water quantity and quality for all."

The Association was a member of the Clean Water Coalition that petitioned President Reagan to sign the Clean Water Bill to ensure that we continue our progress toward cleaning up America's waters. We were one of 30 national organizations consisting of groups such as the League of Cities, National Association of Counties, Sierra Club and the Water and Waste Management Equipment Manufacturers Association to sign this letter.

For State or Local Control

ROBERT C. BAUM

As many of you know, each conservation district develops its long range goals and objectives. Whether these goals are directed toward streams, rivers, estuaries, groundwater, lakes or reservoirs depends on the local situation and the district's recognition of its water needs and problems. My impression is that the majority of conservation districts in the West have recognized the nonpoint source impact on rivers, lakes and estuaries, and groundwater. Their efforts are mostly in the area of voluntary programs using available incentives such as Soil Conservation Service technical assistance and USDA cost sharing. The need for enforcement by a regulatory agency at the state or county level is being recognized as needed for the small percentage not willing to accept voluntary action.

D.B. PORCELLA

States should develop water quality objectives. The paper provides no examples where national standards could reasonably have aided lake restoration efforts. On the other hand, the authors have developed persuasive arguments that Federal money in the Clean Lakes Program (Section 314, Clean Water Act of 1977) has had remarkable success.

National standards could inhibit local uses of lakes, because some uses conflict. Water is used for different purposes in different parts of the United States where water-short areas contrast with water-rich areas. Furthermore, some recreational uses conflict (speed-boating versus fishing), swimming is not permitted in drinking water reservoirs, aesthetic values (clarity) may conflict with fish production, and hydropower water release schedules may conflict with instream flow needs downstream of the power station. Natural conditions such as depth and climatic conditions can affect whether a standard is achieved or is useful. Shallow lakes often are very productive and eutrophic, and water quality standards cannot be achieved without first deepening the lake. Drought can change conditions sufficiently that water quality standards cannot be achieved. Approaches applicable to streams, such as '7-day, 10-year low flow conditions' are clearly inapplicable (e.g., the loading equation would predict better water quality; Vollenweider 1976).

Let me give some examples of how lake objectives or standards have been individualized in the past. In the Great Lakes, individual lake water quality objectives are given for each of the lakes or subbasins, the phosphorus objective being less stringent in more productive waters (Chapra et al. 1983). These objectives were developed in concert by the individual governmental entities concerned with water quality in the Great Lakes. Thus, a basinwide standard does not exist in the Great Lakes.

Or consider the case of Dillon Reservoir in Colorado. Very stringent standards for phosphorus (0.005 mg P/L) were developed by the local people and applied to protect the high quality waters (Lewis et al. 1983). However, such a standard would probably not be protective of Lake Tahoe or Crater Lake.

In the case of Lake Tahoe, State and local agencies have required the export of all effluents to avoid any point source loading of nutrients. In addition, land use controls and BMP's have been implemented to prevent any nutrient input other than natural. It is noteworthy that no specific nutrient standard exists at Lake Tahoe. Judgments about water quality apply primarily to changes in sensitive indicators of the lake's beauty, e.g., clarity (Secchi depth) and productivity (14-C measurements, chlorophyll a). Success of these measures in limiting the nutrient inputs to the lake appear less related to whether a standard is used than to the will to control all pollutant sources, especially land uses.

In Maine, the State has developed a lake quality standard applicable to all lakes within the state (Scott, 1986). These standards have broad applicability within the state because of relatively uniform hydrologic and climatic, geologic, and biologic conditions. Other states might take a different approach where highly variable conditions exist (Heiskary, et al. 1986).

In conclusion, effective water quality control will be attained by maintaining existing approaches, with States judging water quality in lakes and reservoirs. Thus, States can base water quality requirements on use or on natural conditions, or can develop regional requirements for some lake ecosystems while having specific requirements for individual lakes. The Federal sector should provide guidance to States and matching support for maintenance or restoration of water quality. In my opinion this will provide the best mix of local control, with the constraint of meeting national objectives as defined in P.L. 95-12 Section 101 (Clean Water Act, 1977).

SUGGESTED APPROACHES TO SETTING STANDARDS

For Management Classification

BRUCE BAKER

The paper discusses various alternatives including lake classifi-cation, modeling, inflow or mass balances approaches, and innovative management techniques. I believe that a comprehensive lake standards approach would use all of these elements in proper combination. For example, lake classification systems would establish various categories of lakes and each category would need appropriate and corresponding standards. Lakes should be managed based upon their classifications. Management approaches will be different for wildlife lakes versus recreational lakes. Where appropriate and where resources permit, the standards should be supplemented by modeling, mass balance, inflow limits, and other management techniques.

WATERSHED-BASED STANDARDS

ROBERT C. BAUM

The authors of the paper recognize that lakes and their watersheds are a system and in order to be effective, efforts to restore and protect lake quality must consider pollution sources in the entire drainage basin, upstream from the lake or reservoir. This certainly fits in with the long time recognition by the National Association of Conservation Districts and our member conservation districts of the need for a watershed approach to management of our resources.

Usage Based Decisions

D.B. PORCELLA

Arbitrary standards to protect all uses is not possible. As part of a project to develop multiple uses of reservoirs designed for cooling purposes, Grieb et al. (1983) developed a discriminant model based on fish composition and biomass which used morphometric and nutrient data for lakes with similar characteristics. The model accurately predicted group membership in 85 percent of the 29 cases. The major determinants were phosphorus and volume. These variables agree well with those from previous studies of lakes and fish production. Grieb et al also showed that fish biomass was not affected by the presence of power plants. These kinds of results make a case for management for site-specific objectives, not an overall objective that will have to be arbitrary or nebulous to contain all cases.

The problems of conflicting uses and standards are most apparent in reservoirs. In regard to reservoirs, they usually are built for specific purposes to serve two or three objectives: flood control, power generation, irrigation, or water supply. All of these waters can also serve, secondarily, for recreational and other uses. The primary uses must remain predominant even though the secondary uses are important.

When reservoirs are in the planning stage, it is feasible to construct them to optimize multiple uses (e.g., Porcella et al. 1983). In this case, a management perspective for water quality, recreation, and fish productivity can be built into the new design. Standards have useful application in such cases, providing a reference point to evaluate reservoir management.

Old reservoirs, however, might require expensive retrofitting to meet new standards or uses. In these cases, one must consider the expected water quality of the reservoir based on influent waters, whether in-reservoir processes affect water quality (e.g., manganous and ferrous ion oxidation), and whether inflow–outflow mass flows of material indicate that in-reservoir processes are important or external loadings are important. Costs of managing water quality for secondary uses should be carefully evaluated relative to benefits, and allocated to appropriate beneficiaries. In any case, lakes, old reservoirs, and new reservoirs must be evaluated from a management perspective even if we decide not to impose change, as would be the case with wilderness lakes. Control of pollution sources is probably the most important management task, but some lakes receive naturally high sediment loads and nutrient loads, or have poor quality because they are shallow and cover productive soils. One of the reasons that NALMS exists is to deal with the problem of "natural" water quality problems by using in-lake treatment approaches (Cooke et al. 1986).

In conclusion, effective water quality control will be attained by maintaining existing approaches, with States judging water quality in lakes and reservoirs. Thus, States can base water quality requirements on use or on natural conditions, or can develop regional requirements for some lake ecosystems while having specific requirements for individual lakes. The Federal sector should provide guidance to states and matching support for maintenance or restoration of water quality. In my opinion this will provide the best mix of local control, with the constraint of meeting national objectives as defined in P.L. 95-12 Section 101 (Clean Water Act, 1977).

For Bioaccumulation-Based Standard for Toxicity

MARK VAN PUTTEN

Water quality standards & other pollution indicators. In the Great Lakes, the most significant route of human exposure to environmental toxic contaminants is the consumption of contaminated food products, especially fish. A vivid example of this fact is found in Dr. John Black's September 21, 1983, testimony before the U.S. House of Representatives Subcommittee on Fisheries and Wildlife Conservation and the Environment.

An extreme example is the case of the Great Lakes. The relative importance of the fish versus drinking water in this situation can be a little better appreciated if one considers that given a fish contaminated with PCB at 5 ppm, a human would have to drink Great Lakes water for about 1,000 years in order to equal the amount of PCB that you get in a single one pound serving of these contaminated fish.

EPA has considered bioaccumulation and human consumption of contaminated fish in developing the water quality criteria documents. But, there is no real application of this relationship in developing specific, numerical fish consumption advisories and water quality standards. For example, there is no coordination between the development of fish consumption advisories by the Great Lakes states, FDA, and EPA on the one hand and water quality standards and NPDES permit limits on the other hand.

Since the primary route of human exposure to some toxic substances in the Great Lakes basin is through consuming contaminated fish, the "acceptable" contaminant level **in fish** should be a limiting factor in developing open-lake water quality standards. In other words, standards should be back-calculated from acceptable levels of contaminants in fish and compared to the levels which cannot be exceeded in order to avoid other effects (e.g., toxicity to bird life). The most restrictive of these approaches should determine the standard.

Against a Mixing Zone Concept for Lakes

MARK VAN PUTTEN

The efficacy of water quality standards as a tool for controlling pollution sources depends entirely on where in the lake or river the standards are applied. Historically, EPA has allowed states to grant dischargers some segment of a river (or lake) as a zone of dilution (known as a "mixing zone") in which standards, at least for chronic effects, do not have to be met. The use of mixing zones in this way is not explicitly authorized by the Clean Water Act; nonetheless, it has become a common acceptable practice.

The hydrological characteristics of lakes make it much more difficult to articulate uniform controls on the use of mixing zones for lakes than it is for rivers. For example, with respect to toxic pollutants, Michigan's mixing zone rule prohibits the use of more than 25 percent of a river's flow as a dilution credit in calculating water quality-based permit limits. (Mich. Admin. Code. 323.1082(2)). However, for the Great Lakes and inland lakes, mixing zones are defined on a "case-by-case basis" (Mich. Admin. Code. 323.1082(5)). Thus, the tremendous ability of the Great Lakes to dilute pollutant discharges may result in open-lake standards having no effect on pollutant sources.

In response to this problem, the National Wildlife Federation successfully proposed a revision to Michigan's water quality standards which establishes a presumption against **any** mixing zone for new or increased discharges of toxic substances directly into the Great Lakes (Mich. Admin. Code 323.1098(7)).

In other words, these discharges must meet Michigan's toxic substances standard at the end of the pipe with no credit for dilution; the standard becomes the effluent limit. Only by showing that the persistence and environmental fate charac-teristics of a specific pollutant obviate any concern for its impact on the Lakes or their biota can a discharger obtain a mixing zone.

ADDITIONAL COMMENTS BY OTHER REVIEWERS

These comnments were presented following the Symposium. Once again, comments are presented as given, reflecting the sole opinion of the writer.

IN-LAKE STANDARDS

For Appropriate Durations and Frequencies for Criteria

ELIZABETH SOUTHERLAND

The discussion of in-lake water quality standards should be expanded to include the importance of defining appropriate durations and frequencies for these criteria.

In July 1985, EPA published national water quality criteria that specified durations and frequencies to protect aquatic life from toxicity. The new criteria state that the one-hour average concentration should not exceed the acute criterion more than once every three years on the average and the four-day average concentration should not exceed the chronic criterion more than once every three years on the average. The durations specified in these criteria should be transferable to lakes, but the once-in-three-years frequency may not be adequately protective for lake ecosystems.

Actual field data from lakes that experienced oil spills or some other major toxic discharge indicate that 20 years are required to reach a final state of recovery. (Recovery is defined as greater than 95 percent of the original species being present.) This is a much longer time period than the three years currently specified in the national water quality criteria. If toxic criteria protective of aquatic life are developed for lakes, an appropriate frequency for criteria compliance will have to be defined.

Durations and frequencies will also be needed for in-lake human health criteria. Bioaccumulation of toxicants in fish is much more of a threat in lakes than in free-flowing waterbodies because of lake detention times and sediment-water interactions. National human health criteria currently specify allowable concentrations based on cancer risk and assumed rates of human consumption of contaminated water and fish during a 70 year lifespan. As yet, no durations or frequencies of criteria compliance have been developed for national use. Lake researchers could justifiably initiate this important work since many of the nation's lakes are important sources of drinking water and recreational/commercial fish. Decisions regarding durations and frequencies for human health criteria will have a major impact on the cost and technical feasibility of toxic control strategies.

RICHARD SEDLAK

As the authors propose, the establishment of "in-lake" standards seems to be the most rational approach for achieving clean waters in this country. As noted in the paper, it makes sense for some standards to be nationwide while others should be based on regional considerations. For example, national standards for nutrients do not seem appropriate. Not only does the desired level of water quality vary from region to region, or even lake to lake, as the authors note, but it has been shown that the empirical relationships between nutrients and measures of lake conditions, such as algal production, varies on a regional basis (Pearse, 1984). Recognizing that numerous biological, chemical and physical parameters affect algal growth in any given lake, it is most appropriate that standards be based on direct measurements of end-points, such as chlorophyll *a*, rather than a factor or combination of factors that can affect the endpoint, such as nutrients or water clarity. Trophic state indices or single parameters generally explain only a fraction of the variability in observed algal biomass levels.

POINT/NONPOINT TRADING

For Point/Nonpoint Trading

DAVID K. SABOCK

A number of innovative and alternative approaches for restoration of water quality and pollution prevention were presented in the paper. The case studies for the Great Lakes and Dillon Reservoir identified some of these possibilities. The point-nonpoint sources trading management system is a management strategy that could be adopted throughout the country. This approach, by its very nature, would be cost effective and could be adapted to the specific water quality standards of a particular area.

It may be a good idea for EPA to fund several additional case studies on the Point-Nonpoint Source Trading management approach in order to see if a nationwide program along the same lines would be feasible.

Recently developed EPA ambient water quality advisories for many pesticides, metals, and toxic organics could be utilized to develop water quality limits for lakes.

With a few noteable exceptions (e.g. nutrients, selenium) it appears that existing ambient water quality criteria developed by EPA could be utilized as the basis for lake water quality standards.

MICHAEL G. MORTON

The paper has presented a number of alternative approaches for restoration of water quality and pollution prevention; in particular, the case studies for the Great Lakes and Dillon Reservoir identified some of these possibilities. The point/nonpoint source trading management system could be adapted to the specific local water quality standards throughout the country.

It may be a good idea for the government to fund several additional case studies on the Point/Nonpoint Source Trading management approach in order to see if a nationwide program along the same lines would be feasible.

TECHNOLOGY-BASED APPROACHES

For Technology-Based Controls for Some Pollutants

RICHARD I. SEDLAK

The authors may be underestimating the possible benefits of technology-based standards. In view of the relatively high number of lakes and reservoirs impacted by nonpoint sources, and the relatively lower level of implementation of nonpoint control compared to point source controls, a national effort based on minimum, technology-based standards might be considered in order to make significant advances in the control of the nonpoint pollution. With 29 states reporting widespread agricultural pollution and another 12 reporting localized agricultural pollution (Ass. State Interstate Water Pollut. Control Adminstration, 1984), this may be the category of nonpoint source pollution that would be most appropriately addressed by national, general source standards. Many other nonpoint pollution sources have been identified (urban, mining, land disposed, construction, dams and channels, forests, saltwater intrusion). Although each of these other nonpoint sources has been reported by almost one-half to two-thirds of the states as contributors to water quality problems, these are predominantly localized problems. Therefore, technology-based controls do not seem appropriate for these sources.

For Updating Technology-Based Approaches

WALTER RAST

A strong statement should be made about the biological-availability of pollutants. In past decades, our general technical inability to differentiate between biologically-available and -unavailable forms of a particular pollutant was a primary reason for focusing on the "total" form of the pollutant (e.g., total phosphorus versus dissolved reactive phosphorus). However, we now know enough about many pollutants to at least direct primary control efforts to the sources in the drainage basin which contribute the greatest quantities of the bioavailable forms of the pollutant. Otherwise, scarce funds may be spent to control potentially large quantities of pollutants which actually are of little biological significance in a lake/reservoir. This concern also is appropriate in regard to point-nonpoint source "trading" to meet POTW standards at Dillon and Cherry Creek Reservoirs as an innovative approach case study. Nonpoint nutrient sources can be comprised of a large portion (often the majority) of biologically-unavailable nutrients (see PLUARG, 1978). In contrast, point source nutrients are largely in an immediately available form. Consequently, to suggest they are equivalent on a 1:1 basis for "trading" equivalent pollutants does not seem technically justified.

USAGE-BASED STANDARDS

For a Usage-Based Approach

RICHARD I. SEDLAK

Water quality standards are established to prevent lake conditions that prohibit or limit the desired use. As "not to exceed" standards they are triggers for action. One problem that should be addressed in the paper is the monitoring program that would provide assurances that human health and environmental concerns are protected. For example, the dynamics of algal growth compared to lake nutrient or toxic concentrations suggest that using the endpoint chlorophyll *a* rather than an indicator such as nutrients may be difficult. However, monitoring programs can be designed to determine within a desired degree of certainty whether or not a lake or reservoir has algal levels exceeding a desired limit. Regionwide monitoring assessments that many states have conducted can provide the data needed to understand the regional variability in algal production and appropriate monitoring programs for taking it into account.

Once the desired use of a water body and the related standards have been set, one of the most important issues to be addressed in the water quality management process is settled, i.e., what are the goals? This is a great advantage of the water quality standard approach over the general source control approach which should be noted in the paper. People often find it difficult to establish a goal, particularly when faced with a situation where water use is already impaired. This has led people to start the decisionmaking process by looking at the available technologies, estimating the benefits and costs of each one, and then selecting an option or combination of options that provides a politically or economically attractive solution, but an arbitrary in-flow reduction. The possibility of this occurring would be reduced by first establishing water quality goals.

It seems that the use classification approach described in the paper would be a very important component of the water quality management program in any state or region. It is an approach for directing resources to lakes having the greatest social/economic importance. In the implementation of a water quality standard, these are the lakes that should have a monitoring program in place that can identify with reasonable certainty any impairment in water quality. Estimating attainable water quality conditions is very appropriate. Obviously, it would be unreasonable to set water quality criteria for a lake that cannot be met.

With about 100,000 lakes greater than 100 acres in size scattered around the nation, a rational approach for directing the manpower and financial resources needed to address their problems should be developed. Some prioritizing must be done. As the authors suggest, utilizing region-specific information to understand the ecological impacts of watershed on lakes is an important step in prioritizing the problems and their causes in lakes of any given region. Regional evaluations can provide a preliminary indication of the types and amounts of resources that will be needed as lake-specific studies are completed.

The conclusion that the lake management approaches described in the paper must be combined to achieve CWA goals with in-lake standards serving as a cornerstone is very sound. Perhaps this could be discussed in a little more detail with some logical steps identified, such as follows:

1. Classification of all lakes of social and economic importance in each state with regard to use.

2. Based on the use classification, identify in-lake water quality criteria utilizing endpoint parameters that will permit designated uses in these lakes.

3. Develop routine monitoring programs for these lakes to provide in-lake estimates of the parameters of interest with an acceptable degree of uncertainty.

4. For all lakes of importance, investigate the relationship between watershed pollutant in-flow loads and lake quality. For lakes not meeting criteria, determine attainable water quality.

5. Determine in-flow reductions that are needed to achieve or maintain designated use by achieving or maintaining appropriate water quality standards. Determine in-flow reductions that could occur with each control option.

6. Allow local selection of option or mix of options that meet the mandated water quality criteria for the lake. Allowing tradeoffs to be made between sources of pollutants should result in the most economical controls.

LEADERSHIP

For Federal Leadership

RICHARD I. SEDLAK

The federal role in such a program could consist of many components. A larger effort could be made to integrate the various watershed, river and lake models that the various federal agencies have developed. These models could be formatted for personal computers to increase their accessibility to state and local agencies. As recommended in the paper, the federal government could require schedules for the attainment of the various phases of management program, with federal guidance being available for all phases. The Section 305(b) reports would provide a useful mechanism for the states to report to EPA on the status of their programs which could be set to timetables established by the Agency, as suggested in the paper.

MATTHEW SCOTT

In-lake standards. Under the section "Lake Management Approaches" you mention that "no such office exists for protecting lakes." This is where EPA should be blasted for the meager support of the 314 program and its continued efforts to eliminate funding. We are talking about lakes as a significant water quality resource in the United States and the U.S. EPA does not feel or think that these resources are worthy of protection, in my opinion.

The paper defined "in-lake standards" accurately; however, I must point out that standards such as total phosphorus, chlorophyll *a*, and Secchi depth when used by some people indicate that we can allow degradation downward to these established standards. I don't think we want to encourage some backsliding. This needs to be emphasized somehow. On the other hand using a trophic state index or existing trophic state does not allow backsliding or degradation of water quality.

Your policy implication is on target because no state can develop a lake management protection program without some kind of standards. I also don't see how EPA could fund a state that has no plan or strategy for lake protection. We have just finished our 1986 lake protection strategy for Maine and we plan to present it to Region I. We also do this in part for the biennial 305(b) report for Maine.

My own conclusion is that decisionmakers must be constantly informed of the value of lakes and the U.S. EPA must recognize the need for funding protection programs. It is much more cost effective to protect rather than try to restore lakes.

Finally, I have always felt that funding should be established for states with lakes similar to the Dingle-Johnson program in Fisheries. The formula for allocation of funds could be based on lakes surface area and population of the state. We cannot ignore states that have lots of lakes nor states with high population centers. However, someone has to recognize that the lakes are where they are and people are mobile. There are hundreds of thousands of people who come to Maine each year to utilize our lake resources. The protection of water quality is therefore important to the nation especially in the Northeast.

CRITERIA-BASED APPROACHES

Inflow Criteria Approaches — Phosphorus Bans

RICHARD I. SEDLAK

The section of the paper entitled "In-Lake Standards/Inflow Criteria Approaches — The Great Lakes," contains a biased tone. This contrasts with the rest of the paper where information is provided in a factual, straightforward manner.

The section does not describe the relative in-flow reduction that the various components of the Great Lakes program have achieved. This would be important information to present. Regarding phosphate detergent bans, a number of recent scientific publications have concluded that phosphate detergent bans do not perceptibly improve the water quality of lakes (Maki et al. 1984; Schuettpelz et al. 1982; Lee and Jones, 1986a, 1986b; Lee et al. 1985). The inflow reductions are too small. The paragraph overlooks these findings.

In contrast to the rest of the paper, a significant amount of discussion is presented on the economics of the program, specifically phosphate detergents and point source control, with emphasis placed on the former. The referenced paper by Sonzogni and Heidtke (1986) does not address the environmental or consumer impacts of phosphate detergent bans, and therefore falls short of supporting the statement that detergent phosphate bans have been "quite successful." As background, Sonzogni and Heidtke estimate that the combined savings for chemicals and sludge handling they attribute to phosphate detergent bans range from $0.30 to $2.10/per capita per year (1980 dollars). This range spans the lowest and highest reported savings at treatment plants in ban areas and theoretical savings that the authors estimate.

The authors apply this range to the entire sewered population in the basin, including plants in areas without phosphate bans. More importantly, the authors ignored the very significant impact that waste pickle liquor available at no cost to some of the largest metropolitan areas in the Great Lakes (e.g. Milwaukee, 1 million; Detroit, 6 million) would have on their cost estimates. Therefore, the statement "Up to $30 million in annual treatment costs have been saved in the 5 states due to the laundry detergent ban" is incorrect. Rather, the authors concluded that the savings, based on the mid-1970's sewered U.S. populations in the Great Lakes Basin was likely in the range of $3.2 to $27.4 million, including in the estimate savings for population served by plants not practicing phosphorus removal, plants in non-ban areas (all Great Lakes 8 states), and plants using free waste pickle liquor to remove phosphorus. Taking into account the impact of free pickle liquor at Milwaukee and Detroit alone would reduce this range estimate savings to $1.8 to $21.1 million. Importantly, the authors do not provide any estimate of the **expected** savings.

The paper also characterizes the reduction in phosphorus concentrations of wastewater entering treatment plants as significant. A statement of fact is more appropriate (i.e., a 1.5 mg phosphorus/L reduction as estimated by Sonzogni and Heidtke). The paragraph also reports that "major public cost savings have resulted [from the Maryland phosphate detergent ban]," citing an article by Jones and Hubbard (1986). Although chemical consumption was reported to be less in the post-ban period at a few plants in Maryland, no cost savings were reported in the Jones and Hubbard paper. In fact, at the largest sewage plant looked at by Jones and Hubbard, the Blue Plains plant, the observed reduction in chemical consumption was due to factors other than the ban (Booman and Sedlak, in press).

Finally, the paragraph on phosphate detergents fails to mention the other economic component, i.e., the increased laundering costs borne by consumers in ban areas. These costs have been described in publications (Purchase et al. 1982; Viscusi, 1984) and recently confirmed in government evaluations (U.S. Environ. Prot. Agency, 1983; Anonymous, 1984). The range of average consumer costs estimated in the latter evaluation spanning soft to very hard water is $2.00 to $13.41 per capita per year (1983 dollars). Therefore, the highest observed or theoretical reduction in operating costs that Sonzogni and Heidtke reported to be applicable to phosphate detergent bans is similar to the lowest consumer costs that would be expected to occur. For consumers in hardwater areas, the costs could exceed the range of possible savings by 5 to 45 times. Importantly, the treatment savings would be experienced only by consumers served by sewage treatment plants, and only those removing phosphorus with chemicals. The consumer costs would be experienced across all sewered and nonsewered residents in ban areas.

REGIONAL STANDARDS

For Regional Approach Standards

WALTER RAST

I agree with the focus on the institutional and policy shortcomings in managing U.S. resources. Protection of lake and reservoir resources in the United States likely never will be adequately addressed until this deficiency is corrected. Even the progress in the Great Lakes Basin, often cited as a success story, has occurred more as a result of transboundary treaty obligations (is this an institutional factor?) between the United States and Canada than because of enlightened commitment or foresight on the parts of either government.

It is stated that setting uniform national criteria for lake nutrient levels is not practical because "desirable lake water quality conditions vary." Actually, most people's perceptions of "desirable" lake water quality conditions probably would involve a vision of a beautiful, blue, pristine lake surrounded by a pastoral woods or forest. What really varies is the water quality available to people in different locations. For example, relatively turbid, multiple-use reservoirs are the norm here in Texas. Yet, the Wisconsin/Minnesota-type lakes, which limnology texts discuss in much detail, certainly would be preferable. Unfortunately, the geologic/hydrologic realities here are turbid, relatively warm reservoirs used for multiple purposes, occasionally with extensive stands of old tree trunks sticking out of the water.

I have no particular disagreement with the concept of in-lake standards. However, an in-lake standards approach to U.S. lake/reservoir water quality management will have to be flexible enough to incorporate regional differences in natural water quality in lakes and reservoirs. The differing natural and manaltered characteristics of different geographic regions will dictate general water quality in many cases. Thus, realistic inlake standards should incorporate these regional differences. As an example, chlorophyll or water transparency standards appropriate for lakes in the northcentral United States would not be appropriate for turbid, warm-water Texas reservoirs. The water quality in lakes and reservoirs in both regions may be governable via in-lake standards. However, the standards would have to be specific for the two settings, to reflect different natural water quality conditions and causative factors. Thus, if the paper is suggesting uniform national standards, I don't believe this approach will work.

SIMULATION MODELING

Against Overemphasis On Modeling

WALTER RAST

There is no basis for suggesting that a systems modeling approach is a prerequisite to "rational and intelligent decisions" with respect to lake protection. My (and others') experiences suggest that simpler, empirical modeling approaches, when properly used, often are more useful in lake protection efforts than a simulation modeling approach. This is due in part to the fact that they are more easily understood (misuse notwithstanding) by water quality managers. It also is not clear that it is mandatory to use modeling approaches with the ability to route pollutants from their sources to lakes/reservoirs, identify opportunities for source reduction, provide estimated cost information, etc., to insure effective water pollution control programs. A considerable degree of evaluation of nutrient sources, utility of alternative control programs, and possibilities for lake/reservoir rehabilitation is possible with approaches other than simulation models. This is not to exclude simulation models, but to imply that they are the best or only modeling approach to use is without technical foundation.

My suspicion is that, at least in some cases, individuals may be incorporating sophisticated mathematical procedures into their simulation models under the erroneous belief that such procedures somehow can substitute for actual knowledge of the aquatic system. I'm also not persuaded that the statement that modeling and simulations tools have been "widely accepted" for general use is justified. Simple empirical models are certainly adequate in many cases for evaluating in-lake standards and inflow criteria, as well as for developing appropriate nutrient loading targets.

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Appendix B

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Ad Hoc Task Force on Lake Water Quality Standards

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Appendix C

Survey Questionnaire

Composite of Responses and Annotation

Explanatory Note:

The questionnaire, in the majority of cases, offered the respondent the opportunity to answer a question "Yes" or "No." However, frequently the respondent conditioned the answer with an annotation. Additionally, some of the questions required the respondent to prepare a textual comment. The following pages present a composite of the responses. Where it was possible to simply tally responses, the number in the space associated with the question simply indicates the number of States responding. Symbols such as "#," "*," etc. associated with a question indicate that there is relevant annotation by some State respondents. Immediately following the questionnaire, you will find pages containing the annotation grouped by question and State.

WATER QUALITY STANDARDS FOR LAKES: A SURVEY

This questionnaire has been designed to meet specific goals:

1. Determine the thinking of the states regarding the need for lake/reservoir-specific standards.

2. Gather information relating to existing lake/reservoir water quality standards.

While the questionnaire explores these areas in more detail, we would appreciate your summarizing the following three subjects:

- The priority lake issues in your state

- How lake issues rank in comparison to other water quality management issues

- What help you need from the federal level to deal with your identified problems

Thank you for taking the time to thoughtfully complete this questionnaire.

NORTH AMERICAN LAKE MANAGEMENT SOCIETY
LAKE WATER QUALITY STANDARDS QUESTIONNAIRE

STATE ____________________ PREPARED BY ________________________

TITLE: ____________________________

PHONE: ____________________________

I. Is there a Need for Water Quality Standards Specifically for Lakes?

1. Do you feel your state's existing water quality standards are adequate to protect lake water quality?

   32 Yes * 13 No #

2. Does your state have water quality standards which deal specifically with the eutrophication of lakes?

   24 Yes * 22 No #

Questions #3 -7. Answer only if the answer to Question #2 is "Yes".

3. Have these standards been developed or changed since 1982?

   12 Yes 13 No

4. Are your state standards:

Streams		Lakes
24	Narrative	24
20	Numerical	18

5. If numerical, what form do your lake eutrophication standards take?

   8 one standard for the entire state
   1 regional standards
   8 standards based on lake use
   3 lake specific standards
   1 other ______________________________

6. a) If narrative, is an absolute endpoint specified, or is there flexibility in the standard?

   1 specific endpoint 23 flexibility

b) Please paraphrase the standard ____

____

____

____

7. a) In the presence of specific lake standards, is your state's anti-degradation policy successfully used to prevent a "degrade down to the standard" situation?

16 Yes   4 No

b) Do you see "degrade down to" situations as a potential problem with lake standards?

12 Yes   11 No

Why or why not? ____

____

____

Questions #8 - 10. Answer only if the answer to Question #2 is "No".

8. In the absence of specific lake standards, is your state's anti-degradation policy used successfully to protect high quality lakes?

15 Yes *   11 No #

9. Would there be support for establishing lake standards in your state?

Yes	No	
16	12	Agency
6	19	Legislature
16	20	Public Interest Groups (please list)

____

____

____

10. a) Have there been previous attempts to develop such standards?

6 Yes *   22 No

b) If unsuccessful, which of the following contributed to the failure?

______ low state priority
______ low EPA priority
______ lack of EPA guidance
______ lack of technical data
______ political or public opposition
______ other (specify) ______________________________

11. a) In what way(s) are lake shorelands regulated in your state to protect water quality?

__8__ not at all
__34__ provisions for local ordinances to control development (setbacks, lot size, etc.)
__6__ development controlled by state shoreland law
__21__ more stringent requirements for lakeside on-site wastewater disposal systems
__4__ state regulation of stormwater discharges
____ other (please describe in Question #19)

b) Are these regulations based on lake water quality standards or criteria?

__11__ Yes __31__ No

c) Would improved lake water quality standards promote or enhance shoreland regulation in your state?

__18__ Yes * __20__ No #

12. a) Does your state have broad policies, programs or legislation to protect lake water quality ? (These programs may or may not rely on standards, such as an outright ban on point sources to lakes).

__34__ Yes __12__ No #

b) If yes, please paraphrase ______________________________

c) If yes, do you have special use classifications such as water supply watersheds in North Carolina or Florida's Outstanding Waters Classification to protect special lakes?

__18__ Yes * __19__ No #

13. Do you see a need for developing lake-specific standards, criteria or policy in your state? (Note: For the purposes of this question, Standards are plans including water use classifications, criteria, implementation and enforcement; Criteria are legally enforceable limits not to be violated; and Policy may include discharge bans or other management tools).

Standards	Criteria	Policy
27 Yes	22 Yes	34 Yes
17 No	21 No	9 No

14. Would you like EPA to provide more assistance and support to assist your state in adopting lake water quality standards or revising and improving your existing standards?

22 Yes   24 No

b) What type of assistance would be most useful? ____________________

____

____

15. Do you feel EPA should require states to adopt lake trophic standards or criteria, either as a requirement for participation in the Clean Lakes Program or through some other means?

11 Yes   35 No #

16. Does your state allow:

	Routinely	Occasionally	Rarely	Not at all
a) direct discharges containing any P to lakes	16	9	11	8
b) other direct NPDES discharges	17	12	8	7
c) point discharges with any P upstream of lakes	25	14	5	1
d) other upstream NPDES discharges	29	10	5	1
e) new stormwater discharges to lakes	17	10	7	4
f) herbicide use in lakes	20	17	6	2

17. a) Does enforcement of your standards include non-point sources as well as point sources?

_16_ Yes * _13_ NO # _17_ Sometimes ° (please specify)

____

____

b) If yes, what regulatory framework allows this?

____

____

18. a) Are certain activities (such as agriculture or stormwater) exempted from enforcement under your state's lake or other water quality standards?

_16_ Yes _28_ No

b) If yes, what activities? ______________________________

____

19. GENERAL COMMENTS.(optional) Please provide general information on the strong and weak points of your existing water quality standards and the need for lake-specific standards in your state on the last page of this questionnaire.

II. How Are or Might Lake Standards Be Used?

20. For what purpose(s) are or might lake standards be used in your state? Please mark an "E" to indicate an existing use, or a "P" to indicate a potential use.

_25 E, 13 P_ enforcement
_27 E, 15 P_ permitting (NPDES)
_17 E, 23 P_ setting priorities
_20 E, 11 P_ 401 certifications
_14 E, 22 P_ establishing goals
_23 E, 15 P_ siting new discharges
_12 E, 28 P_ managing cumulative impacts
_10 E, 30 P_ non-point regulatory controls
_14 E, 28 P_ watershed planning
_7 E, 31 P_ allocating lake restoration funds
_20 E, 20 P_ evaluating the attainment of water quality goals of the Clean Water Act (for 305(b) Report)

_____ Other ______________________________________

21. Federal regulations for the Clean Lakes Program (40 CFR Part 35, Subpart H) require that a State upgrade its water quality standards to reflect a higher water quality use classification if the higher use was achieved as a result of a Clean lakes Phase 2 project.

a) Has your state every done this for a lake involved in the Clean Lakes Program or other lake restoration program?

_2_ Yes _44_ No

b) If not, why not?

_____ no case where a higher use classification was achieved
_____ no applicable water quality standards
_____ no guidance or pressure from EPA to do so
_____ other (specify) ____________________

22. If possible, please list three examples where lake standards have been successfully used in reversing or slowing eutrophication in your state. In each example, indicate the standard that was applied.

a) ____________________

____

b) ____________________

____

c) ____________________

____

23. If possible, please list three examples where enforcement action was taken based on violations of lake standards. For each example, indicate the standard, violation, action taken, and results of the action.

a) ____________________

____

b) ____________________

____

c) ____________________

____

24. GENERAL COMMENTS.(optional) Please provide any additional information regarding the existing or potential use of lake standards that might assist states to develop or revise their standards on the past page of this questionnaire.

III. Data Needs for Lake Standards Development and Use

If your state has numerical standards for lakes, please answer all the following questions. Otherwise, please go to Question #29.

25. What trophic parameter(s) is(are) specifically addressed in your lake standards?

 14 total phosphorus
 6 chlorophyll-a
 6 transparency
 14 others ______

26. What information was used to derive your lake standards?

 15 literature values
 12 actual monitoring data
 19 professional judgment
 2 public opinion
 3 other (please specify)

27. To what extent did analysis of available state water quality data factor into the development of your standards?

 4 a lot 12 some 6 very little 2 not at all

28. a) How are your standards enforced?

 19 effluent limits
 3 watershed modeling
 7 predictive lake modeling
 14 actual data collection
 2 no enforcement program

b) Please describe, if possible ______

c) If modeling is used, have your standards been tested and upheld in court?

2 Yes * 12 No #

29. If your state doesn't have standards, is there a sufficient information base available to develop standards?

10 Yes * 35 No # ______ Have Standards °

30. a) What approach(es) do you feel should be used to develop categories for lake standards?

32 special use classifications (e.g. nutrient sensitive waters, drinking water, coldwater fishery)
15 ecoregional comparisons (e.g. agricultural land dominated region vs forest land dominated region)
7 urban influence
19 morphometric considerations
7 no categories - all lakes should be considered similarly

5 other * ______________________________

____

b) Please expand upon why you feel this way ______________________________

____

____

31. a) What criteria should be included in the standards?

28 aquatic biota (list) * ______________________________

39 chemical constituents (list) # ______________________________

19 other ° ______________________________

b) Why? ______________________________

32. What type of standard should or might be used to address sedimentation of lake bays? ______________________________

____

____

33. What type standard should or might be used to address macrophytes?

____

____

____

34. a) What is your state's ability to assess the present trophic status of all its publicly owned lakes?

_10_ Good   _11_ Moderate   _24_ Poor

b) How many lakes are in the state? ________

c) How many lakes have been assessed?

_25_ less than 25%   _5_ 50 - 75%
_8_ 25 - 50%   _8_ 75 - 100%

35. Does your state have statewide lake monitoring programs?

_23_ Yes *   _23_ No #

Question #36. Answer only if the answer to Question #35 was "Yes".

36. If your state has more than one monitoring program, number the programs and answer the following questions for each program, using the identifying number, instead of a check mark, in front of the appropriate answers in parts b) - f).

a) Program name:

1. ____________________

2. ____________________

3. ____________________

b) Is this monitoring

_____ once   _____ once/year   _____ once/month   _____ weekly
_____ other (please specify) ____________________

c) What season of the year?

_____ spring   _____ fall   _____ open water
_____ summer   _____ winter   _____ year-round

d) Does this monitoring include

_____ total phosphorus
_____ chlorophyll-a
_____ Secchi disk transparency
_____ other nutrients
_____ toxic substances

e) What percentage of the state's lakes are included in the program?

_____ 0 - 25% _____ 25-50% _____ 50-75% 75-100 %

f) Are these lakes representative of the range and distribution of trophic levels in your state?

_____ Yes _____ No

37. a) Do you feel your state's monitoring program(s) can/will detect changes in lake trophic status?

24 Yes * 17 No

b) If not, why not? _____

38. a) Has your state detected changing trophic status on any lakes in the past?

27 Yes 12 No

b) If so, please describe _____

39. a) Do you have information that links particular numerical values for any parameter with user perception of lake water quality or with actual impaired uses of lakes?

10 Yes * 32 No #

b) If yes, please describe, including any pertinent citations, in the space provided under VI at the end of this questionnaire.

40. a) Do you have information regarding "threshold" concentrations above which significant changes in algal assemblages or quantities may occur?

11 Yes * 31 No #

b) What are they? ______________________________

____

c) Please attach any pertinent papers or citations.

41. GENERAL COMMENTS. Please provide any additional information relative to the data base used, or available, to develop and implement standards in your state on the last past of this questionnaire.

IV. What About Lake Standards for Toxic Substances?

42. a) Does your state have standards for toxic substances in lakes?

 _39_ Yes * _7_ No #

 b) If yes, are they different from the standards for streams?

 _1_ Yes _38_ No #

43. a) Do you see a need for standards for toxic substances in lakes?

 _33_ Yes* _12_ No

 b) If yes, should they be different from stream standards?

 _2_ Yes _34_ No ____ In some cases

44. a) Does your state monitor for toxic substances in lakes statewide?

 _24_ Yes _22_ No

 b) If yes, which of the following are monitored?

 _13_ water _12_ sediments _22_ fish _4_ other (list)

 ____

 ____

45. Does your state have lakes with known or suspected toxicity problems?

 _18_ Known _15_ Suspected _13_ No

46. Would you like to see more EPA assistance for the development of standards for toxic substances in lakes?

 _23_ Yes _11_ No _12_ No opinion

V. <u>Attachment</u>(optional)

Please attach a copy of your state's current water quality standards and any pertinent policies with the areas that specifically refer to lakes or provide protection for lakes clearly marked.

VI. <u>Additional Comments</u>(optional)

Use this page to complete any questions that needed additional space, or to make any general or additional comments.

Please send your completed questionnaire to:

Mr. Robert Johnson
Tennessee Valley Authority
215 Summer Place Building
Knoxville, Tennessee 37902

<u>THANK YOU</u> for taking the time to complete this questionnaire!!!!!!

Annotated Comments on Questionnaire

Question 1

# Arizona	"Not all lakes."
* Arkansas	"Perhaps not in future."
* Delaware	"Nutrients may be the one exception."
Michigan	"It is difficult to say whether Michigan's standards are, of themselves, adequate to protect lake quality. They appear to be adequate to protect against point source impacts. The basic framework could probably be used to protect against nonpoint source impacts if a sufficient regulatory program were defined and enacted." "More lake-specific standards would only improve the situation if coupled with, and designed to support, broader policies and programs which address major lake impacts. We cannot use standards alone to set priorities and drive our programs, without directing our resources to a 'worst-first' approach which is not appropriate in Michigan."
* New Mexico	"Except all lakes are not currently included."
* New York	"But they could be better."
* Ohio	"All publicly owned Ohio Lakes are designated Exceptional Warmwater Habitat and must meet standards for that use."

Question 2

# California	"Lake Tahoe exception; Clean Lakes Priority List adopted in 1984."
# Louisiana	"Because of the natural eutrophic nature of Louisiana lakes, no specific nutrient standards have been developed. Eutrophication is indirectly controlled by setting lake specific dissolved oxygen criteria in the water quality standard."
* Michigan	"To a limited extent."
# Minnesota	"With the following information."
# Missouri	"Do you mean standards or criteria?"
New Hampshire	"Standards are the same for lakes and streams except for one that deals specifically with phosphorus and lake eutrophication."
* New Jersey	"For certain parameters like D.O., nutrients, etc."
# New Jersey	"For other parameters like sedimentation."
* New Mexico	"Narrative."
* <u>and</u> # Ohio	"Current standards do not account for nutrient and sediment loadings from nonpoint sources. In Ohio, this is probably the major cause of lake eutrophication."

Question 4

New Hampshire	"Same standards for lakes and streams; some are numerical – some are narrative."
New Mexico	"For DO, pH, temp, bacteria."

Question 5

Michigan	"Dissolved oxygen standard is divided by warmwater/coldwater fisheries."
Minnesota	"Nuisance conditions prohibited as primarily related to point sources, and nondegradation of 'Outstanding Resource Value Waters' re: Boundary Waters Canoe Area (BWCA)."
North Carolina	"Except for designated trout waters."

Question 6(b)

Arkansas	"Limit on oxygen demanding discharges to 10/15 (BOD/TSS) in most lakes/reservoirs."
Arizona	"Uses shall be maintained and protected. No further degradation which would interfere with or become injurious to uses is allowable."
Connecticut	"Classifications describe use goals, trophic classifications describe water quality conditions. Goals are to protect and improve through implementation of watershed management and lake management."
Florida	"Discharge of nutrients shall be limited as needed to prevent violations of other water quality standards. Nutrient concentrations shall not cause an unbalance in natural populations of aquatic fish or fauna, numerical standards for dissolved oxygen, turbidity."
Illinois	"(1) Prohibition of unnatural sludge, bottom deposits, floatable substances, unnatural plant or algal growth, or unnatural color or turbidity; (2) Phosphorus as P shall not exceed 0.05 mg/L in any lake with a surface area of 20 acres or more or in any stream at the point where it enters any such lake (General Use Water Quality Standards); Effluent Standard: 1.0 mg/L phosphorous as P for all sources of 1500 or more P.E. upstream of lakes with surface areas of 20 acres or more.*" "*Proposed revision before Pollution Control Board limits applicability to discharges of 2500 or more P.E. within 25 miles of a lake of 20 or more surface acres."
Kentucky	"Ability to control dischargers in waters designated as nutrient limited."
Maine	"That there shall not be allowed any increase in trophic state from cultural activity."
Massachusetts	"No new point source discharges of nutrients to lakes/ponds."
Michigan	"Plant nutrients limited to extent necessary to prevent stimulation of plant growth to injurious levels. Dissolved oxygen limits set. All lakes protected for total body contact recreation. Antidegradation clause."

Minnesota	"(1) No sewage, industrial waste, or other wastes, shall be discharged into waters of the State so as to cause nuisance conditions. (2) Nondegradation of outstanding resource value waters such as BWCA, Scientific Areas, and Wild River Segments, etc."
Montana	"Discharges shall not create conditions which produce undesirable aquatic life."
Nebraska	"Chapter 4, paragraph 005. To be aesthetically acceptable, waters shall be free from human induced pollution which causes: 1) noxious odors; (2) floating, suspended, colloidal, or settleable materials that produce objectionable films, colors, turbidity, or deposits; and 3) the occurrence of undesirable or nuisance aquatic life (e.g., algal bloom). . . ."
Nevada	"Target mean summer chlorophyll *a*; total phosphorus."
New Hampshire	"No new point discharge of phosphorus to lakes and no new discharge of phosphorus to tributaries of lakes that would encourage eutrophication (.0115 mg/L in lake)."
New Jersey	"No thermal alteration except where shown to be beneficial to designated and existing uses. Heat dissipation areas developed on a case-by-case basis." "Suspended solids – none which would render the waters unsuitable for the designated uses." "Floating, colloidal, color and settleable solids – none noticeable or in quantities detrimental to natural biota. None which would render the waters unsuitable for the designated uses."
New Mexico	"General standards also apply, i.e., narrative standards for oil, color and taste of fish, nutrients, hazardous substances, radioactivity, pathogens, turbidity." "Varies by designated use, but specifies DO, pH, temperature, turbidity, fecal coliform bacteria; open water shall be free of algae which cause gastrointestinal or skin disorders or nuisance conditions."
North Carolina	"Standard for Chl *a* – not greater than 40 ug/l for lakes, reservoirs, and slow-moving waters. Not greater than 15ug/l in waters designated as trout waters. Not applicable to lakes or reservoirs less than 10 ac. in size. Turbidity not to exceed 25 NTUs due to a discharge, 10 in trout waters. NSW – Nutrient Sensitive Waters – no increase in nutrients over background levels unless it is the result of natural variations or would render economic hardship."
Ohio	"Publicly owned lakes shall be free from nutrients entering the waters as a result of human activity in concentrations that create nuisance growths of aquatic weeds and algae. In areas where such nuisance growths exist, phosphorus discharges from point sources shall not exceed 1 mg/L."
Puerto Rico	"Total phosphorous shall not exceed 1 ppm, except when demonstrated to the Board that higher concentration in combination with prevailing nitrogen will not contribute to eutrophic conditions."
South Carolina	"Direct discharges from waste treatment facilities to lakes shall be prohibited unless the nutrient level discharged will not adversely affect water quality conditions and will maintain classified and existing uses."

South Dakota	"No discharge to lakes allowed which causes nuisance aquatic life to form impair, beneficial uses or cause a health problem."
Washington	"Washington has Lake Class criteria that establish specific limits for bacteria, dissolved oxygen, total dissolved gas, turbidity, and toxics. The standards, however, do not deal specifically with eutrophication in that they do not include nutrient or TSI criteria."
Wyoming	"No degradation to the extent which designated uses are impaired."

Question 7(a)

Arkansas	"In some cases."
Arizona	"Implementation policy not fully developed."
Michigan	"Our standards are not really specific enough to answer this."
New Mexico	"Yes, for point sources; No, for nonpoint sources because BMP implementation is voluntary."
South Carolina	"No occasion to use."

Question 7(b)

Connecticut	"There is no minimum acceptable standard. Goals are to protect and restore; each lake would have a different numerical goal."
Illinois	"If not properly regulated, new or increased waste loads can potentially degrade lake environments significantly to the point of impairing or eliminating some lake uses."
Kentucky	"Its a natural consequence of regulatory agencies to manage this way, its how we allocate allowable loadings to streams, we allow degradation down to a set limit based on stream use criteria."
Maine	"You will never improve water quality if you allow a downgrade."
Massachusetts	"Lakes are given a high level of protection from point source discharges."
Michigan	"If we rely too much on standards in setting management priorities, we may fail to aggressively protect lakes which appear to meet standards. A strong antidegradation rule is needed."
Minnesota	"The common perception is that standards tend to be thresholds or boundaries not to be exceeded."
Missouri	"Very little evidence to indicate that a 'loss' of a designated beneficial use could occur, considering physical characteristics of our 'lakes.'"
Nebraska	"We have not applied anti-degradation to lakes other than a specific problem with D.O. from a hydroelectric facility. Point source discharges are prohibited on lakes."
Nevada	"In some instances fisheries are enhanced by increased production – CHL *a*."
New Hampshire	"It could be – but we would argue that anti-degradation doesn't allow it."

New Jersey	"It is always a potential problem since you must keep track of each incremental load placed on the waterway. Any failure to keep track of changes over time or to define some total allowable change raises the potential for 'degrade down to' situations."
New Mexico	"Antidegradation policy applies to lakes and decisions are made on a case-by-case basis."
North Carolina	"Our anti-degradation policy is not necessarily limited to specific standards, it also encompasses biological responses. Please see attached standards which also contain anti-degradation policy."
Ohio	"All publicly owned Ohio lakes are considered State Resource Waters to which Ohio's Antidegradation Policy applies therefore present ambient water quality will not be degraded."
Oklahoma	"But not in our State due to anti-degradation policy."
Oregon	"No discharges allowed in lakes. Nonpoint sources are the major problem and we are working to minimize those."
Pennsylvania	"Would not make any difference whether specific numerical standards apply."
Puerto Rico	"'Degrade down to' situations introduce an unnecessary flexibility which adversely affects lakes that exceed the quality required by the standard."
South Carolina	"If problem, then standards are not stringent enough."
South Dakota	"Because cumulative effects are not considered or apparent for long time."
Utah	"We have no antidegradation policy."
Wyoming	"Complete reversal of past philosophy of water pollution control."

Question 8

* Alabama	"So far."
Kansas	"Has not been used at all."
* Louisiana	"The antidegradation policy applies equally to lakes as well as streams."
# Minnesota	"Except for outstanding resource value lakes."
* New York	"The policy is most successful where specific lakes or groups of lakes are protected by law (Adirondack Park, Lake George, etc.)"
* Rhode Island	"Expect it to be successful – untested so far."
Texas	"Sometimes – in conjunction with lake specific discharge regulations for nutrients"
# Wisconsin	"The antidegradation policy has been used in specific instances to protect lakes; however, its universal application has not been implemented successfully."

Question 9

Alaska	"Environmental/conservation groups; native organizations."
Delaware	"Bass Anglers Sportsman Society/Delaware Natural Education Society."
Florida	"Audubon, Sierra Club, few lake associations."
Idaho	"Idaho Conservation League, Clarkfork Coalition, Idaho Wildlife Federation, numerous local lake associations."
Louisiana	"The level of support for establishing lake standards by other groups is unknown at this time."
Missouri	"We have 'criteria' for all classified waters, but no nutrient criteria for streams or lakes."
New Jersey	"New Jersey Coalition of Lake Associations."
New York	"Federation of Lake Associations of New York."
North Dakota	"Lake associations, cities (if the funds are provided)."
Ohio	"Ohio Lake Management Society; Ohio Lakes Community Association."
Oregon	"Oregon Environmental Council."
Rhode Island	"Undermanned--dealing with new standards for special cases is difficult without the personnel. One person in planning for State; one person in water quality standards for State."
Texas	"Pro and con interests in all three groups."
Vermont	"Vermont Natural Resources Council, local lake associations."
Virginia	"Virginia Lakes Association."
Washington	"Washington Lake Protection Association, Washington Environmental Council."
Western Caroline Islands	"Palau Cultural and Historical Preservation, Marine Resources, Tourist Commission."
Wisconsin	"Wisconsin Association of Lake Districts, Wisconsin Federation of Lakes (Associations)."

Question 10(a)

* Louisiana	"One study of Louisiana lakes and reservoirs identifies Louisiana lakes as being largely eutrophic by conventional standards yet supporting good to excellent sport fishing in most cases. A condition index system based on T.O.C. was identified as showing promise for possible water quality standards development but more study is needed."
* Vermont	"But no strong attempt."

Question 10(b)

Louisiana	"We do not consider the lack of lake-specific water quality standards as a failure to protect lake water quality. Lack of lake specific standards at this time simply reflects the difficulty in developing defensible water quality standards."
Rhode Island	"(Construction/development lobby extremely powerful in state legislature.)"
Vermont	"Lack of a process to determine practical standards."
Wisconsin	"Lack of technical 'desire.'"

Question 11(a)

Kansas	"<u>Re</u>: on site wastewater disposal system—really ineffective/impractical."
Louisiana	"Various states and local agencies probably have regulations dealing with the protection of lake shorelines. At present, no single State agency monitors these lake regulatory agencies."
Michigan	"Construction along the land/water interface is regulated by the State. Construction in wetlands is also regulated to protect wetlands."
Minnesota	"Phosphorus detergent ban and phosphorus limits for point sources affecting lakes and reservoirs."
Missouri	"Certain size of county can have planning and zoning." "Stricter effluent limitations (10 CSR 20 - 7.015), not septic tanks though."
North Carolina	"Except for some water supply lakes."
Nevada	"(For Lake Tahoe only.)"
New Mexico	"Not at all. Our reservoirs fluctuate considerably—used for flood control."
Ohio	"Any activity resulting in a discharge to surface waters of the State requires a Section 401 Water Quality Certification, certifying that the activity will not violate the State Water Quality Standards."
Rhode Island	"(Wetlands permit) + RIPDES—point source illegal onshore except runoff. Locals can develop ISDS maintenance regulations, etc., under recent enabling legislation."
South Carolina	"Lake owners regulate to some extent, especially utility-owned reservoirs."
Utah	"Corps of Engineers system 404 permits."
Vermont	"A permit program for alteration of lands under public waters—includes shorelines <u>below</u> the mean water level."

Question 11(b)

Louisiana	"Unknown."

Question 11(c)

	Arkansas	"Possibly."
#	Iowa	"Not unless controls on urban and NP runoff were to be implemented."
*	Kansas	"But would be a battle to enact."
	Louisiana	We are not certain at this time that specific lake water quality standards alone would promote or enhance shoreline regulation."
	Michigan	"Maybe."
#	Rhode Island	"Main problem NPS (old sediments in impoundments)--plus ISDS failures or substandard or density of housing/ISDS in area plus watertables high."

Question 12(a)

#	Nevada	"(Lake Tahoe only.)"
#	New York	"Case by case and regional policies (Adirondack Park, NYC Reservoirs, Great Lakes, etc.)"
	Pennsylvania	"We have an anti-degradation regulation which provides for special protection for specific waterbodies."

Question 12(b)

Alaska	"Toxics, turbidity, pH, etc. protected through water quality standards."
Arizona	"Water quality standards with specific numeric limits."
California	"State law, policies, and programs are designed to protect all waters of the State including lakes. Except for Lake Tahoe, lakes are not given special attention."
Connecticut	"Most recreational lakes are Class A waters, do not receive point source wastewater discharges."
Florida	"Effluent limits for point sources; Phosphate detergent ban; Stormwater regulations; Surface Water Improvement/Management Act of 1987."
Idaho	"The State water quality standards include narrative statements prohibiting introduction of hazardous, deleterious or radioactive materials into State waters and State statutes prohibit creation of nuisance conditions."
Illinois	"The Illinois Environmental Protection Act mandates programs to restore, protect, and enhance the quality of the environment."
Iowa	"Direct discharge into natural or artificial State-owned lakes is prohibited (455B.186)."
Kentucky	"Specific State legislation prohibiting direct discharges into one particular lake."

Louisiana	"The Louisiana Water Quality Standards apply equally to all waters of the State which includes both streams and lakes. As such, lake water quality is both broadly and specifically protected by the Water Quality Standards."
Maine	"There shall be no direct discharges to Maine Lakes."
Maryland	"Nutrient control policy to protect lake water quality where deemed necessary (many of our lakes are located in State parks where land use and activities are controlled). Also, outright ban on new point sources to Baltimore City reservoirs."
Michigan	"Detergent phosphorus ban. Antidegradation clause in standards, which designates all inland lakes as 'protected waters.'"
Minnesota	"(1) Phosphorus detergent ban (which does not include industrial cleaners nor domestic dishwashing soaps). (2) Where discharge affects lakes, removal of nutrients from wastes shall be provided. (3) Nondegradation of outstanding resource value waters."
Missouri	"Missouri Clean Water Law gives authority to protect beneficial uses."
Montana	"Waters whose quality is higher than the standards must be maintained at that high quality unless—provisions for lowering after extensive public involvement."
Nebraska	"Chapter 7, paragraph 003—No discharge of effluents from domestic, municipal, or industrial sources will be allowed into 'lakes.'"
New Hampshire	"We have whole host of laws and regulations protecting lakes (and other surface waters)—from both point and nonpoint sources. Can't paraphrase on four lines."
New Mexico	"We have never permitted point source discharges to lakes."
North Carolina	"Recently, North Carolina has legislated a Phosphorus Detergent Ban and we have adopted a classification called Nutrient Sensitive Waters (NSW) which allows the State to regulate nutrients discharged into these waters. Furthermore, our classification system recognizes specific types of water supply watersheds, some with a higher level of protection."
Ohio	"Ohio has a State Lakes Policy that establishes effluent limitations for new point source discharges to publicly owned lakes or reservoirs that comply with the requirement of Ohio's Water Quality Standards as well as prevent degradation of these multi-use systems."
Oklahoma	"But standards are not very stringent."
Oregon	"Overall protection through water quality standards, antidegradation policy, nonpoint source program, no discharge into lakes policy."
Rhode Island	"No surface (point) discharges normally allowed to lakes. All discharges to rivers must be permitted (RIPDES), ISDS must be approved by RIDEM, Land Resources division regulations. NPS controls program being developed under EPA 205(j)(5)."

South Carolina	"Class AA, a class for outstanding recreational or ecological waters or waters used for water supply with minimal treatment, prohibits point source discharges to these waters – lakes may be Class AA."
South Dakota	"Discharges to lakes are not allowed mixing zone. Effluents shall meet standards at point of discharge. No materials may be discharged or caused to be discharged into any lake or stream in concentrations which produce [nuisance] aquatic life, impair beneficial uses or create a health problem."
Tennessee	"Commissioner is mandated to not allow any activity that causes the condition of pollution (alteration of chemical, biological, physical, or radiological properties of water). Agricultural and forestry activities are exempted from regulation."
Texas	"(1) Statewide requirement for advanced treatment of sewage discharges within 5 miles of water supply reservoirs."
	"(2) Extensive sampling and analysis programs for selected reservoirs to determine need for reservoir-specific nutrient controls."
	"(3) Proposed toxic standards."
	"(4) Proposed expansion of antidegradation policy."
Vermont	"(1) Cannot discharge > 1.0 mg/L total phosphorus directly to Lake Champlain or other designated areas."
	"(2) Outstanding Resource Water designation (no lakes so designated yet)."
Virginia	"Protection of beneficial uses of surface waters, regulate thermal discharges into lakes and impoundments, standards for surface water supplies."
Washington	"Washington has a strong grant program designed to encourage the protection and restoration of lakes."
Wisconsin	"Under general water quality protection laws, water quality is afforded protection. However, the direct implementation of lake quality protection is limited by specific authorizations and budgets."

Question 12(c)

# California	"Except in Lake Tahoe basin."
* Illinois	"Public water supply vs general use."
* Kentucky	"We have an outstanding resource water use designation."
# Louisiana	"There are no special lakes classifications in Louisiana."
* Missouri	"Missouri has outstanding waters classification, but no 'lakes' are on the list."
# Rhode Island	"Normal water quality standards classifications."
* Vermont	"(No lakes) so designated yet."

Question 13

Louisiana	"Lake specific criteria are in place in the present Water Quality Standards for $C^{1,}$ SO_4, pH, bacteria, Temp and TDS. These criteria are in place to protect several water uses including section 101 uses of the Clean Water Act."
Maine	"We already have all three."
Pennsylvania	"We have a lake management program."
Rhode Island	"Policy already in place for point source."

Question 14(b)

Arizona	"There is a need for an office to deal with wetlands in the water quality criteria/standards group at EPA Headquarters."
Delaware	"Technology transfer for management of shallow, small lakes."
Florida	"Funds for monitoring to collect data (esp. N, P, Chl *a*) needed to set lake standards. Technical assistance/funds for restoration/preservation projects."
Idaho	"Technical assistance and funding."
Louisiana	"Studies of lake specific nutrient conditions including seasonal fluctuations and possible distinctions between man-made and natural nutrient fractions in water."
Michigan	"Technical guidance-information transfer between States. Financial assistance."
Minnesota	"Continuation of the excellent assistance of Phil Larson, Jim Omernik and support of the Ecoregion Development by Region V."
Nebraska	"Guidance on regulating nonpoint source and guidance on acceptable concentrations of toxics in sediment."
Nevada	"Eutrophication (CHL *a* criteria); toxics such as unionized ammonia."
New Jersey	"Identifying deficiencies and suggesting revisions. Identifying key parameters to protect lakes and recommending criteria/policy."
New Mexico	"Continuing financial support for the Clean Lakes Program."
New York	"$$."
North Carolina	"Technical assistance in determining problems and supporting management decisions. For example, analysis of AGPT (algal growth potential), data collection support (by funding collection programs) and by providing water quality criteria specifically addressing lakes not just streams."
North Dakota	"Funds with no strings attached."
Ohio	"Funding."
Oregon	"Guidelines on how to approach evaluating standards to be used in lakes, enforcement procedures, etc."

Pennsylvania	"Our standards were only recently adopted (1985). We are still in the process of evaluating effectiveness."
Puerto Rico	"Guidance on artificial lake (reservoir) dynamics."
Rhode Island	"$$ for increased monitoring of present water quality conditions in lakes statewide."
South Carolina	"Technical guidance on specific criteria and justification for these criteria."
South Dakota	"Research assistance, monetary or otherwise to determine standards and criteria, literature."
Tennessee	"Technical and financial."
Vermont	"Suggestions on anti-degradation clauses with teeth. Assistance with ways to deal with cumulative impact."
Virginia	"Review of proposed standard for designation of nutrient enriched waters."
Washington	"Research concerning appropriate lake standards or criteria that consider regional and geographical differences."
West Virginia	"BAT determination and defense. Our lakes are impoundments which have many characteristics of both streams and lakes."
Western Caroline Islands	"Guidelines."
Wisconsin	"Specific program requirements to increase agency priority. Coordination of information sharing possibilities amongst States."

Question 15

# Kansas	"No, Please! - every State and lake is different, you can't make lakes in Kansas w/TSI 50!"
# Louisiana	"No requirements for adopting Water Quality Standard should be made until evidence and data is clearly available to develop them."
# Rhode Island	"Eutrophication very difficult to reverse and <u>very</u> expensive and <u>not</u> guaranteed to be long-term correction after all the expense. Need to prioritize problem lakes and deal with those having problem that is amenable to correction (e.g., ISDS failures in small watershed area.)"

Question 16

Illinois	"Tries to discourage through planning, grants, and permitting process, but no regulations or policy prohibiting."
Kansas	"(a) If wasteload allocation/modeling doesn't project problems."
	"(e) Hasn't occurred yet, but could."
	"(f) Public water supplies are controlled."
Kentucky	"(a) With conditions (hypolimnetic release)."
	"(e) These are permitted with condition."

Michigan	"(b) An assessment of this activity has never been made to determine numbers issued, denied, or modified."
Maryland	"(a & c) Where nutrient control policy in effect, P controlled to limits of technology."
	"(f) Requires State-approved permit."
Massachusetts	"(a) Existing only."
Montana	"(a, b, e) We have none, may allow some sometime."
Nebraska	"(a, b) Sources discharging prior to May 10, 1982 are grandfathered."
	"(e) Have not exercised authority or clarified if we have authority."
New Mexico	(f) General standards, which also apply to lakes, address herbicides."
Rhode Island	"(c) Almost all lakes in Rhode Island are artificial impoundments from textile industry period 1800-1900's."
South Carolina	"(e) State doesn't regulate."

Question 17(a)

o Alabama	"Certain agricultural, mining, construction, and timber-harvesting practices are managed as needed."
* Arizona	"Law is in effect, but rules still need to be developed."
o California	"There is a major program to control nonpoint sources of nutrients to Lake Tahoe. Control measures on silviculture also occasionally benefit lakes."
o Delaware	"Certain basins with 'high value' waters. Certain NPS with severe problems."
o Idaho	"Only for those nonpoint source activities where there is a regulatory requirement to use prescribed BMP's."
Illinois	"If a water quality standard violation can be documented to result from a nonpoint source, that activity is subject to enforcement."
o Kansas	"A voluntary program, needs development."
# Kentucky	"We have not used our present standards in an enforcement case; however, we have no enforceable mechanism to control nonpoint sources."
# Louisiana	No specific regulatory mechanism exists at present for nonpoint sources."
# Massachusetts	"NPS is mentioned in regard to BMPs."
# Michigan	"Except for impacts on dissolved oxygen levels in streams and Great Lakes only. Antidegradation rule could be used if appropriate regulatory framework enacted."
o Minnesota	"There are rules pertaining to feedlots."
* Missouri	"Beneficial use impairment would be the key."

o	Montana	"We are stumbling into nonpoint enforcement."
o	Nebraska	"If you include hydroelectric pass-thru of low D.O. water in the definition of nonpoint (8th Circuit ruled it not a point source). We have also attempted to enforce on fish kills where pesticide runoff appeared responsible."
*	New Hampshire	"Primarily turbidity from construction, logging, etc."
o	New Hampshire	"Primarily turbidity from construction, logging, etc."
	New Mexico	"Our standards are not enforced."
#	North Carolina	"Although our water quality standards do pertain to nonpoint sources, there are no practical methods of enforcement of these standards. The regulatory framework for this enforcement is so weak that nonpoint standards do not practically exist."
o	North Dakota	"Clean lakes projects or watershed improvement projects involving nonpoint (205)."
#	Oklahoma	"The potential for enforcement is provided."
o	Oregon	"Chapter 102 – Erosion and Sedimentation Control applied to search moving activities including agriculture."
o	Rhode Island	"Some cooperative work with Rhode Island Department of Transportation on stormwater/road runoff catch basins/BMP on case-by-case basis plus permit required if impacts wetlands on <u>any</u> project."
	South Dakota	"Use of State erosion control act dependent on complaint."
o	Tennessee	"Some construction and stormwater runoff sites are regulated."
	Texas	"Standards do not exempt nonpoint sources, but for practical application, enforcement primarily focuses on permitted effluent parameters, which are based on instream standards."
o	Utah	"In specific management plan."
o	Vermont	"Agricultural and silvicultural nonpoint sources exempted. <u>If</u> they are conducted according to accepted practices <u>and</u> do not result in an undue adverse effect on values/uses of cause irreversible damage."

Question 17(b)

Alabama	"State water pollution control statute."
Alaska	"Water quality standards."
Arizona	"A.R.A. Sections 49-246, 49-247, and 49-203.A.3."
California	"State water quality control plans contain broad controls on all sources of pollution. Also MBP approved pursuant to Section 208 of CWA."
Connecticut	"State law requires erosion control plan for new construction on sites greater than one acre."

Delaware	"Water Quality Standards, Regulations governing control of water pollution."
Florida	"Statewide stormwater and on-site wastewater regulations that are tied to water quality standards."
Illinois	"State statutes."
Maine	"Site selection law; Farm policy; Great Ponds Act."
Maryland	"Water Quality Regulations."
Minnesota	"Feedlot permitting program which covers some of the estimated 90,000 feedlots."
Missouri	"Missouri Clean Water Law, Chapter 644 RsMo."
Montana	"Montana water quality AC – Montana water quality standards."
Nebraska	"Direct enforcement of Surface Water Quality Standards via Administrative Orders, etc."
New Hampshire	"Requires permit."
North Dakota	"Feedlot regulations."
Oregon	"Nonpoint source program; business management practices."
Puerto Rico	"Major nonpoint problem is livestock enterprises. Enforcement is done under broad quasi-judicial Authority of State Environmental Public Policy Act of 1970, as amended."
Rhode Island	"RIPDES, wetlands permits."
South Carolina	"State Pollution Control Act."
Tennessee	"State law."
Washington	"Washington Water Pollution Control Laws."
West Virginia	"Visual pollution such as sludge banks or color are prohibited in our water quality regulations."
Wyoming	"Water Quality Standards are adopted as regulations which are enforceable."

Question 18(a)

Florida	Answered "no" but clarified – "Certain activities (i.e., Agriculture) may be exempt from permitting but all discharges must not cause or contribute to water quality violations and are subject to enforcement (in theory anyway)."
Rhode Island	Answered "no" – "If direct discharge."

Question 18(b)

Arizona	"Irrigation return flows to canals if the only protected use is agricultural irrigation."
Arkansas	"Many nonpoint source controls are voluntary programs only."
Connecticut	"Man's normal use of the land, provided reasonable are used – agriculture, roadway runoff."
Delaware	"In general, most NPSs are not regulated. Developing stormwater regulations."
Florida	"Certain activities (i.e., agriculture) may be exempt from permitting but all discharges must not cause or contribute to water quality violations and are subject to enforcement (in theory anyway)."
Idaho	"Agriculture, injection wells."
Illinois	"Mining operations under certain circumstances"
Iowa	"Agriculture related runoff, urban stormwater."
Kentucky	No. "We have a voluntary nonpoint source program but have taken enforcement action on concentrated feedlot discharges."
Michigan	"While not specifically exempted, most nonpoint sources are not addressed by standards. Agriculture, silviculture, and mining are exempt under some other State regulatory statutes."
Montana	"Conditions resulting from runoff or percolation from developed land where all reasonable soil and water conservation practices have been applied are natural."
New Jersey	"Certain agricultural activities in certain areas."
New Mexico	"Exemptions could occur on a case-by-case basis."
New York	"Herbicide treatment, NPS, but both may change in 1988."
North Carolina	"Exempted by NPDES, not State specifically exempted; however, the Agricultural Department has been designated as the agency responsible for pesticide use enforcement."
North Dakota	"Agricultural or stormwater – nonpoint."
Ohio	"Temporary exemptions due to dredging or construction activities authorized by the Army Corps of Engineers and/or Ohio EPA 401 water quality certification."
Oklahoma	"Routine agricultural, forestry and oil, and gas development activities are exempted by law from consideration of impacts on the quality of sediments."
Tennessee	"Agricultural and forestry nonpoint pollution."
Vermont	"Agriculture, silviculture and stormwater exempt from water quality criteria, but cannot cause an undue adverse effect."

Question 19

Arizona	"A) Grazing management programs by USFS and BLM."
	"B) There is a need for protection by a wetlands/riparian system approach."
Delaware	"Standards do not address eutrophication of lakes."
Massachusetts	"Without specific standards there is flexibility in determining site specific problems."
Vermont	"Weaknesses: Anti-degradation clause is very general and weak. Does not prohibit degradation. No provision for dealing with the cumulative impact of individual discharges. Discharges are allowed to lakes unless cause 'undue adverse affect.' Drainage basins 300 acres unregulated except if significant values/uses not normally found are threatened."
	"Strengths: Indirect discharges are regulated."
Washington	"Washington lake standards are weak in that they do not contain criteria that pertain to trophic status. Before a standard(s) can be established, a statewide monitoring program is needed in order to establish the trophic status of most publicly owned lakes. Establishing a standard with our weak data base would be putting the cart before the horse."
West Virginia	"West Virginia has only one natural lake, trout pond. This small water body is only 1.5 acres. Practically speaking, all of our 'lake acres' are impoundments (16,158 acres total). The vast majority of these acres are US Army Corps of Engineers projects when the shoreline is federally owned."

Question 20

Florida	Other—"All of the above include E or P. However, more definitive lake standards would make the system more effective."
Minnesota	Managing cumulative impacts – "P – very important."
	Other—"Implementation of State funded nonpoint abatement programs/ protection programs."

Question 21(a)

Louisiana	"No Louisiana Lakes have been lowered to a lesser use classification therefore no 'upgrading' of State Water Quality Standards has been necessary."
Rhode Island	"No Phase II completed yet."

Question 21(b)

Alabama	"Have not participated to any degree in clean lakes program."
Alaska	"We've never done a clean lakes phase."
Arizona	"No funded clean lakes projects."
Delaware	"No Phase 2."

Kansas	"Already had high use classification."
Kentucky	"No Phase 2 projects awarded."
Louisiana	". . . or justification at this time"
Michigan	"All inland lakes in Michigan are protected for total body contact recreation."
Nebraska	"We have not had a Clean Lakes Phase 1 or 2."
New Mexico	"No Phase 2 projects."
New York	"Other, lakes often did not meet existing classification prior to restoration."
Ohio	"No Phase 2 projects in Ohio."
Pennsylvania	"Have not had any Phase 2 Projects to this point."
Rhode Island	"No Phase 2 completed yet."
Tennessee	"No Phase 2 projects."
South Carolina	"No Phase 2 projects in State."
Washington	"Washington standards do not contain standards that address eutrophication."
West Virginia	"Never involved in clean lakes program."
Wisconsin	"Lakes are all classified as 'fish and aquatic life.' Phase 2 projects have not changed that classification."
Wyoming	"No lakes upgraded under Clean Lakes Program."

Question 22

Arizona	"Lake problems are typically of nonpoint source origin and are not currently regulated."
Connecticut	"Lake Lillinahan, Lake Zoos (Housatonic River impoundment). Algae blooms abated, point source P control."
	"Bantam Lake – eutrophication slowed by eliminating watershed point sources of P."
	"The standard was not numerical but rather general policy."
California	"No known case."
Florida	"Lake Okeechobee – phosphorus limitation (mainly Ag NPS) based on Vollenweider model. Lake Tohopeliga – phosphorus limitation (mainly point source) based on Vollenweider model & ambient water quality data."
Idaho	"N.A. – no State lake standards."
Illinois	"Skokie Lagoons/Cook Co. – phosphorus standard used to convince wastewater treatment plant to divert effluent around lake. Now Clean Lakes funds being used for restoration."

Illinois (cont.)	Long Lake/Lake Co.—phosphorus standard used to help convince wastewater treatment plant to divert effluent from lake. Lake water quality has improved significantly since diversion."
	Lake Carroll/Carroll Co.—threat of NPDES permit requirements used to dissuade developer from combining septics into common tiles which would discharge to lake."
Kentucky	"Moratorium on new discharges or expansion beyond current capabilities—used State general prohibitions on pollution contained in standards and statutes."
Maine	"For all lakes—no degradation of trophic standards."
Michigan	"Fremont Lake—point source discharges removed, with excess nutrient standard used as guidance."
Minnesota	"Lake Bemiuji—NPDES P limit of 0.3 mg P/L implementation. 5 downstream lakes have also improved."
	"Lake Minnetowa—removal of effluent from WWTF's has caused doubling of transparency."
Montana	"Flathead Lake—all reasonable phosphorus limitations, i.e., 1 mg/L on upstream discharges extended review of nonpoint sources. Many smaller lakes where onsite disposal of sewage was limited or modified to ensure that P (and N in the case of Lake Blaine) inputs to the lakes is limited."
Nevada	"CHL *a* standard Lahontan res. and Lake Mead."
New Hampshire	"Industry proposed to discharge water containing P to a lake; it was denied, based on 'no new P discharge to lakes.'"
	"Development proposed to discharge tertiary treated sewage to stream that went to pond; stringent P limits were imposed so not over .015 mg/L."
	"Secondarily treated sewage has been diverted out of streams that enter lakes in several cases—e.g., Kezar, Winnisquam."
North Carolina	"Falls of the Neuse Lake—Designated NSW, has had phosphorus limits placed on upstream dischargers to reduce the threat of bloom frequency and magnitude. Applicable standards—Chl *a*, NSW."
	"Jordan Lake—same as above."
	"Belews Lake—related to toxics. Selenium lake limits have yielded the removal of a discharge from coal-fired power plant. This discharge had previously resulted in the bioaccumulation of Se which greatly reduced fish populations."
Ohio	"Lake Rockwell (Portage Co.): Anti-Degradation Policy was used to have existing sources add Total P removal."
Oklahoma	"Illinois River—N to P ratio, plus information on algae program showed there was pollution in the river."
	"Lee Creek—anti-degradation policy was used to prove lake development would ruin quality."

Pennsylvania	"Not possible at this time."
South Carolina	"Algal assay work showed large municipal WWTP needed P removal to limit eutrophication in two downstream lakes."
South Dakota	"Stockade Lake – City wastewater discharge removed to different drainage."
	"Lake Madison – City wastewater discharge eliminated."
Utah	"Deer Creek Reservoir – phosphorus standard."
	"Scofield Reservoir – phosphorus." "Pamguitch Lake – phosphorus."
Vermont	"None."
Washington	"Long Lake on the Spokane River – revised standards (in process) establish a P standard."
West Virginia	"Not applicable."

Question 23

Arizona	"None undertaken."
California	"No known case."
Connecticut	"Numerical standard violations have not been used for enforcement of lake eutrophication problems."
Florida	"Lake Apopka – agricultural pump discharges; N, P limits placed in consent orders; Lake Okeechobee – Agricultural pump discharges; N, P limits – New Dairy Rule – limits P discharges in watershed."
Idaho	"N.A. – no State lake standards."
Maine	"None."
Michigan	"Brighton Lake - upstream wastewater treatment plant discharge removed based upon violation of nutrient standard."
Minnesota	"No lake standards."
Montana	"None that I can recall; usually we work with developers in advance of the impacts."
Nebraska	"City of Alma discharged to a reservoir in violation of W.Q.X. & NPDES permit. They are on compl. sched."
	"CNPP&TD constructed new hydro which resulted in low D.O. in receiving lake. currently being resolved. (Compl. sched.)"
New Hampshire	"Failed septic system – 240 total coliform limit – cease and desist order sent – individual put in new system."
	"Turbidity – 10 NTU limit – construction shut down until slopes stabilized and hay bales, filter fabric, etc., in place."

New Hampshire	"Oil tank ruptured—flow to lake; standard no oil or slicks in unreasonable kinds or quantities; we ordered cleanup. Individual paid."
New Mexico	"NM does not enforce water quality standards."
North Carolina	"Selenium standard—fisheries impact—action remove discharge of fly-ash waste from lake. Belews Lake/Hyco Lake."
Pennsylvania	"Not possible at this time."
Rhode Island	"ISDS failures require correction after RIDEM and RIDOH issues notice. Direct discharges are illegal."
Utah	"Pamguitch Lake—phosphorus and coliform—elimination of direct sewage discharge to lake—source eliminated."
	Deer Creek Reservoir—phosphorus management plan to prohibit future point source discharges." Vermont" Fecal coliform (200/100 ml) bacteria; failing septic systems—gray water pipes - manure storage in steambed; problems corrected; bacteria gone."
West Virginia	"Not applicable."

Question 24

Massachusetts	"The main motivation for lake/pond restoration/preservation through Massachusetts Clean Lakes Program is firm voluntary interest at local level."
Washington	"Specific lake standards based on trophic status would assist in watershed management plans and ordinances developed by local jurisdictions for watershed and lake management, and nonpoint source control."

Question 25

Arizona	"Total nitrogen."
Arkansas	"BODs."
California	"Water quality standards differ among the nine regions and are narrative in some cases."
California	"Nitrates, color."
Connecticut	"Total N, macrophyte density and area."
Florida	Others—"Bacteriological quality, DO, turbidity, metals."
Louisiana	"Numerical criteria specific for lakes were listed in question #13."
Maine	Others—"Bacteria; E. Coli."
Michigan	"Dissolved oxygen (only numerical standard)."
New Mexico	"DO, pH, temp, fecal coliform bacteria, algae odor and taste of fish."
North Carolina	"Nutrients (Nitrogen), Turbidity, Selenium."

Ohio	"N to P ratio; stream standards."
Pennsylvania	"These are not specially referenced in our standards but are used in our implementation procedures."
South Dakota	"D. O. Unionized Ammonia – Generally numerical standards are not used to prevent eutrophication – Discharges causing eutrophication are prohibited."
Washington	"Dissolved oxygen – no measurable decrease from natural. Turbidity – not to exceed 5NTU over background. Fecal coliform and enterococci."
Wyoming	"Nuisance conditions can be tied back to a standard for a lake on a case by case basis."

Question 26

Alaska	"EPA guidance."
Arkansas	"EPA guidance."
Maine	Other – "Research and evaluation of lake data sets."
Ohio	Other – "IJC Objective for Lake Erie."

Question 28(b)

California	"Implemented as NPDES permits and Waste Discharge Requirements (Lake Tahoe has special provision of development control in water courses and total ground cover). Septic tank usage has been controlled at some lakes to prevent nutrient impact."
Connecticut	"Lake standards are not enforced, they are descriptive of conditions. Use goals are used for enforcement."
Florida	"Standards enforced through permitting (NPDES, Stormwater) and monitoring programs."
Maine	"Evaluation of the project for total P loading then following up on the project after construction in a few cases."
Michigan	"Data is collected to verify that effluent limits are met."
New Hampshire	"All discharge permits have effluent limits; we have compliance monitoring program plus we investigate all complaints of alleged violations."
New Jersey	"NJPDES permit limits."
North Carolina	"Most standards are enforced through the NPDES program. Limits are set based on model predictions using water quality standards as targets for protection."
Oklahoma	"Case by case depending on the type of pollutant released."
Pennsylvania	"Once a need for phosphorus control is established, appropriate effluent limits are developed and enforced."

Question 28(c)

# Florida	"But have been upheld in administrative procedures."
# Louisiana	"Modeling was not used."
* Michigan	"To support effluent limits."
Pennsylvania	"Modeling is used for development of limits, not for enforcement."

Question 29

* Alabama	"Possibly, but not enough funds or people and other greater priorities."
o New Mexico	"Have standards—but only for main-stream reservoirs."
# Texas	"Because of the typically high seasonal and annual variability of eutrophic indicators."

Question 30(a)

* California	"No formal categories, but ability to protect the designated uses."
Michigan	re: ecoregions—"NO! (not in Michigan)."
* Tennessee	"More widespread use of antidegradation statement."
New Mexico	"NM uses nutrient sensitive waters, drinking water, coldwater fishery."
* North Dakota	"Site specific."
* Ohio	"1) Glacial vs. non-glacial; 2) Lake type (i.e., dug out, impounded, upground)."
* Vermont	"Each lake considered individually."

Question 30(b)

Alabama	"Most lakes in Alabama carry a higher use classification; therefore, their value and the priority for their protection are preestablished."
Arizona	"Reality."
California	"Existing and potential beneficial uses should drive the development of standards for all lakes in the State."
Connecticut	"Urban (residential) development strongly impacts Connecticut lakes; some coldwater fishing lakes are threatened by summer dissolved oxygen depletion."
Delaware	"Lakes in Delaware are relatively homogeneous, with shallow depth and small size."
Idaho	"Protection of the uses defines the management goal. Once this is decided variation in predominant land uses or morphometry should not alter the management goal."

Iowa	"Intrinsic capacity of a lake needs to be the basis of classifying/categorizing lakes. Then separate standards could be developed."
Kansas	"Intrinsic capability of a lake needs to be the basis of classifying/categorizing lakes: then separate standards could be developed."
Kentucky	"If uses are established, criteria can be tailored to protect that use and impairment can realistically be evaluated."
Louisiana	"Differences in coastal freshwater lakes versus inland lakes necessitate some categorization in lake water quality standards."
Maine	"All lakes should be considered similarly, based on modeling data."
Maryland	"Because our lakes range over five physiographic regions from the Coastal Plain to the Appalachian Plateau."
Massachusetts	"Lakes/ponds should be looked at on a site specific basis."
Michigan	"It is particularly important, in Michigan, to protect high quality, sensitive lakes."
Minnesota	"These approaches are refinements of the factors which have given us practical applied predictive and diagnostic tools."
Missouri	"'Standards' should apply to water quality and <u>use</u> attainability. Designate quality which is desired, then implement water <u>quality</u> management."
Montana	"All lakes are unique and individual standards should be developed."
Nebraska	"W.Q.S. should be based on the attainable use of the water body."
New Hampshire	"Anti-degradation protects pristine lakes."
New Jersey	"Fits into existing surface water quality standard format."
New Mexico	"Numeric criteria correspond to designated uses."
New York	"A set of generic standards would not be appropriate for New York State, because of its geographic and ecological diversity."
North Carolina	"All of our water quality standards have been constructed to protect our waters for designated uses. Some of our lakes are actually run-of-river reservoirs. These reservoirs either directly or indirectly receive the effluents from many point sources. Therefore, the use for this waterbody is different than would be desired from a 100 percent protect primary water supply for drinking. It is only logical to protect these uses differently."
North Dakota	"Special use will cover a broad spectrum (such as drinking water) with morphometric and unique site or lake specific situations protected."
Ohio	"Experience with ecoregion concept for streams in Ohio indicates it may be useful for lakes. Ohio also has many manmade lakes and distinct glaciated and unglaciated regions."
Oklahoma	"It overrides other category and variability of lake types is large."

Oregon	"Lakes in Oregon are very diverse geologically and geographically – need to be classified to reflect differences."
Pennsylvania	"Level of nutrient control imposed on point source discharges is lake specific."
Puerto Rico	"In Puerto Rico the lakes are man-made multi-purpose reservoirs."
Rhode Island	"Might be best to categorize by use and location in relation to industrial/urban population. Urban lakes have greater toxics/road runoff problems and need different criteria. May be impossible to get these lakes even close to 'pristine' by <u>any</u> means, plus cleanup involves toxic-laden sediments."
Tennessee	"Special use classifications are more likely to be supported by the public and would address most problem areas. Antidegradation statement could be used on rest."
South Carolina	"Special use classifications will be compatible with existing classification system; morphometric considerations will help justify standards for large, stratified reservoirs."
Texas	"The nutrient-aquatic plant regimes in Texas reservoirs are highly reservoir-specific, and are not amenable to accurate categorization."
Vermont	"Standards should take into account existing water quality, attainable water quality, and public good. Also want standards to assure maintenance of a diversity of lakes. 2-3 categories will not do that. . . could end up with 2-3 types of lakes."
Virginia	"Advice of Technical Advisory Committee of Scientists."
West Virginia	"Almost all of our lakes are Corps impoundments."
Western Caroline Islands	"This lake is the source for one of the two rivers with potential to supply drinking water to the entire island. Other streams can supply individual villages."
Wisconsin	"If lake quality preservation is an important issue, this should be a factor in how standards are established. Furthermore, for lakes currently being affected by land uses, this fact cannot be discounted in setting standards."

Question 31(a)

# Alaska	"P, N plus existing standards for other pollutants."
# Arizona	"Secchi disc, temp."
* Arizona	"Game fish, macroinvertebrates."
* Arkansas	"Fish communities."
* Connecticut	Chl *a*, macrophyte density, area."
# Connecticut	"TP, TN."
o Connecticut	"DO depletion, transparency."
* Delaware	"Measures of fish/invertebrate community."

# Delaware	"Nutrients, DO, bacteria in rec. lakes."
o Delaware	"Possible residence time and loading rate."
* Florida	"Macrophytes, algae (Chl *a*)."
# Florida	"N, P, TSS, metals, bacteriological."
o Florida	"Transparency, sediment metal levels."
* Idaho	"Chl *a*."
# Idaho	"T-phosphorus."
* Illinois	"Algae (chlorophyll); macrophyte coverage."
# Illinois	"Total P, Total Suspended Solids, inorg. N."
o Illinois	"Transparency."
# Iowa	NO COMMENT
* Kansas	"None."
# Kansas	"Phosphorus loading equation."
# Kentucky	"Total residual chlorine, pH, TP/TN ratios."
o Kentucky	"Temperature."
* Louisiana	"No recommendations at this time."
# Maine	"TP, Chl *a*."
o Maine	"Secchi Disc."
* Maryland	"Chl *a*."
# Maryland	"TP."
o Maryland	"Secchi Disk."
* Michigan	"Macrophytes, if feasible; self-sustaining coldwater fish."
# Michigan	"P, DO, Chl *a*."
o Michigan	"Transparency."
* Minnesota	"Chlorophyll *a* (in some fashion)."
# Minnesota	"Total Phosphorus."
o Minnesota	"Secchi Depth."
* Nebraska	"Key species defining existing or attainable community."
# Nebraska	"Site specific criteria as needed."
o Nebraska	"Turbidity or Susp. Solids as site specific criteria as needed."

# New Jersey	"Nutrients."
# New Hampshire	"See enclosed standards."
* New Mexico	"Algae, macrophytes, bacteria."
# New Mexico	"Limiting nutrient(s), toxic substances."
o New Mexico	"DO, pH, temp, turbidity."
* New York	"Qualitative – nuisance vascular plants, loss of specific fish species, fecal bacteria."
New York	"Oxygen, phosphorus, pH, chlorophyll *a*."
o New York	"Transparency."
* North Carolina	Chl *a*."
# North Carolina	"Numerous – those that bioconcentrate or biomagnify. EPA criteria should be developed for lakes not just streams."
* North Dakota	"Algae, invertebrates, sensitive biota."
# North Dakota	"Nutrients, metals, etc."
* Ohio	"Algae – zooplankton – macrophyte."
# Ohio	"Total P, Nitrates, Chl *a*."
* Oklahoma	"Chlorophyll *a*."
# Oklahoma	"Total N and total P."
o Oklahoma	"Dissolved oxygen profile."
# Oregon	"Physical, chem., bio. factors."
# Pennsylvania	"Phosphorus, Ammonia, Nitrogen."
o Pennsylvania	"pH, Temperature."
# Puerto Rico	"Nutrients, toxics, surfactants."
# Rhode Island	"DO, pH, heavy metals, nutrients, org. HC's (pesticides)?"
* South Carolina	"Chlorophyll *a*."
# South Carolina	"Nutrients, pH, DO."
* South Dakota	"Algal Biomass, species."
# South Dakota	"N P Solids."
* Tennessee	"Biomass."
# Tennessee	"DO, nutrients, toxics."
o Tennessee	"pH, solids, temperature."

*	Utah	"Chlorophyll."
#	Utah	"Total P, Nitrogen."
#	Vermont	"Total phosphorus."
o	Virginia	"Chlorophyll *a* exceedence."
#	West Virginia	"P."
*	Wisconsin	"Algae, 'nuisance' macrophytes."
#	Wisconsin	"Maximum/tolerable loadings and concentrations."
o	Wisconsin	"Allowable or desired changes in trophic status."

Question 31(b)

Connecticut	"Basic vital characteristics."
Delaware	"Best possible characterization, most accuracy."
Idaho	"The relationship between Chl *a* and TP possibility for relationship between perceived water quality and Chl *a*, ease and expense of measurement."
Kentucky	"Protection of aquatic life use, possible nuisance b/g algae controls."
Maine	"These describe trophic states."
Maryland	"These are generally agreed to be the most important parameters in assessment of lake trophic states."
Minnesota	"These are the basis of our predictive and diagnostic capability."
Nebraska	"Site specific criteria should be applied where problems are documented and strategies are implemented. The criteria are then used as goals."
New Jersey	"Prevent eutrophication from accelerating."
New York	"Best simple measures of lake quality."
North Carolina	"Lake constituents can bioaccumulate."
Ohio	"There is a need for objective numerical standards."
Oklahoma	"Manifestations of eutrophication (direct indicators)."
Pennsylvania	"Useful in assessing trophic state of lake, limiting nutrient, response to nutrients, productivity, etc."
Puerto Rico	"Because of use classification."
Rhode Island	"Common problems—However since lake sediments are sinks for many chemical constituents, very difficult plus $$$ to clean up problems <u>very</u> costly."
Vermont	"Usually limiting nutrient and models can link to aesthetics, use impairment."

Virginia	"Trigger for classification of nutrient enriched."
West Virginia	"Our standards seem to cover others. No P standard."
Wisconsin	"Standards should be based on 'desired' uses which are influenced by all of the above."

Question 32

Arizona	"None in Arizona."
California	"Best management practices to reduce sediment production."
Connecticut	"A standard would be difficult to develop. Need to control sources of sediment if uses being impaired."
Delaware	"Yield per acre for developed and agricultural lands (TSS)."
Florida	"Water quality standards are not the answer. Effective watershed management programs (land use, stormwater reg. erosion/sed. regs., shoreline development) would be better and preventative."
Idaho	"Land use/activity controls instead of in-lake standards; easier to monitor and enforce if necessary."
Illinois	"Not amenable to effective control by a water quality standard. Lake and watershed management provisions are more effective. Perhaps consideration should be given to a regulatory approach to management practices (shoreline restrictions, land use zoning, etc.)."
Kansas	"Assume 20 year return period for dredging."
Kentucky	"Total suspended solids."
Louisiana	"No recommendations at this time."
Maine	"Do not know."
Maryland	"No response."
Massachusetts	"Narrative—should not unduly alter or cause harm to the = benthic life."
Minnesota	"(1) Permanence index (lost tourism + multiplier $—as related possibly to long term economics); (2) Increased internal load source (surface area x release rates); (3) Loss of viable gamefish habitat (especially for sight feeders, loss of spawning area during peak runoff, etc.)."
Missouri	"This is not a water quality issue. It is a land-use, land management issue and standards shouldn't apply."
Montana	"Ensure 'reasonable' land use owners in the basin."
Nebraska	"Site specific criteria defined through studies. Otherwise, narrative criteria such as contained in Chapter 4, paragraph 005 should be adequate."
New Hampshire	"Turbidity—total solids."

New Jersey	"It does not seem feasible to set a Water Quality Standard for sedimentation. At a given time it is not possible to measure water quality for compliance with sedimentation standard."
New Mexico	"Turbidity."
New York	"I have no idea."
North Carolina	"Strict enforcement of sedimentation control laws already in place in most States and counties."
North Dakota	"TSS on incoming streams or TSS and turbidity in lakes."
Ohio	"Possibly a stream TSS standard."
Oklahoma	"Centimeters per year allowable."
Oregon	"I don't know."
Pennsylvania	"Don't know."
Puerto Rico	"In Puerto Rico most of the sedimentation problem is natural due to the steep slopes, limestone mountains, frequent landslides along river banks. In this case a standard is impractical."
South Carolina	"Turbidity, TSS, Secchi depth, measure of sediment load."
South Dakota	"Same as whole lake."
Tennessee	"Suspended solids in tributaries?"
Texas	"We use a simple 'settled-volume' test to indicate instream sediment loads to reservoirs. The use of any measure of sedimentation (organic, inorganic, or total) as a water quality standard would be highly questionable."
Utah	"Steam standards—Turbidity Section 319 of Clean Water Act, Erosion Control."
Vermont	"Turbidity in inlet streams; instantaneous lake turbidity; settable solids in inlet stream or lake."
Virginia	"Uncertain, perhaps dissolved or suspended solids limit or Secchi transparency."
West Virginia	"Not sure any would be. Nonpoint sources are difficult as the actual source of a violation."
Wisconsin	"Antidegradation or preservation—narrative requirement which prevents smothering or deposition of 'mineral soils' on lake bottoms."
Wyoming	"Turbidity, S. Solids."

Question 33

Arizona	"Distance from shore and trends."
California	"Biostimulatory substances."

Connecticut	"Density, area coverage as percent of lake surface area, dominant species."
Delaware	"Standard won't help—need to be managed using depth (dredge), draw-down/freezing, harvesting, etc."
Florida	"Narrative based on species composition and areal coverage. Must develop balance between beneficial macrophytes and others."
Idaho	"% surface area covered by macrophytes. Identify or establish relationship between macrophyte coverage and beneficial uses and set management goal in terms of % coverage. Compliance with standard achieved via harvest, substrate alt. of water level controls, etc."
Illinois	"Limitation on percentage of surface area coverage."
Kansas	"Narrative; if at all—lots of people like macrophytes."
Kentucky	"I think macrophyte standards would be unrealistic because of the difficulty of any agency controlling their proliferation, there should be weed control programs instead."
Louisiana	"No recommendations at this time."
Maine	"We have a macrophyte policy."
Maryland	"No response."
Massachusetts	"Narrative—based on aesthetics and nuisance conditions."
Michigan	"One which recognizes the value of some macrophyte communities such as deep water marshes, while helping to identify nuisances."
Minnesota	"That which allows balanced use of the resource and reduces some of the potential for multiple use conflicts (open water versus fishing, etc.)."
Missouri	"This is a lake management issue. Until you can manage sunshine and other natural phenomena, 'standards' may not be the tool."
Montana	"Probably none."
Nebraska	"Same as #32."
New Hampshire	"None."
New Jersey	"A standard for macrophytes would have to be something other than a water quality standard."
New Mexico	"NM uses narrative criteria for nuisance plants and plant nutrients."
New York	"1) Presence of certain species (milfoil, water chestnut, hydrilla; 2) % of lakes littoral zone where nuisance species are within one meter of the surface."
North Carolina	"Standards are more oriented towards protection. Suggest an action level based on percent impacted or area of impact. Actions level could promote removal, and other actions."
North Dakota	"Control of noxious weeds and isolation of noxious weeds."

Ohio	"May not be practical since macrophytes may be desirable in some situations, i.e, buffer zone from upstream impacts, fish breeding habitat."
Oklahoma	"Biomass per unit area."
Oregon	"I don't know, but would be interested in exploring this since many of Oregon lakes suffer from excessive macrophyte growth."
Pennsylvania	"Effect on dissolved oxygen standards (excessive primary production would typically result in natural violation of oxygen standards.)"
Puerto Rico	"Numeric standards for nutrients."
Rhode Island	"No suggestions except perhaps bottom coverage by acres and percent of total bottom acres to classify by trophic condition."
South Carolina	"Sediment nutrients, sediment composition."
South Dakota	"Volume per unit – nuisance category use impairment potential."
Tennessee	"Surface coverage and impaired recreational use (hard to quantify)."
Utah	"Nutrients."
Vermont	"No good ideas."
Virginia	"Difficult question. Perhaps percentage of wetted perimeter covered by macrophytes."
Wisconsin	"Changes which result from activities which would influence growth to the detriment of desired uses."

Question 34(b)

Alabama	"Approximately 40."
Alaska	"Approximately 3 million over 5 acres; 107 over 5,000 acres."
Arizona	"10 natural, 100 artificial."
Arkansas	"150 ± ."
California	"4,955."
Delaware	"About 75, half public."
Florida	"> 7,700."
Idaho	"1,300."
Illinois	"900 public; 3,000 total."
Iowa	"250-300."
Kentucky	"Approximately 200 (depending upon your definition of lake)."
Louisiana	"73 inland freshwater lakes (area ≥ 640 acres)." "30 freshwater lakes in coastal zone (area ≥ 100 acres)."

Maine	"3,000 over 10 acres."
Maryland	"76 (publicly owned over 5 acres.)"
Massachusetts	"2,871."
Michigan	"6,440 over 10 acres."
Minnesota	"15,291 (greater than 10 acres)."
Missouri	"10 to 1,500, depending on your size designation."
Montana	"1,000 +."
Nebraska	"412 publicly owned; many more privately owned."
Nevada	"20."
New Hampshire	"1,300 total. 970 > 9 acres; 780 > 10 acres; 570 > 20 acres."
New Jersey	"1,200."
New Mexico	"Approximately 150 publicly owned – more than that privately owned."
New York	"7,500."
North Carolina	"We are presently determining this. It appears that there are several thousand. However, ownership to publicly available lands is likely in the hundreds range."
North Dakota	"350; 170 with fisheries."
Ohio	"330 > 5 acres and publicly owned."
Oklahoma	"Approximately 1500."
Oregon	"> 300. One time assessment of 200 lakes – no followup to confirm results. See Oregon Lake Atlas."
Pennsylvania	"340 with > 14 days detention time (approximately 4000 overall impoundments)."
Rhode Island	"total 383 (including private) – 240 (25 acres); 43 (25 – 50 acres); 74 (≥ 50 acres)."
South Carolina	"233."
South Dakota	"500."
Tennessee	"116."
Texas	"5,700 reservoirs > 10 surface areas; 189 major reservoirs > 5,000 acre-feet."
Utah	"3,000 +."
Vermont	"611 ≥ 5 acres."
Virginia	"170 publicly owned."

Washington	"7,938."
West Virginia	"Approximately 114."
Wisconsin	"15,000."
Wyoming	"Many, many."

Question 34(c)

Delaware	"All public; a few private."
Michigan	"We have assessed all lakes greater than 50 acres having developed public access sites (approximately 650 lakes)."
New Hampshire	"> 98% of surface area."
Nevada	"At least EPA eutrophication survey."
Rhode Island	"Matters on what 'assessed' is defined as. Here, taking as actual chem/phy data on toxics plus nutrient levels. RI does have a classification list based on professional judgment, point sources plus development in the area from topographic maps for public lakes."

Question 35

* Delaware	"For 305b characterization; for fishery."
Louisiana	"All lakes are not monitored."
Michigan	"Minimal."
# Nebraska	"Not a routine ambient program; however, we do special monitoring and get data from other agencies."
New Mexico	"But only 1 person to monitor lakes."
* Pennsylvania	"As part of the implementation of our statewide lake management program."

Question 37(a)

Iowa	"How big a change? For extreme changes, yes."
* New Hampshire	"Only programs #1 and 2 monitor trophic status."
* New Mexico	"But only for a small number of lakes which have adequate data."
* North Carolina	"Only if we have monitored the lake; however we would like to perform lake surveys more often to document."

Question 37(b)

Alabama	"Not extensive enough – inadequate funding."
Alaska	"No monitoring program, per se."
Arizona	"Requires additional parameters and use of STORET."
Connecticut	"No ongoing routine monitoring. Monitoring only of priority projects and complaints of serious problems."
Florida	"Only the few lakes where good long-term data exists."
Maine	"With lots of data and difficulty."
Massachusetts	"Programs can detect major trophic changes in specific lakes but not over a broad range of lakes across the State."
Michigan	"Generally do not sample at frequency necessary to detect change. Self-help may detect tentative changes which must be confirmed by other monitoring, but ignores macrophyte problems."
Minnesota	"Only if there are several consecutive years of monitoring, which cannot be certain, in any of the programs."
Montana	"Only for 'important' lakes."
Nebraska	"Need to develop a routine monitoring program for lakes. Currently we depend on data from other agencies which can be valuable but not always from lakes of interest to us."
New Hampshire	"The lay monitoring program will best determine changes; this only has about 20 ponds in it."
New Jersey	"No monitoring program."
North Dakota	"On lakes frequently monitored which are few (lake restoration projects)."
Ohio	"At the present time there is no program and available historical data to detect trends is very limited."
Oklahoma	"This program is not being conducted to evaluate trophic levels."
South Carolina	"Ambient monitoring program not designed to evaluate trophic status."
Tennessee	"Sampling is more geared towards toxics monitoring than trend analysis."
Utah	"No statewide monitoring program."
Vermont	"But due to variability, only very gross changes. . . which the people have probably already noticed!"
West Virginia	"We do not sample them."
Western Caroline Islands	"Not regularly monitoring at this time."
Wyoming	"Lakes are not routinely sampled."

Question 38(a)

Michigan — "Yes, but only a very small number."

Question 38(b)

California — "Lake Tahoe, changes in transparency (turbidity) indicate eutrophication due to nonpoint (construction, urban runoff, erosion)."

Connecticut — "Improvements at several lakes due to restoration implementation. Declines in several lakes due to various causes."

Illinois — "L. Michigan nearshore water quality has improved significantly since sewage diversions in 1970's. Long L./Lake Co. – significant improvement (reduction in TP) (chlorophyll) with effluent diversion. Clean Lakes projects – significant improvements following restoration. Other trends (improvement/degradation) in lake quality reported in biennial 305(b) report."

Kentucky — "Change in Carlson's Chl-a index indicated a change from oligotrophic to eutrophic, cause was due to a lake fertilization program."

Maine — Lower Secchi disk and increase in total P."

Massachusetts — "Primarily changes in phytoplankton populations and macrophyte density have indicated trophic status changes. Usually it is the public who alerts us to changes."

Michigan — "We have seen definite improvements in lakes monitored before and after removal of point sources. Some declines in clarity have been observed in Self Help Program."

Minnesota — "Historically it has been for point source related cases. Recently, the volume of citizen complaints (about 85 for 1987 thus far) relate to nonpoint source induced degradation."

Montana — "Flathead Lake – most work done by University of Montana Yellow Bay BSO Station."

Nebraska — "Based on TSI for several years data from Corps and other agencies, certain lakes have been noted as changing."

Nevada — "Increasing productivity and blue-green algae blooms of Las Vegas Bay, Lake Mead."

New Hampshire — "Lake survey data on 400 lakes compared to Fish and Game data of the late 1930's. No change in majority but some changed (in both directions)."

New Jersey — "Citizen complaints on specific lakes with excessive plant and/or algal growth."

New Mexico — "Reservoirs trophic state fluctuate as a function of storage volume (significant correlation coefficients.)"

North Dakota — "Observed deepening of thermocline, dominant algae shift, macrophyte changes, one less algal bloom/year, enhanced dissolved oxygens."

Oklahoma — "Work done on Overholser and Lawtonka reservoirs."

Pennsylvania	"Several lakes with high public impact were surveyed or monitored regularly—lake trophic status changes were detected (Lakes Wallenpaupack and Nockamixon)."
South Dakota	"Changes are detected through current implementation and post implementation monitoring programs."
Tennessee	"Rapidly proceeding eutrophication of TVA reservoirs in Middle Tennessee."
Texas	"Lake Arlington has shown improvement since diversion of point sources. A few other reservoirs have shown trends towards eutrophication."
Utah	"Clean Lakes projects, Deer Creek, Scofield, Pamguitch."
Vermont	"Harvey's Lake: spring phosphorus climbed from 0.010 to 0.020 from 1977-1981. It then fell back to 0.010 from 81 to 1986. Natural variation?"
	"Fairfield Pond: spring phosphorus climbed from 0.017 in 1979 to 0.052 in 1986. Diagnostic study has begun."
Virginia	"Reduced in trophic state in Smith Mountain Lake and Occoquan Reservoir following improved point source treatment of sewage waste."
Wisconsin	"Several lakes have been shown to be dramatically degraded."
Wyoming	"Algal blooms on Flaming Gorge Reservoir, Ocean Lake degradation."

Question 39(a)

* Arizona	"Bacteria."
# Arizona	"Other parameters."
* California	"Turbidity, Lake Tahoe."
# Florida	"Not specifically, some experience between TSI and use impairment."
# Illinois	"Not specifically, but from experience have found good correlation between Trophic State Index and lake use impairment (qualitative ratings)—see Illinois Lake Classification (Sefton, et al, 1984)."
# Massachusetts	"Lake classification report offers public a subjective evaluation of their pond relative to others."
# Minnesota	"We are currently collecting."
New Hampshire	"4 feet Secchi disk is used as lower limit for recreationally acceptable waters."
* New Mexico	"Water quality standards."
# Vermont	"Are in the processing of collecting it."

Question 39(b)

Louisiana — "Total organic carbon and Secchi disc depth were identified in a State sponsored study as having the greatest potential to develop a Condition Index System for Louisiana Lakes. Recommendations for further refinement were made by the study."

Question 40(a)

California — "Narrative objectives."

Florida — "We have 'recommended' levels based on TSI which is used in 305(b) report."

* Massachusetts — "See 'classification.'"

* Minnesota — "Paper for NALMS conference in preparation."

Nebraska — "Not State specific info. We have the published values of Vollenweider and others but they don't seem to apply to Nebraska."

* New Mexico — "Quantitative descriptions of algal blooms."

* North Dakota — "Limited basis."

Texas — "Not on a wide geographic basis—only for specific reservoirs which have been extensively studied."

Question 40(b)

Connecticut — ">0.03 mg/L TP algae blooms became noticeable by public. >0.05 mg/L, Aphanizomenon/Anabaena can become dominant."

Iowa — "6 - 10 ug/L chlorophyll."

Massachusetts — "See "Classification Rept."

Michigan — "We generally feel that severe water quality problems (nuisance algal blooms, etc.) do not occur when surface total phosphorus is less than 30 ug/L. Above this level, problems become apparent to the public."

New Hampshire — "Vollenweider's and others' papers—TP >.02 mg/L generally results in algal problems."

Question 41

Massachusetts — "Lake data are being stored on a main frame under a system entitled PALIS (Pond and Lake Information System). Information includes: in-lake and tributary water quality data, bacteriological data, phytoplankton and macrophyte data, watershed information (land use, septic system/sewer data, etc.), sediment data, and morphometric data."

Question 42(a)

* Minnesota	"Point source only – see narrative."
New Jersey	"Only as part of overall standards."
# Nevada	"Not yet; NH_3-N being proposed for Lake Mead."
Oregon	"Not specifically for lakes, for waters of the State.'"

Question 42(b)

Texas	"But additional narrative provisions apply to water supply reservoirs."

Question 43(a)

Missouri	"No more than streams."
* Oregon	"With regards to herbicide application."
* Rhode Island	"For NPDES (or fishing bans also)."

Question 43(b)

Minnesota	"Yes, or how they are applied."
New Jersey	"In some cases, maybe."

Question 44(a)

Michigan	"New. Very limited program."
Missouri	"Not on a regular basis."
New Mexico	"Occasionally."

Question 44(b)

Florida	"Limited shellfish (corbicula) monitoring."
Massachusetts	"Macrophytes occasionally. Possibly invertebrates in the future."
Missouri	"Chlordane, PCBs."
New York	"Invertebrates."

Question 45

# Kansas	"Fish tissue, plus unknown questions of agricultural pesticides."
# Maine	"One lake."
* Maryland	"Only known lake toxicity problem is a small urban impoundment; none of the other impoundments are known or suspected of having a toxicity problem. (Toxicity due solely to chlordane.)"
# Oregon	"Reservoir with mercury contamination."
# Rhode Island	"(Bacterial) standards exceeded. In lakes, toxics not expected to exceed water quality criteria but sediments laden!! Plus some spikes in wet weather."
* West Virginia	"Lake Lynn depressed pH."

Question 46

# Alabama	"If they were optional, we cannot handle more standards requirements from EPA."
* California	"Lakes as well as other waterbodies."
* Kansas	"Anywhere."
* Rhode Island	"For sediment characterization (vs. hazardous waste sale category) plus nutrient levels—trophic state with more recent research information incorporated."

Additional Comments

Arizona

"Many lakes are managed for irrigation deliveries and have large seasonal-level fluctuations. The impact of water quality on biological integrity is typically of lesser impact than drawdown."

California

"Your questions seem to expect that P is the limiting nutrient. We find that N is the limiting factor in many of our waters, including lakes."

Delaware

"Delaware's lake management needs are probably unique. All lakes in the State are very small (200 acres and less) and shallow (average depths less than 10 feet). None of the lakes are natural; all were formed behind millpond dams. All lakes are eutrophic or hypereutrophic based on classical parameter measures. Many lakes have a preponderance of rough (benthivorous) fish, and most have either a macrophyte or algae problem. More research on management approaches to these types of situations would be helpful to Delaware and other coastal plain States."

Louisiana

"Total organic carbon and Secchi disc depth were identified in a State sponsored study as having the greatest potential to develop a condition index system for Louisiana lakes. Recommendations for further refinement were made by the study.

Massachusetts

"Massachusetts Lake data are being stored on a main frame under a system entitled Pond and Lake Information System (PALIS). Information includes: in-lake and tributary water quality data, watershed information (land use, septic system/sewer data, etc.), sediment data, and morphometric data."

Missouri

"I found this questionnaire to be very difficult for the following reasons.

"1) Missouri has many reservoirs, a few oxbow 'lakes,' and no natural 'lakes.' All need to be treated differently. My answers to your lake questions might not fit with Wisconsin's lake questions.

"2) Much confusion when you use the terms 'standards,' 'use,' and 'criteria' interchangeably.

"3) What is a lake? A reservoir, farm pond, subdivision impoundment, dammed river (low head) will all be treated differently in Missouri.

"4) What is eutrophication, . . . the presence of nutrients, the presence of algae, the presence of macrophytes or the loss of a use due to combinations of the above?

"5) What constitutes a 'trophic status assessment'? A full blown limnological investigation or one chlorophyll *a* could both suffice."

Oregon

"We only have one person at .1 FTE to administer the current Clean Lakes Program with three projects. We cannot do any additional work on lake standards unless EPA directs us to do so, and gives us FTE to conduct the work. We are anxious to develop a statewide lakes assessment and classification study and develop standards, but we do not have any resources, or direction to prioritize this work from EPA."

Rhode Island	"We in Rhode Island are interested in lake water quality but the agency is extremely undermanned due to numerous causes. However, even if Rhode Island Department of Environmental Management (DEM) had more than one person for monitoring, and its own analytical laboratory plus a large planning staff, I believe there would still be significant problems with lake water quality standards. Most Rhode Island lakes are impoundments for former mill/hydropower structures. Most are over 50 or 100 years old, and have accumulated sediments from upstream for many decades to a century or more! Dredging solutions to remove these nutrients (and sometimes toxics) laden sediments would run millions of dollars and lead to a cross-media problem: where do you put sediments with high nutrient value (good loam) but also containing heavy metals, etc. The most workable solution may be to allow fresh (cleaner) sediments to cap these areas overtime, and deal with ISDS problems on a local-ordinance basis. For the latter issue, nutrient criteria for lakes may work."
Texas	"Texas 'lakes' are typically mainstream reservoirs with a wide range of turbidity from inorganic suspended solids, and a wide range of nutrient/chl *a* ratios. For the present time, we are finding that reservoir water quality is best managed by conducting extensive studies of selected reservoirs and establishing reservoir-specific regulations on nutrient loadings as indicated by study results."
West Virginia	"The U.S. Army Corps of Engineers has evaluated a hydro power project on Bluestone Lake. The models indicate that a 40 foot increase in pool level (necessary for optional power generation) would cause severe eutrophication problems. Phosphorus is the nutrient of concern."

Appendix D

List of Names and Affiliations of Respondents

Respondents

Alabama	Bob Cooner and Charles Horn Alabama Department of Environmental Management (205) 271-7700
Alaska	Dan Easton Alaska Department of Environmental Conservation (907) 465-2653
Arizona	F. Woodwick/E. Swanson Department of Environmental Quality (602) 392-4038
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California	James W. Baetge State Water Resources Control Board (916) 445-9552
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Delaware	Mike Blosser Department of Natural Resources and Environmental Control (302) 736-4590
Florida	Eric Livingston Department of Environmental Regulation (904) 488-0782
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Idaho	Gwen Burr Department of Health and Welfare (208) 334-5867
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For a copy of this report

Water Quality Standards for Lakes — A Survey

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N O T E S

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