This document contains the National Water Quality Inventory: Report to Congress, 2004 Reporting Cycle: Probability Surveys of Water Quality

The report can be downloaded from:

http://www.epa.gov/305b/

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Probability Surveys of Water Quality

EPA, other federal agencies, and the states have embarked on a cost-effective approach to assess status and track trends in the quality of the nation's waters: probability-based surveys that complement existing monitoring and assessment programs and add to the understanding of national, regional, and local water quality conditions. Probability surveys are designed to yield unbiased estimates of the condition of a whole resource (such as lakes or rivers and streams) based on a representative sample of waters. These surveys are designed to answer key questions asked by Congress, the public, and decision makers, such as the following:

- Is water quality improving?
- What is the extent of waters that support healthy ecosystems, recreation, and fish consumption?
- How widespread are the most significant water quality problems?
- Are we investing in restoration and protection wisely?

Several national probability-based studies have already been completed, and several more are underway. Additional information about these national studies is available at *http://www.epa.gov/owow/monitoring/nationalsurveys.html*.

National Coastal Assessment

The National Coastal Assessment surveys the condition of the nation's coastal resources. The results of these surveys have been compiled into the *National Coastal Condition Report* series. The states, EPA, and partner agencies—NOAA, USGS, and the U.S. Fish and Wildlife Service (FWS)—issued the first three reports of the *National Coastal Condition Report* series in 2001, 2005, and 2008. These reports include evaluations of 100% of the nation's estuaries and coastal embayments in the contiguous 48 states, Puerto Rico, Hawaii, and Southcentral Alaska. Federal, state, and local agencies collected samples using nationally consistent methods and a probability-based design to assess five key indices of coastal water health.

The *National Coastal Condition Report III* finds that the overall condition of the nation's coastal waters is generally fair and has improved slightly since the 1990s. This rating is based on five indices of ecological condition: a water quality index (calculated based on ratings for dissolved oxygen, chlorophyll *a*, dissolved inorganic nitrogen, dissolved

inorganic phosphorus, and water clarity), a sediment quality index (calculated based on ratings for sediment toxicity, sediment contaminants, and sediment total organic carbon), a benthic index, a coastal habitat index, and a fish tissue contaminants index. For each of these indicators, a score of good, fair, or poor was assigned to each coastal region of the United States. Ratings were then averaged to create the overall regional and national scores illustrated in Figure 10, which uses "traffic light" color scoring. Based on the findings of this survey, 57% of the area of the nation's estuaries and coastal embayments is in good condition for the water quality index, 6% is in poor condition, and 35% is in fair condition.

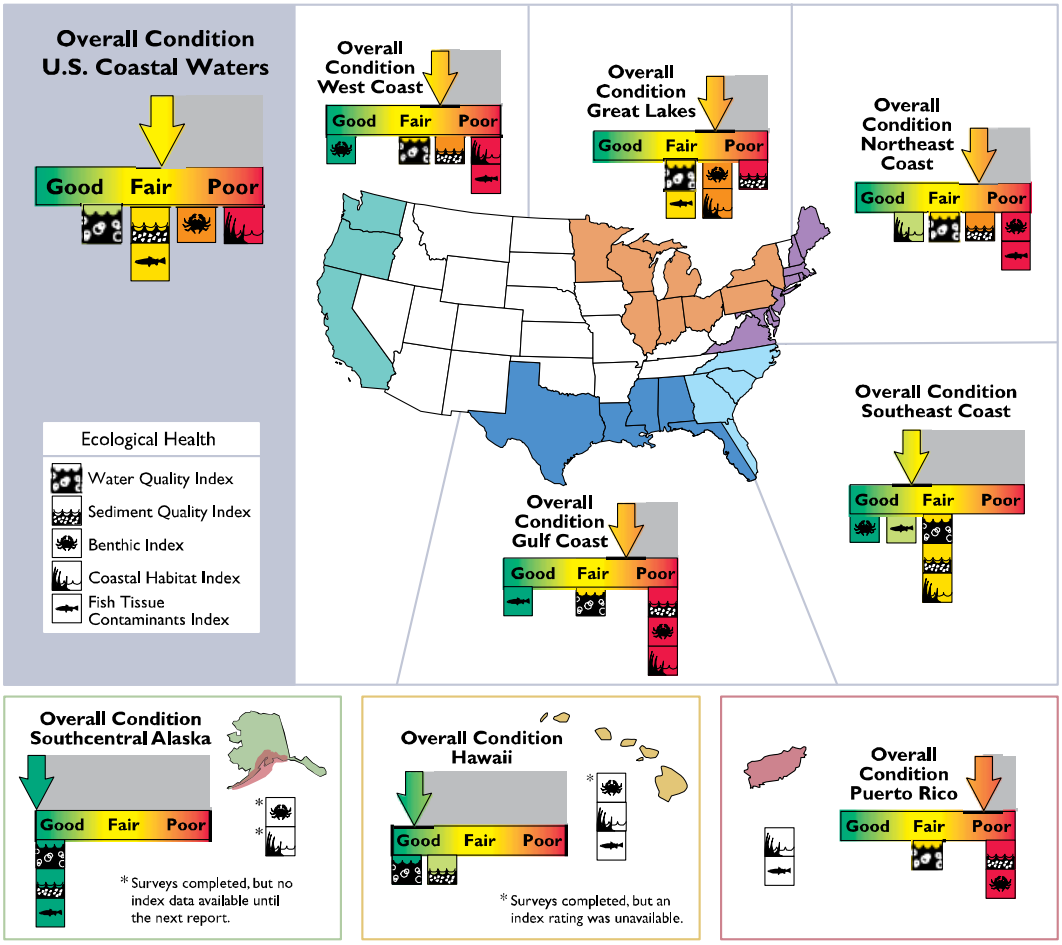

Figure 10. Findings of the *National Coastal Condition Report III* (U.S. EPA, 2008).

Understanding the Value of Probability-based Surveys and the National 305(b) Report

Although some of the findings of the national 305(b) report appear similar to the findings of the national, probability-based coastal and streams surveys, there are many differences in the scope of these reports and how they are best used to inform water quality management.

Probability surveys provide consistent environmental indicators of the condition of the nation's water resources, much as economic indicators report on the health of the nation's economy. Their design ensures that results represent the population of all waters of a certain type across the United States, and their consistent sampling methods ensure that results can be aggregated into regional and national indicators of the health of the resource. The survey results quantify, with documented confidence, how widespread water quality problems are across the country and estimate the extent of waters affected by key stressors. This helps set priorities for water resource protection and restoration. Nationally consistent surveys provide a standardized measure for tracking changes in the condition of the nation's waters over time and for evaluating, at a broad scale, progress in investments to protect and restore water quality.

In contrast to the probability surveys, this national 305(b) report summarizes information reported by states for only a portion of waters (approximately 16% of U.S. river and stream miles, 39% of lake acres, and 29% of bay and estuarine square miles). It tallies state findings based on data collected using a variety of sampling methods and parameters; water quality standards and interpretation methods; extrapolation methods; and time periods. The strength of the 305(b) report is that it provides useful information on the nature of water quality problems identified by state monitoring programs, documents the amount of waters assessed and unassessed, and supports the identification of specific waters not meeting water quality standards; therefore, it helps states set priorities for these waters.

The indices that show the poorest condition are coastal habitat and benthic condition. Two of the individual component indicators of the water quality index generally show the best condition—dissolved oxygen and dissolved inorganic nitrogen.

In 2010, EPA and its partners expect to undertake a new survey of coastal waters and to report survey results in 2012. For more information on the *National Coastal Condition Report* series, go to *http://www.epa.gov/nccr*.

The Wadeable Streams Assessment

The Wadeable Streams Assessment, a survey of the biological health of the nation's wadeable streams, was launched by EPA and the states to provide a national baseline of stream water quality based on conditions at approximately 1,300 randomly selected sites across the conterminous United States. With support from EPA, state water quality agencies sampled streams using the same methods at all sites. Crews collected macroinvertebrates to determine the biological condition of streams and also measured key chemical and physical indicators that reveal stress or degradation of streams. The Wadeable Streams Assessment reports on four chemical indicators (i.e., phosphorus, nitrogen, salinity, and acidity) and four physical condition indicators (i.e., streambed sediments, in-stream fish habitat, riparian vegetative cover, and riparian disturbance).

The Wadeable Streams Assessment found that 42% of U.S. stream miles are in poor biological condition compared to best-available reference sites in their ecological regions, 25% are in fair condition, and 28% are in good condition (Figure 11). The confidence level for these key findings of biological quality is ±2.8%. Five percent of U.S. stream miles were not assessed because the New England states did not include first-order streams in the sample design.

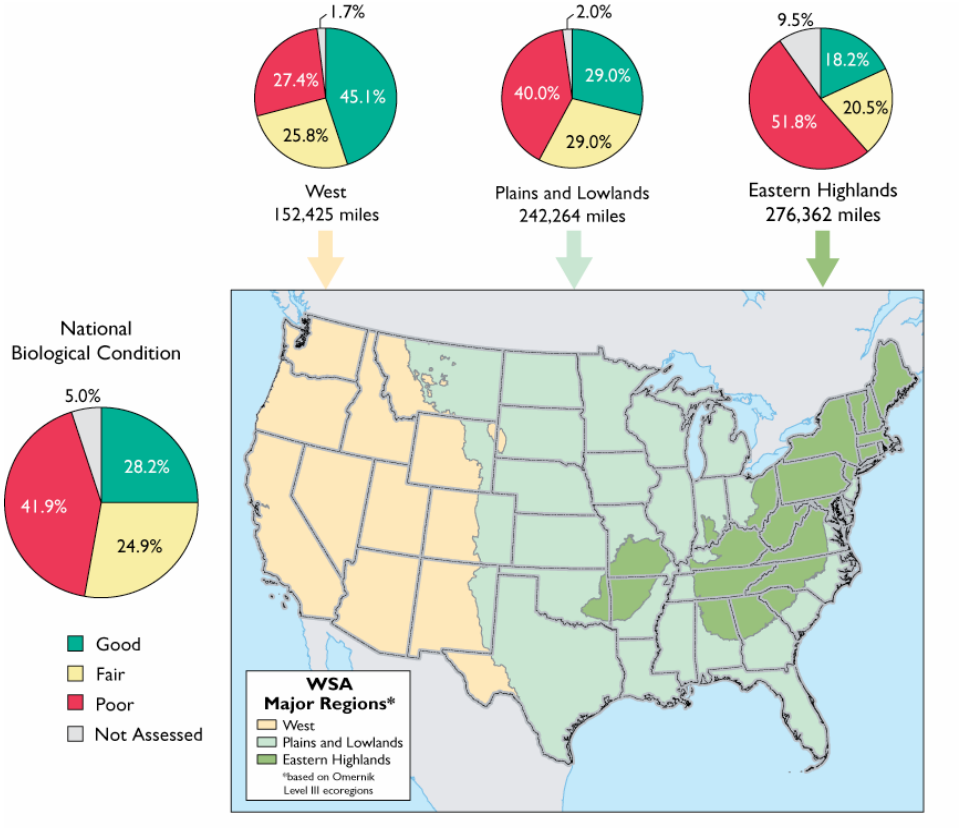

Figure 11. Biological quality of the nation's streams (U.S. EPA, 2006).

The Wadeable Streams Assessment was designed to examine eight key stressors. The most widespread stressors observed across the country and in each of the three major regions are nitrogen, phosphorus, riparian disturbance, and streambed sediments (Figure 12). These stressors can degrade stream conditions for fish and other aquatic life. Nitrogen and phosphorus are nutrients that, when present in excess amounts, can increase the growth of algae, decrease dissolved oxygen levels and water clarity, and degrade stream habitat. Excess streambed sediments can smother habitat for aquatic organisms. Riparian disturbance is evidence of human activity alongside streams, such as pipes, pavement, and pastures. The survey found that increases in nutrients and streambed sediments have the highest impact on biological condition, i.e., streams scoring poor for these stressors are twice as likely to have poor biological condition as streams that score in the good range for the same stressors. For more information on the Wadeable Streams Assessment, go to *http://www.epa.gov/owow/streamsurvey*.

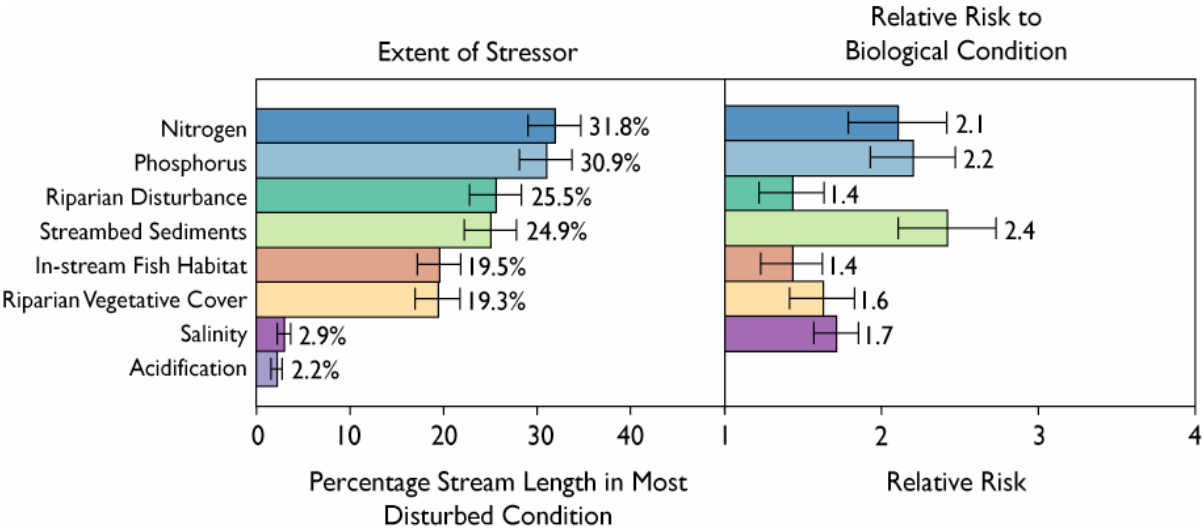

Figure 12. Extent of streams rated poor for aquatic stressors and increase in risk of poor biology in streams rated poor over streams rated good for each stressor (U.S. EPA, 2006).

National Lakes Survey

In 2007, EPA and its state partners completed the field-sampling season for the National Lakes Survey (also known as the National Lakes Assessment [NLA]), a baseline assessment of the condition of the nation's lakes, ponds, and reservoirs. More than 900 lakes were sampled over the course of a summer for this survey (Figure 13). The population of lakes to be sampled was comprised of natural and man-made freshwater lakes, ponds, and reservoirs that were greater than 10 acres in size, at least one meter in depth, and located in the conterminous United States. The survey does not include the Great Lakes, the Great Salt Lake, natural saline systems, or treatment and disposal ponds. In order to examine potential trends in water quality, a representative subset of lakes from EPA's 1972 National Eutrophication Survey (NES) was included.

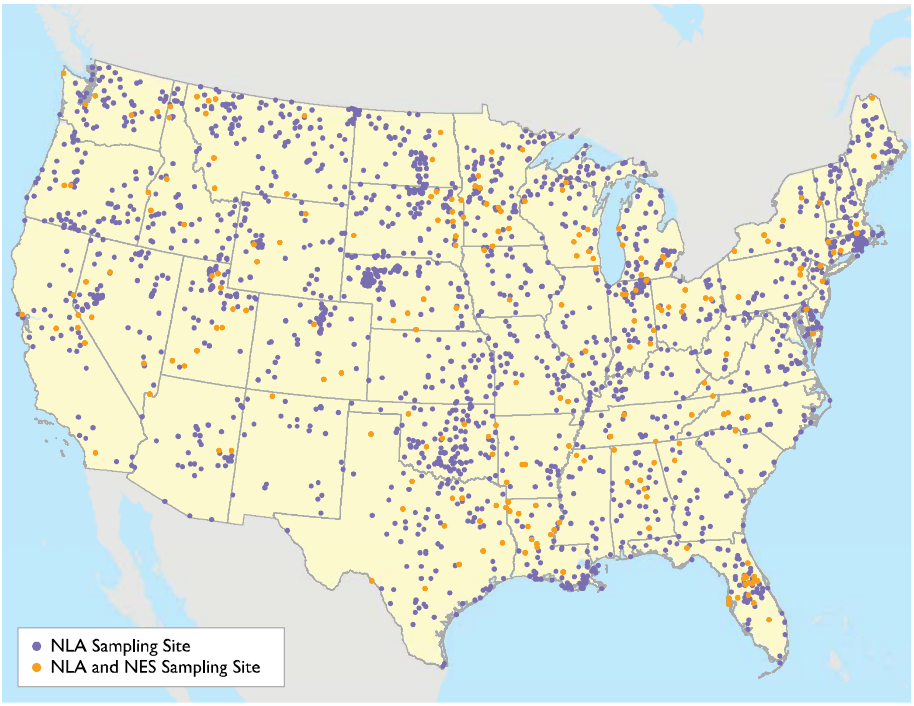

Figure 13. Sampling locations for the survey of the nation's lakes.

Key indicators sampled for the National Lakes Survey included the following:

- **Trophic indicators,** such as *in situ* temperature and dissolved oxygen profiles, water chemical quality, nutrient concentrations, chlorophyll *a* levels, transparency measured by Secchi disk, turbidity, and color
- **Ecological integrity indicators,** such as sediment diatom abundance, diversity, and trends; phytoplankton abundance and diversity; zooplankton abundance and diversity; shoreline physical habitat conditions; and benthic macroinvertebrate abundance and diversity

- **Recreational indicators,** such as pathogen (e.g., *Enterococci*) concentrations, algal toxin (e.g., microcystins) levels, and sediment mercury concentrations.

Analysis of the survey's data is underway in 2008, and a report on the condition of the nation's lakes is planned for 2009.

National Rivers and Streams Assessment

EPA is undertaking a survey of the nation's rivers—including the "Great Rivers" of the United States—and intends to combine it with a second Wadeable Streams Assessment.

In 2008 and 2009, field crews expect to collect data on indicators of the following:

- **Ecological condition,** such as the abundance and diversity of periphyton, phytoplankton, benthic macroinvertebrates, and fish
- **Recreational value,** such, as fecal contaminant concentrations in water and contaminant residue in fish tissue
- **Physical habitat condition,** such as bank stability, channel alterations, and invasive species
- **Water quality,** such as basic water chemistry.

The focus will be on wadeable streams in the first year of monitoring and non-wadeable systems (e.g., rivers) in the second year. Figure 14 shows the locations of the 1,350 new sites and the 450 sites from the 2006 Wadeable Streams Assessment that will be sampled for the National Rivers and Streams Assessment. A national report on rivers and streams is scheduled for 2011. For more information on the National River and Streams Assessment, visit *http://www.epa.gov/owow/riverssurvey/index.html*.

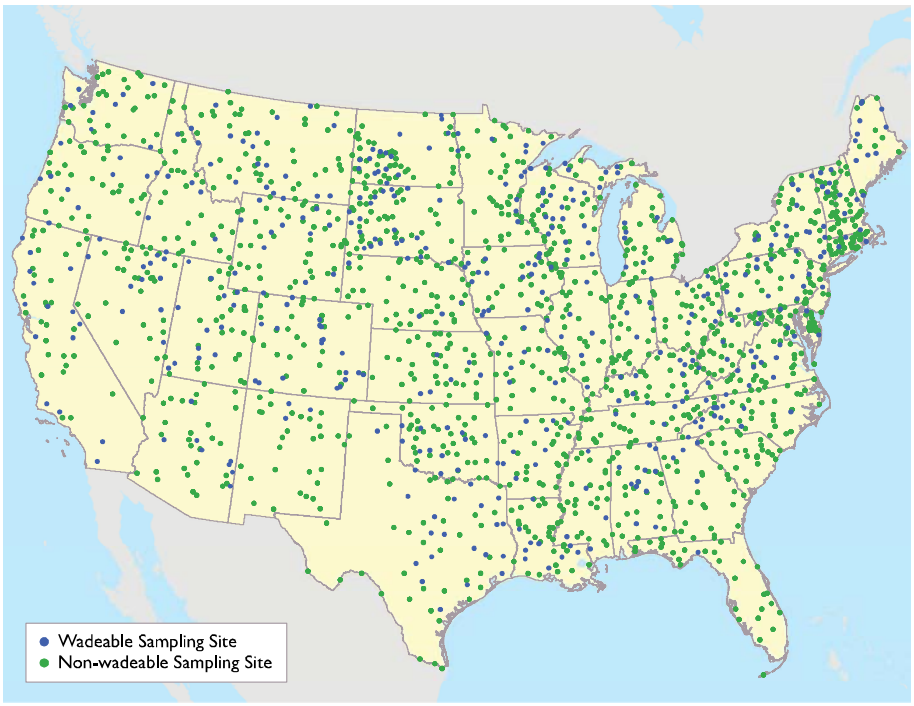

Figure 14. Sampling locations for the national rivers and streams assessment.

National Wetlands Condition Assessment

In 2011, EPA and the states plan to conduct a survey (National Wetlands Condition Assessment) of the condition of the nation's wetlands, with a report planned for 2013. EPA and the states are working with the FWS to design the wetlands assessment to ensure that it effectively complements the FWS *Status and Trends* reports, which focus on the distribution of wetlands rather than their condition.

EPA is currently in the research phase of the National Wetlands Condition Assessment and has identified several significant challenges to designing and implementing a wetland assessment on a national scale. These include designing the best sample frame and methods to support a national report; selecting efficient, scientifically valid indicators; ensuring that adequate resources are available; maintaining the resultant data; and building partnerships to most effectively use the information gleaned from the National Wetlands Condition Assessment.

Through the institution of regular probability surveys of all waterbody types, EPA and its partners in the states and other federal agencies expect to be able to cost-effectively assess 100% of the water resources of the United States and to track trends in water quality over time. This scientifically based data will assist in the evaluation of the effectiveness of pollution-control activities and will greatly improve our ability to manage the nation's water resources.

EPA is coordinating a number of regional pilot projects with the states, academics, and other federal agencies to test design approaches, field protocols, and indicators. EPA

anticipates that in 2009, the project team will be making initial decisions on condition indicators and assessment methods that can apply across the nation's wide range of wetland types. For more information on the National Wetlands Condition Assessment, visit *http://www.epa.gov/owow/wetlands/survey*.

State-Scale Statistical Surveys

More than half of the states have begun to implement state-scale statistical or probabilistic surveys to characterize the full population of a water resource type (e.g., streams, lakes). Most of these surveys are of streams and rivers, although lakes, coastal waters, and wetlands are also surveyed.

The states use probabilistic monitoring designs to develop estimates of water quality across the entire state, based on a representative sample, and to examine trends in water quality over time statewide. Probability surveys can eliminate the risk of generating a biased picture of water quality conditions; provide information on changes in water quality over time statewide; and serve as a cost-effective benchmark of the effectiveness of the state's water quality program. Also as part of the probability assessment, a state can produce an estimate of the accuracy of its assessment results. The assessment results also provide information on whether it would be useful to target certain waters for further assessment, or if limited resources for water quality assessment can be used more effectively in other ways.

On the other hand, the states use targeted monitoring to meet state management objectives such as identifying specific waters that are not meeting water quality standards, setting priorities for impaired waters, and tracking the restoration of individual waters. The two assessment approaches (i.e., probabilistic and targeted monitoring) are not expected to provide the same results because they are designed to achieve different objectives. Comparing the results of the two approaches is a useful evaluation tool for the states. For example, the statistical survey's overall description of the full population of waters provides a useful benchmark for comparing the results of targeted monitoring activities and can help a state identify potential gaps in its targeted monitoring program.

The following are examples of how some states used probability assessments for water quality assessment reporting in 2004. It is important to note that for the 2004 reporting cycle, statewide probability assessments are still a fairly new development, and most states are only beginning to report their findings.

South Carolina

South Carolina's monitoring program includes a probability-based component to complement its targeted monitoring activities. Probability-based monitoring is conducted for streams, lakes/reservoirs, and estuaries. Each year, a new statewide set of probability-based random sites is selected for each waterbody type. These random sites are sampled

on a monthly basis for one year. *The State of South Carolina's 2004 Integrated Report* (South Carolina DHEC, 2004) includes details on site selection. South Carolina provides tables comparing assessment results from its traditional monitoring program and its probability-based assessment results for rivers and streams and for estuaries, including a discussion of the findings.

Table 6 presents a comparison of river and stream data collected using the traditional, 305(b) approach with data collected using a probability-based approach. For rivers and streams, the traditional approach included data from 630 monitoring stations strategically located around South Carolina, many of which include biological (macroinvertebrate) and chemistry data. Approximately 15,300 stream miles—or about half the state's total 29,794 stream miles—were assessed in 2004 using the traditional 305(b) assessment approach. South Carolina summarized data from a total of 58 randomly located stream sites for the probability-based assessment conclusions; 29 of these sites were sampled in 2001, and 29 sites were sampled in 2002. These sites represent the total stream miles in the state, weighted by stream size (i.e., based on the relative proportion of small headwater streams, second-order or intermediate streams, and larger streams to the stream resource as a whole).

Table 6. Traditional vs. Probability-based Assessment Results for Rivers and Streams in South Carolina (South Carolina DHEC, 2004)

Use Support Category	Degree of Use Support	Percent of assessed miles in category—traditional 305(b) approach	Estimated percent of total resource in category—probability-based approach
Aquatic Life Use	Fully supporting	65.3%	79.0%
	Partially supporting	12.1%	5.9%
	Not supporting	22.5%	15.0%
Recreational Use	Fully supporting	59.3%	49.9%
	Partially supporting	21.5%	14.6%
	Not supporting	19.2%	35.5%

For its probability-based estuarine condition conclusions, South Carolina summarized data from 60 randomly located estuary sites—30 sampled in 2001 and 30 sampled in 2002. These sites represent the total estuarine area in the state. Probability-based approach results were compared to the traditional approach, which assessed 221 square miles of South Carolina's total 401 square miles of estuaries (Table 7).

Table 7. Traditional vs. Probability-based Assessment Results for Estuaries in South Carolina (South Carolina DHEC, 2004)

Use Support Category	Degree of Use Support	Percent of assessed square miles in category—traditional 305(b) approach	Estimated percent of total resource in category—probability-based approach
Aquatic Life Use	Fully supporting	68.0%	75.3%
	Partially supporting	14.4%	3.0%
	Not supporting	17.6%	21.7%
Recreational Use	Fully supporting	94.1%	100%
	Partially supporting	4.5%	—
	Not supporting	1.4%	—

Indiana

In Indiana, probability-based representative samples are used to determine overall aquatic life use support as part of the state's rotating-basin approach (i.e., a plan for monitoring a subset of the state's watersheds on a rotating 5-year cycle, such that in 5 years, all watersheds have been cumulatively monitored). A stratified random sampling design is used to generate sampling sites and provide a representative sample set for each basin. A fish community Index of Biotic Integrity is determined for each sampling location, and the results of each year's sample data are analyzed to estimate the percentage of stream miles supporting aquatic life use for each basin. This approach allows the state to make statistically valid estimates of aquatic life use support for a large geographic area (e.g., a basin) with a relatively small number of representative samples. For its *Indiana Integrated Water Quality and Assessment Report* (Indiana DEM, 2004), Indiana's probability-based program found that 22,157 stream miles in the state's major river basins supported aquatic life and 13,168 miles did not support uses, for a total of 35,325 river and stream miles covered by the probabilistic assessment.

Indiana's probability-based sampling design, known as the Watershed Monitoring Program, allows the state to predict with reasonable certainty what percentage of its rivers and streams are impaired. An individual stream or stream reach is considered assessed only when sufficiently detailed monitoring data representative of that stream are

available. According to the state, the principal advantage of the probabilistic monitoring approach is that it allows the agency to meet the goals of assessing all the waters of the state (in terms of the overall quality of each basin) while providing data that can also be used to make waterbody-specific assessments.

Florida

Florida uses a three-tiered approach to monitor surface water quality, ranging from the general to the specific. Tier 1, or probability monitoring, addresses statewide and regional questions and is used to develop statistical estimates of statewide water quality based on a representative sample. This approach allows the state to assess 100% of the waters of the state over a 5-year period. Tier 2 addresses basin-specific and stream-specific questions (e.g., to verify waterbody impairment), and Tier 3 addresses site-specific questions, such as those associated with permits and the development of TMDLs.

The first cycle of the statewide probability assessment through the Integrated Water Resource Monitoring Network began in 2000 and was completed in 2003. The results for each basin are aggregated by waterbody type and assessed against water quality targets to determine the overall health of that type of water in the basin. Florida used this approach to assess rivers and streams, large lakes, and small lakes (see Figure 15).

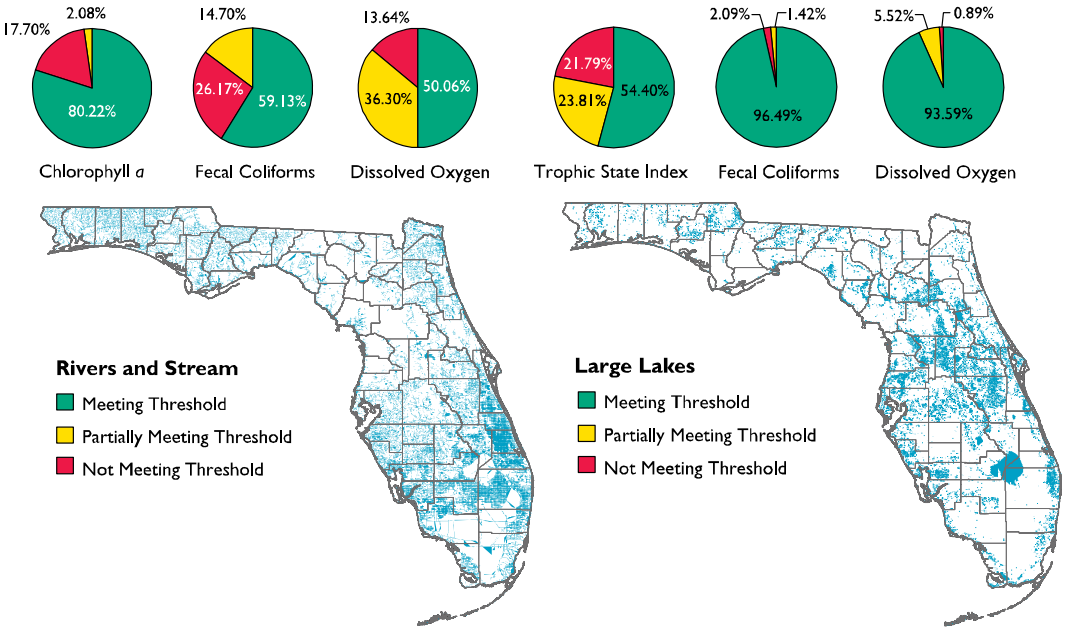

Figure 15. Summary of statewide condition for Florida rivers and streams (left) and large lakes (right) (adapted from Florida DEP, 2004).

Although the *Integrated Water Quality Assessment for Florida: 2004 305(b) Report and 303(d) List Update* (Florida DEP, 2004) presents preliminary results for the statewide probability assessment, it also notes the fundamental differences between this approach and the basin and stream assessments of the Tier 2 approach. Assessment targets, parameters monitored, and sample sizes are different between the two assessment approaches. The results of the probability network should be more representative of statewide conditions and may be able to shed light on any biases in the basin and stream assessments due to, for example, the location of monitoring stations. Florida plans to make comparisons between both types of monitoring approaches as its probability network continues to evolve.