ENVIRONMENTAL MONITORING AND ASSESSMENT PROGRAM

SURFACE WATERS FIELD OPERATIONS MANUAL FOR LAKES

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lake_hab.pdf	Protocols for temperature, dissolved oxygen, shoreline physical habitat (Section 5)
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lake_wat.pdf	Protocols for Secchi transparency, water sample collection, chlorophyll a, zooplankton, sediment diatom (Section 7)
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ENVIRONMENTAL MONITORING AND ASSESSMENT PROGRAM SURFACE WATERS

FIELD OPERATIONS MANUAL FOR LAKES

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ABSTRACT

The methods and instructions for field operations presented in this manual for lake surveys were developed and tested through 4 years of pilot and demonstration projects from 1991 through 1994. These projects were conducted under the sponsorship of the U.S. Environmental Protection Agency and its collaborators through the Environmental Monitoring and Assessment Program (EMAP). This program focuses on evaluating ecological conditions on regional and national scales. This document describes procedures for collecting data, samples, and information about biotic assemblages, environmental measures, or attributes of indicators of lake ecosystem condition. The procedures presented in this manual were developed based on standard or accepted methods, modified as necessary to adapt them to EMAP sampling requirements. In addition to methodology, additional information on data management and other logistical aspects is integrated into the procedures and overall operational scenario. Procedures are described for collecting chlorophyl *a*, water, sedimentary diatoms, and zooplankton data in conjunction with the development of standard methods to obtain acceptable index samples for macrobenthos, fish assemblage, fish tissue contaminants, riparian birds, and physical habitat structure. The manual describes field implementation of these methods and the logistical foundation constructed during field projects. The manual includes flow charts with overall summaries of specific field activities required to visit a lake site and collect data for these indicators. Tables give step-by-step protocol instructions. These figures and tables can be extracted and bound separately to make a convenient quick field reference for field teams. The manual also includes example field data forms for recording measurements and observations made in the field and sample tracking information. Checklists of all supplies and equipment needed for each field task are included to help ensure that these materials are available when required.

SECTION 1
INTRODUCTION

by
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The U.S. Environmental Protection Agency (EPA), in cooperation with other federal and state organizations, has designed the Environmental Monitoring and Assessment Program (EMAP) to periodically assess the condition of the Nation's ecological resources. This document provides background and procedures for field personnel working with the EMAP Surface Waters Resource Group, one of seven EMAP ecological resource groups. The Surface Waters Group focuses on monitoring and assessment of the condition of lakes and streams. This manual covers field operations for lakes. The procedures and protocols described in this manual have been tested, modified, and refined during 4 years of pilot and demonstration studies in the northeastern United States.

1.1 OVERVIEW OF EMAP SURFACE WATERS

The intent of EMAP is to assist decision makers, both within and outside the Agency, to evaluate the cumulative effectiveness of current environmental regulations in protecting the Nation's natural resources, prioritize issues of concern and regions in which action is needed, and set environmental policy. This Program is a strategy to identify and bound the extent, magnitude, and location of degradation or improvement in the environment. In the long-term, the Program intends to contribute to answering the following critical questions:

- What is the current extent of our ecological resources (e.g., estuaries, lakes, streams, forests, and grasslands) and how are they distributed geographically?
- What percentage of resources appears to be adversely affected by pollutants or other anthropogenic environmental stresses?
- Which resources are degrading or improving, where, and at what rate?
- What are the relative magnitudes of the most likely causes of adverse effects?
- Are adversely affected ecosystems improving as expected in response to cumulative effects of control and mitigation programs?

To answer these questions, the various, integrated monitoring networks within EMAP focus on the following objectives:

- Estimate the current status, extent, changes, and trends in indicators of the condition of the Nation's ecological resources on a regional basis with known confidence.

- Monitor indicators of pollutant exposure and habitat condition and seek associations between human-induced stresses and ecological condition that identify possible causes of adverse effects.

- Provide periodic statistical summaries and interpretive reports on ecological status and trends to the EPA Administrator and to the public.

The EMAP Surface Waters resource group plans to estimate the condition of lakes, reservoirs, streams, and rivers on relatively broad, regional scales. The design of the program uses an integrated, probability-based monitoring framework based on a systematic grid and is explained in detail by Paulsen et al. (1991), Larsen and Christie (1993), and Larsen et al. (1994). Figure 1-1 summarizes the probability-based selection process. Lake, reservoir, stream, and wetlands resource information is initially derived from hydrologic information which is part of U.S. Geological Survey (USGS) 1:100,000 scale Digital Line Graphs (DLGs). Specific spatial information associated with surface water bodies (e.g., geographic coordinates and surface area or stream "blue line" length) extracted from the DLGs into a data base file. After accuracy and completeness checks, missing surface water bodies are added to the spatial file.

The first stage (Tier I) of the probability sample is developed by intersecting the spatial file of surface water body information with a second file containing spatial information related to the EMAP systematic sampling grid. The Tier I sample represents all surface water bodies whose digitized labeling points are located within the boundaries of one of the hexagons.

The second stage of site selection involves selecting a subset of the Tier I sample. This subset (Tier II) represents sites that are expected to be visited by field sampling crews. The Tier II sample is selected through a process that incorporates the desired Tier II sample size and any Tier I stratification needed (e.g., lake area). Sites are selected randomly from the Tier I sample, with the constraint that the spatial distribution of sites be preserved. Each Tier II site has an associated inclusion probability with which any measured attribute can be related to the target population of sites.

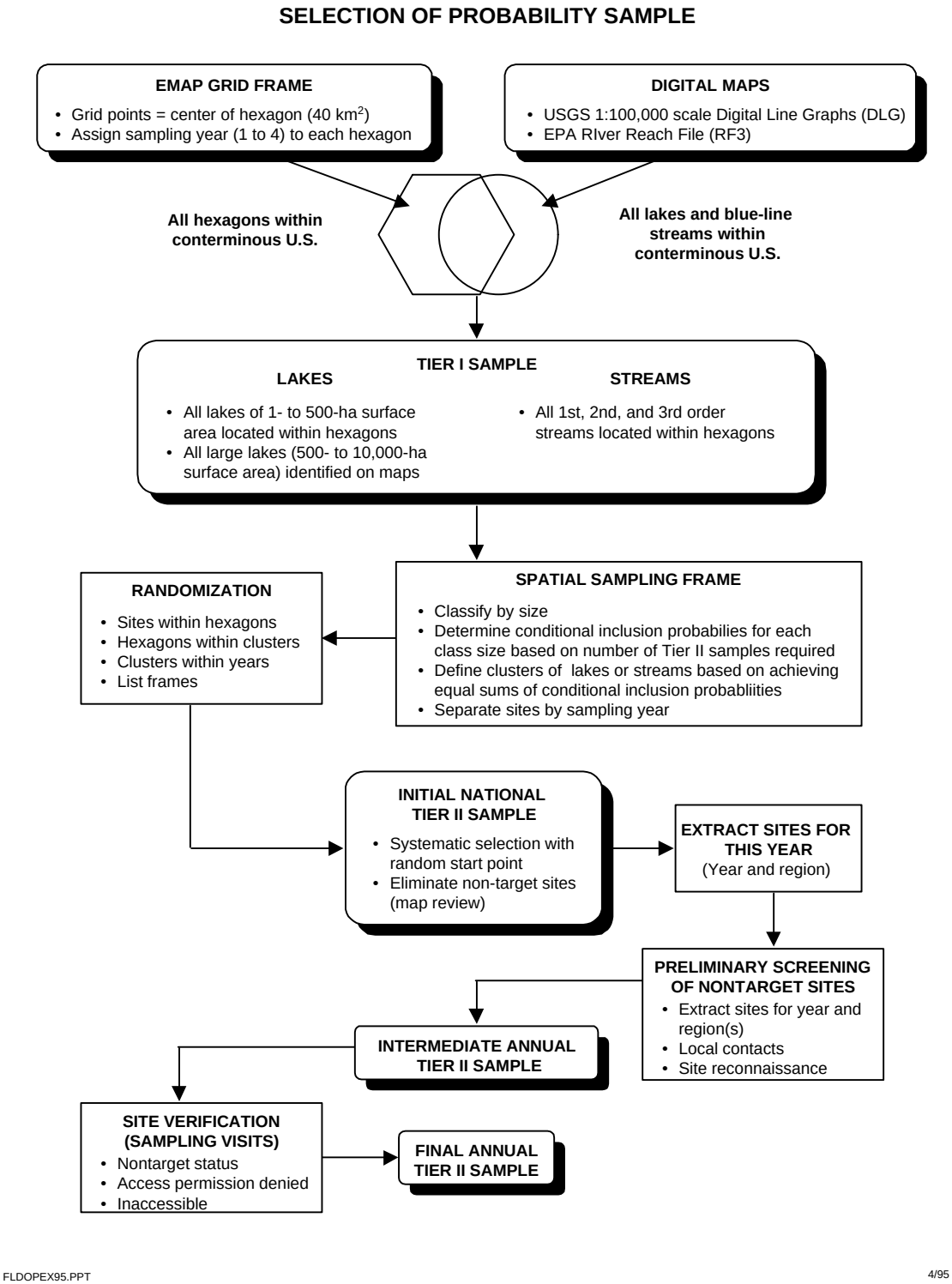

Figure 1-1. Selection of probability sample.

A sample size of at least 30 to 50 is necessary for making statements about the condition of a regional subpopulation with reasonable precision. Larger total sample sizes are necessary if the condition of numerous subpopulations are to be described. Overselection should protect against a reduction in sample size due to: (1) landscape-related errors not portrayed by the DLGs, (2) the inability to visit a site due to weather conditions or lack of access permission, or (3) the reclassification of a site to nontarget status when it is visited.

Data obtained from Surface Waters projects allow estimation of the spatial extent and geographical distribution of various classes of surface waters. Additionally, investigators can use the data to estimate the current status of, and changes or trends in, indicators of lake ecological condition.

1.2 SYNOPSIS OF THE LAKE SAMPLING COMPONENT OF EMAP SURFACE WATERS

Field activities conducted by the EMAP Surface Waters resource group for lake monitoring and assessment from 1991 through 1994 consisted of pilot and demonstration projects in the Northeast. The pilot projects were designed to answer questions related to development of proposed "indicators" of the condition of surface waters. Various aspects of each indicator were evaluated during the pilot projects, including plot design, sensitivity to various stressors, magnitude of spatial and measurement variance components, evaluation of methods and other logistical constraints. The 1994 demonstration project was designed to evaluate the capability of indicators to be implemented on a regional scale and their ability to estimate the condition of regional populations of lakes.

Ecological indicators are measurements, metrics, or indices that quantify physical, chemical or biological condition, habitat, or stress (Larsen and Christie, 1993). Measurements of a biological assemblage (e.g., fish or diatoms) or other ecosystem attribute are converted into numerical metric or index scores. The distribution of indicator values is presented and used to determine the status of the resource populations of interest.

Because it is not possible to measure all attributes in all parts of all waterbodies at all times, an "index" sample is collected. To be valid, index sampling at a lake must take place at appropriate times and locations. Index samples must adequately represent the waterbody character. In addition, the lakes and streams selected for sampling must represent the population of waters from which they are drawn--the survey must be conducted on a spatially balanced, probabilistic selection of lakes and streams.

Selection of the appropriate measurements for each indicator is necessary to begin development of a diagnostic plan that guides the search for associations between indicators

of condition (response indicators) and indicators of stress induced by both humans and nature (diagnostic indicators). Response indicators are developed based on field data collected for chlorophyll *a*, macrophytes, fish, riparian birds, zooplankton, benthos, and sedimentary diatoms. Diagnostic indicators are developed using exposure, habitat, and available stressor data to allow testing hypotheses that poor biological conditions are associated with hydrological, physical habitat, chemical, or biological modifications.

Acceptable index sampling approaches for chlorophyll-*a*, water quality, sedimentary diatoms, and zooplankton had already been determined before the 1991 pilot. These methods were used as a regional probability sample of lakes to answer questions about the logistics of conducting regional surveys and to begin to collect data on important components of variance. Standard methods for obtaining an acceptable index sample for macrobenthos, fish assemblage, fish tissue contaminants, riparian birds, and physical habitat structure were not available in the literature or in methodologies of the monitoring community. For these indicators, focused pilot studies helped to develop efficient indexing protocols appropriate for a single visit by a small field team. These protocols were then applied to the regional probability sample for further evaluation. The protocols and instructions for field operations presented in this manual are an outgrowth of the testing and refinement of the existing and developed methods and the logistical foundation constructed during their implementation in the field from 1991 through 1994.

Field operations and training were planned and conducted by representatives from several organizations. These include the EPA (involving EPA personnel from several laboratories [Las Vegas, Nevada; Corvallis, Oregon; and Cincinnati, Ohio], EPA Regions 1 and 2, and EPA cooperators and contractors) and the U.S. Fish and Wildlife Service (involving personnel representing Region 5 and a cooperative agreement); state agencies; cooperators; and contractors. Training prepared six to eight field teams of three or four members each to collect samples and data from 80 to 100 lakes annually in the Northeast. Field work also included collecting samples from approximately two to four dozen lakes by helicopter for the Temporally Integrated Monitoring of Ecosystems (TIME) project. Field operations usually began the first week in July and continued through August, sometimes continuing into early September. In addition to actual sampling tools and supplies, other equipment provided to each team included two 4-wheel-drive vehicles, a boat and trailer, and a portable computer. Field Coordinators provided support for the teams and a Communications Center served as a central point of contact for exchange of information and requests for supplies or assistance.

1.3 INDICATOR SUMMARY

Each of the following subsections describes biotic assemblages, environmental measures, or attributes of indicators used by EMAP-Surface Waters to evaluate the condition of lakes. To aid field personnel in understanding sampling procedures, these sections address the rationale for these measures and the significance of certain aspects of the methodologies. These indicators do not represent all possibilities, but were selected based on an evaluation approach using criteria deemed appropriate to meet EMAP requirements. Additional information regarding this evaluation can be found in Paulsen et al. (1991).

1.3.1 Physical Habitat

The magnitude of aquatic ecosystem degradation and loss due to physical habitat alterations in the United States may exceed degradation due to other human activities. The physical habitat shoreline and littoral surveys that the Surface Waters field teams conduct serve three purposes. First, this habitat information is absolutely essential to the interpretation of what lake biological assemblages "should" be like in the absence of many types of anthropogenic impacts. Second, the habitat evaluation is a reproducible, quantified estimate of habitat condition, serving as a benchmark against which to compare future habitat changes that might result from anthropogenic activities. Third, the specific selections of habitat information collected aid in the diagnosis of probable causes of ecological impairment in lakes.

In addition to information collected in the field by the shoreline and littoral surveys, the physical habitat description of each lake includes many map-derived variables such as lake surface area, shoreline length, and shoreline complexity. Furthermore, an array of information, including watershed topography and land use, supplements the physical habitat information. The shoreline and littoral surveys concentrate on information best derived "on the ground." As such, these survey results provide the all-important linkage between large watershed-scale influences and those forces that directly affect aquatic organisms day to day. Together with water chemistry, the habitat measurements and observations describe the variety of physical and chemical conditions that are necessary to support biological diversity and foster long-term ecosystem stability. These characteristics of lakes and their shorelines are the very aspects that are often changed as a result of anthropogenic activities.

The shoreline and littoral habitat surveys employ a randomized, systematic design with 10 equally spaced observation stations located around the shore of each sample lake. Teams go to the field with premarked lake outlines showing these stations. The observations at each station include

quantitative and semiquantitative observations of vegetation structure, anthropogenic disturbances, and bank substrate onshore. In-lake littoral measurements and observations deal with littoral water depth, bottom substrate, nearshore fish cover, and aquatic macrophyte cover. With quantifiable confidence, investigators condense these observations into descriptions applicable to the whole lakeshore and littoral zone. For example, team observations lead to quantitative descriptions such as the mean canopy or aquatic macrophyte cover along the lakeshore, the extent of shoreline disturbed by various human activities, and the dominant littoral substrate in the lake.

1.3.2 Fish Assemblage

Major objectives for the fish assemblage indicator work are to collect an index sample of the fish assemblage at each lake and to use the data derived from these samples to develop metrics of biological integrity. Biological integrity is a measure of the ability of the biotic components of an ecosystem to maintain a level of diversity and functional organization that is comparable to natural systems unimpacted by human disturbance (Karr and Dudley, 1981; Karr et al., 1986; Noss, 1990). Following the approach of Karr (1986) for use in streams, metrics are developed from numerical measures of various attributes of lake fish assemblage structure and composition. Responses of individual metrics are then compared to expected conditions in lake fish assemblages if human disturbance is absent or minimal. High biological integrity should be reflective of good lake water quality and lake habitat conditions.

For EMAP an index sample of lake fish is collected by catching (a) all except rare species; (b) enough individuals to indicate relative proportions of abundant and common species, which species are uncommon or rare, and the general population structure of abundant and common species; and © nonadults of naturally reproducing species.

Because of the various habitats in lakes, the habitat preferences of different species, and habitat specificity of sampling gear, there is no single method to index fish assemblages in all lakes. Therefore, EMAP Surface Waters uses a combination of gear types in a variety of habitats. The challenge is to index fish assemblages in large numbers of lakes of varying sizes, physical structures, and accessibility using multiple teams to collect samples and data. At each lake a team assesses the presence and proportion of major fish habitats. All habitats are sampled regardless of their expected productivity (gear are not placed to maximize catch), using a stratified random protocol. Littoral habitats are classified by presence and type of cover and by substrate type. Areas of extensive human modification are considered to be a habitat type. Samples are collected in as many as five of the most

extensive littoral habitats at each lake, as close as possible to randomly chosen physical habitat stations.

Fish are collected with passive gear--gill nets set overnight in oxygenated midlake areas, trap nets set overnight in littoral habitats, and minnow traps placed in shallow water with cover near the trap nets. After sunset, appropriate locations are seined. The fish are identified to species and examined for external gross pathology. Long-lived species are measured for length (short-lived species are recorded by size class). Specimens of all small fishes are preserved for archival storage in a museum. At most lakes a sample consisting of five large fish is collected for tissue contaminant analysis (Section 1.3.3).

Data collected in the lake surveys are used to evaluate several metrics of lake fish assemblages as indicators of biological integrity including (1) species richness as a measure of assemblage diversity, (2) numbers of introduced species and individuals relative to native species as a measure of biological stress and resiliency of the native fauna, and (3) proportion of individuals sensitive to human perturbation relative to proportion of tolerant species. In addition, the EMAP Surface Waters team will evaluate combining several metrics into an overall index of biological integrity reflecting changes in the species structure related to individual stressors, combinations of stresses, or reductions in impacts.

1.3.3 Fish Tissue Contaminants

As an indicator of accumulation of toxic chemicals in a lake, levels of contaminants in fish tissue can be used to estimate regional hazards to predators of fish, either wildlife or human. The EMAP Surface Waters group proposes to track how these hazards change with time. The fish tissue contaminants indicator has characteristics of both response and diagnostic indicators (Paulsen et al. 1991). As a response indicator tissue contaminant levels can be used to infer effects on piscivorous populations in and around lakes. When response indicators identify lake degradation, the fish tissue contaminants indicator can also be used in conjunction with other diagnostic indicators (physical habitat, water chemistry, land use, population density, and other records of relevant anthropogenic stresses) to discover the probable causes. Analyses of fish tissue detect contaminants such as a number of organochlorinated pesticides, PCB congeners, and heavy metals, including mercury.

It would be optimal, in representing fish bioaccumulation of contaminants, to collect samples of both top predators and bottom feeders from each lake. However, for Surface Waters lakes surveys, priority is given to top predators primarily because of their ecological significance as likely prey of the

consumers of main concern--piscivorous birds (including endangered raptors), mammals (e.g., mink and otter), and man. Bottom feeders are considered secondary target fish (lowest in the ranking order).

Various studies of fish tissue contaminants have focused on different parts of the fish, such as fillets or livers, or on the whole fish. The EMAP Surface Waters group will focus on whole fish because of the Program focus on the ecological health of the whole lake (as opposed to a focus solely on human health concerns). Whole fish are a reliable ecological indicator and a better indicator of risk to piscivorous wildlife than fillets, as wildlife (and some human consumers, i.e., subsistence fishermen) are likely to consume more parts of the fish than just the fillets. Results derived from analyzing whole fish also provide information about risks to human health. In addition, whole fish present fewer logistical problems for field crews (no gutting is required in the field, and use of dry ice for preserving and shipping is not necessary) and the analytical laboratory (no filleting is necessary).

Repeated lake sampling within the index period for fish tissue will answer two questions: "Will repeat visits yield the same types and numbers of fish?" and, most importantly, "Will the five-fish composite from each of two visits yield a similar value for level of contaminants in that lake?" In trying to answer these questions and provide reproducible (useful) data, the efforts of field teams to apply the protocol for sampling, handling, and shipping, in a consistent manner are very important.

1.3.4 Water Chemistry and Associated Measurements

The primary functions of lake water samples collected from the Van Dorn sampler and in situ water column measurements are to determine acid-base status, trophic state, and classification of water chemistry type. Lake water collected in Cubitainers is used to measure major cations and anions, nutrients, turbidity, and color. Water samples, collected in sealed syringes to minimize contact with the atmosphere, are analyzed for pH, dissolved inorganic carbon, and monomeric aluminum species (believed to be toxic to fish under acidic conditions). The concentration of each of these analytes will change if the lake water sample equilibrates with atmospheric carbon dioxide. Both the Cubitainers and the syringes must be shipped as soon as possible by overnight courier service because the syringe samples need to be analyzed and the Cubitainer samples need to be stabilized (filtration and/or acidification) within a short period of time (72 hours).

The filter paper from the lake water filtration is used to determine chlorophyll concentration, an indicator of algal biomass in the lake. The filtration (and filter paper) should be shielded from light as much as possible because light breaks down chlorophyll.

Throughout the water chemistry sampling process it is important to take precautions to avoid contaminating the sample. Many lakes in some regions (e.g., the Northeast) have a very low ionic strength (i.e., very low levels of chemical constituents) and samples can be contaminated quite easily by perspiration from hands, sneezing, smoking, suntan lotion, insect repellent, fumes from gasoline engines or chemicals used during sample collection (e.g., the narcotizing agent used for zooplankton or formalin).

1.3.5 Zooplankton

Zooplankton are important components of the open water environment of lakes and ponds. Most species are microscopic and consist of crustaceans (copepods, cladocerans, and opossum shrimp), rotifers ("wheel-animals"), pelagic insect larvae (phantom midge), and aquatic mites. In lakes of the northeastern United States, more than 200 species have been recorded. Zooplankton are important elements of the food chain where they transfer energy from algae (primary producers) to larger invertebrate predators and fish. The zooplankton species assemblage responds to environmental stressors such as nutrient enrichment, acidification, and fish stocks. The effects of environmental stress can be detected through changes in species composition and abundance, body size distribution, and food web structure.

Body size (0.05 to 15 mm long) and swimming abilities vary greatly among zooplankton species. Some species can swim fast enough to avoid being caught by the net. Therefore, we use two kinds of nets to optimize capture of size-based fractions--a coarse mesh net for fast swimming macrozooplankton ($\geq$600 µm long) and a fine mesh net for the microzooplankton (<600 µm long). The net is hauled from about 0.5 m off the bottom to the surface in the deepest part of the lake. It is important to avoid bottom sediments which clog the net pores and make the sample unusable. If bottom sediments occur in the sample, the net must be washed out and the procedure repeated. The net should be towed slowly (about 0.5m/sec) to reduce the pressure wave at the "bow" of the net. Some species can detect this frontal wave and swim out of the path of the net. The reducing collar on the fine mesh net decreases the volume of water passing through the net, thus increasing the filtration efficiency of the net and reducing the pressure wave problem. Because the net phytoplankton and debris are collected primarily in the fine mesh sample, laboratory preparation and processing is greatly facilitated for the macrozooplankton fraction. Finally, it is important to thoroughly rinse the nets to avoid contaminating later samples with species that may adhere to the inner sides of the net. Placing the nets into a mild bleach solution will help alleviate this problem and reduce the possibility of spreading resistant stages of exotic species to other lakes.

As the summer progresses, wind-driven mixing enlarges the warm water epilimnion and reduces the cold water hypolimnion. This mixing becomes increasingly important in small, shallow (10 to 15 m deep) lakes where the later summer, cold water hypolimnion may be only 1 to 3 meters thick. Therefore, when sampling such lakes, it is very important to take the tow at the deepest spot. Missing the deep spot by 1 or 2 meters of depth can miss such a cold water stratum and greatly confound interpretation of the true species assemblage in such lakes. This possibility is a concern for fish as well as zooplankton samples.

1.3.6 Sediment Diatoms

The diatom indicator is unique in that it can potentially tell us the "original" or pristine condition of the lake. None of the other indicators can provide this information. Thus, sampling the sediments in a precise and consistent manner is particularly critical. To assess the original condition, sediments dating from that time need to be collected. A general understanding of the diatom indicator and the sampling and analysis process will enhance sample collection.

The diatom cell wall is composed of silicon dioxide and is preserved in lake sediments. Markings on the cell wall are used to distinguish species and even varieties. Dozens of different species occur in any lake and its drainage basin, many of which end up in the sediments at the center of the lake. Each of the species has slightly different environmental requirements; for many species, these requirements are known. By studying the diatom community, it is possible to make inferences about previous conditions in the lake and its basin.

To study the microscopic cells, the sediments are cleaned of organic matter with strong oxidizing agents and slides are made. The analysis is made by identifying and counting 500 individual cells. Any contamination of the samples can produce significant errors in the resulting interpretation. Samplers must be careful not to contaminate the bottom sample with higher levels of the core or with lake water or with the tools used to collect the sample (i.e., the corer, core tube, and spatulas) and not to mix the top layer with the deeper sediments, thus obscuring small changes in community structure which are critical to monitoring trends.

Results from the 1991 Surface Waters pilot study indicated that some productive lakes were not sampled at a deep enough level to get a sample of sediments representing the preindustrial condition. Samplers should make an effort to get at least a 45-cm core from all lakes that have a Secchi disk reading of 2.5 m or less. Some judgment is necessary. For example, if the lake is artificial, there is no point in sampling through its sediments into the soil profile below. For most other lakes, a core 35 cm in length is adequate.

Since an undisturbed sediment sample is needed, outboard motors should not be used in shallow lakes near the sampling site nor should there be vigorous use of paddles or oars. If for some reason the first core is not satisfactory, a second try should be made in another spot. If the boat is well-anchored, the second try could simply be on the other side of the boat. If a corer begins to malfunction frequently, another should be acquired. The team should keep good notes--for example, if it is not possible to get a 45-cm core in a lake that seems to be very productive, the notes should explain the situation.

Data on diatom abundance and species composition is obtained from the cell counts. These data are combined with environmental data (e.g., chemical concentrations) and analyzed using multivariate statistical techniques. From this analysis, the expected abundance of individual taxa as a function of one or more environmental variables is determined. These expected abundance distributions are then used to infer historical conditions based on cell counts obtained from the bottom of the core samples.

1.3.7 Benthic Invertebrate Assemblages

Bottom dwelling invertebrates have long been used as indicators of water quality throughout this country and abroad. In the United States their use as living monitors of environmental conditions has principally been applied in environmental assessments of rivers and streams. However, European biologists have used benthic invertebrates for purposes of classifying lakes as to trophic status since the 1920s. Although their use for this purpose has not been as widespread in North America as it has been in Europe, these organisms show great potential as indicators of the biotic integrity and ecological condition of this Nation's lakes and reservoirs.

Freshwater benthic invertebrates are those organisms that spend at least part of their life cycles in or upon the substrates of aquatic systems. They are represented by forms that cling to, burrow in, or crawl over the sediments or other substrata of waterways and waterbodies. The larger forms that can be seen with the unaided eye and retained by a U.S. Standard No. 30 mesh sieve (28 meshes per inch and openings of 595 µm) are the benthic macrofauna or macroinvertebrates. It has become customary within the EPA to focus on these larger forms because they are relatively easy to separate from debris and to identify. This bias toward the larger animals undoubtedly can be traced back to the days when invertebrates were sampled principally to provide an estimate of the forage available for fish, since most of the animal biomass within and upon a unit area of substrate is contained within the larger animals. Secondly, the very early instars of insect larvae are difficult to identify reliably and, until fairly recently, good taxonomic descriptions of small oligochaetes (naidid worms) were not available.

In the lake sediment sample, the small benthic invertebrates that pass through a No. 30 mesh sieve may far outnumber those larger animals retained by the sieve. Because these small organisms contribute substantially to the total taxonomic diversity and standing stock of all benthic assemblages, to exclude them from the analyses of invertebrate samples could result in the loss of considerable information about the biological integrity of the system in question. For this reason we have elected not to restrict our analyses to the macroinvertebrates, but to include all true, identifiable benthic animals that are retained by a U.S. Standard No. 60 mesh sieve (60 meshes per inch and openings of 250 µm). Excluded from the analyses are the copepods, cladocera, and other forms that are not necessarily true benthic dwellers or that are not reliably identifiable by most aquatic biologists beyond broad taxonomic groups.

Currently there are a number of indices of biotic integrity for invertebrate assemblages in streams, but these indices have not been widely applied to lake assemblages. Considerable research is needed to evaluate and modify those indices for application to lake benthos. It is our intent to focus on the most promising metrics and indices for purposes of validating their use as a measure of biological integrity of lakes and reservoirs.

Benthos sampling is restricted to the sublittoral zones of EMAP grid lakes. Single modified K-B (Glew) corer samples are taken in the soft, weedless sediments at similar depths at 10 approximately evenly spaced locations around the perimeters of each lake. Each of the 10 sites corresponds to the 10 physical habitat observation stations located during the physical habitat and lake shoreline survey. In thermally stratified lakes, the samples are taken in well-oxygenated areas at depths equal to or less than the depth where the upper limits of the metalimnion intersect the lake bottom. In nonstratified lakes, samples are collected in weedless areas at depths greater than 1 m.

Only the upper 13 cm of each core sample are retained for analysis, as the uppermost sediments contain the majority of the animals. At the laboratory, a composite sample are prepared for each lake from individual core samples from alternate sites at the lake (i.e., the composite sample is composed of between 1 and 5 core samples). The composite sample is divided into eight equal fractions in the laboratory, using a device developed specifically for this purpose. Individual fractions are processed under microscopes until 150 animals have been sorted from the debris. This number excludes microcrustaceans, plankton, nematodes, terrestrial insects, dead or empty snail shells, and all other nonbenthic animals that may have settled on the bottom of the lake. After the target number of animals has been achieved, the entire fraction of the sample being examined is completely processed. If a minimum of 150 animals cannot be obtained from the initial composite sample, a second composite sample is prepared from the remaining individual core samples from the lake, and the

process repeated until at least 150 animals have been sorted from the composited fractions. After the individuals have been identified, the numbers are normalized to numbers per tenth of a square meter of substrate surface area.

In addition, team members make a qualitative survey for the exotic zebra mussel at each physical habitat station and at the launch site. They look for mussels attached to hard substrates and, if any are found, collect and preserve an example. This procedure is meant to record and document whether or not the presence of adult zebra mussel is detected for each lake. The larval forms may be detected in the zooplankton collections.

1.3.8 Lake Assessment or Site Characteristics

Observations and impressions made on the lake by the field teams are extremely useful for ecological value assessment, development of associations and stressor indicators, and data verification and validation. Thus, it is important that observations of the field teams about lake characteristics be recorded for future data interpretation and validation. The form provided for this purpose is designed as a guide for recording pertinent field observations. It is by no means comprehensive and any additional observations should be recorded in the "Comments" section. Team members complete the form at the end of the lake sampling, taking into account all observations made while on site.

1.3.9 Riparian Bird Assemblage

The riparian bird assemblage measures are being developed as an indicator of riparian zone condition and its role linking aquatic conditions with terrestrial sources of disturbance. Observations are intended to evaluate measurement variability among EMAP grid lakes during the spring index period and to determine which species and guild combinations provide the most information about ecosystem condition. Other goals are to correlate avian guild rankings of sensitive and tolerant taxa, trophic groups, wetland dependent species, and habitat specialists with the range of conditions presented at the sampled lakes. Teams of ornithologists generally visit the EMAP grid lakes between late May and early July each year. At each lake, a team traverses a shore transect by canoe around the shore, stopping every 200 m to record birds seen or heard within a 5-minute period and to record habitat information. Procedures for the bird assemblage indicator are provided in Appendix A.

1.4 OBJECTIVES AND SCOPE OF THE FIELD OPERATIONS MANUAL

Two separate documents describe field operations activities for continuing investigations of lakes by the EMAP Surface Waters resource group. The field operations manual (this document)

describes field protocols, quality assurance (QA) and quality control (QC) procedures, and operations directly related to EMAP Surface Waters that should be capable of being implemented consistently across all regions. Section 2 provides a summary of daily field operations. Section 3 describes base site activities both before departure to a site and after sampling. Sections 4 through 6 describe the protocols for the first day in the field, and Sections 6 through 9 describe protocols for activities conducted the second day at a site. Appendix A is the field operations manual developed at the University of Maine for collecting data on riparian bird assemblages. Checklists for equipment and supplies required to conduct various activities are presented in Appendix B. Appendix C contains a complete set of blank field data forms.

The second document, a regional activities plan, contains operations and safety information and other procedures that apply to a specific regional project. This volume is developed by the various regional organizations that implement the field program; its contents may vary from region to region because of different regional requirements.

For use in the field, each team receives a quick-reference handbook that contains tables and figures summarizing protocols and other pertinent information from this Field Operations Manual for Lakes and the regional activities plan. This waterproof handbook is the primary field reference used by field teams after an intensive 2- to 3-week training program. Each field team also receives an information management handbook that contains instructions for tracking samples and generating sampling status reports as well as using the computers and associated hardware and software. The field teams are also required to keep the field operations manual available in the field for reference and for possible protocol clarification.

Large-scale and/or long-term monitoring programs such as those envisioned for EMAP require a rigorous QA program that can be implemented consistently by all participants throughout the duration of the monitoring period. Quality assurance is a required element of all EPA-sponsored studies that involve the collection of environmental data (Stanley and Verner, 1986). Field teams are provided a copy of the integrated QA plan for EMAP Surface Waters (Chaloud and Peck, 1994). The QA plan contains more detailed information regarding QA/QC activities and procedures associated with general field operations, sample collection, measurement data collection for specific indicators, and data reporting activities.

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SECTION 2
DAILY OPERATIONS SUMMARY

by
John R. Baker and David V. Peck

2.1 SAMPLING SCENARIO

Two days are required to sample most lakes. A third day is allotted for predeparture and postsampling activities (e.g., cleaning equipment, repairing gear, shipping samples, and traveling to the next lake). In a normal week, if there is no down time due to weather or supply problems, a field team can sample two lakes over 6 days. Larger lakes (>74 ha) require additional travel time on the lake and 3 to 4 days are scheduled to sample these lakes.

A field team is usually composed of three to four people. Under certain circumstances, additional people may be required to assist teams sampling large lakes or hike-in lakes. Two people are always in the boat to execute the sampling activities and ensure safety. The remaining team member(s) usually remains on shore to provide logistical support. Team members should rotate between boat and shore activities.

A daily field sampling scenario showing how the work load may be split between team members is presented in Figures 2-1 through 2-3. Each field team should work with and modify this scenario, defining roles and responsibilities for each team member, to organize field activities efficiently. Most roles and responsibilities should be defined by the end of the training program.

The sequence of sampling events presented in Figures 2-1 through 2-3 cannot be changed without prior direction from the Communications Center (see Section 3.2.3). The sequence is based partially on the need to protect some types of samples from potential contamination and to minimize holding times once samples are collected. The following sections further define the sampling sequence and the protocols for sampling activities.

Day 1

Sampling activities on the first day will extend past dusk. The team should arrive at the lake before midmorning to accomplish all of these activities. The sampling sequence for Day 1 is to:

- verify lake and locate index site,
- conduct depth profile measurements of dissolved oxygen and temperature,

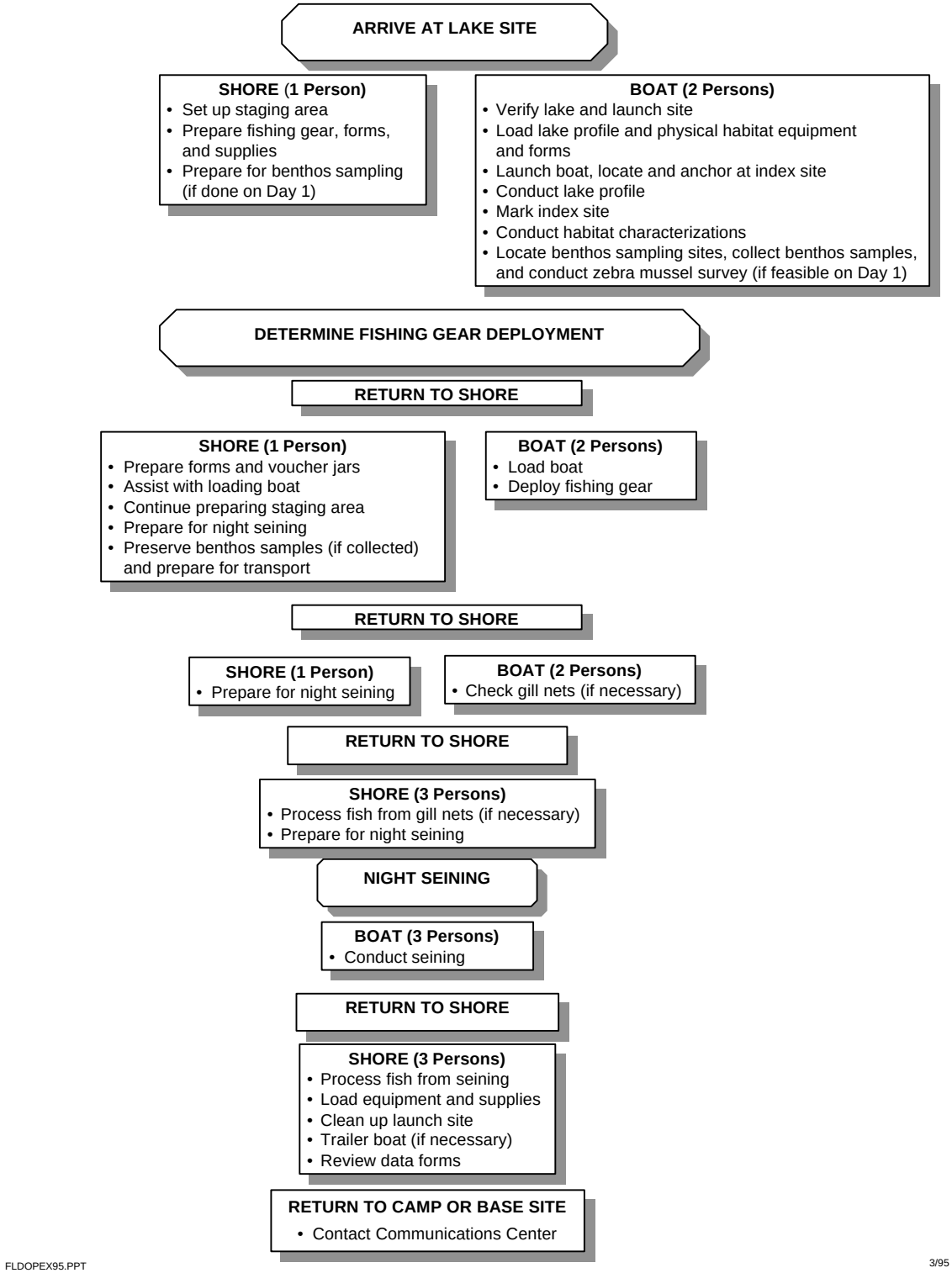

Figure 2-1. Day 1 field sampling scenario.

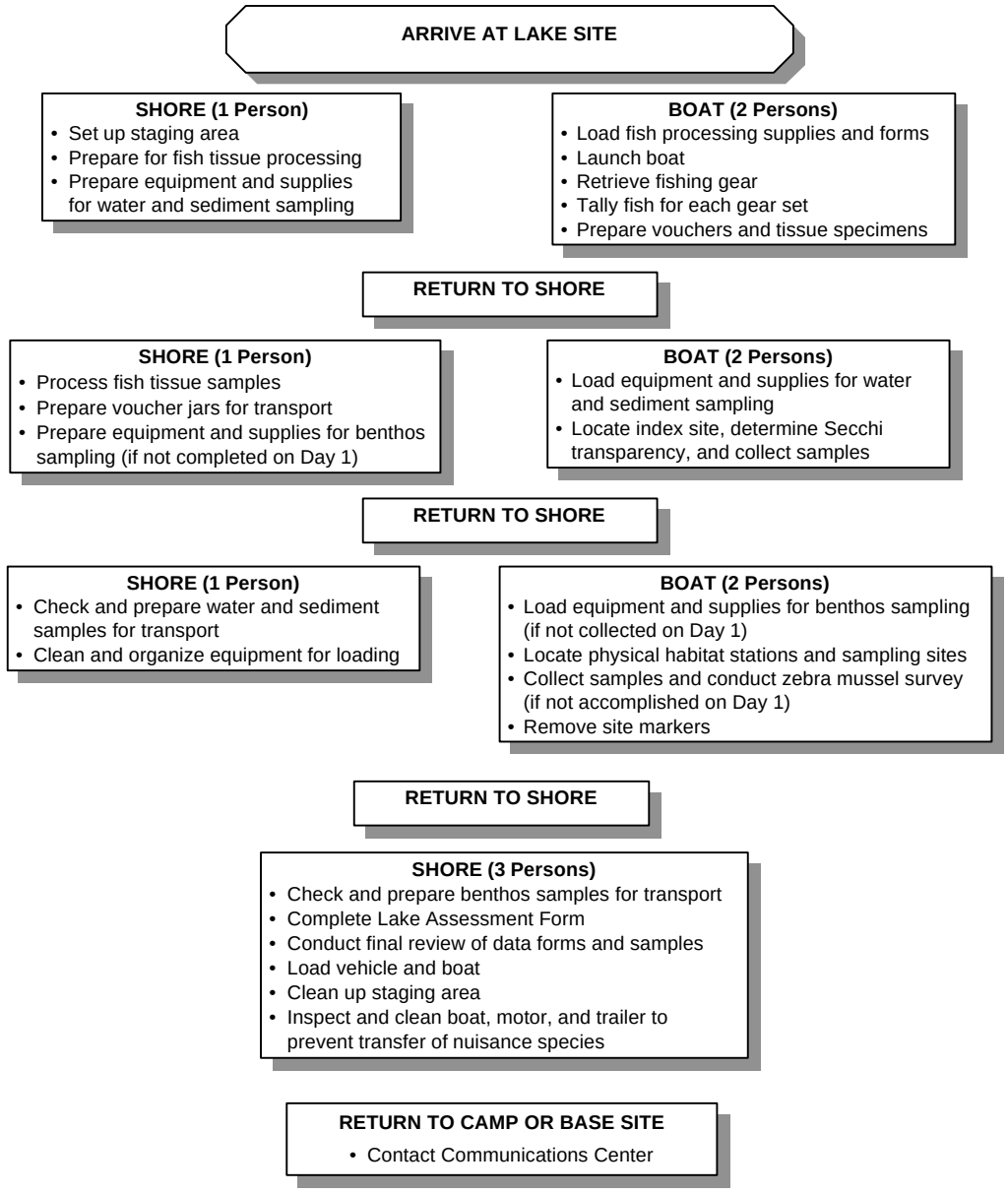

Figure 2-2. Day 2 field sampling scenario.

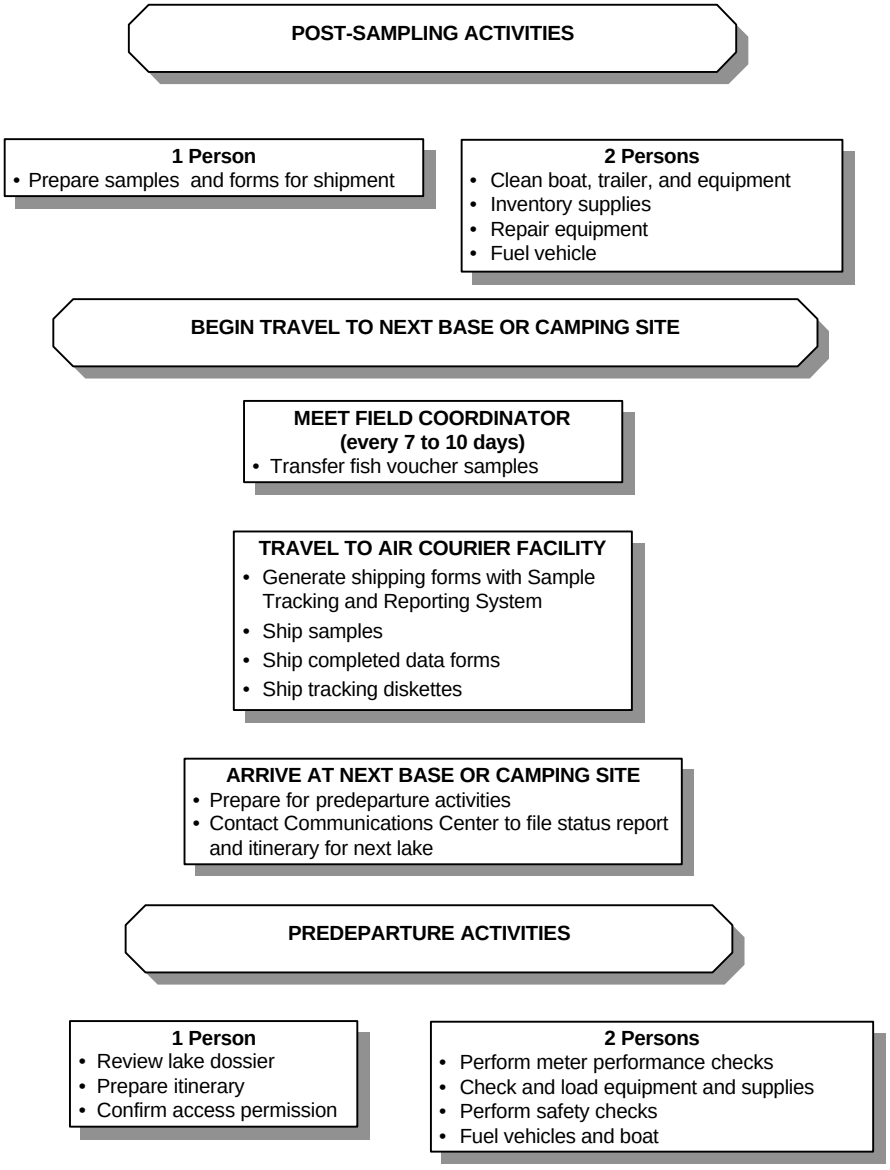

Figure 2-3. Day 3 field sampling scenario.

- conduct physical habitat characterization (optional: collect benthos sample and conduct zebra mussel survey),
- deploy fishing gear, and
- check gill nets (if required by permit) and conduct night seining activities.

Protocols for these activities are described in Sections 4 through 6.

Day 2

A full day is required for Day 2 sampling activities. The team should arrive at the lake in the early morning to complete the sampling at a reasonable time. The sampling sequence for Day 2 is to:

- retrieve fish gear and tally fish,
- process fish tissue samples,
- prepare fish voucher specimens,
- determine Secchi disk transparency,
- collect water chemistry samples and filter chlorophyll sample,
- collect zooplankton samples,
- collect sediment diatom samples, and
- collect benthos samples (if not previously collected) and conduct zebra mussel survey.

Protocols for these activities are described in Sections 6 through 9.

A third day is allotted for these lake activities on large lakes (>74 ha) with only half the fish gear set out on Day 1; the first half of the gear is retrieved and the second half is set out on Day 2. On Day 3 the second half of the gear is retrieved and the remainder of Day 2 activities are completed.

Day 3

Section 3 of this manual discusses Day 3 activities at a base site. These activities consist of preparations required before departing for a lake site and of postsampling activities required after leaving the lake site.

2.2 RECORDING DATA AND OTHER INFORMATION

During the 2- to 3-day visit to a lake, a field crew is required to obtain and record a substantial amount of data and other information for all the various ecological indicators described in Section 1. In

addition, all the various samples collected need to be identified and tracked, and associated information for each sample must be recorded.

It is imperative that field and sample information be recorded accurately, consistently, and legibly. Measurement data that cannot be accurately interpreted by others besides the field crews and samples with incorrect or illegible information associated with them are lost to the program. The cost of a sampling visit coupled with the short index period severely limits the ability to resample a lake if the initial information recorded was inaccurate or illegible. Some guidelines to assist field personnel with information recording are presented in Table 2-1. These include a list of flags or qualifiers for data and samples and guidance for completing forms and labels while in the field and before shipping.

TABLE 2-1. GUIDELINES FOR RECORDING FIELD DATA AND OTHER INFORMATION

Activity	Guidelines
	Field Measurements
Data Recording	Record measurement values and observations on data forms preprinted on water-resistant paper. Use No. 2 pencil only (fine-point indelible markers can be used if necessary) to record information on forms. Record data and information using correct format as provided on data forms. Print legibly (and as large as possible). Clearly distinguish letters from numbers (e.g., 0 versus O, 2 versus Z, 7 versus T or F, etc.), but do not use slashes. In cases where information is to be recorded repeatedly on a series of lines (e.g., fish species codes or physical habitat characteristics), do not use "ditto marks" (") or a straight vertical line. Record the information that is repeated on the first and last lines, then connect these using a wavy vertical line. When recording comments, print or write **legibly**. Make notations in comments field only; avoid marginal notes. Be concise, but avoid using abbreviations or "shorthand" notations. If you run out of space, attach a sheet of paper with the additional information, rather than trying to squeeze everything into the space provided on the form.
Data Qualifiers (Flags)	Use only defined flag codes and record on data form in appropriate field. K = Measurement not attempted or not recorded. Q = Failed quality control check; remeasurement not possible. U = Suspect measurement; remeasurement not possible. F*n* = Miscellaneous flags (*n*=1, 2, etc.) assigned by a field crew during a particular sampling visit (also used for qualifying samples). Explain reason for using each flag in comments section on data form.
Review of Data Forms	Review data forms for accuracy, completeness, and legibility before leaving lake. The Field Coordinator or the Communications Center personnel must review all data forms for consistency, correctness, and legibility before transfer to the Information Management Center.

(continued)

TABLE 2-1 (continued)

Activity	Guidelines
Sample Collection and Tracking	
Sample Labels	Use adhesive labels with preprinted ID numbers and follow the standard recording format for each type of sample. Use a fine-point indelible marker to record information on labels. Cover completed labels with clear tape.
Sample Collection Information	Record sample ID number from label and associated collection information on sample collection form preprinted on water-resistant paper. Use a No. 2 pencil only (fine-point indelible fine-tipped markers can be used if necessary to record information on forms). Record collection information using correct format as provided on the sample collection form.
Sample Qualifiers (Flags)	Use only defined flag codes and record on sample collection form in appropriate field. K = Sample not collected or lost before shipment; resampling not possible. U = Suspect sample (e.g., possible contamination, does not meet minimum acceptability requirements, or collected by non-standard procedure). F*n* = Miscellaneous flags (*n*=1, 2, etc.) assigned by a field crew during a particular sampling visit (also used for field measurements). Explain reason for using each flag in comments section on sample collection form.
Review of Labels and Collection Forms	Compare information recorded on labels and sample collection form for accuracy before leaving lake. Review labels and sample collection form for accuracy, completeness, and legibility before leaving lake. The Field Coordinator or the Communications Center personnel must review sample collection forms for consistency, correctness, and legibility before transfer to the Information Management Center.

SECTION 3
BASE SITE ACTIVITIES

by

Glenn D. Merritt, Victoria C. Rogers, and David V. Peck

Field teams conduct a number of activities at their base site. These include tasks that must be completed both before departure to the lake site and after return from the site (Figure 3-1). A full day is allotted to these predeparture and postsampling activities. Close attention to these activities is required to ensure that the field teams know where they are going, access is permissible and possible, equipment and supplies are available at the lake in good order to complete the sampling effort, and samples are packed and shipped appropriately. All activities are organized through the Field Coordinator who provides team supervision.

3.1 PREDEPARTURE ACTIVITIES

Predeparture activities include development of sampling itineraries, instrument calibration, equipment checks and repair, supply inventories, and sample container preparation. Procedures for these activities are described in the following sections.

3.1.1 Daily Itineraries

The Field Coordinators are responsible for developing sampling schedules and Team Leaders are responsible for developing daily itineraries. The Team Leader reviews each lake dossier to ensure that it contains the appropriate maps, contacts, copies of permission letters, and access instructions. Additional activities include confirming the best access routes, calling the landowners or local contacts, confirming lodging plans, and coordinating rendezvous locations with individuals who must meet with field teams prior to accessing a site. This information is used to develop an itinerary. Each Team Leader is required to provide the Field Coordinator (through the Communications Center) with a team schedule for each week of sampling. Schedules include departure time, estimated duration of excursion, routes of travel, location of any overnight stops (including telephone number), and estimated time of arrival at the final destination for each lake and for each day. The portable computer each team takes into the field is furnished with an electronic "road atlas" software package that provides general assistance in planning routes to the site. Changes in the itinerary during the week must also be relayed by the Team Leader through the Communications Center to the Field Coordinator as soon as possible. Miscommunications can result in the initiation of expensive search and rescue procedures and disruption of carefully planned schedules. Communications requirements and schedules are described in the regional activities plan.

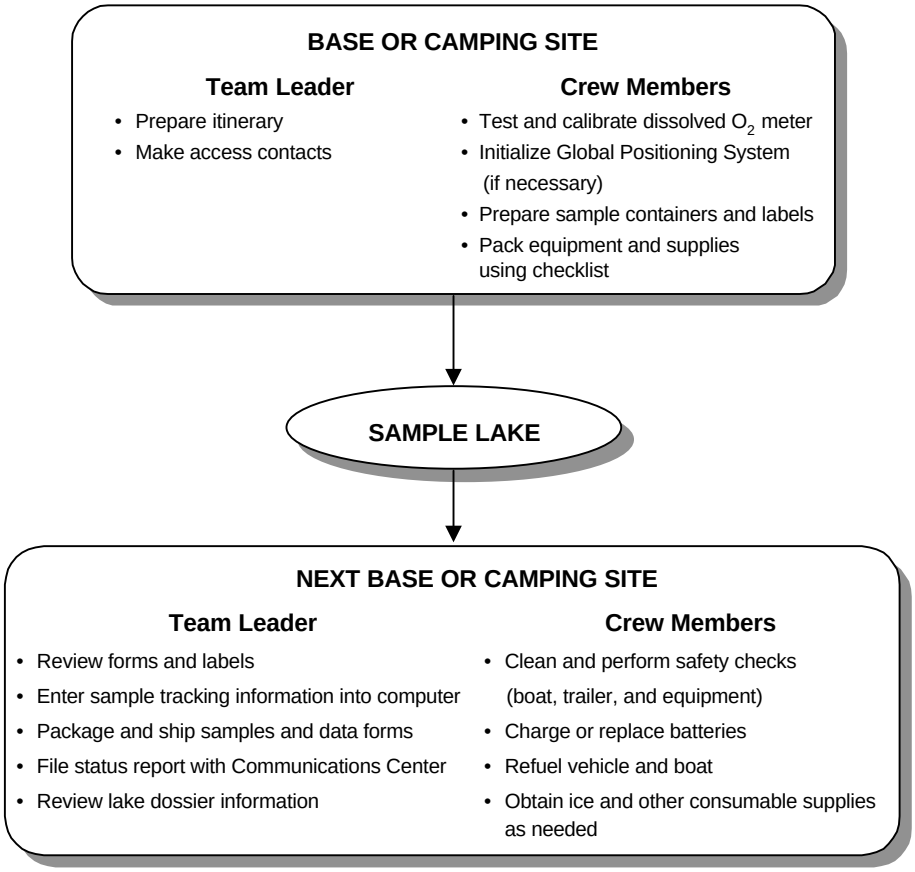

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Figure 3-1. Overview of base site activities.

3.1.2 Instrument Checks and Calibration

Each field team must test and calibrate instruments prior to departure for the lake site. Field instruments include a Yellow Springs Instrument (YSI) Model 57 dissolved oxygen (DO) meter equipped with a 60-m cable and a Magellan NAV 5000 Global Positioning System (GPS) receiver. The procedures described here are designed for these instruments. Additional backup instruments are available through the Field Coordinator if instruments fail the performance tests or calibrations described in the following subsections.

3.1.2.1 Dissolved Oxygen Meter Performance Test--

Test and precalibrate the dissolved oxygen meter prior to departure from the lodging location. Figure 3-2 summarizes the dissolved oxygen meter performance test and calibration procedure. Turn on the instrument, place the function selection switch to "ZERO," and adjust the electronic zero. Verify that the salinity switch is turned to the "ZERO-FRESH" position. Set the function selection switch knob to "RED LINE" and align the needle with the red line using the adjustment knob. Replace the batteries if the instrument will not adjust to the red line. These checks and adjustments ensure that the batteries are charged and the electronics are functional.

Follow this procedure by checking the membrane of the dissolved oxygen probe. If bubbles are present, if the membrane is discolored or torn, use a backup probe and replace the membrane on the original probe. (Note: new membranes must stabilize for 24 hours before use if possible.)

To test whether the dissolved oxygen meter can be calibrated, place the probe in an air-filled calibration chamber. Submerge the chamber in a water bath with the air valve open and the air tube above water. After thermally equilibrating for 15 minutes, determine the chamber temperature by turning the function selection switch to **"TEMPERATURE."** Check temperatures measured with the thermistor against an accurate thermometer. If temperatures differ by more than ±1.0 °C, replace the probe. Determine the theoretical oxygen concentration for water-saturated air at the chamber temperature by using the temperature and altitude-correction factor tables provided on the back of the meter or in the manufacturer's operation manual. Multiply the theoretical oxygen value by the altitude-correction factor (estimated to the nearest 100-ft elevation) to get the calibration value. Then set the function selection switch to one of two dissolved oxygen scales and adjust the oxygen calibration knob to the calibration oxygen value. Do not record the base site performance test information at this time. The meter is calibrated again at the lake. Calibration information is recorded at that time.

If the instrument does not pass the performance test and calibration, replace the meter and/or probe. After the test, turn the meter off, fill the calibration chamber with tap water, and insert the probe for storage. Each field crew receives a copy of the manufacturer's calibration procedures and maintenance information.

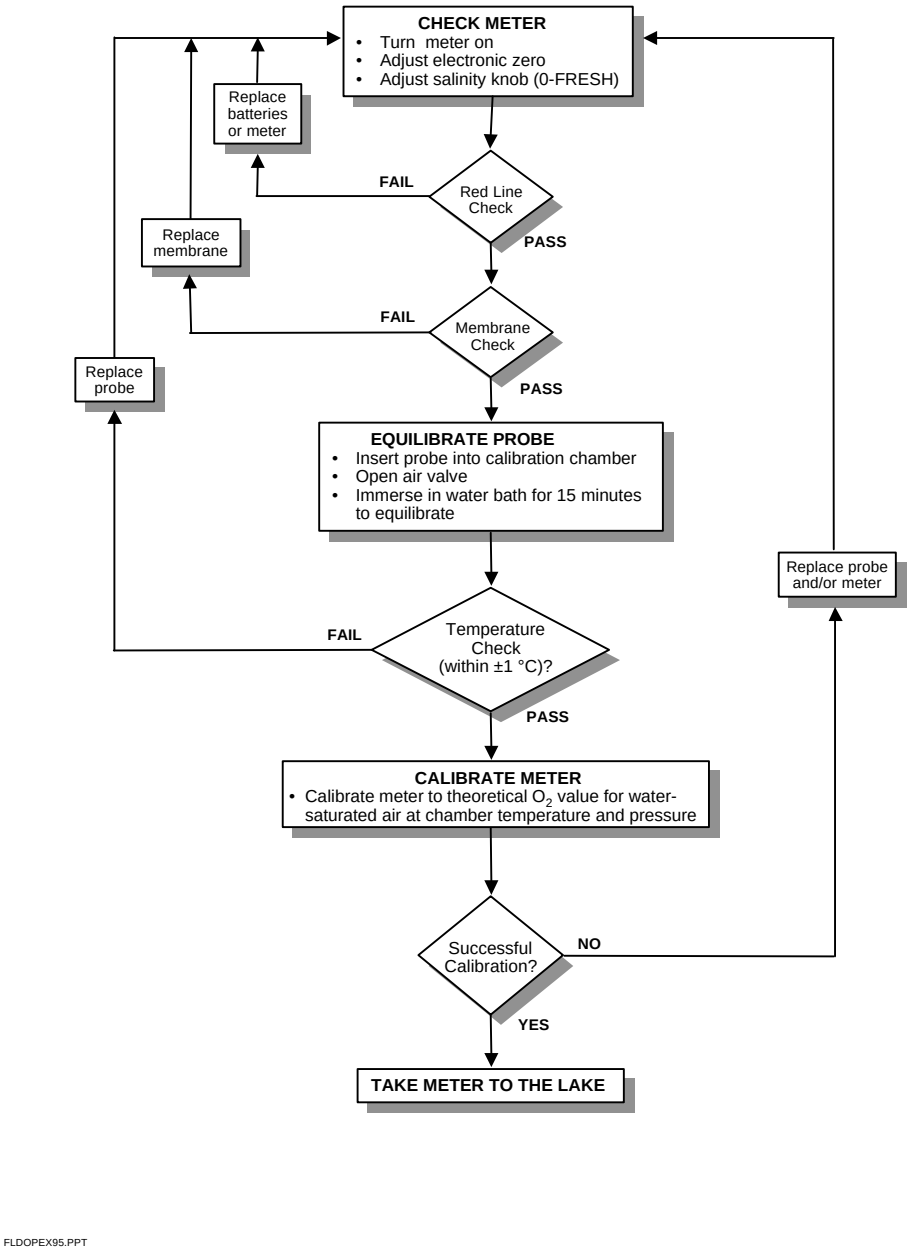

Figure 3-2. Performance test and calibration procedure for the dissolved oxygen meter.

3.1.2.2 Global Positioning System Battery Check and Position Initialization--

Turn on the GPS receiver and check the batteries prior to departure. During the self-test procedure the display indicates battery operation by displaying "battery power." Low battery power is indicated by a battery symbol that appears in the lower right-hand corner of the display. This symbol remains until the batteries are replaced. Replace batteries immediately if a battery warning is displayed.

WARNING: The batteries must be replaced when you see the second warning display: "REPLACE BATTS OR LOSE DATA." If shut off within 2 minutes of this display, the unit will retain memory for a month if the batteries are not removed. Replacing the battery packs must be completed within 2 minutes or the memory will be lost.

The GPS receiver must be Initialized prior to its first use. The receiver must be initialized again if it transported more than 300 miles from the previous initialization point. Instructions for initializing the unit are in Table 3-1.

3.1.3 Equipment Preparation

To ensure that all activities at a lake can be conducted completely and efficiently, field teams must check all equipment and supplies before traveling to a lake site. In addition, they must label and assemble packets of sample containers.

Check the inventory of supplies and equipment prior to departure using the lake-visit checklists. Appendix B contains a complete set of checklists. Use these checklists to ensure that all needed materials are taken to each lake; use of the lists is mandatory. Pack meters, probes, and sampling gear in such a way as to minimize physical shock and vibration during transport. If necessary, prepare stock preservation solutions as described in Table 3-2. Follow the regulations of the Occupational Safety and Health Administration (OSHA). Those pertaining to formalin are in 29 CFR 1910.1048 (see

TABLE 3-1. INITIALIZATION PROCEDURES FOR THE GLOBAL POSITIONING SYSTEM[a]

1. Turn unit ON.

2. At the "READY" display, push "SETUP."

3. Press "CLEAR" to erase previous position.

4. Enter the latitude of a known reference point from a USGS quadrangle map to the nearest degree. Trailing zeroes are entered automatically. Press "→" to get the "N" display. Press "ENTER" to store.[b]

5. Enter the longitude of the same reference point to nearest degree. Trailing zeroes are entered automatically. Press "→" to get the W display. Press "ENTER" to store.[b]

6. Press "↓" and then "CLEAR" to erase altitude. Enter the altitude to the nearest 50 feet. Press "ENTER" to store.

7. Initialization completed. Turn unit OFF or press "POS" for position.

[a] These procedures are specific to the Magellan NAV 5000 global positioning system unit used during EMAP-Surface Waters surveys.

[b] Initialization is effective for a 300 mile radius from the reference point. If a GPS receiver is transported outside of this radius, the receiver must be re-initialized using a new reference point.

TABLE 3-2. STOCK SOLUTIONS, USES, AND METHODS FOR PREPARATION

Solution	Use	Preparation
Bleach (10%)	Clean nets, other gear, and inside of boat.	Add 400 mL bleach to 3,600 mL distilled water.
Sucrose (saturated)	To equalize osmotic pressure of zooplankton samples.	Add 320 g granular sucrose per liter of distilled water. Chill. Add 1 to 2 mL formalin per liter as preservative.
Borax buffered formalin[a] (pH 7-8)	Preservative for fish vouchers and for zooplankton samples.	Add 400 g borax to each 20-L carton of 100% formalin. Test with pH paper.
Carbonate buffered formalin[b] (pH 10)	Preservative for benthic invertebrate samples.	Add 500 g Na_2CO_3 to each 20-L carton of 100% formalin. Test pH with paper.

[a] Handle formalin according to 29 CFR 1910.1048.

[b] High pH solution required to preserve mollusk shells.

regional activities plan). Add 10 mL of saturated sucrose solution to 4 mL of stock formalin (100%, pH 7-8) to each of two zooplankton sample bottles, using either a syringe or a bottle labeled with the appropriate volumes. Seal the jars with electrical tape prior to departure and place each jar in a 1-qt self-sealing plastic bag.

In addition, inspect the vehicles, boats, and trailers every morning before departure. Pay particular attention to the trailer hitch, electrical connections, tiedowns, and air pressure in tires and the boats. Refuel vehicles and conduct maintenance activities the night before a sampling trip. Check trailer lights, turn signals, and brake lights before departure.

Label sample containers before departing from the base site. Figure 3-3 provides examples of preprinted labels. Labels or tags that will be placed with samples stored in formalin must be printed on 100 percent rag content or water resistant paper. Label and package the sample containers into sample kits prior to departure. Container labels should not be covered with clear tape until all information is completed during sampling at the lake. Store an extra kit of sampling supplies (syringes, syringe valves, Cubitainers, bottles, chlorophyll filters, foil, gloves, and labels) in the vehicles. Inventory these extra supply kits prior to each lake visit.

3.2 POSTSAMPLING ACTIVITIES

Upon return to a lodging location after sampling, the team reviews all labels and completed data forms (with the Field Coordinator when possible) for accuracy, completeness, and legibility and makes a final inspection of samples. If information is missing from the forms or labels, the Team Leader attempts to fill in the information accurately. The Team Leader will initial all data forms after review. If obtainable samples are missing, the lake must be rescheduled through the Communications Center for complete sampling. Other postsampling activities include: inspection and cleaning of sampling equipment, inventory and sample preparation, sample shipment, and communications.

3.2.1 Equipment Cleanup and Check

Table 3-3 describes the equipment cleaning procedures. Inspect all equipment, including nets, boat, and trailer, and clean off any plant and animal material. This effort ensures that introductions of nuisance species such as water-milfoil and zebra mussels do not occur between lakes. Prior to leaving a lake, drain all bilge water or live wells in the boat and discard all water from the fish buckets. Inspect, clean, and handpick plant and animal remains from vehicle, boat, motor, and trailer that contact lake water. Be especially careful that all nets are cleared of any fish or fish parts. Dry out gill nets, trap

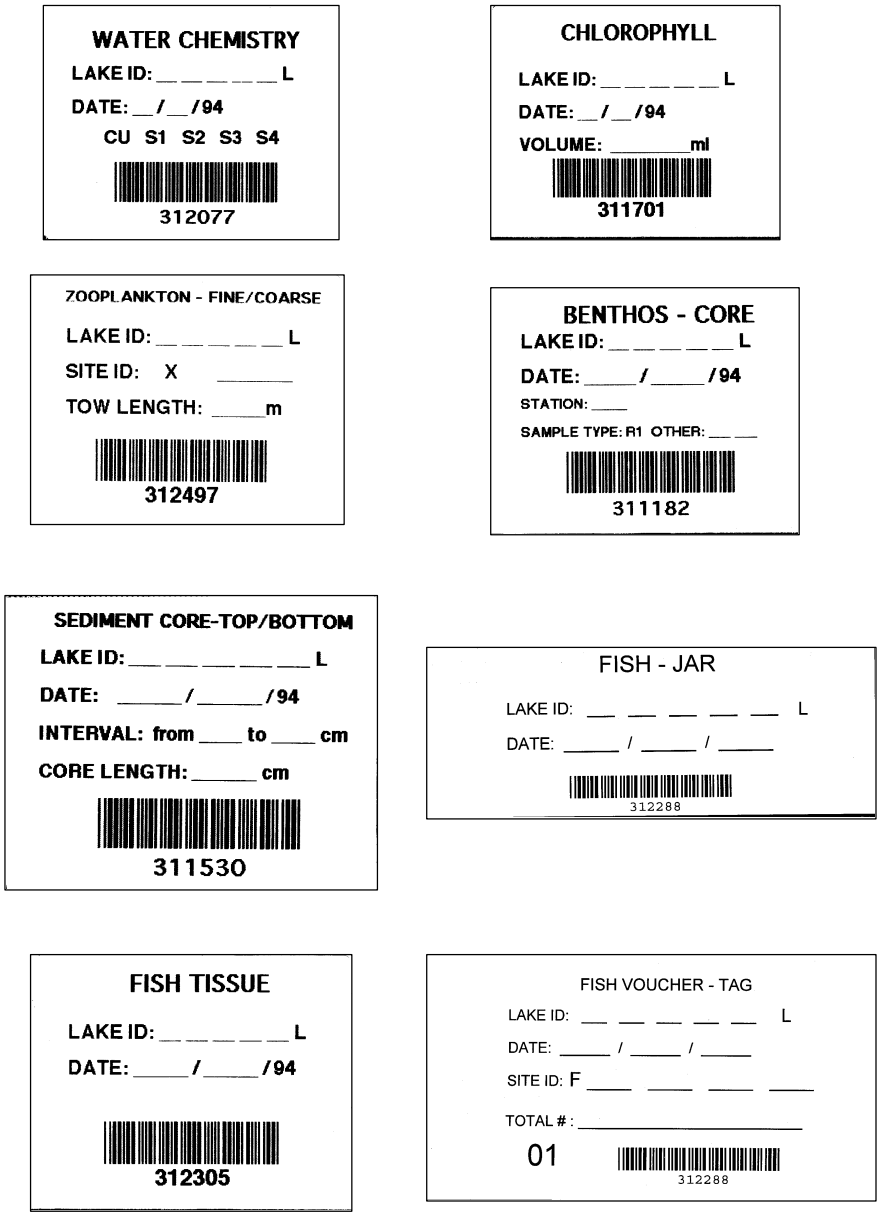

Figure 3-3. Sample container labels.

TABLE 3-3. POSTSAMPLING EQUIPMENT CARE

1. Clean for biological contaminants (e.g., water milfoil, zebra mussels, and alewife).

    - Prior to departing from a lake, drain all bilge and live-well water from the boat and discard water in fish buckets.

    - At the lake, inspect motors, boat, and the trailer for evidence of plant fragments especially in or near the propeller and water intakes. Remove all plant fragments.

    - At the lake or base site, dry out gill nets, trap nets, seines, and minnow traps and inspect and remove any remnant vegetation or animal life. If the weather is rainy and fishing gear cannot be dried, then use a different (backup) set of gear at the next lake, if available. If an additional set of gear is not available, disinfect gear with 10 percent bleach solution.

    - If a commercial car wash facility is available, take vehicle, boat, trailer, and fishing gear and thoroughly clean (hot water pressurized rinse--no soap).

2. Clean and dry other equipment prior to storage.

    - Rinse chlorophyll filtration chamber three times with distilled water after each use.

    - Briefly soak zooplankton nets in a dilute bleach solution (10 percent) and dry after each use. Do not dry in sunlight because the mesh is photosensitive.

    - Rinse core sampler, sectioning apparatus, and siphon with tap water at the base site.

    - Rinse coolers with water to clean off any dirt or debris on the outside and inside.

3. Check fish nets for holes and repair, if possible; otherwise, set damaged gear aside and locate replacements.

4. Inventory equipment and supply needs and relay orders to the Field Coordinator through the Communications Center.

5. Remove dissolved oxygen meters and GPS from carrying cases and set up for predeparture checks and calibration. Examine the oxygen membranes for cracks, wrinkles, or bubbles. Replace if necessary.

6. Recharge batteries (e.g., 12-V wet cells and computer batteries) overnight if possible. Replace other batteries (e.g., GPS unit and dissolved oxygen meter) as necessary.

7. Recheck field forms from the day's sampling activities. Make corrections and completions where possible, and initial each form after review.

8. Replenish fuel.

nets, seines, and minnow traps and inspect and remove any remnants of vegetation or animal life. If weather is rainy and fishing gear cannot be dried out, then use a different (backup) set of gear, if available, at the next lake. If an additional set of gear is not available, disinfect with a 10 percent bleach solution. Take care regarding application of bleach to nets to avoid damage to lawns and plantings. Pavement is a preferred location for treatment of trap nets with bleach solution. Before moving to the next lake, if a commercial car wash facility is available, wash vehicle, boat, trailer, and fishing gear and thoroughly clean (hot water pressurized rinse--no soap).

3.2.2 Shipment of Samples and Forms

The field team ships samples as soon as possible after collection. Samples are usually shipped on the full day allotted for predeparture and postsampling activities. The regional activities plan gives specific information for shipping destinations and times within a region. Initiate sample tracking at this time using the notebook computers, bar-code readers, and the Information Management Handbook. Log samples into the sample tracking and reporting system. For more detailed information refer to the Information Management Handbook. If the computer and bar-code reader are inoperable, complete the tracking information by hand on the backup forms provided. Packaging and shipping guidelines for each type of sample are summarized in Table 3-4.

Ship samples of chlorophyll, water chemistry, and fish tissue samples in coolers packed with ice. Line each shipping cooler with a large 30-gallon plastic bag. Inside, contain the ice separately within numerous (as many as possible) 1-gallon self-sealing plastic bags and ensure that the ice is fresh before shipment. Use block ice when available. It should be sealed in a 30-gallon plastic bag. White or clear bags will allow for labeling with a dark indelible marker. Label all bags of ice as "ICE" with an indelible marker to prevent misidentification by couriers of any leakage of water as a possible hazardous material spill.

To ship the Cubitainer and syringes, line the shipping cooler with a 30-gal plastic bag. Place another garbage bag in the cooler, and place the samples in the second bag. For each sample ensure that the Cubitainer and each of the four syringes have identical bar codes. Ensure that all entries are complete and close the bag of samples. Place bags of ice around it. Then close the cooler liner (outer garbage bag). Ship water samples on the day of collection whenever possible. If not possible, they must be shipped the next day.

The chlorophyll sample is collected and wrapped in foil and placed into a 1-quart self-sealing plastic bag as described in Section 7. When preparing this sample for shipping, make sure that the label with bar code is on the foil, all entries are complete, and the label is completely covered with clear

plastic tape. Place each 1-quart sample bag in a 1-gallon self-sealing plastic bag. Place the self-sealing plastic sample bags inside the cooler liner in a manner that protects them from exposure to water from melting ice. Then seal the cooler liner. Ship the chlorophyll samples with the corresponding water chemistry samples on the day of collection whenever possible. If this is not possible, they must be shipped the next day.

The composite fish tissue sample(s) is prepared, packed in one plastic bag which is then sealed in a second plastic bag, and chilled at the lake (as described in Section 6). For shipping, upon arrival at the base site, open the cooler and the cooler liner. Remove the bags of ice and replace them with fresh bags of ice. Put in as many bags of ice as will fit into the cooler. Then seal the cooler liner. Close the cooler. Package and label the cooler for shipping as described in the regional activities plan. Ship fish tissue samples the same day they are processed, whenever possible. If not possible, they must be shipped the next day with fresh ice.

For sediment core samples, open the hard plastic box and ensure that the labels with bar codes are complete, covered with clear plastic tape, and attached to each of the two bags of sediment (top and bottom). Close the box and seal it with electrical tape. Place the box in the shipping cooler. Core samples can be placed in coolers containing fish tissue samples, if desired, for shipping.

Zooplankton samples are preserved in a 10 percent solution of sucrose and borax-buffered formalin and then sealed at the lakeside (as described in Section 7). To prepare zooplankton samples for shipping, ensure that there is a different label with bar code taped on each of the two jars (one labeled "coarse" and one "fine"). If a sample requires an additional jar, make sure the bar code number of the corresponding labeled sample is recorded on the label and it is marked either "coarse" or "fine" to agree with first jar. Verify that each jar is sealed with electrical tape and sealed in a quart-size self-sealing plastic bag. Place both quart-size self-sealing plastic bags in a gallon-size self-sealing plastic bag. Zooplankton samples can be included in a hardshell plastic cooler with benthic samples for transport.

Benthic invertebrate samples are preserved in 10 percent carbonate-buffered formalin (4 percent formaldehyde) and sealed at the lakeside as described in Section 8 where up to twenty 500-mL jars are placed in each hardshell plastic cooler and surrounded with crumpled newspaper or vermiculite. Ensure that the bar code number is entered on the jar label, and the label is covered with tape. For shipping, label the shipping containers and complete the airbills as directed in the regional activities plan for such samples. Zooplankton samples can be shipped with benthic samples.

TABLE 3-4. SAMPLE PACKAGING AND SHIPPING GUIDELINES

The regional activities plan gives specific information for shipping destinations and times within a region. Log samples into the sample tracking and reporting system developed for the region.

In general, ship samples that require preservation in hardshell plastic coolers packed with ice:

1. Line each cooler with a large, 30-gallon plastic bag.
2. Pack ice in as many 1-gallon self-sealing bags as possible to fit inside the 30-gallon plastic bag. Use block ice when available (seal it in a 30-gallon plastic bag). Mark each bag "ICE" with an indelible marker to prevent misidentification of any water leakage as a possible hazardous material spill.
3. Place samples and bags of ice inside the cooler liner and seal the cooler liner.
4. Close the cooler.
5. Package and label the cooler for shipping as described in the regional activities plan.

A. Water chemistry, chlorophyll, and fish tissue samples

Water chemistry--Cubitainer and syringes.

1. Place another garbage bag inside the cooler liner.
2. Confirm that the Cubitainer and each of the four syringes are labeled and have identical bar codes.
3. Place the Cubitainer in the second bag and close. Place syringes in a plastic box, seal it with electrical tape, and put the box in the cooler with the Cubitainer.
4. Ship water samples on the day of collection whenever possible. If not possible, these samples must be shipped the next day with fresh ice.

Chlorophyll--previously wrapped in foil and placed in a 1-qt self-sealing plastic bag.

1. Confirm that the label with bar code on the foil is completed and covered with clear tape.
2. Place the 1-qt sample bags in a 1-gal self-sealing plastic bag.
3. Place the 1-gal bag in the cooler. To reduce the risk of exposure to meltwater, the sample may be placed in the container with the water chemistry syringe samples.
4. Surround the bag with bags of fresh ice. It is important to keep chlorophyll samples as cold as possible.
5. Ship the chlorophyll samples, with the corresponding water chemistry samples when appropriate, on the day of collection whenever possible. If shipping on the day of collection is not possible, the samples must be shipped the next day with fresh ice.

Fish tissue--previously prepared, bagged, and chilled.

1. At the base site open the cooler and the cooler liner.
2. Remove the bags of ice and replace them with fresh bags of ice. Put in as many bags of ice as will fit into the cooler.
3. Ship the fish tissue samples the same day they are processed whenever possible. If not possible, they must be shipped the next day with fresh ice.

(continued)

TABLE 3-4. (continued)

B. Sediment Core Samples--stored in plastic box.
   1. Open the box to confirm that the labels with bar codes attached to each of the two bags of sediment (top and bottom) are complete and covered with clear plastic tape.
   2. Close the box and seal it with electrical tape.
   3. Place the box in the shipping cooler. Core samples may be placed in coolers containing fish tissue samples, if desired.

C. Zooplankton samples--preserved in a 10% solution of sucrose and borax-buffered formalin and then sealed at the lake.
   1. Confirm that the two jars have different labels (one for "coarse" and one for "fine") with the bar code taped on each. If a sample requires an additional jar, confirm that the bar code number of the corresponding labeled sample is recorded on the label.
   2. Verify that each jar is sealed with electrical tape and sealed in a quart-size self-sealing plastic bag.
   3. Place both quart-size self-sealing plastic bags in a gallon-size self-sealing plastic bag.
   4. Place the bags in the appropriate shipping container. Zooplankton samples may be placed in the cooler with the benthic samples for transport.
   5. Samples can be held for a short period before shipment. Transport the samples as described in the regional activities plan.

D. Benthic invertebrate samples--preserved in 10% carbonate-buffered formalin and sealed at the lake.
   1. Check to make sure jars are sealed with electrical tape.
   2. Place up to twenty 500-mL jars in each cooler.
   3. Surround the jars with crumpled newspaper, vermiculite, or other absorbent material.
   4. Transport the samples as described in the regional activities plan. Benthic samples can be shipped with zooplankton samples as hazardous materials.

E. Fish voucher specimens--preserved in 10% borax-buffered formalin and sealed at the lake. For shipping:
   1. Make sure jars are sealed with electrical tape.
   2. Place the voucher sample containers in plastic coolers.
   3. Surround the jars with crumpled newspaper, vermiculite, or other absorbent material.
   4. Transport the samples as described in the regional activities plan. The Field Coordinator may collect the coolers of voucher specimens, the team may deliver them directly to the museum, or the team may need to ship these samples by courier as hazardous materials.

Fish voucher specimens are preserved in 10 percent borax-buffered formalin (4 percent formaldehyde) and sealed at the lakeside as described in Section 6 and the regional activities plan. Check to confirm that each jar has a completed label, completely covered with clear tape. Voucher sample containers are placed in hardshell plastic coolers and surrounded with crumpled newspaper, vermiculite, or other absorbent material. The Field Coordinator may periodically collect the coolers of voucher specimens, takes them to the museum, and supplies the team with cases of empty containers for vouchers. In some instances a team may deliver vouchers directly to the museum and obtain empty bottles. In other cases, samples and containers may need to be shipped by courier. If shipping by courier, complete airbills as directed in the regional activities plan for such samples. If required, attach the appropriate hazardous material label to the outside of the cooler or other container used to ship the samples **.**

To improve their fish identification skills, team members may examine their voucher specimens, but it is essential to maintain voucher integrity and specimen quality and to follow appropriate safety precautions. Handling of specimens should be very limited during the first 72 hours after collection to allow the fish tissue to harden. Open only one bottle at a time to prevent inadvertent mixing of vouchers; return specimens to the bottle when finished. Only handle specimens with forceps and wear protective clothing (see the regional activities plan). Open bottles and examine vouchers in a well-ventilated area, preferably outdoors.

3.2.3 Communications

A regional communications center (see regional activities plan for regional locations and telephone numbers) is the central point of contact for information exchange among field teams, the EMAP-Surface Waters management and QA staffs, the information management team, analytical laboratories, and the public. The Communications Center also monitors all aspects of field sampling activities, including coordinating and tracking field sample shipments to the analytical laboratories, and responds to supplies replenishment requests.

Requests to replenish consumable supplies can be made weekly but are not restricted to that frequency. When possible, teams should inventory their supplies after each lake visit and submit requests well in advance of exhausting on-hand stocks. Requests for supplies can be shipped with the lake data package by overnight courier. Should supplies need to be replenished more quickly, notify the Communications Center by telephone and the appropriate sources will be contacted.

As specified in the regional activities plan, each field Team Leader must call the Communications Center and provide a brief description of activities during the previous week including lakes visited, samples shipped, problems encountered, and requests for information. The Communications Center compiles a periodic status report from reports submitted by the Team Leaders which is distributed to the management team, other Team Leaders, and any interested individuals.

SECTION 4
LAKE VERIFICATION AND INDEX SITE LOCATION

by
John R. Baker and David V. Peck

Sampling the correct lake and locating the index site (deepest point on the lake) are critical to the sampling design and to making regional lake population estimates about condition. Data collected from the wrong lake are of no value to EMAP Surface Waters monitoring and assessment efforts. On arriving at a lake, the GPS is a valuable tool to verify the identity and location of a lake, however, lake verification must be supported by all available information (e.g., maps, road signs, and GPS). Do not sample the lake if there is reason to believe it is the wrong lake. Contact the Field Coordinator (via the Communications Center) to resolve discrepancies.

Rigorous quality assurance practices are observed in the field. To assure accuracy, completeness, and legibility in recording, field forms are completed by one individual and checked by another to verify that all pertinent information is included. Figure 4-1 summarizes the activities described in this section.

4.1 LAKE VERIFICATION AT THE LAUNCH SITE

Record directions to the lake and a description of the launch site on the Lake Verification Form, Side 2 (Figure 4-2) regardless of whether the site is sampled or not. This information is very important and will be used in the future when the lake is revisited by another sampling team. Provide information about signs, road numbers, gates, landmarks, and any additional information you feel will be useful to another sampling team in relocating this lake. It is also helpful to describe the distance traveled (miles) between turns. Also describe the launch site on the same form. For example: Can the boat be launched with a trailer? Are there fees? Is the launch paved or does it consist of soft sand? What landmarks are at the launch?

The field team must verify that the lake is correctly identified and located. Lake verification is based on map coordinates, locational data from the GPS when possible, and any other evidence such as signs or conversations with local residents. Table 4-1 provides operational instructions for the GPS receiver. Record locational coordinates for the lake on the Lake Verification Form, Side 1 (Figure 4-3). Record the map coordinates for the lake provided in the regional activities plan and the lake dossier on

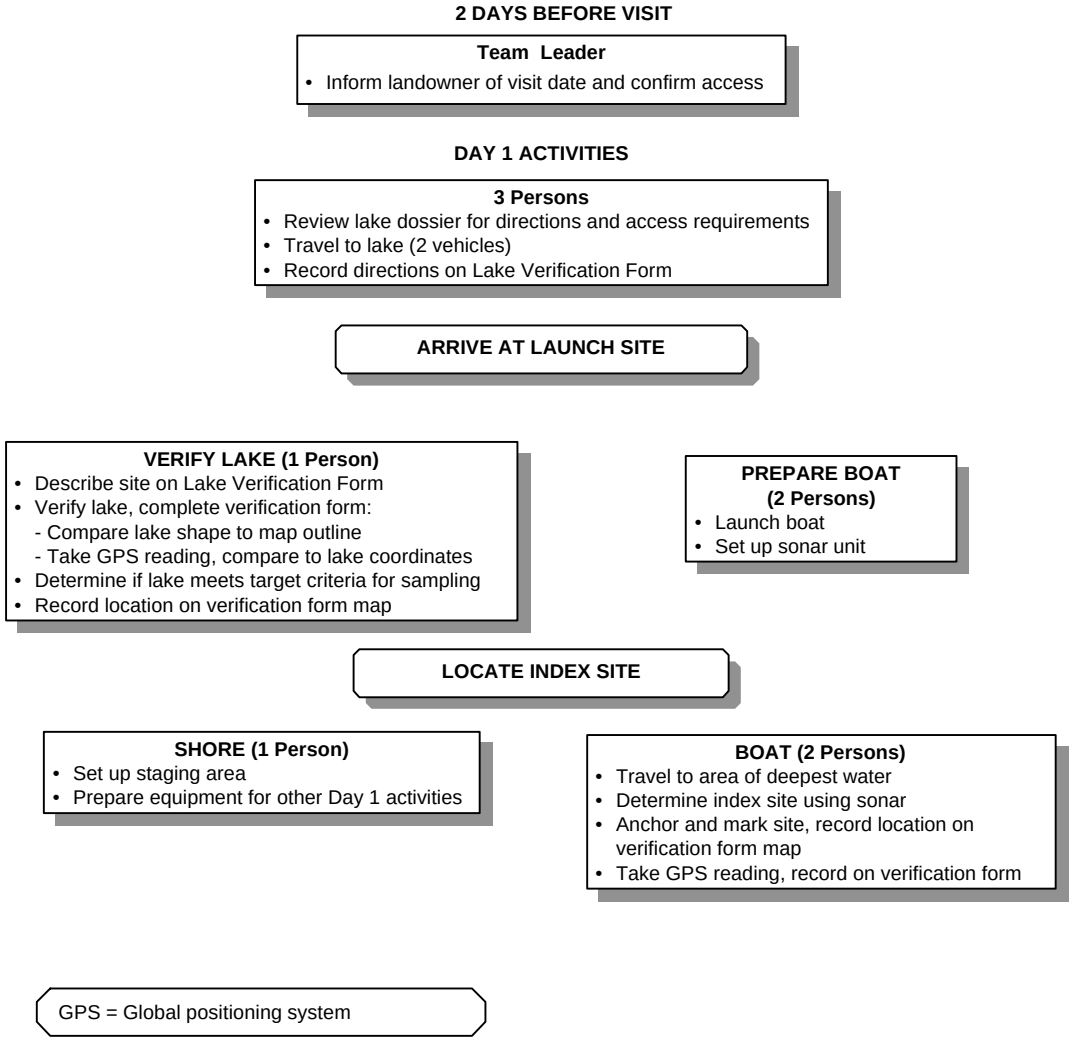

Figure 4-1. Summary of lake verification and index site activities.

LAKE ID: NY0000L LAKE VERIFICATION FORM (continued) VISIT #: (1) 2

DIRECTIONS TO LAKE & LAUNCH SITE

From Boomtown, take Rt. 999 E for 2 mi. Turn left at police station. Follow road for 5.6 mi, then turn left. Follow road for ~6 mi. until road forks. Take right-hand fork and follow for 3 mi. until you reach Peaceful Acres camp (third camp on left). Boat can be launched at camp.

LAUNCH SITE DESCRIPTION

Boat must be launched by hand. Vehicle can get to within 50 meters of shore. Portage is easy, as launch site is open (no trees), with little or no slope.

GENERAL COMMENTS

Residents friendly. Public launch is available about 0.25 mi. past Peaceful Acres camp on right.

EXPLANATION FOR NOT SAMPLING THE LAKE (continued from front)

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Rev. 3/95 FLDFRMS.95 Lake Verification Form - 2

Figure 4-2. Lake Verification Form, Side 2.

TABLE 4-1. GLOBAL POSITIONING SYSTEM SURVEY PROCEDURES

1. Turn the unit ON.[a]

2. At the "READY" display, push "SETUP." Press "↓" once and check if the mode is "AUTO." Otherwise, use the "→" key to move to "AUTO." Then push "POS" for position.

3. If fix is "3D," note it on the Lake Verification Form. If fix is "2D," go to "SETUP," press "↓" once, press clear. Type in the altitude (ft) and "ENTER," then push "POS" and write down the 2D fix.

4. For both 2D and 3D fixes, push "↓" twice and note the lowest signal quality (SQ) and geometric quality (GQ)[b] as a number from 0-9 on the Lake Verification Form, Side 1.

5. If battery warnings appear, make sure that the unit is turned off immediately and the fresh battery pack is inserted in the unit (six size AAs are needed).

6. Turn unit OFF.

[a] These procedures are specific to the Magellan NAV 5000 global positioning system unit used during EMAP-Surface Waters surveys. Initialization of unit is required if it is moved more than 300 miles from last position fix. See the unit manual.

[b] If GQ $\leq$3, the crew should try to obtain another fix because the geometric quality is inadequate.

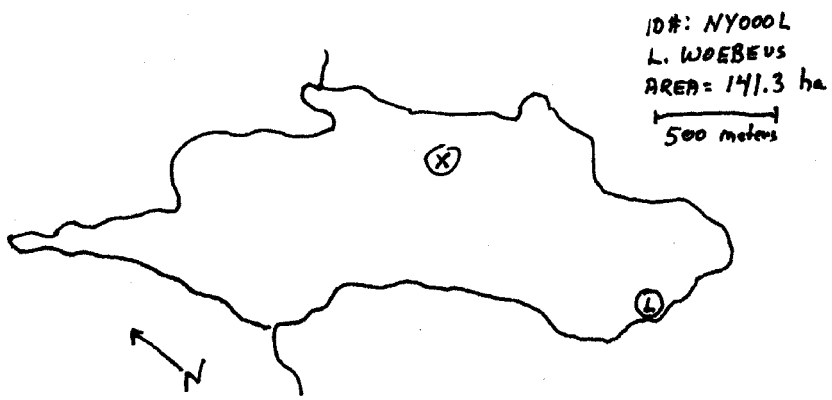
LAKE VERIFICATION FORM

LAKE NAME: L. WOEBEUS DATE OF VISIT: 7/14/94 VISIT #: (1) 2

LAKE ID: NY000L MODE OF ACCESS: (VEHICLE) HIKE-IN AIRCRAFT

TEAM ID (CIRCLE): 1 (2) 3 4 5 6 7 8 9 10 OTHER: ____

ARROW INDICATES NORTH MARK SITE: L = LAUNCH X = INDEX



LAKE VERIFICATION INFORMATION

LAKE SHAPE COMPARES TO MAP? X YES ☐ NO

LAKE VERIFIED BY (✓ all that apply): X GPS ☐ LOCAL CONTACT ☐ SIGNS ☐ ROADS X TOPO. MAP

☐ Other (Describe Here): ☐ NOT VERIFIED (Explain in Comments)

COORDINATES	LATITUDE (dd mm ss) North	LONGITUDE (ddd mm ss) West	TYPE OF GPS FIX	SIGNAL QUALITY	GEOMETRIC QUALITY	Are GPS Coordinates w/i ±1 min. of map?
Map:	45.16.43.	067.50.20.				
Launch Site:	45.16.52.	067.50.42.	☐ 2D X 3D	8	5	X YES ☐ NO
Index Site:	45.16.37.	067.50.35.	☐ 2D X 3D	6	9	X YES ☐ NO

LAKE SAMPLED? X YES ☐ NO

REASON NOT SAMPLED (EXPLAIN BELOW): ☐ NOT VISITED ☐ NON-TARGET ☐ INACCESSIBLE ☐ OTHER

Explanation:

CHECK HERE IF EXPLANATION IS CONTINUED ON BACK. ☐

DESCRIBE LAUNCH SITE, LAKE DIRECTIONS, AND ADD COMMENTS ON BACK

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Rev. 3/95 FLDFRMS.95 Lake Verification Form - 1

Figure 4-3. Lake Verification Form, Side 1.

the Lake Verification Form. If a GPS fix is obtained, check the GPS box and record the latitude, longitude, and the type of satellite fix (2D or 3D) for the launch site. Compare the dossier map coordinates recorded for the lake with the GPS coordinates displayed for the launch site. Check the Lake Verification Form to see if the two sets of coordinates are within ±1.0 minute of latitude and longitude. This distance is approximately equal to the precision of the GPS receiver (± 100 m) without differential correction of the position fit. If a GPS fix is not available, do not record any information but try to obtain the information at a later time during the visit. A fix maybe taken at any time during a lake visit and recorded on the form. Mark the location of the lunch site with an “L” on the lake outline on the Lake Verification Form, Side 1 (Figure 4-3).

In addition to the GPS, use as many of the following methods as possible to verify the site:

1. Obtain confirmation from a local person familiar with the area.

2. Identify confirming roads and signs.

3. Compare lake shape to that shown on the topographic map included in the lake dossier (USGS 7.5 minute map or equivalent).

4. Determine lake position relative to identifiable topographic features shown on the map.

If the lake shape on the map on the Lake Verification Form, Side 1 (Figure 4-3) and on the USGS map do not correspond with each other or with the actual lake shape, check "Not Verified" and provide comments on the Lake Verification Form. The lake should <u>not</u> be sampled if there are major differences in lake shape and the sketch map cannot be used for locating the physical habitat stations described in Section 5. At each lake, evaluate whether or not the lake meets the EMAP definition of a lake:

- ≥1 ha in total surface area
- ≥100 square meters of open water
- ≥1 meter in depth

If the lake does not fit this definition, check "nontarget" in the lake sampled section on the bottom of the Lake Verification Form, Side 1 (Figure 4-3) and provide an explanation for not sampling the lake. Add any additional explanation as required.

4.2 LAKE VERIFICATION AT THE INDEX SITE LOCATION

Estimate the deepest point in the lake (designated as the "index site") by using sonar and a bathymetric map (if available in the dossier for the lake) and by observing the lake shape and surrounding topography. Table 4-2 outlines sonar operation and procedures for finding the index site. Once in the general area, use the sonar unit to locate the deepest point. When an acceptable site is located, anchor the boat. Lower the anchor slowly to minimize disturbance to the water column and sediment. Determine the coordinates of the index site by GPS (if satellite coverage is available) and record on the Lake Verification Form, Side 1 (Figure 4-3). If satellite coverage is not available at that time, try again during the sample collection activities on Day 2 (The index site will be marked with a buoy). Identify the index site on the sketch map with an "X" on the Lake Verification Form, Side 1 (Figure 4-3).

Compare the dossier coordinates recorded for the lake with those GPS coordinates recorded for the index site. Check on the Lake Verification Form, Side 1 (Figure 4-3) if the two sets of coordinates are within ±1.0 minute of latitude and longitude. If coordinates at the launch site or the index site are not within ±1.0 minute of the map coordinates listed in the regional activities plan and the dossier, question whether or not you are at the correct lake. Information collected through the other methods described in the previous subsection should always be considered before deciding whether or not the identity of a lake can be verified. If the lake is sampled and coordinates are not within criteria or the lake shape does not match, provide comments justifying your actions on the Lake Verification Form, Side 2 (Figure 4-2).

4.3 EQUIPMENT AND SUPPLY LIST

Figure 4-4 is the checklist for equipment and supplies required to conduct protocols described in this section. It is similar to but may be different somewhat from the checklist in Appendix B that is used at a base site to assure that all equipment and supplies are taken to and available at the lake. Field teams must use the checklist presented in this section to assure that the equipment and supplies are organized and available on the boat in order to conduct protocols correctly and efficiently.

TABLE 4-2. LOCATING THE INDEX SITE*

1. Attach the transducer bracket to boat transom. Position the transducer so that the streamlined end faces forward. Connect the power supply and the transducer to the sonar unit.

2. Operate Sonar unit according to manufacturer's specific operating procedures. If possible, depth readings should be made in metric units.

3. Use the sonar in the area expected to be the deepest. Mentally note the location of maximum depth.

4. Return to the location of maximum depth. Anchor the boat.

5. Determine the coordinates using GPS. Record GPS coordinates on Side 1 of the Lake Verification Form.

* Total time to locate index site should be $\leq$ 30 min.

LAKE VERIFICATION CHECKLIST

	Number Needed Each Lake
Dossier for lake to be sampled	1
Clipboard	1
Lake Verification Form	1
Field notebook	1
Field Operations Manual and Field Handbook	1
Field Quick Reference Handbook	1
EMAP pamphlets	20
Sampling permit	1
Sonar	1
Pigtail adapter for 12-V battery	1
Transducer with bracket and C-clamp	1
12-V wet cell battery (charged) in battery case	1
GPS unit with manual, reference card, extra battery pack	1
Anchor with 50 m line	1-2
Float to attach to anchor	1

Figure 4-4. Lake verification checklist.

SECTION 9
FINAL LAKE ACTIVITIES

by
Alan T. Herlihy

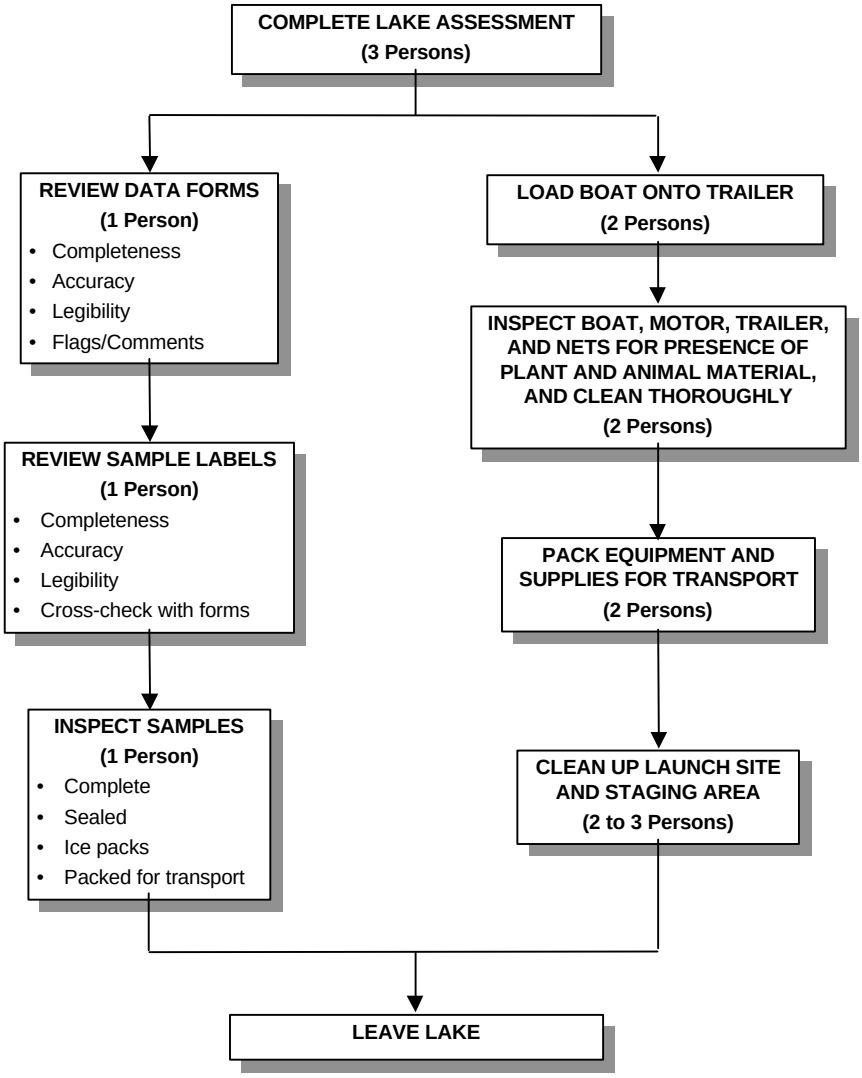
Prior to leaving the lake, the field team makes a general assessment of the lake and makes a final check of the data forms and samples. The objective of the lake assessment is to record field team observations of catchment and lake characteristics that are useful for future data interpretation, ecological value assessment, development of associations, and verification of stressor data. The observations and impressions of field teams are extremely valuable. The objective of the second check of data forms and samples is to assure completeness of all sampling activities. Activities described in this section are summarized in Figure 9-1.

9.1 GENERAL LAKE ASSESSMENT

The team members complete the Lake Assessment Form (figures 9-2 and 9-3) at the end of lake sampling, recording all observations from the lake that were noted during the course of the visit. This Lake Assessment Form is designed as a template for recording pertinent field observations. It is by no means comprehensive and any additional observations should be recorded in the comments section. The form consists of five major sections: Lake Site Activities and Disturbances, General Lake Information, Shoreline Characteristics, Qualitative Macrophyte Survey, and Qualitative Assessment of Environmental Values.

9.1.1 Lake Site Activities and Disturbances

Record any of the stressors listed in Table 9-1 on the Lake Assessment Form, Side 1 (Figure 9-2), that were observed while on the lake, while driving or walking through the lake catchment, or while flying over the lake and catchment. For activities and stressors that you observe, rate their abundance or influence as low, moderate, or heavy by putting an L, M, or H on the line next to the listed stressor. Leave the line blank for any stressor not observed. The distinction between low, moderate, and heavy will be subjective. For example, if there are two to three houses on a lake, mark the "Houses" line with an "L" for low. If the lake is ringed with houses, rate it as heavy (H). Similarly, a small patch of clear-cut logging on a hill overlooking the lake would rate a low ranking. Logging activity right on the lake shore, however, would get a heavy disturbance ranking. The section for “Lake Site Activities and Disturbances Observed” includes residential, recreational, agricultural, industrial, and lake management categories.



FLDOPEX95.PPT 3/95

Figure 9-1. Final lake activities summary.

LAKE ASSESSMENT FORM

LAKE NAME: L. WOEBEGUS DATE OF VISIT: 7/4/94 VISIT #: (1) 2

LAKE ID: NY0000L TEAM ID (circle): 1 (2) 3 4 5 6 7 8 9 10 OTHER:___

LAKE SITE ACTIVITIES AND DISTURBANCES OBSERVED (INTENSITY: BLANK = NOT OBSERVED, L = LOW, M = MODERATE, H = HEAVY)

RESIDENTIAL	RECREATIONAL	AGRICULTURAL	INDUSTRIAL	LAKE MANAGEMENT
M RESIDENCES	L PARKS, CAMPGROUNDS, BEACHES	___ CROPLAND	___ INDUSTRIAL PLANTS	___ MACROPHYTE CONTROL
L MAINTAINED LAWNS	___ PRIMITIVE PARKS, CAMPING, BEACHES	___ PASTURE	___ MINES/QUARRIES	___ LIMING
___ CONSTRUCTION	___ RESORTS	___ LIVESTOCK	___ POWER LINES	___ DRINKING WATER TREATMENT
___ PIPES, DRAINS	___ MARINAS		___ POWER PLANTS	M ANGLING PRESSURE
___ TREATMENT PLANT	___ TRASH/LITTER		___ LOGGING	
___ LANDFILL, DUMPING	___ SURFACE FILMS, SCUMS, OR SLICKS		___ EVIDENCE OF FIRE	
			___ ODORS	

GENERAL LAKE INFORMATION

HYDROLOGIC LAKE TYPE	☐ RESERVOIR	☒ DRAINAGE (OUTLETS PRESENT)	☐ SEEPAGE (NO OUTLETS OBSERVED)	
OUTLET DAMS	☒ NONE	☐ ARTIFICIAL	☐ NATURAL	
LOW ELEVATION FLIGHT HAZARDS	☐ YES	☒ NO		
MOTOR BOAT DENSITY	☐ HIGH	☒ LOW	☐ RESTRICTED	☐ BANNED
GENERAL AESTHETICS	☒ PLEASANT	☐ SOMEWHAT PLEASANT	☐ UNPLEASANT	
SWIMMABILITY	☒ GOOD	☐ FAIR	☐ NOT SWIMMABLE	
LAKE LEVEL CHANGES	☐ ZERO	☒ ELEVATION CHANGE = 0.3 M		

SHORELINE CHARACTERISTICS (% of shoreline)

FOREST/SHRUB	☐ RARE (<5%)	☐ SPARSE (5 TO 25%)	☐ MODERATE (25 TO 75%)	☒ EXTENSIVE (> 75%)
AGRICULTURE	☒ RARE (< 5%)	☐ SPARSE (5 TO 25%)	☐ MODERATE (25 TO 75%)	☐ EXTENSIVE (> 75%)
OPEN GRASS	☒ RARE (< 5%)	☐ SPARSE (5 TO 25%)	☐ MODERATE (25 TO 75%)	☐ EXTENSIVE (>75%)
WETLAND	☒ RARE (< 5%)	☐ SPARSE (5 TO 25%)	☐ MODERATE (25 TO 75%)	☐ EXTENSIVE (>75%)
BARREN (BEACH)	☒ RARE (< 5%)	☐ SPARSE (5 TO 25%)	☐ MODERATE (25 TO 75%)	☐ EXTENSIVE (>75%)
DEVELOPED	☒ RARE (< 5%)	☐ SPARSE (5 TO 25%)	☐ MODERATE (25 TO 75%)	☐ EXTENSIVE (>75%)
SHORELINE MODS. (DOCKS, RIPRAP)	☒ RARE (< 5%)	☐ SPARSE (5 TO 25%)	☐ MODERATE (25 TO 75%)	☐ EXTENSIVE (>75%)

QUALITATIVE MACROPHYTE SURVEY

MACROPHYTE DENSITY	☐ ABSENT	☒ SPARSE	☐ MODERATE	☐ DENSE
EMERGENT/FLOATING COVERAGE (% LAKE AREA)	☒ 0 TO 25%	☐ 25 TO 50%	☐ 50 TO 75%	☐ > 75%
SUBMERGENT COVERAGE (% LAKE AREA)	☒ 0 TO 25%	☐ 25 TO 50%	☐ 50 TO 75%	☐ > 75%

DESCRIPTION:

(Continued on reverse side)

REVIEWED BY (INITIAL): JA

Figure 9-2. Lake Assessment Form, Side 1.

LAKE ID: NY0000L LAKE ASSESSMENT FORM (continued) VISIT #: (1) 2

QUALITATIVE ASSESSMENT OF ENVIRONMENTAL VALUES

TROPHIC STATE ☒ OLIGOTROPHIC ☐ MESOTROPHIC ☐ EUTROPHIC ☐ HYPEREUTROPHIC

VISUAL ASSESSMENT: CLEAR WATER - NO SCUM OR EVIDENCE OF ALGAL BLOOMS

ALGAL ABUNDANCE & TYPE: NONE OBSERVED

NUTRIENT STATUS: APPEAR TO BE LOW -- NO SOURCES OBSERVED AROUND LAKE

OTHER:

FISHABILITY: ☒ EXCELLENT ☐ GOOD ☐ FAIR ☐ POOR

CONDITIONS:

LOCAL CONTACTS:

OBSERVATIONS: GOOD TROUT AND SALMON POPULATIONS. ABUNDANT BAIT FISH.

OVERALL BIOTIC INTEGRITY ☒ EXCELLENT ☐ IMPACTED ☐ SEVERELY IMPACTED

GENERAL ASSESSMENT: LITTLE HUMAN IMPACT IS APPARENT.

WILDLIFE OBSERVED: MOOSE, SEA GULLS, FROGS, GROUSE, MINK, LOON, DEER

WATERBODY CHARACTER (CIRCLE ONE)

PRISTINE	(5)	4	3	2	1	DEVELOPED
APPEALING	(5)	4	3	2	1	UNAPPEALING

COMMENTS:

REVIEWED BY (INITIAL): JA

Rev. 3/95 FLDFRMS.95 Lake Assessment Form - 2

Figure 9-3. Lake Assessment Form, Side 2.

TABLE 9-1. LAKE SITE ACTIVITIES AND DISTURBANCES

Observe any lake activities or disturbances listed below and record as L (low), M (moderate), or H (heavy) intensity on Side 1 of the Lake Assessment Form (except as noted below):

Residences	Presence of any houses and residential buildings around the lake.
Construction	Presence of any recent construction in the immediate area around the lake or signs of recent sedimentation events (depositional fans).
Pipes/Drain	Presence of any pipes or drains feeding into or out of the lake. If known, write down what type of activity the pipe is associated with (e.g., storm sewer, plant intake) in the "Comments" section on Side 2.
Treatment Plant	Presence of sewage treatment facility.
Landfill	Any evidence of landfill or dumping around the lake, including garbage pits and informal dumping of large amounts of trash or cars and appliances along roads or lakeshore. This does not include small amounts of litter. If informal dumping areas exist, note that they are informal sites in the "Comments" section on Side 2.
Parks, etc.	Presence of organized public or private parks, campgrounds, beaches or other recreational areas around the lake. If there are signs of informal areas (e.g., swimming hole) for camping, swimming, or boating around the lake, record them on the "parks, campground, beaches" line and note that they are informal in the "Comments" section on Side 2.
Resorts	Level of resort activity; this could include motels, resorts, golf courses, and stores.
Marinas	Presence of any marinas.
Trash/Litter	Relative abundance of trash or litter around the lake.
Scum/Slicks	Relative abundance of scum or slicks on the lake.
Agriculture	Presence of cropland, pasture, orchards, and livestock.
Industry	Any industrial activity (e.g., canning, chemical, pulp) around the lake or in the catchment. Describe the type of industry in the "Comments" section on Side 2.
Mine/Quarry	Any evidence of mining or quarrying activity in the catchment or around the lake.
Power Lines	Presence of any power generating facilities or heavy duty transmission lines around or across the lake (not ordinary telephone or electric wires).
Power Plants	Presence of any power plants.
Logging/Fires	Any evidence of logging or fire removal of trees in the lake area.
Odors	Presence of any strong odors.
Macrophyte Control	Any evidence of dredging or the application of chemicals; describe these in the "Comments" section on Side 2.
Liming	Any evidence of liming activities.
Drinking Water Treatment	Presence of any drinking water treatment facilities.
Angling Pressure	Estimate of the intensity of fishing activity in the lake.

Record any other oddities observed or additional information for any specific activity in the "Comments" section on Side 2.

9.1.2 General Lake Information

Observations regarding the general characteristics of the lake are described in Table 9-2, and are recorded on Side 1 of the Lake Assessment Form (Figure 9-2). The hydrologic lake type is a very important variable for defining subpopulations for acidic deposition effects. Note any flight hazards that might interfere with either low-altitude fly-overs by aircraft (for future aerial photography or videography) or landing on the lake for sampling purposes (either by float plane or helicopter). When estimating the intensity of motor boat usage, in addition to the actual number of boats observed on the lake during the visit, use other observations such as the presence of boat houses, docks, and idle craft.

9.1.3 Shoreline Characteristics

Shoreline characteristics of interest during the final lake assessment are described in Table 9-3. Observations related to this portion of the assessment are recorded on the Lake Assessment Form, Side 1 (Figure 9-2). To estimate the extent of major vegetation types, limit the assessment to the immediate lake shoreline (i.e., within 20 m of the water). Also estimate the percentage of the immediate shoreline that has been developed or modified by humans.

9.1.4 Qualitative Macrophyte Survey

Macrophytes (aquatic plants large enough to be seen without magnification) are important indicators of lake trophic status. The most important indicator for EMAP-SW purposes is the percentage of the lake area covered with macrophytes. For both "emergent/floating" and "submergent" coverage, choose one of the four percentage groupings (0 to 25 percent, 25 to 50 percent, 50 to 75 percent, 75 to 100 percent), on Side 1 of the Lake Assessment Form, that best describes the lake. In some cases, it will be fairly easy to estimate the percentage from observations made during sampling. In other cases, it will be an educated guess, especially if the water is turbid. After recording the areal percentage of macrophyte coverage, record the density of the plants in the observed macrophyte beds as either dense, moderate, or sparse. Finally, provide any qualitative description (genera present, dominant type [floating, emergent, or submergent]) of the macrophyte beds that would be useful for interpreting the trophic status of the lake. All activities described in this subsection are recorded on Side 1 of the Lake Assessment Form (Figure 9-2).

9.1.5 Qualitative Assessment of Environmental Values

The goal of EMAP-SW is to assess three major ecological values with respect to lakes: trophic state, fishability, and biotic integrity. Based on your field experience, record your own assessment of

TABLE 9-2. GENERAL LAKE INFORMATION NOTED DURING LAKE ASSESSMENT

Hydrologic Lake Type	Note if there are any stream outlets from the lake, even if they are not flowing. If no lake outlets were observed, record the lake as a seepage lake. If the lake was created by a man-made dam (not that a dam is present just to raise the water level), record the lake as a reservoir. Otherwise record the lake as a drainage lake.
Outlet Dams	Note the presence of any dams (or other flow control structures) on the lake outlet(s). Differentiate between artificial (manmade) structures and natural structures (beaver dams).
Flight Hazards	If there are any hazards (above tree level) that would interfere with low elevation aircraft flights or landing on the lake, check "Yes"; otherwise check "No." Examples include radio towers or power lines.
Motor Boats	Record your impression of the density of motor boat usage on this lake (high or low). If there is a restriction on the size of motor boat engines, check "Restricted." If motor boats are banned, check "Banned." Consider the day of the week and weather in your assessment as well as the number of boathouses, idle craft. Count jet skis and any other motorized craft, which could stir up the lake, as motor boats.
General Aesthetics	Record your impression of the general aesthetic atmosphere of the lake.
Swimmability	Record a subjective impression about the aesthetics of swimming in this lake (swimmability) along the range of "good" to "not swimmable."
Lake Level	Examine the lake shoreline for evidence of lake level changes (e.g., bathtub ring). If there are none, check "zero"; otherwise try to estimate the extent of vertical changes in lake level from the present conditions based on other shoreline signs.

TABLE 9-3. SHORELINE CHARACTERISTICS OBSERVED DURING FINAL LAKE ASSESSMENT

Check percent of shoreline characteristics:

Forest/Shrub	Deciduous, coniferous, or mixed forest, including shrub and sapling vegetation.
Agriculture	Cropland, orchard, feedlot, pastureland, or other horticultural activity.
Open Grass	Meadows, lawns, or other open vegetation.
Wetland	Forested and nonforested wetlands (submerged terrestrial vegetation).
Barren	Nonvegetated areas such as beaches, sandy areas, paved areas, and exposed rock.
Developed	Immediate shoreline area developed by human activity; this includes lawns, houses, stores, malls, marinas, golf courses, or any other human-built land use.
Shoreline Modifications	Actual shoreline that has been modified by the installation of riprap, revetments, piers, or other human modifications.

these values on the Lake Assessment Form, Side 2 (Figure 9-3). Write comments on these values in this section. The key words on the left side of each value section are there to stimulate thought and are not comprehensive. It is not necessary to address each of these key words.

Trophic state is the rate or amount of phytoplankton and macrophytes produced or present in a lake. List any observed potential nutrient sources to the lake (e.g., septic tanks and agricultural runoff). Give your visual impression of the trophic status as oligotrophic (little or no biomass in the lake water), mesotrophic (intermediate amounts of biomass in the lake water), eutrophic (large amounts of biomass in the lake water), or hypereutrophic (choked lake, with more biomass than water).

Fishability is a fish assemblage containing fish that are catchable, desirable, and safe to consume by wildlife and humans. Write down any observations about fishability derived from impressions of fish habitat, conversations with locals, or the presence of fish and fishermen.

Biotic integrity is the ability to support and maintain a balanced, integrated, adaptive community with a biological diversity, composition, and functional organization comparable to natural lakes of the region. Record your overall impression of the "health" of the biota in the lake. Note any on possible causes of impairment. The presence of higher order consumers (fish-eating birds and mammals) is an indication of a healthy food web and should be noted here. Similarly, the absence of an organism that you might expect to see is an important observation.

In addition, rate the *water body character* which is the physical habitat integrity of the water body and is largely a function of riparian and littoral habitat structure, volume change, trash, turbidity, slicks, scums, color, and odor. The EMAP Surface Waters group attempts to define water body character through two attributes: degree of human development and aesthetics. Rate each of these attributes on a scale of 1 to 5. For development, give the lake a "5" if it is pristine, with no signs of any human development. A "1" would indicate a lake is totally developed; for example, the entire lake is ringed with houses, seawalls, docks, etc. For aesthetics (whether the lake is appealing or not) base the decision on any factors about the lake that disturb you (trash, algal growth, weed abundance, overcrowding). Circle the number that best describes your opinion about how suitable the lake water is for recreation and aesthetic enjoyment today:

1. Enjoyment is nearly impossible.

2. Level of enjoyment is substantially reduced.

3. Enjoyment is slightly impaired.

4. There are very minor aesthetic problems; it is otherwise excellent for swimming, boating, and enjoyment.

5. It is beautiful and could not be any nicer.

Use the comments section on Side 2 to note any other pertinent information about the lake or its catchment. Here the field team can record any observations that may be useful for future data interpretation.

9.2 DATA FORMS AND SAMPLE INSPECTION

After the Lake Assessment Form is completed, one team member reviews all of the data forms and sample labels for accuracy, completeness, and legibility. The same team member also inspects all sample containers and packages them in preparation for transport, storage, or shipment. The other team members load the boat on the trailer, pick up the equipment and supplies for transport, and clean up the launch site area as described in Section 9.3.

Ensure that all required data forms for the lake have been completed. It is important to verify that there is a Fish Tally Form completed for every piece of fishing gear used on the lake. Confirm that the LAKE-ID is correct on all forms, as well as the date of the visit. On each form, verify that all information has been recorded accurately, the recorded information is legible, and any flags are explained in the comments section. Ensure that written comments are legible and use no "shorthand" or abbreviations. After reviewing each form initial the lower right corner of each page of the form.

Ensure that all samples are labeled, all labels are completely filled in, and each label is covered (except for those in the fish jars) with clear plastic tape.

9.3 LAUNCH SITE CLEANUP

Load the boat on the trailer and inspect the boat, motor, and trailer for evidence of weeds and other macrophytes. Clean the boat, motor, and trailer as completely as possible before leaving the launch site. Inspect all nets for pieces of macrophyte and dead fish and remove as much as possible before packing the nets for transport. Pack all equipment and supplies in the vehicle and trailer for transport; keep them organized as presented in the equipment checklists (Appendix B).

Clean up all waste material at the launch site and dispose of or transport it out of the site if a trash can is not available. Dispose of fish carcasses as directed by the collecting permit or the fish protocol.

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ACRONYMS AND ABBREVIATIONS

BPJ	Best Professional Judgment
DLGs	Digital Line Graphs
DO	dissolved oxygen
EMAP	Environmental Monitoring and Assessment Program
EPA	U.S. Environmental Protection Agency
GPS	Global Positioning System
GQ	geometric quality
ID	identification
ORD	Office of Research and Development
OSHA	Occupational Safety and Health Administration
P-Hab	physical habitat
PVC	polyvinyl chloride
QA	quality assurance
QC	quality control
SQ	signal quality
STARS	Sample Tracking and Reporting System
T	Top
TIME	Temporally Integrated Monitoring of Ecosystems
USGS	United States Geological Survey
YOY	young of year
YSI	Yellow Springs Instrument system

Measurement Units

ha	hectare
m	meter
ppm	parts per million