MONITORING DESIGN DOCUMENT

Florida Department of Environmental Protection
Watershed Monitoring Program
Tallahassee, FL 32399-2400

2009-2011

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LIST OF ACRONYMS AND ABBREVIATIONS

Acronym/Abbreviation	Definition
µg/L	Micrograms per Liter
ADM	Automated Data Management
ASCII	American Standard Code for Information Interchange
BARS	Bureau of Assessment and Restoration Support
BDL	Below Detection Level
CDF	Cumulative Distribution Function
CWA	Clean Water Act
DEAR	Division of Environmental Assessment and Restoration
DGPS	Differentially Corrected Global Positioning System
DQO	Data Quality Objective
EMAP	Environmental Monitoring and Assessment Program
EPA	U.S. Environmental Protection Agency
ESRI	Environmental Systems Research Institute
F.A.C.	Florida Administrative Code
FAS	Floridan Aquifer System
FDEP	Florida Department of Environmental Protection
FDOH	Florida Department of Health
FRS	Field Reference Sample
F.S.	Florida Statutes
FTP	File Transfer Protocol
GIS	Geographic Information System
GPS	Global Positioning System
GRTS	Generalized Random Tessellation Stratified
GWIS	Generalized Water Information System
HA	Habitat Assessment
IAS	Intermediate Aquifer System
K-S	Kolmogorov-Smirnov
K-W	Kruskal-Wallis
LCB	Lower Confidence Bounds
LVI	Lake Vegetation Index
m^2	Square Meter
mg/L	Milligrams per Liter
M-K	Mann-Kendall
$M\text{-}K_h$	Mann-Kendall (for homogeneity)
mL	Mililiter
MLE	Maximum Likelihood Estimation
M-W	Mann-Whitney
NELAP	National Environmental Laboratory Accreditation Program
NHD	National Hydrography Dataset
NO3	Nitrate
NPDES	National Pollutant Discharge Elimination System
NTU	Nephelometric Turbidity Unit
NWFWMD	Northwest Florida Water Management District
OPS	Other Personnel Services
OTIS	Office of Technology and Information Services
PCU	Platinum Cobalt Unit
Q1, Q2, Q3	First, Second, and Third Quartiles
QA	Quality Assurance
QAO	Quality Assurance Officer

Acronym/Abbreviation	Definition
QA/QC	Quality Assurance/Quality Control
QC	Quality Control
SAS	Surficial Aquifer System
SCI	Stream Condition Index
SJRWMD	St. Johns River Water Management District
S-K	Seasonal Kendall
SM	Standard Methods
SOP	Standard Operating Procedure
S-S	Sen-Slope
SSF	Standard Storage Format
STORET	STOrage and RETrieval Database
su	Standard Unit
TDS	Total Dissolved Solids
TMDL	Total Maximum Daily Load
TSI	Trophic State Index
UCB	Upper Confidence Bounds
USGS	U.S. Geological Survey
VISA	Very Intense Study Area
WMD	Water Management District
WMS	Watershed Monitoring Section
ZOD	Zone of Discharge

INTRODUCTION

The Florida Department of Environmental Protection (FDEP) is committed to protecting and restoring Florida's waters and to conducting sound, scientific water quality monitoring. Water resources cannot be managed without comprehensive water quality monitoring and assessment. The overall goal of FDEP's monitoring activities is to determine the quality of the state's surface and ground waters, and document how they are changing over time.

Under the federal Clean Water Act (CWA), regulated by the U.S. Environmental Protection Agency (EPA), states are required to do the following:

Determine whether waters meet water quality standards (i.e., attain their designated uses, or functional classifications);

Identify impaired waters;

Identify the causes and sources of water quality impairments;

Support the implementation of water management programs;

Establish, review, and revise water quality standards;

Establish special monitoring for unique resources, such as Florida's springs; and

Support the evaluation of program effectiveness.

Monitoring is also required under Florida law through a series of rules that govern FDEP's regulatory activities. The 1997 Water Quality Assurance Act (Section 403.063, Florida Statutes [F.S.]) directs FDEP to establish and maintain a ground water quality-monitoring network designed to detect or predict the contamination of the state's ground water resources. In addition, Section 62-40.540, Florida Administrative Code (F.A.C.), Florida's Water Policy, states that FDEP ". . . shall coordinate district, state agency, and local government water quality monitoring activities in order to improve data quality and reduce costs."

Background

Starting in 1996, FDEP initiated a redesign of its water resource monitoring activities, resulting in an efficient, multi-resource, comprehensive monitoring network. Multiple monitoring networks at FDEP are coordinated through the Division of Environmental Assessment and Restoration (DEAR). The Watershed Monitoring Section (WMS) in the Bureau of Assessment and Restoration Support (BARS) oversees two of the networks that were designed to address the goals listed above. The Status Monitoring Network provides a snapshot of the overall quality of waters in the state, answering questions about chemical and biological water quality standards. The Trend Monitoring Network measures changes in water quality over time.

FDEP's surface and ground water monitoring programs contain three tiers, ranging from the general to the specific, as follows:

Tier I addresses statewide and regional (within Florida) questions. It consists of a probabilistic monitoring network (the Status Monitoring Network), which is used to develop statistical estimates of statewide water quality, and a fixed station trend network (the Trend Monitoring Network), designed to examine changes in *water quality over time in ground water and riverine systems throughout the state.*

Tier II addresses basin-specific and stream-specific questions. Strategic monitoring for the Total Maximum Daily Load (TMDL) Program addresses impaired waters in individual basins and stream segments in order to develop and implement TMDLs for impaired waters that do not meet water quality standards.

Tier III addresses site-specific questions. It includes intensive surveys for TMDLs, monitoring to establish or revise water quality standards, monitoring to evaluate site-specific alternative criteria, and fifth-year inspections for wastewater facilities under the National Pollutant Discharge Elimination System Program (NPDES).

Federal Monitoring Strategy Guidance

A well-designed monitoring network is founded on core design elements. The following elements are described in the EPA guidance document, *Elements of a State Water Monitoring and Assessment Program:*

Monitoring program strategy;

Monitoring objectives;

Monitoring design;

Indicators;

Quality assurance;

Data management;

Data analysis and assessment;

Reporting;

Programmatic evaluation, and

General support and infrastructure planning.

This report follows EPA guidance. It articulates the strategy, goals, objectives, and design of FDEP's Status and Trend Monitoring Programs related to fulfilling Florida's commitment to protect surface and ground water resources by providing sound, scientific water quality monitoring programs. This document does not cover FDEP programs providing Tier II and III monitoring.

ELEMENT 1: MONITORING PROGRAM STRATEGY

A monitoring program strategy addresses implementation and documents the timeline and plan needed to carry it out. FDEP initiated the monitoring programs for ambient ground and surface freshwater resources in 2000. Only a few modifications have occurred since their implementation.

The Status and Trend Monitoring Networks are not designed to address regulatory or point source contamination (thus the term "ambient"); rather, they are a tool to help document the condition of state waters. Management needs are routinely evaluated to ascertain whether the monitoring programs answer questions that are relevant to state interests and other agency programs. In response, the strategy and design of the programs are revised to address needed modifications.

The objective of the Status and Trend Monitoring Networks is to provide scientifically defensible and relevant data to support long-term ambient monitoring goals, as follows:

The Status Monitoring Network, as described in this document, provides an overview of the condition of state waters. The results from the Status Monitoring Network are used to calculate the proportion of waters meeting water quality standards compared with those waters that do not.

The Trend Monitoring Network tracks changes in the quality of targeted waters over time. The data derived from both networks can be examined to determine if there are changes in water quality due to management and restoration efforts throughout the state. Resource management focused on protecting water quality is less costly than the restoration of impaired waters.

The Status and Trend Monitoring Networks focus on freshwater resources—lakes, rivers, streams, and ground water—which are further described in **Element 3**. There are other water resources in the state: wetlands, springs, estuaries, and near and offshore marine waters. However, due to resource limitations and the lack of specific mandates, these resources are monitored only as funding or management needs arise. Examples of management needs include monitoring to support the development of wetland standards, monitoring of harmful algal blooms, and monitoring to document the local contamination of drinking water sources. These needs are not currently covered by the scope of the Status and Trend Monitoring Networks. When the need for criteria development arises, it is likely that the monitoring programs and subsequent strategy will be modified.

A number of impediments and shortcomings have been identified in the implementation of the monitoring programs, including the following:

Continued funding is needed to support staff, expenses, and the addition of analytes of concern. Both state and federal funds support the monitoring program at FDEP. In the current budget climate at both the state and federal levels, adequate funding is uncertain.

Many personnel in the program are temporary employees, leading to a high turnover rate. The training and mastery of skills needed to meet state Standard Operating Procedures (SOPs) is time intensive. The loss of these staff reflects a significant loss of resources.

A well-trained personnel base is a necessary part of any monitoring program. Currently, the Status and Trend Monitoring Networks have the following personnel located in Tallahassee: environmental administrator, quality assurance officer (QAO), data analysts, data managers, and project managers. Field support is provided through contracted regional government agencies and through FDEP staff in district offices to allow reasonable spatial coverage of the state. Many of the positions are called Other Personnel Services (OPS), which are temporary positions without benefits. **Figure 1-1** shows FDEP's watershed monitoring organizational chart.

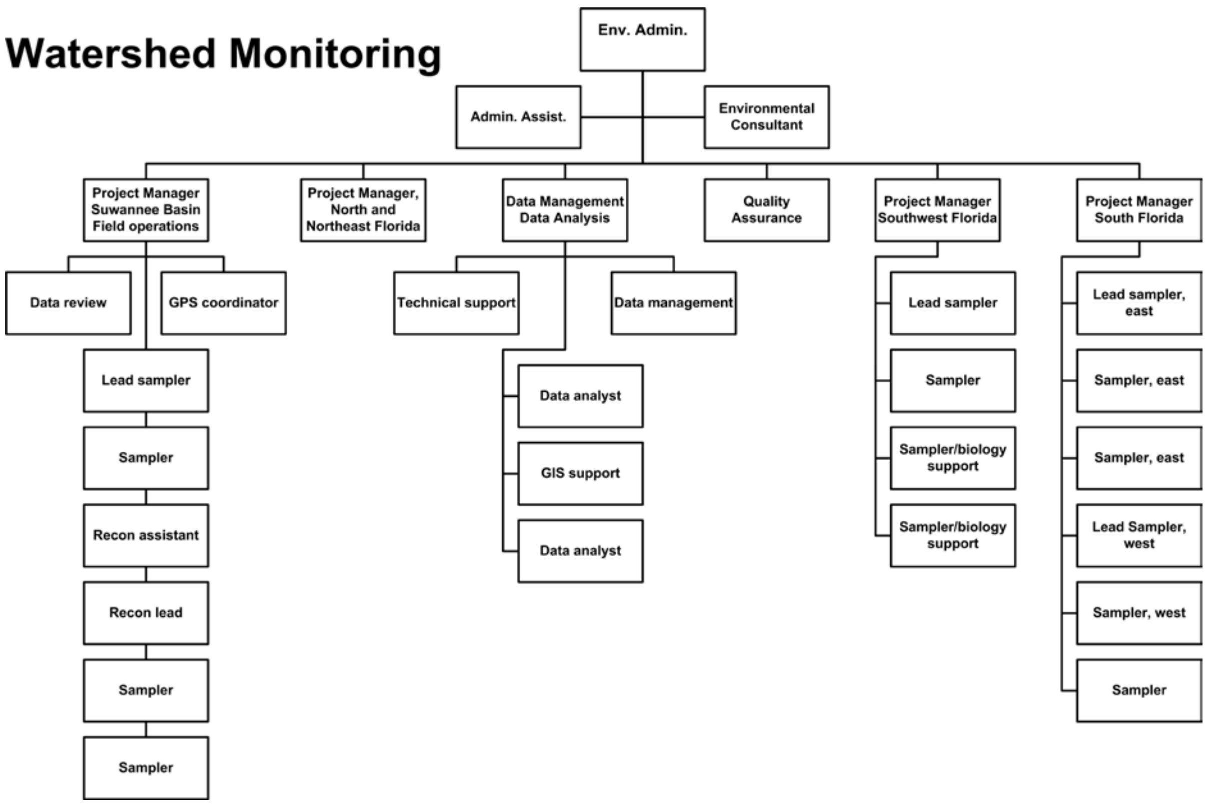

Figure 1.1. FDEP's watershed monitoring organizational chart

Other EPA Elements that Address the Status and Monitoring Networks

The rest of the chapters in this report describe the elements of EPA guidance that address the Status and Trend Monitoring Networks. These are briefly described below, with a short discussion of element-specific constraints.

Element 2: Monitoring Objectives

This section describes monitoring objectives in both the Status and Trend Monitoring Networks, for the current monitoring design. Monitoring objectives are based on current agency priorities and initiatives, and are subject to change. All modifications influence the remaining elements, and the implementation of changes takes an extraordinary commitment of time and resources. When revisions to this document occur, the contractual agreements, staff training, lab scheduling, site reconnaissance, analyte selection, data management and analysis, and reporting format will all require updating.

Element 3: Monitoring Program Design

The section on monitoring program design addresses the following:

Design of surface and ground water probabilistic monitoring network (Status Monitoring Network):

- Reporting units: state and regional zones;
- Geographic design of the Status Monitoring Network;
- Site selection for the Status Monitoring Network;
- Reconnaissance of sites; and
- Status Monitoring Network sampling and frequency.

Design of surface and ground water trend monitoring network (Trend Monitoring Network):

- Surface water; and
- Ground water.

The design section also addresses the following specifics common to both sampling networks:

Water resources sampled; and

Sampling protocols.

Due to constraints in funding and personnel to support the monitoring program, the number of water resources that can be monitored is limited. For example, the number of rivers, streams, and ground water stations in the Trend Monitoring Network is limited. The specific stations that are monitored have been prioritized and were selected from a larger population. The same constraints exist for the Status Monitoring Network. A greater spatial coverage of the state could be achieved with additional sampling sites.

Element 4: Core and Supplemental Indicators

The section on core and supplemental indicators contains the following:

- *Designation of waters and uses;*
- *Indicators with water quality standards or guidelines; and*
- *Tables with indicators listed for both the Status and Trend Monitoring Networks, with approved analytical methods.*

Indicators are selected to monitor water quality and to support standards and criteria development. The indicator lists for both networks have been reviewed to be certain they support program needs, or can aid in the development or validation of new criteria. If additional funds were available, the indicator lists could be expanded based on additional agency needs.

Element 5: Quality Assurance

The quality assurance (QA) section addresses the following:

- *Position description and responsibilities of the QA officer (this position is required under state SOPs);*
- *QA procedures and protocols;*
- *Reference to comprehensive sampling manual; and*
- *Quality control (QC) procedures.*

All quality assurance/quality control (QA/QC) procedures relevant to program needs must be changed to reflect updates to state SOPs and protocols. The QA officer and WMS are responsible for these updates and for training personnel to comply with current SOPs.

Element 6: Data Management

The data management section discusses the following:

- *Data management protocols;*
- *Details of data pathways and database containing field and laboratory records;*
- *Metadata;*
- *STOrage and RETrieval (STORET) data repository; and*
- *Status and Trend Monitoring Networks data management.*

Data management concerns include connectivity among FDEP enterprise databases, the incorporation of ground water data into STORET, and the uncertainty of data compatibility with future STORET. Additionally, Information Technology support is required, since the program is not allowed to fully administer its own database and the applications that access it. Finally, the mission-critical data manager position is a temporary OPS position.

Element 7: Data Analysis/Assessment

This section discusses data analysis and assessment in detail with regard to the Status and Trend Monitoring Networks, including the following:

Statistical design of networks;

Statistical analyses used for both networks;

Status Monitoring Network target population characterization;

Statistical inference;

Data quality objectives and uncertainty levels; and

Missing values and censored data.

Environmental sampling has its own challenges. Occasionally samples are lost or delayed. Efforts are made to re-collect those samples, but if this is not possible, protocols are in place to deal with lost data. Once again, both data analysts are temporary OPS employees; this situation presents continued concern as it leads to employee turnover, and loss of expertise.

Element 8: Reporting

The reporting section addresses the following:

The schedule and nature of reporting for the Status and Trend Monitoring Networks.

The process of sample collection combined with laboratory and statistical analyses is lengthy but required before reports can be prepared. Delays in any of these steps may result in reports that are rushed or incomplete. In addition, it has taken four years of data collection before any Trend Monitoring Network results could be reported. Finally, the technical report writer is a temporary OPS employee.

Element 9: Programmatic Evaluation

The programmatic evaluation section discusses the following:

Review of program design to ensure that the Status and Trend Monitoring Networks use the best scientific approach;

Changes in FDEP priorities and initiatives that require alterations to the program design;

Addition of indicators to support criteria development for agency programs; and

EPA support.

The monitoring programs must comply with EPA guidance, while adjusting to changing environmental concerns and fiscal constraints. Adding indicators to the monitoring program strengthens the data but adds costs that may not be supported. The Status and Trend Monitoring Networks are continually evaluated in an attempt to address all stakeholder needs while balancing budget realities.

Element 10: General Support and Infrastructure

The general support and infrastructure section addresses the following:

Support:

- Funding support through EPA and FDEP;
- Support from outside agencies/programs; and
- Data management support.

Infrastructure:

- QA manuals;
- Training to ensure compliance with state SOPs;
- Training to ensure that all staff are up to date on program design and the results of the monitoring program;
- Tenets of design to produce the least variability in field and lab protocols; and
- Project manager manual.

There are many challenges to maintaining solid support and infrastructure, including changing environmental concerns and fiscal constraints. Fiscal or administrative changes to the organization may limit WMS's ability to maintain its monitoring program. Finally, the monitoring programs must comply with EPA guidance and state requirements, while relying on OPS staff in mission-critical positions.

ELEMENT 2: MONITORING OBJECTIVES

Program Goals and Objectives

Starting in 1996, FDEP initiated a redesign of its water resource monitoring activities, resulting in an efficient, multi-resource, comprehensive monitoring network. WMS has designed two networks to address the goals of both FDEP and the CWA. The goals of FDEP consist of monitoring to provide insight into the condition of Florida's surface and ground water, thus allowing protection and conservation of state water resources. The Status Monitoring Network provides a snapshot of the overall quality of waters in the state, answering questions about chemical and biological water quality standards. The Trend Monitoring Network measures changes in water quality over time.

This report articulates the strategy, goals, objectives, and design of FDEP's Status and Trend Monitoring Programs as it pertains to fulfilling Florida's commitment to protect surface and ground water resources by providing sound, scientific water quality monitoring programs. Other sections within FDEP, such as the TMDL Section, utilize Status and Trend Monitoring network data to determine if the water resource is impaired. Data are also made available to outside agencies and other FDEP programs to use in their water quality evaluations.

Background

Monitoring is required under Florida law through a series of rules that governs FDEP's regulatory activities. Florida Statue 403.063 directs FDEP to establish and maintain a ground water quality-monitoring network designed to detect or predict the contamination of the state's ground water resources. In addition, Section 62-40.540, F.A.C., Florida's Water Policy, states that FDEP ". . . shall coordinate district, state agency, and local government water quality monitoring activities in order to improve data quality and reduce costs." Ambient monitoring of the state's surface waters is performed to meet the federal requirements in the CWA (33 U.S.C. 1315[b]).

Status Monitoring Network

FDEP's approach to comprehensive monitoring is designed to meet the CWA and Florida's statutory and regulatory monitoring requirements. The network is designed to provide information on the statewide condition of surface and ground water. The results provide valuable information for more in-depth investigations, including setting reporting unit and indicator-specific priorities. A probabilistic monitoring network can answer questions such as the following:

What percentage of river miles statewide has less than optimal habitat (defined as X, Y, or Z)?

What number or area of lakes statewide exceeds the standard for fecal coliform?

The Status Monitoring Network activities collectively address the following goals and objectives:

Identify and document the statewide condition of Florida's water resources with a known certainty;

Determine the proportion of the state's waterbodies that meet water quality thresholds and other indicators of ecosystem health;

Collect data on important chemical, physical, and biological parameters to characterize waterbodies in accordance with Florida water quality standards in Rules 62-302 and 62-303, F.A.C.;

Contribute to a database, with known Data Quality Objectives and QA, that can be used to determine the status of a watershed's long-term overall health and to establish water quality standards;

Provide reliable data for management decision making;

Provide technically sound information to managers, legislators, agencies, and the public.

Sampling in the Status Monitoring network is conducted for both surface and ground water resources statewide each year. A biennial summary of the state's annual assessments is submitted to EPA for inclusion in the National Water Quality Inventory Report to Congress through the integrated 305(b) and 303(d) reporting process.

Trend Monitoring Network

Similar to the Status Monitoring Network, the Trend Monitoring Network provides information to support federal and state requirements. Designed to examine water quality changes in ground water and riverine systems over time, the Trend Monitoring Network consists of fixed station monitoring sites across the state. The program was initiated in 2000 and now has a sufficient amount of data available for analysis.

A fixed-site monitoring network can answer many of the same questions as the Status Monitoring network, as well as the following questions:

Has water quality significantly improved or worsened for the measured indicators at this location?

Is there seasonality to the data?

Can the Trend Monitoring Network results be compared with the Status Monitoring Network results?

The Trend Monitoring Network is an integral part of FDEP water quality monitoring. The WMS uses trend data in its submission to the integrated 305(b) and 303(d) report.

Data Quality Objectives

The Data Quality Objective(s) (DQO) process is a planning tool that can save resources. Good planning streamlines the study process and increases the likelihood of efficiently collecting appropriate and useful data. DQO invests up-front time and money in the planning stages to ensure that the final product satisfies the needs of data users. It focuses data collection activities so only the most critical questions are addressed.

The DQO process consists of two major activities, as follows:

Specifically state the question(s) that needs to be answered for the problem at hand; and

Specifically state the amount of uncertainty that investigators are willing to tolerate when attempting to answer that question with collected data.

DQOs then provide cradle-to-grave justification of data collection.

Other issues addressed by the DQO process are missing samples and the censoring of data. **Element 7** addresses procedures for dealing with missing data values for both the Status and Trend Monitoring Networks. Censoring of data has its own concerns and procedures, which are the same for both networks. The laboratory instrumentation detection limits are often higher than actual values for environmental samples. These laboratory detection limits are referred to as minimum detection levels and can lead to censoring of environmental data—that is, the data distribution is truncated at its lower end.

For the statistical analyses, all data reported as below detection level (BDL) are assigned values either based on the maximum likelihood estimation (MLE) calculation or arbitrarily given the value of the minimum detection level. On occasion, the laboratory instrumentation detection limits change for specific analytes. New analytical methods or instrumentation upgrades may result in better detection limits at lower concentrations, but this is not always the case. When preparing descriptive statistics, BDLs are assigned either the lowest laboratory detection limit or an MLE-based value.

Some Data Quality Objectives can be used by both monitoring networks. An overarching DQO for both Networks is:

1) Providing data of a known quality and confidence for use in FDEP programs and to aid in the development of rules and thresholds.

Other DQOs are specific to the monitoring program. DQOs specifically focused to the requirements of the Status Monitoring Network are:

1) Produce data for an estimate of condition for each type of water resource with a 95% confidence interval that has a margin of error between 5 and 15%.

DQOs specific for the Trend Monitoring Network are:

1) Produce an adequate amount of data to determine whether trends exist in surficial or ground water resources across the state.

2) Collect data over a period of time that covers temporal cycles in the data (e.g.- temperature changes over time and sampling must be at a rate that shows the seasonal fluctuations).

ELEMENT 3: MONITORING PROGRAM DESIGN

It is fiscally and logistically prohibitive to sample every segment of river or stream, every acre of lake, or each individual well in the state (i.e., census) on a regular basis. EPA suggests that a probabilistic monitoring design is a cost-effective approach in producing a statistical statement of known confidence to describe the aggregate condition of water resources. A probabilistic approach allows an unbiased subsampling of these resources.

Following EPA guidelines, FDEP initiated the Status Monitoring Network, based on a probabilistic design, to address the statewide spatial representation of targeted fresh water resources. The Status Monitoring Network enables FDEP to estimate the condition of 100 percent of accessible water resources in the state with a known statistical confidence. Status Monitoring Network data are used to comply with the integrated 305(b) and 303(d) reporting.

FDEP has also designed the Trend Monitoring Network to monitor changes in selected waterbodies over time. To achieve this goal, rivers, streams, and wells are regularly sampled at fixed locations. The Trend Monitoring Network complements the Status Monitoring Network by providing spatial and temporal information about resources and potential changes from anthropogenic or natural influences, including extreme events (i.e., droughts and hurricanes).

Water Resources Monitored

The following resources are monitored for the Status and/or Trend Monitoring Networks:

Ground water (confined and unconfined aquifers): *Ground water includes those portions of Florida's aquifers that have the potential for supplying potable water or affecting the quality of currently potable water. However, this does not include ground water that lies directly within or beneath a permitted facility's zone of discharge (ZOD) and water influenced by deep well injection (Class I and II wells).*

Rivers and streams (including canals): *Rivers and streams include linear waterbodies with perennial flow that are waters of the state (Chapters 373 and 403, F.S.). For the Status Network, canals were only sampled in 2009.*

Lakes (Status Monitoring Network only): *Lakes include natural bodies of standing water and reservoirs that are waters of the state and are designated as lakes on the U.S. Geological Survey (USGS) National Hydrography Dataset (NHD). This does not include many types of artificially created waterbodies, or streams/rivers impounded for agricultural use or private water supply.*

Neither the Status nor Trend Monitoring Network is currently intended to monitor estuaries, springs, wetlands, or marine waters.

Sampling

FDEP and the water management districts (WMDs) regularly collect samples from the water resources listed above to monitor water quality. All samples are collected and shipped following FDEP-approved protocols (Status and Trend Monitoring Networks Sampling Manual). Samples are shipped to the FDEP Bureau of Laboratories in Tallahassee for analysis. **Element 4** provides a complete list of indicators.

Status Monitoring Network

The Department launched the Status Monitoring Network in January 2000. Starting in 2009, an annual assessment of statewide water resource condition was instituted. This Status Monitoring Network design directs that 60 samples for each surface water resource type (see the section on water resource types below) and 120 samples for each ground water resource type are collected annually to assess the condition of these waters. Based on these sample sizes, the 95% confidence interval for the estimate of statewide condition is ±12% for surface water and ± 9% for ground water.

The Generalized Random Tessellation Stratified (GRTS) sampling design, supported by EPA's Environmental Monitoring and Assessment Program (EMAP), is used to select sampling sites. The design incorporates a stratified random approach to sampling and reporting on Florida's water resources. Geographic stratification breaks the state into non-overlapping areas (zones), from which the sample sites are chosen using simple random selection. GRTS design ensures that the sites are representative of the target resources and that their selection is not biased. Random sites are generated from an extensive list (list frame).

The implementation of the GRTS sample design in Florida has limitations due to the unequal distribution of water resources. For example, there are few small lakes in the southern portion of the state. Other factors such as periods of drought or access denials can reduce the number of sites sampled.

Parent and Target Populations

The parent populations for the Status Monitoring Network are all statewide ground and surface waters. The water resources defined above are the target populations. Sites are randomly selected from each target population. For example, the confined aquifer parent population is defined as the water from wells tapping confined aquifers that are generally considered potable; the target population includes those wells with the exclusion of ground water that lies directly within or beneath a permitted facility's ZOD and water influenced by deep well injection (Class I and II wells).

Water Resource Types

The following resources are monitored as part of the Status Monitoring Network:

Ground water:

- Confined aquifers; and
- Unconfined aquifers.

Surface water:

- Rivers and streams (including canals in 2009 only); and
- Lakes (small and large lakes).

Ground Water

Florida has three major aquifer systems, all of which are sampled: the surficial aquifer system (SAS), the intermediate aquifer system (IAS), and the Floridan aquifer system (FAS). The ground water resource is subdivided into two target populations, as follows, for the purposes of sampling and resource characterization: (1) unconfined aquifers and (2) confined aquifers. Unconfined aquifers, such as the SAS, are near the land surface and can be readily affected by human activities. In areas where the SAS is not present, the IAS or the FAS may be unconfined; these aquifers are sampled as part of the unconfined aquifer target population. The confined aquifer target population includes confined portions of the IAS or the FAS that are heavily used as a source of water.

Individual wells are selected from an annually updated list. The well population consists of wells from the following:

Recommendations submitted by each WMD;

The Ground Water Quality Monitoring Background Network;

The Very Intense Study Area (VISA) Network;

A Florida Department of Health (FDOH) private well survey cosponsored by FDEP;

WMD and county saltwater intrusion networks;

Upgradient monitoring wells associated with FDEP-permitted facilities;

USGS monitoring wells; and

Public and private water supply wells.

The well list is a dynamic and diverse representation of the state's ground water resource. The ground water target population is chosen such that wells in areas of industrialization, known contamination, and saltwater intrusion are avoided. Only unaffected wells from the VISA network and upgradient wells from FDEP-permitted facilities are included on the list and considered for sampling.

The target population includes public supply wells because pumping typically removes high volumes of water, which may induce the lateral or upward movement of saline water. The effects of saltwater intrusion are irreversible. The resulting degradation of water quality results in significant and costly changes in water supply systems.

Surface Water

Florida's surface waters are diverse and challenging to categorize. Surface waters are divided into two groups: flowing (lotic) or still waters (lentic).

Rivers, Streams, and Canals

The lotic group consists of rivers, canals, springs, spring runs, and sinking streams. Certain waters are excluded from the target population due to saline or marine conditions, such as estuaries and marine waters, while others are removed because other sections of FDEP focus on those resources, e.g., wetlands, springs, and spring runs.

Targeted flowing surface waters, which are waters of the state, are divided into rivers or streams based on size and input from FDEP and WMD staff. Rivers are initially identified, and the remaining flowing surface waters are classified as streams. Rivers and streams that are artificially altered with a loss of sinuosity and/or have box cut banks are deemed canals. Canals are part of the 2009 target population, however they are not included in the 2010 and 2011 target populations. Segments of impounded rivers and streams have also been removed from this resource.

Large and Small Lakes

The lentic group consists of many types of natural lakes, including sandhill lakes, sinkhole lakes, and oxbow lakes, and established reservoirs (i.e. not impoundments used for agriculture). Artificial waterbodies, such as stormwater retention ponds, golf course ponds, or other man-made water features that are not waters of the state are common but are not part of the target population, and are removed from the resource list frame.

Targeted lakes are subdivided into two populations: (1) small lakes between 4 and less than 10 hectares (10 to 25 acres); and (2) large lakes over 10 hectares (25 acres). The lakes must be at least 1,000 square meters (m^2) (~1/10 hectare or 1/4 acre) of open water in size, at least 1 meter deep at the deepest point, and not in direct contact with or influenced by oceanic waters. The differentiation on the basis of size is intended to accommodate different sampling strategies and methods and allow better representation of the resource types. If all lakes were in one category, the size of large lakes would skew site selection and cause small lakes to be under-represented,

Reporting Units

All stratified random sampling networks use predefined subunits (strata) that segregate the population of interest into two or more groups. The use of strata in a water quality sampling design enhances the power to detect differences in water quality because it optimizes the design based on the variability of the water resource. As an example of stratification, the state is divided into six water resource types. To accommodate geography, the state's water resources are further stratified into six reporting units or zones (**Figure 3.1**).

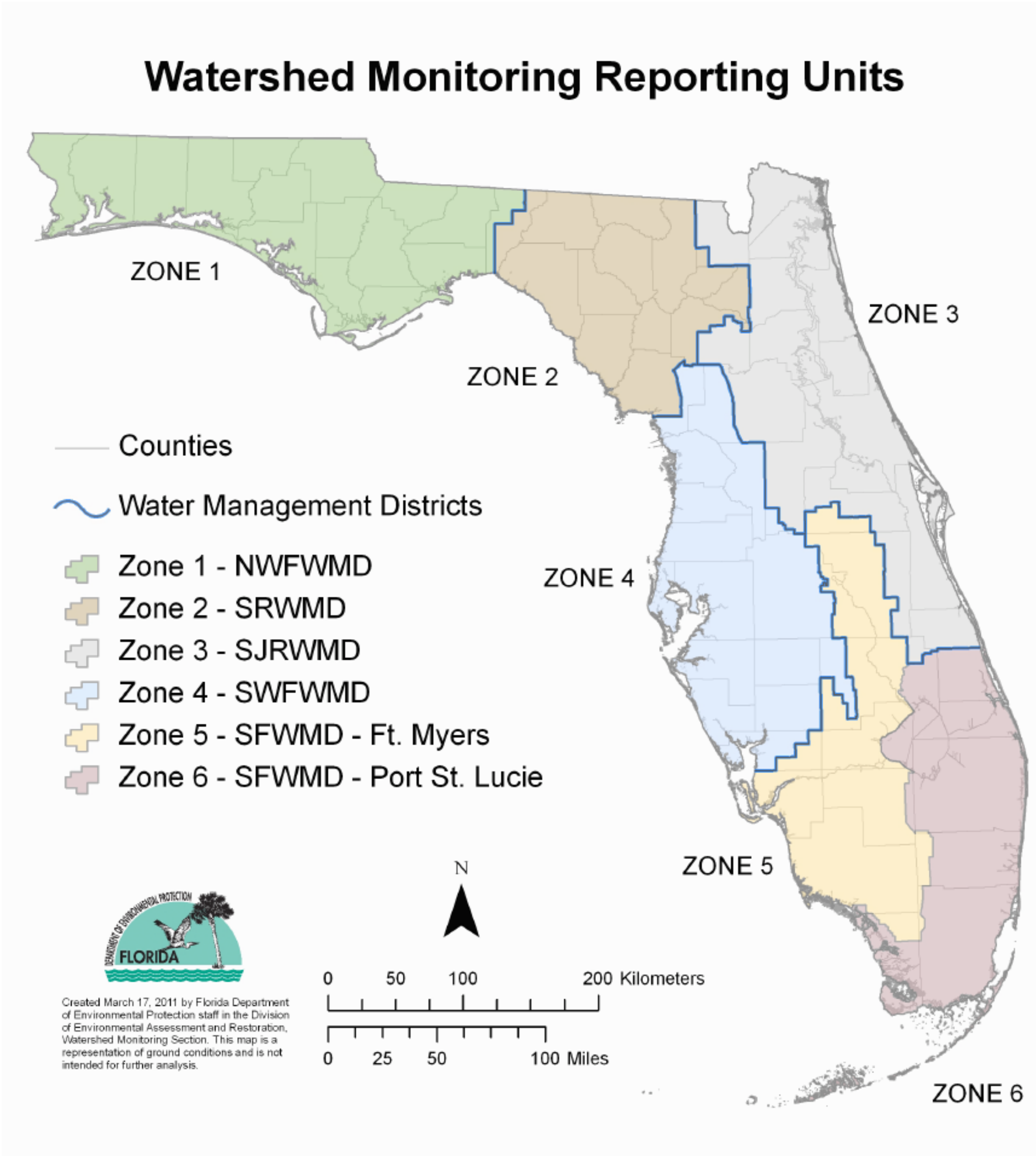

Figure 3.1. Florida reporting unit map showing zones

Geographic Design

Location information for water resources is organized as an electronic representation of the state's water resources in a Geographic Information System (GIS) database (**Appendix A**), using the Environmental Systems Research Institute's (ESRI) ArcGIS. WMS staff use GIS data, with associated information (metadata), to select sample sites (**Figure 3.2**). In 2009 only, an EPA statistician reviewed and approved the site selections generated by FDEP staff.

Site Selection

Florida's 6 zones (**Figure 3.1**) facilitate the spatial distribution of sites throughout the state. Annually, ten random sites (primary sites) and a 9-time oversample (alternate sites), for a total of 100 possible sites, are selected from each surface water resource type in each zone, resulting in 600 potential sample sites statewide. Twenty primary sites and a 9-time oversample, for a total of 200 possible sites, are selected annually from each ground water resource type in each zone, resulting in 1,200 potential sample sites statewide. The oversample is required due to the high probability of sampling problems, such as access denials, dry resources, and other challenges associated with random versus fixed station sampling designs.

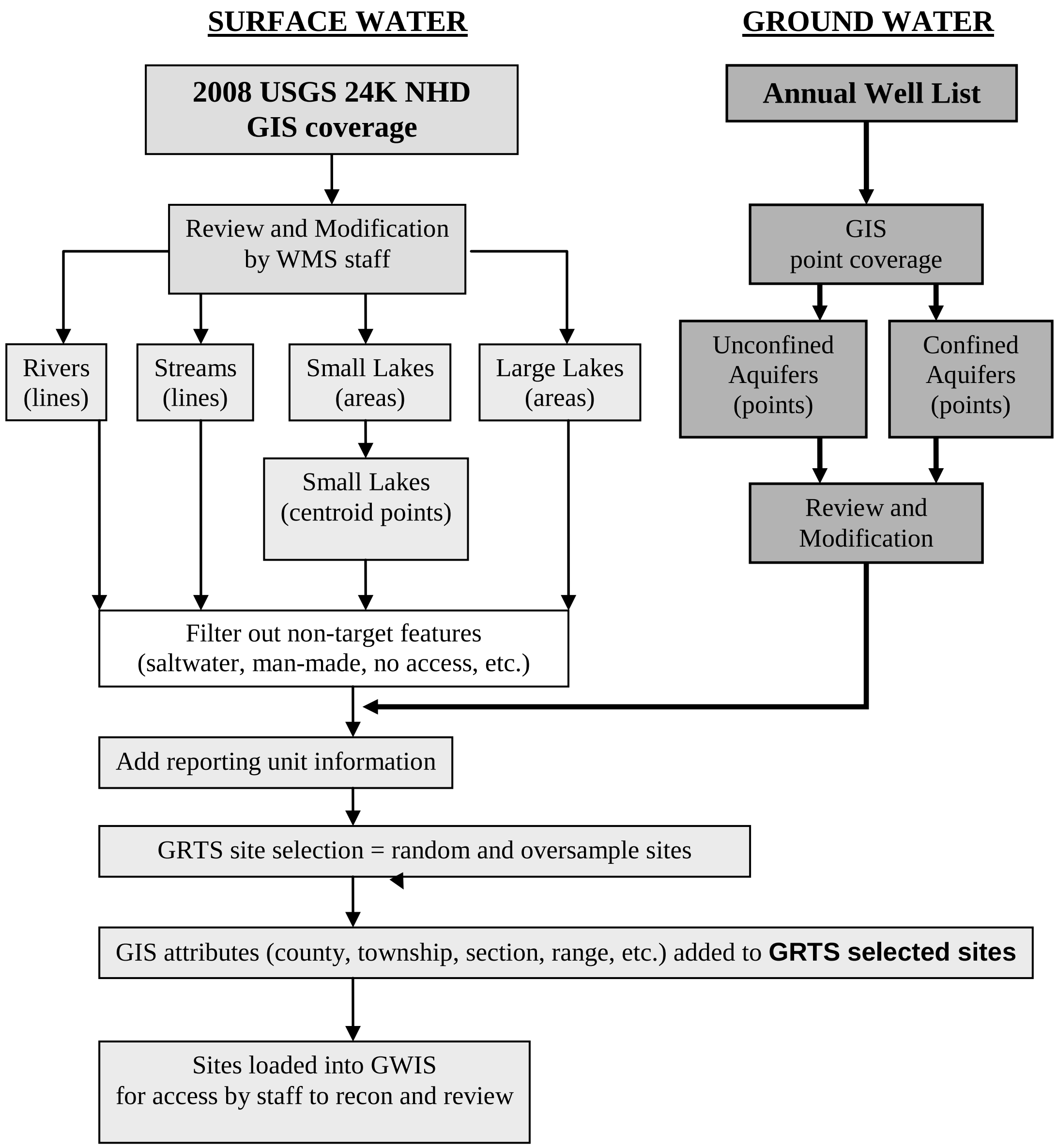

Figure 3.2. Status Monitoring Network flow chart of steps required to select sites

Potential sample sites, along with added geographic information, are placed into an Oracle database and accessed by staff through an Internet-based application called the Generalized Water Information System (GWIS) (see **Element 6**). This application allows staff to review selected sites using an Internet-based, interactive mapping system (MapDirect). Resource coverages are continually updated using staff comments stored in GWIS.

Sample Site Reconnaissance

Reconnaissance is a process by which sites are assessed before they are sampled. Site reconnaissance begins in the office using GIS to review all available documentation. After the primary sites are evaluated, alternate sites are reviewed in the order in which they were generated. When a site is deemed sampleable, permission from the property owner must be obtained. FDEP makes three attempts to contact the owner before moving on to the next site.

The final stage of reconnaissance takes place during a site visit. Staff investigates the selected sites and determines if they meet established criteria. If criteria are met, the site is sampled; otherwise staff record exclusion details and proceed to the next site.

Sampling and Frequency

An attempt is made to annually take 60 samples statewide for each surface water resource type and resample each site in an "opposite" season 6 months later. **Figure 3.3** indicates the month samples are to be collected and lists the distribution of samples for each resource type. The potential number of samples collected in a year for each resource type is 120.

Intra-annual (seasonal) variability in surface waters may be observed in the proposed indicators. The purpose of the resample in an opposing season is to account for potential seasonal differences and determine if they are statistically significant. These results will be used to determine whether compliance with thresholds is maintained over time. **Element 7** discusses the statistical analyses further.

Annually, an attempt is made to sample 120 wells chosen for each of the ground water resource types without resampling. The previous evaluation of ground water trends from wells representing both confined and unconfined aquifers did not indicate any seasonal response; therefore, representative samples can be collected at any time during the year.

STATUS NETWORK SAMPLING PERIODS

Month	Confined Aquifer	Unconfined Aquifer	Streams	Rivers	Small Lakes	Large Lakes
Jan					60	
Feb	120					
Mar						
Apr				60		
May			60			
Jun						60
Jul					60	
Aug		120				
Sep						
Oct				60		
Nov			60			
Dec						60

Primary Sampling Period (Confined Aquifer Feb–Mar; Unconfined Aquifer Aug–Sep; Streams May; Rivers Apr; Small Lakes Jan; Large Lakes Jun)   Revisit Sampling Period (Streams Nov; Rivers Oct; Small Lakes Jul; Large Lakes Dec)

* Total does not include QA samples
--- Dashed line indicates current Contract Period Start/Finish

Figure 3.3. Status Monitoring Network sampling periods indicating when resources are to be sampled. The numbers represent the statewide target sample size.

Trend Monitoring Network

The Trend Monitoring Network is designed to determine if there are changes over time in the selected indicators (**Table 4.6a-f Element 4**). A certain number of samples must be collected continuously to complete a statistically valid trend analysis. Before trends can be determined, variability in data over seasons must be taken into account and adjusted for in the analysis.

To make trend results comparable to the Status Monitoring Network, the state has separated the Trend Monitoring Network into surface water (rivers and streams) and ground water (confined and unconfined aquifers) resources. Lake resources are not part of the Trend Monitoring Network due to fiscal and logistical limitations. During the evaluation of resource condition, Status and Trend Monitoring Network data are compared. Trend Monitoring Network data provide a temporal reference on a regional scale for the Status Monitoring Network.

Surface Water Trend Monitoring Network

The Surface Water Trend Monitoring Network consists of 76 fixed sites that are sampled monthly (**Figure 3.4**). Most of these sites are nontidal rivers, at or near existing gauging stations. The sites, often located at the lower end of a watershed, enable FDEP to obtain biology, chemistry, and loading data at a point that integrates land use activities. Some Surface Water Trend Network sites are also located at or near the Florida boundary with Alabama and Georgia. These sites are used to obtain chemistry and loading data for major streams entering Florida.

Data from Surface Water Trend Monitoring sites are used to evaluate temporal variability in Florida's surface water resources and determine indicator trends. They are not designed to monitor point sources of pollution, since these sites are located away from known outfalls or other regulated sources.

Figure 3.4. Surface Water Trend Monitoring Network sites

Ground Water Trend Monitoring Network

The Ground Water Trend Monitoring Network consists of 48 fixed sites (**Figure 3.5**) that are used to obtain chemistry and field data in confined and unconfined aquifers. These data are used to quantify temporal variability in ground water resources. Water samples are collected quarterly at all wells in the Ground Water Trend Monitoring Network. Field analytes are measured monthly at the unconfined aquifer sites. A microland-use form, completed at all sites annually, aids in determining potential sources of contamination for ground water resources.

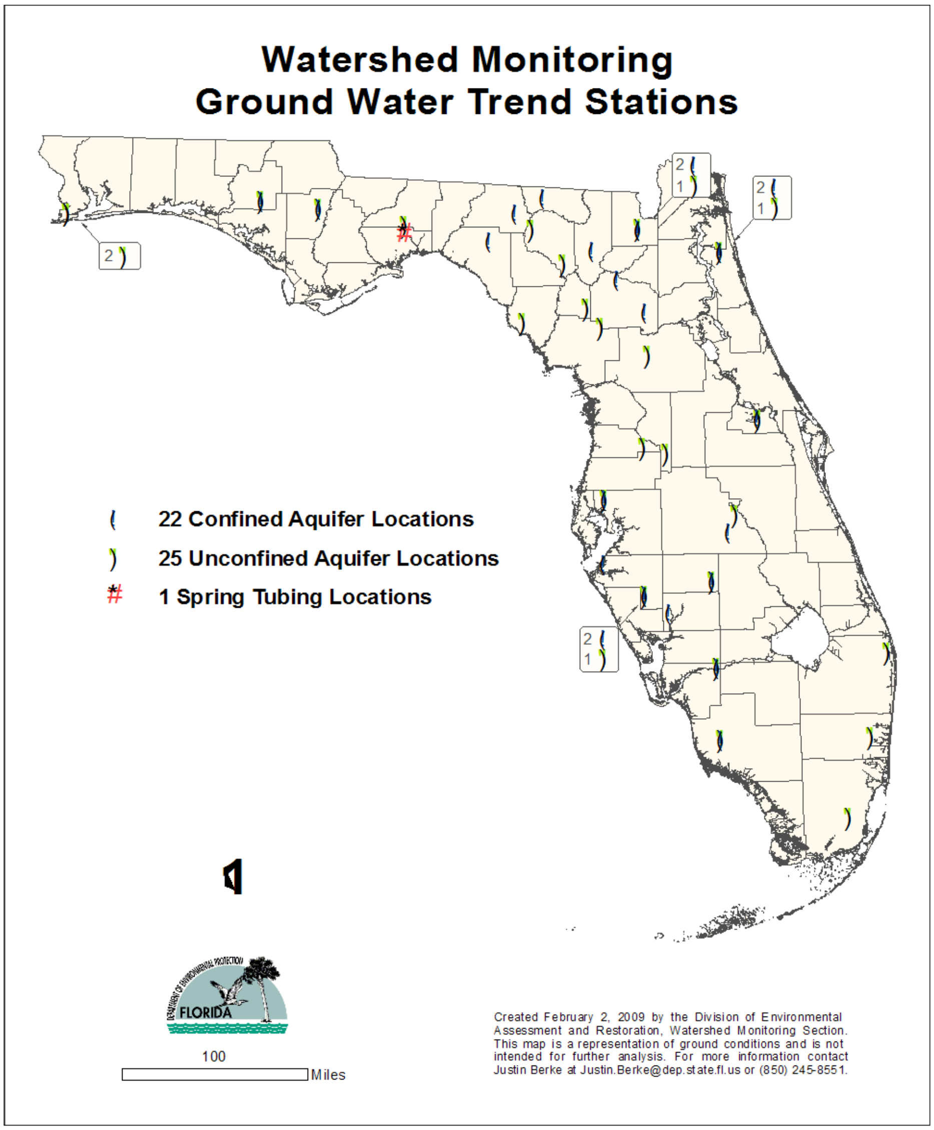

Figure 3.5. Ground Water Trend Monitoring Network sites

ELEMENT 4: CORE AND SUPPLEMENTAL INDICATORS OF WATER QUALITY

While most water quality monitoring has historically focused on chemistry, FDEP's Status and Trend Monitoring programs expand this scope to include biological and physical indicators. Together, the chemical, physical, and biological indicators provide scientific information about the condition of the state's water resources and whether they meet their designated uses based on state and EPA guidance. Indicators, specified as core or supplemental, are used to evaluate the condition of the resource.

Core indicators provide information about the chemical, physical, and biological status of surface and ground water, including suitability for human and aquatic uses. These data can be used to gauge condition based on water quality standards or guidance. Supplemental indicators provide extra information about the status of surface and ground water and aid in screening for potential pollutants of concern. These indicators are often chosen to support special projects or used to develop water quality criteria.

Some indicators are combined to form indices that help to evaluate waterbody condition—for example, the Trophic State Index (TSI). Indices that use multiple indicators provide a broader understanding of a waterbody's health.

Core and supplemental indicators consist of many different chemical, physical, and biological parameters, only some of which are applicable for all water resource types. Bacteriological and chemical indicators are collected for all resource types. Certain biological indicators are collected only in rivers, streams, and lakes (i.e., chlorophyll *a*). It is appropriate in FDEP's program to collect sediment chemistry indicators only in lakes.

Waterbody Designation and Uses

Florida classifies its surface waters into five categories according to their use, as follows:

Class I—Potable water supply;

Class II—Shellfish propagation and harvesting;

Class III—Recreation and a well-balanced population of fish and wildlife;

Class IV—Agricultural water supply; and

Class V—Navigation, utility, and industrial use.

Water quality classifications are listed according to the degree of required protection with Class I water generally having the most stringent water quality criteria and Class V the least. Surface waters designated as Class I or III under Florida Surface Water Quality Standards (Rule 62-302, F.A.C.) are sampled in the Status and Trend Monitoring Networks. Class I criteria protect surface waters used as a potable water supply. Class III waters include recreational activities such as fishing, swimming, boating, and the protection of aquatic life. Many of the indicators sampled in the Status and Trend Monitoring Networks have numeric surface water quality criteria to protect one or more of these uses (**Tables 4.1a-4.1d**).

Table 4.1a. Partial list of the Status and Trend Monitoring Network primary indicators for potable water supply with water quality criteria / thresholds.

Note: The water quality criteria and thresholds in Tables 4.1.a-4.1.d are derived from Section 62-302.530, F.A.C., Criteria for Surface Water Classifications; Rule 62-550, F.A.C., Drinking Water Standards; Rule 62-303, F.A.C., Identification of Impaired Surface Waters; and Section 62-520.420, F.A.C., Standards for Class G-I and Class G-II Ground Water.

This is a two-column table. Column 1 lists the indicators and Column 2 lists the water quality criterion/thresholds.

mg/L – milligrams per liter; µg/L – micrograms per liter;

Primary Indicator/Index for Potable Water Supply	Criterion/Threshold
Fluoride	≤4 mg/L
Arsenic	≤10 µg/L
Cadmium	≤5 µg/L
Chromium	≤100 µg/L
Lead	≤15 µg/L
Nitrate-Nitrite	≤10 mg/L
Sodium	≤160 mg/L
Total Coliform Bacteria (#/100mL)	≤4

Table 4.1b. Partial list of the Status and Trend Monitoring Network secondary indicators for potable water supply with water quality criteria / thresholds.

This is a two-column table. Column 1 lists the indicators and Column 2 lists the water quality criterion/thresholds.

mg/L – milligrams per liter; su – standard units;

Secondary Indicator/Index for Potable Water Supply	Criterion/Threshold
Aluminum	≤0.2 mg/L
Chloride	≤250 mg/L
Copper	≤1 mg/L
Fluoride	≤2 mg/L
Iron	≤0.3 mg/L
Manganese	≤0.05 mg/L
pH	≥6, ≤8.5 su
Sulfate	≤250 mg/L
Total Dissolved Solids	≤500 mg/L
Zinc	≤5 mg/L

Table 4.1c. Partial list of the Status and Trend Monitoring Network microbiological indicators for recreation use with water quality criteria / thresholds.

This is a two-column table. Column 1 lists the indicators and Column 2 lists the water quality criterion/thresholds.

mL – milliliters;

Microbiological Indicator/Index for Recreation Use (Surface Water)	Criterion/Threshold
Fecal Coliform Bacteria	< 400 colonies/100mL

Table 4.1d. Partial list of the Status and Trend Monitoring Network physical or other indicators for aquatic life use with water quality criteria/thresholds.

This is a two-column table. Column 1 lists the indicators and Column 2 lists the water quality criterion/thresholds.

mg/L – milligrams per liter; µg/L – micrograms per liter; PCUs – platinum cobalt units; su – standard units; NTU – nephelometric turbidity units.

Physical/Other Indicators/Index for Aquatic Life Use (Surface Water)	Criterion/Threshold
Dissolved Oxygen	≥ 5 mg/L
pH	≥ 6, ≤ 8.5 su
Unionized Ammonia	≤ 0.02 mg/L
Alkalinity	≥20 mg/L
Fluoride	≤10 mg/L
Specific Conductance	≤1,275 or 50% above background
Turbidity	≤29 NTU above background
Chlorophyll *a**	≤ 20 µg/L
TSI*	Color ≤ 40 PCUs, then TSI ≤ 40 Color > 40 PCUs, then TSI ≤ 60

* Both TSI and chlorophyll *a* are not criteria, but thresholds used to estimate the impairment of state waters. These thresholds are used in the analysis of Status Monitoring Network data, based on single samples. The analysis and representation of these data are not intended to infer the verification of impairment, as defined in Rule 62-303, F.A.C.

Florida classifies ground water as a potable water supply based on Section 62-520.460, F.A.C. Primary and secondary drinking water standards are used to determine if aquifers meet designated uses (Rule 62-550, Drinking Water Standards). Core and supplemental indicators support the evaluation of aquifer condition (i.e., contamination and saltwater intrusion).

Although biological indicators do not have numeric criteria set forth in Section 62-520.460 or Rule 62-550, F.A.C., they are collected and used to evaluate a waterbody's suitability for aquatic life (Classes II and III). FDEP has been instrumental in developing biological indices to evaluate waterbody condition in Florida. Two bioassessment tools, one for rivers and streams (Stream Condition Index [SCI]) (**Table 4.2**) and another for lakes (Lake Vegetation Index [LVI]) (**Table 4.3**), have been adopted. Similar tools for periphyton are currently being developed for implementation in rivers and streams.

Table 4.2. Stream Condition Index (SCI) thresholds used by the Status and Trend Monitoring Networks.

Note: For ***Tables 4.2*** and ***4.3***, the SCI and LVI thresholds are derived from DEP-SOP-002/01, LT 7000 Determination of Biological Indices.

This is a three-column table. Column 1 lists the SCI 2007 Category Name, Column 2 lists the SCI score, and Column 3 lists an example description.
Note: *any score of 35 and above is not impaired using the current interpretation categories.*

SCI 2007 Category Name	SCI Score	Example Description
Category 1 (“exceptional”)	**68–100**	Higher diversity of taxa than for Category 2, particularly for Ephemeroptera and Trichoptera; several more clinger and sensitive taxa than found in Category 2; high proportion for Tanytarsini; few individuals in the dominant taxon; very tolerant individuals make up a very small percentage of the assemblage.
Category 2 (“healthy”)	**48–67**	Diverse assemblage with 30 different species found on average; several different taxa each of Ephemeroptera, Trichoptera, and long-lived and, on average, 5 unique clinger and 6 sensitive taxa routinely found; small increase in dominance by a single taxon relative to Category 1; very tolerant taxa represent a small percentage of individuals, but noticeably increased from Category 1.
Category 2 (“healthy”)	**35-47**	Diverse assemblage with 30 different species found on average; several different taxa each of Ephemeroptera, Trichoptera, and long-lived and, on average, 5 unique clinger and 6 sensitive taxa routinely found; small increase in dominance by a single taxon relative to Category 1; very tolerant taxa represent a small percentage of individuals, but noticeably increased from Category 1.
Category 3 (“impaired”)	**0–34**	Notable loss of taxonomic diversity; Ephemeroptera, Trichoptera, long-lived, clinger, and sensitive taxa uncommon or rare; half the number of filterers than expected; assemblage dominated by a tolerant taxon; very tolerant individuals represent a large proportion of the individuals collected.

Table 4.3. Lake Vegetation Index (LVI) thresholds used by the Status and Trend Monitoring Networks.

This is a three-column table. Column 1 lists the Aquatic Life Use Category, Column 2 lists the LVI Range, and Column 3 lists a description.

Aquatic life use category	LVI Range	Description
Category 1 “exceptional”	**78–100**	Nearly every macrophyte present is a species native to Florida, invasive taxa typically not found. About 30% of taxa present are identified as sensitive to disturbance.
Category 2 “healthy”	**38–77**	About 85% of macrophyte taxa are native to Florida; invasive taxa present. About 15% of taxa present are identified as sensitive to disturbance .
Category 3 “impaired”	**0–37**	About 70% of macrophyte taxa are native to Florida. Invasive taxa may represent up to 1/3 of total taxa. Less than 10% of taxa present are identified as sensitive to disturbance.

Status Monitoring Network

The Status Monitoring Network indicators (**Table 4.4a-4.4b and 4.5a-4.5f**) were chosen after discussions within FDEP and participating agencies. Total constituents (non-filtered) are collected to reflect conditions consistent with drinking water standards. Selected indicators, such as chloride, nitrate, and bacteria, serve to assess the suitability of ground water for drinking water purposes. Likewise, the indicator lists for surface water resources are selected to detect major threats to water quality, such as nutrient enrichment, which can lead to eutrophication and habitat loss.

In addition to the suite of water chemistry indicators, Florida has also developed geochemically- and biologically-based tools to assess sediment quality. Sediment data from lakes are compared with thresholds developed to measure naturally-occurring concentrations of metals. Additionally, a biologically based tool is used in conjunction with other indicators to estimate the levels of potentially toxic contaminants in lake sediments. Methyl mercury has been added as a supplemental indicator to aid in the development of a statewide TMDL for mercury.

Table 4.4a. Status Network Organic, Nutrient, and Major Ion Indicators for Sediment Analysis in Lakes

Note: For ***Tables 4.4a*** and ***4.4b***, all methods, unless otherwise stated, are based on EPA 600, Methods for Chemical Analysis of Water and Wastes.

This is a two-column table. Column 1 lists the indicators and Column 2 lists the analytical method numbers.

Sediment Organic/Nutrient Indicator	***Analysis Method***
Total Organic Carbon (TOC)	In-house based on 415.1
Total Phosphorus (TP)	Method 365.4
Total Kjeldahl Nitrogen (TKN)	Method 351.2
Sulfate	Method 300 (modified)

Table 4.4b. Status Network Metal Indicators for Sediment Analysis in Lakes

This is a two-column table. Column 1 lists the indicators and Column 2 lists the analytical method numbers.

Sediment Metal Indicator	***Analysis Method***
Aluminum, Arsenic, Cadmium, Chromium, Copper, Iron, Lead, Nickel, Silver, Zinc	Method 6010B/6020
Mercury	DEP-SOP-001/01 Hg-008-3 (based on EPA 7471)
Methyl Mercury	SOP Hg-003-2 (based on EPA 1630)

Table 4.5a. Status Network Core and Supplemental Indicators for Field Measurements

Note: For ***Tables 4.5a*** through ***4.5f***, all samples are unfiltered unless stated. All methods, unless otherwise stated, are based on *EPA 600, Methods for Chemical Analysis of Water and Wastes*.

This is a three-column table. Column 1 lists the indicator, Column 2 lists the analytical method numbers, and Column 3 lists the sampled resource(s).

Field Measurement Indicator	*Analysis Method*	*Sampled Resource(s)*
pH	Method 150.1	Lakes, Streams/Rivers, Aquifers
Temperature	Method 170.1	Lakes, Streams/Rivers, Aquifers
Specific Conductance	Method 120.1	Lakes, Streams/Rivers, Aquifers
Dissolved Oxygen (DO)	Method 360.1	Lakes, Streams/Rivers, Aquifers
Turbidity	DEP-SOP-001/01 FT 1600	Aquifers
Secchi Depth	Welch (1948); EPA 620/R-97/001	Lakes, Streams/Rivers
Total Depth	Manual/electronic measuring device	Lakes, Streams/Rivers, Aquifers
Sample Depth	Manual/electronic measuring device	Lakes, Streams/Rivers
Micro Land Use	Sampling manual (01/09), Section 4	Aquifers
Depth to Water	Manual/electronic measuring device	Aquifers

Table 4.5b. Status Network Core and Supplemental Indicators for Biological and Microbiological Indicators

This is a three-column table. Column 1 lists the indicator, Column 2 lists the analytical method numbers, and Column 3 lists the sampled resource(s).

[1] Dropped QPS from rivers and streams on July 22, 2009.
[2] Adopted new criteria for performing SCI on May 1, 2010.

Biological/Microbiological Indicator	*Analysis Method*	*Sampled Resource(s)*
Chlorophyll *a*	SM 10200 H (modified)	Lakes, Streams/Rivers
Qualitative Periphyton (QPS)[1]	SOP AB03.1, SOP AB03	Streams/Rivers
Rapid Periphyton Survey (RPS)	SOP FS 7130	Streams/Rivers
Biological Community (SCI)[2]	SM 10500 C (modified)	Streams/Rivers
Habitat Assessment	DEP-SOP-001/01 FT 3000	Streams/Rivers
Lake Vegetation Index	DEP-SOP-001/01 FS 7220	Lakes
Total Coliform	SM 9222B	Aquifers
Fecal Coliform	SM 9222D	Lakes, Streams/Rivers, Aquifers
Enterococci	EPA 1600	Lakes, Streams/Rivers

Table 4.5c. Status Network Core and Supplemental Indicators for Organic and Nutrient Indicators

This is a three-column table. Column 1 lists the indicator, Column 2 lists the analytical method numbers, and Column 3 lists the sampled resource(s).

[3] Added TOC for Aquifers on October 1, 2010.

Organic/Nutrient Indicator	Analysis Method	Sampled Resource(s)
Total Organic Carbon (TOC)	SM 5310 B	Lakes, Streams/Rivers, Aquifers[3]
Nitrate + Nitrite	Method 353.2	Lakes, Streams/Rivers, Aquifers
Ammonia	Method 350.1	Lakes, Streams/Rivers, Aquifers
Total Kjeldahl Nitrogen (TKN)	Method 351.2	Lakes, Streams/Rivers, Aquifers
Phosphorus	Method 365.1/365.4	Lakes, Streams/Rivers, Aquifers

Table 4.5d. Status Network Core and Supplemental Indicators for Major Ion Indicators

This is a three-column table. Column 1 lists the indicator, Column 2 lists the analytical method numbers, and Column 3 lists the sampled resource(s).

Major Ion Indicator	Analysis Method	Sampled Resource(s)
Chloride	Method 300	Lakes, Streams/Rivers, Aquifers
Sulfate	Method 300	Lakes, Streams/Rivers, Aquifers
Fluoride	SM 4500 F-C	Lakes, Streams/Rivers, Aquifers
Calcium	Method 200.7/200.8	Lakes, Streams/Rivers, Aquifers
Magnesium	Method 200.7/200.8	Lakes, Streams/Rivers, Aquifers
Potassium	Method 200.7/200.8	Lakes, Streams/Rivers, Aquifers
Sodium	Method 200.7/200.8	Lakes, Streams/Rivers, Aquifers

Table 4.5e. Status Network Core and Supplemental Indicators for Metal Indicators

This is a three-column table. Column 1 lists the indicator, Column 2 lists the analytical method numbers, and Column 3 lists the sampled resource(s).

Metal Indicator	Analysis Method	Sampled Resource(s)
Aluminum, Arsenic, Cadmium, Chromium, Copper, Iron, Lead, Manganese, Zinc	Method 200.7/200.8	Aquifers

Table 4.5f. Status Network Core and Supplemental Indicators for Physical Property Indicators

This is a three-column table. Column 1 lists the indicator, Column 2 lists the analytical method numbers, and Column 3 lists the sampled resource(s).

[4] True color replaced apparent color for laboratory analysis on 1/1/2010.

Physical Property Indicator	Analysis Method	Sampled Resource(s)
Alkalinity	SM 2320 B	Lakes, Streams/Rivers, Aquifers
Turbidity (Lab)	Method 180.1	Lakes, Streams/Rivers, Aquifers
Specific Conductance (Lab)	Method 120.1	Lakes, Streams/Rivers, Aquifers
Color[4]	SM 2120 B	Lakes, Streams/Rivers, Aquifers
Total Suspended Solids	SM 2540 D	Lakes, Streams/Rivers
Total Dissolved Solids	SM 2540 C	Lakes, Streams/Rivers, Aquifers

Trend Monitoring Network

The Trend Monitoring Network indicators (**Table 4.6a-4.6f**) were also chosen after discussions with participating agencies. For data comparability, many of the same indicators are included in both the Status and Trend Monitoring Network indicator lists. To maintain the historical aspect of the data, changes to the indicator list are minimized but not restricted.

Table 4.6a. Trend Network Field Measurement Indicators

Note: For ***Tables 4.6a*** through ***4.6f***, all methods, unless otherwise stated, are based on EPA 600, *Methods for Chemical Analysis of Water and Wastes*.

This is a four-column table. Column 1 lists the indicator, Column 2 lists the analytical method number, Column 3 lists the sampling regime for surface waters, and Column 4 lists the sampling regime for ground waters.

X = Other sample or measurement; N/A = Not applicable

Field Measurement Indicator	*Analysis Method*	*Surface Water*	*Ground Water*
pH	Method 150.1	X	X
Temperature	Method 170.1	X	X
Specific Conductance/Salinity	Method 120.1	X	X
Dissolved Oxygen	Method 360.1	X	X
Turbidity	DEP-SOP-001/01 FT 1600	N/A	X
Secchi Depth	Welch (1948); EPA 620/R-97/001	X	N/A
Total Depth	Manual/electronic measuring device	X	X
Sample Depth	Manual/electronic measuring device	X	N/A
Depth to Water	Manual/electronic measuring device	N/A	X

Table 4.6b. Trend Network Biological and Microbiological Indicators

This is a four-column table. Column 1 lists the indicator, Column 2 lists the analytical method number, Column 3 lists the sampling regime for surface waters, and Column 4 lists the sampling regime for ground waters.

[1] Dropped QPS from rivers and streams on July 22, 2009.
[2] Collected once a year per site
[3] Collected twice a year per site
[4] Adopted new criteria for performing SCI on May 1, 2010.
T = Total sample (unfiltered sample); X = Other sample or measurement; N/A = Not applicable

Biological/Microbiological Indicator	*Analysis Method*	*Surface Water*	*Ground Water*
Chlorophyll *a*	SM 10200 H (modified)	T	N/A
Qualitative Periphyton (QPS)[1]	SOP AB03.1, SOP AB03	X[2]	N/A
Rapid Periphyton Survey (RPS)	SOP FS 7130	X[3]	N/A
Biological Community (SCI)[4]	SM 10500 C (modified)	X[2]	N/A
Habitat Assessment	DEP-SOP-001/01 FT 3000	X[3]	N/A
Total Coliform	SM 9222B	N/A	T
Fecal Coliform	SM 9222D	T	T
Enterococci	EPA 1600	T	N/A

Table 4.6c. Trend Network Organic and Nutrient Indicators

This is a four-column table. Column 1 lists the indicator, Column 2 lists the analytical method number, Column 3 lists the sampling regime for surface waters, and Column 4 lists the sampling regime for ground waters.

[2] Collected once a year per site
*Prior to October 2009, total analytes were collected once a year; dissolved analytes were collected quarterly
T = Total sample (unfiltered sample); D = Dissolved sample (filtered sample); N/A = Not applicable

Organic/Nutrient Indicator	Analysis Method	Surface Water	Ground Water
Total Organic Carbon	Method 415.1	T	T
Nitrate + Nitrite	Method 353.2	T	D[2]/T*
Ammonia	Method 350.1	T	D[2]/T*
Total Kjeldahl Nitrogen	Method 351.2	T	D[2]/T*
Phosphorus	Method 365.1/365.4	T	D[2]/T*
Orthophosphate	Method 365.1	N/A	D

Table 4.6d. Trend Network Major Ion Indicators

This is a four-column table. Column 1 lists the indicator, Column 2 lists the analytical method number, Column 3 lists the sampling regime for surface waters, and Column 4 lists the sampling regime for ground waters.

[2]Collected once a year per site
*Prior to October 2009, total analytes were collected once a year; dissolved analytes were collected quarterly
T = Total sample (unfiltered sample); D = Dissolved sample (filtered sample)

Major Ion Indicator	Analysis Method	Surface Water	Ground Water
Chloride	Method 300	T	D[2]/T*
Sulfate	Method 300	T	D[2]/T*
Fluoride	SM 4500 F-C	T	D[2]/T*
Calcium	Method 200.7/200.8	T	D[2]/T*
Magnesium	Method 200.7/200.8	T	D[2]/T*
Sodium	Method 200.7/200.8	T	D[2]/T*
Potassium	Method 200.7/200.8	T	D[2]/T*

Table 4.6e. Trend Network Metal Indicators

This is a four-column table. Column 1 lists the indicator, Column 2 lists the analytical method number, Column 3 lists the sampling regime for surface waters, and Column 4 lists the sampling regime for ground waters.

[2] Collected once a year per site
[5]Collected quarterly at predetermined SCI-applicable sites beginning in October 2009
T = Total sample (unfiltered sample); N/A = Not applicable

Metal Indicator	Analysis Method	Surface Water	Ground Water
Arsenic, Cadmium, Chromium, Copper, Lead, Zinc	Method 200.7/200.8	T[5]	N/A
Arsenic, Iron, Lead	Method 200.7/200.8	N/A	T[2]

Table 4.6f. Trend Network Physical Property Indicators

This is a four-column table. Column 1 lists the indicator, Column 2 lists the analytical method number, Column 3 lists the sampling regime for surface waters, and Column 4 lists the sampling regime for ground waters.

[2] Collected once a year per site
[6] True color replaced apparent color for laboratory analysis on 1/1/2010.
[7] Dropped TSS for ground water on October 1, 2009.
*Prior to October 2009, total analytes were collected once a year; dissolved analytes were collected quarterly
T = Total sample (unfiltered sample); D = Dissolved sample (filtered sample)

Physical Property Indicator	Analysis Method	Surface Water	Ground Water
Alkalinity	SM 2320 B	T	D[2]/T*
Turbidity (Lab)	Method 180.1	T	T
Specific Conductance (Lab)	Method 120.1	T	T
Color[6]	SM 2120 B	T	T
Total Suspended Solids[7]	SM 2540 D	T	T
Total Dissolved Solids	SM 2540 C	T	T

ELEMENT 5: QUALITY ASSURANCE

Quality Assurance Responsibilities

In a multiagency, statewide program, it is essential to have a centralized QA system to ensure that data are properly and consistently collected and analyzed. The QA system, as part of the DQO process, warrants that data are useful and defensible. The QA program for the Status and Trend Monitoring Networks is coordinated by the QAO in cooperation with FDEP staff, QA officers at sampling agencies, and the FDEP Bureau of Laboratories. However, QA is the responsibility of everyone associated with the Status and Trend Monitoring Networks.

The QAO coordinates and oversees data quality activities, monitors adherence to state and federal policies and procedures, and has direct authority to implement corrective actions. The QAO's responsibilities are as follows:

Reviews quality control data to determine if data are acceptable (based on the blank contamination guidance in Rule 62-160, F.A.C., Quality Assurance, as well as the Process for Assessing Data Usability Document);

Coordinates and enters sampling schedules into the Laboratory Information Management System;

Performs annual audits to ensure compliance with all QA plans and SOPs. Distributes the results of internal and external audits to management and all affected individuals. Oversees, recommends, reviews, and verifies corrective actions based on audit results;

Prepares QA reports for management as requested;

Coordinates and oversees the preparation and review of QA manuals, including Quality Assurance Project Plans;

Reviews new or proposed procedures to determine appropriate use;

Provides Status and Trend Monitoring Network training classes;

Provides information to the FDEP Standards and Assessment Section for the annual Quality Assurance Report to the Secretary.

Procedures and Protocols

SOPs are set forth in Rule 62-160, F.A.C., Quality Assurance, and specified in the FDEP document Standard Operating Procedures for Field Activities. Following these SOPs is required to meet program-specific DQOs. Similarly, the FDEP Bureau of Laboratories has SOPs for Laboratory Activities that address handling and analyzing samples and reporting precision, accuracy, and method detection limits, and also provide guidance on reporting data.

FDEP SOPs require each agency to establish and maintain a QA system that must adhere to the following:

Identify, implement, and promote QA policies and procedures that will produce data of a known and verifiable quality;

Create and/or identify and follow SOPs for all activities, both technical and administrative;

Monitor adherence to the established policies, procedures, and written SOPs; and

Establish and use procedures for continual improvement through both corrective and preventive action policies.

WMS employs a program-specific Quality Manual that adheres to all of these requirements and serves as the foundation of the QA system for the Status and Trend Monitoring Networks. This document incorporates many elements of the program, including a sampling manual, a data management SOP manual, a project manager manual, and the GWIS Users Manual, available upon request. The Quality Manual is a "living" document and is therefore revised as needed.

WMS employs a program-specific Status and Trend Monitoring Networks Sampling Manual addressing all Status and Trend sampling activities. During all sampling events, field staff must carry a current copy of the sampling manual for reference. Sampling manual updates are communicated to WMS staff through emails, staff meetings, training classes, statewide meetings, and the WMS Website. The training classes, conducted by FDEP staff, focus on WMS program-specific sampling requirements. Attendance is required for all new WMS staff and once every five years thereafter.

Quality Control

The Status and Trend Monitoring Networks use QC measures to assure that data collected meet the standards set forth in FDEP SOPs. Some QC measures are required (equipment and/or field blanks) under the FDEP SOPs, while others are program specific. WMS samplers collect blanks at a 20% frequency rate. This allows staff to monitor the on-site environment, equipment decontamination, container cleaning, suitability of preservatives and analyte-free water, and sample transport and storage conditions. Associated sample data are qualified if detections at levels greater than or equal to sample results are found in blanks.

WMS incorporates additional QC measures not required under FDEP SOPs. For example, field reference sample (FRS) verifications are used to ensure the accuracy of field measurements. Samplers test instrument calibrations by checking blind FRS approximately every 10 sites (a 10% frequency rate) and call in the results to the QAO or Project Manager. FRS are not intended to replace required calibration verifications.

Extensive QA/QC procedures continue after the samples have been collected. To ensure analysis consistency, all samples are analyzed at FDEP's Bureau of Laboratories. The lab consistently scores high, compared with other environmental labs in the nation, based on performance reviews by the USGS and EPA. It is certified under the National Environmental Laboratory Accreditation Program (NELAP) by FDOH for most of the Status and Trend indicators. In addition to the lab's internal QA/QC procedures, WMS submits blind analytical reference samples. The results are evaluated by the QAO and have consistently remained within acceptance criteria.

ELEMENT 6: DATA MANAGEMENT

The management of data and metadata generated by the Status and Trend Monitoring Networks encompasses the use of GIS, an Oracle database, and several in-house software applications. The Data Management Protocols document details how these platforms interact and how staff can use them to review, load, and distribute data.

Data Flow and Storage

The smooth and timely flow of field- and lab-generated data into state and federal data repositories is a high priority. WMS data are stored in an Oracle database called GWIS (Generalized Water Information System), which houses current and historical data. An Internet application, GWIS Database Utilities, allows access to the database. All surface water data are uploaded biannually to FDEP STORET and annually to EPA STORET. Ground water data are stored in GWIS and currently are not accommodated by FDEP or EPA STORET. **Figure 6.1** shows a schematic of the electronic data flow path.

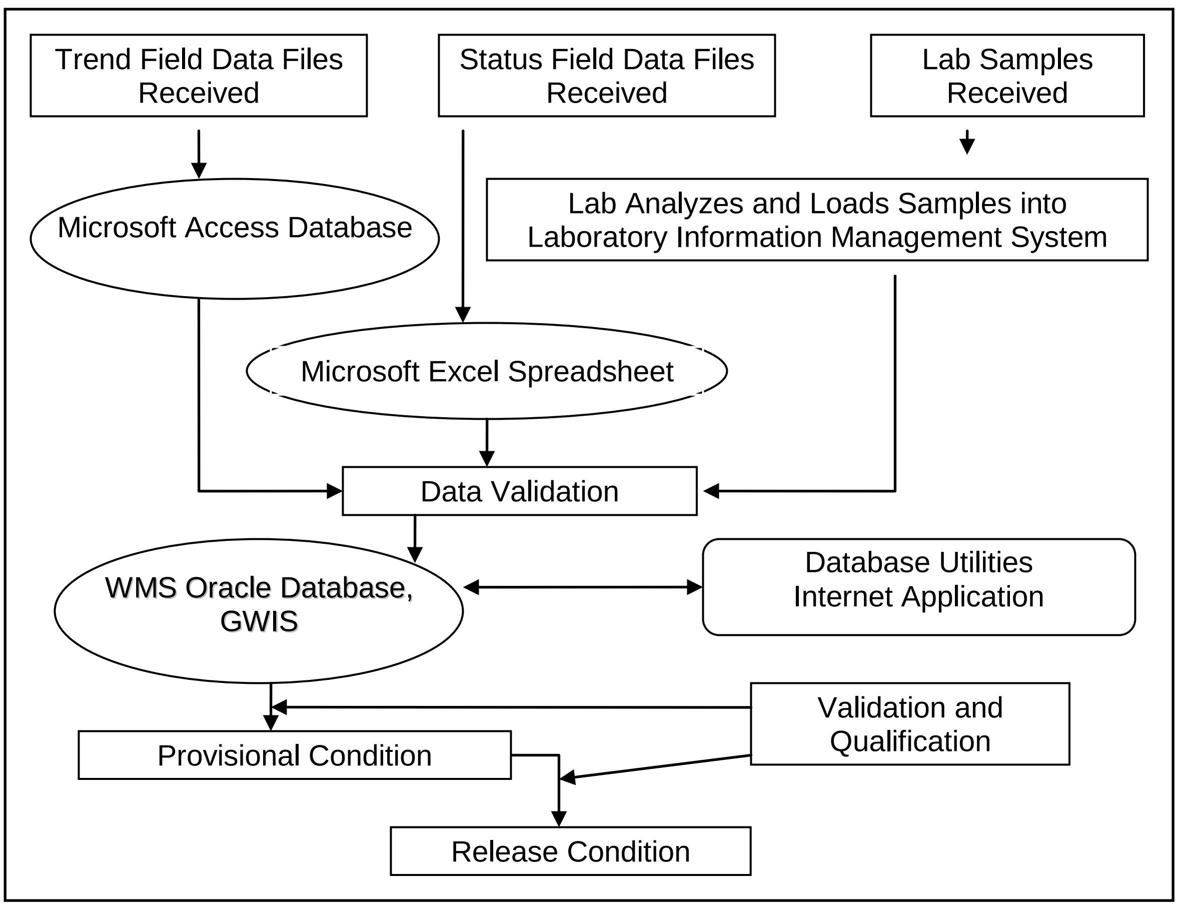

Figure 6.1. Generalized Status Monitoring Network and Trend Monitoring Network data flow path. Surface water data are exported to FDEP/EPA STORET for public availability; ground water data are provided to public with a direct data extraction from the GWIS database.

Metadata

Metadata are used to describe the content, context, and structure of data. In short, they are data that describe data. Metadata for the WMS Oracle database are presented in the GWIS Data Dictionary, which is available from WMS on request. All tables and relationships in the database are identified, as are the individual data elements contained in each table. GIS layers are generated directly from data contained in the database. Metadata describing each GIS layer and its associated data are stored electronically in FDEP's GIS library.

Status Monitoring Network

Data management for the Status Monitoring Network begins with the generation of a GIS representation for each water resource (see **Element 3, Geographic Design**). The GIS coverages are generated annually and site selections drawn and loaded into GWIS. Initial site reconnaissance is performed in the office, followed by field reconnaissance. Sites are evaluated in sequential order for the assignment of the correct water resource and the determination of sampleability. The results of the office reconnaissance are stored in GWIS using the Database Utilities interface.

Several forms of data are generated during field reconnaissance. Once the site is deemed sampleable, its latitude and longitude coordinates are collected with a differentially corrected global positioning system (DGPS) instrument and stored electronically along with the field measurements (**Appendix B**). Individual site data files are batch loaded into GWIS once all data for a specific project are received.

Once site measurements for a project are loaded into the database and all lab analyses have been processed, lab and field data are combined for each site and then loaded into the GWIS production database tables. At that time, data are ready for review by the samplers and project managers via an in-house Oracle Forms application known as Automated Data Management (ADM). FDEP staff use ADM to conduct accuracy and completeness checks, including the notation of missing data and outliers. During ADM data review, staff document anomalies and export data into a spreadsheet. They use this spreadsheet to identify any random or systematic errors.

After in-house data review is completed, the spreadsheet and its data QA summary are transferred to the sampling agency for further evaluation. The data are considered "release quality" and made available to the public after final review. Notification of drinking-water quality exceedances required by FDEP are generated automatically and sent to FDOH, FDEP/WMD programs, and property owners. A more detailed description of the data management process is provided in the Data Management Protocols document.

Trend Monitoring Network

The data flow path for the Trend Monitoring Network is the same as that for the Status Monitoring Network (**Figure 6.1**). Field data are submitted via a field data entry Internet application or by file transfer with a common data structure. These procedures facilitate a common data exchange format for the field data. The Data Management Protocols document outlines procedures for submitting trend field data, combining these data with their corresponding laboratory data, and reviewing and distributing the final data product.

ELEMENT 7: DATA ANALYSIS/ASSESSMENT

Statistical analyses of data allow WMS to determine if water resources are complying with state and federal guidance. The analyses used range from exploratory to higher level examinations. These analyses rely heavily on nonparametric statistics, which use ranking as a means to describe variance within the data. Preliminary screening allows the determination of data completeness and potential outliers. An analysis of maximum allowable concentrations of selected indicators based on a pass/fail categorization (a binomial distribution) is used.

The design of the monitoring network determines which statistical analyses are appropriate. The statistical analyses for the Status Monitoring Network are determined by the methodology and design of the site selection, i.e., probabilistic, as opposed to the Trend Monitoring Network, which relies on fixed stations. The evaluation of the resulting data allows water quality differences to be determined within and among reporting units (zones). For example, as previously reported in the biennial integrated 305(b) and 303(d) report submitted to EPA, the TSI varied widely among reporting units.

To ensure that useful goals are being met, the monitoring networks are periodically reviewed. Design review guarantees that the networks monitor variables that are useful for assessing the health of an ecosystem, add new variables when necessary, and make any other changes that would improve their operation. WMS reviews both the Status and Trend Monitoring Networks annually to make sure water quality monitoring needs are met.

Status Monitoring Network

The Status Monitoring Network enables FDEP to estimate the condition of 100% of accessible water resources in the state with a known statistical confidence. The design of the Status Monitoring Network allows reporting on state water quality annually and triennially for each of the 6 zones. The annual statewide 95% confidence interval for the estimate of the condition of surface waters based on 60 samples is ± 12% and ± 9%, based on 120 samples for ground water. To obtain a similar confidence interval for each zone will take at least 3 years of data collection. Data can also be post stratified, or subdivided, according to smaller geographic units, land uses, or resource subdivisions. **Figure 7.1** shows the distribution of sample size vs. margin of error for a binomial population.

The probabilistic design of the Status Monitoring Network permits FDEP to answer many water resource–related questions. Addressing these questions is a three-step process. First, the monitoring must be accomplished following standardized protocols for data acquisition. Second, the larger, "parent" population from which the sample data were collected must be characterized. This characterization involves statistically describing the magnitude and variability of indicator distributions. This step is termed "population characterization." Finally, the distributions are used to draw inferences about the overall status of the resource (the target population) in question. This last step is termed "statistical inference."

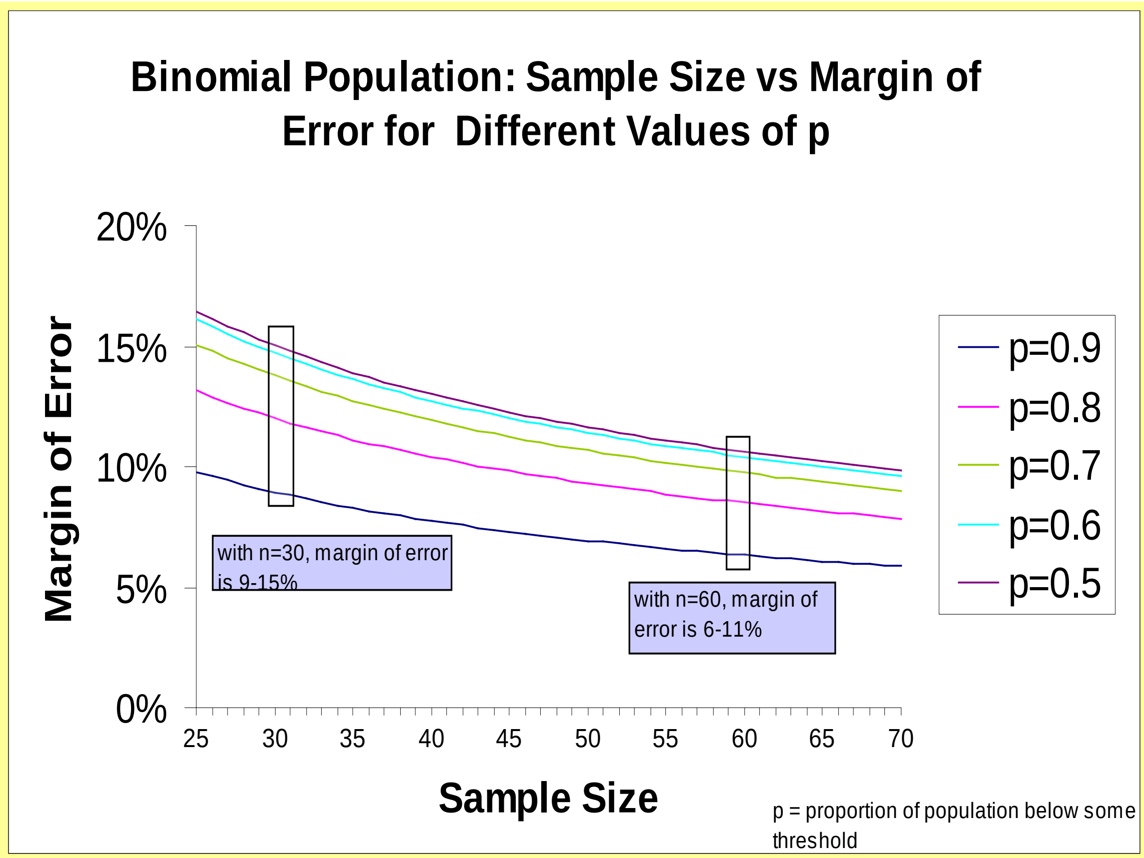

Figure 7.1. Binomial population used for determining the error associated with sample size. As the sample size increases, the margin of error decreases; however, after approximately 30 samples, the error decreases slowly, and is offset by the cost of the increased number of samples.

Target Population Characterization

To measure or characterize the overall distribution of each indicator, one starts with a question, such as, "What is the distribution of nitrates in Florida streams?" Several population descriptors are used in the Status Monitoring Network to characterize the data. These include the following:

Median*—Defined as the 50th percentile of the cumulative distribution function (CDF). Half of the values of the indicator fall below this value.*

Percentiles*—10th, 25th, 75th, 90th, and other percentiles are used to describe what proportion of the resource has an indicator value less than the percentile.*

Range*—The total range of values for an indicator is a measure of its variability.*

Environmental data can be highly skewed and may contain extreme values or outliers. Some descriptors are sensitive to these extreme values or outliers and are therefore inadequate to describe the distribution (i.e., range). As a result, descriptors such as the median and percentiles, which are not sensitive to extreme values, are used for the analysis of water quality.

A CDF (Cumulative Distribution Function), based on the above descriptors, is created to describe the overall variability of the indicator. The example in **Figure 7.2** shows the values of the indicator on the horizontal axis. The percentage of samples (and by inference the overall population) less than or equal to each indicator value is given on the vertical axis. The 95% upper and lower confidence bounds (UCB and LCB, respectively) are used to provide an estimated range of the percentage of the target population for the given indicator value. The CDF is a fundamental tool for characterizing indicator distributions for target populations.

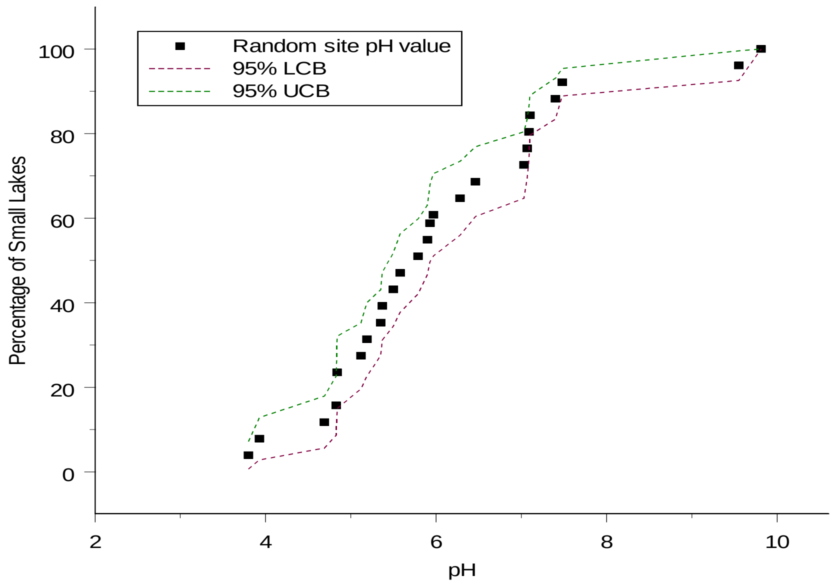

Figure 7.2. Example of cumulative distribution function

To determine if statistically significant changes have occurred for each indicator, nonparametric statistical tests comparing medians and CDFs are used. Nonparametric tests make no assumptions about the symmetry of indicator distributions. Examples of tests used in the Status Monitoring Network include the chi-square and the two-sample Mann-Whitney. Statistical analyses selected for the Status Monitoring Network use a 5% significance level.

The results of the analyses are categorized as either “attaining,” or “not attaining” a threshold for each indicator. This categorization allows the creation of an overall summary to communicate the quality of the reporting unit’s resources. The number of “attaining” or “not attaining” assignments is compared over time using a chi-square contingency table. This quantifies statistically any change (improvement or deterioration) of the resource. FDEP’s Data Analyses Protocols document contains guidelines for these analyses.

Statistical Inference

Population characterization facilitates a description of the condition of a resource. To evaluate the quality of a resource in the state or an individual zone, it is necessary to transition from samples to the target population. This transition is the primary reason for the random sample design of the Status Monitoring Network. The sites are randomly chosen, with each segment having an equal probability of being sampled. The resulting sample set is an adequate representation of the resource. The final step in the evaluation is using the indicators to draw conclusions about the entire resource. The percentage of the resource that passes or fails attainment thresholds can be used to infer the status of the target population.

An example of statistical inference is illustrated using 2000–03 dissolved oxygen data collected from small lakes (**Figure 7.3**). The threshold for dissolved oxygen set by the state is 5 mg/L. Values below this threshold fail. The CDF indicates that 27% of all small lakes sampled were below the threshold and therefore failed. The remaining 73% of small lakes met or exceeded the threshold value. Therefore, it can be inferred that 73% of the target population meets the state threshold for dissolved oxygen.

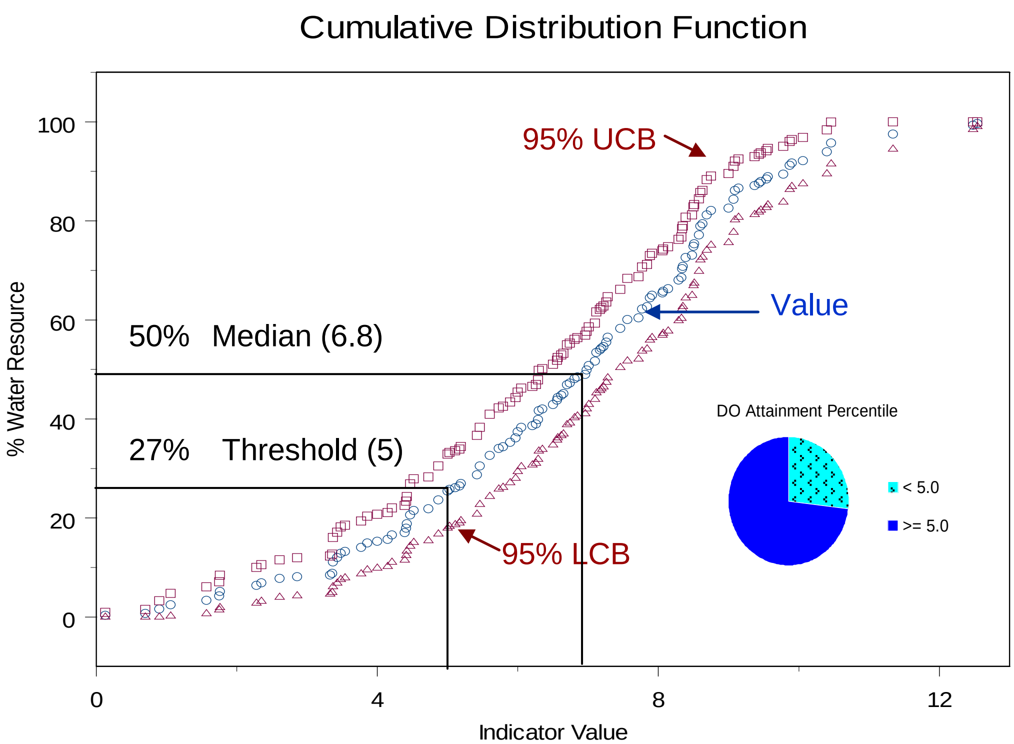

Figure 7.3. CDF of 2000–03 dissolved oxygen data collected from small lakes. The pie chart is another representation of water quality, indicating percent attainment in dark blue, and failed attainment in cross-hatched light blue.

Uncertainty Levels and Missing Values

The level of uncertainty (margin of error) for annual status assessments is ± 12% for surface waters and ± 9% for ground waters at a 95% confidence level for a binomial distribution. These uncertainty levels are dictated by sample size: 60 for surface water resources; 120 for ground water resources. Higher sample sizes yield lower uncertainty levels, and fewer samples increase the level of uncertainty. After several years, samples can be aggregated, lowering the uncertainty level.

When every part or site in the target population of a resource is sampled, it is referred to as a census of the resource. Ideally, conducting a population census is preferred, because it eliminates any margin of error. A census for many resources is not possible due to fiscal and logistical constraints. At the current sampling intensity, it is unlikely that a census of any resource type will occur.

On occasion, less than the maximum number of samples (60 or 120) may be collected. When this occurs, the reasons for the missing samples must be documented. If the sample size is reduced to a point that creates a margin of error greater than 20%, no analyses will be conducted.

Trend Monitoring Network

The statistical analyses used to evaluate data from the trend monitoring program require a long period of record—at least 4 years—to be meaningful. Due to the constraint of the Trend Monitoring Network design discussed earlier, statistically valid data analyses could not be initiated until the end of 2004. WMS staff continue to carry out statistical evaluations as more data are made available. The results of these analyses are presented in various reports, including the biennial integrated 305(b) and 303(d) report submitted to EPA and to the Florida Geological Survey for Special Publication No. 69.

Florida has predominantly two seasons: wet and dry. The effect of seasonality on surface waters can mask trends in water quality. The Trend Monitoring Network design is based on collecting samples 12 times per year (i.e., monthly) to increase data resolution and easily remove seasonality prior to analysis. The previous evaluation of ground water trends from wells representing both confined and unconfined aquifers did not indicate any seasonal response. Since there is no seasonality, ground water is sampled four times per year (i.e. quarterly) (see **Appendix C** for more detail on questions and analyses).

Missing Values and Censored Data

Missing values may occur for a variety of reasons, resulting in an incomplete dataset. Suppose that 12 monthly samples were scheduled to be collected for a waterbody in a given year but only 10 were actually collected. Thus, there would be 2 missing samples and 2 missing values for each indicator. For the statistical analyses of Trend Monitoring Network data, unless stated otherwise, missing values are treated as if they were never collected. For example, if only 10 samples were collected, then descriptive statistics would be based on 10 samples, instead of 12.

ELEMENT 8: REPORTING

An integral part of the Status and Trend Monitoring Networks is reporting on the condition of Florida's freshwater resources to EPA, FDEP, the Legislature, and the general public. The design of the networks, through statistical inference, allows reporting on water quality for the entire state. The reporting frequency is dictated by the design of the monitoring program and federal and state guidelines.

Schedule of Reporting

Reports are written after analyses and assessments have been completed on data from the Status and Trend Monitoring Networks. An annual report on the condition of state waters is prepared for the Legislature and general public. Biennially, an integrated 305(b) and 303(d) report is completed to comply with the CWA. Interpretative reports are prepared for FDEP's technical and management staff as requested.

Status Monitoring Network

The stratified random design of the Status Monitoring Network was created to allow statewide reporting on water quality. Samples must be analyzed and the resultant data checked, verified, and released before a report may be written. Annually, a report on the condition of the state's waters will be prepared. Reporting on the condition of waters in each zone can only be completed once three years of data have been collected.

Reports use the categories of "attaining" or "not attaining" for indicator thresholds set by the state. Pie charts graphically depict the percentages of indicators attaining and not attaining thresholds (see **Figure 7.3**). Those values not attaining an indicator threshold are termed exceedances. When exceedances occur, WMS staff inform FDOH, FDEP section staff, and affected property owners. For example, when arsenic exceedances were observed in Tampa region wells, the proper authorities were notified. The result of this action was a comprehensive effort to determine the extent of contamination of the area's ground water.

Periodically, assessments independent of the annual and biennial reports are generated. These reports will be distributed to programs in FDEP, other state agencies, the WMDs, local governments, and the public as needed. For example, the statewide distribution of indicators associated with nutrient enrichment is provided to FDEP's Standards and Assessment Section for nutrient criteria development.

Trend Monitoring Network

Reporting for the Trend Monitoring Network is similar as for the Status Monitoring Network, but indicator trends are also included. There is a lag in the generation of reports because at least 4 years of data are required for adequate trend analysis. Since the Trend Monitoring Network was initiated in 1999, sufficient data are available and analyses have been completed. These results are detailed in various reports, including the biennial integrated 305(b) and 303(d) report submitted to EPA and the Florida Geological Survey Special Publication No. 69. The reports describe the overall temporal variability for specific waterbody segments.

ELEMENT 9: PROGRAMMATIC EVALUATION

Programmatic evaluations measure the effectiveness and success of programs and identify areas in need of potential improvement. The key to a good programmatic evaluation is regular and systematic review. Programmatic changes are made as needed and are carefully designed to ensure year-to-year data compatibility and significance to agency programs. The expected outcome of this process is improved program effectiveness for FDEP.

DEAR maintains a Monitoring Strategy with EPA as mandated by the Clean Water Act Section 106. As the plan evolves, changes are made and updates are provided to EPA. EPA provides guidance to FDEP after reviewing the strategy and its associated updates.

The state of Florida, in consultation with EPA, annually reviews its monitoring programs to determine how well they serve the water quality decision needs for all state waters. The evaluation of WMS's Status and Trend Monitoring Networks incorporates direction provided by the Legislature and other state and local agencies. For example, in 2008, the Legislature's need for an annual statewide water quality assessment resulted in the evaluation of FDEP monitoring programs and the subsequent redesign of the Status Monitoring Network.

The integration of WMS with other FDEP entities facilitates programmatic evaluation of the Status and Trend Monitoring Networks. WMS consults with FDEP divisions, bureaus and sections to determine whether the monitoring networks are meeting their needs. Recently, WMS modified its Status and Trend Monitoring Network indicator lists to support the Division of Environmental Assessment and Restoration (DEAR) request for additional ground water information.

WMS receives an annual review of the program's monitoring design from DEAR and the Bureau of Assessment and Restoration Support (BARS), which is the chain–of-command for the WMS. This review provides guidance for modifications to the design that support management's monitoring needs. WMS periodically modifies the indicator lists to reflect DEAR's water quality criteria development needs. These modifications allow metrics, such as the Lake Vegetation Index (LVI), Stream Condition Index (SCI), and Rapid Periphyton Survey (RPS) to be "field-tested" prior to division validation and subsequent adoption. The monitoring design's flexibility allows the section to respond as departmental needs change.

Program implementation, reviewed most often at the section level, is tightly orchestrated among the Project Managers, their staffs, the FDEP Bureau of Laboratories, the data manager, and the data analysts. Project Managers within the section work closely with the QA officer, who conducts field sampling audits and responds to procedural issues. The audits are used to ensure compliance with EPA, FDEP, and internal WMS requirements. Incorporating sampler feedback leads to changes in protocols and is considered a valuable tool in the program design.

The section is committed to excellence and is constantly improving its procedures, data flow, and data quality based on resource conditions and FDEP data needs. For example, when it was discovered that no data existed for a major river considered a high priority in its springshed, WMS added a fixed site to collect trend data at a critical location. Furthermore, FDEP's need to develop a statewide TMDL for mercury resulted in the addition of sediment methyl mercury sampling to the 2009 design plan.

By incorporating guidance, program review, data needs, and staff feedback, WMS is able to continuously evaluate and respond to changing resource conditions. This flexibility supports the effectiveness and success of federal, state, and FDEP water quality monitoring objectives.

ELEMENT 10: GENERAL SUPPORT AND INFRASTRUCTURE

The success of a long-term monitoring program relies on continual support and an established infrastructure. WMS has been managing water quality monitoring programs for over 10 years and has developed considerable in-house expertise. WMS has nurtured professional relationships within the Department and other agencies. All of these efforts have allowed the development and maintenance of a comprehensive infrastructure.

The foundation of the WMS monitoring program consists of the field sampling staff. Safety, QA, and training require the presence of two or more sampling staff at all sampling events. Newly hired samplers are paired with experienced staff to ensure compliance with SOPs, and they must participate in a three-day WMS Samplers' Training course held annually. All samplers are required to attend a refresher course every five years and must also complete an FDEP-approved safe boating course before using a boat and trailer.

The Standards and Assessment Section (SAS) staff train Project Managers and samplers in conducting biological assessments, such as the Habitat Assessment (HA), SCI, and periphyton surveys. It also provides instruction and audits for conducting LVI metrics during biannual statewide biocriteria meetings. An apprenticeship program for less experienced samplers is in place to provide long-term training in HA and SCI. Before samplers are allowed to collect HA and SCI data on their own, they must pass Standards and Assessment Section audits for both metrics. The Project Manager uses best professional judgment of the sampler's ability to determine which samplers may train others. FDEP district biologists and HA/SCI-certified trainers often provide additional training, expertise, and support.

Project Managers, each assigned a reporting unit within the state, are trained and provided with guidance by WMS staff—specifically, other Project Managers, QAO, Data Manager, and Administrator. The *Project Managers' Manual*, updated annually, is available as part of the WMS Quality Manual to provide written guidance on policies, procedures, and practices. Project Managers and samplers are apprised of new procedures and data management provided by the QAO, GIS analyst, and Data Manager.

All staff receive ongoing, standardized training through classes, manuals, meetings, conferences, and day-to-day interactions. For example, WMS holds annual meetings, which serve as forums for training, monitoring issues, problem solving, networking, and the presentation of sampling results and their interpretation. The WMS sponsors and attends these meetings, with frequent presentations or participation by staff from other FDEP sections and outside agencies. In addition, staff participate in annual program evaluations, plan for new monitoring cycles, and maintain collaborative relationships with other entities.

Currently, WMS receives state and EPA funding to retain talented staff, fund laboratory analyses of indicators, and provide and maintain samplers' field equipment. Field equipment includes water quality sondes, resource-grade GPS units, vehicles, and ground water pumps, all of which are required to run a high-quality monitoring program. The QAO, Project Managers, laboratory staff, and samplers are responsible for guaranteeing that supplies needed for sampling, calibration, and QA are provided or kept in stock. Occasionally, WMS collaborates with FDEP districts, other agencies, and contractors to ensure that samplers have working equipment, vehicles, and backup assistance. The WMS budget is overseen by the Environmental Administrator with support from the Administrative Assistant, who processes purchases, documents travel, and maintains personnel files.

WMS, DEAR, and FDEP provide data management resources at different levels. WMS includes a Data Manager and an Assistant Data Manager who work in concert with Project Managers in preparing, combining, correcting, and storing data. WMS uploads its data to an Oracle database supported and managed by FDEP's Office of Technology and Information Services (OTIS). OTIS maintains servers, provides computer support, and updates applications. WMS data are also uploaded into Florida STORET, managed by the Bureau of Watershed Management, and EPA STORET. Written references for data management procedures can be found in the WMS Data Management Protocols and the Oracle GWIS Users' Manual.

As noted earlier in the document, WMS keeps two data analysts on staff to select sites for the Status Monitoring Network and analyze data for the Status and Trend Monitoring Networks. The analysts, in conjunction with the Data Manager and Administrator, develop reports, write peer-reviewed scientific papers, present at conferences and meetings, and make recommendations for future program design. The analysts and the Data Manager have extensive academic backgrounds in statistical analysis. WMS maintains a dedicated GIS position, since GIS is an essential component of refining resource coverage for the Status Monitoring Network. The WMS technical writer prepares reports, documents, brochures, webpage content, and presentations. All WMS staff participate in this process.

WMS has a full-time QAO who audits samplers one to two times a year, develops and maintains the Status and Trend Monitoring Networks Sampling Manual, maintains blank and FRS records for WMS and the Bureau of Laboratories, troubleshoots issues, and often assists with program evaluation and planning. As reported in the QA section, audits require that samplers respond to the QAO and Project Managers to ensure that state SOPs are followed.

WMS works closely with the FDEP Bureau of Laboratories, which is accredited by NELAP for indicators sampled by WMS. Laboratory staff include highly trained aquatic invertebrate and plant taxonomists, as well as individuals skilled in calculating the biological indices used by WMS.

Challenges to maintaining solid support and infrastructure include changing environmental concerns and fiscal constraints, which may be political in nature. Fiscal or administrative changes to the organization and to enterprise wide databases that support WMS efforts may also limit support and infrastructure. Finally, the monitoring programs must comply with EPA guidance and state requirements, while relying on OPS staff in mission-critical positions.

APPENDICES

Appendix A: Watershed Monitoring Program Surface Water List Frame Development Methodology

Lakes

Features from the 1:24,000-scale National Hydrography Dataset (24k NHD) "Waterbody" layer are used as a base coverage for the Lakes coverage in the Watershed Monitoring Surface Water List Frame geodatabase (**Figure A.1**). In an attempt to reduce the dataset to features that are most likely permanent, non-ephemeral/non-intermittent, non-wetland features, lakes whose size falls below the threshold of 4.0 hectares (40,000 m^2) are not included in the Lakes coverage. Attribution is applied to each feature in the Lakes coverage to classify the dataset into two categories:

- Small Lake – feature area ≥ 4.0 hectares, and < 10.0 hectares
- Large Lake – feature area ≥ 10.0 hectares

Additionally, WMS staff conduct a manual review of the statewide coverage in an attempt to remove features that appear unsampleable. Criteria which may disqualify a feature include: artificial waterbodies (roadside borrow pits, residential stormwater retention/detention ponds, restoration areas, etc.), dry/wetland/low water areas, large land owner refusal properties, saline/estuarine conditions (via field observation or ancillary GIS data), inaccessibility, or any other similar staff recommend exclusion.

A final dataset is sent to project managers to perform a final review of the Lakes list frame. After any necessary final edits are applied the centroids of the polygons in the small lakes coverage are identified, and used to represent Small Lakes as point features. The Large Lake features remain polygons, as sampling points within the lakes are determined during the selection process. Sampleable features (coverages of Small Lakes centroid points and Large Lakes polygons) are exported as individual shapefiles and sent for GRTS selection. GIS tools and ancillary coverages are used to add the following fields of attribution to the selected features:

- Latitude / Longitude (Decimal Degrees, and DMS)
- Watershed Monitoring Program Reporting Units: one field of Zones and another of Basin Names
- Water Management District
- DEP District
- Ecosystem Management Area
- DOQQ Number
- DOQQ ID
- Hydrologic Unit Code Number
- Hydrologic Unit Code Name
- TMDL Basin Name (WMS Cycle 2 Basins)
- County Name
- FIPS County Number

Samplers and project managers perform office and field reconnaissance of the selections and provide site verification information in the GWIS database. Information regarding changes to the list frame are used to update the database for the following year's list frame. Edits are again sent to project managers for approval and the cycle repeats.

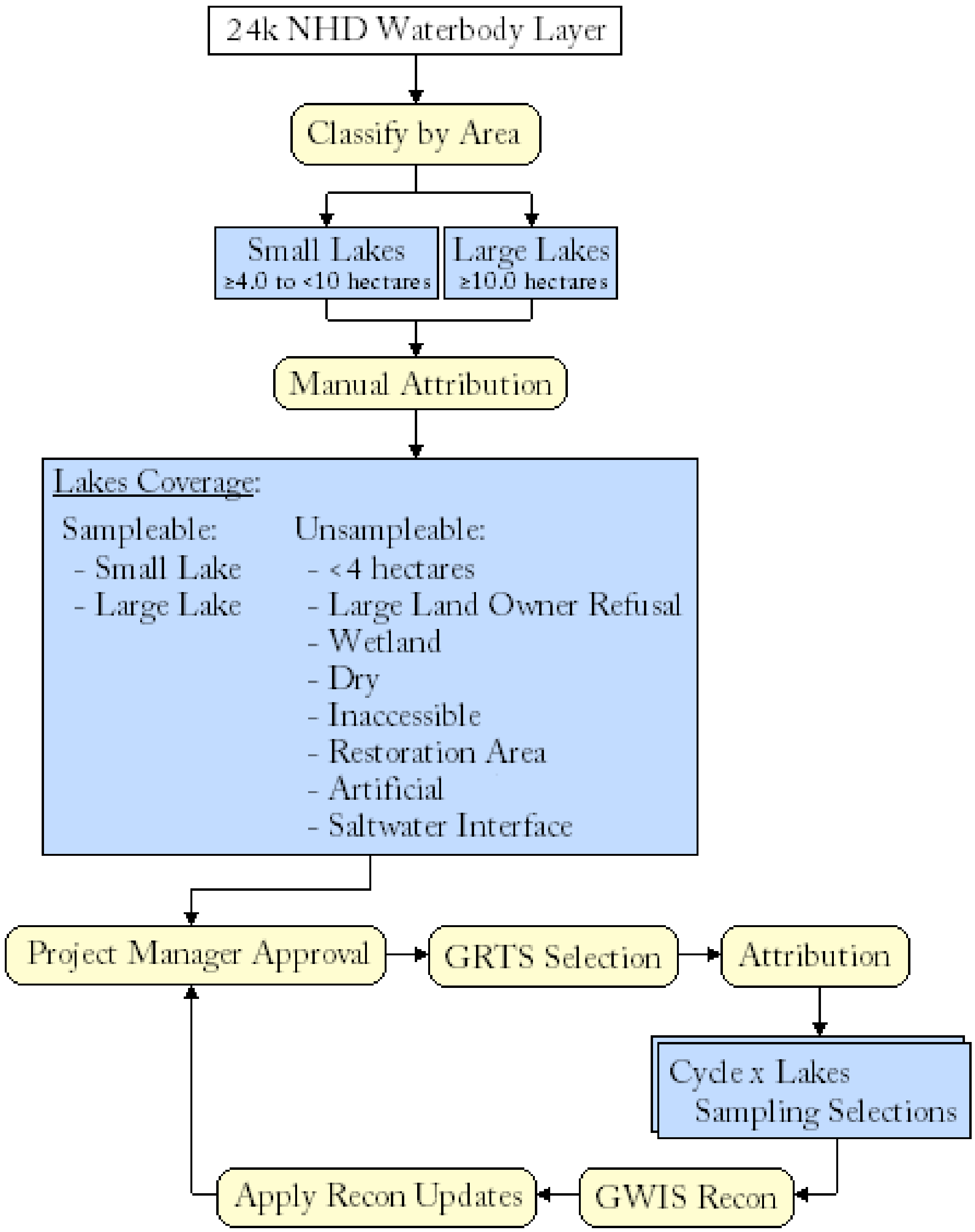

Figure A.1 Status Monitoring Network flow chart of steps required to create the Lakes Coverage in the Watershed Monitoring Surface Water list frame geodatabase.

Flowing Waters:

Features from the 1:24,000-scale National Hydrography Dataset (24k NHD) "Flowline" layer are used as a base coverage for the Flowing Waters coverage in the Watershed Monitoring Surface Water List Frame geodatabase (**Figure A.2**). In an attempt to reduce the dataset to features that are most likely permanent, non-ephemeral/non-intermittent segments, manual editing is performed by WMS staff to remove segments from this snapshot that do not match the features in the 1:100,000-scale NHD Flowline network.

From this point, WMS staff utilize customized GIS tools and ancillary coverages to review the Flowing Waters layer at scales between 1:1,000 and 1:30,000. Attribution is applied to each segment in the Flowing Waters coverage to classify the dataset into a number of categories which are further used to identify sampleable and unsampleable features across the state.

Sampleable Feature Types

- River
- Stream
- Canal (2009 only)

Unsampleable Feature Types

- Ditch
- Large Land Owner Refusal
- Wetland
- Dry
- Inaccessible
- Restoration Area
- Centerline through Lake
- Saltwater Interface

Project managers perform a final review of the Flowing Waters list frame. After any necessary final edits are applied, sampleable features are exported as individual shapefiles and sent for GRTS selection. GIS tools and ancillary coverages are used to add the following fields of attribution to the selected features:

- Latitude / Longitude (Decimal Degrees, and DMS)
- Watershed Monitoring Program Reporting Units: one field of Zones and another of Basin Names
- Water Management District
- DEP District
- Ecosystem Management Area
- DOQQ Number
- DOQQ ID
- Hydrologic Unit Code Number
- Hydrologic Unit Code Name
- TMDL Basin Name (WMS Cycle 2 Basins)
- County Name
- FIPS County Number

Samplers and project managers perform office and field reconnaissance of the selections and provide site verification information in the GWIS database. Information regarding changes to the list frame are used to update the database for the following year's list frame. Edits are again sent to project managers for approval and the cycle repeats.

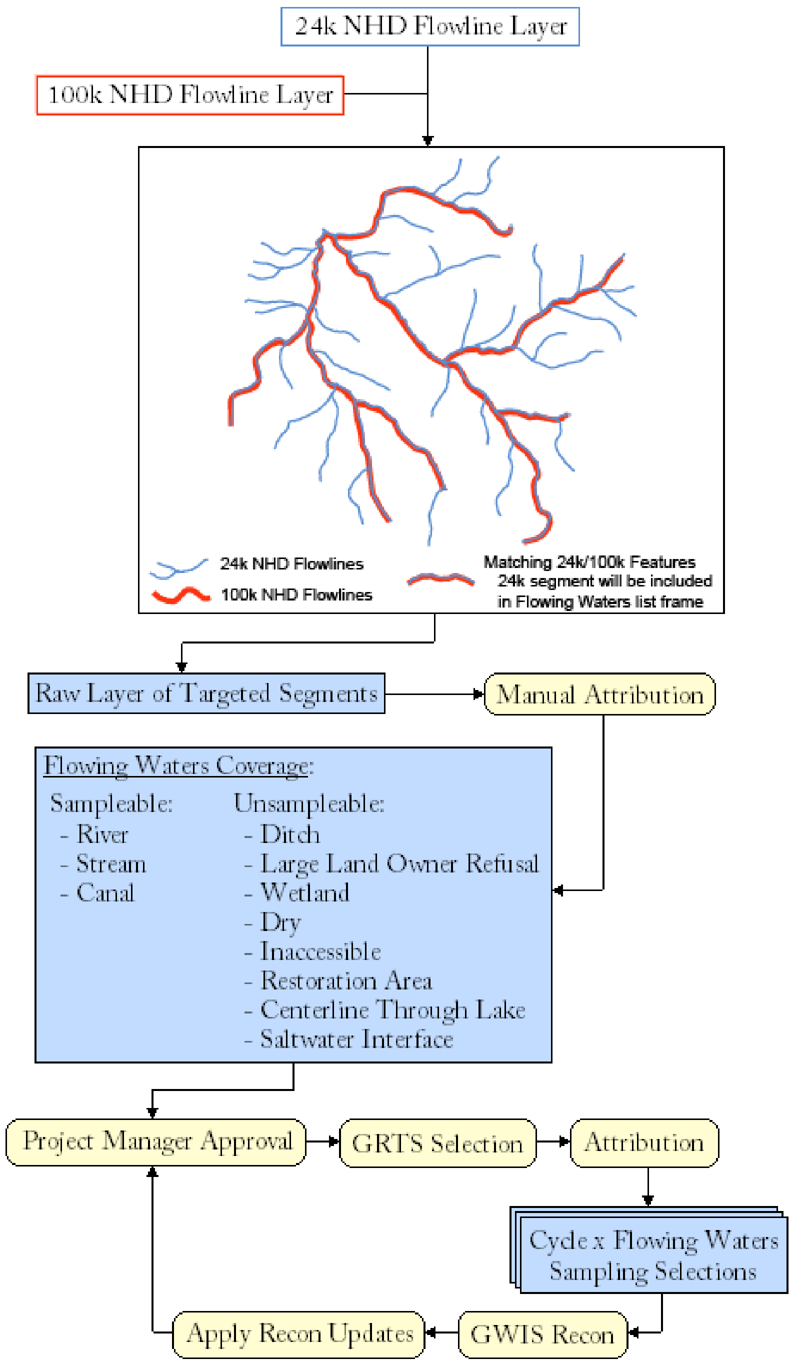

Figure A.2. Status Monitoring Network flow chart of steps required to create the Flowing Waters Coverage in the Watershed Monitoring Surface Water list frame geodatabase.

Appendix B: Status Monitoring Network GPS Data Management Procedures (updated 2/16/2009)

What is an SSF file?
SSF (Standard Storage Format) is a file format used by Trimble GPS equipment and software.

Outline of the steps required to process Trimble SSF files for the Status Monitoring Network:

1. *SSF data files are sent within 30 days of the project end date from Field Personnel to the Watershed Monitoring Section in Tallahassee via e-mail, FTP (File Transfer Protocol software), or in person.*

2. *The GPS Coordinator receives the SSF files and places them in the appropriate folder on the computer network (\\\tlhwrm\sol Z Status Network SSF 3rd Cycle). Folders are named by zones and contain subfolders labeling the resource type (e.g., 2009 St. Johns River Water Management District (SJRWMD) SSF data for confined aquifer resource type are located in \\tlhwrm\sol Z\Status Network SSF 3rd Cycle\Zone 3\Confined).*

3. *The files are postprocessed using the nearest base station data and are then combined into a single file named by the project name (e.g., Z3CA0901.ssf). This file is saved in the same location as the original SSF files; however, the file now has the .cor suffix. The .cor is a Trimble SSF file that has been postprocessed with a differential correction applied.*

4. *The combined file is then exported as an ASCII vertical bar delimited text file to the root folder (e.g., \\tlhwrm\sol Z\Status Network SSF 3rd Cycle\Zone 3\Confined for the Z3CA0901.ssf file). The text file name is changed from the feature name to the project name. This name is followed with .GPS as the extension. (i.e., Z3CA0901.ssf is exported to Z3CA0901.GPS).*

5. *The text file is opened in Microsoft Excel as a vertical bar delimited text file. The headers are included in the export and should be changed to bold font.*

6. *The text file is then saved as a Microsoft Excel file by project name (e.g., Z3CA0901.xls) in \\tlhwrm\sol Z \Status Network SSF 3rd Cycle \GPS Export Data\Zone 3.*

7. *The Excel file is sent to the project manager for review. This is documented in \\tlhwrm\sol Z \STATUSFD under the appropriate year in the Dataload Schedule for the project name.*

8. *A shape file for each combined project file is created and placed in the appropriate folder in the shapefiles subfolder found in \\tlhwrm\sol Z \Status Network SSF 3rd Cycle.*

Appendix C: Information Goals for the Ground Water Trend Monitoring Network

Goal 1. Statistically describe the analytes/indicators.

A descriptive statistics table is prepared with data from each Trend Monitoring Network well (**Table C.1**). The table labels the analyte (or indicator); measurement unit; number of samples collected; number of samples with concentrations below the laboratory detection level (BDL); minimum value; first, second, and third quartiles; and maximum value. The first, second, and third quartiles (Q1, Q2, and Q3) correspond to the 25th, 50th (median), and 75th percentiles, respectively. For a given analyte, the reported minimum concentration value in the table mostly reflects the minimum detection level reported by the analytical laboratory.

Table C.1. Example of descriptive statistics for Ground Water Trend Monitoring Network wells

Analyte	Measurement Unit	Number of Samples	Number of BDLs	Minimum Value	Q1 Value	Median Value	Q3 Value	Maximum Value
NO3	mg/L	30	7	0.05	0.09	1.00	2.00	10.30
o-PO4	mg/L	29	4	0.05	0.10	0.10	0.15	1.30

NO3 – nitrate; o-PO4 – ortho-phosphate; mg/L – milligrams per liter

Goal 2. Determine if seasonality exists in the time series data.

For each well or spring set of data, for the period of record, seasonality is determined by conducting a Kruskal-Wallis (K-W) test. As it turns out, data from the wells and springs have generally been collected either monthly or quarterly for the period of record. For this reason, seasonality tests are conducted on monthly and quarterly data, whichever is applicable. For quarterly sampling, the quarters are as follows: (1) December–February; (2) March–May; (3) June–August; and (4) September–November.

The K-W test compares the distribution of two or more populations by indirectly comparing their mean or their median values. If only two populations are compared, the test is equivalent to a Mann-Whitney (M-W) test. Consider a situation in which one wants to determine if two populations have the same distributions. For the M-W test, the null hypothesis is that the distributions of the two populations are the same, while the alternate hypothesis is that they are not. The two samples are combined into a single sample ordered from smallest to highest. Each observation is then assigned a rank, without regard to which sample it originally came from. The sum of the ranks assigned to those values from one of the populations is generated. If the rank sum of the corresponding population is very small (or very large), this indicates that the values from one population are smaller (or larger) than the values from the other. If so, the distributions of the two populations are not equal. It should be noted that if the rank sums of the two populations are not equal, their medians will not be equal.

The K-W test compares the distribution of more than two populations (e.g., seasons). For this report, each test is two-sided. The null hypothesis is that the median concentration of an analyte sampled in any season is equal to the median of the remaining seasons. The alternate hypothesis is that the median concentration for at least one season is not equal to the remaining seasons. The α level is preset at 0.05. For monthly datasets, tests are conducted assuming that each month is a season. For quarterly data, tests are conducted assuming that each quarter is a season.

If seasonal cycles are present, the effects of the seasonal cycles are removed. The procedure is discussed in the following section (Goal 3).

Goal 3. Determine if linear time series trends exist. If yes, determine the slopes.

During the conceptual phases of this monitoring network, there was a concern that a linear trend in a time series might be found for one period, while another trend might be found for a different period. For example, suppose an upward trend was found for the first half of a time series, while a downward trend was found for the second half, or vice versa. Detectable trends depend on the period for which they are analyzed. Based on this logic, and with only about 10 to 12 years of record, it was decided that 3 different timeline datasets would be generated for each well or spring analyzed. Segment A includes the entire period of record (≈ 10 to 12 years). Segment B includes the first half of the timeline (≈ 6 years of data), while Segment C includes the second half (≈ 6 years of data) of the timeline.

For nonseasonalized data (datasets with no seasons), the existence of upward or downward linear trends in the data is determined. At each well or spring, for each analyte, a Mann-Kendall (M-K) statistical test for a monotonic linear trend is conducted. The M-K test is a very useful procedure, because missing values are allowed. In addition, data reported as trace or BDL can be used by assigning them a common value that is smaller than, or equal to, the smallest measured value in the dataset. For this report, BDLs are assigned an arbitrary value equal to the lowest detection level for the period of record.

The M-K tests for a linear temporal trend in nonparametric data. It does not depend on an assumption of a particular underlying distribution. The test identifies correlations in data by temporally ranking the data and then determining the number of times the concentration goes up or down compared with the previous time step. It only uses the relative magnitudes of the data, rather than their measured values. For this application, each test is two-sided. The null hypothesis is that there is no monotonic linear slope in the concentration. The alternate hypothesis is that there is a slope. The α level for determining the significance of the results is 0.05.

If seasonal cycles are present in the data, they are deseasonalized by subtracting the mean of the corresponding season from each datum and then adding the overall average back to the original datum. For example, suppose 10 years of quarterly data are collected at a site for chloride. The overall mean of the data is 1.0, while the mean of the winter quarter is 0.2 mg/L. Suppose a concentration for a winter quarter sample is 1.2 mg/L. In mg/L, the corresponding transformed, deseasonalized datum becomes the following:

$$x = 1.2 \text{ (original)} - 0.2 \text{ mg/L (winter mean)} + 1.0 \text{ (overall mean)} = 2.0 \text{ (transformed)}$$

Once all data have been transformed, an M-K test is performed on the deseasonalized data. As before, the null hypothesis is that there is no slope in the concentration of an analyte over the timeline. The alternate hypothesis is that there is a slope. The α level is 0.05.

If a trend exists, its corresponding slope is determined using a Sen-Slope (S-S) estimator. The method measures the median difference between successive concentration observations over the time series.

In addition to the S-S estimator, a time series plot of the data is produced. Time is plotted on the horizontal axis, while concentrations are plotted on the vertical axis. Smoothing procedures make visual inspections of time series plots easier to interpret. For this reason, Loess smoothing is used on the time series curve. This is a tri-cube kernel technique used on the nearest 50% of the data in order to produce an estimated predicted value for a corresponding observed data point on, for example, a timeline.

Goal 4. Determine the spatial, depth, land use, or other related relationships for wells with detectable trends.

For each well or spring for which a trend is detected, the location of the station on a map is plotted for each analyte. Visual estimates are made about whether clusters of stations exist. If clusters do exist, M-K tests for homogeneity ($M\text{-}K_h$) of stations are conducted, since when data are collected at several stations in a region, there may be interest in making a regional statement about trends. A general statement about the presence or absence of monotonic trends is meaningful if the trends at all the stations are in the same direction.

The $M\text{-}K_h$ procedure estimates whether two or more stations display homogeneous trends. For this analysis, the test is two-sided. The null hypothesis is that there is homogeneity in trends among the stations in question. The alternate is that homogeneity does not exist. The α level is preset at 0.05.

In addition to visual detections of clusters, other types of possible associations are checked, including relationships with geomorphology, land use, and depth. For example, if several wells located in the same geomorphic region display positive trends, homogeneity tests for those wells are conducted. The same procedure is used as needed for land uses, well depths, and other possible relationships.

Goal 5. Discuss probable causes and, if trends are believed to be human induced, discuss possible solutions.

A table is generated for data displaying a trend. ***Table C.2*** provides an example. The table includes the station (well or spring) with a trend, the tests on which the results were based, the time segment for which the trend is identified, the analyte with a trend, the direction of the trend, and the p-value of the corresponding test.

The stations and analytes that display homogeneity in trends are displayed in a separate table. For each trend, possible reasons as to why the analyte has a trend are discussed. If homogeneity in trends exists for a group of stations, the plausible reasons for the homogeneity are noted. If the trend is believed to be human induced, plausible solutions to the problem are discussed.

Table C.2. Sample results of time series statistical tests for wells

Only analytes displaying a significant difference are displayed.
M-K = Mann-Kendall, S-K= Seasonal Kendall (Total comparisons = 110) (α = 0.05)

Station	Test	Time Segment	Analyte	Direction	P-Value
SR Well 10	M-K M-K	A	Water level Nitrate (NO3)	Down Up	0.003 0.001
SR Well 10	M-K	B	Water level	Down	0.021
SR Well 10	M-K	C	NO3	Up	0.001
SW Well 5	S-K	B, winter	Total dissolved solids (TDS)	Up	0.020
SW Well 5	S-K	C, winter	TDS	Down	0.024

Goal 6. Compare analyte concentrations collected during the Status Monitoring Network sampling index period with the overall 12-month cycle based on the Trend Monitoring Network period of record.

One of the objectives of the Status Monitoring Network is to sample a reporting unit once during a sampling cycle and make a statement about the overall ground water quality in that reporting unit. The reporting unit is sampled during a two-month index period during a year. The index period is chosen to represent a time of the year when the overall conditions of the water resource in the reporting unit are thought to be relatively poor.

The index period time frames were established by consensus among a group of scientists from across the state. Generally, specific data were not used in the decision; however, for Cycle 3, rainfall was used to determine the optimal times for sampling rivers and streams. Early on during Cycle 1 sampling, more and more individuals expressed concern that the index period did not actually represent a time when a resource is in a stable condition.

For example, suppose that an unconfined Ground Water Trend Monitoring Network well is located in the Northwest Florida Water Management District (NWFWMD), in the NW1 Reporting Unit. Suppose that it was sampled quarterly for a 10-year period and, during that time frame, the concentration range of an analyte was 100 mg/L. Suppose that between June and August 2002, a total of 30 randomly located unconfined wells was sampled in NW1 as part of the Status Monitoring Network during Cycle 1. Now suppose that the range of the random sampling during the one index period was only 50 mg/L. Are the variances statistically different? Are the medians different? Do the two sets of data come from the same parent population?

Questions such as these are being addressed both qualitatively and quantitatively. Field analytes are sampled as part of the Ground Water Trend Monitoring Network monthly (unconfined) or quarterly (confined). Laboratory analytes are also sampled, in addition to the field analytes, during the year in which the reporting unit is sampled as part of the Status Monitoring Network. This means that comparisons need to be made for the following 3 periods: (1) the 10- to 12-year period for field analytes (monthly or quarterly) from the Trend Monitoring Network; (2) the 12-month period for laboratory analytes collected either monthly or quarterly as part of the Trend Monitoring Network, but during the year that the Status Monitoring Network is sampled; and (3) the index period in which the 30 randomly located wells are sampled as part of the Status Monitoring Network. Since interest centers on the index period, for each type of analysis discussed below, comparisons will be made between (a) Status Monitoring Network data collected during the index period, and Trend Monitoring Network data collected during the year in which the Status Monitoring Network is sampled; and (b) Status Monitoring Network data collected during the index period, and Trend Monitoring Network data collected during the 10- to 12-year duration of the Trend Monitoring Network.

For (a) and (b) for each analyte, the minimum value, Q1, Q2, Q3, maximum value, interquartile range (Q3 through Q1), and range are included in a table. In addition, box-plots of the two sets of data are plotted side by side for qualitative comparisons.

Quantitative comparisons are also conducted. For (a) and (b), median values of the different distributions are compared using the M-W test. In addition, a Conover test is used to determine whether the variances are equal. The test is a nonparametric test that is analogous to an M-W test, in that it is based on ranks. Recall that for the M-W test, the two samples are combined into a single ordered sample, from the smallest to the highest. Each observation is assigned a rank, without regard to which sample it came from.

The Conover test is slightly different. First, the Sample 1 mean is subtracted from each observation in Sample 1. Then the Sample 2 mean is subtracted from each observation in Sample 2. The absolute values of both samples are combined into a single ordered sample, from smallest to highest. Each value is assigned a rank, without regard to which sample it came from. The sum of the ranks assigned to those values from one of the samples is then generated. If the rank sum of the corresponding population is too small (or too large), then there is an indication that the value from one population tends to be smaller (or larger) than the value from the other. If so, the variances of the two populations are not equal. Each test is two-sided and the α level is 0.05. The null hypothesis for the first test is that the dispersions (variances) of the two populations are equal. The null hypothesis for the second test is that the dispersions of the two populations are equal; while the alternate hypothesis is that the dispersions are not equal. A two-sided test with an α level of 0.05 is used for each test.

Finally, a Kolmogorov-Smirnov (K-S) test is also used to compare the populations mentioned in (1) and (2). The test compares the cumulative frequency distributions of the two populations and locates the greatest deviation between the two distributions. If the maximum deviation exceeds a critical value, then the two distributions are not considered to be equal. The null hypothesis is that the distributions are equal, while the alternate hypothesis is that the distributions are not equal. A two-sided test with an α level equal to 0.05 is used.

Goal 7. Summarize the major ground water quality issues and recommend sampling strategies.

Using the information generated from Goals 1 through 6, as well as other information generated as necessary, the major ground water quality issues for each spring and Trend Monitoring Network well are summarized. This will also lead to recommendations on the future sampling of both springs and wells.

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Janelle Madden
Pam Novak

Administrative Support
Dana Jones
Wanda Harpley
Anne Baatstad

South District (Fort Myers)
Matthew Bearden
Ben Faria
William Lasley
Sara Mechtensimer
Erin Rasnake
Kadee Price
Andy Roach
Stan Tucker

Southeast District (Port St. Lucie)
Abner Gamboa
Bill Karlavige
Dawn Miller
Harold Moesch

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Brett Ursin
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Russ Frydenborg
Joy Jackson
Nia Wellendorf

DEP Management Team
Drew Bartlett
Daryll Joyner

Editors
Linda Lord
Dave Ouellette