12.0 FUTURE DIRECTION

12.1 Introduction

The interim assessment (Stober et al. 1996) and the results of the final technical assessment for Phase I (this report) indicate the importance of hydropattern, nutrient, habitat, vegetation, and food web information for ecosystem management and restoration efforts. Continued monitoring of water, soil/sediment, periphyton, and fish is critical both for better understanding of Hg cycling in the ecosystem and to evaluate the effectiveness of ecosystem restoration activities and natural hydropattern changes that are occurring over time. This research and monitoring, which is consistent with the South Florida Mercury Science Program (SFMSP), and the Everglades restoration activities will be extended. The studies in Phase II in 1999 will be designed to fill existing data gaps in the ecological baseline assessment (habitat assessment), initiate trend monitoring, provide additional input for models of Hg cycling, landscape, and water management and to determine systemwide responses to management actions. It is important that comparable long-term monitoring occurs to assess the multiple interactions observed across this dynamic system because it is doubtful that the scale, magnitude, and complexity of experimental studies needed to define the interacting variables can adequately predict future changes.

12.2 Objectives

The USEPA South Florida ecosystem assessment project is an innovative, large-scale, multimedia, monitoring and assessment program designed to measure the current and changing conditions of ecological resources in South Florida using an integrated, holistic approach. The ultimate goal of this program is to provide decision makers with sound ecological data to improve environmental management decisions on multiple environmental issues and restoration efforts in the Everglades. The South Florida ecosystem assessment project provides a foundation for addressing the multiple issues that are critical to the restoration of the Everglades ecosystem and contributing to the Interagency Task Force on Ecosystem Restoration efforts. The South Florida ecosystem assessment project uses the EPA ecological risk assessment framework (USEPA 1992)

as a foundation for providing decision makers with critical information. The program is guided by seven policy relevant assessment questions:

1) **Magnitude** - What is the magnitude of the problem(s) in the Everglades?
2) **Extent** - What is the extent of the problem(s)?
3) **Trend** - Is the problem(s) getting better, worse, or staying the same?
4) **Cause** - What factors are associated with or causing the problem(s)?
5) **Source** - What are the sources contributing to the causes and what is the importance of different sources to the problem(s)?
6) **Risk** - What are the risks to different ecological systems and species from the stressors of factors causing the problem(s)?
7) **Solutions** - What management alternatives are available to ameliorate or eliminate the problem(s)?

The seven questions listed are equally applicable to each issue impacting the Everglades ecosystem, such as, hydropattern modification, Hg contamination, eutrophication, habitat alteration, and endangered and exotic species.

The USEPA South Florida ecosystem assessment project is a long-term research, monitoring and assessment program. Initial conceptual models and testable hypotheses have been developed. A number of studies will be required to test all of the hypotheses and to refine the conceptual models and complete the ecological risk assessment in the Everglades. Initially, the South Florida ecosystem assessment project has focused on a subset of hypotheses that are directly related to the first four policy-relevant assessment questions identified above. Additional coordinated studies directed at addressing other high priority elements of the interagency program will be conducted and merged with this program as additional resources are made available.

12.3 Approach

12.3.1 Revised Monitoring Design

Following the analyses conducted and presented in the South Florida Ecosystem Assessment Interim Report (Stober et al. 1996), the baseline monitoring design was revisited to consider reducing the cost while improving the efficiency of monitoring. The importance of hydropattern modifications, nutrient and Hg cycling, and habitat alteration for marsh restoration indicated monitoring should emphasize the marsh ecosystem reducing emphasis on canals and

structures. Compliance monitoring of nutrient and Hg discharge from the future STAs was also considered. Design scenarios considered included nesting compliance monitoring stations and/or fixed long-term sites within the probability monitoring matrix. A similar compliance status and trends network was successfully implemented in the Southern California Bight area (Stevens 1997). The location of the compliance monitoring stations would require a cluster of sites below the STA discharge areas in WCA2 and the northern area of WCA3. Fixed long-term stations representing locations that have previously been monitored by the USGS, NPS, or SFWMD and/or at which process studies have been conducted or are likely to be conducted in the future were considered. Some of the design scenarios considered are shown in Figure 12.1.

A maximum design constraint of no more than 125 stations can be sampled during any cycle. Therefore, 119 probability samples with six long-term monitoring and process study sites can be included without significantly reducing the design-based estimate. Tradeoffs associated with the revised probability design include the power for trend detection, minimization of within site variance compared to among site variance, pattern recognition, and cost. The monitoring design selected satisfies the SFMSP Phase II objectives, provides information to assess the effectiveness of restoration efforts in support of the Everglades Forever Act and the GPRA.

The initial Phase II design includes six long-term monitoring sites located in each of the six latitudinal zones identified in the Phase I analysis. These sites are Lox 8 (center of Loxahatchee), U3 (center of WCA2), WCA3-11 (2.5 mi south of Alligator Alley), WCA3-15 (Hg hot spot), P33 (west of L67 extension) and P37 (southern ENP). Site selections were made on the basis of existing water level, rainfall or water quality information or the presence of past or future Hg cycling process studies. Compliance monitoring was not considered in the final fixed site selection because many of these sites have already been identified in permit requirements and will be monitored under permit schedules. BCNP will not be included in the 1999 random sample. The selection of a minimum of six long-term sites also has the least effect on data analysis and design-based estimates allowing ease of comparison with the Phase I data.

12.3.2 Aerial Photo Vegetation Assessment

A Phase I probability assessment of vegetation was accomplished by visually determining the major habitat types at each sampling location and documenting the sites with 35 mm photographs. These measures permitted qualitative estimates of presence and dominance of selected emergent plant species and floating periphyton at each site. However, quantitative estimates are needed to provide plant biomass and Hg concentrations for input to Everglades Hg cycling models. Estimates of plant biomass along the system are also needed to document baseline responses to the nutrient gradient by key indicator species and for input to Everglades landscape models. The Center for Remote Sensing and Mapping Science (CRMS) at the University of Georgia is developing vegetation maps and digital databases for ENP using aerial photo interpretation techniques. These techniques will be applied in this study, however, they will be adapted to the USEPA probability sampling design used for assessment and monitoring of the Everglades ecosystem. CRMS has the necessary experience and tools to accomplish this task in a minimum time frame while ensuring systemwide data comparability.

- CRMS will obtain USGS National Aerial Photography Program (NAPP) color infrared aerial photo transparencies for the study area (WCA1, WCA2, WCA3, ENP, and Rotenberger). USEPA will provide CRMS with the Universal Transverse Mercator (UTM) map coordinates North Atlantic Datum (NAD 83) for the approximately 260 random sample points to be used in the survey. Map interpretation will be conducted in the following order to facilitate the pilot study scheduled for January 1999, dry season survey (April 1999) and the wet season survey (September 1999). Six geographically distributed points will be sampled in the pilot study, followed by 125 points in each dry and wet season survey. The pilot study and each survey will have a unique set of randomized spatially distributed sampling points which will be identified with a unique numbering system. The survey points will be ordered by latitude from north to south. The aerial photo interpretation will provide the detailed information for each site on which the field sampling will be based; therefore, completion of the digitized vegetation maps will precede the field sampling by at least 2 months.

- The CRMS will plot the sample site locations on the NAPP color infrared aerial photographs and interpret the vegetation type and density. While particular attention will be focused on sawgrass, cattails, and periphyton at each location with subsequent biomass sampling by USEPA, interpretation of the photos to evaluate all plant species/communities that can be consistently identified in the

photos for changes in presence or absence and abundance and/or density will maximize the information generated. Interpretation will focus on 1 km^2 plots centered at the GPS coordinates for each sample point. A vegetation map in digital format will be prepared for each 1 km^2 plot.

In an effort to try to expedite vegetation sampling the pilot study digital vegetation maps will be provided to ORD EMAP (Corvallis) for development of an algorithm to weight (near the center point) the selection of random sampling points for plant species biomass determination. This will be tested on the six pilot study stations. Following development of the algorithm it will be tested on the dry season survey points to evaluate the logistical requirements of the systemwide sampling efforts. With development of the final working algorithm it will be provided to CRMS for point location on the remaining digital vegetation maps.

The USEPA Region 4 field sampling team will load each site map with associated vegetation type polygons into Field Notes on a GPS linked laptop and the field sampling crew will ground truth the plant type communities. CRMS experts will assist EPA vegetation assessment teams making field observations most appropriate to aerial photo interpretation and accompany the vegetation assessment team during the pilot study. Various programs will be used to interpolate these point data across the system to establish general spatial variations or trends in plant distributions to provide a basis for future systemwide comparisons.

12.3.3 Plant Biomass Estimation

Responses of the macrophyte and periphyton communities to nutrient inputs has important implications not only for Hg cycling and bioaccumulation, but also for ecosystem restoration. High Hg methylation rates in periphyton and the higher MeHg mass estimates in floating periphyton suggest a key interaction between atmospheric Hg deposition, nutrient concentrations, and Hg methylation. In addition, increased density in cattail and sawgrass habitats due to nutrient stimulation may inhibit periphyton growth through shading in parts of the system. Quantitative studies of plant biomass will be conducted on key emergent species and the periphyton community in Phase II of the program.

This project proposes to develop a rapid biomass estimation method during the pilot study, which is compatible with the study design and which can be implemented by the USEPA Region 4 field sampling team. Clip plots ranging in areas of 0.25, 0.5, and 1.0 m^2 will be tested during the pilot study on the random sampling points for each indicator plant species (e.g., sawgrass, cattails). Above ground live leaf number, leaf length, culm diameter at base and culm number, and wet weight will be determined in the field followed by transport of the samples to the laboratory where they will be tagged and dried at 70° C to a constant dry weight and reweighed. A ratio will be developed between the wet and dry weights for each plant species sampled in an effort to eliminate transport of macrophyte biomass from the field via helicopter and airboat. During the pilot study each plant species will be sampled in triplicate at each site.

The logistical requirements of vegetation sampling needed for the systemwide surveys will be assessed from the aerial photo interpretations. Replicate samples will be taken from a spatially distributed 10% the dry and wet season stations. All replicate samples will be weighed wet and dried to determine seasonal changes in the wet to dry ratio.

Phase I floating and soil periphyton samples were collected at each station when present; however, biomass was not measured. Phase II monitoring proposes to include quantitative biomass estimates of soil and epiphytic and floating periphyton. A 1 m^2 throw trap will be used to collect floating and epiphytic periphyton. Each type of periphyton will be removed by hand and transferred to a perforated plastic 1000 ml volumetric cylinder. The volumetric to dry weight ratios will be determined for the pilot study and each systemwide survey and compared to similar ratios developed by J. Trexler and B. Loftus (personal communication). The quantity of soil periphyton will be determined during the soil core sampling from which the soil periphyton can be removed as a complete sample. Following the pilot study, standard macrophyte and periphyton sampling protocols will be reported in the results of the pilot study and submitted for peer review.

12.3.4 Food Habits Analysis

A strong north to south gradient in the BAF calculated for Hg uptake in mosquitofish was found during Phase I research and monitoring of the Everglades ecosystem. This discovery has led to the hypothesis that a series of important interactions are occurring in the system primarily

affected by phosphorus loading from the north, which impacts the food chain dynamics in the system. One means of assessing these impacts is to analyze the food habits of the omnivorous mosquitofish across the system. This was done once during the September 1996 marsh survey and will be repeated again in the pilot study, and both dry and wet sampling cycles in 1999. Twelve to fifteen individual fish will be analyzed at each site for stomach contents. These data will be used in a comparative study with the 1996 food habits analysis to develop an understanding of how changes in the food chain may affect the habits and uptake of this ubiquitous fish species across the system.

12.4 Monitoring & Assessment Indicators

The three laboratories utilized in Phase I (FIU-SERP, Battelle MSL, and USEPA-SESD) will analyze the comprehensive array of samples of water, soil, and tissue (plants and fish) and conduct the routine QA/QC requirements in Phase II. FIU-SERP will continue as the primary analytical laboratory for this project and provide the facility from which the USEPA field sampling team will stage field activities. The methods previously developed by FIU-SERP for Phase I will be utilized in Phase II to maintain continuity of results. FIU-SERP will assist USEPA in the testing and development of new field sampling and analytical methods during the pilot study in January 1999. New methods for Phase II include development of pore water sampling, dissolved nutrients and selected anions, sulfate/sulfide ratios, methane and CO_2 in soil, diatom species composition, periphyton pigment analyses and macrophyte Hg analyses.

All sampling and analyses to be carried out during the next cycles of the study will be tested and proven during the pilot study. The pilot study analytes will include THg, MeHg, TP, TN, dissolved nutrients (NH_4, NO_2, NO_3, PO_4), TOC, sulfate, and sulfide in surface water; TP, TN, dissolved nutrients, selected anions (Br, Cl, F, NO_2, NO_3, O-p, TSO_4), and sulfide in pore water; THg, MeHg, sulfate, sulfide, TP, CH_4, and CO_2 in soil; THg, MeHg, and EtHg in floating and soil, periphyton; THg, MeHg, and EtHg in sawgrass and cattails; and THg in mosquitofish.

Selected media collected during the pilot study will be composited and split with equal amounts of water, soil or tissue going to each laboratory. The mosquitofish will be analyzed as individual fish (7 per sample) as well as a homogenate for QA/QC purposes. For certain

parameters, each laboratory will analyze three replicates of each sample for each station to provide a statistically valid data set on which to conduct an analysis of the interlaboratory calibration. USEPA SESD Ecological Assessment Branch (EAB) field sampling team will be responsible for "clean" sample collection, splits will be conducted in the FIU-SERP laboratory and the EPA/Environmental Services Assistance Team (ESAT) field team will be responsible for ensuring chain-of-custody, sample tracking, and shipping of blind, split, duplicate and replicate samples to each laboratory. The data will be returned to FTN Associates, Ltd. (FTN) of Little Rock, Arkansas, who will be responsible for statistical analysis of the data and report preparation and presentation to EPA Region 4 SESD Office of Quality Assurance (OQA) for final review to ensure the QA/QC requirements have been fulfilled. Following protocol testing in the pilot study the same methods will be applied in the systemwide surveys.

A list of the pilot study (interlaboratory calibration) samples indicating the analyte, subarea, analyzing laboratory and the number of samples to be analyzed by each laboratory is presented in Table 12.1. A complete list of the analytical parameters by laboratory, MDL, and number of samples to be analyzed per survey cycle are listed in Table 12.2. Ten percent of the samples in each analyte will be replicated for QA/QC purposes.

12.5 Statistical Analyses

Numerous opportunities exist to develop both design-based and model-based statistical analyses of the data requiring the development of new statistical methods. Design-based analyses require methods for assessing the uncertainty of statistical summaries such as provided by cdfs. In addition, methods are required for evaluating the current sampling designs to ensure that adequate power is achieved to answer the objectives of the respective monitoring initiatives. Model-based analyses require the development of models that mimic the complex processes that occur in nature. Environmental processes are complex, involving interactions of numerous biotic and abiotic factors over different spatial and temporal scales. Spatio-temporal models will be developed for these data that take into consideration processes occurring at all spatial and temporal scales including habitat, Hg, and water quality indicators. Methods for combining data

Table 12.1 Everglades Jan '99 Pilot Study and Laboratory Intercalibration (triplicate analysis).

Sites Parameter	LOX	AA-N	WCA3-C	WCA3-S	ENP-N	ENP-S
Surf-Water						
Turbidity	1,3	1,3	1,3	1,3	1,3	1,3
APA	1	1	1	1	1	1
Chlorophyll *a*	1	1	1	1	1	1
THg	1,2	1,2	1,2	1,2	1,2	1,2
MeHg	1,2,	1,2	1,2	1,2	1,2	1,2
TP	1,3	1,3	1,3	1,3	1,3	1,3
TN	1,3	1,3	1,3	1,3	1,3	1,3
Diss. Nut-NH_4,NO_2,NO_3, PO_4	1,3	1,3	1,3	1,3	1,3	1,3
TOC	1,3	1,3	1,3	1,3	1,3	1,3
TSO_4	1,3	1,3	1,3	1,3	1,3	1,3
H_2S	1,3	1,3	1,3	1,3	1,3	1,3
Porewater						
TP	1,3	1,3	1,3	1,3	1,3	1,3
TN	1,3	1,3	1,3	1,3	1,3	1,3
Diss. Nut-NH_4,NO_2,NO_3,PO_4	1,3	1,3	1,3	1,3	1,3	1,3
Selected Anions	1,3	1,3	1,3	1,3	1,3	1,
TSO_4	1,3	1,3	1,3	1,3	1,3	1,3
H_2S	1,3	1,3	1,3	1,3	1,3	1,3
Soil						
THg	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3
EtHg	1	1	1	1	1	1
MeHg	1,2	1,2	1,2	1,2	1,2	1,2
TSO_4	1,3	1,3	1,3	1,3	1,3	1,3
H_2S	1,3	1,3	1,3	1,3	1,3	1,3
APA	1	1	1	1	1	1
AFDW	1	1	1	1	1	1
Bulk Den.	1	1	1	1	1	1
Min. Conc.	1	1	1	1	1	1
TP	1,3	1,3	1,3	1,3	1,3	1,3
CH_4&CO_2	1,3	1,3	1,3	1,3	1,3	1,3

Table 12.1 (Continued).

Sites Parameter	LOX	AA-N	WCA3-C	WCA3-S	ENP-N	ENP-S
Peri-F						
THg	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3
MeHg	1,2	1,2	1,2	1,2	1,2	1,2
EtHg	1	1	1	1	1	1
Diatom comp.	1	1	1	1	1	1
Pigment	1,3	1,3	1,3	1,3	1,3	1,3
Peri-S						
THg	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3
MeHg	1,2	1,2	1,2	1,2	1,2	1,2
EtHg	1	1	1	1	1	1
Diatom Comp.	1	1	1	1	1	1
Pigment	1	1	1	1	1	1
Sawgrass						
THg	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3
MeHg	1,2	1,2	1,2	1,2	1,2	1,2
EtHg	1	1	1	1	1	1
Cattails						
THg	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3
MeHg	1,2	1,2	1,2	1,2	1,2	1,2
EtHg	1	1	1	1	1	1
Fish						
THg-indiv.	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3
THg-homo	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3	1,2,3

1 - FIU-SERP
2 - BATTELLE
3 - EPA-SESD

Table 12.2 Proposed REMAP Phase II parameters by cycle.

Parameter	Primary Lab	Primary QA/QC	Secondary QA/QC	MDL	Site No. Per Cycle	Samp No.
SURFACE WATER						
DO	SESD	SESD-SOP		0.2 mg/L	129	129
pH	SESD	SESD-SOP		0.1 s.u.	129	129
Temp	SESD	SESD-SOP		0.15 C	129	129
Conductance	SESD	SESD-SOP		1.0 uS	129	129
Eh	SESD	SESD-SOP		1 mV	129	129
Depth	SESD	SESD-SOP		1 cm	129	129
Turbidity	FIU	SESD		0.1 NTU	129	155
TP	FIU	SESD		0.6 ug/L	129	155
TN	FIU	SESD		0.03 mg/L	129	155
Dissolved Nutrients * (NH_4,NO_2, NO_3, PO_4)	FIU	SESD		NO3-0.4ug/L NO2-0.1ug/L NH4-0.7ug/L SRP-0.3ug/L	129	155
TOC	FIU	SESD		0.12 ug/L	129	155
Sulfate	SESD	SESD		0.01 mg/L	129	155
Sulfide*	SESD	SESD		0.01 ug/L	129	155
APA	FIU	FIU		0.01uM/h	129	155
Chlorophyll *a*	FIU	FIU		0.1 ug/L	30	33
THg	FIU	Battelle	SESD	0.3 ng/L	129	187
MeHg	Battelle	FIU		0.02 ng/L	129	187
PORE WATER						
TP*	FIU	SESD		0.6 ug/L	129	171
TN*	FIU	SESD		0.03 mg/L	129	155
Dissolved Nutrients * (NH_4, NO_2, NO_3, PO_4)	FIU	SESD		NO3-0.4ug/L NO2-0.1ug/L NH4-0.7ug/L SRP-0.3ug/L	129	155
Anions * (Br,Cl,Fl,NO_2,NO_3,O-p,TSO_4)	FIU	SESD		ion chrom.	129	155
Sulfate	SESD			0.01 mg/L	129	171
Sulfide*	SESD	SESD		0.01 ug/L	129	171
SOIL/SEDIMENT						
Type	SESD				129	129
Thickness	SESD			1 cm	129	129
pH	SESD				129	129
Eh (in situ)	SESD			1 mV	129	129
Eh (lab)*	SESD			1 mV	129	129
THg	SESD	FIU	Battelle	3 ug/kg	129	155

Table 12.2 (Continued).

Parameter	Primary Lab	Primary QA/QC	Secondary QA/QC	MDL	Site No. Per Cycle	Samp No.
SOIL/SEDIMENT (Continued)						
MeHg	FIU	Battelle		0.2 ug/kg	129	155
EtHg	FIU			0.2 ug/kg	129	155
Sulfate	SESD			0.01 ug/kg	129	155
Sulfide*	FIU			0.01 ug/kg	129	155
TP	FIU	SESD		0.06 mg/kg**	129	155
Ash Free Dry Wt	FIU			0.02 mg/kg**	129	155
Bulk Density	FIU			0.001 g/cc**	129	155
Mineral Content	FIU			3%	129	155
CH_4*	FIU	SESD			129	155
CO_2*	FIU	SESD			129	155
APA	FIU	FIU			129	155
PERIPHYTON--floating						
THg	FIU	SESD	Battelle	3 ug/kg	100	110
MeHg	FIU	Battelle		0.2 ug/kg	100	110
EtHg	FIU			0.2 ug/kg	100	110
Biomass*	SESD			1 g	100	110
Surface Area* (%cover)	UGA				50	
Diatoms*	FIU				30	33
Pigments*	FIU				30	33
PERIPHYTON-soil						
THg	FIU	SESD	Battelle	3 ug/kg	100	110
MeHg	FIU	Battelle		0.2 ug/kg	100	110
EtHg	FIU			0.2 ug/kg	100	110
Biomass*	SESD			1 g	100	110
Diatoms*	FIU				30	33
Pigments*	FIU				30	33
SAWGRASS						
THg*	FIU	SESD	Battelle	3 ug/kg	65	72
MeHg*	FIU	Battelle		0.2 ug/kg	65	72
EtHg*	FIU			0.2 ug/kg	65	72
Biomass*	SESD			10 g	65	72

Parameter	Primary Lab	Primary QA/QC	Secondary QA/QC	MDL	Site No. Per Cycle	Samp No.
Surface Area* (% cover)	UGA				65	

Table 12.2 (Continued).

Parameter	Primary Lab	Primary QA/QC	Secondary QA/QC	MDL	Site No. Per Cycle	Samp No.
CATTAILS						
THg*	FIU	SESD	Battelle	3 ug/kg	40	44
MeHg*	FIU	Battelle		0.2 ug/kg	40	44
CATTAILS (Continued)						
EtHg*	FIU			0.2 ug/kg	40	44
Biomass*	SESD			10 g	40	44
Surface Area* (% cover)	UGA				40	
Habitat Evaluation * (% cover, pres/absence)	UGA				129	129
Mosquito-Fish						
THg	FIU	SESD	Battelle	1 ug/kg	129	1043
Length	FIU			0.1 mm	129	993
Weight	FIU			0.05 g	129	993
Sex	FIU				129	993
Food Habits Analysis	FIU				129	993

* = new parameter
** = minimum reportable quantities
THg in water = 129 sites, 16 field blanks, 13 duplicates, 16 equip. blanks, 13 splits = 187
Porewater (nutrients/anions) = 129 sites, 13 dups, 16 equip blanks, 13 splits = 171
THg in soil = 129 sites, 13 dups, 13 splits = 155
THg in fish = 129 sites @ 7 fish/site = 903, 90 dups, 50 stand. tissue = 1,043

collected at different spatial and temporal scales and trophic levels will be tested as will methods required for analyzing spatially and temporally correlated data when some observations are left-censored by the detection limits of instruments used to measure contaminants. This support will be provided by EMAP contract support and the University of Georgia, Statistics Department.

12.6 QA/QC Requirements

12.6.1 Data Quality Requirements and Validation

In all data collection activities, data quality requirements will be specified in seven areas: (1) accuracy and bias, (2) precision, (3) comparability, (4) completeness, (5) representativeness, (6) tolerable background levels, and (7) DQOs (Stanley and Verner 1985, Smith et al. 1988). Method detection limits have been specified based on the Phase I REMAP monitoring and some have been lowered where lower detection levels are needed. The validation process will consider each of the following components using a statistically appropriate method.

- **Accuracy and Bias** - Accuracy is the degree to which a measured value or property agrees with an accepted "true" value (Taylor 1988). Accuracy is estimated by measuring a sample with a known reference value. Bias is the systematic error inherent in a method or caused by some artifact or idiosyncrasy of the measurement system. One-way bias is estimated by interlaboratory comparison of performance evaluation samples among laboratories**.**
- **Precision** - Precision is a measure of the scatter among independent repeated observations or measures of the same property made under prescribed conditions (Taylor 1988). Precision can be estimated at several points in the data collection process in order to estimate the effects of different sources of error. Precision can be partitioned into analytical and measurement system precision. Analytical precision refers to precision of the analysis performed by analytical instruments; it is estimated by laboratory replication, including replicates of performance audit samples. Measurement system precision refers to the precision of the sampling process, including sample collection, storage, transport, preparation, and analysis. Collocated field duplicates are used to estimate precision of the entire measurement system, and laboratory splits are used to estimate the precision of sample processing after the sample has been received at the laboratory.
- **Comparability** - Comparability is defined as "the confidence with which one data set can be compared to another" (Stanley and Verner 1985, Smith et al. 1988). Comparability studies will be conducted with cooperating laboratories and

agencies through round robin analyses. Identical field collection and laboratory procedures will be used when possible**.**

- **Completeness** - Completeness requirements for this monitoring effort will be that 90% of all proposed samples are collected and analyzed**.**
- **Representativeness** - Representativeness is defined as "the degree to which the data accurately and precisely represent a characteristic of a population parameter, a variation of a property, a process characteristic, or an operation condition" (Stanley and Verner 1985, Smith et al., 1988). The statistical survey, sampling periods and sample locations were selected to ensure representative samples**.**
- **Tolerable Background Levels** - Background is operationally defined as the amount of contamination due to collection, handling, processing, and measurement. It is particularly relevant to the measurement of trace concentrations of Hg species. Background levels will not be tolerated due to the use of "clean sampling and analytical techniques" and if detected the source will be isolated and eliminated. Field and laboratory blank samples will be added to each day's samples and used to control and eliminate background contamination.
- **Data Quality Objectives** - The assessment of DQOs will follow the guidance provided in EPA QA/G-4 (EPA 1994) or a revision intended for research projects that is currently under development. This assessment of the data will be compared after the pilot study and each cycle of spatial sampling for conformance to the Phase I results. Deviations with Phase I results will be investigated and the most probable explanation developed. The overall goal of maintaining consistency in the database between Phase I and Phase II is most important to provide the most accurate basis for trend assessments.

Precision and bias are estimates of random and systematic error in a measurement process (Kirchner 1983, Hunt and Wilson 1986). Collectively, they provide an estimate of the total error or uncertainty associated with an individual measurement, or set of measurements. Estimates of the various error components will be determined primarily by replicate sampling. The statistical design and sampling plan will minimize systematic errors in all components except measurement error by using documented methodologies and standardized procedures. If new more sensitive methods must be developed or analytical modifications made documentation will be provided as the process moves toward standardization. In addition, standard samples will be included in the field and subjected to the entire collection and measurement process. Variance components of the collection and measurement process (e.g., among analytical laboratories) will be estimated after

the pilot study and at the completion of each cycle so the QA efforts can be allocated to control major sources of error.

12.6.2 Specific Data Package Requirements

The specific requirements for laboratories that submit results and data packages to the USEPA Region 4, SESD for validation are contained in the document entitled *Laboratory Documentation and Quality Control Requirements for Data Validation, August 1998*. These requirements must be addressed in the laboratory's QA plan, which must be approved by the SESD OQA prior to the initiation of sample analysis. All data reported from each analytical laboratory for Phase II will be transmitted in electronic format (variable by numeric station ID indicating analytical batch order and all other required QA information) in either Excel, Quattro Pro, or dBase IV. Any additional format requirements will be specified by EPA prior to initiation of the data collection. FTN will be the initial repository for the data who will compile the database and conduct the initial QA/QC review of the data.

12.8 Mercury Modeling

A Hg screening model has been developed by EPA ORD NERL-Athens for the South Florida Everglades ecosystem (Ambrose et al. 1998). The model encapsulates the current understanding of processes contributing to Hg cycling within the marsh ecosystem and permits preliminary evaluations of selected management strategies for ecosystem restoration. This screening model also provides output that is used as input for the BASS model (Barber 1998). BASS is a bioenergetics model that describes the bioaccumulation, depuration, and biomagnification of Hg through the food chain to piscivorous fish. The data developed in this project will allow additional simulations with the Hg screening and BASS models to evaluate selected hypotheses and alternative pathways for Hg bioaccumulation**.** These data will support the USEPA ORD NERL-Athens Everglades Mercury Cycling model currently under development.

12.9 Comparative Ecological Risk Assessment

The EPA Ecological Risk Assessment Framework (EPA 1992,1998) has served as the guidance for the monitoring and research studies conducted under this program. A Visual Basic model, known as VB-EcoRisk, has been developed to serve as an organizing structure for conducting the comparative ecological risk assessment (Thornton et al. 1995). Information from this program, the SFMSP, and other sources will be analyzed and integrated into the VB-EcoRisk model by EPA Region 4 as a part of this project. A relative, comparative ecological risk assessment is critical for the Everglades because of the multiple, interacting issues, in addition to Hg, associated with ecological restoration of the Everglades. A relative ranking approach will be used to assess risk so that disparate effects from different stressors (e.g., hydropattern modification, nutrient loading, etc.) can be compared. An interim ecological risk assessment by FTN is scheduled for completion in 1999.

12.10 Ecosystem Restoration Modeling and Assessment

In addition to providing information critical for a better understanding of mercury contamination in the Everglades ecosystem, Phase II of this project will simultaneously provide information useful for a variety of ongoing ecosystem restoration modeling and assessment efforts. For example, the systemwide phosphorus condition information for marsh water and soil will be useful for tracking the ongoing effectiveness of Phase I phosphorus control efforts and for bettering models used to predict vegetation response to soil phosphorus. Dry season and wet season water depth information will be useful for verification of hydrologic models, such as the South Florida Water management Model, that are being used to select Everglades restoration alternatives. Systemwide nutrient, macrophyte biomass, and periphyton biomass data can be used as model input for the Everglades Landscape Model, a regional scale ecological model designed to predict landscape response to different water management scenarios. Phase II of the project will be the first scientific effort to provide this wide variety of information on a systemwide basis. This collective monitoring is vital for providing baseline information for evaluating the effectiveness of USACE Restudy Everglades ecosystem restoration project.

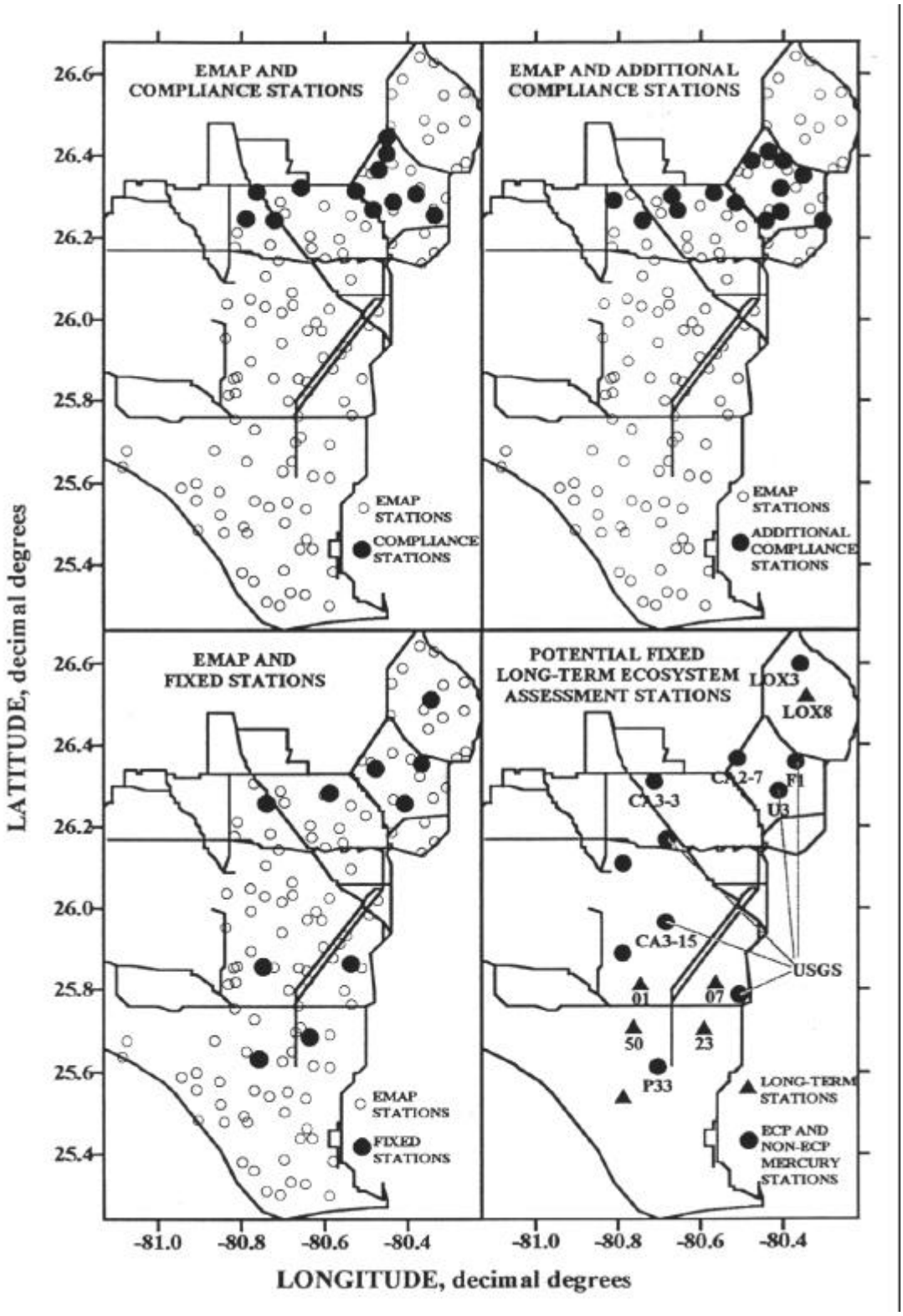

Figure 12.1 Potential monitoring network configurations combining probability, compliance and fixed sites.