COASTAL CHARLOTTE HARBOR MONITORING NETWORK

DESCRIPTION AND STANDARD OPERATING PROCEDURES

Prepared by Catherine A. Corbett

CHARLOTTE HARBOR NATIONAL ESTUARY PROGRAM

TECHNICAL REPORT 02-03

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ACKNOWLEDGEMENTS

Many organizations and individuals contributed to this document. W. Dexter Bender and Associates, Inc. developed, with the insightful comments and help of the Charlotte Harbor National Estuary Program's Management Conference members, the *Charlotte Harbor National Estuary Program Long Term Monitoring Strategy and Gap Analysis* (2000) of which much of this document is based. The overall program design for water quality monitoring in the coastal areas of the Charlotte Harbor watershed was, in turn, based in part on *A Long-Term Water Quality Monitoring Design for Charlotte Harbor, Florida* by Coastal Environmental, Inc. for the Southwest Florida Water Management District (1995). The current regional monitoring program was developed by Charles Walters (Charlotte County), David Tomasko (SWFWMD), Mark Hammond (SWFWMD), Gerold Morrison (CHEC), Dave Moldal (CHNEP), Rebecca Hensley (FWC-FMRI), Michael Tisch (Charlotte County), Alton Cheatham (CHEC), Judy Ott (DEP-CHASBP), Catherine Corbett (CHNEP), Elizabeth Staugler (formerly of DEP-CHASBP), Keith Kibbey (Lee County Environmental Lab), Connie Jarvis (City of Cape Coral), James Evans (City of Sanibel), Peter Doering (SFWMD), Dan Crean (SFWMD), Matt Giles (SFWMD), Karen Bliss (Charlotte County), Dan Quick (Charlotte County) and Tiffany Lutterman (CHNEP). Catherine Corbett (CHNEP) prepared the text of this document. Rebecca Hensley (FWC-FMRI) created the initial Standard Operating Procedures, and these procedures were then modified with considerable input from the aforementioned persons. The Long Term Monitoring Strategy section was taken from the NEP document noted above. The current water quality monitoring section was developed by Catherine Corbett (CHNEP) with substantial help from Paul Hansard (DEP); Sam Stone (Peace River/ Manasota Region Water Supply Authority); Roberta Starks, Dave Tomasko and Chris Anastasiou (SWFWMD); Greg Blanchard (Manatee County); Joe King and Diane Gibson (Polk County); Keith Kibbey (Lee County); Judy Ott and Betty Staugler (DEP-CHASBP); John Ryan (Sarasota County); Matt Giles and Peter Doering (SFWMD); Joseph Boyer (FIU) and Connie Jarvis (City of Cape Coral). Tim Walker (SWFRPC) and Catherine Corbett (CHNEP) developed the report graphics. Finally, Bob Diogo (SWFRPC) and Lisa Beever (CHNEP) were of tremendous help with GIS and report graphics.

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INTRODUCTION

In February 2000 the Comprehensive Conservation and Management Plan (CCMP) for the Charlotte Harbor National Estuary Program (NEP) was approved by the Management Conference. Included with this management plan is a long-term monitoring strategy to track status and trends of fish and wildlife habitat, hydrologic and water quality conditions for the greater Charlotte Harbor watershed. This long-term strategy recommends a stratified, random sampling design based on the U.S. Environmental Protection Agency's Environmental Monitoring and Assessment Program (EMAP) for the region's coastal water quality programs.

This document provides an explanation of the Long Term Monitoring Strategy approved by the Charlotte Harbor NEP's Management Conference in 2000 and a regional program that helps implement this strategy. The regional program is a cooperative, inter-agency program consisting of the Southwest and South Florida Water Management Districts; Charlotte and Lee Counties; the Florida Department of Environmental Protection-Charlotte Harbor Aquatic Preserves; the Florida Fish and Wildlife Conservation Commission-Florida Marine Research Institute and the Cities of Cape Coral and Sanibel. Whereas the NEP's monitoring strategy requests a program with 6 strata that monitors 30 randomly chosen sites twice a year, this program divides the coastal areas of the watershed into 12 strata that monitors 5 randomly chosen sites within each strata for the core analytes in the CCMP on a monthly basis.

BACKGROUND

In 1995, Governor Lawton Chiles nominated Charlotte Harbor as an *"estuary of national significance*." As a result of this nomination, Charlotte Harbor was accepted into the National Estuary Program, one of only 27 other watersheds in the United States. The Charlotte Harbor National Estuary Program is a partnership of citizens, elected officials, resource managers, and commercial and recreational resource users working to improve the water quality and ecological integrity of the greater Charlotte Harbor watershed. A cooperative decision-making process is used within the program to address diverse resource management concerns in the 4,400 square mile study area.

The mission of the Charlotte Harbor National Estuary Program is to first bring together all of the local organizations, both public and private, into a "management conference" to write a *Comprehensive Conservation and Management Plan (CCMP)* for the watershed. On February 11, 2000, the CCMP was approved by the program's Management Conference, and in Spring 2001 it was approved by the U.S. Environmental Protection Agency. The plan details the actions needed to protect and improve the greater Charlotte Harbor watershed and includes a long term monitoring strategy to keep track of the

status of the region's natural resources and pick up future trends. With the approval of the management plan, the NEP management conference members have begun the arduous task of implementing the goals in the CCMP, including its monitoring strategy.

Charlotte Harbor itself only covers 270 square miles, but the Greater Charlotte Harbor Watershed extends over an area of 4,400 square miles. The study area includes all or part of eight counties and many cities and towns. Two water management districts — Southwest Florida and South Florida — have jurisdiction over water supply and flood control in the Charlotte Harbor NEP study area. Regional and emergency planning are conducted by three regional planning councils, and two districts of the Florida Department of Environmental Protection perform environmental regulation, park management, enforcement, and aquatic preserve management. This large study area and the interconnected jurisdictions of the public and private institutions have created both management opportunities as well as critical gaps in the complex legal and organizational framework. One of the major goals of the Charlotte Harbor NEP is to help facilitate inter-agency cooperation and coordination to utilize the region's assets for more collaborative natural resources management and research, including the area's monitoring programs.

Water quality monitoring programs in the region usually consist of fixed stations that are designed to sample for analytes and in areas that are of interest to the various monitoring agencies. For example, some State monitoring programs consist of background sites upriver of a point-source discharge and then others that are placed downstream of this discharge in the contaminant plume to estimate the pollutant loadings to the water body from this point-source. This monitoring design only lends itself to assumptions of the point-source and its immediate effects on that area of the water body. It would be very problematic statistically to make assumptions about the larger water body itself from the use of the data collected from this program. However, the data can be very useful information for the enforcement of the Department of Environmental Protection's permitting regulations.

In addition, between the various monitoring agencies, the number of individual monitoring sites, the frequency of the collection and the sampled analytes at each site are highly variable, depending on the resources of each individual agency. Monitoring agencies also often use different protocols for lab analysis and sample collection. These inconsistencies can result in data gaps and incomparable data across basins.

The creation of the Southwest Florida Regional Ambient Monitoring Program (SWF-RAMP) in the early 1990s, the Southwest Florida Consortium in the late 1990s and the Charlotte Harbor Regional Ambient Monitoring Program (CH-RAMP) have increased the inter-governmental coordination in sampling methodologies and monitoring sites for the southwest Florida region as a whole.

These programs include two Water Management Districts (South and Southwest Florida), the Florida Department of Environmental Protection, the National Park System (Big Cypress NP) and local city and county governments from Hillsborough to Monroe Counties. The SWF-RAMP includes the monitoring agencies for the greater watersheds of Tampa and Sarasota Bays and Charlotte Harbor, while the Southwest Florida Consortium included the agencies monitoring the Caloosahatchee basin on south to the Keys. The Consortium essentially folded into the SWF-RAMP. The CH-RAMP was established in 2000 as a subcommittee of the NEP to implement the NEP's Long Term Monitoring Strategy for the greater Charlotte Harbor watershed and provide some coordination between the other two groups. The overlapping groups have tremendously helped strengthen data comparability between the area's monitoring agencies through their efforts to increase sampling and lab analyses consistencies. The groups also have made great strides to reduce sampling site redundancies in the region as well.

AMBIENT WATER QUALITY MONITORING EFFORTS IN CHARLOTTE HARBOR

The map of water quality monitoring sites in Figure 1 below was compiled by the Charlotte Harbor-Regional Ambient Monitoring Program, a subcommittee of the Charlotte Harbor NEP, in 2000. Members of this subcommittee include Charlotte, Lee, Polk, Manatee and Sarasota counties; the Cities of Cape Coral, Sanibel and Punta Gorda; the Peace River/Manasota Region Water Supply Authority; the Department of Environmental Protection and both the South and Southwest Florida Water Management Districts. All of these entities have water quality monitoring programs that sample for the various core analytes in the NEP's CCMP on different frequencies. A brief description of each follows:

CHEVWQMN—The Charlotte Harbor Estuaries Volunteer Water Quality Monitoring Network—This program is managed by the Department of Environmental Protection, Charlotte Harbor Aquatic Preserves in Punta Gorda. There are over 100 volunteers that take monthly water quality samples at approximately 40-44 fixed stations from Lemon Bay, Charlotte Harbor and southward to Estero Bay. This program started in 1996.

City of Cape Coral—This program is managed by the City's Environmental Resources Division. There are 33 sites sampled on a monthly basis. Samples are also collected twice annually for metals and yearly for pesticides.

Canalwatch-- The Canalwatch program is a proactive component of the Cape Coral's canal management program and is a volunteer effort that effectively screens large portions of the City for potential

canal problems. Canalwatch volunteers act as sentinels for any emerging problems in the canal system. Currently there are forty-three sampling sites, nine are located on freshwater canals and the remainder on saltwater canals. Since May of 1995, on the first Wednesday of the month, Canalwatch volunteers from around the City take a 1-liter water sample from their canals. The samples are brought to the lab and analyzed for nitrites, nitrates, ammonia, and phosphates. Sampling day volunteers record Secchi depth (water clarity), weather conditions, and site conditions. During the month they are asked to collect rainfall data and to note any wildlife activity or other activity on the canal.

City of Punta Gorda—This program is a requirement of the consumptive use permit with the Southwest Florida Water Management District for the City's Water Treatment Facility. The program monitors 6 fixed sites for chemistry and some physical parameters (see PRMRWSA information below for more detailed description) within Shell Creek, 1 site at the confluence of the Peace River and Shell Creek, and 1 site above and below each the mouth of Shell Creek within the Peace River on a monthly frequency since 1991. The City and the PRMRWSA coordinate their water quality monitoring programs for data comparability.

Lee County—This program, managed by the County's Environmental Lab, samples 14 sites on a monthly basis at fixed stations equally distributed around Pine Island throughout Pine Island Sound and Matlacha Pass as well as at 14 fixed sites in Estero Bay. The County also runs a new atmospheric deposition monitoring station on Lover's Key that collects both wet and dry nitrogen deposition rates.

Pondwatch—This program is a volunteer monitoring program created in 1993 by the Lee County Hyacinth Control District to help residents manage ponds and lakes and to answer their concerns about problems related to aquatic weeds in Lee County. Both seasonal and permanent residents participate in the program, averaging 10 – 15 per month. Water samples are collected monthly and brought to the District's water quality laboratory for chemical analysis of total phosphorus, orthophosphate, ammonia, nitrites-nitrates, and chlorophyll *a*. Some of the benefits experienced by some participating groups have been a reduction of the chemical control required to maintain the ponds. Other communities have followed recommendations for aeration systems minimizing the potential for stratification and dissolved oxygen problems.

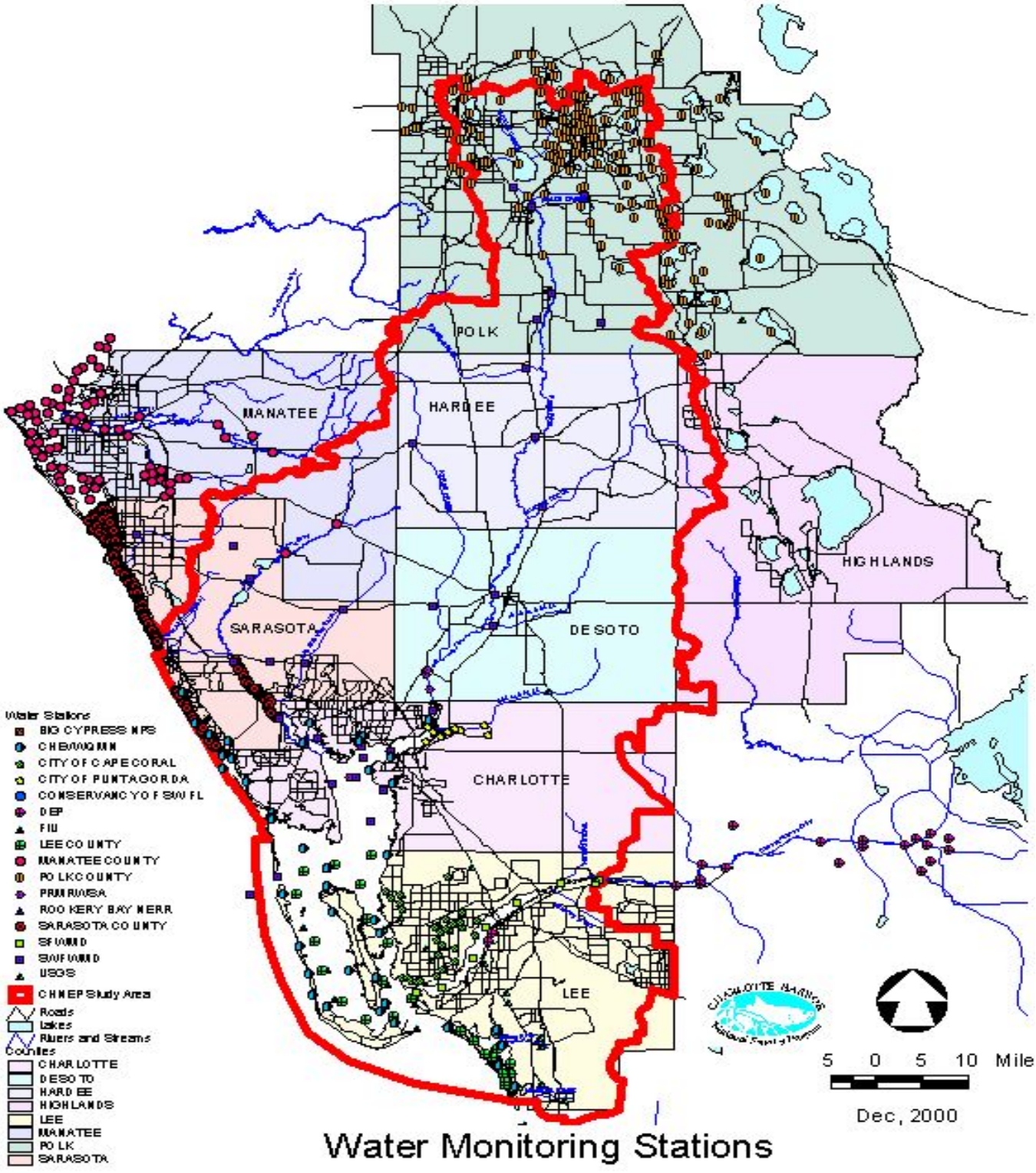
Manatee County—The County's ambient monitoring program samples two fixed sites in the upper Myakka River on a monthly basis. With the advent of TMDL development for the Myakka River in 2001, the County added an additional bi-weekly sampling at 9 stations in the Myakka watershed. These stations extend from the headwaters to the County line and include several major tributaries.

Polk County—This program monitors sections of the Peace River basin, including Saddle and Peace Creeks, Lake Hancock and the Winter Haven Chain of Lakes on a quarterly basis. The number of fixed stations in the upper peace watershed varies between 27 - 33 sites per year. The data is then reported annually in the County's Annual Lakes and Streams Report. Special projects also augment these data.

See also Florida LakeWatch Program, which is active in monitoring the lakes within this County at http://lakewatch.ifas.ufl.edu.

Sarasota County— This program was initiated in 1995. The County was divided into 12 segments that contain approximately 5 stations per month. The program sites were randomly chosen, and over 51 sites within the entire County are sampled every month. During the subsequent month, another 51 sites are sampled, so that by the end of the year, a total of 612 sites are sampled (the number of sites may change annually depending on resources). Randomization was done only once, so all 612 sample locations are sampled once every year. Each site is re-sampled every year in the same month as the preceding years. This randomized, stratified monitoring program characterizes overall estuarine health by describing entire bay and river segments rather than isolated locations in each water body.

Aqueous samples are taken from mid-depth from the entire coastal estuarine system in Sarasota County, including Sarasota Bay, Roberts Bay (Sarasota), Little Sarasota Bay, Blackburn Bay, Lyons Bay, Dona Bay, Roberts Bay (Venice), Lemon Bay and the estuarine portion of the Myakka River. Dataloggers are deployed at the same stations defined by the sampling program. Datalogger site selection produces a balanced distribution of data from throughout the study area. Two dataloggers are deployed monthly to measure temperature, salinity, dissolved oxygen concentration, percent oxygen concentration, pH, and specific conductance at 15 minute intervals for at least one complete 24-hour period. Field meter readings are taken at top, middle and bottom depths.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MANATEE
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SARASOTA
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CONSERVANCY OF SW FL
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LEE COUNTY
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POLK COUNTY
PRMRWSA
ROOKERY BAY NERR
SARASOTA COUNTY
SFWMD
SWFWMD
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CHNEP Study Area
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HIGHLANDS
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Water Monitoring Stations

FIGURE 1.

SFWMD—South Florida Water Management District—This program in the Caloosahatchee River was established in April 1999. The program monitors 4 fixed sites on a monthly frequency through a contract with Lee County Environmental Lab (the SFWMD has sampled 8 sites off and on since the late 1980s; the 4 chosen for this program were part of the original 8 sites). Water quality data are used to produce annual technical reports on the current status and trends of several nutrients and physical attributes of the system, provide supporting data for water supply modeling and contribute to a growing body of regional data made available to all interested parties.

PRMRWSA—Peace River/Manasota Region Water Supply Authority—This program, initiated in 1976, was developed by the Southwest Florida Water Management District and General Development Utilities, Inc. for the Water Supply Authority's consumptive use permit. The program was designed to evaluate the impacts and significance of natural salinity changes on the aquatic fauna and flora in upper Charlotte Harbor and to determine if freshwater withdrawals by the Authority could be shown to alter these patterns.

The program includes U.S.G.S 15-minute interval water level recorders at Boca Grande, Harbour Heights and just downstream of the Peace River Facility. These latter two gages also provide surface and bottom conductivity information at 15-minute intervals. Monthly chemical and physical water quality measurements are conducted at 4 "moving" salinity-based isohaline locations (0,6,12 and 20 ppt) along a river kilometer center-line, running from the mouth of the Peace River upstream to above its junction with Horse Creek, and downstream to Boca Grande Pass. Monthly water column physical profiles are conducted at 16 locations along a transect running from just below the river's mouth upstream to a point just above the Peace River Facility. Chemical water quality samples are collected at 5 of these locations also. Finally, both the "moving" and fixed stations include physical *in situ* water column profile measurements (temperature, dissolved oxygen, pH, conductivity and salinity) at 0.5-meter intervals from the surface to the bottom and light attenuation (PAR—photosynthetically active radiation) information.

SWFWMD—Southwest Florida Water Management District—This program was initiated in 1997 and currently monitors 11 fixed stations in the Peace River basin and 5 fixed stations in the Myakka River basin on a monthly basis. The District also collects field data for 16 fixed sites on a monthly basis in Flatford Swamp in the upper Myakka watershed. SWFWMD also had numerous monthly sampled, fixed sites within the harbor itself that were revamped into the program described herein.

EPA—The U.S. Environmental Protection Agency's Environmental Monitoring and Assessment Program (EMAP) has initiated a monitoring effort in the Southwest Florida area, formerly called Coastal 2000. The objectives of the Coastal 2000 National Coastal Survey are: (1) to create an integrated comprehensive coastal monitoring program across the Nation's coastlines to assess the condition of the estuarine and coastal waters at the National, State, and Tribal scales; (2) to estimate the condition of estuarine resources for the United States, the 24 coastal states, Puerto Rico, and appropriate coastal Tribal Nations; and (3) to complete this objective with as little modification to existing State programs as possible.

In 2000-2001, all 24 coastal states in the United States, and Puerto Rico were sampled to estimate the condition of their estuarine resources. The minimum number of sampling locations in each state and Puerto Rico will be 50 sites located through a probabilistic design. EPA through an agreement with FWC-FMRI collected biotic condition indicator, exposure indicator, habitat indicator and stressor indicator information for Charlotte Harbor. Depending on resources, the Harbor will be re-sampled for the Coastal Assessment in future years.

EXPLANATION OF THE FLORIDA DEPARTMENT OF ENVIRONMENTAL PROTECTION PROGRAMS

In 1996 FDEP formed the **Integrated Water Resource Monitoring (IWRM) Committee** to develop strategies and techniques for implementing an integrated monitoring plan that would combine surface water, groundwater, and biological monitoring. The U.S. Environmental Protection Agency (EPA), FDEP, water management districts, and local governments were all asked to participate. The program subsequently established a three-tiered assessment approach.

Tier 1 **Status Network** monitoring program uses a stratified, random sampling design to characterize the overall health of Florida's water resources and observe possible trends. The State has been divided into 20 geographic reporting units, or strata, with four reporting units roughly within each water management district boundary. Every year each reporting unit is monitored but then five are intensely monitored, one within each district. After four years all 20 units will have been completed, and the cycle will begin again.

During each cycle, the five intensely monitored reporting units sample six resource categories. The categories are:

- confined aquifers,
- unconfined aquifers,
- high-order streams (Horton order greater than 4),
- low-order streams,

- small lakes (1-10 hectares),
- and large lakes.

Thirty randomly selected sampling sites within each of these resource categories will be sampled each year, making a total of 180 sites for each reporting unit. Thus, 30 sampling sites will be located in small order streams, another 30 in large order streams and another 30 in large lakes, etc. until all six resource categories are sampled in that reporting unit. It is possible to have all 30 sites for a resource category located, for example, in one large lake if that is the only relevant resource for that category in the reporting unit or if all sample sites fall within that location during the randomization process. Currently, the status network samples chemical and physical water quality parameters, such as pH, dissolved oxygen, water clarity, organic carbon, and ortho-phosphate. FDEP expects to add biological parameters, such as habitat assessments, at a later date.

The recently revised **Trend Network** can also be considered part of Tier 1 monitoring. With the recent inception of the IWRM program and resource reallocations, the network has decreased from approximately 430 to 80 fixed surface water quality sampling stations, monitored on a monthly basis and 50 groundwater sites. The revamped network is designed:

- to correlate Tiers 1, 2, and 3 monitoring results with seasonal climatic changes,
- to estimate general basin-wide loadings for the sampled parameters, and
- to make best estimates of the temporal variance of the sampled parameters in the basin.

The results generated from these Tier 1 sampling programs are used to generate the **305(b) Water Quality Assessment Report**, a requirement of the Clean Water Act. In this report, water quality is evaluated using the results from the programs listed above as well as biological data, other chemistry data from the federal water quality database (STORET), mercury fish consumption advisories, and information solicited through public workshops. The 305(b) report is the primary method of informing the public and Congress about the water quality conditions in the State of Florida. Information from this list and the Impaired Waters Rule is then used to help generate the 303(d) or impaired waters list. (This 305(b) report, submitted in 1996, is available on the Internet at www.dep.state.fl.us/water/division/monitoring/pubs.htm.)

Florida is presently using the 303(d) list that was approved by EPA in November 1998 from data generated for the 1996 305(b) list. FDEP is currently working on assembling available biological and water quality data for a 2002 303(d) list. Ultimately FDEP, under provisions of the Clean Water Act, will need to establish **Total Maximum Daily Loads (TMDLs)** for those waters on the 303(d) list for each parameter that does not meet the standards of the State classification system. TMDLs are quantitative analyses of water bodies where one or more

water quality standards are not being met and are aimed at identifying management strategies necessary to attain those water quality standards.

The **Tier 2 monitoring programs** consist of strategically placed fixed sampling stations with the goal of further characterizing water body segments on the 303(d) list. This tier of ongoing water quality monitoring provides:

- in-depth information of water quality conditions for individual water body segments,
- identifies specific water resource problems and the extent and severity of these problems, and
- evaluates the effectiveness of management activities.

This tier of monitoring will be used in conjunction with a land use model from EPA to extrapolate pollutant loading rates for the various land uses on an impaired water body segment and the assimilative capacity for that segment in the process of TMDL development and allocation. To help fulfill these goals, FDEP hopes to play a role in coordinating the regional water quality monitoring efforts of local governments, water management districts and organizations.

Finally, **Tier 3 monitoring programs** function mainly as ongoing compliance monitoring programs and will determine if permitted facilities are in compliance with their permits. This monitoring tier provides in-depth information on individual water body segments and yields the basis for evaluating the effectiveness of the management choices relating to facilities.

LONG TERM MONITORING STRATEGY FOR THE COASTAL CHARLOTTE HARBOR REGION

OBJECTIVES OF MONITORNG DESIGN

The Comprehensive Conservation and Management Plan (CCMP) of the Charlotte Harbor NEP has seven goals pertaining to water quality degradation. At least two of these goals require water quality monitoring throughout the study area to determine if the management conference members are obtaining these goals:

> **WQ-1:** *Identify those waterbodies that do not meet their designated water quality standards, and develop a plan during the year 2000 to meet those standards.*
>
> **WQ-6:** *Meet or exceed designated water quality standards throughout basins of the Charlotte Harbor NEP study area by the year 2015 with possible exceptions for natural and/or site-specific conditions.*

The objectives of the CCMP require obtaining objective, unbiased results from monitoring programs that answer the following water quality questions:

a) Is water quality changing through time for a specific water body?
b) Did water quality change as the result of implementing some management practice?
c) Did water quality change by some specific target level?

These questions beg the examination of all water bodies within the Charlotte Harbor NEP's study area for all water column constituents at all times of the year. To answer these broad questions regarding the status or trends of a water body, the Charlotte Harbor NEP's management conference decided that EPA's Environmental Monitoring and Assessment Program (EMAP) approach using a random sampling protocol would provide statistically unbiased results for the coastal areas. This design is consistent with statistical considerations and should provide a relatively high level of precision in estimates of means and a high level of power in tests for trends. The EMAP design also allows flexibility for existing local agency programs and resource limitations. Finally, EMAP-based programs now exist in the regional estuarine systems from Tampa Bay to southern Sarasota County. The creation of this Charlotte Harbor water quality program would create a unified approach within the study area and consistency with programs in Sarasota, Manatee, Pinellas and Hillsborough Counties.

To the extent possible, given the constraints imposed by local monitoring programs, the Charlotte Harbor NEP strategy seeks to obtain unbiased estimates of all water quality parameters included in the monitoring effort. For statistical purposes, unbiased parameter estimation requires that sampling stations be

selected randomly and with equal probability or that the selection probabilities of all stations be known. To achieve random selection of sampling stations within each water body included in the proposed NEP monitoring network, the hexagonal GIS grid that was developed by EMAP for that program's monitoring effort in the eastern Gulf of Mexico would need to be generated at an appropriate spatial scale and randomly overlaid over a map of the selected water body. A sampling station would then be randomly chosen within each hexagon of the grid, allowing selection probabilities for each site and joint selection probabilities for pairs of sites to be calculated using standard methods. The result is a stratified sampling design in which sampling sites are randomly located within blocks, which are systematically placed within strata.

For a general approximation of normal distribution, obtaining adequate statistical precision in the estimation of percentages (e.g., the percentage of the area of interest that meets or fails to meet a selected constituent target) requires that 30 or more sampling points be included within the area of interest. Placement of approximately 30 grid cells in each of the estuaries or major estuarine segments considered here will require that the EMAP grid be scaled to an appropriate size for each area (strata). The scale of the grid can be specified as the number of times and the magnitude by which the original national EMAP grid was divided (e.g., 7X7 refers to a grid density twice increased by a factor of seven).

The number of samples taken during the period or season is a function of how soon a decision is needed and financial support. To have robust comparisons of means between stations (fixed or random), between seasons (wet and dry) and between years, ˙30 sampling sites is desirable for approximating normal distribution. Data can be pooled across categories over time if costs or human resources are limiting. Such data pooling will lengthen the time to accumulate enough observations to reach statistical requirements for a decision about water quality. The minimum sample size is very important for the randomized designs to state with confidence conclusions about spatial or temporal water quality status. About 10 years of data will be needed for robust analyses of long-term trends.

Previous EMAP studies have demonstrated that this approach allows the Horvitz-Thompson estimation to be applied to measured water quality data to generate unbiased estimates of the percentage of the area that meets or fails to meet selected criteria, using the following equations:

$$\hat{y} = \frac{\sum_{i=1}^{n} \frac{y_i}{\pi_i}}{A}$$

where,

$\hat{y}$ = estimate of percentage of area

y_i = sample response at site i (1of meets criteria, 0 otherwise)

π_i = selection probability for site i

n = number of samples (sites)

A = total area of region of interest

and

$$se(\hat{y}) = \left(\frac{1}{A}\right)\sqrt{\sum_{i=1}^{n}\sum_{j>i}^{n}\frac{(\pi_i \pi_j)}{\pi_{ij}}\left(\frac{y_i}{\pi_i} - \frac{y_j}{\pi_j}\right)^2}$$

$se(\hat{y})$ = estimated standard error of $\hat{y}$

π_{ij} = joint selection probability of sites i and j

Under the proposed monitoring program, sampling stations may be occupied on a monthly, quarterly, or annual basis, depending on the needs and resources of the local monitoring program. The lowest sampling frequency used within the region (e.g., monthly, quarterly, annually) will determine the temporal scale on which statistical inferences can be made for the region as a whole, although inferences concerning water quality status and trends within an individual estuary (or major segment of an estuary) will be possible on the temporal scale on which sampling is performed in that area.

LONG TERM MONITORING STRATEGY DESIGN

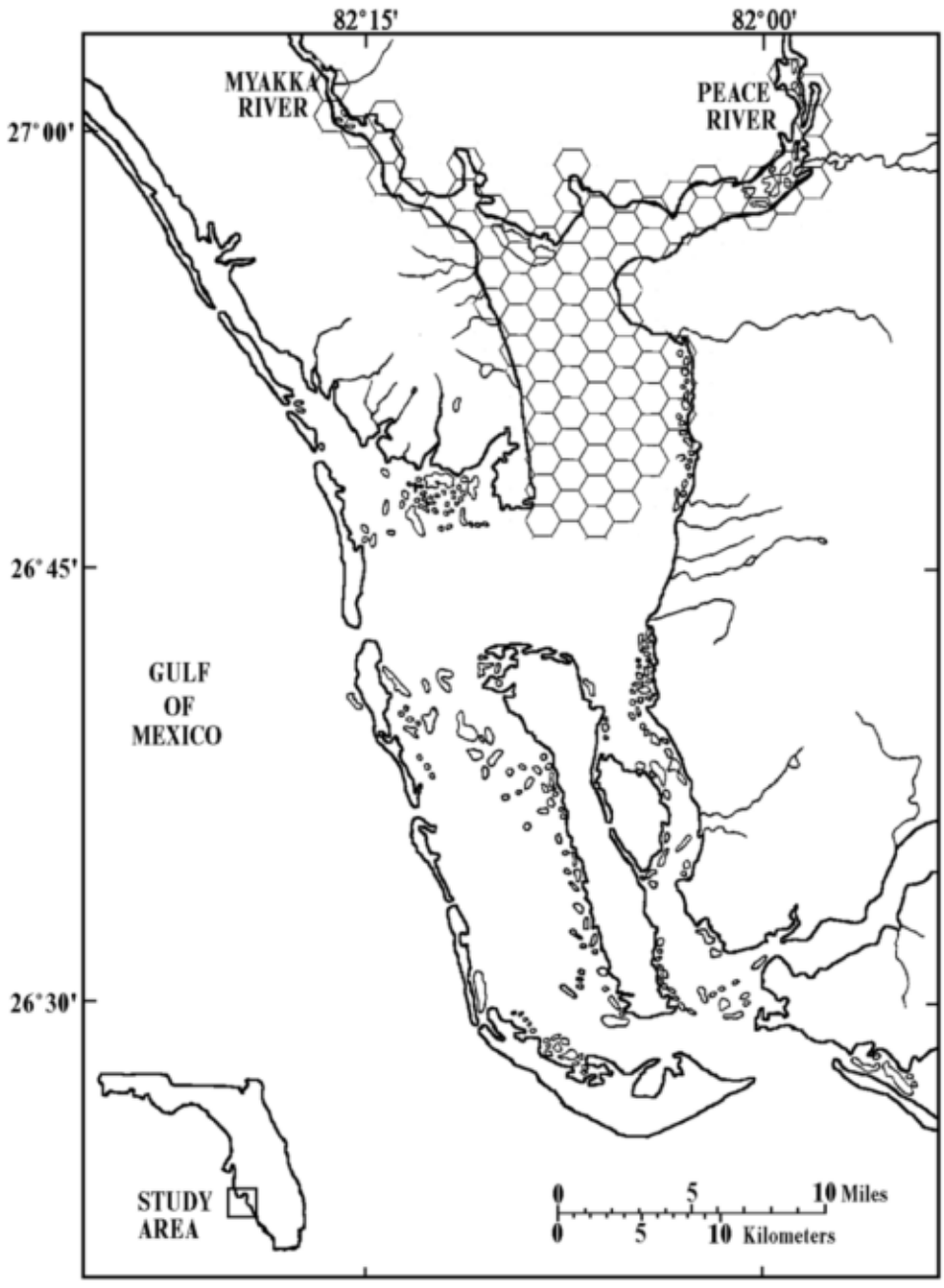
A random-stratified program was examined for Charlotte Harbor during a series of meetings in 1994 by SWFWMD staff, Coastal Environmental, Inc. staff and the Charlotte Harbor SWIM Project Review Committee. A final version of sampling strata was determined in November 1994 after two workshops and subsequent discussion, and this supplies the basis for the Charlotte Harbor NEP's Long Term Monitoring Strategy. The Charlotte Harbor NEP was tasked with covering a much larger area for sampling, and divided the estuary area into six sampling

zones or strata (see Figures 2-7) without regard to very shallow areas, mud/sand flats, oyster bars or seagrass areas. These areas were discussed in detail, and some water quality will be sampled over time in these areas. Sampling specific habitats were not set aside as other possible substrata as part of the questions about broad general water quality trends. Such subsets may be practical and part of other NEP priority actions.

The strategy suggests that water quality data should be taken in a stratified-random design for all tidal or tidally influenced water. Tidally influenced basins for the NEP study area have been divided in to six EMAP regions (Figures 2-7). There are two coastal/lagoonal regions (Roberts Bay - Gasparilla Sound and Pine Island Sound), two riverine/upper bay estuaries (upper Charlotte Harbor and tidal Caloosahatchee River) and two bay systems (lower Charlotte Harbor and Estero Bay). Natural lakes larger than 10 hectares (~ 24 acres) should be randomized for stations. Smaller lakes should have a station near the central point. Flowing fresh water stations will be fixed and where possible co-located with gages or fixed structures. Sub-basins within watersheds should be based on basin definitions by USGS as the minimum criteria.

FIGURE 2.

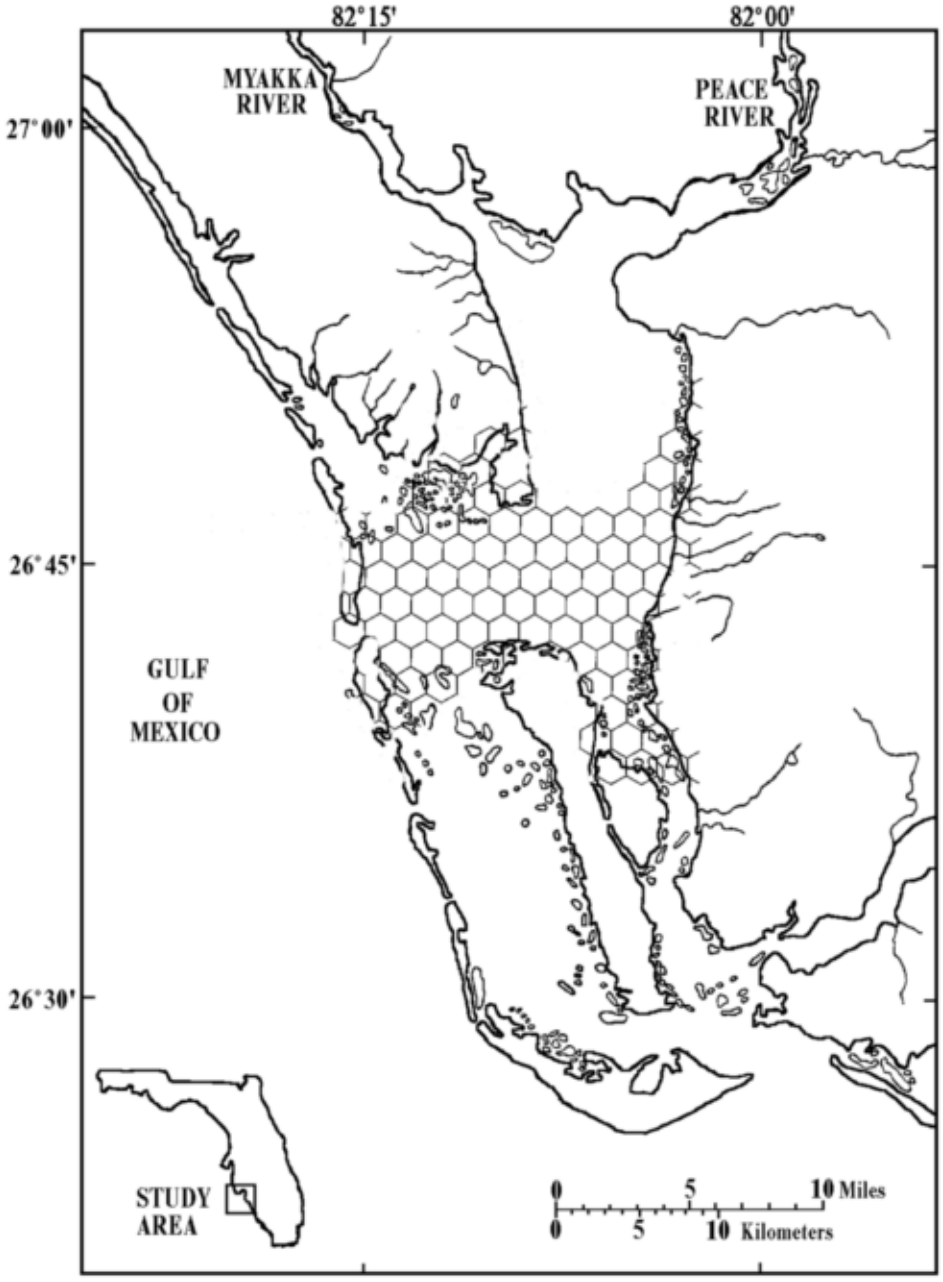
UPPER CHARLOTTE HARBOR STRATUM



(W. Dexter Bender and Associates, Inc. 2000)

FIGURE 3.

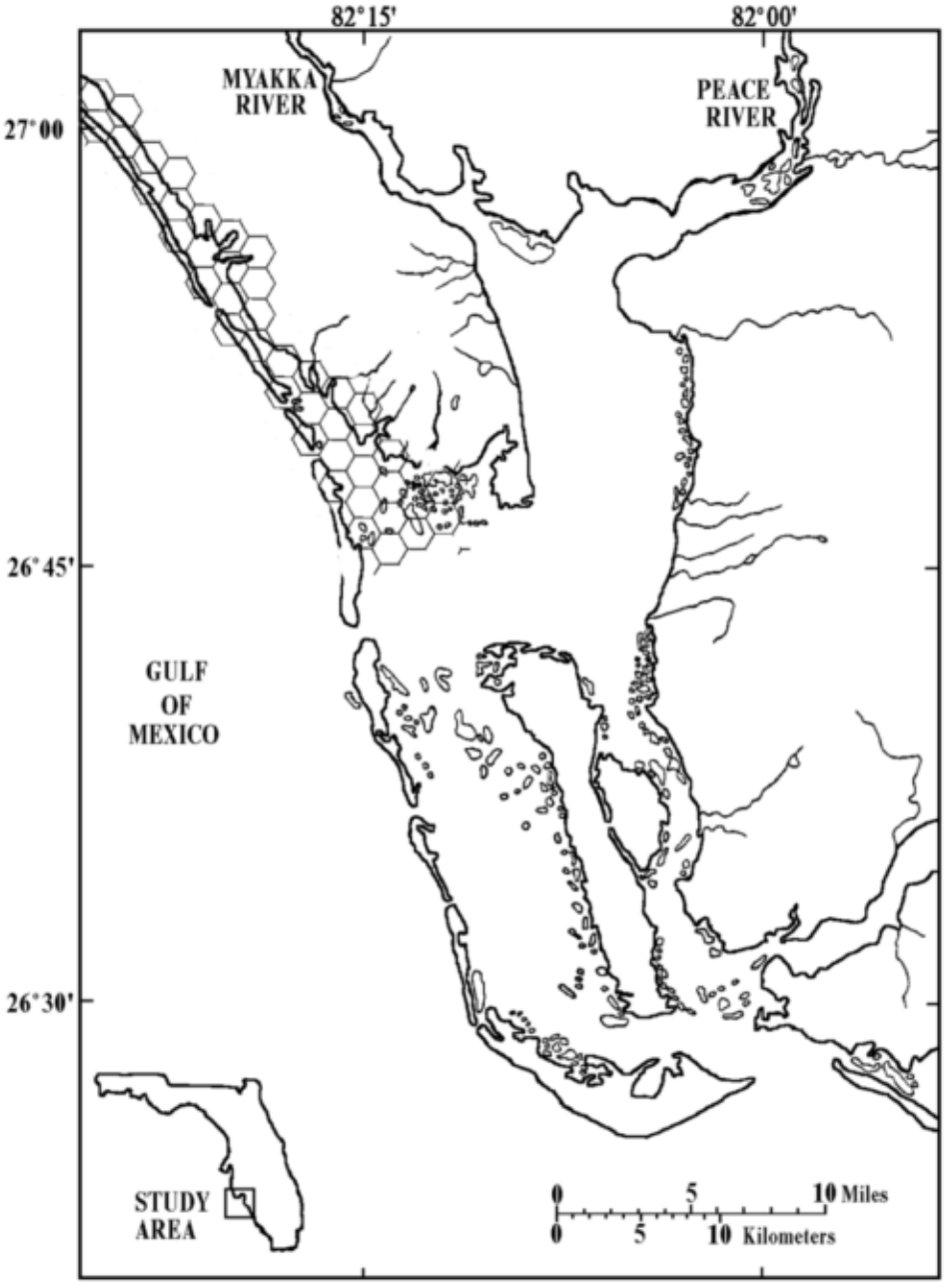
LOWER CHARLOTTE HARBOR STRATUM



(W. Dexter Bender and Associates, Inc. 2000)

FIGURE 4.

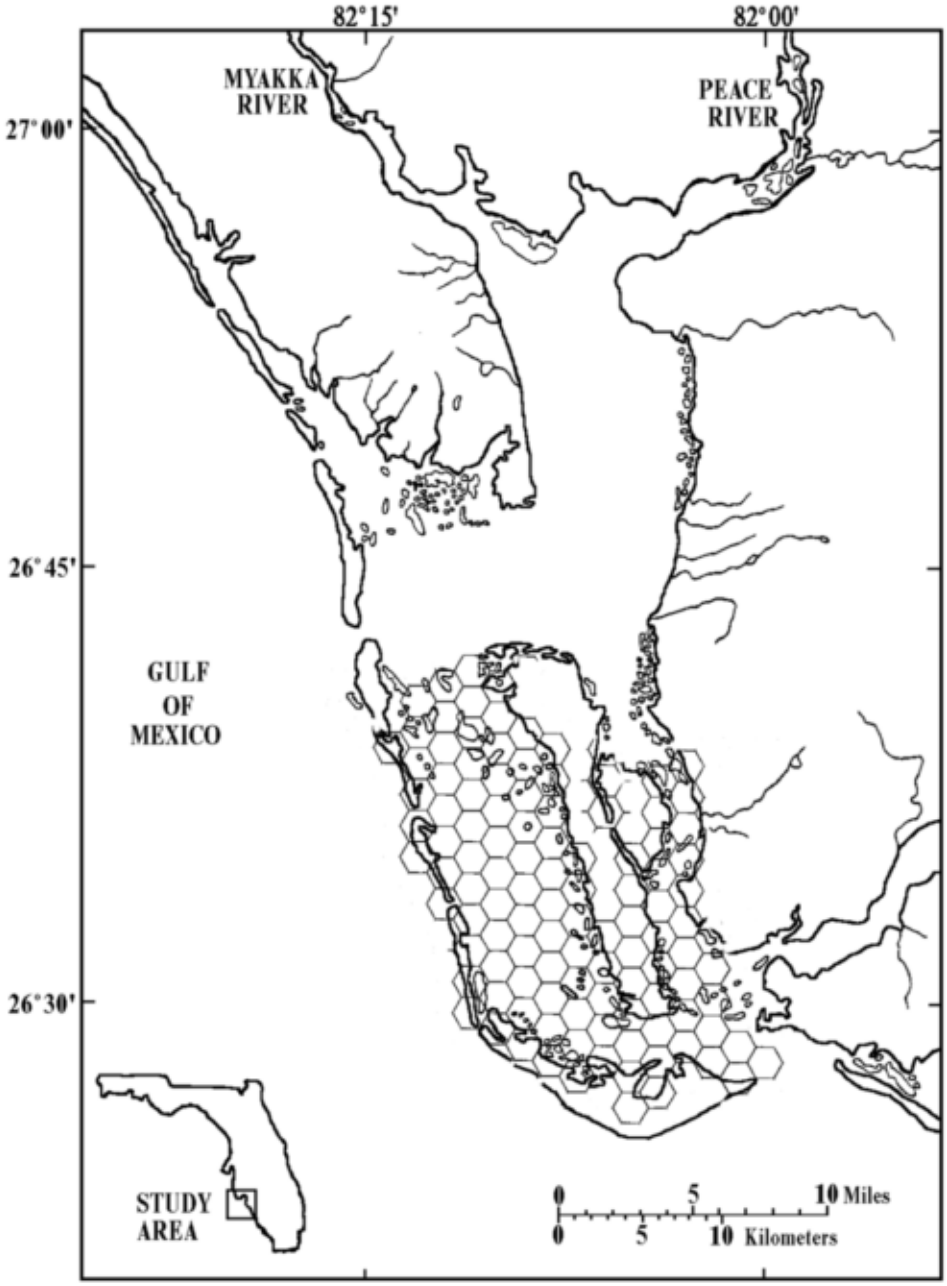
GASPARILLA - VENICE STRATUM



(W. Dexter Bender and Associates, Inc. 2000)

FIGURE 5.

PINE I. SOUND - SAN CARLOS BAY STRATUM



(W. Dexter Bender and Associates, Inc. 2000)

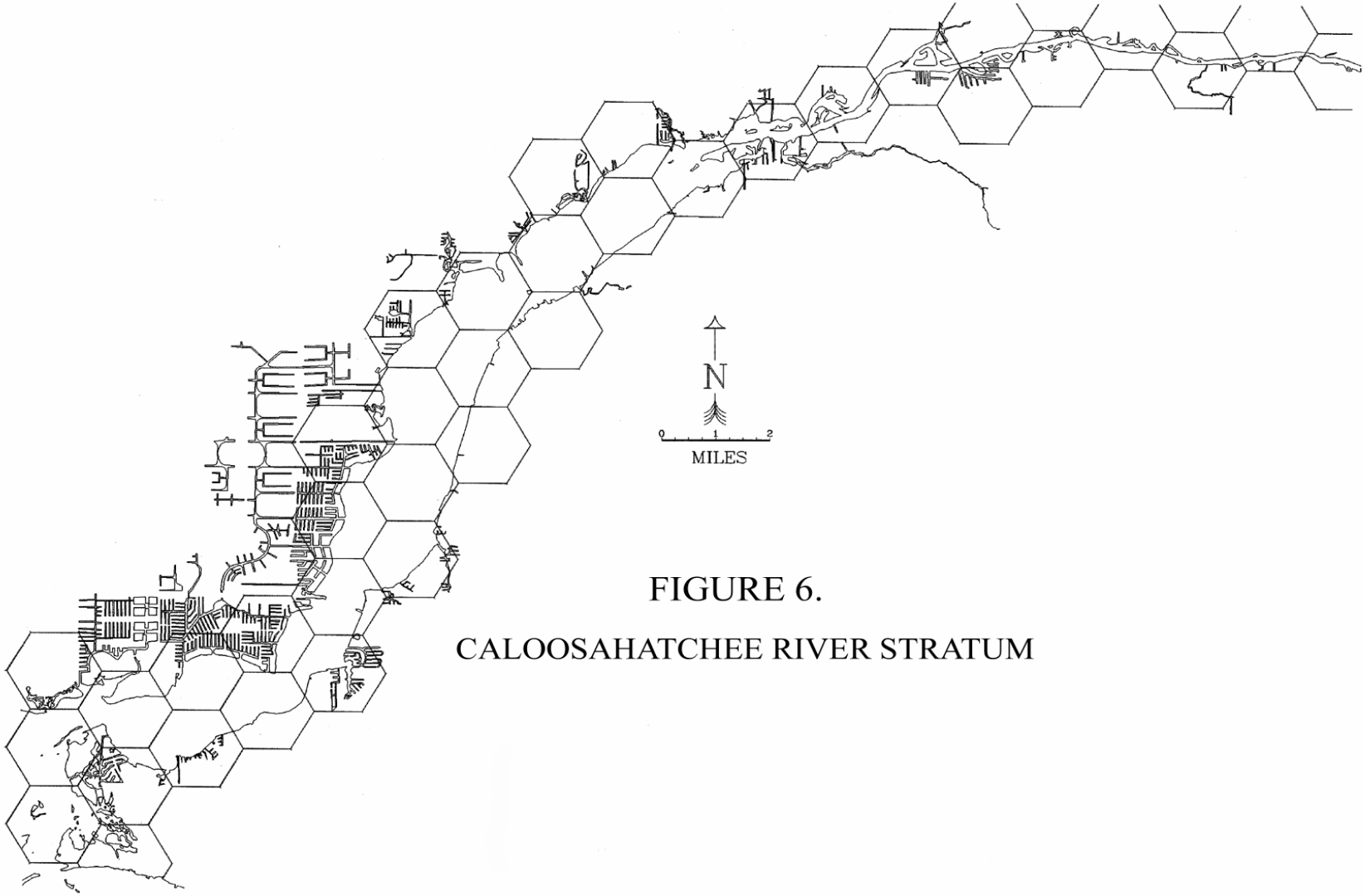


FIGURE 6.

CALOOSAHATCHEE RIVER STRATUM

(W. Dexter Bender and Associates, Inc. 2000)

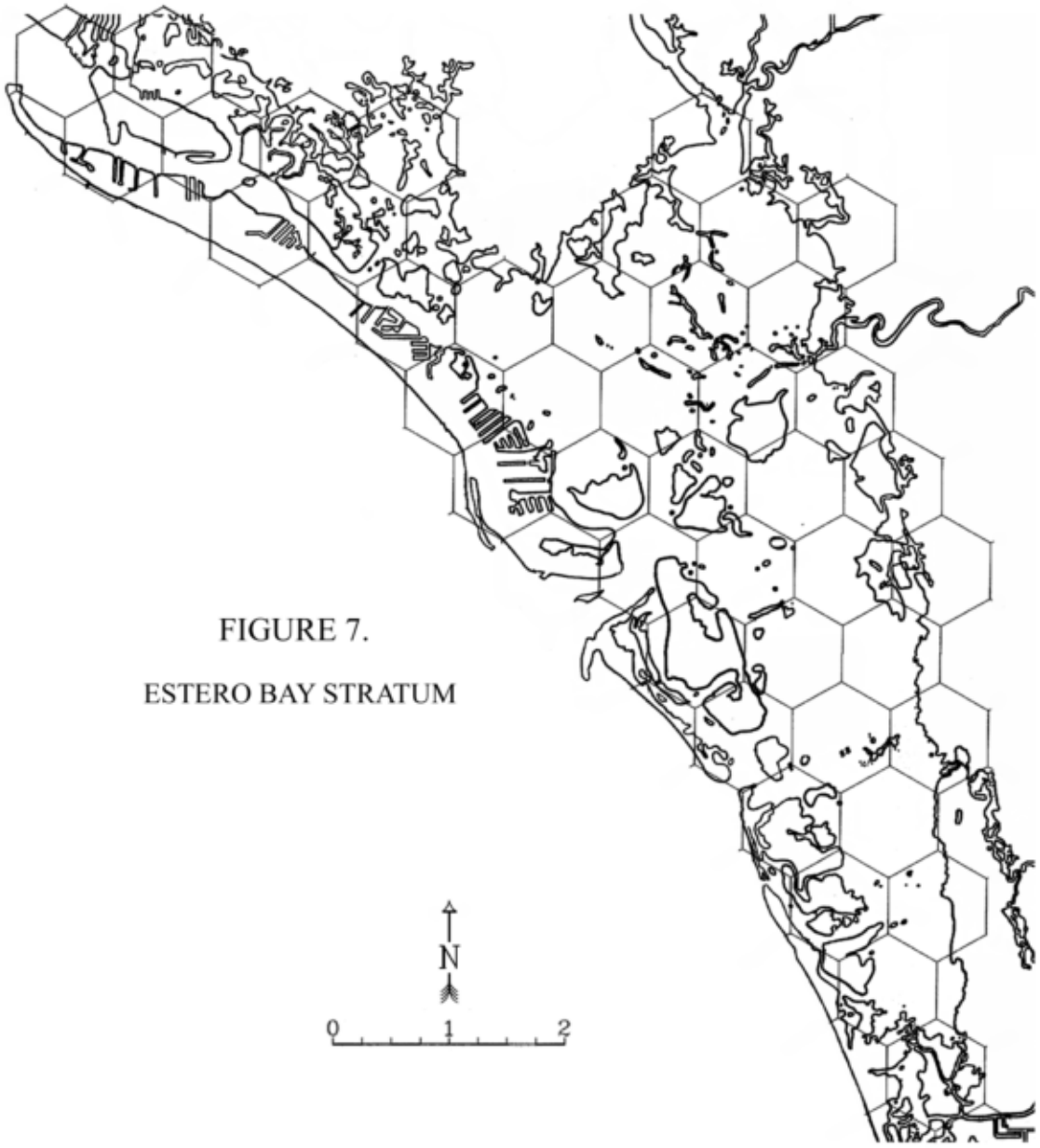


FIGURE 7.

ESTERO BAY STRATUM

(W. Dexter Bender and Associates, Inc. 2000)

Sampling Frequency

Samples should be taken during the wet season (June - September) and during the dry season (October - May). The total number of samples for the year is dependent on funding. Under optimal conditions, at least 30 samples per estuarine basin should be taken per season (30 x 2 x 6 = 360 water samples). Costs can be halved by collecting at least 15 samples per season over a year (180 water samples). However, statistically robust analyses should wait for two years of data to help determine the status of the water body and for any comparisons with other basins with reduced sampling. A sampling schedule should be setup for a total of 32 samples (32x2x6 = 384) through out the year in a given stratum. This will account for stations that may not be sampled because of denied access (tide, weather), and insure at least 30 samples will be taken. Random numbers for choice of days and choice of location within each stratum can be generated at the following web site: http://www.randomizer.org.

Two Six-Month Seasons

In this scenario, the year is divided into two six-month seasons, and each season is divided into eight three-week periods. Sampling will occur over a total of 48 weeks during each year. Four weeks out of each year will not be sampled. These four weeks will provide the sampling crew time to repair equipment and gear, and/or will provide time for scheduled holidays and vacations as appropriate. Due to logistical constraints, sampling cannot be undertaken on Fridays, Saturdays, or Sundays. The first day of the first period is chosen at random within the first three weeks of the season. The periods are defined at three week intervals from the first day. In the two season scenario, there are twelve possible sampling days within each three-week period (Monday-Thursday of three weeks). Sampling days for each stratum are selected similarly to the three season scenario, with six of twelve possible days selected for stratum sampling. All locations within a stratum are scheduled to be sampled on the same day of the period. Since there are six strata, one-half of the possible sampling days within a period will be used for sampling a stratum.

The allocation of samples to locations and days resulted in a sampling design that has the following properties:

- Sampling locations are randomly distributed throughout each stratum;
- Sampling (4 stations) is undertaken once per stratum in each three-week period; and
- All locations sampled in a stratum and period are sampled on the same day.

The selection of sampling locations and sampling periods should be conducted independently for each of the seasons.

Two Season Program:	Season 1:	June - November
	Season 2:	December - May

Season 1 would represent warm-wet season months. Season 2 would represent the dry-cool season months of the year.

General Sampling Protocols

Sampling sites will be visited twice on each sampling day if light attenuation is to be measured. The first visit (i.e., morning visit) will occur in the time period from 1.0 hour before sunrise to 1.5 hours after sunrise, as published by the National Weather Service. The morning visit is scheduled near sunrise to coincide with the time period when the diurnal dissolved oxygen minima would be anticipated to occur. The second visit (i.e., mid-day visit) will occur between 1000 and 1400 hours. Sampling during this time period will allow for the most accurate measure of light attenuation at each sampling location.

At each station, vertical profiles as well as grab samples from the surface and bottom of the water column will be collected. Vertical profiles are defined as measurements taken at regular intervals from the surface to the bottom of the water column taken within 0.2 m below the water surface, at a minimum interval of 1.0 m from the surface to the bottom of the water column, and include a near bottom measurement taken 0.2 m above the bottom substrate.

Water quality grab samples may be collected from just the surface, or from the surface and bottom of the water column at each station. Only one surface sample will be collected if the total station depth is $\leq$ 3 m. Both a surface and a bottom sample will be collected if the total station water depth is >3 m. A surface sample is defined as a water sample collected within the upper 0.5 m of the water column. A bottom sample is defined as a water sample collected within the lower 0.5 m of the water column. Some consideration will need to be made for bottom samples since these will be <30 in any given year.

Metadata

Data that are associated with the parameters will add to the value of analysis and confidence in the data. These data include the quality control data, quality assurance data and typical field information such as time of day, wind, weather, water elevation and tidal cycle. Data without metadata may lose its value and will be rejected for use within or in support of NEP programs. The recommended field and analytical methods will be consistent with FDEP Quality Assurance Standard Operating Procedures (SOPs) for field and laboratory activities, and to the extent possible, with the ongoing methods coordination by the Southwest Florida Regional Ambient Monitoring Program (RAMP). Almost all water quality data taken by agencies and environmental laboratories meet the FDEP and DHRS requirements in their FAC regulations for quality assurance/quality controls.

All of the implemented monitoring programs will have to follow well-defined sample collection procedures, sample processing (chain of custody), and sample analyses with equivalent methods. Representative samples (splits) will need to be exchanged for analyses by different organizations. Verification of data methods such as data proofing and authentication will be required. Personnel exchanges between participating organizations will be needed to keep the knowledge base at the same minimum levels for all phases of data acquisition and management.

Data Analysis

Comparisons with State or Federal Standard for surveys of problem area are straight forward and without some minimum sample size. Specific questions for specific analytes/parameters related to apparent trends, numerical performance targets or identifying real differences require substantial data sets of differing sizes. Comparisons between NEP estuarine study areas (Tampa and Sarasota Bays) will be consistent because the sampling designs will be statistically robust and with the same suite of core analytes/parameters.

Core water quality parameters assessed at each station and sampling date have been recommended by a group of technical water quality professionals working in southwest Florida as the analytes/parameters by type of water during a workshop. This list provides the minimum recommended constituents to be considered by any local programs. These two lists do not imply that nothing else should be sampled. Herbicides, pesticides, other organics, metals and sediment may be required in specific geographic areas or for specific questions. These include:

MARINE/COASTAL/ESTUARINE/TIDAL RIVERS CORE ANALYTES FOR WATER QUALITY

Analyte/Parameter	Method
PAR (light attenuation, k)	approved RAMP protocol
Secchi disc	20 cm.
temperature	EPA (1983), 170.1
salinity	SM (1 7th Ed., 25.213 (from conductivity)
specific conductance	EPA (1983), 120.1
dissolved oxygen	EPA (1983), 360.1
pH	EPA (1983), 150.1
color (PCU)	EPA (1983), 110.3 (spec.) RAMP method issue
turbidity (NTU)	EPA (11983), 180.1
total suspended solids	EPA (1983), 160.2
Total organic carbon	EPA 415.2
chlorophyll-*a* (corrected for phaeophytin)	SM 16th Ed., 1002G

	SM 17th Ed., 10200 H
total nitrogen	calculation (TKN + N02-NO3-N)
total Kjeldahl nitrogen	SM 17th Ed., 4500-N org B or C
total ammonia nitrogen	EPA (1983), 350.1 RAMP method issue
total nitrite+nitrate nitrogen	EPA (1983), 353.2
dissolved orthophosphate	EPA (1983), 365.1 (requires field filtration)
total phosphorus	EPA (1983), 365.1 or 365.4

OPTIONAL ANALYTES

dissolved silica	USGS 102700-8 (autoanalyzer)
5-day BOD	EPA (1983), 405.1
Total coliform bacteria	Most probable number (SM 9221B)/membrane filter (SM 9222B)
Fecal coliform bacteria	Most probable number (SM 9221C)/membrane filter (SM 9222D)
Enterococci bacteria	SM 9230C
Dissolved organic carbon	SM 5310B

As a cost-saving measure, the concentrations of potential toxics (heavy metals, synthetic organics) in the water column or sediments will be assessed at a selected subset of sites on a less frequent (annual or multi-year) basis.

COASTAL CHARLOTTE HARBOR MONITORING NETWORK

In April 2001 a cooperative monitoring network commenced implementing the NEP Long Term Monitoring Strategy through a stratified, random monitoring program in upper Charlotte Harbor, the tidal Peace and Myakka Rivers and Lemon Bay. The Southwest Florida Water Management District, Florida Fish and Wildlife Conservation Commission-Florida Marine Research Institute, Department of Environmental Protection-Charlotte Harbor Aquatic Preserves, and Charlotte and Sarasota Counties participate in this program. This program has divided upper Charlotte Harbor into 5 strata:

1. tidal Peace River,
2. tidal Myakka River,
3. west wall of Charlotte Harbor,
4. east wall of Charlotte Harbor and
5. Cape Haze area of Charlotte Harbor.

A final stratum exists for lower Lemon Bay (Figure 8). This latter stratum extends from the Tom Adams Bridge to Englewood Beach, south to the Boca Grande Causeway at Placida.

Five randomly chosen sites within each stratum are sampled each month for the marine core analytes within the CCMP:

MARINE/COASTAL/ESTUARINE/TIDAL RIVERS CORE ANALYTES FOR WATER QUALITY:

Analyte/Parameter	**Analyte/Parameter**
PAR (light attenuation, k)	Total organic carbon
Secchi disc	chlorophyll-a (corrected for phaeophytin)
temperature	total nitrogen
salinity	total Kjeldahl nitrogen
specific conductance	total ammonia nitrogen
dissolved oxygen	total nitrite+nitrate nitrogen
pH	dissolved orthophosphate
color (PCU)	total phosphorus
turbidity (NTU)	
total suspended solids	

Five additional sites are re-randomly chosen the following month. This allows an equal opportunity of sampling all sites within a stratum at all times of the year within the agencies' temporal sampling protocols. In addition, if a site is 3 meters or deeper, a bottom and top sample is taken to incorporate the possible stratification of the water column.

This program will obtain the 30 samples per season and 60 samples per year per stratum (5 sites per month x 6 months per season x 2 seasons per year) requested by the NEP Long Term Monitoring Strategy, explained above. This design, therefore, should lend results approximating normal distribution and allow parametric statistical analysis for robust comparisons of means between strata, between seasons (wet and dry) and between years.

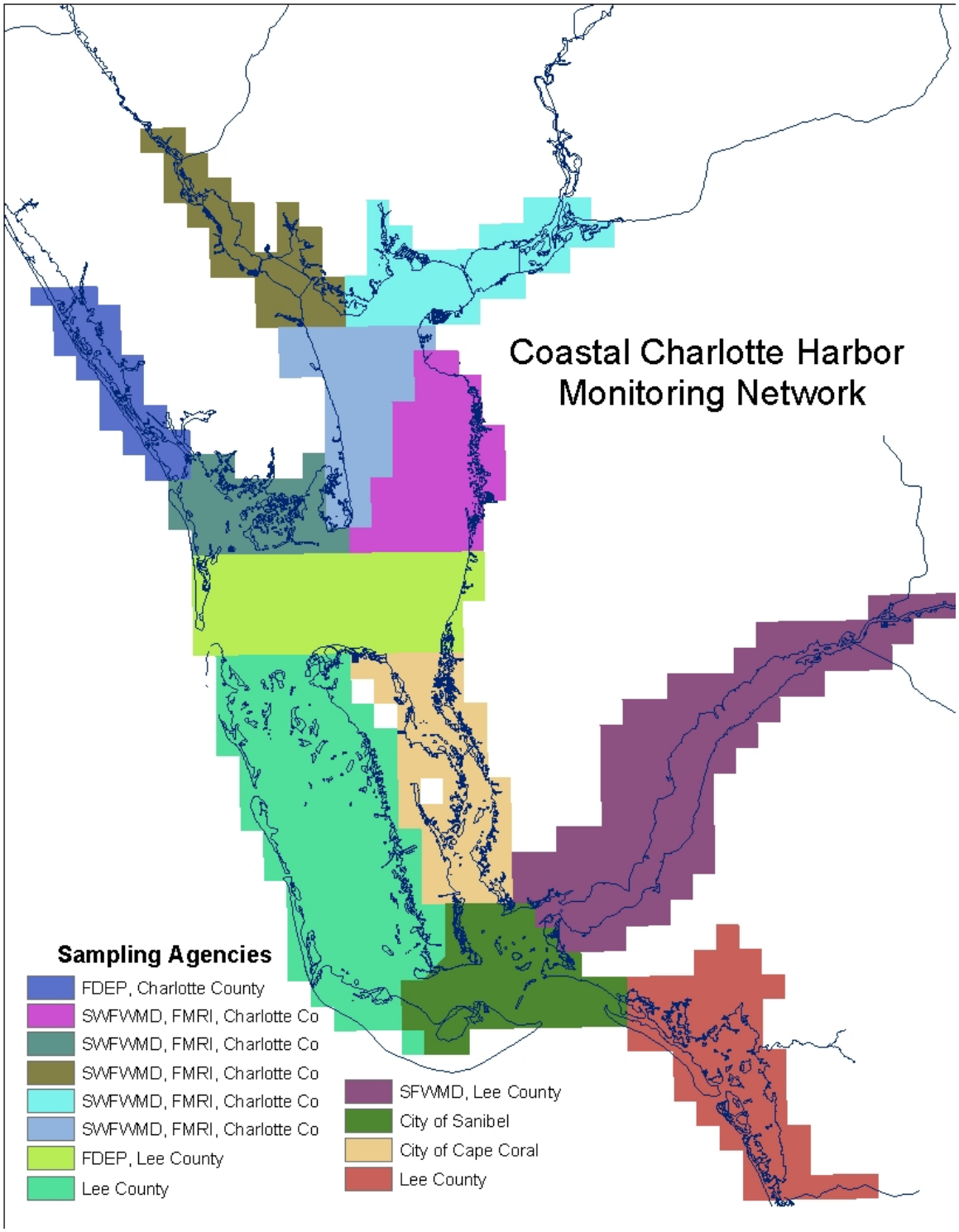


FIGURE 8

Finally, in April 2002, Lee County, the Cities of Cape Coral and Sanibel, DEP-Charlotte Harbor Aquatic Preserves and South Florida Water Management District expanded this program into the southern Charlotte Harbor region. This expansion consists of six additional strata:

1. the Bokeelia region around northern Pine Island and southern Charlotte Harbor,
2. Pine Island Sound,
3. Matlacha Pass,
4. tidal Caloosahatchee River,
5. Estero Bay and
6. San Carlos Bay.

This sampling design is somewhat different than the Long-Term Monitoring Strategy design of the Charlotte Harbor NEP in that it uses the FMRI's square grid system in lieu of the hexagonal grids of EPA's EMAP and 5 sites per month are sampled versus 4 sites every 3 weeks for 10 months. These modifications were made because of the ease they allow the participants in the randomization process and to help ensure comparability of the water quality data collected by this network with the fisheries data collected by FMRI-Fisheries Independent Monitoring program in the future. The grid system and strata delineations are shown in Figure 9.

COASTAL CHARLOTTE HARBOR MONITORING NETWORK

SAMPLING PROCEDURES

The overall program manager for this Network shall be the Senior Scientist of the Charlotte Harbor National Estuary Program. Questions or concerns regarding this Network should be directed to Catherine A. Corbett, Charlotte Harbor National Estuary Program, 4980 Bayline Drive, North Fort Myers, Florida, 33917-3909; telephone: 239/995-1777 extension 241 and email: ccorbett@swfrpc.org.

Staff from the FWC-FMRI shall collect water quality samples and record data on field parameters for 5 strata in Charlotte Harbor, including the tidal Peace and Myakka rivers; East and West walls of Charlotte Harbor and the Cape Haze Peninsula for the Southwest Florida Water Management District. Staff from the Department of Environmental Protection-Charlotte Harbor Aquatic Preserves shall collect water quality samples and record data on field parameters for lower Lemon Bay. Lee County Environmental Laboratory shall collect water quality samples and record data on field parameters for the tidal Caloosahatchee River, Estero Bay and Pine Island Sound. Staff from the Department of Environmental Protection-Charlotte Harbor Aquatic Preserves and the Cities of Cape Coral and Sanibel shall collect water quality samples and record data on field parameters for the Bokeelia area of Charlotte Harbor up to the District boundary, Matlacha Pass and San Carlos Bay, respectively. The program manager for this Network, the NEP Senior Scientist, shall perform annual field audits for sample collection for each sampling agency. The results of these audits will be presented at an annual Coastal Charlotte Harbor Monitoring Network meeting for this express purpose as well as resolve outstanding issues.

The square grid system used by the Fisheries Independent Monitoring Program of the Florida Fish and Wildlife Conservation Commission-Florida Marine Research Institute will be used in the sampling site selection process. Each stratum will be delineated by a series of these grids (see Figure 9). The site selection process shall include randomly choosing 5 grids per month per stratum and then randomly choosing a site within each one of these 5 grids.

At each randomly chosen sample site, staff from the aforementioned agencies will record at least the following: water temperature, salinity, specific conductivity, pH and dissolved oxygen. In addition, staff personnel will determine secchi disk depths and light attenuation coefficients using light meter instruments.

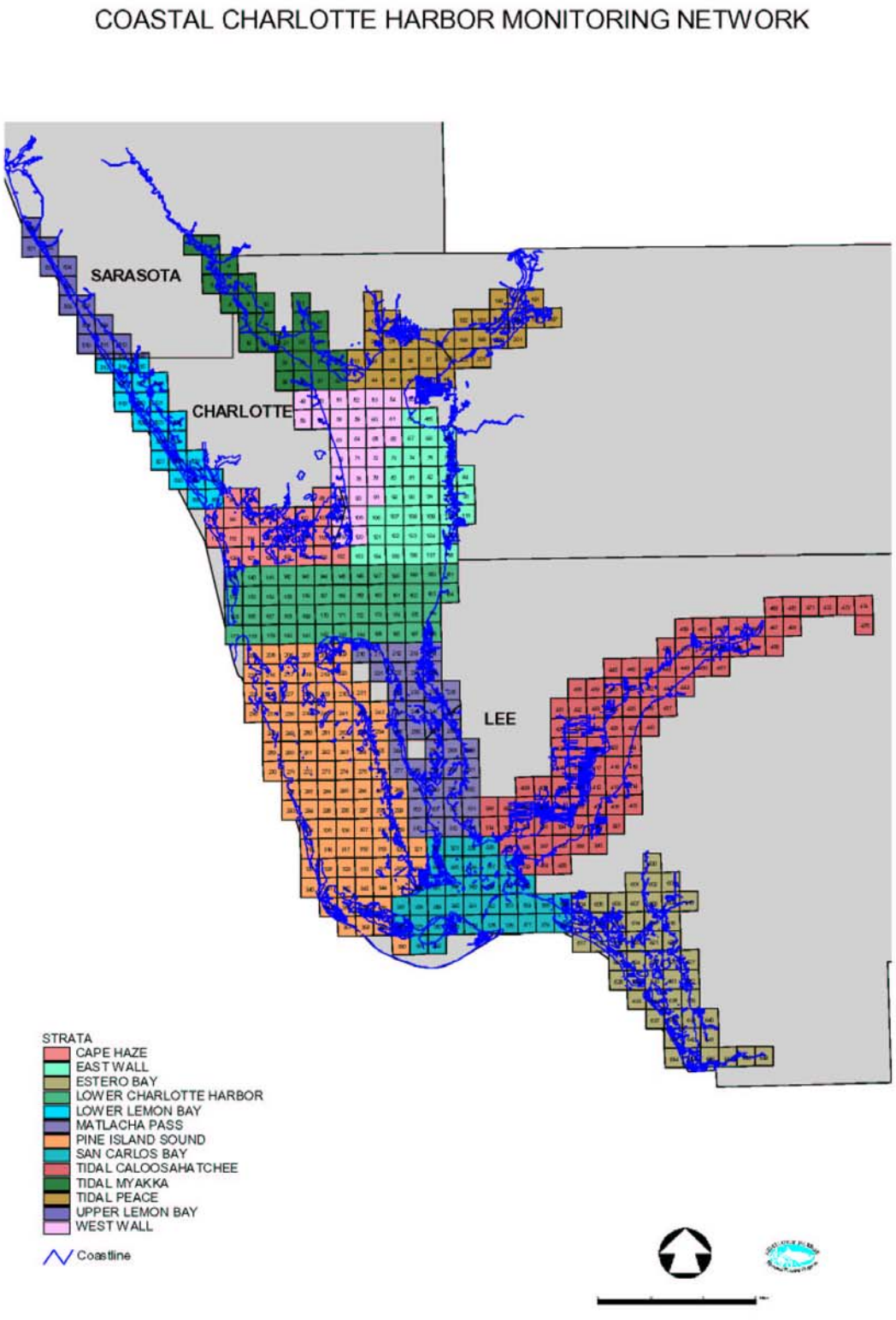


Figure 9. Strata Delineations and FMRI Grid Numbers

For water quality samples, a single sample will be collected at 0.5 meters below the surface for those locations where the bottom depth is less than 3.0 meters. For locations where he bottom depth is greater than 3.0 meters, two samples will be collected (0.5 meters below the surface and 0.5 meters above the bottom). Light attenuation coefficients will be taken if sites are visited between the hours of 9:00 a.m. and 3:00 p.m. (local time) with 10:00 a.m. to 2:00 p.m. the optimal time period.

Water quality parameters analyzed by the laboratories within this Network shall include at least the following: turbidity (nephelometric turbidity units), total suspended solids (milligrams per liter), “color” (platinum-cobalt units), chlorophyll A (phaeophytin-corrected in micrograms per liter), total nitrogen (milligrams per liter), total Kjeldahl nitrogen (milligrams per liter), ammonia nitrogen (milligrams per liter), total nitrite plus nitrate nitrogen (milligrams per liter), dissolved orthophosphate (milligrams per liter), total phosphorous (milligrams per liter) and total organic carbon (milligrams per liter).

Charlotte County will analyze water quality grab samples for the 6 strata within their region, including those collected by FWC-FMRI and DEP-Charlotte Harbor Aquatic Preserves staff. Lee County will analyze samples from Estero Bay, tidal Caloosahatchee River, Pine Island Sound and the Bokeelia section of Charlotte Harbor. Finally, the City of Cape Coral will analyze grab samples collected with the Matlacha Pass and San Carlos Bay strata. All laboratories involved in this Network shall follow all applicable federal and state guidelines for quality assurance and quality control of water quality analyses, including the use of appropriate duplicate samples and equipment blanks. The laboratories shall also participate in quarterly inter-laboratory split-sample exercises with the Southwest Florida Regional Ambient Monitoring Network to help ensure data comparability region-wide.

The data owner for each stratum will be responsible for data handling and uploading their respective data into STORET. Strata data owners are as follows:

Data Owner	**Stratum**
Charlotte County	Lower Lemon Bay
	Tidal Peace River
	Tidal Myakka River
	Charlotte Harbor West Wall
	Charlotte Harbor East Wall
	Charlotte Harbor Placida
Lee County	Charlotte Harbor Bokeelia
	Pine Island Sound
	Estero Bay
SFWMD/Lee County	Tidal Caloosahatchee River

City of Cape Coral	Matlacha Pass
City of Sanibel	San Carlos Bay

Data owners may assign the uploading of data to STORET to the certified lab undertaking the lab analysis of their grab samples as part of a contract, but the data owner is ultimately responsible for ensuring this process is fulfilled.

I. GENERAL

A. SAMPLE COLLECTION

- Samples shall be collected from randomly selected sites. These sites will be selected prior to field sampling (see below for procedure). Alternate sites can be chosen for these reasons:
  - Water depth to shallow
  - Unable to get to sample site
- Five randomly chosen sites per stratum per month will be sampled.
- A minimum of one duplicate every 10 sites or one every sampling trip will be taken.
  - Water samples are collected by using an opaque, horizontal sampling device, such as an Alpha or Niskin bottle. All appropriate sample bottles are filled in the order listed below and labeled properly.
  - This entire procedure, including refilling the horizontal sampling device is to be repeated.
- A blank will be taken every sampling trip.

- Split samples for the testing the precision of lab analysis is optional.

B. USE OF PROTECTIVE GLOVES

- DEP recommends wearing protective gloves when conducting all sampling protocols, however, their use is not mandatory.
- Use gloves if sampler has come in contact with potential contaminants (i.e., sun tan lotion, outboard motor oil):

C. CONTAINER AND EQUIPMENT RINSING

- When collecting aqueous samples the sample collection equipment and non-preserved containers shall be rinsed with sample water before the actual sample is taken.
- This protocol shall not be followed for:
  - Sample containers with pre-measured preservatives in the container (acidified bottles).

D. DEDICATED EQUIPMENT STORAGE

- All dedicated equipment are stored in a non-contaminating environment.

E. FUEL-POWERED EQUIPMENT AND RELATED ACTIVITIES

- All sampling is done away from fuel-powered equipment activities. Samplers will make every effort to observe winds, currents and other parameters to ensure no contamination.

F. PRESERVATION

- All samples shall be preserved by the certified lab involved in the Network and delivered to the sampling entity, ready for use.

II. DECONTAMINATION

- All equipment shall be cleaned in a controlled environment and transported to the field pre-cleaned and ready to use.
- All equipment must be immediately rinsed with water after use. Field cleaned equipment (alpha bottle, pump tubing and re-usable filters) are cleaned between samples.
- Alpha bottles are cleaned with ambient sample water, while the pump tubing and re-usable filters are cleaned with deionized water (between samples). Proper cleaning protocol, upon return to the field lab, is followed.
- Detergents used are Liquinox (or equivalent) or Alconox (or equivalent).
- Deionized water is used as the final rinse for all cleaning (suitable for only inorganic analyses (metals, nutrients, etc.)

III. AQUEOUS SAMPLING PROCEDURES

A. GENERAL

- There are several requirements that are common to all types of surface water sampling events and are independent of technique. Several of these requirements are concerned with sample parameters that are inherently difficult to sample. In addition to the below procedures, overall care must be taken in

regards to equipment handling, container handling/storage, decontamination, and record keeping.

- Sample collection equipment and non-preserved sample containers must be rinsed with sample water before the actual sample is taken.
- If protective gloves are used they shall be clean, new and disposable. These should be changed prior to the next sampling site.
- If possible, one member of the field team should take all the notes, fill out tags, etc., while the other member does all of the sampling. To ensure sampling precision, each member should continue to assume the same duties for the entire sampling trip, especially secchi disk readings.

B. ACCESS

- Access will be left up to the sampling group. Ease of access should not be the main criteria for sampling site choice. If sampling by boat, there are certain precautions that must be considered:
- If sampling with a boat, samples should be taken from the bow, away and upwind from any gasoline outboard engine. Every effort will be taken to prevent contamination. (Charlotte Harbor – FWC-FMRI—has mid-hull engines and does sampling behind the outboard and fuel tank. Winds, currents and boat position

are taken into account when sampling, in order to meet these criteria.)

- Care should be taken not to disturb sediments when motoring to the sampling sites (especially shallow water sites).

C. SITE SELECTION

- 5 sites per stratum per month will be sampled. Samples are randomly selected for every month and every Region (strata).
    - Each of the 5 sites is selected by first randomly choosing a grid (1X1 nmile) within a Region (stratum) using a random number generator (or other program).
    - The site location within that grid is then randomly chosen using the following process:
        - Use a random number generator or other program to randomly obtain a number between 0 and 1.
        - Using the latitude and longitude coordinates of the bottom right corner for the selected grid (defines the degrees, minutes for the grid), add this randomly generated number to the latitude to obtain seconds for the site latitude coordinates. The location is recorded in 0.001 format (Example 82 deg 36.156 minutes).
        - Repeat these last 2 steps for site longitude coordinates.

    - The 13 strata have been delineated and coordinates for each are available within a Shapefile obtainable from the Charlotte Harbor NEP office.
- Every attempt to collect samples from the pre-selected sites are made. Selected and actual locations are recorded on the datasheets. Any alteration from the pre-selected site will be noted.
- Site changes will be done in this order:
    - If site is too shallow or on land, then movement from the selected site toward the Intracoastal Waterway or center of grid until appropriate depths are achieved (1.0m in Charlotte Harbor, tidal Peace and Myakka rivers; 0.7m in Lemon, San Carlos and Estero Bays; 0.7 m in Bokeelia section of Charlotte Harbor, Pine Island Sound, Matlacha Pass and tidal Caloosahatchee River).
    - If the grid has a deeper area, and no channel nearby, movement will be made toward that area until depths are achieved.
    - If the area is shallow and the knowledge of the grid dictates that water level (or other factors) will not allow for sampling, then an alternate grid can be chosen. (Priority of the grid selection should include (region/stratum is first, Grid is next, sample area is last):

- sampling must not be done more than once per grid
- grid must remain in the same region or strata
- the closest grid to the original grid should be chosen unless conditions in surrounding grids are similar
- pre-selected alternate(s), (prior to sampling trip) may also be used).

D. SAMPLE ACQUISITION

- Water samples are collected by using a horizontal sampling devise, such as an Alpha or Niskin bottle, opaque if possible, with depths taken from the center of the container.
- The initial grab is taken at 0.5 m below the surface. If the sample site > 3m, then an additional sample is taken at 0.5m above the bottom.
- Once the sampling device is triggered and sample is trapped, the sample is brought on board.
- The proper order for filling sample bottles is as follows: non-preserved, preserved and finally filtered samples.
- Filtered samples (NH3 and Orthophosphate) are collected by a peristaltic pump or syringe-filter combination. All filters will be .45 microns. The tubing for the peristaltic pump is rinsed with the sample water (through the spigot).

- While the filtered sample is being collected, the non-acidified bottles are filled (Chlorophyll first). These bottles are rinsed with sample water, prior to filling).
- Acidified bottles are filled next, without rinsing.
- It is preferred that once filled, all bottles are put on ice, except the chlorophyll bottles. This bottle must not be temperature shocked. It can lay upon the other bottles in the ice chests. Once it begins to cool down, it can then be completely iced (as other bottles).
- Ensure all caps are tightened prior to placing in the ice chests.

E. DATA RECORDING

- Data recording members will record environmental parameters, collect light meter (2pi and 4pi) readings (between 900 and 1500 with 1000 and 1400 the preferred time window, minimally one per region per month), multi-parameter sampling meter (e.g. Hydrolab or YSI) readings, Secchi disks values and any other pertinent information needed.
- For water >1.2 m, light meter air and water readings are taken at surface, 0.2, 0.4, 0.6,0.8 and 1.0 m and 170, 270, 370, 470, 570, 670 and 770 centimeters, or until you can no longer receive positive numbers.
- For <1.2m, readings are taken for surface, 0.2, 0.4,0.6, 0.8 and 1.0 m, as applicable.

- Submerged aquatic vegetation or algae should not occlude light meter. For very rough, high wave conditions, light meter readings are optional.
- It is preferable to use similar light meters for the entire study area; however, 4 pi light meters will be used in Pine Island Sound, Matlacha Pass, tidal Caloosahatchee River and Estero Bay, and 2 pi will be used all elsewhere. A data qualifier will be used to record bottom composition information (mucky, sandy, submerged aquatic vegetation, hard bottom or unknown), especially when using a 4 pi light meter over white, sandy sediments.
- Secchi disk depth will be taken on shady side of boat without the use of sunglasses, and light meter readings will be taken on sunny side of boat.
- Multi-parameter sampling meter values (pH, DO, salinity, pH, temperature) are recorded to the nearest 0.01 values. Conductivity readings are recorded to the nearest unit. Values are recorded at 0.5m below the surface and <0.5m above the bottom (for >3m depths). Profiles of the water column at every meter are optional. Depths are recorded from the probes, not the bottom of the instrument.

- Additional information is recorded as per the datasheet, including K-values calculated from collected light meter readings (See attachment).
- See datasheets and lists

Quality Assurance plans

See individual labs for lab analyses. Each lab will provide sampling field staff with pre-labeled bottles and equipment as needed. The grab samples will be returned to the lab within 24 hours of sampling period. Field sampling staff will handle and drop off the samples to their respective lab within that allotted time period.

Labs will participate in the Southwest Florida Regional Ambient Monitoring Program on a quarterly basis to ensure inter-lab data comparability. Field audits for each sampling entity will be performed by the Senior Scientist of the Charlotte Harbor NEP annually to ensure sampling comparability between agencies.

Data management

Data will be maintained and uploaded to STORET by data owners. Data will be available to public and partnering agencies at all times.

Data Owner	Stratum
Charlotte County	Lower Lemon Bay
	Tidal Peace River
	Tidal Myakka River
	Charlotte Harbor West Wall
	Charlotte Harbor East Wall
	Charlotte Harbor Placida
Lee County	Charlotte Harbor Bokeelia
	Pine Island Sound
	Estero Bay
SFWMD/Lee County	Tidal Caloosahatchee River
City of Cape Coral	Matlacha Pass
City of Sanibel	San Carlos Bay

The Charlotte Harbor NEP will analyze and make publicly available the results, the data collected for this Network on a tri-annual basis.

BUDGET

Annual Budget for Charlotte Harbor Monitoring Network

Agency	Sampling	Lab Analysis
Southwest Florida Water Management District		
for cooperative agreement with FWC-FMRI to sample monthly 5 strata including Charlotte Harbor, tidal Peace and Myakka rivers ($120 per effort x 5 sites per stratum x 5 strata x 12 months per year)	**$ 36,000.00**	
Charlotte County		
for lab analysis of 7 strata including Alligator Bay, lower Lemon Bay, Charlotte Harbor and tidal Peace and Myakka Rivers ($127 per sample x 45 stations per stratum per year x 7 strata)	**$14, 589 (to DEP)**	**$ 40,005.00**
DEP-Aquatic Preserves		
to sample lower Lemon Bay stratum monthly	**$ 7,164.00**	
to sample Bokeelia stratum of Charlotte Harbor	**$ 9,485.00**	
FWC-FMRI		
(to sample 5 strata including Charlotte Harbor, tidal Peace and Myakka rivers)	**$ 42,336.00**	
Lee County		
to sample 2 strata including Pine Island Sound and Estero Bay to analyze samples from 3 strata, including Charlotte Harbor, Pine Island Sound and Estero Bay (using current levels of effort to estimate costs)	**$ 9,800.00**	**$ 48,700.00**
City of Cape Coral		
to sample Matlacha Pass stratum monthly	**$14, 639**	
(lab costs= 5 sites per month x $81 per sample)		**$ 5,295.00**
City of Sanibel		
to sample San Carlos Bay stratum monthly (will probably require top and bottom samples at each site plus duplicates= 13 per month)	**$ 14,623.00**	**$ 21,060.00**
South Florida Water Management District		
to sample and analyze 3 fixed and 5 randomly located sites in the tidal Caloosahatchee River	**$**	**47,000.00**
Grand Total	**$ 148,636.00**	**$ 115,060.00**
Total Agency Contribution	**$ 310,696.00**	

REFERENCES

Charlotte Harbor National Estuary Program, February 2000. *Long Term Monitoring Strategy and Gaps Analysis*, Charlotte Harbor National Estuary Program, North Fort Myers, FL.

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Southwest Florida Water Management District, October 1995. *A Long-Term Water Quality Monitoring Design for Charlotte Harbor, Florida*, Southwest Florida Water Management District, SWIM Department, Tampa, FL.

St. Johns River Water Management District, March 2000. *Florida's Integrated Water Resource Monitoring Network*, St. Johns River Water Management District.

APPENDIX

AGENCY MONITORING BUDGETS (Based Upon 2002 Estimates)

Charlotte County

Sanders Lab Analytical Services Only

Location	Stations per year	Samples per year	Cost per sample	Estimated Annual Cost
Alligator Bay	45	45	$127	$5,715
Charlotte Harbor (east side)	45	45	$127	$5,715
Charlotte Harbor (west side)	45	45	$127	$5,715
Gasparilla Sound	45	45	$127	$5,715
Lemon Bay	45	45	$127	$5,715
Tidal Myakka River	45	45	$127	$5,715
Tidal Peace River	45	45	$127	$5,715
				$40,005

5 samples per area per month

Sanders Lab Analytical Services & Field Sampling

Location	Stations per year	Samples per year	Cost per sample	Estimated Annual Cost
Alligator Bay	15	15	$167	$2,505
Charlotte Harbor (east side)	15	15	$167	$2,505
Charlotte Harbor (west side)	15	15	$167	$2,505
Gasparilla Sound	15	15	$167	$2,505
Lemon Bay	15	15	$167	$2,505
Tidal Myakka River	15	15	$167	$2,505
Tidal Peace River	15	15	$167	$2,505
				$17,535

5 samples per area per month

City of Sanibel's Estimated Cost for San Carlos Bay Stratum

Estimated cost breakdown for one strata with five sites per month sampling top and bottom with an equipment blank, field blank and field duplicate

CHNEP's Contribution (Lab Analysis)

Parameter:	Cost Per Analysis:	Number of Samples Per Month
NO3	$14.00	13
No2	$14.00	13
NH4	$10.00	13
TKN	$18.00	13
TP	$9.00	13
Chlorophyll a	$15.00	13
O-PO4	$8.00	13
TSS	$7.00	13
Turbidity	$7.50	13
TOC	$15.00	13
Color (PCU)	$7.50	13
Total Ammonia Nitrogen	$10.00	13
Total for one Sample:	**$135.00**	
Total Per Month:	**$1,755.00**	
Total Per Year:	**$21,060.00**	

The City of Sanibel's Contribution

Field Sampling Equipment & Maintenance	$6,975.50
Maintenance of Sampling Boat	$240
Staff Time (16hrs x $35.00 Per Month)	$6,720.00

Other Equipment to be Purchased by the City Specifically for the CHNEP Strata

Disposable Syringes	$150.00
DI Water	$100.00
Disposable Filters	$250.00
Disposable Latex Gloves	$44.00
Boat Fuel ($12 per month)	$144.00
Total Per Year:	**$14,623.50**

Last Modified in February 2002

Charlotte Harbor Aquatic Preserves: **Lemon Bay**

Service	Cost	CHAP In Kind	Charlotte County In Kind
Service of CHAP staff x 32 hr/mo x 12 mo (sampling, prep., lab delivery, post sampling cleanup)	**$5568**	**$5568**	
Gas/maintenance for boat and truck @ Boat = $50/trip + Truck = $30/trip x 12 mo	**$960**	**$960**	
Hydrolab: Datalogger 4a w/ 4a Sonde: $35/sampling event x 12 sampling events	**$420**	**$420**	
LiCor: 1400 w/ 2pi sensors: $12/sampling event x 12 sampling events	**$144**	**$144**	
Alpha Bottle: 6.2L horizontal acrylic bottle w/ line, messenger, case & repair kit: $6/sampling event x 12 sampling events	**$72**	**$72**	
PH Buffers (7.0 & 10.0) from Fisher Scientific 1 gal. each	**$120**		**$120**
Conductivity Standard from Fisher Scientific 2 cs. (16 pts) 50,000 umohs #NC9356193	**$200**		**$200**
In-line filtration apparatus: 1 Masterflex E/S Sampling Pump Drive (Cole Palmer #U-07571-00) 1 @ $895/ea.	**$895**		**$895**
Pump Head for In-line filtration apparatus: 1 Masterflex L/S 24 Easy-Load pump head (Cole Palmer #U-07518-02) 1 @ $135	**$135**		**$135**
Tubing for Pump Drive: 25 ft. Tygon LFL L/S tubing (Cole Palmer # U-96400-24) 1 pack @ $64	**$64**		**$64**
In-line filter holders: 9 (8 samples/mo + 1 extra) 47 mm Polycarbonate holders (Cole Palmer # U29828-00) @ $60/holder	**$540**		**$540**

In-line filter holder replacement support screens (U-29828-50) and replacement o-rings (U-29828-52) 9 ea @$3.80/screen and $$6.76/o-ring	**$95**		**$95**
In-line filters: 150 (8 samples/mo x 12 mo @ 1-2 filters/sample) 47mm Filter unit, 0.45*u*m NY+GL T20-1/8 (Cole Palmer #U-06644-16) 2 packs (100/pk) @ $30.35/pk	**$60**		**$60**
Laboratory Contract: (8 sample kits/mo x 12 mo) @ $130 per kit	**$12,480**		**$12,480**
Totals	$21,753	$7,164	$14,589

Charlotte Harbor Aquatic Preserves: Bokeelia Region of Charlotte Harbor

Service	Cost	CHAP In Kind	Costs To Be Covered
Service of CHAP staff x 32 hr/mo x 12 mo (sampling, prep., lab delivery, post sampling cleanup)	**$5568**	**$5568**	
Gas/maintenance for boat and truck @ Boat = $50/trip + Truck = $30/trip x 12 mo	**$960**	**$960**	
Hydrolab: Datalogger 4a w/ 4a Sonde: $35/sampling event x 12 sampling events	**$420**	**$420**	
LiCor: 1400 w/ 2pi sensors: $12/sampling event x 12 sampling events	**$144**	**$144**	
Alpha Bottle: 6.2L horizontal acrylic bottle w/ line, messenger, case & repair kit: $6/sampling event x 12 sampling events	**$72**	**$72**	
PH Buffers (7.0 & 10.0) from Fisher Scientific 1 gal. each	**$120**	**$120**	
Conductivity Standard from Fisher Scientific 2 cs. (16 pts) 50,000 umohs #NC9356193	**$200**	**$200**	

	In-line filtration apparatus: 1 Masterflex E/S Sampling Pump Drive (Cole Palmer #U-07571-00) 1 @ $895/ea.	**$895**	**$895**	
	Pump Head for In-line filtration apparatus: 1 Masterflex L/S 24 Easy-Load pump head (Cole Palmer #U-07518-02) 1 @ $135	**$135**	**$135**	
	Tubing for Pump Drive: 25 ft. Tygon LFL L/S tubing (Cole Palmer # U-96400-24) 1 pack @ $64	**$64**	**$64**	
	In-line filter holders: 12 (10 samples/mo surface and bottom + 2 QA) 47 mm Polycarbonate holders (Cole Palmer # U29828-00) @ $60/holder	**$720**	**$720**	
	In-line filter holder replacement support screens (U-29828-50) and replacement o-rings (U-29828-52) 12 ea @$3.80/screen and $$6.76/o-ring	**$127**	**$127**	
	In-line filters: 180 (12 samples/mo x 12 mo @ 1-2 filters/sample) 47mm Filter unit, 0.45*u*m NY+GL T20-1/8 (Cole Palmer #U-06644-16) 2 packs (100/pk) @ $30.35/pk	**$60**	**$60**	
	Laboratory Contract: (12 sample kits/mo x 12 mo) @ $130 per kit	**$18,720**		**$18,720**
	Totals	$28,205	$9,485	$18,720

City of Cape Coral: Matlacha Pass

Service	Cost	Cape Coral In Kind
Two staff people for 24 hours total (Two people at 8 hours – sampling One person at addl 8 hours -prep/breakdown)		$5,045
Gas for Boat & Truck ($5 / truck + $20 / boat)		$300

Hydrolab (purchased 6/95)		$8,275
Licor (purchased 6/89)		$327
Peristaltic Pump (purchased 6/89)		$692
In-line filters: 72 (5 stations + 3 QA samples/mo x 12 mo) 50 mm filter unit, 5 packages @$87/pkg	$435	
Laboratory Analysis $81/sample 5 samples mo x 12 mos	$4,860	
Total	**$5,295**	**$14,639**

FMRI---Charlotte Harbor/Lemon Bay Water Quality Monitoring Project

Table 3. In-kind services provided by Florida Fish and Wildlife's Florida Marine Research Institute. Three Charlotte Harbor staff plus one new hire (from grant monies) will participate in the water quality sampling. The samples will be collected during the routine stratified random sampling program. Estimates of in-kind contribution are based on a maximum of 12 days of sampling.

Item	cost per day	Total per month (12 days)	Total per year
boat/vehicle use	$100.00	$1,200.00	$14,400.00
Hydrolab	$20.00	$240.00	$2,880.00
3 staff (max 4 hours/day@ $14.50/hr)	$174.00	$2,088.00	$25,056.00
Total contributions			**$42,336.00**