# BISCAYNE BAY PARTNERSHIP INITIATIVE

# SURVEY TEAM FINAL REPORTS

BISCAYNE BAY
PARTNERSHIP INITIATIVE

# WATER AND SEDIMENT QUALITY

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# BACKGROUND

Biscayne Bay water quality has been the subject of monitoring and study for many decades. A network of surface water monitoring stations within the Bay was established by the Miami-Dade Department of Environmental Resources Management in the late 1970's, with support from the State of Florida. The network was expanded to include the Miami River and other canals and tributaries in the mid-1980's in connection with the Biscayne Bay Surface Water Improvement and Management Program. The database established through this ongoing program is shared with public and private sector organizations and includes approximately one-half million observations. Additional monitoring conducted by Florida International University focuses on nutrient parameters and links to other south Florida monitoring databases. The US Geological Survey (U.S.G.S.) has also monitored canals and groundwater in the Biscayne Bay watershed. Miami-Dade DERM conducts groundwater monitoring and stormwater monitoring in connection with selected regulatory activities. Sediment chemistry studies have been conducted by local, state, and federal agencies over the past 20 years.

Biscayne Bay's water quality has improved substantially in the past 30 years, and water quality generally meets or exceeds federal, state, and local standards for recreational uses and propagation of fish and wildlife. In recognition of its exceptional values, the State of Florida has designated the Bay and its natural tributaries as Outstanding Florida Waters, and as such they receive the highest level of protection from degradation. However, some portions of the bay have been significantly affected by past development and water management practices. Loss of wetland and seagrass communities has contributed to changes in physical and ecological water quality characteristics. Also, the Bay still receives dissolved nutrients, trace metals, organic chemicals, and particulates via stormwater runoff, canal discharge, and discharges from industrial facilities or vessels. Canal water typically has lower dissolved oxygen and clarity and higher concentrations of contaminants than receiving waters of the Bay, and so represents a source of degradation. The Biscayne Bay SWIM Plan provides a detailed analysis of water quality patterns and trends and includes numerous recommendations for protecting and enhancing the Bay (Alleman, et al 1995). The following brief review focuses on selected water quality issues.

## WATER CLARITY

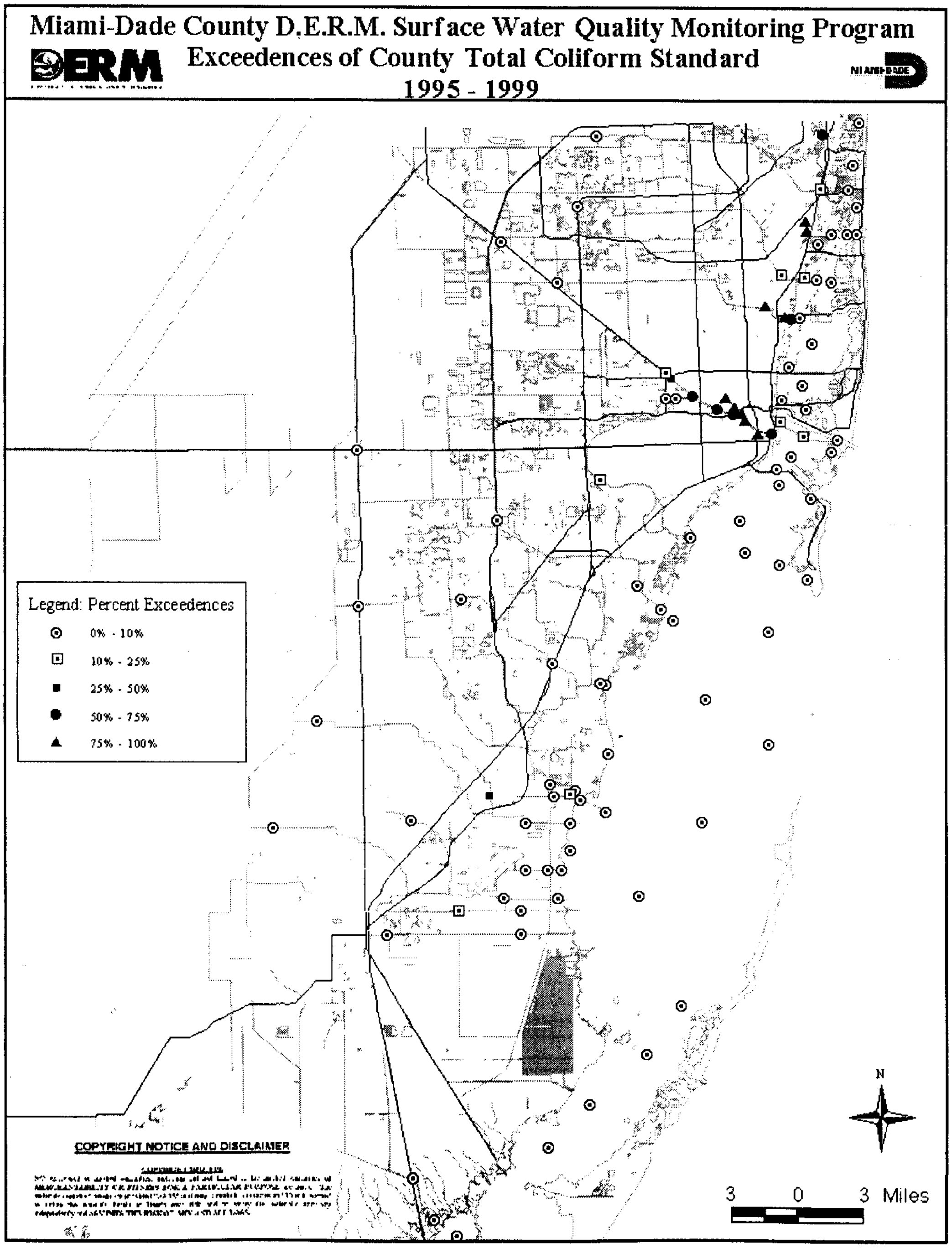
Because Biscayne Bay productivity is dominated by seagrass and benthic algae, which depend on light reaching the bay bottom, water clarity or transparency is of critical significance. Biscayne Bay is characterized by low turbidity levels, typically less than 2 NTUs, although wind-driven resuspension of bottom sediments can occur following storm events. In most areas of Biscayne Bay, water clarity is adequate to sustain growth of benthic vegetation. However, there are some areas where turbidity and transparency are a concern particularly in regions of the bay north of Coconut Grove/Key Biscayne.

The Bay bottom and shorelines north of Coconut Grove/Key Biscayne were altered by dredging, primarily to provide fill for development of surrounding lands and for navigation channels in the 1920's and 1930's. Dredging of the Bay bottom eliminated seagrass and increased depths in portions of north Biscayne Bay, making it impossible for benthic vegetation to recover. Loss of stabilizing vegetation and continuing resuspension and erosion of unconsolidated sediment are the principal cause of chronic turbidity in some areas of north Biscayne Bay (Wanless, et al., 1984). Seawalls, which replaced some natural shorelines in north Biscayne Bay and reflect wave energy, also contribute to resuspension of bottom sediments. Although dredging and filling are strictly regulated, localized turbidity impacts sometimes occur in connection with dredging, coastal construction, or vessel traffic. Nutrient enrichment, particularly near canal mouths and in Dumfoundling Bay, can lead to intermittent declines in water transparency as a result of phytoplankton blooms. Tannin-colored water associated with canal discharges also reduces light penetration.

# SEWAGE AND SANITARY QUALITY

Direct discharge of sewage effluent to Biscayne Bay was largely eliminated in the mid-1950's when regional sewage treatment plants were constructed, and consequently sanitary quality of the water improved dramatically (McNulty, 1970). However, indirect sewage contamination from improper or illegal discharges to storm sewers or groundwater remain problematic in some tributaries (DERM, 1993; Alleman et al. 1995). Use of appropriate indicators of sewage pollution for marine waters is the subject of ongoing scientific interest. Coliform and enterococcus bacteria are common in human waste and easy to culture in the laboratory. However, they may also be associated with other sources, such as soils and other animal waste, and are attenuated to varying degrees after exposure to saltwater. Despite these shortcomings, there has not been adequate epidemiological research to relate the occurrence and persistence of indicator organisms in tropical marine waters to the incidence of swimming-related human illness or to identify a superior indicator. Therefore, current state and local water quality criteria are based upon coliform or fecal coliform bacteria concentrations. See **figure 1**.

**Figure 1**

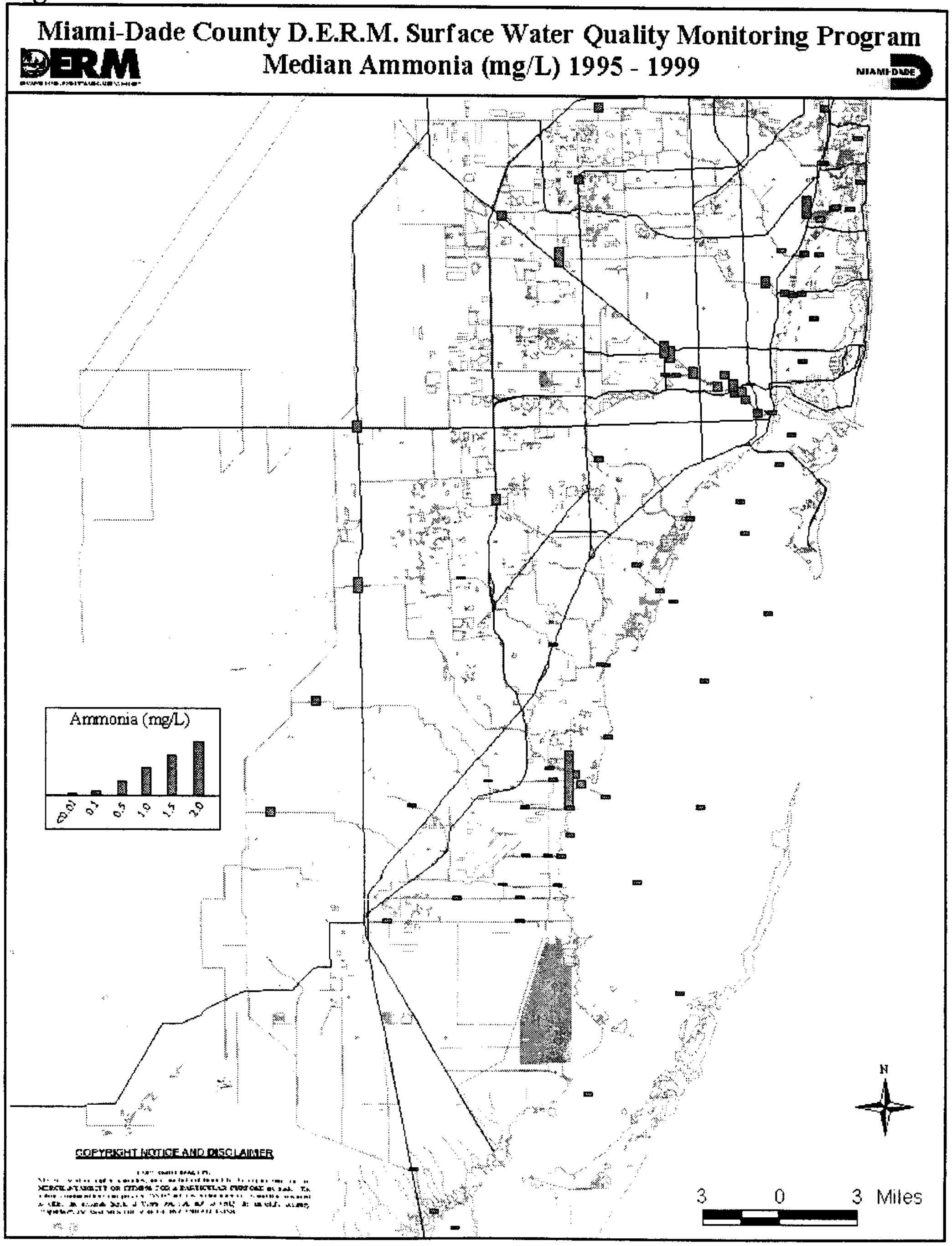



Based on these parameters, open water areas of the Bay rarely have exceeded standards for recreational contact over more than 20 years. In contrast, the Miami River and its tributaries chronically exceed standards, and occasionally exhibit coliform bacteria concentrations that exceed standards by several orders of magnitude (Markley, et al., 1990; DERM, 1993). With the exception of the Wagner Creek area, coliform bacteria concentrations in the Miami River have improved over the last five years, although they generally still exceed standards. Other highly urban canals, including the upper Oleta River, Arch Creek, and Little River also exhibit frequent incidence of sewage contamination. During tropical storms, flooding, or damage to sewer infrastructure, contaminated canal water periodically affects adjoining portions of the Bay. In view of the possibility that coliform data may not adequately characterize sewage contamination in saltwater comparative sanitary surveys, using other bacterial, viral, and chemical indicators of sewage pollution have been conducted in the Biscayne Bay area (Pierce and Brown, 1986; McQuorcodale, 1987). These studies generally confirmed the geographic patterns of contamination, showing evidence of sewage in the Miami River, urban tributaries, and poorly flushed nearshore areas. In 1999, the Florida Department of Health added routine sampling for Enterococcus to its beach monitoring program. In 2000, the Florida Legislature provided additional funding statewide for FDOH to continue monitoring this indicator.

## NUTRIENTS

In general, water clarity in the Bay is high and inorganic nutrient concentrations are low. Since concentrations of nutrients in the bay are low, Biscayne Bay is vulnerable to nutrient loading. Brand (1988) determined that phosphorus is the limiting nutrient for phytoplankton growth in the bay. Excess nutrients can stimulate the growth of phytoplankton and epiphyte populations that can prevent sufficient light penetration to sustain the vital benthic communities. High levels of ammonia can be toxic to invertebrates and fish. The SWIM Plan describes several significant water quality trends for Biscayne Bay. It concludes that increases in ammonia and nutrient concentrations accounted for most negative water quality trends. Sources of ammonia and nutrients can include stormwater runoff, sewage contami-

Figure 2

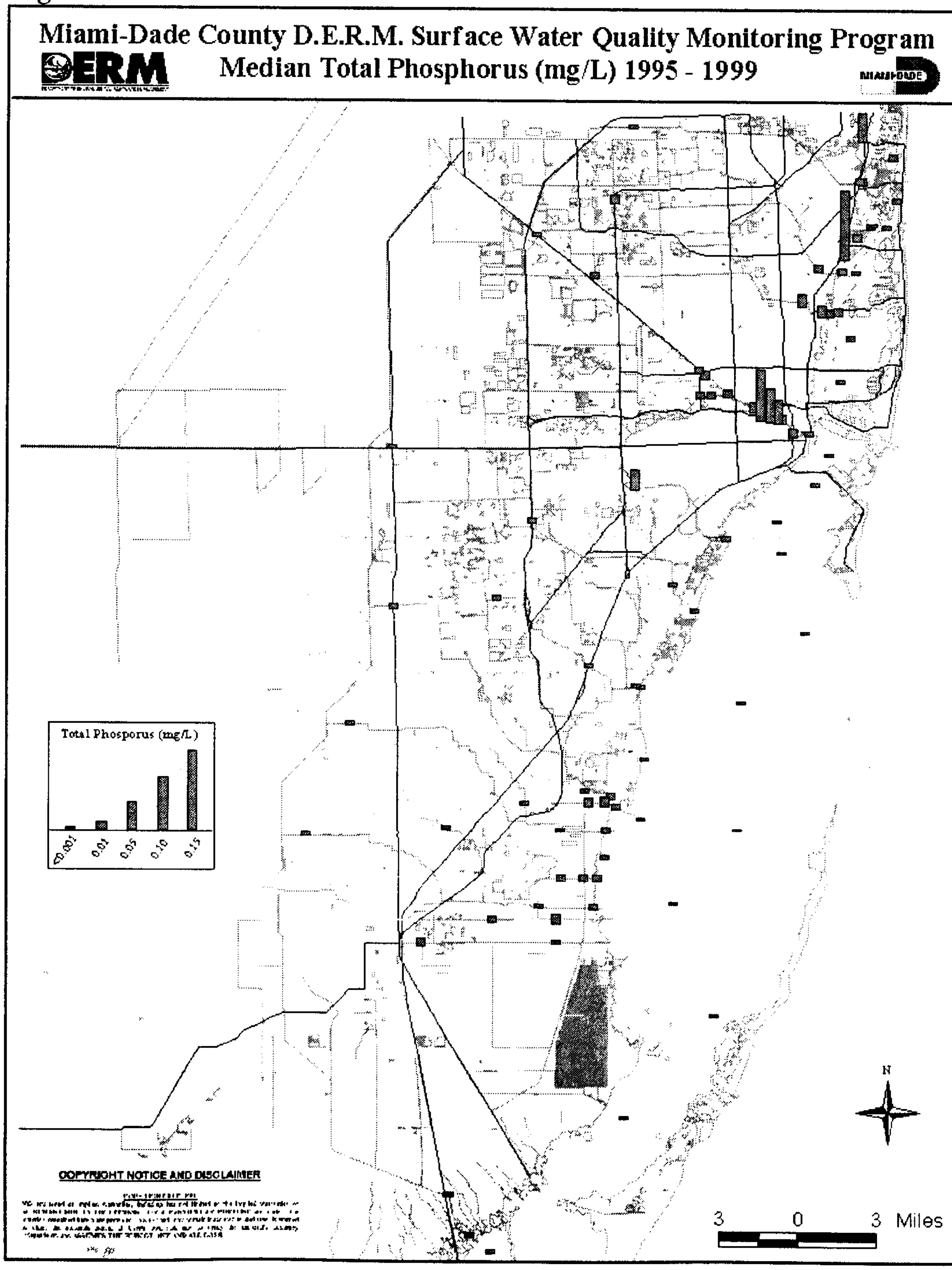


nation, leachate from landfills, fertilizers, and natural decay of plant material. These sources of contaminants can reach the Bay via surface water discharges from canals, direct upland runoff, or through groundwater pathways.

Rules governing protection of the water resources of Biscayne Bay contain a narrative standard that protects the Bay from degradation of water quality and the loss of its designated uses. However, there are presently no numerical water quality standards for nutrient levels in Biscayne Bay. A multi-agency review team was convened as part of efforts to define numerical targets or performance measures to ensure that water quality in Biscayne Bay, particularly Biscayne National Park, is not degraded by changes in water management practices or by development in the watershed. The group evaluated existing water quality data and identified nutrient concentrations in open areas of south Biscayne Bay. They concluded that in order to prevent degradation of water quality in Biscayne Bay, the following nutrient concentrations should not be exceeded: total ammonia, 0.02-0.05 mg/L (20 – 50 ppb) (dependent on sampling method); nitrate-nitrite, 0.01 mg/L (10 ppb); and total phosphorus, 0.005 mg/L (5 ppb). Although water quality performance measures have not been formally adopted for Biscayne Bay, the review team's determinations serve as valuable guidelines. While nutrient concentrations in the bay are low, levels observed in freshwater canals discharging to the bay are higher. More work is needed to define acceptable nutrient concentrations for a near shore estuarine mixing zone.

An evaluation of data from the Miami-Dade DERM Biscayne Bay Surface Water Quality Monitoring Program supports the conclusion of a land use based watershed effect on nutrient levels. **Figures 2,3, and 4** represent the median ammonia, phosphorus, and nitrate/nitrite levels for the five year period ending December 1999. Higher

**Figure 3**

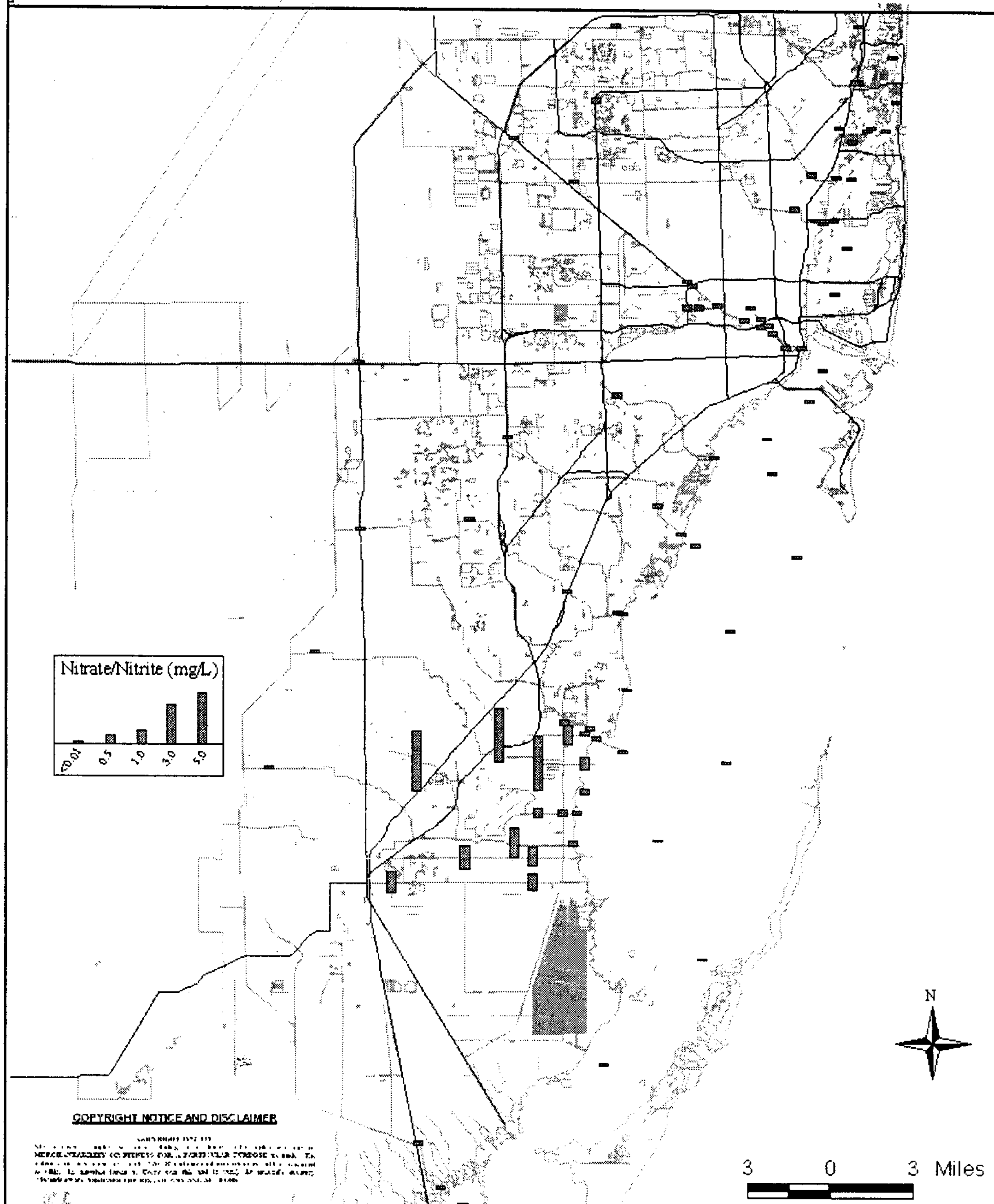


ammonia and phosphorous levels occur in the heavily urbanized portions of northern Miami-Dade County. Nutrient loading in this region of the bay is primarily related to stormwater runoff and sewage contamination. Studies by DERM in the late 1980's (Alleman, 1990) identified high ammonia levels in ground and surface waters near the South Dade landfill and nearby uncontrolled dumps. Ammonia contamination from landfills, particularly old dumps that have not been properly closed or remediated, is considered a significant threat to the natural resources of the Bay. Highest surface water ammonia concentration during the preceeding five-year data period occurred in Goulds Canal adjacent to older dumps and the active South Dade landfill. Efforts are underway to reduce the impact of the south Dade landfills on local groundwater and surface water quality. The South Dade Landfill program includes capping to reduce leachate formation, collection and treatment of existing contaminated groundwater, and stormwater management features. The old dumps are undergoing extensive remediation which include removal and relocation of old waste from areas east of the levee, treatment of contaminated groundwater, and establishment of a system to reduce formation of leachate.

Higher nitrate/nitrite levels occur in surface and groundwater in the southern region of the county in watersheds which support large areas of agriculture. Nitrate/nitrite concentrations in south Dade canals such as Mowry and Princeton are typically an order of magnitude higher than levels seen in other canals. This strongly suggests a connection to the agricultural based land use that dominates south Dade.

Lietz (1999) sampled nutrient concentrations in 15

**Figure 4**




Miami-Dade County D.E.R.M. Surface Water Quality Monitoring Program
Median Nitrate/Nitrite (mg/L) 1995 - 1999

major canals for two years and developed models that predict load as a function of discharge. The study showed that the concentration of various nitrogen and phosphorus constituents was related to land use, categorized as urban, agriculture, or forested/wetland. Organic nitrogen concentrations were highest in urban and forested/wetland areas than elsewhere. Inorganic nitrogen was highest in agricultural areas. Ammonia and phosphorus concentrations were highest in urban areas. These conclusions are consistent with results reported by Miami-Dade County. Lietz also estimated loading from canals based upon estimated discharge rate and observed nutrient concentrations. For example, the model predicted that a discharge rate of 300 $ft^3$/second would result in a total nitrogen load of 3.2 to 4.76 tons per day from the Biscayne Canal, where the mean total nitrogen concentration was 1.10 mg/L. Miami-Dade DERM is currently developing watershed models to estimate pollutant loading in connection with stormwater management planning programs.

Groundwater inputs to Biscayne Bay are not very well understood. Modifications to the south Florida landscape during this past century are believed to have significantly altered historic groundwater flow to the Bay. Several studies do suggest that groundwater inputs to the Bay are a near shore phenomenon with most discharge occurring within 100 m of shore (Meeder et al 1997). Meeder's study of groundwater nutrient loading to the near shore areas of the Bay supports this conclusion and suggests that groundwater can contribute significant amounts of nutrients to the bay. This study identified elevated nutrient concentrations in both surface and groundwater and concluded that groundwater nutrient inputs to the bay can be significantly higher than loading from surface water discharges.

# TOXIC POLLUTANTS IN WATER AND SEDIMENTS

Ongoing monitoring programs include sampling for pollutants such as trace metals and synthetic organic chemicals, which can be toxic at certain concentrations. Trace metals are detected in marine waters and occasionally in canals, but rarely exceed State or local regulatory standards. Organic chemicals are generally not detected in surface or groundwater. However, this is not unexpected, since metals and organic chemicals are not highly soluble. Rather than remaining in solution, they tend to bind to particulate matter and settle in sediments. For this reason, local, state and federal studies intended to examine the pollution climate of Biscayne Bay have included evaluation of sediment chemistry and toxicity.

Several studies have documented the presence of contaminants in the sediments of Biscayne Bay and adjoining canals (Corcoran et al, 1983, Alleman, 1995). Data on chemical concentrations show a familiar pattern: highest concentrations of most substances in peripheral canals, rivers, streams, and marinas and lowest concentrations down the central north-south axis of the bay. The Miami River and Wagner Creek exhibit higher levels of trace metals and organic contaminants, such as some pesticides and PCB's, than any other area in the State of Florida (Schmale, 1991; DERM, 1993; Gulf Engineers and Consultants, 1993; Seal et al, 1994). Other than relatively small-scale analyses performed in conjunction with dredging projects, very little toxicological data have been generated for the bay.

The toxicity of sediments in Biscayne Bay and many adjoining tributaries was investigated as part of a bioeffects assessments program managed by NOAA's National Status and Trends Program (Long et al., 2000). This study showed that contamination and toxicity were most severe in several peripheral canals and tributaries, including the lower Miami River. In the open basins of the bay, chemical concentrations and toxicity were generally higher in areas north of the Rickenbacker Causeway than south of it. Sediments from the main basins of the bay generally were less toxic than those from the adjoining tributaries and canals. The different tests indicated overlapping patterns or gradients in toxicity. The least sensitive test indicated severe toxicity (high mortality) in tests of sediments from the lower Miami River. Compared to conditions in the adjoining portions of the bay, the sediments of the Miami River were contaminated with mixtures of toxicants, were highly toxic in acute tests, and supported relatively depauperate benthic assemblages.

Results from four different toxicity tests, overall, indicated highest toxicity in samples from the lower Miami River, Black Creek Canal, other canals adjoining the south bay, and canals and tributaries adjoining the bay near Miami and Miami Beach. Samples that were least toxic were collected from the far north and far south ends of the study area. The causes of toxicity could not be determined in this study. However, the weight of evidence strongly suggests that for the lower Miami River, toxicity as measured in the amphipod survival tests could have been caused, at least in part, by mixtures of some metals and synthetic organic chemicals. In the canals of the south bay, both toxicity and contamination were less severe and the identities of chemicals that most probably contributed to toxicity were less clear. Concentrations of PAHs, PCBs, and several trace metals, however, may have been sufficient to contribute to toxicity in the more sensitive sublethal tests.

A section of southern Biscayne Bay showed remarkably high toxicity that could not be explained with the chemical data. Results of many of the toxicity tests were highly significant in the samples from this section of the bay, yet they were surrounded by many stations in which there was little or no toxicity. Concentrations of chemicals for which analyses were performed were uniformly low, usually near or below detection limits, in toxic samples from this region. Concentrations of ammonia in some toxic samples were sufficiently elevated to raise concerns that pore water ammonia may have contributed to toxicity. Therefore, the data suggest that chemical substances other than those for which analyses were performed likely caused or contributed to the toxic conditions in at least some samples. Both the degree and spatial extent of chemical contamination and toxicity in this study of Biscayne Bay were similar to or less severe than those observed in many other areas in the U.S. The spatial extent of toxicity in all tests performed throughout the bay were comparable to the "national averages" calculated by NOAA from previous surveys conducted in a similar manner.

Concurrent with NOAA's study of Biscayne Bay sediments, a similar study of sediment chemistry and toxicity in 28 freshwater canals was conducted by Miami-Dade DERM. In this study, sediments from Wagner Creek, Little River, near Miami International Airport, and Military Canal exhibited significant toxicity. Data from this study showed highest concentrations of several metals including mercury, silver, cadmium, and copper were found in Military Canal. A follow up study of Military Canal by the U.S. EPA confirmed these findings and linked contamination in the Canal to past activities at Homestead Air Force Base (U.S. EPA 1999).

Living resources of the bay are exposed to sediment contaminants through benthic food webs and when sediments are resuspended in the water column. Sediment resuspension and redeposition is an ongoing process. Mechanisms include sediment resuspension caused by wave action during periods of high winds and storms, and due to vessel traffic. Furthermore contaminated sediments in canals and the Miami River can move into the bay when discharge velocities are sufficient to cause resuspension or sediment transport.

## WATER QUALITY ISSUES RELATED TO PROPOSED EVERGLADES RESTORATION

A component of the Comprehensive Everglades Restoration Plan (CERP) proposes to discharge advanced treatment wastewater from an upgraded South Dade Wastewater Treatment Plant into Biscayne Bay after routing it first through coastal wetlands in order to meet projected freshwater volume requirements for south Biscayne Bay. Although reuse of wastewater may be an appropriate water conservation strategy in urban or agricultural settings, this concept has raised concerns when coupled with discharge to sensitive oligotrophic natural systems. This component is controversial because (1) it is questionable whether a practical technology is available to provide the level of advanced treatment required to prevent harm to the bay, (2) other constituents in sewage (e.g., industrial wastes, heavy metals, and estrogen hormones and other pharmaceuticals) may not be adequately removed by treatment to avoid harm to the bay or wetlands, and (3) plant breakdowns or accidents could cause a spill that effects the bay or wetlands. Two of the first projects to be implemented by the U.S. Army Corps of Engineers in CERP will be a demonstration advanced treatment pilot plant and an experiment on the ecological effects of its effluent. The bay may not need this water source if improvements in the regional plan allow more water from other sources to flow to the bay.

# RECOMMENDATIONS

1) **Quantify pollutant loading to Biscayne Bay.**

(*Justification: Extensive monitoring data provides a basis for description of geographic and temporal patterns, but this information must be coupled with hydrologic data to develop more dynamic estimates of pollutant loading and nutrient mass balance. Hydrologic models now under development are expected to provide the foundation for water quality models that should be useful in projecting changes in geographic patterns, trends, and loading of nutrients and contaminants. However, there are little or no data presently available on atmospheric deposition or flux rates, and little information available on sediment-water column exchange of nutrients or contaminants.*

## *Specific Science Recommendations*

a) Conduct water quality and hydrologic studies necessary to quantify pollutant loading to Biscayne Bay. This should include studies to quantify groundwater inputs to the bay and address the role groundwater plays in pollutant loading.

b) Conduct additional studies to identify fate and transport mechanisms for contaminants in the bay system. This should include studies to address atmospheric deposition or flux rates, and provide information on sediment-water column exchange of nutrients or contaminants.

c) Conduct studies to evaluate impact of elevated nutrient levels in south Dade watershed on the receiving waters of Biscayne National Park.

2) **Refine water quality standards used to indicate the presence of sewage in surface water.**

(*Justification: Various techniques exist for identifying the presence of sewage in surface waters. However, each method has inherent limitations and method performance may vary with climate. Epidemiological data on the incidence of swimming-related illness is needed to refine standards for sewage indicator organisms used in South Florida.*)

## *Specific Science Recommendations*

a) Conduct surveys to determine the incidence of swimmer related illness for public beaches in South Florida. Correlate results from the survey with beach water quality monitoring data results to identify the most effective indicator of sewage contamination, and use this information to develop an appropriate numerical standard.

b) Continue and expand water quality monitoring at public beaches to provide data necessary to evaluate survey results and provide to inform the general public.

3) **Determine the effect of exposure to contaminants in surface water and sediments on local plant and animal populations.**

(*Justification: With the exception of health-risk assessments conducted in the Military Canal area, there are little data available on levels of mercury or other toxic contaminants in fish and shellfish tissues for the Bay. There are also little or no information on the acute or chronic effects of these contaminants on resident plant and animal populations. Such data are necessary for directing resource management efforts, and are needed to evaluate potential human-health implications of subsistence fishing in urban surface waters with potential water and sediment quality degradation.*)

### Specific Science Recommendations

a) Conduct studies of local plant and animals to determine body burdens for toxic contaminants detected in surface water and sediments. These studies should include evaluations of species of special concern such as the bottlenose dolphin.

b) Conduct studies of local plant and animal populations to determine effects of exposure to surface water and sediment contaminants. These studies should address issues such as the effects of herbicides on seagrasses.

4) **Determine the causes for toxicity observed in sediments from south Biscayne Bay.**

*(Justification: Recent studies conducted by N.O.A.A. have identified the presence of toxicity in sediments from south Biscayne Bay. However, evaluation of paired sediment chemistry data does not show contaminant concentrations at levels that can explain the observed toxicity. Further study is needed to identify the causes of toxicity in sediments from this region. In addition, while the use of standardized testing can be a valuable tool for identifying relative toxicity, it is suggested that further studies are needed to quantify the impact of sediment contaminants on resident biota.)*

### Specific Science Recommendations

a) Conduct investigations to determine the cause for observed toxicity in sediments from southern region of the bay. These studies should include paired chemistry and toxicity analysis.

b) Conduct studies to quantify the impact of sediment toxicity on resident biota.

## Management Related Recommendations

1) **Develop a routine schedule of review and publishing scientific data for Biscayne Bay.**

*(Justification: While there are many unanswered science questions for Biscayne Bay, various entities with ongoing monitoring programs are generating useful data. It is suggested that efforts be made to develop a program of regular evaluation, summarization, and publishing of results from these programs. In addition, it is recommended that standard analysis methods with lowest available detection limits be used to more accurately characterize contaminant levels in the bay.)*

2) **Continue and expand efforts to reduce contaminant loading to the Bay.**

*(Justification: Studies have identified the presence of contaminants in canal and bay sediments. Monitoring programs have identified exceedances of surface water and groundwater quality standards in the Bay and its watershed. Efforts to reduce sources of contaminants and minimize inputs to the bay should continue. These efforts should also be expanded to address continued pressures from future growth and development. This includes continuing efforts to reduce contaminant loading from surface water runoff, reducing contamination of groundwater from landfill leachate, and reducing nutrient loading to the bay.)*

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