11.0 MANAGEMENT IMPLICATIONS

11.1 Policy-Relevant Questions

The South Florida Everglades Ecosystem Assessment project has been guided by seven policy-relevant questions:

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

This section will provide preliminary answers to these seven questions based on the data collected in this assessment study. The first four questions can be answered with greater certainty that the last three questions. The seven questions listed are equally applicable to each issue impacting the Everglades ecosystem such as hydropattern modification, Hg contamination, eutrophication, habitat alteration, and endangered and exotic species.

11.1.1 Magnitude - What is the magnitude of the problem(s) in the Everglades?

Mercury

Biota

1) Significant numbers of sportfish species including largemouth bass exceed the Florida fish consumption advisory of 0.5 ppm. (FGFWFC)
2) Less than 20% of the mosquitofish in the South Florida canals exceed the proposed predator protection level of 100 ppb for Hg.

3) Almost 70% of the mosquitofish in the South Florida marsh exceed the USFWS proposed predator protection level of 100 ppb for Hg.

Air

1) Atmospheric Hg concentrations in South Florida are as high as that found near industrial sources in the midwest. (FDEP)

2) Annual average Hg emissions to air for South Florida (0.48 $kg/m^2/yr$) are 3 times higher than the state average. (FDEP)

Water

1) 100% of the marsh and canals have THg concentrations less than the Florida 12 ng/L water quality criterion for protection of designated uses: recreation and propagation and maintenance of a well-balanced population of fish and wildlife.

2) Concentrations of water MeHg are two to three times higher in the marsh (0.2 to 0.6 ng/L) than in the canals (0.1 to 0.2 ng/l).

3) Water MeHg to THg ratios (MeHg/THg) were consistently higher in the marsh during the dry season (up to 36% in WCA2).

Soil

1) There are no apparent patterns of THg in soils that would indicate a specific source of Hg.

2) MeHg in surface soil is generally <10 μg/kg or <1 μg/cc with no spatial pattern. MeHg in soil is less than MeHg in soil periphyton.

Total Phosphorus

Water

1) 95% of the marsh currently has TP concentrations less than the 50 μg/L Phase I target TP concentration.

2) 45% of the marsh has TP concentrations equal to or less than 10 μg/L.

3) 55% of canal miles have TP concentrations less than 50 μg/L.

4) The EAA canals are loading the marsh with P.

5) There is an observable gradient in TP concentrations in the marsh with the highest concentrations found north of Alligator Alley and the lowest concentrations in the ENP.

Soil

1) TP in surface soil is highest in WCA2 and northern WCA3, with lower concentrations in central WCA3 and ENP. Lowest concentrations tend to occur in the marl soils.

11.1.2 Extent - What is the extent of the problem(s)?

Mercury

1) All of Florida Bay and the freshwater Everglades and BCNP are under a human health fish consumption advisory because of Hg contamination of certain gamefish species (FDHRS, FGFWFC, FDEP).

2) About 5,100 km^2 (2,000 mi^2), which is almost 70% of the South Florida marsh area has prey fish (mosquitofish) Hg concentrations that exceed the 100 ppb USFWS proposed guideline for protection of predators. In contrast only 20% or 210 km (130 mi) of the canal length exceed this guideline.

3) There is a Hg hot spot south of Alligator Alley in WCA3A extending into ENP where Hg concentrations are highest in water, algae, mosquitofish, gamefish, wading birds, alligators, and the Florida panther.

Phosphorus and Other Nutrients

1) Ninety-five percent (95%) of the marsh was sampled and 7,358 km^2 had TP concentrations less than the Phase I TP target concentration of 50 μg/L. Forty-seven percent (47%) or 3,654 km^2 of the marsh had TP concentrations less than 10 μg/L.

2) Fifty-five percent (55%) or 678 km (421 miles) canal had TP concentrations less than the Phase I TP target of 50 μg/L.

3) The canal system draining the EAA transports water with elevated concentrations of TP, TOC, and TSO_4 into the Everglades and contributes to water quality gradients from north to south across the marsh changing in extent with wet and dry seasons.

4) The APA, an indicator of microbial P limitation, shows clear gradients within the Everglades marsh system from north (little P limitation) to south (highly P limited).

11.1.3 Trend - Is the problem(s) getting better, worse, or staying the same?

Mercury

1) No data are available to determine whether Everglades biota were contaminated with Hg prior to 1989.

2) Monitoring of Hg in Everglades soil, water, algae, and mosquitofish has not been in place long enough to determine presence or absence of trends over time.

3) A 2-year baseline has been established with two wet and two dry seasons per year in the marsh grid. However, a record wet year occurred during one of these years.

4) Annual largemouth bass monitoring in Everglades canals since 1989 indicate that a significant number of bass exceed the Florida fish limited consumption advisory level of 0.5 ppm. There has been no significant decrease in bass Hg concentrations since 1989. (FGFWFC)

5) It is not possible to determine whether there is a trend over time in Everglades wading bird Hg contamination because monitoring has not been conducted on a consistent basis. (FDEP)

6) Everglades soil core dating indicates that there has been an increase in Hg deposition over the last 40 years. (FDEP)

Habitat

1) From 1946 to 1995 soil thickness across northeastern WCA3 has decreased from 0.9 to 1.5 m (3 to 5 feet) thick to only 0.3 to 0.6 m (1 to 2 feet) thick.

2) Approximately 50% of the historical freshwater marsh has been lost in the Everglades since the early 1900s. (SFWMD)

3) Preliminary data are available that indicate that cattails are becoming more abundant and dominant in more areas of the Everglades marsh.

11.1.4 Cause - What factors are associated with or causing the problem(s)?

1) It is the interaction of hydroperiod, TP, TOC, and TSO_4 concentrations with the biota that results in the methylation and bioaccumulation of Hg in the ecosystem, not a single factor.

2) It is thought that TP plays an important role in effecting plant and floating periphyton communities distributions and structure of food webs, thereby affecting Hg methylation and bioaccumulation.

3) Hg methylation is occurring not only in marsh soils, but also in periphyton mats. Therefore, there are multiple entry points for MeHg into the system.

11.1.5 Source - What are the sources contributing to the causes and what is the importance of different sources to the problem(s)?

Mercury

1) No single Hg point source has been identified that can be linked to the remote areas of marsh affected.

2) Atmospheric Hg loading is from 35 to 70 times greater in the Everglades than Hg loading in canal water from the EAA.

3) The EPA ORD South Florida Atmospheric Mercury Monitoring Study (SoFAMMS) study indicated urban municipal and medical waste incineration emissions had higher Hg concentrations than emissions from a coal-fired cement kiln and that these emissions might be transported over the marsh.

Total Phosphorus

1) The EAA is contributing TP to the canals in the north and this TP is being transported as far south as ENP, which is contributing to eutrophication of the Everglades ecosystem.

2) Eutrophication of the marsh and canals is caused by P being discharged from the EAA and transported downstream.

11.1.6 Risk - What are the risks to different ecological systems and species from the stressors or factors causing the problem(s)?

Mercury Trends

1) Hg toxicity is thought to have contributed to the death of a Florida panther in 1989. (FDHRS)

2) Hg concentrations in Everglades WCA3 great white herons are higher than those shown to cause adverse effects in common loons. (FDEP)

3) No evidence of adverse human health effects contributed to ingestion of Hg contaminated biota have been found to date. Sampled concentrations of Hg in human blood or hair from human populations at potential increased risk were normal. (FDHRS)

4) Juvenile wading birds are able to move Hg from their blood into feathers, thereby decreasing their risk to Hg contamination, however, this does not preclude possible effects on survival when on a contaminated diet. (FDEP)

5) The critical concentrations of Hg in Everglades wildlife such as wading birds and the Florida panther above which adverse chronic or acute effects occur are unknown. (FDEP)

6) Water THg concentrations average 2.5 ng/L. Since the THg 12 ng/L water quality criterion for protection of fish and wildlife has not been exceeded, the criterion is inadequate for preventing Hg bioaccumulation.

Total Phosphorus

1) Ninety-five percent (95%) of the marsh has TP concentrations less than the Phase I target TP concentration of 50 μg/L. The marsh is at risk if TP concentrations remain at the Phase I target.

2) The effectiveness of the STA's is unknown, but the ENR demonstration project has reduced inflowing TP concentrations by about 80%. (SFWMD)

Greatest Risk

1) The greatest risk to the Everglades is to assume the problems can be addressed independently.

11.1.7 Solutions - What management alternatives are available to ameliorate or eliminate the problem(s)?

1) Atmospheric Hg loading to the Everglades is much greater than Hg loading from EAA stormwater.

2) In its first year of operation, the ENR project removed over 50% of the THg, 75% of the MeHg, and 80% of TP in stormwater runoff from EAA. (SFWMD)

3) Various threats to the long-term viability of the Everglades, such as Hg contamination, nutrient enrichment, and water management, are interrelated.

11.2 Potential Considerations

The management implications from this baseline assessment and preliminary answers to the policy relevant questions are:

1) Revised THg water quality criterion lower than 12 ng/L are needed to protect predator species in the food web.

2) MeHg rather than THg criterion should be developed because MeHg, not THg, is bioaccumulated and biomagnified. There is no statistical relationship between THg and MeHg concentrations.

3) Hg emission controls should be considered to reduce atmospheric Hg concentrations and deposition over the Everglades ecosystem.

4) Waste disposal is a multi-media problem. Controlling Hg emissions might create other problems such as disposal of solid waste, including not only the waste, but also the Hg removed from the emissions.

5) Wildlife in the marsh aquatic food web appear to be at greater risk from Hg biomagnification than wildlife in the canal food web. Management actions directed at reducing wildlife risks from Hg contamination should be directed at the marsh system.

6) In contrast, Hg concentrations in gamefish such as bass are highest in the canals. People fish predominantly in the canals. Management actions directed at human health concerns or environmental concerns for the alligator should be directed at the canal system.

7) Nutrient gradients appear to influence methylation by stimulating floating and soil periphyton mat production, which function as sites for methylation. Reducing nutrient inputs also should affect Hg contamination.

8) Because Hg is a naturally occurring element, cycling of Hg through the marsh ecosystem likely will continue for decades, even if inputs were reduced today. Rapid changes in the system should not be expected after reducing Hg inputs.

9) There is no “magic bullet” that can be easily implemented to control one factor and thereby alleviate Hg contamination. Hg contamination is affected by hydropattern, TP, TOC, and TSO_4 concentrations and biotic interactions.

10) The environmental conditions and Hg bioaccumulation processes in the hot spot need to be identified and compared to those in other portions of the Everglades with less Hg bioaccumulation to determine the factors controlling Hg contamination. Once identified, it may be possible to manage these factors.

11) TP criterion must be significantly lower than 50 μg/L to protect the Everglades from eutrophication.

12) Cattail presence and abundance is associated with soil TP concentrations. Unlike water TP concentrations, higher soil TP concentrations might take decades to centuries to decrease. Management actions should focus on preventing additional TP loading to marsh soils.

13) Hydroperiod modifications have contributed to peat loss in northern WCA3.

14) This study was conducted during an abnormally wet period. If the spatial patterns change significantly by season or by year, management practices could be implemented at the wrong locations and be ineffective.

15) Continued monitoring over time is required both to determine trends in TP and Hg contamination and, as part of Government Performance and Review Act (GPRA), to determine the effectiveness of water and other management actions. Monitoring is an integral component of the adaptive management process.

16) Management actions in the Everglades ecosystem must be coordinated and integrated. The greatest risk to the Everglades ecosystem is to assume the problems are independent.

11.3 Relevance

This study permits a synoptic look at the ecological condition of the entire freshwater canal and marsh system in South Florida from Lake Okeechobee to the Florida mangrove systems. This large-scale perspective is needed to understand the impacts of different factors, such as TP, Hg, habitat alteration, or hydropattern modification, on the entire system rather than a small piece or area. Looking only at isolated pieces in any given area and extrapolating to South Florida would provide a distorted perspective. The statistical sampling approach permits quantitative estimates, with known confidence, about population characteristics, such as acres of marsh in cattails, percent of the marsh with fish Hg concentrations greater than the proposed predator protection level of 100 ppb, or percent of the canal miles with TP concentrations greater than the Phase I control target level of 50 μg/L. Study information is aiding decision makers with its significant findings related to the major issues facing ecosystem restoration in South Florida.

In addition to providing answers to policy-relevant questions, the project also is contributing to a better scientific understanding of the Everglades ecosystem. A holistic picture of soil thickness, percent organic matter, and water quality is not only scientifically important but also provides insight into areas with peat subsidence, areas of organic soils that might bind P or metals or indicate water quality gradients in the system. This study, while contributing to the development of adaptive management practices, also provides the information needed to evaluate the effectiveness of these management practices. For example, once the Phase I P control program is in place, TP concentrations throughout the canal and marsh system can be reassessed

to evaluate the effectiveness of the control program. With the passage of GPRA, monitoring and assessment programs such as this have taken on even greater importance.