Appendix 7-16: Mercury Restoration Evaluation Study for STA-6

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SUMMARY

This is the summary of the two-year Mercury Restoration Evaluation Study for Stormwater Treatment Area 6 (STA-6). It is a report card on the mercury impacts of STA-6 within its own borders and downstream. STA-6 did not create newly nutrient-impacted downstream areas and contributes marginally, if at all, to the already nutrient-impacted areas in northern and central WCA-3A created by occasional overflows and infrequent breaches of the Miami Canal levees. Although methylmercury bioaccumulation in fish is higher in the interior and at the outflow of STA-6 than the inflow, these differences are decreasing over time, and it is highly unlikely that STA-6 could significantly increase methylmercury risks to wildlife feeding within its borders or downstream. Additional STA-6 follow-up studies on mercury accumulation in soil or fish or on the effect of drying and reflooding on mercury release and bioaccumulation are not warranted at this time. Technical support for these key findings, conclusions, and recommendations is contained in Appendices 7-8 through 7-15. From a mercury standpoint, operation of STA-6 for total phosphorus removal should continue unchanged, because no environmentally significant adverse mercury impacts have been detected or are anticipated. However, routine mercury monitoring of fish and wading birds will continue to ensure an appropriate and expeditious response to any emerging significant adverse mercury impacts.

INTRODUCTION

This is the Mercury Restoration Evaluation Study (MRES) required by Condition 8.b.4 of the 404 ECP Permit for STA-6. The purpose of the MRES is to determine whether each STA, after two full years of operation, has caused or contributed to an environmentally significant increase in the bioaccumulation of mercury in fish or fish-eating birds within its borders or in the newly impacted areas, already impacted areas, or the unimpacted areas downstream. The MRES is to be disseminated for agency and public review and comment in a formal hearing. Following this review, if the Corps concludes that STA-6 has caused or contributed to significant adverse mercury impacts within its borders or downstream, the Corps will take appropriate action pursuant to Condition 8.b.5. Those conditions are reproduced in **Attachment 7-16-I**. Technical support for the key findings, conclusions, and recommendations in the MRES is contained in **Appendices 7-4** and **7-8 through 7-15**.

BACKGROUND

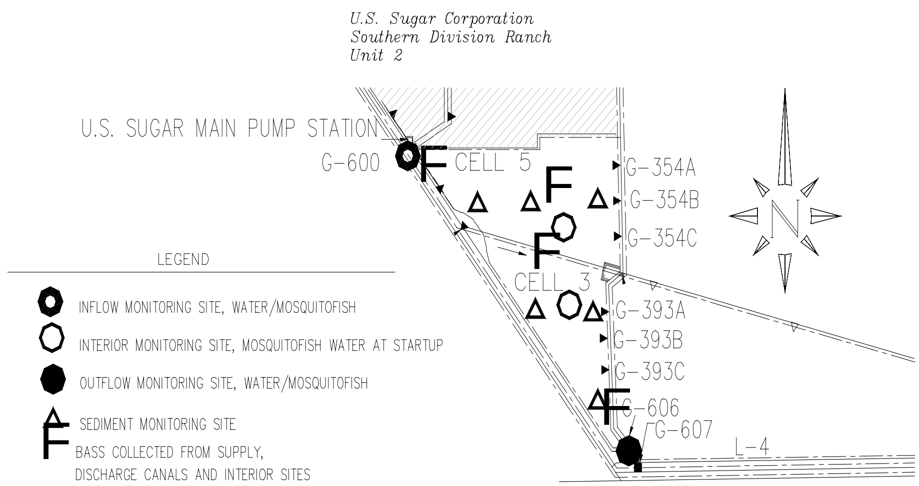
The Everglades is under assault from development and drainage, the invasion of exotic species, nutrient over-enrichment (eutrophication), and mercury contamination. The presence of high levels of mercury in Everglades sport fish prompted the Florida Department of Health to issue fish consumption advisories to protect human health. The high levels of mercury in the aquatic ecosystem also represented a potential threat to some fish-eating wildlife populations or their predators, including the endangered wood stork and the Florida panther.

The excess nutrients in farm and urban runoff and Lake Okeechobee releases are to be removed using constructed wetlands created by diking and flooding former farmlands. Some have predicted that these flooded farmlands could release some of the mercury stored in their peat soils, resulting in an increase in fish mercury concentrations to harmful levels. If discharged, the mercury flushed from the soil could have the same effect on the downstream environment (Florida Governor's Mercury in Fish and Wildlife Task Force, 1991). Others have predicted that changes in downstream water quality brought about by the constructed wetlands could exacerbate the mercury problem in the already impacted areas of the interior marshes.

The Everglades Construction Project (ECP) is to consist of six Stormwater Treatment Areas (STAs), which, in order of construction, are STA-6, STA-1W, STA-5, STA-2, STA-3&4, and STA-1E. At the time of this writing, STA-6 is fully operational and STA-1W and STA-5 have met start-up criteria but have not yet begun discharging. To ensure the protection of the resource from potential adverse mercury impacts, no matter how remote the possibility (Letter from Colonel Rice, USACE-Jacksonville to District Executive Director, March 1997), mercury monitoring and evaluation requirements were included in the Dredge and Fill Permit No. 199404532 issued by the U.S. Army Corps of Engineers-Jacksonville District Office to the District on March 13, 1997, for the construction and operation of the ECP pursuant to Section 404 of the Federal Clean Water Act (404 ECP Permit). The relevant section is reproduced in Attachment I. The permit issued by the Florida Department of Environmental Protection (FDEP) under the Everglades Forever Act (EFA) for each STA also includes mercury monitoring and evaluation requirements.

STA-6, Section 1 (STA-6-S1) is located at the southeastern corner of Hendry County and southwest corner of the EAA (**Figure A7-16-1**). STA-6 operation began in December 1997 and two full years were completed in December 1999. STA-6-S1, has two treatment cells (Cell 5=252 ha and Cell 3=99 ha) designed to provide a total effective treatment area of 352 ha (870 acres). The United States Sugar Corporation, (USSC), has operated the two cells as a storm water retention area since 1989. Approximately 4,210 ha of USSC's agricultural production area (Southern Division Ranch, Unit 2) drains into STA-6-S1, via a supply canal and existing pump station, G600. To prevent the operation of STA-6-S1 from interfering with water management to meet the demand for agricultural irrigation makeup water, G600 is operated at the discretion of USSC. STA-6 discharges through six culverts (G-354 A-C for Cell 5 and G-393 A-C for Cell 3) each with a fixed crest weir at 13.6 ft NGVD to limit drawdown of each treatment cell to the desired static water level of 13.6 ft NGVD (maximum combined discharge of 500 cfs). This outfall then enters the USSC's discharge canal, which gravity discharges to the L-4 borrow canal via six culverts, which are confluent to G607. The L-4 Borrow Canal conveys flows eastward to the S-8 pump station, which discharges into Water Conservation Area 3A.

Upon demand, water can be conveyed from L-4 canal backward (using stop logs at G604 to bypass flows to the L-4 from the G607 culverts) to USSC Unit 2 farm for irrigation. As a consequence, unlike other STAs, the operation of G600, including timing, quantity, duration of inflows and backflows, and thus mean depth, hydraulic loading rate and hydraulic residence time (HRT) of STA-6 is controlled by USSC.



STA 6- SECTION 1 SITE PLAN

Figure A7-16-1. Site Map of STA 6-Section 1.

BASELINE CONDITIONS

The mercury-related changes brought about by STA-6 after two full years of operation are to be evaluated relative to the baseline conditions in rain, upstream water, soil, fish, and birds that existed before construction. For each STA, the baseline condition is defined in terms of the total mercury and methylmercury concentrations in pre-operational soil. For the newly impacted areas, the already impacted areas, and the unimpacted areas in the downstream environment, the baseline conditions are defined with respect to the sites identified in **Figure A7-16-2**. Baseline bulk rainfall data were collected atop 48-ft towers at the ENR Project, Andytown, and Everglades National Park for the Florida Atmospheric Mercury Study (**Appendix 7-9**). The baseline conditions summary for fish and wading birds is reproduced in **Table A7-16-1** from the Everglades Background Report submitted to the Corps pursuant to Condition 8.b.3 in February 1999. Only data for age class 3-year largemouth bass were routinely collected at some but not all of these sites prior to STA-6 construction. Nestling great egret feathers were collected at two colonies in WCA-3A prior to STA-6 construction. The remaining relevant baseline data have been summarized in **Appendix 7-9**.

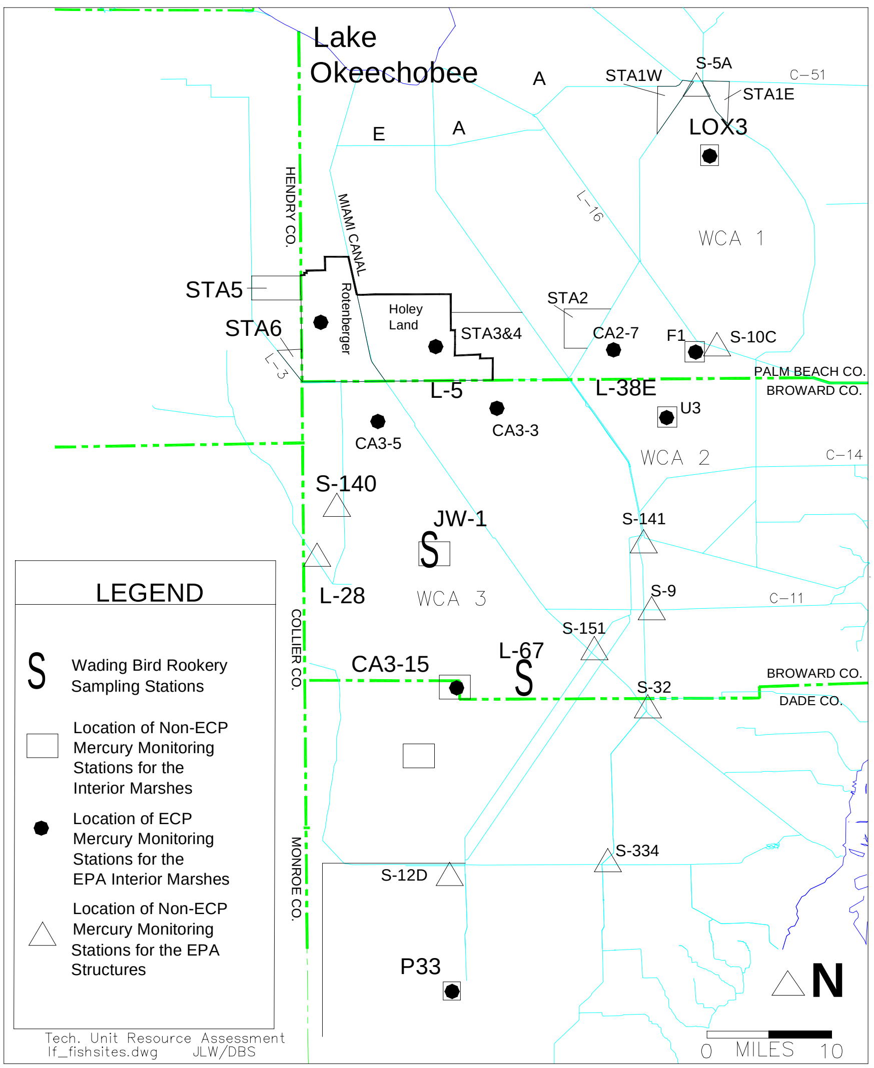


Figure A7-16-2. Downstream Mercury Monitoring Locations

The STA-6 discharge is into the L-4 canal, which is tributary to the Miami Canal, and, as a consequence, there is no newly impacted area in WCA-3A attributable to STA-6. There are limited areas in WCA-3A already impacted by the excess nutrients in farm runoff due to the occasional overflow and infrequent breaches of the Miami Canal levee. There are no already impacted areas in WCA-3A known to be influenced by the discharge from STA-6. Even if such areas could be identified, the quantities of total mercury and methylmercury discharged from STA-6 are more than an order of magnitude lower than the corresponding quantities being moved by the L-4 canal during the same two-year period, so any STA-6 impact would be undetectable. There are no nutrient or mercury studies ongoing in these areas. However, based on the nutrient and mercury studies conducted in the already impacted area in WCA-2A, there is likely to be some increase in the methylmercury in sport fish when these already impacted areas are restored to unimpacted conditions (**Appendix 7-2** and **7-3**, EIR 1999; **Appendix 7-3B**, ECR 2000), but these increases should not be of significance from the standpoint of protecting human health or the overall effort to restore the sport fishery or protect fish-eating wildlife. There are no presently unimpacted areas in WCA-3A known to be influenced by the discharge from STA-6, and, even if such areas could be identified, the quantities of total mercury and methylmercury discharged from STA-6 are more than an order of magnitude lower than the corresponding quantities being moved by the L-4 canal during the same two-year period, so any STA-6 impact would be undetectable.

Table A7.16-1. Everglades Mercury Baseline Conditions

	Largemouth Bass Baseline				Great Egrets Baseline			
Monitoring Station	Mean (+/- SD) (mg/Kg-wet)	Range min-max	N	date range	Mean ranges (mg/Kg-wet)	Range min-max	N	date range
LOX3								
CA2-7								
F1								
U3	0.85 (+/-0.47)	0.15B2.53	43	1992B1996				
ROTEN								
HOLEY								
CA3-3								
CA3-5								
JW1					14.51B30.07	X	12	1994B1995
CA3-15	0.96 (+/-0.51)	0.09-1.99	32	1992-1996				
L67					15.51B17.23	X	29	1994B1995
P33								
S-5A								
S-10C								
S-140								
S-141								
S-9								
S-151	1.28 (+/-0.63)	0.38B4.23	127	1992B1996				
S-32								
S-344								
S-12D								
S-334								

Data Source: [(a)]Lange 1997 [(b)]Frederick et al. 1997

POST-STA-6 TWO-YEAR EVALUATION OF MERCURY IMPACTS

MERCURY REMOVAL EFFICIENCIES

Based on the performance of the prototype STA, the ENR Project, STAs are expected to remove between 50 and 75% total mercury and methylmercury from inflow water and wet and dry deposition (Chapter 7, ECR, 2000). The mechanisms of removal are most likely sorption to settling and settled plant litter and the mining of inorganic mercury from the surficial peat soils by rooted macrophytes that release it to the air as elemental mercury. These processes are discussed in **Appendix 7-3**. While a detailed mercury mass budget cannot be developed for STA-6, the average outflow concentrations of total mercury and methylmercury are less than those of the inflow over the first two years of operation, so there is little likelihood that STA-6 is a net source of total mercury or methylmercury, even with the input of total mercury in wet and dry atmospheric deposition. Even on those infrequent occasions when STA-6 appeared to be a net source of total mercury or methylmercury, these differences were not statistically significant and the quantities discharged were small relative to the quantities being transported in the L-3 and L-4 canals, so it is highly unlikely that this localized increase in the total mercury or methylmercury load will have any detectable effect on downstream water quality.

SOIL ACCUMULATION

The soil total mercury concentration in the new peat soil forming in an STA is determined by the net downward flux of total mercury to the sediment divided by the rate of formation of peat soil. If the downward total mercury flux remains constant but the peat accretion rate decreases, then the total mercury concentration will increase, but the mass of total mercury accumulating in the newly forming peat soil will be unchanged. If the total mercury flux increases and the rate of accretion of newly forming peat increases proportionally, then the concentration of total mercury will remain the same, but the mass of total mercury accumulating in the newly accreting peat soil will increase. If the post-operational increase in the downward total mercury flux exceeds the corresponding increase in peat soil accretion, the total mercury concentration will increase. The corresponding methylmercury concentration is determined by net downward flux of methylmercury plus net production in the soil, divided by the rate of accretion of the new peat soil layer.

The mass of peat accreted in the first two years of operation is determined by the depth of accretion and the bulk density of the accreted material. No measurements were taken of the depth of new peat accretion nor the bulk density of the consolidated peat soil or the newly accreting peat soil, so it is not possible to calculate the change in the quantity of total mercury or methylmercury in soil over the first two years of operation of STA-6. The focus must then shift to the change in the concentration of total mercury and methylmercury in newly accreting peat soil. As detailed in **Appendix 7-9**, there has been an apparent decrease in the concentrations of total mercury and methylmercury in peat soil in the first two years of operation of STA-6. This is unlikely to be due to the discharge of inorganic mercury previously stored in soils, because such small quantities of total mercury and methylmercury are involved, while the soil reservoir is correspondingly much larger. Instead, the cause may be (1) the "mining" of inorganic mercury by rooted aquatic macrophytes with subsequent emission to the air as elemental mercury, the so-called "Lindberg Effect," which was first detected in the ENR Project and subsequently verified in the Everglades proper; or (2) an increase in the rate of peat production, diluting the inflow and atmospheric deposition fluxes of mercury species. These processes are discussed in **Appendix 7-3**.

USE OF THE SPORT FISHERY

The issuance of fish consumption advisories to protect human health is predicated on the average total mercury concentration in age class 3-year largemouth bass. This value is derived from a linear regression model of age vs. total mercury concentration in individual fish from a number of age cohorts. If the calculated average total mercury concentration in this bass cohort is less than 0.5 mg/Kg, then the Florida Department of Health recommends unlimited consumption for all ages and both sexes. If the average total mercury concentration in this age cohort is at or above 0.5 mg/Kg, the Florida Department of Public Health recommends the consumption of no more than one, eight-ounce (one-half pound) meal of fish per week for adult males and no more than one, eight-ounce meal per month for women contemplating pregnancy, pregnant women, nursing mothers, and children. If the average total mercury concentration in this age cohort is at or above 1.5 mg/Kg, the Department of Public Health recommends no fish be consumed for all ages and both sexes.

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As summarized in **Appendix 7-9**, the results indicate that the total mercury concentrations in largemouth bass collected from the outflow and interior are higher than the corresponding concentrations in inflow fish in both paired individual samplings and as a paired two-year average. However, it was not possible to test the statistical significance of these differences, because not all test criteria were met. Nevertheless, the difference appears to be significant by inspection. In 1998, the average total mercury concentration calculated for age class 3-year bass collected at the interior and outflow sites exceeded the 0.5 mg/Kg level of concern for human health established by the Florida Department of Health, while the inflow concentration was less than this benchmark. In 1999, this pattern was repeated, but there were too few large fish from the interior with which to calculate the average total mercury concentration for age class 3-year bass. It should be noted, however, that the average concentrations in STA-6 bass are less than the Everglades-wide average for the canal sites sampled by the Florida Fish and Wildlife Conservation Commission (Lange et al., 2000), and the differences between inflow and interior or outflow are decreasing over time (**Appendix 7-9**).

General Spatial Trends

Advisories recommending no consumption of several sport fish species have been issued for WCA-2A, WCA-3A, and ENP, and advisories recommending limited sport fish consumption have been issued for the Arthur R. Marshall Loxahatchee National Wildlife Refuge (WCA-1), the Big Cypress National Preserve, and Eastern Florida Bay. The maximum concentrations of mercury in fish occur at WCA-3A-15, which is unlikely to be impacted by STA discharges.

General Temporal Trends

Between 1995 and 1998, there appears to have been a general decline in total mercury in largemouth bass at the L-7 and L-67A canal sites, and the LOX 4, WCA-2A-U3, and WCA-3A-15 interior marsh sites. Between 1996 and 1998, this same declining trend was noted at a number of other unimpacted sites, including WCA-2A-U3, an interior marsh site in WCA-2A (**Appendix 7-9**). However, in 1999, this trend was reversed at WCA-2A-U3, where concentrations in age class 3-year largemouth bass increased by about 28%, by 57% in age class 2-year bass, and by

169% in young-of-the year bass. This age-contamination pattern suggests that something increased the production or bioccumulation of methylmercury in 1999, resulting in the most dramatic increase in the smallest bass, which consume proportionally more per unit body weight than older, larger fish and which cannot dilute the effect of such dramatic increase in methylmercury production in a large quantity of body mass. Should this increased methylmercury production persist, eventually each age class would reflect that increase, and the relationship between age, size, and methylmercury body burden would restabilize at a higher average concentration in each age cohort. Conversely, if the increase in methylmercury production is short-lived, the young-of-the-year fish will dilute this methylmercury pulse in increasing body mass over time, eventually resulting in an age-magnitude distribution of methylmercury concentrations more in line with what was observed in the period 1996-1998. The increase in methylmercury production is believed to be a transient phenomenon brought about by the extended drawdown, dryout, and fires that occurred in the spring of 1999 (**Appendix 7-8**). Evidence for its transience is the eventual decline in the methylmercury concentrations in water, sediment, periphyton, and mosquitofish following reflooding after the extended dry out.

WADING BIRD RISKS

USFWS has suggested a wildlife level of concern of 0.1 mg/Kg total mercury (Eisler, 1980) and USEPA (1997) has suggested a corresponding value of 0.077 mg/Kg total mercury for trophic level 3 (TL 3) fish. The trophic level 4 (TL 4) fish wildlife level of concern is 0.346 mg/Kg, but this would apply to large fish-eating wildlife that preferentially consume large fish or large fish-eating birds that tear their prey before ingesting. Mosquitofish are opportunistic omnivores but generally feed TL 2 or 3, depending on size. Sunfish, which are the preferred prey for a variety of wading birds, are generally considered TL 3 fish, although large sunfish will forage occasionally to frequently at TL 4, while largemouth bass are generally considered TL 4 fish, but will feed occasionally as TL 5 fish. However, the largemouth bass that are small enough to be consumed by wading birds (<180, 250, and 300 mm for great egret, wood stork, and great blue heron, respectively) probably feed as if they were TL 2-4 fish. To apply these wildlife protection benchmarks to the Everglades, it must be remembered that these levels of concern are based on generalizations of exposure and sensitivity to methylmercury toxicity not supported by the site-specific toxicity, epidemiology, and risk assessment studies (**Appendix 7-2**, EIR, 1999; **Appendix 7-3B**, ECR 2000).

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Unlike the experience at the ENR Project, the first year results of semi-annual mosquitofish monitoring and annual largemouth bass monitoring at the inflow, interior, and outflow of STA-6 indicated that interior and outflow fish exceeded inflow fish on a number of occasions. A follow-up study was initiated in June of 1999 to determine whether the anomalies in STA-6 performance relative to the ENR Project were real or an artifact of the sampling type, location, or timing. Mean concentrations of THg in mosquitofish and sunfish collected from STA-6 during this follow-up study were 61 ±36 ng/g and 99 ±82 ng/g, respectively. These concentrations were higher than concentrations generally observed in fish from the ENR Project, but were lower than or similar to levels in fish collected from the northern portions of the Water Conservation Areas (**Appendices 7-9** and **7-14** this report).

As summarized in **Appendix 7-13**, for the second year of compliance monitoring, the average concentration of mosquitofish total mercury, considered to be at TL 2-3 depending on age, was below both the USGS and USEPA wildlife protection criterion. For STA-6 sunfish (TL 3-4), the average total mercury concentrations were near the USFWS predator protection guidance value but slightly above the USEPA guidance value for TL 3 fish. However, based on the conservatism built in to the application of these levels of concern to the Everglades, it is highly unlikely that wading birds and other fish-eating wildlife populations will experience an unacceptable frequency of occurrence of biologically significant toxic effects from methylmercury exposure via ingestion of contaminated prey from STA-6. Likewise, after adjusting fillet concentration to whole-body, the average concentration of total mercury in largemouth bass (TL 4-5) from STA-6 was 275 ng/g (for data see **Appendix 7-9** and **7-13** this report), and, thus, was below USEPA's guidance criterion for TL 4 fish.

General Spatial Trends

The concentrations of methylmercury in small, medium, and large fish are at a maximum in the central portion of WCA-3A (**Appendix 7-9**). This is where the two great egret colonies monitored by the District are located. During egg laying, nesting, and nestling feeding prior to fledging, both parents tend to forage in the immediate vicinity (roughly a 10 km radius) of the nest (**Appendix 7.3B**, ECR 2000). As a consequence, the great egret hatchlings are fed the most contaminated small fish in the Everglades. However, during this sensitive life stage, the feathers are rapidly growing, and methylmercury is efficiently excreted into the feathers, so the high methylmercury dose rate is offset by the high methylmercury excretion rate (**Appendix 7-2**, ECR 2000). There is no evidence of increased frequencies of reduced mating pairs, clutch size, hatching failure or chick mortality in these highly exposed populations (**Appendix 7-2**, EIR 1999; **Appendix 7-3B**, ECR 2000). Thus, while the feathers of great egret hatchlings from the WCA-3A colonies are the most contaminated of any of the feather samples collected in South Florida, there is no corresponding spatial trend in the manifestation of toxic effects attributable to methylmercury exposure.

General Temporal Trends

Wading Bird Forage

Over the last five years, a trend of decreasing methylmercury concentrations has been observed in largemouth bass and sunfish species (**Appendix 7-9**). The cause of these decreasing trends is now under investigation. Some have attributed them to a decrease in local air emissions of reactive gaseous mercury from waste incinerators due to voluntary and then mandatory reductions of mercury in waste feedstocks that began in the late 1980s. However, these trends were broken at WCA-2A-U3 by an upturn in methylmercury concentrations in mosquitofish, sunfish, and young-of-the year bass that occurred in the fall of 1999 following the extended period of drawdown, dryout, and fire in the Everglades (**Appendix 7-9**) and may have been caused by it (**Appendix 7-8**). A slight upturn in largemouth bass concentrations was also detected at the District's L-67 alternative compliance monitoring site. Even if these increases in methylmercury concentrations in forage fish persist through the great egret breeding and nesting periods in 2001, one should still not expect a corresponding substantial increase in methylmercury concentrations in wading bird eggs and nestling feathers collected from the WCA-3A colonies in the spring of 2001, as long as the nesting adults feed their young by foraging locally.

Wading Bird Feathers

With the exceptions noted above, there appears to be a statistically significant downward trend in methylmercury in nestling feathers over the last four years that parallels the declines in forage fish concentrations (**Appendix 7-9**). If the value reported by Bouton et al. (1999) is used as a lowest observed adverse effects benchmark for methylmercury in feathers, then the nestlings in the present study do not appear to be at an elevated risk of toxic effects from environmental exposure to MeHg in their diet (**Appendix 7-9**).

OTHER CONSIDERATIONS

GENERAL SPATIAL AND TEMPORAL TRENDS IN DOWNSTREAM WATER QUALITY

The STAs are designed to remove about 75% of the total phosphorus present in Lake Okeechobee releases and EAA stormwater runoff. In addition, based on the performance of the ENR Project from 1994 to 1999, the STAs with soil composition and plant communities similar to those of the ENR Project are likely to remove between 50 and 75% of the total mercury in stormwater directed through the inflow. This should be beneficial in terms of reducing the average concentration of total mercury in the downstream canals and perhaps that of methylmercury, as well, to the extent that some of the methylmercury in the canals originates with external loads as opposed to internal production.

However, STA-6 has a very different soil composition, and, based on the difference in operation, STA-6 is likely to be removing consistently less than the 50% of total mercury and methylmercury routinely achieved by the ENR Project. This is reflected in the inflow and outflow concentration data. Nevertheless, based on the small quantities of total mercury and methylmercury involved and the high flow in the L-4 canal, even if STA-6 should become a net exporter of either or both on occasion, this is unlikely to have any environmental consequences even immediately down stream and less so much farther down stream (**Appendix 7-9**).

In addition, based on the results of studies published in Chapter 6 of the Everglades Consolidated Report 2000, the STAs will not substantially reduce the loads and concentrations of dissolved organic carbon (DOC), calcium, sulfate, chloride, and iron, all of which are known or reasonably anticipated to directly or indirectly influence methylmercury production or bioaccumulation. This means that in areas of the northern Everglades where canal releases influence water and sediment chemistries, the absolute concentrations of total phosphorus and total mercury in water and sediment will be decreasing, while the concentrations of these other constituents will not change substantially. The reduction in the absolute and relative concentrations of total phosphorus are likely to result in corresponding changes in methylmercury production and bioaccumulation over time, such that the impacted, eutrophic areas will approach the conditions that already exist in the oligotrophic, unimpacted areas farther downstream. However, the reduction in the absolute and relative concentrations of total mercury in stormwater runoff and the presence of excess pore water sulfide in concentrations still sufficient to retard methylation in the restored areas may mitigate this worst-case scenario. Further studies are planned to qualify and quantify the influence of the sulfur cycle on the routes and rates of methylmercury production and destruction under the conditions extant along the unnatural sulfur gradient in the Everglades (**Appendix 7-4**).

RELATIONSHIPS OF METHYLMERCURY BIOACCUMULATION IN FISH WITH WATER AND SEDIMENT QUALITY

Based on the univariate and multivariate regression analyses carried out in **Appendix 7-11**, water column total phosphorus, filtered calcium and magnesium as hardness, dissolved organic carbon (DOC), or pH may influence methylmercury bioaccumulation by mediating net production, removal from the water column, or uptake at the base of the food chain. In addition, water column dissolved oxygen and sediment pore water sulfide are known to or can be reasonably anticipated to influence net methylmercury production, as well as the structure of the food chain itself. As the number of steps in the food chain increases, opportunistic omnivores can feed higher in the food chain, increasing bioaccumulation factors. However, where water quantity or quality do not meet the requirements for the development of higher trophic levels, bioaccumulation factors will remain low, even though one would infer otherwise from the absolute and relative concentrations of the other influential factors present in surface water or sediment. In the multivariate analysis carried out two years ago in the 1999 Everglades Interim Report (EIR, 1999), a divariate empirical model based on DOC and filtered calcium (Ca-F) was the best predictor of total mercury in mosquitofsih. DOC was positively correlated and Ca-F negatively correlated with mosquitofish total mercury. The positive relationship with DOC has also been observed in rivers and drainage lakes receiving runoff from wetlands in their watersheds (**Appendix 7-11**).

Unlike the results of the multivariate analysis carried out two years ago, using only the "F" transect data for regression analysis and empirical model development, DOC does not now appear to be of prominent influence in the already impacted area in WCA-2A. This is probably a result of the fact that its concentrations do not change very much along the WCA-2A "F" transect. Although not generally reported in the literature, the inverse relationship with Ca-F might be predicted from the inverse relationship between hardness and heavy metals uptake and toxicity, as reflected in the national water quality criteria published by USEPA for a number of the heavy metals. The absence of a correlation between pore water sulfate or sulfide and mosquitofsh total mercury is perhaps surprising, based on the strong links between the sulfur and mercury cycles (**Appendix 7-4**). However, the water chemistry in the pore water from the top 4 cm of the sediment where the maximum rates of methylation and demethylation occur is likely to be strongly influenced by diel changes in DO and redox potential, but the pore water chemistry data were obtained at 10-20 cm depth, which is much less likely to be influenced by these diel fluctuations. This likely obscured the influence of the absolute and relative concentrations of sulfide and sulfate on net methylmercury production. While sulfate concentrations were obtained from the near-surface sediments using pore water equilibrators, there were no equivalent sulfide data, so it is not possible to test the sulfur hypothesis using the District data extant. However, a strong inverse correlation between surface sediment pore water sulfide and mosquitofish total mercury was obtained using the average concentration data collected by the USGS about three times per year at nine sites in the Everglades from 1995 to 1999.

FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

Based on the literature reviewed in the Everglades Interim Report 1999 and the Everglades Consolidated Report 2000, the conceptual model developed from that review, the refined conceptual model presented in **Appendix 7-4** of this report, the data presented in **Appendix 7-8**, and the analysis carried out in **Appendix 7-11**, the relationship between water or sediment quality and methylmercury production and bioaccumulation is complex, varies with the magnitude, duration, and frequency of recurrence of antecedent meteorological, hydrological, and oxidation conditions, and varies with seasonal spatial and temporal trophic dynamics. Where apparent strong correlations exist between surface water or sediment pore water quality and methylmercury bioaccumulation, such as is the case in WCA-2A along the nutrient gradient south of the S-10 structures, these models are unable to accurately predict the methylmercury concentrations in mosquitofish from other sites collected at the same time (**EIR, 1999**). That being the case, scientists whose work supports environmental restoration management decision-making should be discouraged from using such univariate or multivariate empirical models to predict post-STA changes in methylmercury bioaccumulation and resource managers should be discouraged from using such models to support Everglades restoration management decision-making. The results of biogeochemical and bioaccumulation process studies will be incorporated into a mechanistic model with which to make valid predictions of post-STA mercury impacts.

KEY FINDINGS

Based on the data and analysis summarized above, the following are the key findings relevant to the evaluation of post-STA-6 mercury impacts over the first two years of operation of STA-6:

- The effect of STA-6 on downstream total mercury and methylmercury concentrations in the L-4 canal and the Miami Canal to which the L-4 canal is tributary must be considered undetectable.
- It is highly unlikely that there could be new areas of adverse mercury effects in previously nutrient-unimpacted areas or new adverse mercury effects in already nutrient-impacted areas.
- Both total mercury and methylmercury in STA-6 sediments have declined.
- The average outflow concentration of total mercury and methylmercury is now less than the inflow concentration.
- The total mercury concentrations in STA-6 interior and outflow mosquitofish and largemouth bass are higher than at the inflow, but the differences appear to be decreasing over time.
- The calculated concentrations of total mercury in largemouth bass standardized to age class 3 years at the interior and outflow collection sites exceeded the 0.5 mg/Kg threshold of concern for human health adopted by the Florida Department of Health, but are less than the Everglades-wide average in the canal sites sampled by Florida Fish and Wildlife.
- The average total mercury concentrations in sunfish collected from the STA-6 interior did not exceed the USFWS 0.1 mg/Kg suggested level of concern for fish-eating birds but did exceed the USEPA 0.077 mg/Kg suggested level of concern for TL 3 fish.
- The STA-6 sunfish concentrations are less than the corresponding average concentrations at WCA-3A-15, the most contaminated site in the interior Everglades, where there have been no documented adverse impacts on any fish-eating wildlife populations.

KEY CONCLUSIONS AND RECOMMENDATIONS

- Although methylmercury bioaccumulation in fish within and at the outflow of STA-6 is higher than at the inflow, it is highly unlikely that STA-6 could significantly increase methylmercury risks to wildlife feeding within or down stream.
- Additional STA-6 follow-up studies on mercury accumulation in soil or fish or the effect of drying and reflooding on mercury release and bioaccumulation are unwarranted at this time.
- Operation of STA-6 for phosphorus removal should continue unchanged, because no environmentally significant adverse mercury impacts have been detected or are anticipated.
- Downstream monitoring of fish and great egrets should continue to ensure that any changes to these conclusions.

Attachment A7-16-I

Condition 8.b. of permit No. 199404532 issued on March 13, 1997, for the construction and operation of the ECP pursuant to Section 404 of the Federal Clean Water Act by the U.S. Army Corps of Engineers-Jacksonville District Office.

Condition 8

b. Mercury. The permittee shall submit a restoration evaluation plan to determine if construction or operation of the STAs causes adverse accumulation of mercury in the biota, including wading birds. To accomplish this, the permittee shall:

(1) By August 1, 1997, submit to this office, U.S. Environmental protection Agency (USEPA), U.S. Fish and Wildlife Service (USFWS), Florida Game and Fresh Water Fish Commission (FGFWFC), and FDEP a plan and schedule to implement a mercury monitoring program that meets the information needs of the evaluation described below. Prior to submission, the permitte shall solicit comments on the draft plan through a publicly-noticed meeting that shall include representatives of this office, USEPA, USFWS, NPS, FGFWFC, FDEP, and other interested parties. Upon review and acceptance of the plan, the plan shall be incorporated into this permit.

(2) By November 1, 1997, initiate the field work necessary to establish baseline conditions: (a) within the STAs; (b) in the areas receiving discharges from the STAs; (c) and in the areas of the Everglades Protection Area already impacted by the Everglades Agricultural Area (EAA) discharges.

(3) Within 90 days after the first discharge from each STA, submit to this office, the USEPA, USFWS, NPS, FGFWFC, and FDEP the report evaluating the baseline conditions described in paragraph (2), above.

(4) Within two years plus 120 days of the date of the first discharge from each STA, submit to this office, the USEPA, USFWS, NPS, FGFWFC, and FDEP an evaluation, based on the first two full years of operation, of the effects of construction and operation of the STAs and downstream water quality improvements on mercury species storage, release and bioaccumulation. At a minimum, the evaluation shall include information to determine: (1) release of mercury into the water column of the STAs upon initial flooding, (2) the rate of removal of mercury from EAA discharges to the STAs prior to discharge to downstream waters, (3) the rate of accumulation of mercury in sediments of the STAs, and (4) net change in bioaccumulation of mercury in fish and wading birds within the STAs, and in the areas of the Everglades protection Area already impacted by EAA discharges. Prior to submission, the permittee shall solicit comments on this evaluation through a publicly-noticed meeting that shall include representatives of this office, USEPA, USFWS, NPS, FGFWFC, FDEP, and other interested parties.

(5) Within 90 days of submission, the permittee, this office, the USEPA, USFWS, NPS, FGFWFC, FDEP, and other interested parties shall determine if adverse effects on mercury species storage, release or bioaccumulation associated with construction and operations of the STAs are occurring. Based on the determination, this office shall decide if a remedial plan is required.