Project ID: 14-0380

Everglades Ecosystem Assessment Phase IV

Miami, FL

Project Date: September 3-21, 2014

Science & Ecosystem Support Division

Project Leader: Peter I. Kalla, Ph.D.
Ecology Section
Field Services Branch
Science & Ecosystem Support Division
USEPA – Region 4
980 College Station Road
Athens, Georgia 30605-2720

The activities depicted in this report are accredited under the US EPA Region 4 Science and Ecosystem Support Division ISO/IEC 17025 accreditation issued by the ANSI-ASQ National Accreditation Board. Refer to certificate and scope of accreditation AT-1644.

Requestor:

Douglas Mundrick, Deputy Director
Water Protection Division
61 Forsyth St. SW
Atlanta, Georgia 30303-8960

Analytical Support:

Florida International University
Southeastern Environmental
Research Center
11200 S.W. 8th Street
Miami, Florida 33199

Analytical Services Branch
Science and Ecosystem Support Division
USEPA – Region 4
980 College Station Road
Athens, Georgia 30605-2720

Approvals:

SESD Project Leader:

Peter Kalla June 8, 2017

Peter Kalla Date
Ecology Section
Field Services Branch

Approving Official:

Stacey Box June 8, 2017

Stacey Box, Chief Date
Ecology Section
Field Services Branch

This report should be cited as:

Kalla, P.I., and D.J. Scheidt. 2017. Everglades ecosystem assessment – Phase IV, 2014: Data reduction and initial synthesis. U.S. EPA, Science and Ecosystem Support Division, Athens, GA. SESD 14-0380. 58 pp.

Introduction

In September 2014, the U.S. Environmental Protection Agency, Region 4 Science and Ecosystem Support Division (EPA SESD), in cooperation with Florida International University (FIU) and the EPA Region 4 Water Protection Division, conducted a comprehensive survey of the Florida Everglades as part of a recurring Everglades Ecosystem Assessment described in the next section. This report presents the findings of the survey for three key pollutants and one important measure of ecosystem integrity. Summary and bivariate statistics on mercury, phosphorus, sulfur, and soil depth are presented in this initial report. Only physical and biogeochemical results are included here. Plant community mapping information was collected by other Principal Investigators at FIU. They will present those findings in a separate report.

Planning and study design for the Everglades Ecosystem Assessment began in 1992. This Program has focused on mercury because of its potency as a neurotoxin in wildlife and concerns about human health risks associated with consumption of mercury-laden gamefish. Phosphorus has been assessed because of its potential to eliminate the native periphyton community, favor replacement of the native marsh with invasive cattail, and aid in conversion of the natural ridge-and-slough microtopography to a flatter landscape supporting only monospecific stands of unnaturally tall, dense sawgrass. Sulfur is of concern due to its role in conversion of elemental mercury to its bioavailable form. A review of the historical literature on these pollutants is available in Scheidt and Kalla (2007).

Background

Phases I - III: Since 1993, EPA has been conducting a landscape-level assessment of the Everglades ecosystem in association with many partners, including Everglades National Park (ENP). The Program uses EPA's Environmental Monitoring and Assessment Program (EMAP) statistical survey design (reviewed in Diaz-Ramos et al. 1996) to sample all of the Marl Prairie/Rocky Glades and the Everglades Ridge and Slough physiographic regions. The Everglades Ecosystem Assessment [EEA, also known as Everglades Regional EMAP (REMAP)] is the only comprehensive probabilistic monitoring and assessment program that preceded the development of the Comprehensive Everglades Restoration Program (CERP), which subsequently defined several monitoring and assessment objectives to include: documenting status and trends, determining baseline variability, detecting responses to management actions, and improving the understanding of cause and effect relationships. The EEA has provided this information system-wide for the entirety of the freshwater Everglades. In Phases I (1993-1996) and II (1999) EPA provided pre-2000 baseline conditions for a broad array of indicators against which future changes can be measured. In Phase III (2005) changes were detected in mosquitofish (*Gambusia holbrooki*), mercury burdens and soil phosphorus concentrations. EEA Program data have been featured in approximately 30 peer-reviewed publications or agency reports which have been cited over 800 times. Data have been used by the National Academies of Sciences and about 30 federal or state agencies, Indian Tribes, environmental groups, agricultural interests, or universities.

The overarching objectives of the EEA are to measure the condition of ecological resources in the Marl Prairie/Rocky Glades and the Everglades Ridge and Slough physiographic regions; and to document ecosystem responses as CERP restoration efforts change the quality, quantity, timing and distribution of water, and as State agencies implement control strategies for pollutants such as phosphorus, sulfur, and mercury. EEA employs an integrated, holistic approach in a consistent manner at the landscape level – the only effort to do so throughout the entire freshwater Everglades ecosystem.

EEA has provided data relevant to 23 CERP performance measures for the Everglades Ridge and Slough and the Marl Prairie/Rocky Glades physiographic regions - seven for the Greater Everglades, one for the Miccosukee Reservation, three for Everglades National Park, one for soil performance, one for animal performance, five for plant performance and five for hydrological performance. Among these 23 are nine water quality measures.

This monitoring and assessment project has been guided from the outset by the following seven policy-relevant questions which are equally applicable to the four major issues affecting the Everglades ecosystem (hydropattern modification, eutrophication, habitat alteration and mercury contamination): What is the magnitude of the problem? What is the extent of the problem? Has it changed over time? What are the associations with the problem? What are the sources of the problem? What is the risk to ecological resources? What are the solutions?

In Phase IV (2013-2014) of the Program, EPA continued change detection and/or assessments of:

- concentrations of drivers, including nitrogen, phosphorus, carbon, and sulfur, in water and soil over time and space;
- hydropattern modifications in the system and responses during the wet season;
- soil thickness;
- habitat alterations associated with nutrient loading and hydropattern changes;
- methylmercury contamination;
- mechanisms controlling mercury methylation;
- bioaccumulation of methylmercury;
- interacting stressors through structural equation modeling; and
- management implications of these issues.

The information will be critical as baseline data for the Central Everglades Planning Project, a new component of CERP that features restoration of the central flow-way.

Methods

Design: The probability design EPA uses to sample the Everglades marsh was developed from the EMAP base grid, a Generalized Random-Tessellation Stratified approach (Stevens and Olsen 2004), in order to ensure spatial coverage. The design includes stratification by the four major subareas of the system, the Water Conservation Areas [WCAl (also known as Arthur R. Marshal Loxahatchee National Wildlife Refuge - LOX), WCA2, and WCA3] and the Park (ENP), to ensure that coverage of smaller subareas is adequate for obtaining variance estimates. A consistent sample size of approximately 125 random points per seasonal survey ensures acceptable confidence intervals around estimated environmental parameters. This design criterion is compatible with logistical considerations allowing helicopter-supported crews to complete all sampling in about 15 days, which also matches throughput capacities of cooperating analytical laboratories.

In Phase IV, EPA utilized an improved design that features a 50-50 mix of new random points and points from the previous Phase (III, 2005). EPA's Office of Research and Development (ORD), Western Ecology Division, National Health and Environmental Effects Research Laboratory, provided the statistical design and sample draw. The 2014 statistical design is a probability survey design that consists of two parts: a) 50% of the sites are a probability subsample of the prior survey design (2005) and b) 50% of the sites are a new probability sample. Since the two designs are completed independently, the combined survey design is also a probability survey design. The combined design has two objectives. The first objective is to estimate the current status across space as has been done in the past. The second objective is to estimate change between the two time periods (2005 and 2014). The power of detecting a change is increased by visiting some sites in both time periods (Breidt and Fuller 1999, USEPA 2015). Simulation studies of alternative designs for estimating change favor survey designs where approximately 50% of the sites are visited in both time periods. The 2014 change estimation is based not only on the panel of 50% revisits, but also on the panel of sites from the previous time period (2005) not revisited, and on the panel of new sites from the current time period (2014).

In September 2013, the EPA SESD initiated Phase IV sampling at 125 target stations, and successfully collected biogechemical data at 51 stations within ENP and WCA3. Due to a federal government shutdown during the sampling period, the project was not completed as planned. However, analysis was completed for the samples obtained prior to the shutdown. Summary statistics are presented in USEPA (2014a).

EPA's synoptic, probabilistic approach is the only multi-media Program in the Everglades that produces quantitative statements with known confidence about environmental conditions across an entire resource over space and time. For example, the proportion of the Everglades marsh having a total phosphorus concentration greater than 400 milligrams per kilogram (mg/kg) (the CERP goal) in soil was 49.3 ± 7.1 % in 2005, and this proportion was statistically significantly greater than the 33.7 ± 5.4 % measured in 1995-1996.

Tasks: EPA conducted a probabilistic, multimedia, synoptic survey of the entire freshwater flow-way of the greater Everglades ecosystem, an area of 2098 square miles, during September of 2014. This survey focused on the biogeochemistry of key pollutants in the marsh, namely mercury, phosphorus, and sulfur. Media sampled were surface water, bottom water, periphyton, soil, flocculent detrital matter (floc), macrophytic vegetation, and mosquitofish.

There was no dry season survey in Phase IV. Soil pore water, sampled in Phases II and III, was replaced by bottom water. Aquatic community sampling by throw-trap, conducted in Phase III, was omitted. These changes were made to match the Phase IV effort to available funding.

Field Protocols: Crews obtained samples of water, floc, soil, periphyton, and mosquitofish at each station. EPA Region 4 Field Branch Standard Operating Procedures, which can be found at http://www.epa.gov/region4/sesd/fbqstp/index.html, were followed as applicable. At half of the stations, sawgrass leaf clippings were also collected. At these stations plant communities present were classified at the 2-meter scale, with a total of up to four GPS locations obtained at sub-meter accuracy in the communities. Whole sawgrass plants were also collected at a quarter of the stations.

Sediment, benthic periphyton, and floc were collected in core tubes. A vacuum chamber was used to collect a clean sample of surface water for trace-level mercury analysis. Periphyton in the water column was collected by direct dipping. Mosquitofish were collected with an "A"-frame dip-net or a large aquarium net for analysis of whole-body total mercury. Mosquitofish are used in the Program because they are an excellent indicator of mercury bioaccumulation due to their varied diet, small home range, great abundance, ubiquity and short life cycle. They are also common forage for many other fish.

A number of procedures have been developed specifically for the Program over the years. These techniques and equipment, including a new procedure developed for collection of bottom water for sulfide analysis, are described in the Quality Assurance Project Plan (USEPA 2014b).

Data Analysis

The spatial survey statistics used for this report are described in Scheidt and Kalla (2007). Since its inception, the Program has featured techniques to examine probabilistic survey data. Complementary descriptive methods included here are box-and-whisker plots and kriged mapping, to show the distribution of the data over the range of the variable and over actual space, respectively. The cumulative distribution function (CDF) is used here to estimate the magnitude and extent of key pollutants and other parameters. CDF curves are tested (Wald F test) against each other to infer a change, or lack thereof, in these variables between surveys. In this report, conclusions about change are based on the Wald F test results. This report includes correlation analysis as an initial exploration of relationships among the data.

Outcome

The survey took place from September 4th through the 20th, 2014. All stations were in the greater Everglades freshwater flow-way (Figure 1). Approximately 6,000 continuous data values were generated.

All but six of the 125 stations in the base design were sampled. Two stations in ENP were not sampled because they were non-target. One was a tree island and the other was a forested upland. Another station in the Park was not attempted because of the potential to disturb an endangered species of butterfly. The remaining three stations were not sampled because of safety concerns about landing on site, due to the presence of tall woody vegetation.

Throughout this report the results from the 2014 survey are compared to those from previous surveys. The years chosen for comparison are 1995, which was the first assessment of the marsh, and 2005, which was the midpoint in three decades of successive effort. Because of three successive hurricanes in September and October, the 2005 survey was not conducted until November.

The 2014 survey was conducted during a period of lower water levels than in 2005, which had levels lower than in 1995 (Figure 2). Water depths in the REMAP study area are determined by precipitation and water management in the greater Everglades watershed. The watershed begins in the Kissimmee River basin, which drains into Lake Okeechobee, which is drained by canals. Some canals move water to the Atlantic or Gulf coasts, while others flow south through the Everglades Agricultural Area (EAA). These southern canals then pass through the marsh on their way to outlets along the east coast (Figure 1). Some water in these canals eventually goes into the marsh, either by direct pumping, by overbank flow, or by seepage through levees. In the EAA, the canals are used for irrigation and drainage, depending on the season and on local rainfall. In drier years, less water is discharged from the EAA downstream into the marsh. There was far less discharge in the wet season of 2014 than in the wet season of 2005 (Figure 3).

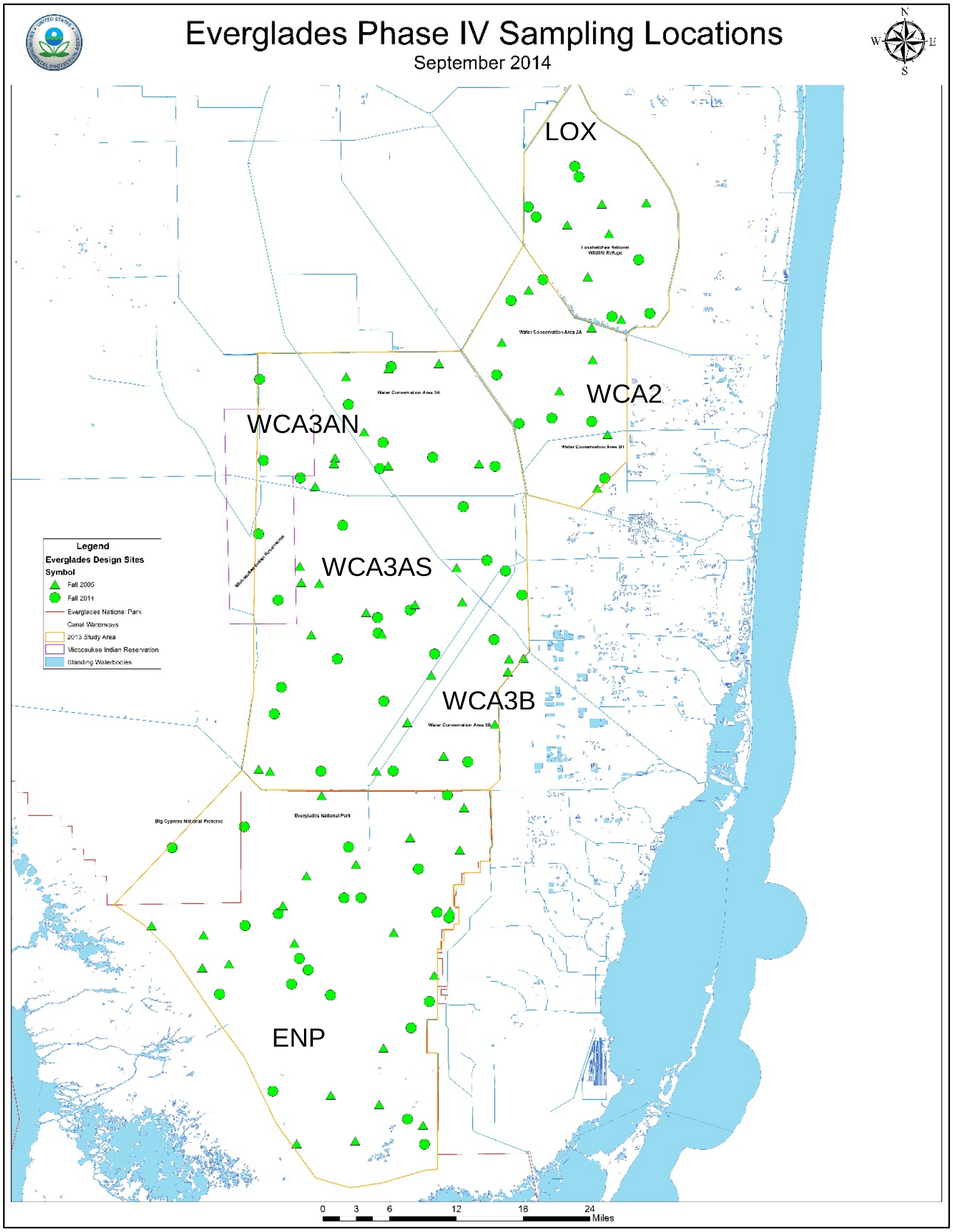

Figure 1. REMAP station draw for the September 2014 survey. Subareas shown are Everglades National Park (ENP); Water Conservation Areas 3A North (WCA3AN), 3A South (WCA3AS), 3B (WCA3B), and 2 (WCA2); and Loxahatchee National Wildlife Refuge (LOX). The triangles are re-visits of 2005 wet season stations and the circles are new visits. The thin blue lines are drainage canals.

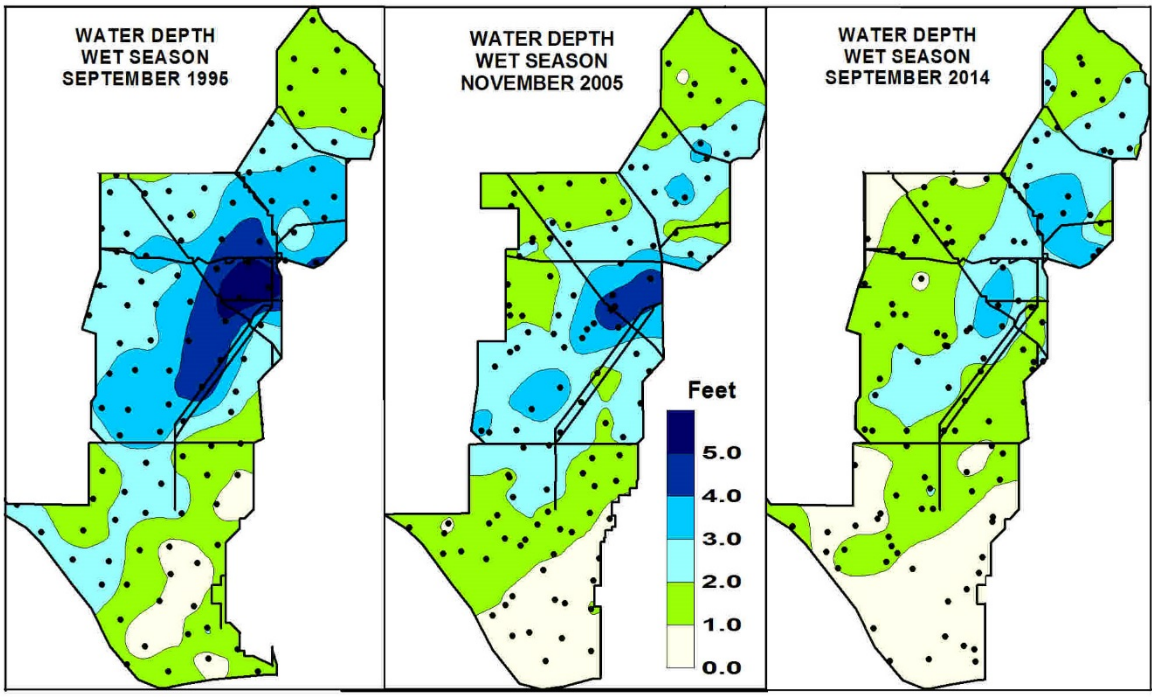

Figure 2. Wet season water depths during the 1995, 2005, and 2014 Everglades Ecosystem Assessments. The black dots are biogeochemical sampling station locations.

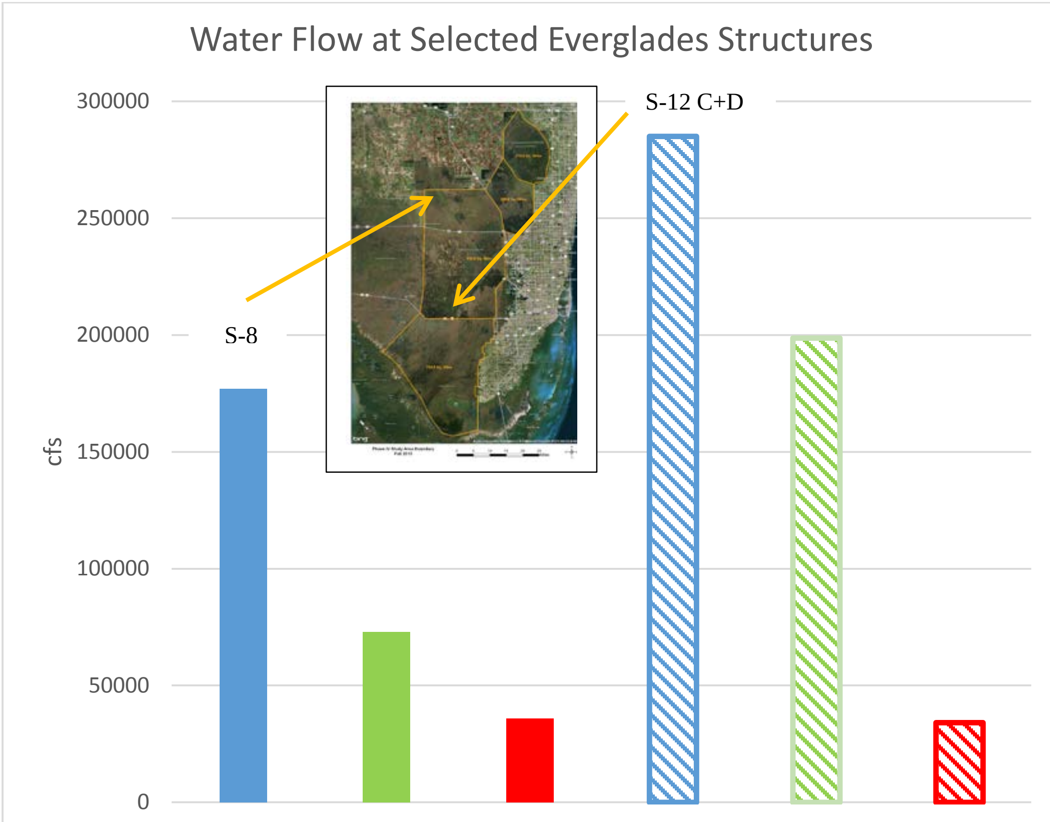

Figure 3. Cumulative discharge, in cubic feet per second (cfs), in the summer months of 2005 and 2014 at water control structures discharging from the EAA into WCA3 (S-8, solid bars) and from WCA3 into ENP (S-12 C + S-12 D, crosshatched bars). Blue bars are June through October 2005, green bars are August through October 2005, and red bars are June through August 2014. The 2005 sampling occurred during November and the 2014 sampling occurred during September. Blue bars represent the entirety of the wet season prior to sampling; red and green bars represent the three months prior to sampling. Data from DBHydro (https://www.sfwmd.gov accessed 4/17/2015).

Results and Discussion

This section is focused on the three contaminants of concern discussed in the Introduction – mercury, phosphorus, and sulfur. We also include new information on soil thickness, since historical soil loss in the northern Everglades is still a matter of ecological concern to be addressed by the Central Everglades Planning Project, which is a part of CERP. The section concludes with a brief summary of all analyses, observations, and measurements conducted for the survey. Except where noted, all findings refer to the study area as a whole.

Mercury

Mercury burdens in mosquitofish have declined sharply over the history of Everglades REMAP (Figure 4). EPA recognizes a predator protection threshold of 77 nanograms per gram (ng/g) (USEPA 1997). In 2014, for the first time, both the median and even the entire interquartile range were below this threshold. However, as Figure 5 shows, there were still places in the system where that level was exceeded, as was the U.S. Fish and Wildlife Service's threshold (Eisler 1987) of 100 ng/g for protection of piscivorous birds and mammals. In fact, mercury in largemouth bass still exceeded the 300 ng/g criterion for protection of human health throughout the system (Julian et al. 2016), and a gamefish consumption advisory is still in effect system-wide (Florida Department of Health 2017).

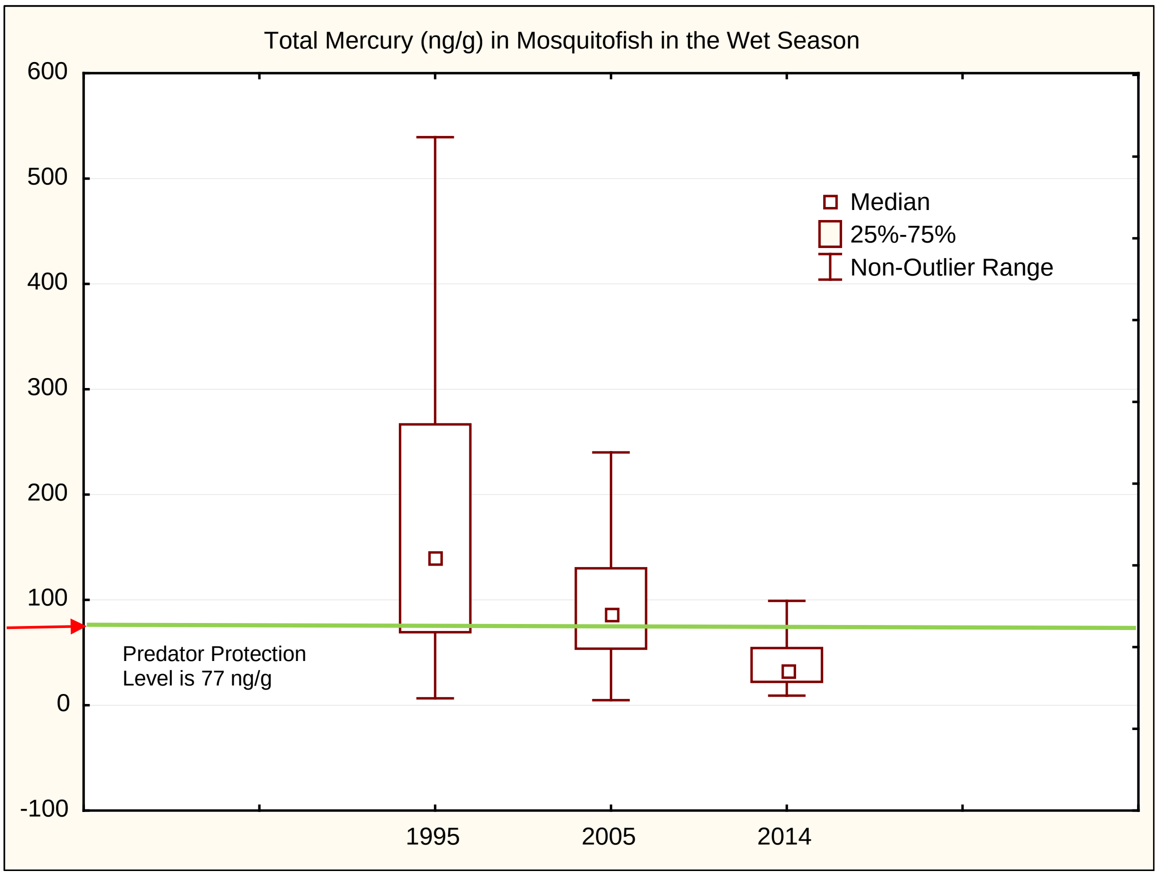

Figure 4. Box-and-whisker plots of total mercury in mosquitofish, by survey year. The non-outlier range includes 99, 95, and 93 % of the data for 1995, 2005, and 2014, respectively.

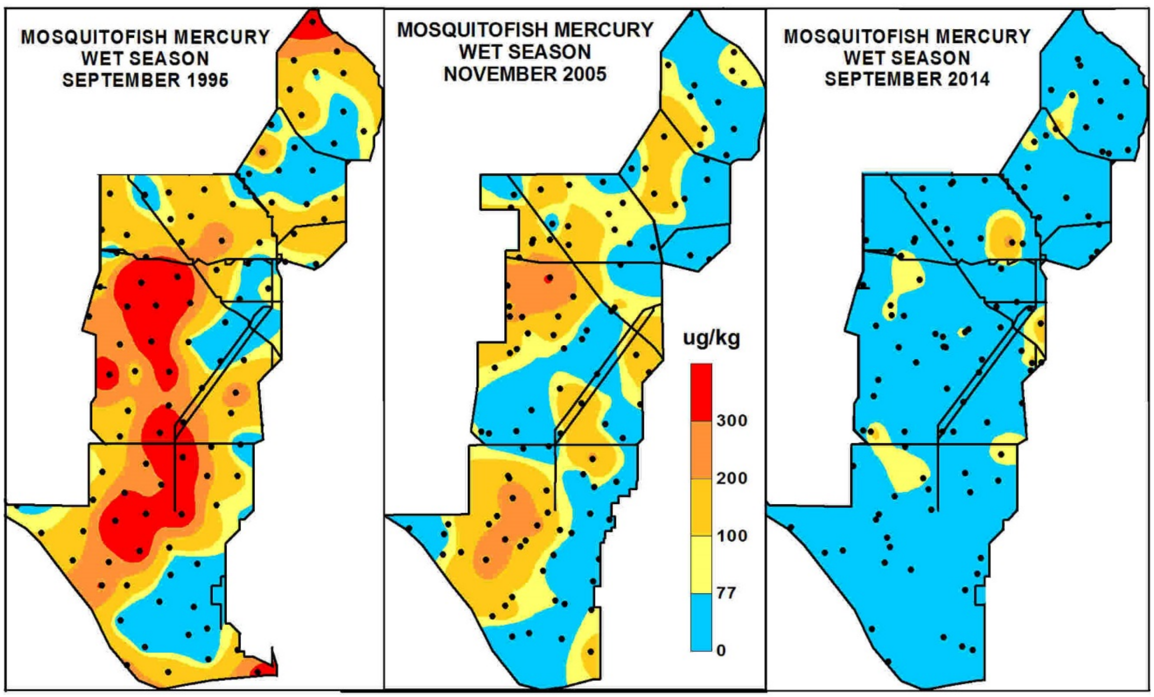

Figure 5. Krigs of total mercury in mosquitofish, in micrograms per kilogram (ug/kg), over the history of REMAP surveys.

Consistent with the other analyses, the CDF curves have also shifted considerably (Figure 6). The solid black vertical line in the figure is at 77 ng/g (or 77 ug/kg). The dashed green horizontal lines are the corresponding y-intercepts, showing the proportion of the system below that level. In 2014 the intercept was at 87%, thus only 13 % of the marsh was above 77 ng/g. The 95% confidence interval about this estimate is $\pm$ 6 %, well within the data quality objective for the Program of $\pm$ 10 %. The apparent differences among the curves are statistically significant (Wald *F*, P $\leq$ 0.05). Analysis of variance indicated that the lower concentrations observed in 2014 compared to 2005 cannot be explained by fish length or weight.

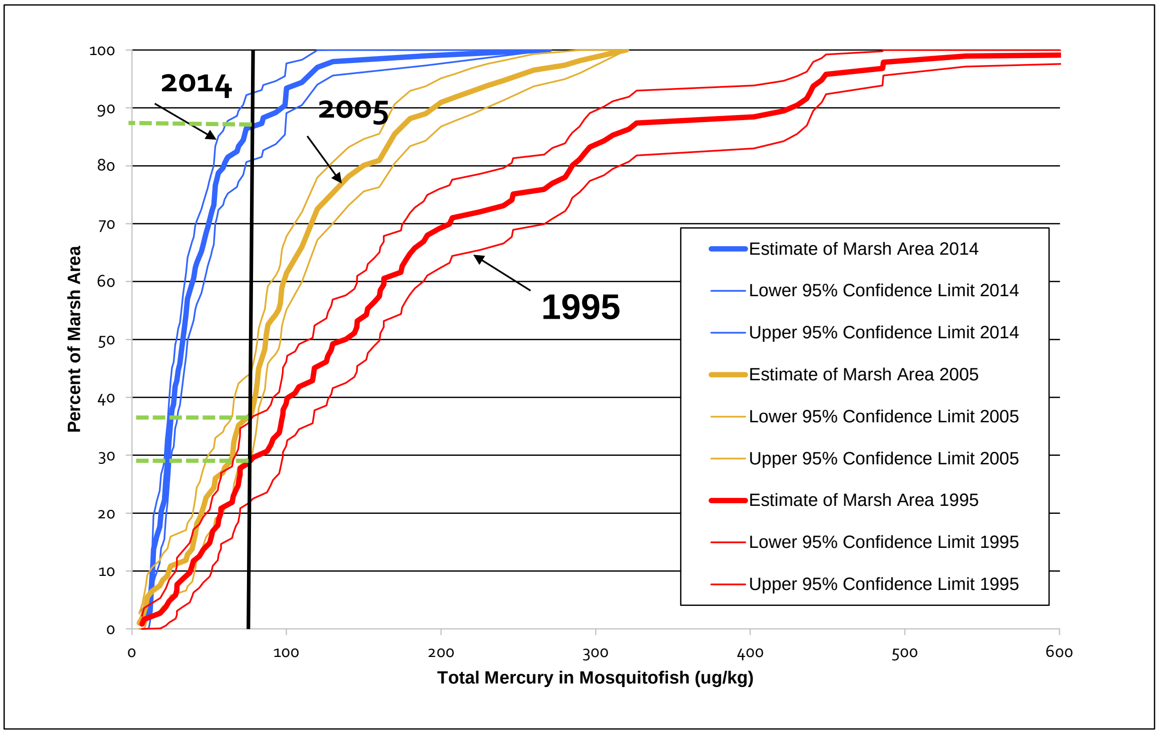

Figure 6. Cumulative distribution function (CDF) curves of total mercury in mosquitofish in the wet season, showing changes over the course of REMAP.

The changes described here for the whole study area also apply to all four major subareas (ENP and the three WCAs). The CDFs (not shown here) for those places in 2014 are all different than in 2005 and in 1995 (Wald *F*, P < 0.04).

There was less mercury in mosquitofish because there was less methyl mercury in the system (Figures 7 and 8). Methyl mercury is the form of mercury that is bio-accumulated via the food web. The pattern of change in methyl mercury concentrations in surface water (Figure 7) resembles the pattern for total mercury concentrations in mosquitofish (Figure 4). There have been consistent declines in the median, the interquartile range, and the non-outlier range for both analytes over the course of the REMAP surveys. The apparent differences among the CDF curves in Figure 8 are statistically significant (Wald *F*, $P \leq 0.05$).

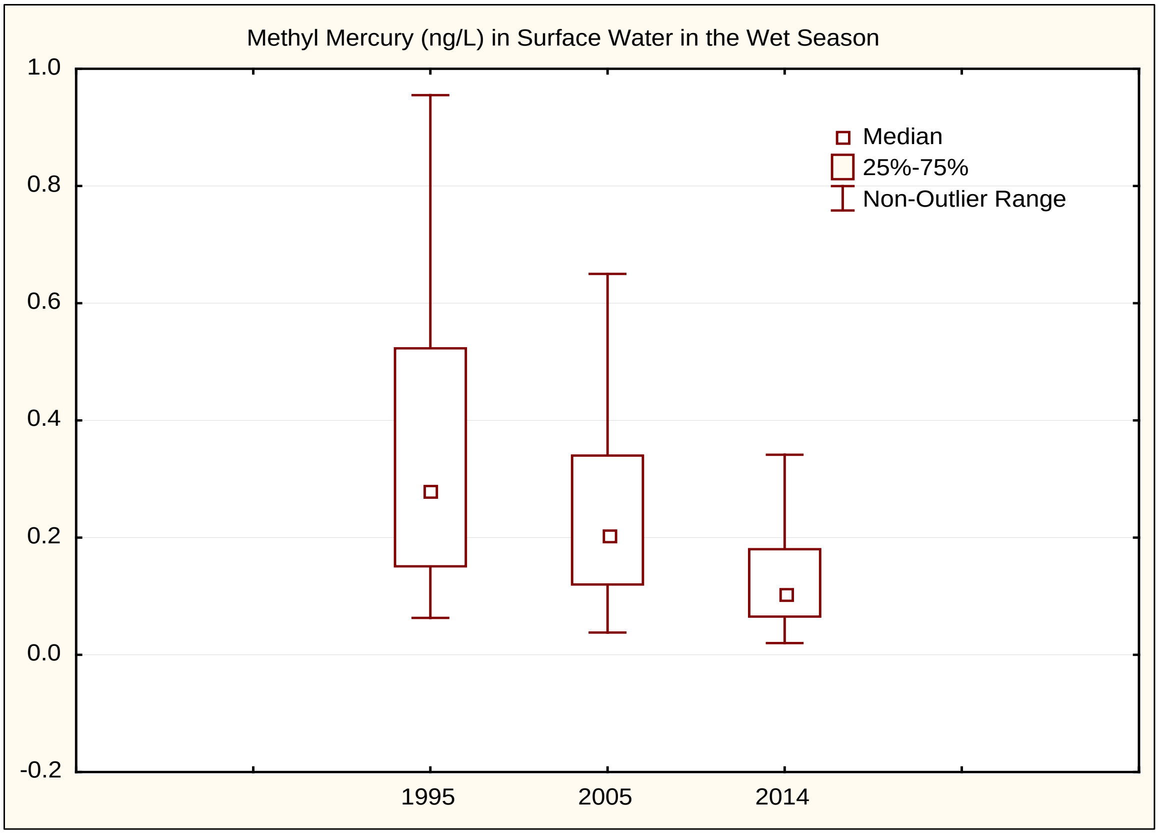

Figure 7. Box-and-whisker plots of methyl mercury [nanograms per liter (ng/L)] in surface water, by survey year. The non-outlier range includes 91, 94, and 90 % of the data for 1995, 2005, and 2014, respectively.

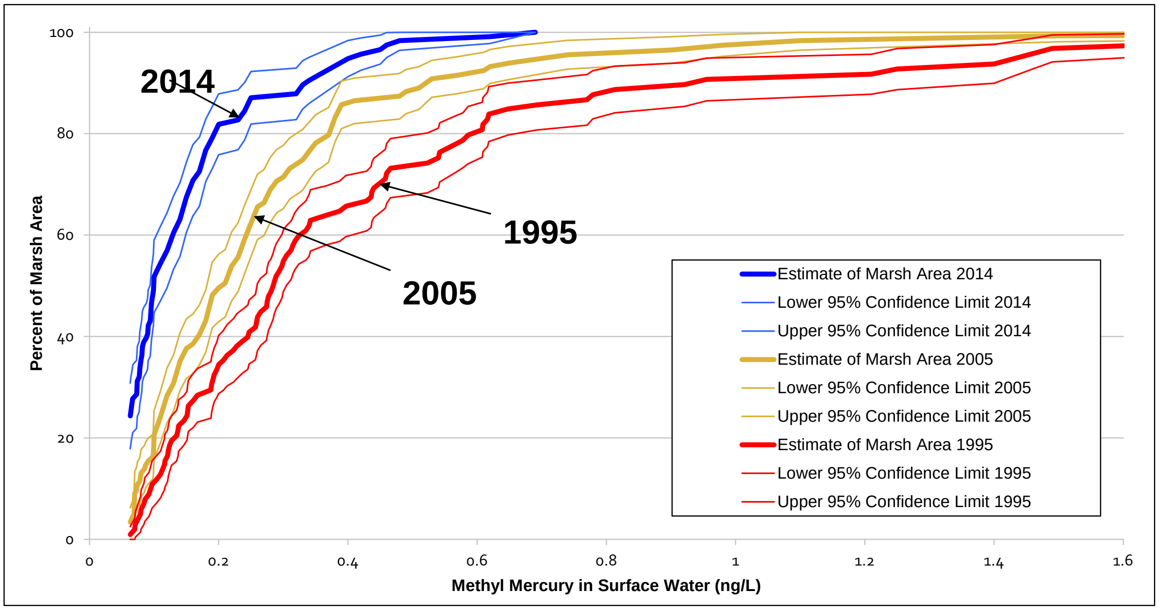

Figure 8. CDF curves of methyl mercury in surface water in the wet season, showing changes over the course of REMAP.

The changes described here for the whole study area also apply to the three WCAs for 2014 compared to 2005, and for 2014 compared to 1995. The CDFs (not shown here) for those three places in 2014 are all different than in 2005 (Wald *F*, $P < 0.02$); and 2014 is also different than in 1995 (Wald *F*, $P < 0.01$).

There was also less total mercury in surface water at the time of the survey in 2014 (Figure 9). As compared to 1995, the curves show a slight increase in the 2005 survey and a noticeable decrease in 2014. Both differences are significant (Wald *F*, $P \leq 0.05$). As the units on the x-axes of Figures 8 and 9 show, methylated mercury is present in concentrations that are about an order of magnitude less than total mercury.

The bulk of total mercury in surface water consists of inorganic mercury atoms that are deposited from the atmosphere (reviewed in Liu et al. 2008). Atmospheric deposition of mercury is influenced by precipitation, by local sources, and by global sources and air circulation patterns. Though there has been a decline in global atmospheric mercury emission in recent years (Zhang et al. 2016), wet deposition by summertime thunderstorms in the study area was unchanged in 2014 compared to 2005 (Julian et al. 2016). For example, Table 1 shows data from the monitoring station at Everglades National Park that is part of the Mercury Deposition Network of the National Atmospheric Deposition Program (MDN-NADP). There was no difference in mercury loading between 2005 and 2014. A hypothetical reason for finding less total mercury in the water column in 2014 is that the residence time of that water was longer than in previous surveys, because discharge into the system, and therefore possible outflow from it, was so much lower. Longer residence time provides a greater opportunity for removal of mercury from the water column by a variety of mechanisms, and elemental mercury has less affinity for water than for other ecosystem compartments, notably soil (Liu et al. 2008).

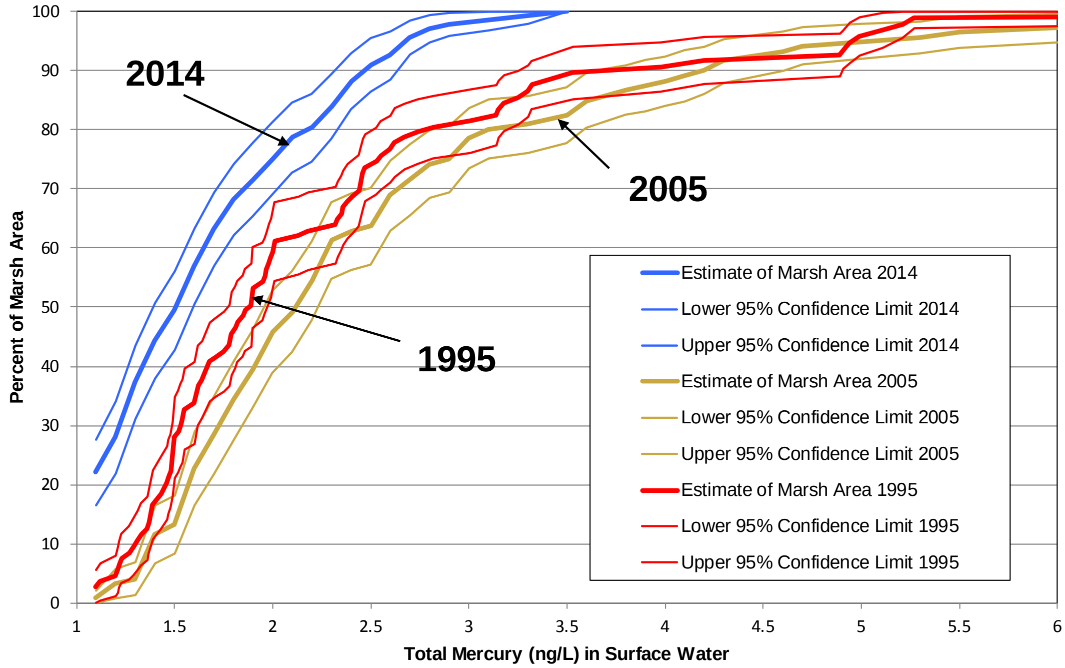

Figure 9. CDF curves of total mercury in surface water in the wet season, showing changes over the course of REMAP.

The change described here for the whole study area comparing 2014 to 2005 also applies to all four of the major subareas. The CDFs (not shown here) for those places in 2014 are all different than in 2005 (Wald *F*, P < 0.01). The CDFs are different for 2014 compared to 1995 for the Park and WCA1 subareas (Wald *F*, P < 0.01).

Table 1. Weekly measurements of wet deposition of atmospheric total mercury from June through September at Everglades National Park in 2005 (Phase III) and 2014 (Phase IV), in ng/m^2. 2005 sampling was completed during November, while 2014 sampling was completed during September. The two years are not different (t-test, P = 0.42). Data from MDN-NADP (http://nadp.sws.uiuc.edu/mdn/ accessed 11/4/16).

Phase III	Phase IV	
187.15	637.36	
2079.07	765.63	
1864.39	1596.65	
349.76	883.83	
428.5	91.34	
850.65	480.69	
89.38	2217.73	
302.59	1382.86	
1234.8	1853.69	
593.14	768.74	
579.12	830.2	
511.25	379.29	
572.14	120.4	
1422.04	478.23	
135.89	525.33	
1388.44	101.57	
90.57	300.3	
1523.39	24.74	
789.015	746.5878	mean
14202.27	13438.58	sum

Phosphorus

Successive surveys have shown consistently less total phosphorus in surface water (Figure 10). Both the Miccosukee Tribe of Indians and the State of Florida have adopted a 10 micrograms per liter (ug/L) water quality criterion for total phosphorus for the parts of the Everglades within their jurisdiction. The CDF curves reveal that the proportion of the marsh above the water quality criterion has been cut in half twice. The differences are statistically significant (Wald *F*, $P \leq 0.05$). The State of Florida has been building stormwater treatment areas (STAs) in the Everglades Agricultural Area to remove phosphorus from water flowing into the native marsh. As of 2012 there were 57,000 acres of STAs. In Water Year 2016 (which included September 2014), over 80 % of the total phosphorus leaving EAA farms was removed by STAs before it got to the public Everglades (SFWMD 2016).

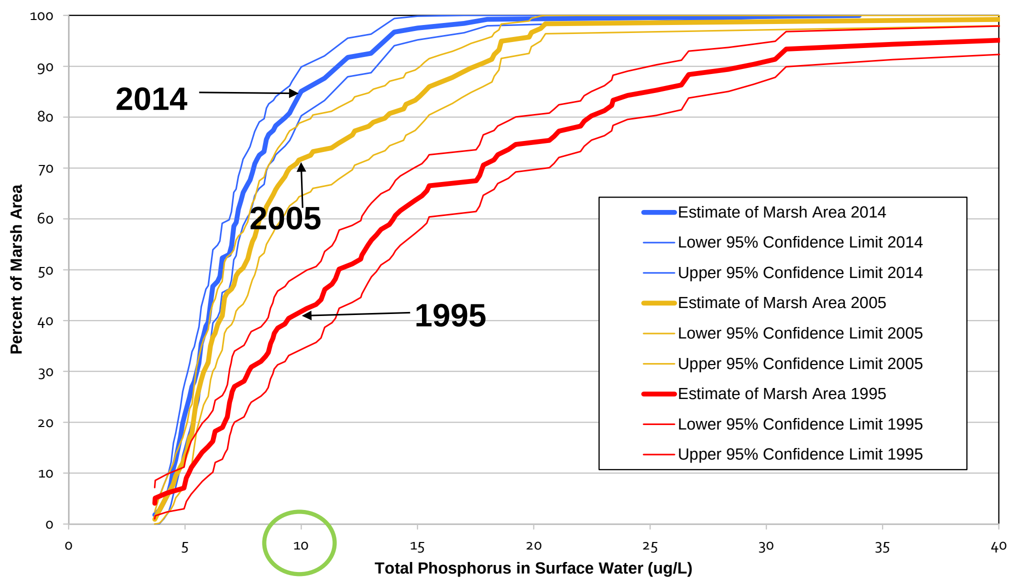

Figure 10. CDF curves of total phosphorus in surface water in the wet season, showing changes over the course of REMAP. The 10 ug/L water quality standard is circled on the x-axis.

The Park and WCA3 had less total phosphorus in surface water in 2014 than in 1995. The CDFs (not shown here) for both places are different between years (Wald *F*, $P < 0.01$). For 2014 only the WCA1 subarea had less phosphorus in surface water than in 2005 (Wald *F*, $P < 0.01$).

Though phosphorus enters the public Everglades in surface water, it exerts an impact in the soil. Despite a remarkable decrease in total phosphorus loading via inflowing water over the course of REMAP, there was no change in its concentration in the soil system-wide from 2005 to 2014 (Figure 11; Wald *F*, P = 0.82). For all four subareas there was no change in soil phosphorus in 2014 as compared to 2005. There was an increase in 2005 from the mid-1990s (Wald *F*, P $\leq$ 0.05). System-wide, the median concentration went from 343 mg/kg in the mid-1990s to 390 mg/kg in 2005 and 2014. The Refuge and WCA3 had more total phosphorus in soil in 2014 than in 1995. The CDFs (not shown here) for both places are different between years (Wald *F*, P $\leq$ 0.05). These findings indicate the effect of continued, though diminished, loading of phosphorus above background levels, which are less than 4 ug/L (Figure 10). Forty-six percent of the marsh is still above the CERP goal of 400 mg/kg (Figure 11).

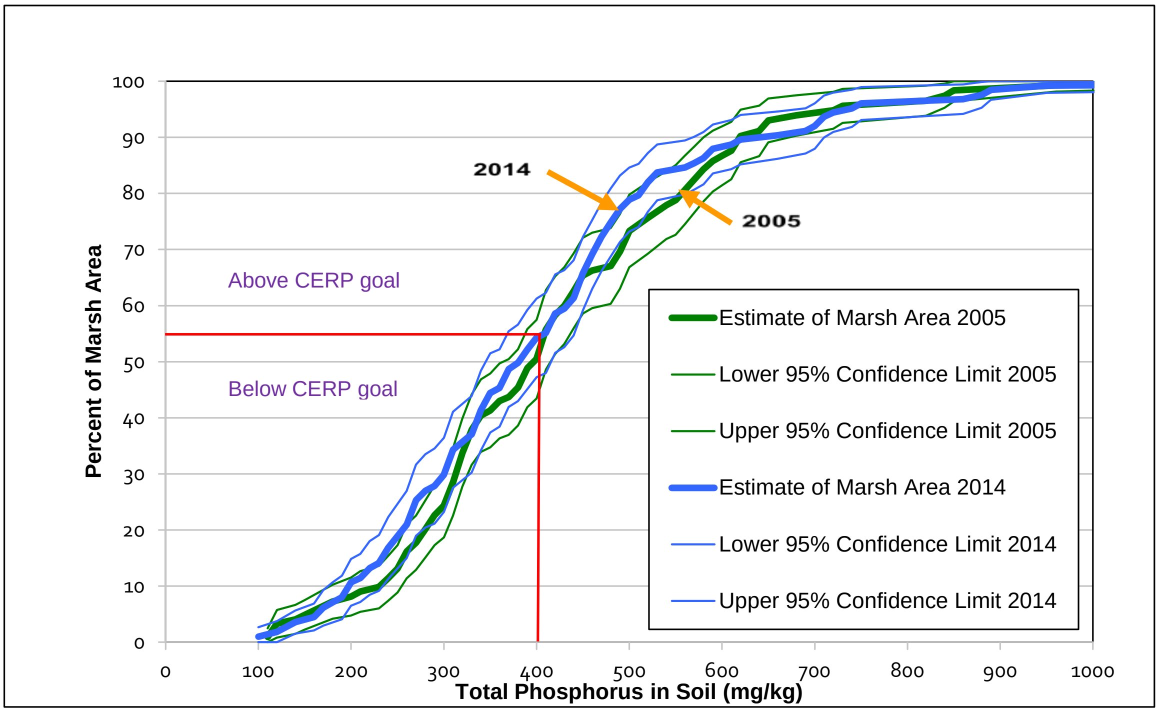

Figure 11. CDF curves of total phosphorus in soil in the wet season, showing no change between 2014 and 2005.

Sulfur

The pattern of change in methyl mercury (Figure 7) resembles the pattern for sulfate (Figure 12). There have been consistent declines in the median, interquartile range, and non-outlier range for sulfate over the course of the REMAP surveys. The analytical method detection limit (MDL) improved by two orders of magnitude between 1995 and 2005, so the apparent differences between those surveys in Figure 12 are probably exaggerated. The 2014 median was below the CERP goal of 1 mg/L, and very close to background level which is near 0.

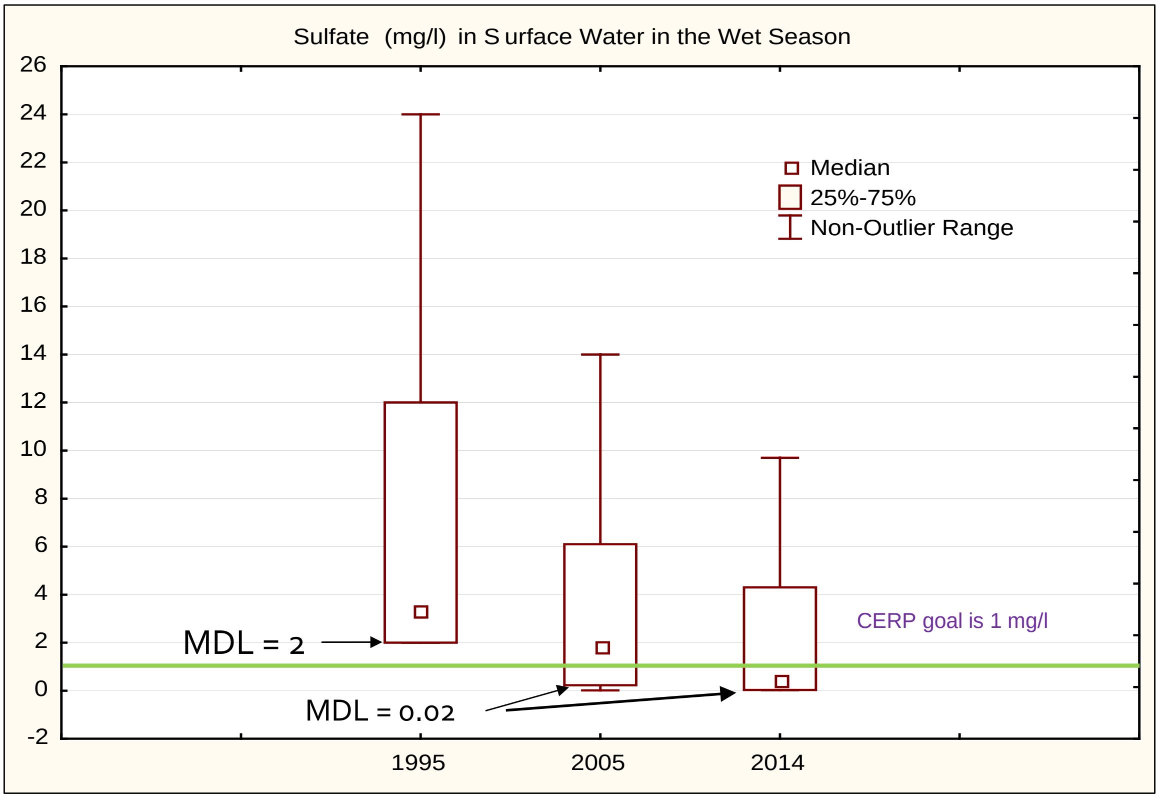

Figure 12. Box-and-whisker plots of sulfate in surface water, in milligrams per liter (mg/l), by survey year. The non-outlier range includes 86, 85, and 88 % of the data for 1995, 2005, and 2014, respectively.

Elevated sulfate levels in 2014 followed the same landscape pattern as in previous years (Figure 13), though the influence of canal overflows into the marsh in the wet season was more apparent in 2005. There was some spatial correspondence between moderately elevated sulfate in water and moderately elevated mercury in mosquitofish (Figure 5).

The highest sulfate concentrations originate within the Everglades Agricultural Area (Scheidt and Kalla 2007). Sources include legacy deposits in the soil in the EAA, where sulfate was, and continues to be, used as a soil amendment (Julian et al. 2016).

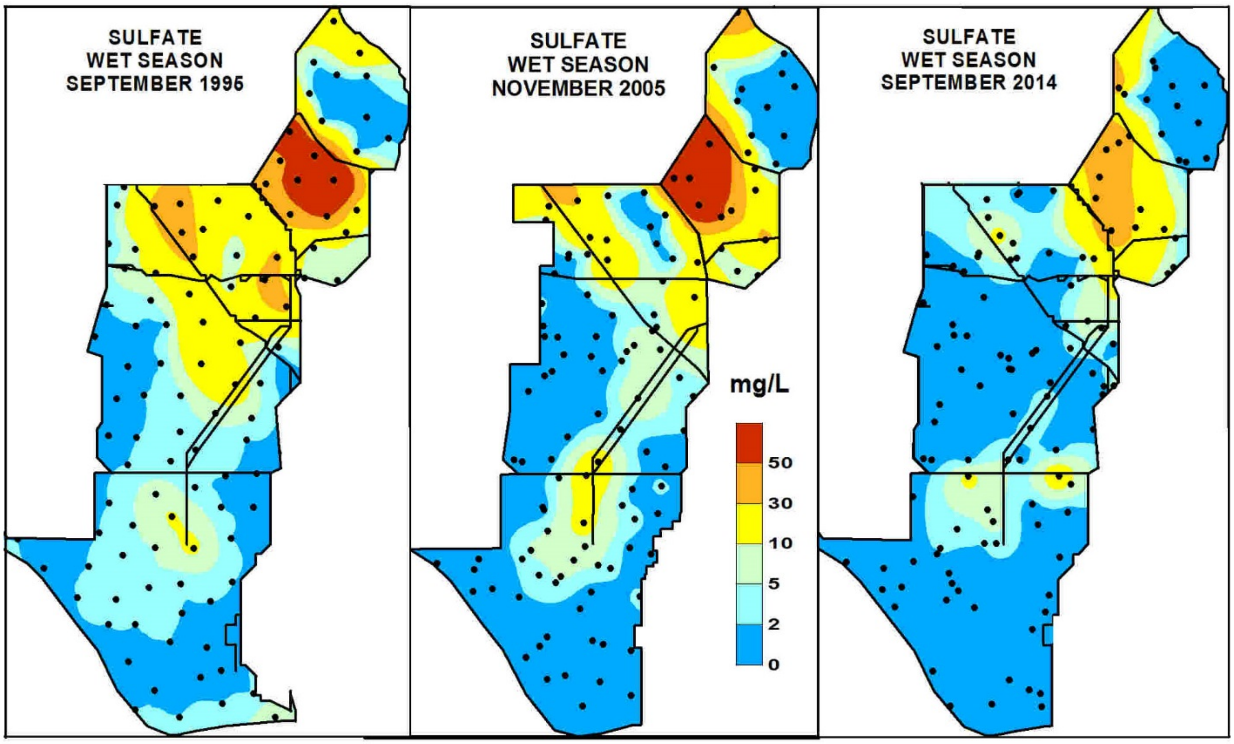

Figure 13. Krigs of sulfate in surface water in the wet season over the history of REMAP surveys. Some of the heavy black lines in and around the study area are levees and canals.

The data for the CDF curves for all years in Figure 14 were truncated at the 1995 MDL of 2 mg/L. Despite this censorship and considerable overlap of confidence intervals, the curves are all different (Wald *F*, $P \leq 0.05$). The same temporal pattern observed in most other analytes also held for sulfate. The STAs do little to remove sulfate from water that will enter the public Everglades. As with other pollutants, concentrations in surface water are influenced by precipitation in the EAA and the marsh, and by local water management practices.

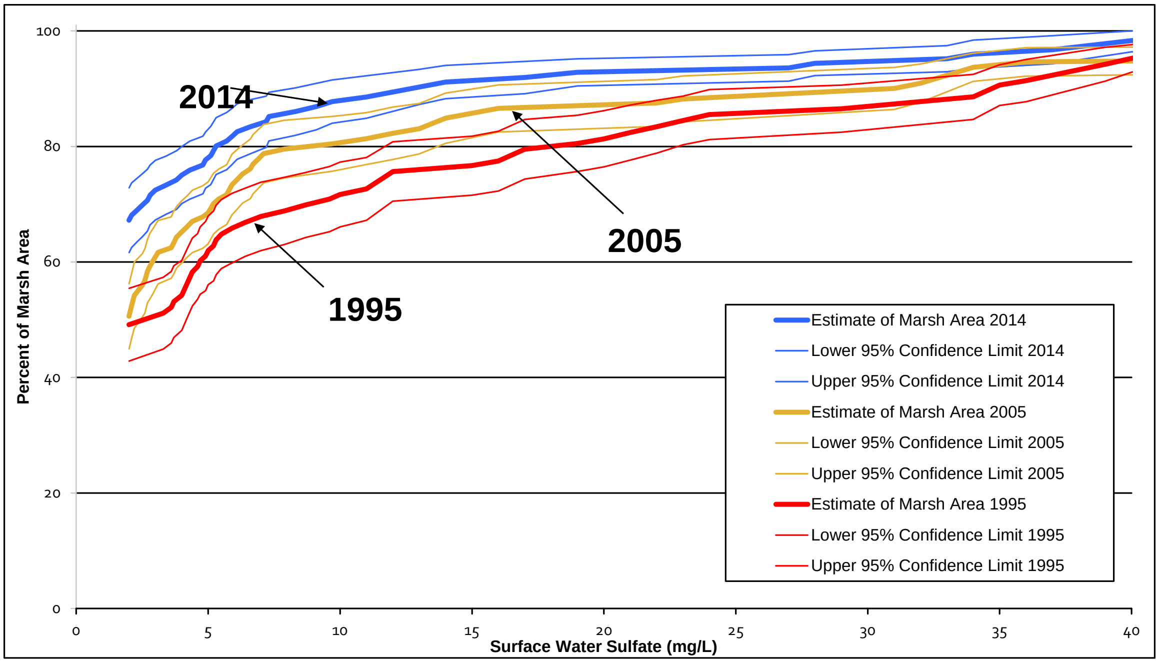

Figure 14. CDF curves of sulfate in surface water in the wet season, showing changes over the course of REMAP.

The Park, the Refuge, and WCA3 had less sulfate in surface water in 2014 than in 2005 (Wald *F*, $P < 0.02$).

<u>Conclusion and Synthesis on Mercury, Sulfur, and Phosphorus</u>

Comparing the 2014 REMAP survey to prior surveys, antecedent discharge from the EAA at S-8 appeared to be down, sulfate in surface water was down, methyl mercury in surface water was down, and total mercury in mosquitofish was down. Program data over two decades of REMAP show that mercury in mosquitofish was strongly associated with other constituents including moderate levels of sulfate in surface water (Pollman 2012). There was some spatial correspondence between moderately elevated sulfate in water and moderately elevated mercury in mosquitofish. This association was spatially explicit, most obviously in Phase III (Scheidt and Kalla 2007). Any inorganic mercury present in surface water can be methylated by sulfur-reducing bacteria (SRB) if sulfate concentration is above background. Methylated mercury can be efficiently bioaccumulated by mosquitofish where phosphorus in soil is not so high that the habitat has become poor (Pollman 2014), resulting in a depauperate food web (Abbey-Lee et al. 2013), and where sulfate is not so high that toxic levels of sulfide are also present.

Soil Thickness

There has been no change in soil thickness over the study area as a whole during the course of REMAP. Figure 15 shows the pooled data. In previous decades, peat loss due to drainage, oxidation, and subsidence was severe in northern WCA3A and the northeastern corner of ENP (reviewed in Scheidt and Kalla 2007). Current sample sizes are too small in these sub-areas to detect recent changes in either direction, but future surveys may provide enough data to do so.

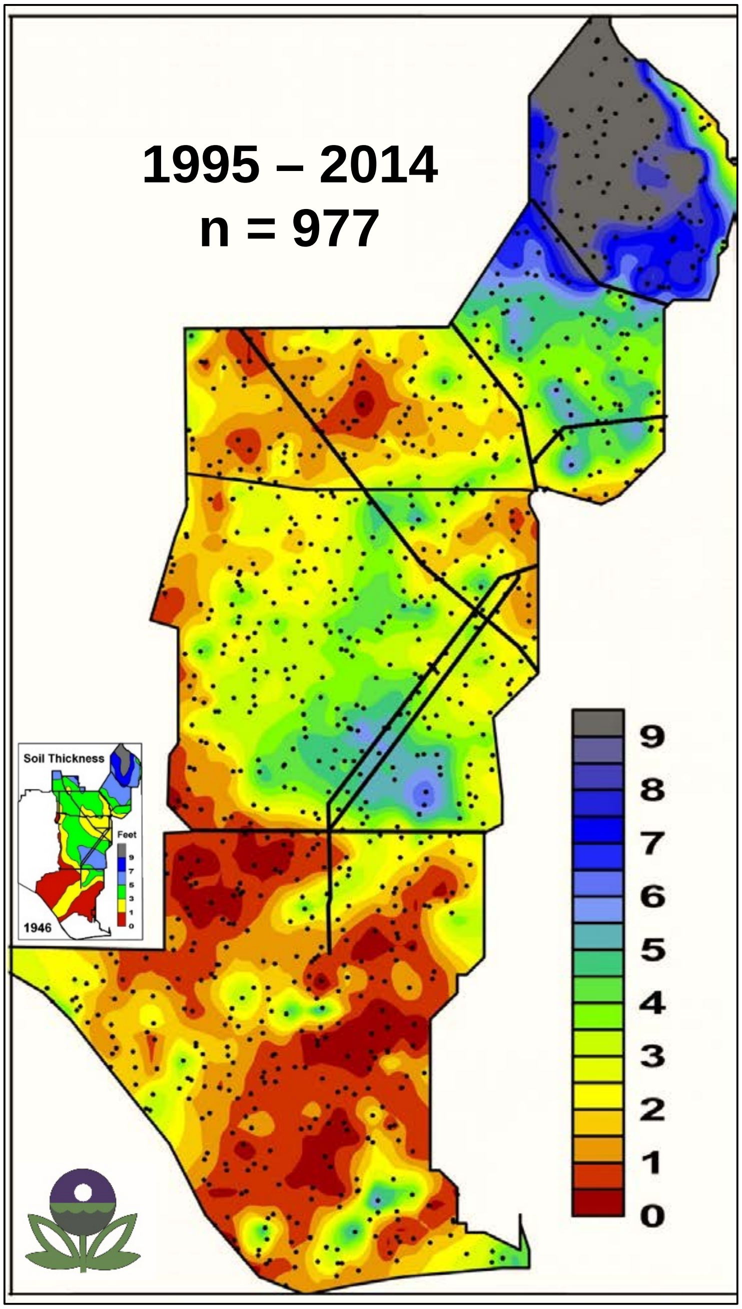

Figure 15. Krig of soil thickness (feet) based on REMAP data. The inset figure from the 1940s (Davis 1946) has a similar scale.

<u>Project Analytes by Media</u>

Much other physical and biogeochemical data was generated during the course of the project that is not discussed in this report. All data were collected to describe, diagnose, and predict the ecological health of the Everglades. Subsequent reports and publications by various Principal Investigators will include this information. The following is a complete listing of all measurements taken and observations made, many of which are potential explanatory variables that could be used to model mercury in mosquitofish. These data were obtained at every station where the given medium was present to sample, measure, or observe. The letters in parentheses are measurement, media, and analyte codes used in the variable names in Table 2 and in the correlation matrix that comprises the Appendix.

Field Data on Surface Water, Soil, Floc, Periphyton, and Vegetation:

TEMPERATURE (TEMP)
CONDUCTIVITY (COND)
pH
TURBIDITY (TURB)
DISSOLVED OXYGEN (DO)
OXIDATION-REDUCTION POTENTIAL (ORP)
WATER DEPTH (WATDEPAV)
SOIL THICKNESS (SOILTHAV)
FLOC THICKNESS (FLOCTHAV)
BENTHIC PERIPHYTON THICKNESS (PBTHAV)
SOIL TYPE
PERIPHYTON % COVER (PERICOV)
PERIPHYTON GROWTH FORMS PRESENT
WATER COLUMN PERIPHYTON BIOVOLUME (PERIVOL)
VEGETATIVE COMMUNITY TYPE
DOMINANT MACROPHYTE
CATTAIL PRESENCE

Laboratory Analytical Data:

Surface Water (SW)

CHLORIDE (CL)
SULFATE (SO4)
DISSOLVED ORGANIC CARBON (DOC)
TOTAL ORGANIC CARBON (TOC)
TOTAL PHOSPHORUS (TP)
SOLUBLE REACTIVE PHOSPHORUS (SRP)
FILTERED NITRATE+NITRITE (FNN)
FILTERED NITRATE (FNO3)
FILTERED NITRITE (FNO2)
FILTERED AMMONIA (FNH4)
TOTAL NITROGEN (TN)

CHLOROPHYLL A (CHLA)
TOTAL MECURY (THG)
METHYL MERCURY (MEHG)

Bottom Water (BW)

SULFIDE (H2S)

Floc (FC)

pH
WATER CONTENT (H2O)
ASH-FREE DRY WEIGHT (ASH)
BULK DENSITY (BD)
TOTAL CARBON (TC)
TOTAL NITROGEN (TN)
TOTAL PHOSPHORUS (TP)
CHLOROPHYLL A (CHLA)
TOTAL MERCURY (THG)
METHYL MERCURY (MEHG)

Soil (SD)

pH
WATER CONTENT (H2O)
ASH-FREE DRY WEIGHT (ASH)
ORGANIC MATTER (OM)
BULK DENSITY (BD)
TOTAL CARBON (TC)
TOTAL NITROGEN (TN)
TOTAL PHOSPHORUS (TP)
TOTAL MERCURY (THG)
METHYL MERCURY (MEHG)

Sawgrass Leaf Clippings (VG)

TOTAL CARBON (TC)
TOTAL NITROGEN (TN)
TOTAL PHOSPHORUS (TP)

Whole Sawgrass Plants, Above-ground Parts (SGA)

TOTAL MERCURY (THG)
METHYL MERCURY (MEHG)

Whole Sawgrass Plants, Below-ground Parts (SGB)

TOTAL MERCURY (THG)
METHYL MERCURY (MEHG)

Benthic Periphyton (PB) and Water Column Periphyton (PC)

pH
WATER CONTENT (H2O)
ASH-FREE DRY WEIGHT (ASH)
BULK DENSITY (BD)
TOTAL CARBON (TC)
TOTAL NITROGEN (TN)
TOTAL PHOSPHORUS (TP)
CHLOROPHYLL A (CHLA)
TOTAL MERCURY (THG)
METHYL MERCURY (MEHG)

Mosquitofish (FS)

TOTAL MERCURY (THG)

Summary statistics for all continuous variables are presented in Table 2. The order of the variables matches the order in the correlation matrix. The last two letters in each name of a measurement are laboratory codes. Five different laboratories were used in the project, the FIU mercury lab (FC), FIU nutrient lab (FB), FIU soil lab (FS), EPA field lab (EE), and EPA Regional lab at SESD (EA). As an example of the codes given above and on the preceding pages, the first measurement in Table 2 is THGFSFC, which is total mercury in mosquitofish analyzed at the FIU mercury lab.

Table 2. Minimum, 25th percentile, median, 75th percentile, maximum, and sample size for all continuous data generated for the 2014 REMAP survey.

measurement	unit	min	25th %-ile	median	75th %-ile	max	n
THGFSFC	ng/g	4.9	22	33.5	54	270	104
THGSWFC	ng/L	0.63	1.2	1.6	2.08	3.5	116
MEHGSWFC	ng/L	0.02	0.064	0.1	0.18	0.69	116
CHLAFCFB	mg/g	0.014	0.173	0.34	0.683	2.4	64
THGFCFC	ng/g	5.9	81.25	120	160	290	96
MEHGFCFC	ng/g	0.04	1.13	2.55	5.68	32	96
THGSDFC	ng/g	19	94	150	200	290	117
MEHGSDFC	ng/g	0.04	0.36	0.77	1.85	7.9	117
CHLAPBFB	mg/g	0.008	0.068	0.14	0.29	1	31
THGPBFC	ng/g	3.6	11.5	24	46	160	42
MEHGPBFC	ng/g	0.065	0.255	0.505	1.125	8.5	42
CHLAPCFB	mg/g	0.052	0.29	0.6	0.95	2.8	71
THGPCFC	ng/g	5.9	13	19	33	130	71
MEHGPCFC	ng/g	0.077	0.66	1.8	3	16	71
FLOCTHAV	cm	0	0.9	2.7	6.1	18.7	117
PBTHAV	cm	0	0	0	0.8	5.7	117
PERICOV	%	0	0	20	80	100	117
PERIVOL	mL	0	0	50	285	2500	117
THGSGAFC	ng/g	4.3	5.7	6.2	7.4	9.8	27
THGSGBFC	ng/g	3.7	6.4	9.4	13	25	27
MEHGSGAFC	ng/g	0.12	0.15	0.18	0.26	0.44	27
MEHGSGBFC	ng/g	0.24	0.38	0.52	0.77	3.2	27
CLSWEA	mg/L	7	21	36	61	100	116
SO4SWEA	mg/L	0.022	0.033	0.39	4.225	48	116
DOCSWEA	mg/L	8.7	15	18	21	32	116
TOCSWEA	mg/L	9.4	15	18	21	32	116
TPSWFB	ug/L	3.4	5.3	6.6	8.6	34	116
SRPSWFB	ug/L	0.9	0.9	1	1.6	19	116
FNNSWFB	mg/L	0.0008	0.0016	0.0023	0.0048	0.042	116
FNO3SWFB	mg/L	0.0001	0.0006	0.00135	0.0049	0.041	116
FNO2SWFB	mg/L	0.0004	0.001	0.0012	0.0014	0.0026	116
FNH4SWFB	mg/L	0.004	0.0095	0.013	0.02	0.21	116

TNSWFB	mg/L	0.36	0.54	0.66	0.85	1.2	116
CHLASWFB	ug/L	0.3	1.6	3.0	5.8	58	116
H2SBWEE	mg/L	0.007	0.009	0.012	0.033	0.6	116
pHFCFS	std units	6.23	7.19	7.54	7.69	8.2	64
H2OFCFS	%	66	96	98	98	99	64
ASHFCFS	%	5.8	10.1	14.5	32.8	84	64
BDFCFS	g/cc	0.01	0.01	0.02	0.04	0.36	64
TCFCFS	mg/g	170	350	410	450	490	64
TNFCFS	mg/g	7.3	27.3	32	38	44	64
TPFCFB	mg/g	0.100	0.405	0.530	0.668	1.200	64
pHSDFS	std units	6.37	7.25	7.54	7.76	8.7	117
H2OSDFS	%	43	80	88	91	99	117
ASHSDFS	%	3.3	12	20	67.5	93	117
OMSDFS	%	7	32.5	80	88	96.7	117
BDSDFS	g/cc	0.04	0.08	0.11	0.19	0.6	117
TCSDFS	mg/g	75	210	430	460	530	117
TNSDFS	mg/g	4.4	15	29	33	46	117
TPSDFB	mg/g	0.100	0.270	0.390	0.490	1.700	117
TCVGFS	mg/g	98	460	470	470	500	60
TNVGFS	mg/g	6	8.5	9.4	11	16	60
TPVGFB	mg/g	0.210	0.243	0.280	0.310	0.550	60
pHPBFS	std units	7.42	7.69	7.91	8.07	8.54	31
H2OPBFS	%	55	81	84	93	97	31
ASHPBFS	%	8.4	40	66	76	79	31
BDPBFS	g/cc	0.01	0.08	0.15	0.23	0.44	31
TCPBFS	mg/g	180	200	220	280	440	31
TNPBFS	mg/g	7.3	9.4	12	19	37	31
TPPBFB	mg/g	0.064	0.093	0.130	0.220	0.550	31
pHPCFS	std units	6.71	7.68	7.84	8.05	8.39	71
H2OPCFS	%	80	91	95	96	98	71
ASHPCFS	%	7	23	49	62	80	71
BDPCFS	g/cc	0.02	0.04	0.06	0.09	0.26	71
TCPCFS	mg/g	190	230	270	360	460	71
TNPCFS	mg/g	5.3	10	15	20	42	71
TPPCFB	mg/g	0.049	0.091	0.150	0.280	2.100	71
TEMP	C	24	27.61	28.92	30.31	34.3	116
COND	umhos/cm	48	315	386	489	780	116
pH	std units	5.84	7.08	7.26	7.56	8.25	116
TURB	NTU	0.0	0.3	0.7	1.7	12.6	116
DO	mg/L	0.65	2.33	4.00	6.37	10.64	116
ORP	mV	-189.6	-11.8	23.7	127.2	196.7	115
WATDEPAV	feet	0.00	0.99	1.52	2.10	3.83	118
SOILTHAV	feet	0.07	1.27	2.28	3.97	12.07	118

In addition to the critical analytes and media discussed earlier in this report, specific uses of other measurements and media will be as follows. As requested by the EPA Region 4 Water Protection Division, most of the mercury, nutrient, and carbon data, as well as physical and chemical measurements of periphyton, floc, and soil, will be used in mass balance calculations for the study area by Principal Investigators at FIU. Chlorophyll-*a* is a measure of the palatability of periphyton (Sargeant et al. 2011) and food value (carbon quality) of floc (Neto et al. 2006, Pisani et al. 2015), which can be used in mercury modeling by other members of the South Florida scientific community. Elevated chloride levels occur in connate seawater that appears in canals that drain the EAA, and thus could be used by the community to trace the sheet-flow of canal water through the marsh.

Correlation Analysis

The correlation matrix in the Appendix presents Spearman rank order correlations. This approach is non-parametric, which does not assume that the data distribution is normal. The Shapiro-Wilk test for normality indicted that most data were not normally distributed.

The Spearman results show that no single variable was found to have a statistically robust association [coefficient (*rho*) $\geq$ 0.7 and $p < .001$] with mercury in mosquitofish. The palatability, nutritional status, and methyl mercury content of benthic periphyton were moderately correlated with mosquitofish mercury (chlorophyll-*a* Spearman *rho* = 0.512, total carbon *rho* = 0.466, total nitrogen *rho* = 0.433, ash content *rho* = - 0.549, water content *rho* = 0.435, methyl mercury *rho* = 0.370, all $.001 < p < .05$). Periphyton mats are known to be an important food source for primary and secondary aquatic consumers in the Everglades (reviewed in King and Richardson 2007). However, in the 2005 wet season the parameter most highly correlated with fish mercury was methylmercury in epiphytic periphyton (*rho* = 0.568, $p < .001$). These findings suggest that mosquitofish were exposed to mercury by somewhat different pathways in 2005 and 2014. Methylation of mercury could occur within benthic periphyton, or at the soil-water interface immediately below it, where organic carbon, sulfate, and reducing conditions can be present together. With low discharge into the system in 2014, meaning less sulfur in the environment, benthic periphyton may have been the only place where significant amounts of methylated mercury were available in the food web. But, given the generally widespread and precipitous drop in mosquitofish mercury levels in 2014, it is not surprising that strong correlations were not found in the data.

Methyl and total mercury in surface water were weakly correlated with dissolved and total organic carbon (DOC, TOC) in water (methyl *rho* = 0.288, 0.232, total *rho* = 0.200, 0.266, all $.001 < p < .05$). Elemental mercury can become bound to complex organic molecules (Liu et al. 2009), thereby being held in the water column prior to translocation to the soil-water interface and entry into SRB. Methyl mercury was also weakly correlated with sulfate (*rho* = 0.219, $.001 < p < .05$).

Total phosphorus (TP) in soil was moderately inversely correlated with benthic periphyton thickness (*rho* = - 0.401, p < .001), water column periphyton volume (*rho* = - 0.426, p < .001), and total periphyton cover (*rho* = - 0.534, p < .001). These relationships indicate the negative effect of elevated soil phosphorus on the native ridge and slough community. This diverse community is dominated by periphyton in the sloughs and sawgrass on the ridges. Where excessive phosphorus has accumulated in the soil, the native community can be replaced by invasive cattail (Scheidt and Kalla 2007). Sawgrass size responds positively to soil phosphorus (Stober et al. 2001). Sawgrass can be twice as tall (~2 m) and twice as dense (above 50 culms/m^2) in high phosphorus locations (Richards and Kalla, unpublished data from 2005 REMAP survey). Such habitats have periphyton largely excluded and have less aquatic food web diversity and shorter food chain length (King and Richardson 2007, Wang et al. 2014).

Sulfate was moderately to strongly correlated with other constituents of agricultural drainage water – organic carbon (TOC *rho* = 0.661), phosphorus (TP *rho* = 0.427), and chloride (*rho* = 0.735) (all p < .001). Sulfide in bottom water was moderately associated with sulfate and organic carbon in surface water (sulfate *rho* = 0.362, DOC *rho* = 0.378, both p < .001) and with water depth (*rho* = 0.546, p < .001), and strongly inversely correlated with oxidation-reduction potential measured at the bottom of the water column (*rho* = - 0.605, p < .001). Field studies subsequent to the 2014 survey (Kalla et al. 2017) showed that sulfide in bottom water was an acceptable predictor of sulfide in pore water in the Everglades.

Path analysis uses a correlation matrix as input. Such an analysis of the REMAP data can produce structural equation models relating multiple variables to each other and, directly or indirectly, to mosquitofish mercury (Pollman 2014).

Quality Assurance

<u>Laboratory Audits</u>

Prior to the survey, an independent Project Quality Assurance Officer (QAO), assisted by other staff from the Quality Assurance Section (QAS) at SESD, audited all participating laboratories at FIU and SESD, including the portable lab of the in-house contractor field chemist. A small number of corrective actions were identified and implemented. There were no findings that compromised use of any data to fulfill the Project's data quality objectives as defined in the Quality Assurance Project Plan (QAPP).

<u>Pre-survey Blanks</u>

At SESD, rinse blanks are run on equipment and supplies before they are used in the field. This precaution falls within the SESD Quality Management Plan and is overseen by QAOs. For REMAP, 29 blanks were run on sample bottles and gloves, by lot, and on all vacuum chambers, for trace-level mercury. Another 57 blanks were run for bottles, gloves, and filtration syringes and filters, as applicable, for total phosphorus, sulfate, dissolved organic carbon, and the nitrogen series.

Mercury

Three sequential blanks were run on each of the four chambers. During this process, all of them were cleaned so that the second and third blanks were non-detect for every chamber.

Other Analytes

Total nitrogen (TN) and sulfate were detected in glove blanks. These blanks were made by submersing a glove in a beaker of water. This method was inapplicable to the Program since the vacuum chambers were used to draw all surface water samples. No glove ever touched the water during sampling. All other blanks for TN and sulfate, as well as all blanks for all other analytes, were non-detects.

Summary

Results from the pre-survey blanks demonstrated that there was no contamination of the sampling equipment and supplies that could have compromised the data for critical analytes in surface water from the Everglades. The solid media did not need to be blanked, since only water has low analyte levels that could be affected by contamination.

<u>Field Procedures</u>

Training overseen by the Program Leader on field procedures was provided to all biogeochemical sampling crew members before the start of the survey in order to assure consistency and adherence to the methods described in the QAPP. Training consisted of classroom presentations, field simulations conducted in the Athens, GA area, and demonstrations given on-site in the Everglades. During the field simulations, emphasis was placed on avoiding cross-contamination between stations. Discussion during the on-site demonstrations focused on safety, accuracy, and efficiency.

All media were sampled in accordance with the QAPP. Field laboratory operations were also conducted in accordance with the QAPP. The QAPP references SESD's applicable Standard Operating Procedures, as well as the Quality Management Plans of all participating laboratories.

Field Blanks

Trip blanks, air deposition blanks, and vacuum chamber blanks for trace-level mercury in water were collected daily during the survey. Trip blanks and vacuum chamber blanks were also collected daily for sulfate. A total of 264 blanks was produced.

Mercury

All blanks were non-detect.

Sulfate

All blanks were below the Method Reporting Limit (MRL) of 0.10 mg/L. Eight were very slightly above the MDL of 0.022 mg/L, ranging up to 0.058 mg/L. These low-level findings did not affect the environmental data, aside from presenting a small potential for extremely slight upward bias in the very bottom of the data distribution, which is of no scientific or management interest. For comparison, the field samples included 21 non-detects and 18 values between the MDL and MRL, while ranging up to as much as 48 mg/L.

Field Duplicates and Laboratory Splits

Eight stations were duplicated for surface water for all analytes except chlorophyll-*a*. Two stations were duplicated for sediment, and another four sediment samples were split after homogenization at the field operations base. One station was duplicated twice for chlorophyll-*a*. In order to obtain sufficient sample volume for laboratory analytical requirements and meet QA requirements, all stations were duplicated for DOC and seven stations were quadruplicated for DOC. A total of 536 data values were generated from the duplicate and split samples.

Methyl Mercury

The Relative Percent Difference (RPD) threshold of 30 % specified in the QAPP was exceeded twice for methyl mercury in split sediment samples and once for a duplicate sediment sample. It was also exceeded in four surface water duplicates.

The surface water duplicates are potentially of greater concern because methyl mercury in surface water is an important variable in models of mercury bioaccumulation in mosquitofish. However, all values of duplicate pairs were at or near the MRL (0.060 ng/L), where analytical variation is greatest. And, assuming that the true concentration is better approximated by more than one measurement, the averages of the pairs are all at or below the minimum associated with threshold mercury levels in mosquitofish as shown by past Program data (approximately 0.2 ng/L). Therefore, these exceedances likely do not indicate that the data are not reliable for Program purposes.

Of the two sediment splits that exceeded 30 % RPD, one yielded values that were both near the MRL of 0.12 ng/g. The other was just over the limit, at 37 %. While this split could suggest that homogenization of the sample was insufficient, no other analytes from this sediment sample split exceeded the threshold.

A duplicate sediment sample exceeded the 30% RPD threshold. The concentrations in the sample and the duplicate were 0.39 and 0.23 ng/g respectively (41% RPD). The range of methyl mercury in sediment system-wide was 0.04 to 7.9 ng/g (n=117, Table 2). The difference between the sample and the duplicate was only 2% of the range. These results indicate the minor heterogeneity present in sediment at the plot scale.

Nitrogen Series

There were eight exceedances for duplicates of filtered nitrogen compounds in surface water. All associated values were very small, with measured concentrations of ammonia, nitrate+nitrite, and nitrite falling between the MDL and the MRL (generally in the 10,000ths to 1000ths of a milligram per liter). Nitrate was calculated by subtracting nitrite from nitrate+nitrite. All values were considered estimates due to the lessened certainty of results below the MRL.

Other Analytes

Duplicates of soluble reactive phosphorus (SRP) and sulfate in surface water exceeded 30 % RPD at one station each, out of 8 stations. The sulfate values were both below the MRL of 0.10 mg/L. The SRP values were also very small, one a non-detect (assigned a result equal to the MDL) and the other below the MRL.

One duplicate, at station 27, for total phosphorus (TP) in surface water had an RPD of 47 %. The seven other duplicates ranged from 0 - 27 %. The exceedance pair included a value of 17 ug/L, whereas all other values ranged from 1.4 to 12 ug/L. Samples in containers for TP were also analyzed for total nitrogen (TN). At station 27 the RPD for TN was 3 %. Filtered water was analyzed for SRP and the nitrogen series, all from the same container. The RPD for SRP from station 27 was 0 %, while those for the nitrogen series ranged from 18 - 27 %. These results, in the aggregate, suggest that there was no failure of sampling or analytical technique that led to the 47 % RPD for TP at station 27.

One laboratory split for TN in sediment yielded an RPD of 34 %, slightly above the 30% threshold. While this split could suggest that homogenization of the sample was insufficient, no other analytes from this sample split exceeded the threshold.

Both duplicates from station 262 for chlorophyll-*a* in surface water resulted in exceedances. Except for methyl mercury discussed above, no other duplicate from surface water at that station exceeded the threshold. The chlorophyll-*a* results were more likely to have been caused by fine-scale variation in the contagious distribution of phytoplankton in the water column.

No RPD exceedances occurred for any other duplicated or split analytes. All standard deviations of quadruplicate DOC values were less than 7 % of any DOC measurement.

Summary

No field duplicates or laboratory splits indicated that survey data were compromised. This finding applies particularly to the elements critical to the Program – mercury, phosphorus, and sulfur. It is noteworthy that there were no RPD exceedances for total mercury in surface water and sediment, and none for total phosphorus in sediment.

<u>Field logbooks</u>

Logbooks were audited by the Project Leader, Associate Project Leader, or Field Quality Assurance Officer on site at the end of each day of sampling. Implausible field data and other deficiencies in record-keeping were noted and corrected where possible by the field sampling crew, before leaving the field operations base. At each sampling site, 12 photographs were taken to document habitat and soils. Photographic records of sampling activities were reviewed daily by the Project Leader, Associate Project Leader, or Field Quality Assurance Officer to assure that field measurements and descriptions were consistent with photographic evidence. Appropriate corrective actions were taken with the sampling crews before their next day in the field.

<u>Data Review</u>

All laboratory analytical data values were subjected to a quality assurance process that exceeded EPA standards. The process was applied to 100 % of the data for all analytes except the nitrogen series and SRP, which were done at 10 %. The process consisted of formal data review by the independent QAO and other QAS staff and in-house contractors, verification of data transcription by staff from the SESD Ecology Section, and validation by the Project Leader and Associate Project Leader. None of the approximately 5000 laboratory analytical data values were rejected.

Field data were also subjected to 100 % verification and validation. This process was iterative, as internal review of the calculations in an intermediate draft of this report revealed a small number of values (9 out of about 1000) that required final editing.

References

Abbey-Lee, Robin N., Evelyn N. Gaiser and Joel C. Trexler. 2013. Relative roles of dispersal dynamics and competition in determining the isotopic niche breadth of a wetland fish. *Freshwater Biology* 58:780–792 doi:10.1111/fwb.12084.

Breidt, F.J., and W.A. Fuller. 1999. Design of supplemented panel surveys with application to the national resources inventory. *Journal of Agricultural, Biological, and Environmental Statistics* 4(4):391-403.

Davis, John H., Jr. 1946. The Peat Deposits of Florida: Their Occurrence, Development and Uses. Geological Bulletin No. 30. Florida Geological Survey. Tallahassee, Florida. 247 pp.

Diaz-Ramos, S., D.L. Stevens, Jr., and A.R. Olsen. 1996. EMAP statistical methods manual. U.S. EPA, Corvallis, OR. EPA/620/R-96/002.

Eisler, R. 1987. Mercury hazards to fish, wildlife, and invertebrates: A synoptic review. U.S. Fish and Wildlife Service Biological Report 85 (1.10). 90 pp.

Florida Department of Health. 2017. Your guide to eating fish caught in Florida. http://www.floridahealth.gov/programs-and-services/prevention/healthy-weight/nutrition/seafood-consumption/_documents/advisory-brochure.pdf. 41 pp.

Julian, Paul II, Binhe Gu, Garth Redfield and Ken Weaver, editors. 2016. South Florida environmental report: Volume I, Chapter 3B: Mercury and sulfur environmental assessment for the Everglades. South Florida Water Management District. http://apps.sfwmd.gov/sfwmd/SFER/2016_sfer_final/v1/chapters/v1_ch3b.pdf. 47 pp.

Kalla, P.I., M. Parsons, and J. Ackerman. 2017. Operating procedure for bottom water sampling for sulfide, SESDPROC-515-R0. USEPA Region 4, SESD, Athens, Georgia.

King, R.S., and C.J. Richardson. 2007. Subsidy-stress response of macroinvertebrate community biomass to a phosphorus gradient in an oligotrophic wetland ecosystem. *Journal of the North American Benthological Society* 26(3):491-508. doi: http://dx.doi.org/10.1899/06-002R.1

Liu, G., Y. Cai, P. Kalla, D. Scheidt, J. Richards, L. J. Scinto, E. Gaiser, and C. Appleby. 2008. Mercury Mass Budget Estimates and Cycling Seasonality in the Florida Everglades. *Environmental Science and Technology* 42:1954–1960.

Liu, G., Yong Cai, Yuxiang Mao, Daniel Scheidt, Peter Kalla, Jennifer Richards, Leonard Scinto, Georgio Tachiev, David Roelant and Charlie Appleby. 2009. Spatial Variability in Mercury Cycling and Relevant Biogeochemical Controls in the Florida Everglades. *Environmental Science and Technology* 43 (12):4361–4366. DOI: 10.1021/es803665c

Neto, Renato R., Ralph N. Mead, J. William Louda and Rudolf Jaffe. 2006. Organic biogeochemistry of detrital flocculent material (floc) in a subtropical, coastal wetland. *Biogeochemistry* 77:283-304.

Pisani, Olivia, Leonard J. Scinto, Jay W. Munyon and Rudolf Jaffé. 2015. The respiration of flocculent detrital organic matter (floc) is driven by phosphorus limitation and substrate quality in a subtropical wetland. *Geoderma* 241-2:272-282.

Pollman, C.D. 2012. Modeling sulfate and *gambusia* mercury relationships in the Everglades (Technical No. SP696). Florida Department of Environmental Protection, Tallahassee, FL.

Pollman, C. D. 2014. Mercury cycling in aquatic ecosystems and trophic-state related variables—implications from structural equation modeling. *Science of the Total Environment* 499:62–73.

Sargeant, Brooke L., Evelyn E. Gaiser, and Joel C. Trexler. 2011. Indirect and direct controls of macroinvertebrates and small fish by abiotic factors and trophic interactions in the Florida Everglades. *Journal of Freshwater Biology* DOI: 10.1111/j.1365-2427.2011.02663.x

Scheidt, D.J., and P.I. Kalla. 2007. Everglades ecosystem assessment: water management and quality, eutrophication, mercury contamination, soils, and habitat: monitoring for adaptive management: a REMAP status report. U.S. EPA Region 4, Athens, GA. EPA 904-R-07-001. https://www.epa.gov/everglades/everglades-ecosystem-assessment-water-management-and-quality-eutrophication-mercury. 98 pp.

South Florida Water Management District. 2016. South Florida environmental report: Highlights.
https://www.sfwmd.gov/sites/default/files/documents/2016_sfer_highlights.pdf

Stevens, D.L., Jr. and A.R. Olsen. 2004. Spatially-balanced sampling of natural resources. *Journal of the American Statistical Association* 99(465):262-278. DOI: 10.1198/016214504000000250

Stober, Q.J., K. Thornton, R. Jones, J. Richards, C. Ivey, R. Welch, M. Madden, J. Trexler, E. Gaiser, D. Scheidt, and S. Rathbun. 2001. South Florida ecosystem assessment: Phase I/II (technical report) – Everglades stressor interactions: Hydropatterns, eutrophication, habitat alteration, and mercury contamination. EPA 904-R-01-003.

USEPA. 1997. Mercury study report to Congress. Volume VI: an ecological assessment for anthropogenic mercury emissions in the United States. USEPA Office of Air Quality Planning & Standards and Office of Research and Development. EPA-452/R-97-008.

USEPA. 2015. National rivers and streams assessment 2013-14: Quality assurance project plan. EPA-841-B-12-007. U.S. Environmental Protection Agency, Office of Water, Washington, DC.

USEPA. 2014a. Everglades ecosystem assessment phase IV. Miami, Florida. September 23-29, 2013. SESD Project Identification Number: 13-0513. U. S. EPA Region 4, Athens, GA. 22 pp.

USEPA. 2014b. Everglades ecosystem assessment phase IV quality assurance project plan. U.S. EPA Region 4, Athens, GA. 135 pp.

Wang, Y., Gu, B., Lee, M. K., Jiang, S. J., Xu, Y. F. 2014. Isotopic evidence for anthropogenic impacts on aquatic food web dynamics and mercury cycling in a subtropical wetland ecosystem in the US. *Science of the Total Environment* 487: 557-564.

Zhang, Y, D.J. Jacob, H.M. Horowitz, L. Chen, H.M. Amos, D.P. Krabbenhoft, F. Slemr, V.L. St. Louis, and E. Sunderland. 2016. Observed decrease in atmospheric mercury explained by global decline in anthropogenic emissions. Proc. National Academy of Sciences 113(3):526-531. doi: 10.1073/pnas.1516312113.

Acknowledgements

Collaborative support makes this Program possible. Extramural funding for REMAP IV was provided by the South Florida Ecosystem Office of the National Park Service under Interagency Agreement # P13PG7. EPA funding was from the Region 4 Water Protection Division's South Florida Geographic Initiative and from the Office of Water. The Department of Interior and the Park provided helicopter operations support. Sampling permits or access permission were received from the Miccosukee Tribe of Indians of Florida, the Arthur R. Marshall Loxahatchee National Wildlife Refuge, and Everglades National Park.

The following individuals contributed significantly to REMAP IV 2014:

<u>Field Operations Base</u>
Don Fortson, Field Support Team Leader
Kevin Simmons, Sample Manager
Louie Pounds, Field Chemist
Nathan Mangle, Instrumentation Manager

<u>Samplers</u>
Jerry Ackerman*
Chris Decker*

Sue Dye*
Morris Flexner*
Hunter Johnson
Derek Little*
Jon McMahan*
Michael Roberts
John Ruiz*
Tim Simpson
Brian Striggow
Greg White*
(Note: Samplers with an asterisk were SESD Ecology Section members who also contributed to method development, sample booking, the QAPP, inventory and preparation of supplies, mapping, management of personal protective equipment, and data verification.)

<u>Base Support Personnel</u>
Lonnie Dorn
Cornell Gayle
Tara Houda
Eric Somerville

<u>Laboratory Quality Assurance Officers</u>
Ray Terhune, Jeff Hendel

<u>Field Quality Assurance Officers</u>
Landon Pruitt, Art Masters

<u>SESD Chemists</u>
Pam Betts
Tony Carroll
Yvette Lane-Walcott
Danny Adams

<u>SESD Quality Assurance Section</u>
Denise Goddard
Sandra Aker
John Thomason
Jeff Wilmoth

<u>EPA Region 4</u>
Jennifer Shadle
Robyn Polinsky

<u>HMC Helicopters, Inc.</u>
Gary Freeman, Carlos Luque, Jorge Gomes

ENP Aviation Support
Clayton Camblin, Andrew Gill, Gary Carnall

DOI Office of Aircraft Safety
Margaret Gallagher

FIU On-site Logistical Support
Len Scinto
Mark Kershaw
Jenny Richards
Daniel Gann

FIU Laboratories
Pedro Lorenzo
Ruth Justiniano
Guangliang Liu
Diana Johnson
Yong Cai

ENP Science and Administration
Heather Walker
Kim Gomez
Carol Mitchell
Donatto Surratt
Joffre Castro
PJ Walker
Nick Aumen

USFWS
Marcie Kapsch, Rebekah Gibble

Miccosukee Tribe of Indians of Florida
James Erskine

EPA ORD
Tony Olsen, Tom Kincaid

Alion, Inc. Data Reviewers
Sue Jones, Michael Keller

Statistics and Statistical Review
Ray Popovic, Nathan Barlet

APPENDIX

Spearman Rank Order Correlations for Variables from the 2014 Everglades REMAP Survey.

Notes:

See pages 25 – 28 for analyte, media, and laboratory codes.

Coefficients in red font are considered statistically significant. The 0.001 alpha level was selected for this matrix due to the large size of the matrix.

Coefficients in **bold** font are considered to be of environmental interest, as discussed in the text. Only coefficients with p-values less than 0.05 are bolded. Such coefficients for variables correlated with mercury in mosquitofish are also in blue font.

Trivial, weak, spurious, and auto-correlations are not excluded.

	THGFSFC	THGSWFC	MEHGSWFC	CHLAFCFB	THGFCFC	MEHGFCFC	THGSDFC
THGFSFC	1.000000						
THGSWFC	0.041713	1.000000					
MEHGSWFC	-0.094374	0.074471	1.000000				
CHLAFCFB	-0.165615	0.145357	-0.087765	1.000000			
THGFCFC	-0.107326	0.270337	0.061545	-0.005715	1.000000		
MEHGFCFC	0.229732	0.134497	0.060718	0.001237	0.224166	1.000000	
THGSDFC	-0.010123	0.378659	0.026337	0.307527	0.459078	-0.064447	1.000000
MEHGSDFC	0.082661	0.293900	0.101887	0.256155	0.109628	0.238180	0.396940
CHLAPBFB	**0.511723**	0.490553	0.132868	0.587879	0.205072	-0.022051	0.686245
THGPBFC	-0.003414	0.253065	-0.120247	0.516248	0.425430	0.426580	0.464187
MEHGPBFC	**0.369927**	0.074374	0.139466	0.532843	0.433551	0.498583	0.394571
CHLAPCFB	-0.010445	0.226637	-0.202569	0.370292	0.348022	0.131771	0.382174
THGPCFC	-0.019245	0.276116	-0.067924	0.311200	0.279618	0.068040	0.562154
MEHGPCFC	0.051430	0.303498	0.145187	0.118923	0.295002	0.297496	0.422728
FLOCTHAV	-0.083398	0.128502	0.152138	0.262420	0.154784	-0.138875	0.418647
PBTHAV	0.019998	-0.334473	-0.130005	-0.374662	-0.350745	-0.111005	-0.442481
PERICOV	-0.006747	-0.396927	-0.053525	-0.317562	-0.369594	-0.253686	-0.342448
PERIVOL	-0.043444	-0.272054	0.018537	-0.313093	-0.407955	-0.263319	-0.205080
THGSGAFC	-0.022740	-0.286348	0.009337	0.314212	0.190827	-0.180842	-0.288297
THGSGBFC	0.162074	0.115884	-0.067963	0.064083	-0.137677	-0.263500	0.151195
MEHGSGAFC	0.153757	0.543924	-0.182656	0.127913	0.155417	0.196434	0.507373
MEHGSGBFC	0.370763	0.444071	0.046206	-0.242769	0.018115	0.284746	0.425204
CLSWEA	0.178469	-0.121928	0.188235	-0.379002	-0.068728	-0.198216	-0.034571
SO4SWEA	0.148702	0.215014	**0.219239**	-0.102713	-0.008699	-0.104241	0.151068
DOCSWEA	0.193870	**0.200300**	**0.288334**	-0.250095	0.049533	-0.088122	0.272726
TOCSWEA	0.206557	**0.266243**	**0.232499**	-0.294212	0.107986	-0.097404	0.302415
TPSWFB	-0.136217	0.351162	0.080901	0.048048	0.154938	0.095580	0.132469
SRPSWFB	0.256595	0.040139	-0.198869	-0.352355	-0.018841	-0.102786	-0.055541
FNNSWFB	0.027409	-0.156459	0.078562	-0.080176	-0.089353	0.168376	-0.264798
FNO3SWFB	-0.122036	-0.277285	0.091500	0.042867	-0.022398	0.078204	-0.205562
FNO2SWFB	0.253729	0.332941	0.071316	0.128742	0.158522	0.099254	0.298335
FNH4SWFB	-0.102822	-0.159385	0.147185	-0.182366	-0.072014	-0.090190	-0.057770
TNSWFB	0.025410	0.057759	0.299712	-0.291986	0.054959	-0.168852	0.217382
CHLASWFB	-0.221231	0.373906	0.234278	0.237027	0.248767	0.217081	0.166232
H2SBWEE	-0.079946	0.193672	0.103859	0.380109	-0.035093	-0.162967	0.200953
pHFCFS	0.177456	-0.283662	-0.227226	-0.196038	-0.475315	-0.182779	-0.212526
H2OFCFS	-0.141399	0.181379	-0.142027	0.730689	0.089659	0.089383	0.357008
ASHFCFS	0.151988	-0.330354	0.042582	-0.526418	-0.446476	-0.307647	-0.437231
BDFCFS	0.089489	-0.167745	0.161633	-0.725594	-0.128681	-0.111689	-0.375077
TCFCFS	-0.149595	0.435258	-0.089933	0.469094	0.476217	0.227144	0.458468
TNFCFS	-0.247438	0.203174	-0.062983	0.571020	0.396458	0.218351	0.368508
TPFCFB	-0.341989	0.314090	0.123086	0.230704	0.595347	0.202736	0.214324
pHSDFS	-0.042343	-0.335882	-0.117885	-0.279575	-0.406911	-0.227682	-0.447332

	THGFSFC	THGSWFC	MEHGSWFC	CHLAFCFB	THGFCFC	MEHGFCFC	THGSDFC
H2OSDFS	0.014433	0.471112	0.033202	0.474336	0.315589	-0.014129	0.635782
ASHSDFS	0.020221	-0.450275	-0.053274	-0.463098	-0.408176	-0.044840	-0.688112
OMSDFS	-0.020221	0.450275	0.053274	0.463098	0.408176	0.044840	0.688112
BDSDFS	-0.042878	-0.478874	-0.048055	-0.471291	-0.267021	-0.074784	-0.607304
TCSDFS	0.062611	0.462201	-0.009108	0.371554	0.399661	0.049568	0.642196
TNSDFS	-0.041339	0.353619	-0.057205	0.548970	0.258784	-0.024987	0.747952
TPSDFB	0.009298	0.297436	0.089828	0.182493	0.203832	0.233547	0.463799
TCVGFS	0.165154	0.359845	-0.294705	0.045269	0.209730	0.256467	0.149938
TNVGFS	-0.029872	-0.109480	0.247750	0.141036	-0.299606	-0.127638	0.003740
TPVGFB	0.197419	0.079165	0.064801	0.171283	-0.047952	0.213864	0.058637
pHPBFS	-0.337840	-0.025286	0.080787	-0.656538	-0.316079	-0.473568	-0.062582
H2OPBFS	**0.434702**	0.490301	0.006654	0.871967	0.153253	0.082690	0.604532
ASHPBFS	**-0.548785**	-0.429711	-0.124387	-0.869305	-0.484581	-0.425110	-0.809370
BDPBFS	-0.342990	-0.364402	-0.077507	-0.887542	-0.203744	-0.031938	-0.629282
TCPBFS	**0.465837**	0.280639	0.092041	0.818558	0.698016	0.500005	0.713684
TNPBFS	**0.433271**	0.326988	0.028840	0.717329	0.614113	0.549063	0.706174
TPPBFB	0.283856	0.211665	-0.015647	0.437692	0.485683	0.568282	0.453958
pHPCFS	-0.007616	-0.019351	0.024992	-0.264942	-0.297360	-0.186240	-0.289646
H2OPCFS	-0.133062	0.199333	-0.096068	0.351528	0.266179	0.076540	0.455093
ASHPCFS	-0.046863	-0.223907	0.044733	-0.320823	-0.531996	-0.306139	-0.546380
BDPCFS	0.066886	-0.136631	0.109371	-0.415346	-0.265064	-0.021326	-0.419531
TCPCFS	0.090621	0.249255	-0.004858	0.240991	0.477409	0.285093	0.511876
TNPCFS	-0.035442	0.202306	-0.030206	0.332589	0.374895	0.138459	0.493994
TPPCFB	-0.006989	0.241946	-0.007742	0.458115	0.320490	0.164258	0.483639
TEMP	0.043794	-0.156172	-0.086767	-0.233305	-0.155615	-0.179582	-0.040273
COND	0.183100	-0.195744	0.175707	-0.382399	-0.079180	-0.241780	-0.048757
pH	0.136896	-0.331085	-0.105307	-0.440672	-0.306765	-0.242497	-0.281052
TURB	0.012739	0.057798	0.146517	0.190748	0.013294	0.136865	0.006645
DO	0.103216	-0.189288	-0.139290	-0.244250	-0.222888	-0.163821	-0.204261
ORP	0.051559	-0.018847	0.085508	-0.092907	0.164270	0.078941	-0.046671
WATDEPAV	0.094644	0.239223	0.017196	0.341647	0.112882	-0.304280	0.499603
SOILTHAV	0.042802	0.341920	0.154265	0.282252	0.315822	-0.178218	0.552458

	MEHGSDFC	CHLAPBFB	THGPBFC	MEHGPBFC	CHLAPCFB	THGPCFC	MEHGPCFC
THGFSFC							
THGSWFC							
MEHGSWFC							
CHLAFCFB							
THGFCFC							
MEHGFCFC							
THGSDFC							
MEHGSDFC	1.000000						
CHLAPBFB	0.418948	1.000000					
THGPBFC	0.505175	0.147644	1.000000				
MEHGPBFC	0.384459	0.349077	0.365605	1.000000			
CHLAPCFB	0.292778	0.410193	0.432405	0.204864	1.000000		
THGPCFC	0.413128	0.762129	0.326269	0.316273	0.658104	1.000000	
MEHGPCFC	0.452486	0.653970	0.293857	0.581130	0.447089	0.660195	1.000000
FLOCTHAV	0.191323	0.475168	0.246506	0.254600	0.371204	0.442940	0.374126
PBTHAV	-0.402206	-0.261133	-0.486098	-0.262506	-0.563857	-0.551329	-0.476321
PERICOV	-0.464962	-0.323469	-0.481869	-0.056869	-0.512937	-0.547975	-0.425825
PERIVOL	-0.392266	0.003574	-0.427908	-0.091168	-0.518769	-0.438571	-0.311029
THGSGAFC	-0.086365	-0.360375	0.100844	-0.050422	0.156854	-0.269248	-0.236819
THGSGBFC	-0.067411	0.563730	0.378165	0.285724	0.218366	0.017158	-0.286907
MEHGSGAFC	0.239731	0.860753	0.570342	0.859769	0.239724	0.537654	0.392315
MEHGSGBFC	0.280672	0.486506	0.368204	0.343099	-0.027668	-0.014512	-0.047870
CLSWEA	-0.120668	0.090099	-0.273385	0.164021	-0.289518	-0.180577	0.044382
SO4SWEA	0.047224	0.284076	0.028072	0.148546	-0.080182	0.061609	0.252057
DOCSWEA	0.147003	0.609780	0.054324	0.296356	0.114117	0.205694	0.382681
TOCSWEA	0.148053	0.604832	0.081092	0.287866	0.157724	0.229992	0.405779
TPSWFB	0.293010	-0.104009	0.143343	-0.153668	0.085951	0.232955	0.368627
SRPSWFB	0.053478	0.302522	-0.016494	0.084201	0.104344	0.065113	0.074785
FNNSWFB	-0.157348	-0.450690	-0.234061	-0.133377	-0.381268	-0.370654	-0.136384
FNO3SWFB	-0.150181	-0.534016	-0.257104	-0.173077	-0.334654	-0.261718	-0.145993
FNO2SWFB	0.143855	0.319496	0.147462	0.329076	0.204879	0.246939	0.399352
FNH4SWFB	-0.198148	0.295189	-0.294437	-0.077515	0.022480	0.014785	0.071660
TNSWFB	-0.017540	0.467491	0.049686	0.269362	0.061236	0.157253	0.326066
CHLASWFB	0.308244	0.274602	0.213691	-0.033547	0.169847	0.237032	0.391319
H2SBWEE	0.129651	0.249521	0.264629	0.105393	0.440618	0.385549	0.247708
pHFCFS	-0.340201	-0.121581	-0.230770	-0.648183	-0.351632	-0.475640	-0.339646
H2OFCFS	0.438294	0.603670	0.498474	0.590224	0.335006	0.363164	0.293618
ASHFCFS	-0.415482	-0.407297	-0.618405	-0.590910	-0.520769	-0.611779	-0.428027
BDFCFS	-0.428676	-0.565352	-0.525972	-0.568699	-0.336577	-0.362354	-0.249737
TCFCFS	0.340245	0.463423	0.607628	0.499385	0.521080	0.591719	0.408604
TNFCFS	0.298145	0.309091	0.579239	0.557196	0.517376	0.616257	0.385781
TPFCFB	0.345702	0.322190	0.481573	0.327798	0.347777	0.358285	0.297638
pHSDFS	-0.458286	-0.351428	-0.358631	-0.578538	-0.447009	-0.484998	-0.444018

	MEHGSDFC	CHLAPBFB	THGPBFC	MEHGPBFC	CHLAPCFB	THGPCFC	MEHGPCFC
H2OSDFS	0.523396	0.823417	0.407573	0.500081	0.492836	0.596804	0.454516
ASHSDFS	-0.470200	-0.771631	-0.487327	-0.431643	-0.582023	-0.635736	-0.515352
OMSDFS	0.470200	0.771631	0.487327	0.431643	0.582023	0.635736	0.515352
BDSDFS	-0.549173	-0.830962	-0.451122	-0.483153	-0.411446	-0.576778	-0.489088
TCSDFS	0.422679	0.773089	0.394454	0.423121	0.535817	0.585575	0.479879
TNSDFS	0.422759	0.689022	0.508037	0.422463	0.576269	0.663730	0.461749
TPSDFB	0.470656	0.575844	0.472335	0.324839	0.285106	0.427181	0.453838
TCVGFS	0.107692	-0.149244	0.502569	0.278903	0.095026	0.200816	0.001941
TNVGFS	-0.166377	-0.177901	-0.130326	0.152691	-0.363710	-0.161743	-0.060926
TPVGFB	0.205420	0.262122	0.060606	0.121292	-0.047205	0.151328	0.065168
pHPBFS	-0.306294	-0.103027	-0.429898	-0.513778	-0.054689	-0.168111	-0.257298
H2OPBFS	0.351048	0.782307	0.207849	0.419137	0.507202	0.744414	0.755526
ASHPBFS	-0.450081	-0.648128	-0.597738	-0.449616	-0.535051	-0.693928	-0.731798
BDPBFS	-0.311659	-0.764243	-0.240174	-0.276448	-0.456485	-0.712975	-0.703521
TCPBFS	0.442316	0.600351	0.674041	0.488598	0.519596	0.619682	0.762618
TNPBFS	0.511073	0.502425	0.785390	0.554512	0.579534	0.584036	0.741888
TPPBFB	0.376112	0.157464	0.899536	0.428211	0.571287	0.281327	0.416481
pHPCFS	-0.526725	-0.174753	-0.306061	-0.504901	-0.351189	-0.458453	-0.355667
H2OPCFS	0.357815	0.606187	0.321174	0.327274	0.774197	0.719691	0.497539
ASHPCFS	-0.572671	-0.637645	-0.543143	-0.457097	-0.709171	-0.782078	-0.595029
BDPCFS	-0.280691	-0.672474	-0.374713	-0.321004	-0.776947	-0.713473	-0.444158
TCPCFS	0.555017	0.756670	0.498742	0.529369	0.670051	0.769633	0.606068
TNPCFS	0.550064	0.672086	0.352229	0.627420	0.731801	0.833893	0.607638
TPPCFB	0.547150	0.696979	0.369989	0.460303	0.742446	0.823677	0.607683
TEMP	-0.284521	0.078344	0.073766	0.256855	-0.348027	-0.252435	-0.088822
COND	-0.131112	-0.054653	-0.396471	0.012992	-0.306047	-0.218240	0.005409
pH	-0.428671	-0.052432	-0.241654	-0.065100	-0.489655	-0.502940	-0.283485
TURB	0.064874	-0.206545	-0.188595	-0.036583	0.004863	0.101945	0.127149
DO	-0.299096	-0.176274	-0.096367	0.077500	-0.467435	-0.443023	-0.249199
ORP	-0.094096	-0.089473	-0.233085	-0.216381	-0.407664	-0.254255	-0.104990
WATDEPAV	0.170507	0.798849	0.298137	0.364969	0.434205	0.464700	0.231317
SOILTHAV	0.308485	0.779403	0.182360	0.402765	0.357749	0.381105	0.347584

	FLOCTHAV	PBTHAV	PERICOV	PERIVOL	THGSGAFC	THGSGBFC	MEHGSGAFC
THGFSFC							
THGSWFC							
MEHGSWFC							
CHLAFCFB							
THGFCFC							
MEHGFCFC							
THGSDFC							
MEHGSDFC							
CHLAPBFB							
THGPBFC							
MEHGPBFC							
CHLAPCFB							
THGPCFC							
MEHGPCFC							
FLOCTHAV	1.000000						
PBTHAV	-0.515382	1.000000					
PERICOV	-0.185943	0.582822	1.000000				
PERIVOL	0.031067	0.358318	0.798104	1.000000			
THGSGAFC	0.162214	0.097939	0.110688	0.095014	1.000000		
THGSGBFC	-0.114901	-0.242298	-0.305166	-0.188617	0.005046	1.000000	
MEHGSGAFC	0.310229	-0.148409	-0.335308	-0.304854	0.066084	0.140755	1.000000
MEHGSGBFC	-0.295874	-0.069872	-0.313988	-0.233039	-0.214122	0.277396	0.239541
CLSWEA	-0.155914	0.045488	0.248175	0.298342	-0.335474	-0.264067	-0.227232
SO4SWEA	-0.144836	-0.166158	-0.062160	0.003830	-0.478807	-0.109986	0.028189
DOCSWEA	0.151974	-0.300936	-0.009374	0.114326	-0.248125	-0.107761	0.043438
TOCSWEA	0.127526	-0.302975	-0.048475	0.077650	-0.216113	-0.059427	0.119183
TPSWFB	-0.036918	-0.395269	-0.408532	-0.328596	-0.306669	-0.210921	0.118099
SRPSWFB	-0.203693	0.071836	0.064227	0.039141	-0.465396	0.047355	-0.105561
FNNSWFB	-0.532789	0.423200	0.273122	0.150780	-0.208748	-0.073559	0.003680
FNO3SWFB	-0.381737	0.329483	0.212972	0.073376	-0.132486	-0.110584	-0.116726
FNO2SWFB	0.015966	-0.304586	-0.212459	-0.202715	-0.274270	0.021074	0.455193
FNH4SWFB	-0.020007	0.075500	0.272476	0.290504	-0.172303	-0.246366	-0.130121
TNSWFB	0.125977	-0.146799	0.129721	0.253543	-0.074006	-0.066514	0.042012
CHLASWFB	0.447489	-0.490790	-0.505183	-0.406013	0.024771	-0.240673	0.314322
H2SBWEE	0.396102	-0.520284	-0.179582	-0.063768	-0.084362	0.149018	0.163941
pHFCFS	-0.489400	0.530863	0.472839	0.457563	-0.444215	-0.027893	-0.342652
H2OFCFS	0.344140	-0.504556	-0.461512	-0.421631	0.309884	-0.096280	0.107551
ASHFCFS	-0.362086	0.466418	0.701322	0.687266	-0.356477	-0.087565	-0.512461
BDFCFS	-0.362055	0.501416	0.473599	0.445116	-0.337737	0.091252	-0.132432
TCFCFS	0.308271	-0.480680	-0.759380	-0.714317	0.269291	0.054894	0.480540
TNFCFS	0.399693	-0.521560	-0.457627	-0.435574	0.169783	-0.096574	0.354319
TPFCFB	0.084158	-0.459599	-0.671245	-0.687978	0.064666	-0.281428	-0.117678
pHSDFS	-0.461981	0.496460	0.495673	0.410538	0.018032	-0.305776	-0.359027

	FLOCTHAV	PBTHAV	PERICOV	PERIVOL	THGSGAFC	THGSGBFC	MEHGSGAFC
H2OSDFS	0.420446	-0.571476	-0.567978	-0.400928	0.076805	0.305535	0.462414
ASHSDFS	-0.483600	0.548181	0.577312	0.415892	-0.064526	-0.269725	-0.563940
OMSDFS	0.483600	-0.548181	-0.577312	-0.415892	0.064526	0.269725	0.563940
BDSDFS	-0.387971	0.539055	0.587011	0.411023	-0.041597	-0.197085	-0.489765
TCSDFS	0.496138	-0.520879	-0.520706	-0.352508	0.040557	0.278849	0.557245
TNSDFS	0.431097	-0.505374	-0.363929	-0.243549	0.102525	0.159296	0.620225
TPSDFB	0.050316	**-0.400848**	**-0.534491**	**-0.426328**	-0.324924	-0.018502	0.293623
TCVGFS	-0.016491	-0.245877	-0.303236	-0.226302	-0.105812	0.249958	0.344999
TNVGFS	0.254036	0.153129	0.207682	0.243558	0.093559	-0.166565	-0.048139
TPVGFB	0.195554	-0.331468	-0.379884	-0.295498	-0.149272	0.057495	0.107754
pHPBFS	-0.223799	0.118675	0.146467	0.202301	0.181818	0.064223	-0.396509
H2OPBFS	0.637823	-0.117195	-0.136889	0.130058	-0.055048	0.185185	0.971825
ASHPBFS	-0.540881	0.616993	0.520054	0.340676	0.576600	-0.254588	-0.804617
BDPBFS	-0.668361	0.253968	0.155753	-0.045387	0.155970	-0.194444	-0.743161
TCPBFS	0.460444	-0.577665	-0.445846	-0.339428	-0.162169	0.363696	0.767193
TNPBFS	0.396154	-0.642503	-0.456667	-0.352468	0.234244	0.418251	0.804617
TPPBFB	0.250754	-0.588705	-0.406123	-0.409526	0.252262	0.436436	0.580073
pHPCFS	-0.281985	0.368590	0.368835	0.405391	0.120053	0.093228	-0.407269
H2OPCFS	0.476015	-0.531669	-0.485404	-0.464310	-0.114041	0.022274	0.422430
ASHPCFS	-0.351310	0.580328	0.647196	0.613289	0.059341	0.058022	-0.420807
BDPCFS	-0.468425	0.561723	0.490949	0.456812	0.186453	-0.186010	-0.311190
TCPCFS	0.338603	-0.548431	-0.658633	-0.611769	-0.111454	-0.079295	0.455438
TNPCFS	0.391612	-0.538652	-0.539434	-0.543293	-0.057658	-0.003961	0.671256
TPPCFB	0.486697	-0.652254	-0.577003	-0.525128	-0.035683	-0.029956	0.489585
TEMP	-0.097431	0.304700	0.330520	0.281733	-0.047052	-0.005805	0.114890
COND	-0.160422	0.052034	0.240919	0.269956	-0.363789	-0.357983	-0.333386
pH	-0.426107	0.545497	0.620370	0.529261	-0.138121	0.053018	-0.300753
TURB	0.322350	-0.237820	-0.196749	-0.137140	0.106119	-0.102132	0.179763
DO	-0.321678	0.475671	0.438542	0.332519	0.061717	0.192179	0.096814
ORP	-0.226254	0.341848	0.015846	-0.097766	0.092270	-0.048274	-0.075675
WATDEPAV	0.459586	-0.460700	-0.270058	-0.069757	-0.095951	0.273644	0.305809
SOILTHAV	0.570239	-0.498927	-0.448392	-0.280361	0.190374	0.088465	0.400340

	MEHGSGBFC	CLSWEA	SO4SWEA	DOCSWEA	TOCSWEA	TPSWFB	SRPSWFB
THGFSFC							
THGSWFC							
MEHGSWFC							
CHLAFCFB							
THGFCFC							
MEHGFCFC							
THGSDFC							
MEHGSDFC							
CHLAPBFB							
THGPBFC							
MEHGPBFC							
CHLAPCFB							
THGPCFC							
MEHGPCFC							
FLOCTHAV							
PBTHAV							
PERICOV							
PERIVOL							
THGSGAFC							
THGSGBFC							
MEHGSGAFC							
MEHGSGBFC	1.000000						
CLSWEA	0.034235	1.000000					
SO4SWEA	0.233382	**0.734885**	1.000000				
DOCSWEA	0.212516	0.709599	0.655359	1.000000			
TOCSWEA	0.266841	0.698024	**0.661165**	0.973921	1.000000		
TPSWFB	0.424094	0.153527	**0.427089**	0.268571	0.296468	1.000000	
SRPSWFB	0.338213	0.183353	0.120794	0.180906	0.174090	-0.032600	1.000000
FNNSWFB	0.033629	0.290095	0.204865	0.018517	0.009487	-0.053015	0.042480
FNO3SWFB	-0.090478	0.138566	0.055196	-0.044015	-0.046766	-0.048101	-0.094245
FNO2SWFB	0.424671	0.277427	0.450595	0.561035	0.571748	0.363291	0.106460
FNH4SWFB	-0.382380	0.276083	0.043353	0.258517	0.232145	-0.068699	0.059307
TNSWFB	-0.036375	0.673231	0.508831	0.847124	0.830665	0.144698	0.013349
CHLASWFB	0.098273	-0.202304	-0.051066	0.056177	0.058788	0.386195	-0.125936
H2SBWEE	-0.233427	0.220126	**0.361904**	**0.377697**	0.377112	0.212118	-0.000806
pHFCFS	-0.007228	0.411912	0.345115	0.142361	0.141896	-0.110331	0.017935
H2OFCFS	-0.069412	-0.384232	-0.172907	-0.199296	-0.244803	0.108512	-0.236876
ASHFCFS	-0.093216	0.651776	0.413481	0.354968	0.362083	0.024494	0.153749
BDFCFS	0.011532	0.430208	0.226896	0.254082	0.301325	-0.058325	0.196488
TCFCFS	0.023810	-0.565015	-0.248247	-0.279199	-0.267295	0.094572	-0.096318
TNFCFS	-0.133369	-0.472908	-0.315058	-0.256284	-0.296713	0.048602	-0.148389
TPFCFB	-0.388315	-0.255590	0.003741	-0.127881	-0.133195	0.283681	-0.078930
pHSDFS	-0.225600	0.298418	0.182831	-0.108944	-0.100231	-0.128016	-0.135228

	MEHGSGBFC	CLSWEA	SO4SWEA	DOCSWEA	TOCSWEA	TPSWFB	SRPSWFB
H2OSDFS	0.401320	-0.173538	0.050153	0.248156	0.258455	0.206712	0.073388
ASHSDFS	-0.372459	0.271620	0.033237	-0.189277	-0.202379	-0.185319	-0.029620
OMSDFS	0.372459	-0.271620	-0.033237	0.189277	0.202379	0.185319	0.029620
BDSDFS	-0.439863	0.161176	-0.082130	-0.237762	-0.245933	-0.253057	-0.040433
TCSDFS	0.354444	-0.238265	0.014546	0.183567	0.194961	0.135307	0.146004
TNSDFS	0.301469	-0.203998	0.052934	0.202498	0.204056	0.200087	-0.022523
TPSDFB	0.630750	0.061553	0.382347	0.276824	0.285492	0.491425	-0.035542
TCVGFS	0.138855	-0.073062	0.114932	0.175248	0.187617	0.246488	0.133484
TNVGFS	-0.151158	-0.075610	-0.183096	-0.145527	-0.133775	-0.261060	-0.403952
TPVGFB	0.165184	-0.151538	0.188293	-0.058349	-0.085575	0.227537	0.041563
pHPBFS	0.045455	-0.060147	-0.154360	0.004912	0.049291	0.077514	-0.208750
H2OPBFS	0.165145	0.020878	0.220027	0.503637	0.508515	-0.370954	0.210156
ASHPBFS	-0.306319	-0.004123	-0.246574	-0.542552	-0.569275	-0.093593	-0.195354
BDPBFS	0.082572	0.000669	-0.293711	-0.517828	-0.517683	0.132806	-0.113140
TCPBFS	0.054056	-0.018693	0.222386	0.448509	0.467483	0.118636	0.133423
TNPBFS	0.108112	-0.079625	0.205732	0.387840	0.408238	0.097012	0.160043
TPPBFB	0.486506	-0.040562	0.130474	0.131785	0.150174	0.109972	0.067099
pHPCFS	0.036923	0.177740	0.059526	-0.054348	-0.063095	-0.174694	-0.298691
H2OPCFS	-0.244902	-0.234994	-0.103462	0.114962	0.112631	0.061118	0.097813
ASHPCFS	-0.158172	0.241434	-0.014030	-0.183271	-0.205728	-0.225311	-0.224407
BDPCFS	0.375398	0.229765	0.090234	-0.108754	-0.091902	-0.037157	-0.055988
TCPCFS	0.180538	-0.198353	0.059364	0.229639	0.253985	0.273759	0.264988
TNPCFS	0.032116	-0.255078	-0.051745	0.164847	0.187033	0.220972	0.176942
TPPCFB	-0.082783	-0.230168	-0.002208	0.200853	0.216968	0.313484	0.109368
TEMP	-0.007940	0.125801	0.016941	-0.067292	-0.071369	-0.183714	-0.186210
COND	0.015119	0.952331	0.710199	0.649657	0.638016	0.137017	0.215158
pH	-0.035431	0.413014	0.169180	0.047080	0.038899	-0.295119	0.109192
TURB	-0.233141	-0.254002	-0.312860	-0.149954	-0.184283	-0.034031	-0.136811
DO	0.092228	0.074931	-0.095479	-0.184079	-0.170920	-0.291702	-0.038744
ORP	0.395175	-0.185536	-0.263761	-0.213477	-0.198858	-0.093031	-0.113977
WATDEPAV	0.001222	0.128200	0.319265	0.347434	0.352823	0.047179	0.058532
SOILTHAV	0.131185	-0.091460	0.021880	0.242556	0.260599	0.092642	0.019511

	FNNSWFB	FNO3SWFB	FNO2SWFB	FNH4SWFB	TNSWFB	CHLASWFB	H2SBWEE
THGFSFC							
THGSWFC							
MEHGSWFC							
CHLAFCFB							
THGFCFC							
MEHGFCFC							
THGSDFC							
MEHGSDFC							
CHLAPBFB							
THGPBFC							
MEHGPBFC							
CHLAPCFB							
THGPCFC							
MEHGPCFC							
FLOCTHAV							
PBTHAV							
PERICOV							
PERIVOL							
THGSGAFC							
THGSGBFC							
MEHGSGAFC							
MEHGSGBFC							
CLSWEA							
SO4SWEA							
DOCSWEA							
TOCSWEA							
TPSWFB							
SRPSWFB							
FNNSWFB	1.000000						
FNO3SWFB	0.635676	1.000000					
FNO2SWFB	0.218738	0.022416	1.000000				
FNH4SWFB	0.347135	0.170415	0.145626	1.000000			
TNSWFB	0.128351	0.075722	0.438126	0.398744	1.000000		
CHLASWFB	-0.249189	-0.268590	0.126445	0.008500	-0.028932	1.000000	
H2SBWEE	-0.210327	-0.166022	0.229739	0.026324	0.256204	0.167861	1.000000
pHFCFS	0.127242	-0.025621	-0.157515	0.065229	0.088699	-0.491994	-0.078928
H2OFCFS	-0.184299	-0.043163	0.180122	-0.179313	-0.283923	0.332846	0.316736
ASHFCFS	0.179215	0.038995	-0.184769	0.372752	0.427242	-0.404555	-0.061389
BDFCFS	0.213932	0.070140	-0.137992	0.255177	0.342399	-0.345797	-0.316619
TCFCFS	-0.088024	-0.016856	0.310272	-0.372154	-0.368881	0.364523	0.059671
TNFCFS	-0.194381	0.010727	0.148133	-0.184693	-0.238184	0.288146	0.264661
TPFCFB	-0.004620	-0.043102	0.169301	-0.177163	-0.285041	0.415520	0.149470
pHSDFS	0.306094	0.153846	-0.294353	0.216311	-0.015071	-0.409882	-0.149540

	FNNSWFB	FNO3SWFB	FNO2SWFB	FNH4SWFB	TNSWFB	CHLASWFB	H2SBWEE
H2OSDFS	-0.326862	-0.287758	0.422162	-0.187421	0.072191	0.331620	0.338852
ASHSDFS	0.317283	0.191972	-0.410084	0.163782	-0.049989	-0.356440	-0.259946
OMSDFS	-0.317283	-0.191972	0.410084	-0.163782	0.049989	0.356440	0.259946
BDSDFS	0.316510	0.303792	-0.423497	0.213076	-0.041885	-0.365583	-0.291869
TCSDFS	-0.346187	-0.242179	0.405177	-0.206375	0.023659	0.328895	0.255242
TNSDFS	-0.352035	-0.171608	0.349448	-0.117175	0.122765	0.176546	0.272671
TPSDFB	-0.105723	-0.082807	0.354317	-0.204179	0.067051	0.234759	0.114472
TCVGFS	-0.198828	-0.028780	0.212164	-0.175158	0.031685	0.071200	0.168819
TNVGFS	-0.019171	0.147948	-0.051288	-0.021201	0.055759	0.057526	-0.173054
TPVGFB	-0.139913	-0.151195	0.164543	-0.253063	-0.296262	0.195679	-0.053795
pHPBFS	0.010798	0.038530	-0.464957	0.232806	-0.060350	-0.151806	0.058239
H2OPBFS	-0.454364	-0.506978	0.258978	0.083156	0.406251	0.066473	0.252542
ASHPBFS	0.423544	0.479612	-0.397388	-0.109585	-0.423861	-0.330732	-0.262824
BDPBFS	0.546144	0.592151	-0.288189	-0.094578	-0.432219	-0.278764	-0.214341
TCPBFS	-0.355861	-0.406563	0.385488	0.097621	0.387943	0.215840	0.246871
TNPBFS	-0.384084	-0.430372	0.308303	0.023477	0.355519	0.228546	0.261540
TPPBFB	-0.235438	-0.262144	0.232694	-0.191354	0.163306	0.183765	0.191623
pHPCFS	0.123383	0.116680	-0.219451	0.118705	0.045061	-0.188762	0.027351
H2OPCFS	-0.398355	-0.317984	0.057991	0.144262	0.127863	0.355442	0.448458
ASHPCFS	0.373437	0.282899	-0.266901	0.152765	-0.088826	-0.251450	-0.287374
BDPCFS	0.379598	0.331157	-0.080464	-0.169331	-0.111540	-0.309646	-0.464728
TCPCFS	-0.331300	-0.261717	0.346283	-0.144486	0.089754	0.250469	0.212237
TNPCFS	-0.339218	-0.276551	0.273509	-0.003574	0.115005	0.234633	0.267502
TPPCFB	-0.405260	-0.353218	0.277886	-0.056489	0.090444	0.344073	0.368645
TEMP	0.041602	0.075732	-0.106753	-0.063195	0.128688	-0.223228	-0.226635
COND	0.291734	0.130864	0.228431	0.299875	0.572381	-0.213876	0.203433
pH	0.340591	0.210629	-0.189683	0.185561	0.175619	-0.509709	-0.249575
TURB	-0.170790	-0.107627	-0.078528	0.087666	-0.165282	0.362836	0.090796
DO	0.190816	0.195328	-0.225292	-0.123097	-0.023985	-0.299827	-0.293259
ORP	0.137386	0.074657	-0.054752	-0.222368	-0.153109	0.025905	**-0.604955**
WATDEPAV	-0.280650	-0.203638	0.319941	-0.058935	0.244805	0.080165	**0.546028**
SOILTHAV	-0.337266	-0.264626	0.404872	-0.150228	0.158986	0.337643	0.255233

	pHFCFS	H2OFCFS	ASHFCFS	BDFCFS	TCFCFS	TNFCFS	TPFCFB	pHSDFS
THGFSFC								
THGSWFC								
MEHGSWFC								
CHLAFCFB								
THGFCFC								
MEHGFCFC								
THGSDFC								
MEHGSDFC								
CHLAPBFB								
THGPBFC								
MEHGPBFC								
CHLAPCFB								
THGPCFC								
MEHGPCFC								
FLOCTHAV								
PBTHAV								
PERICOV								
PERIVOL								
THGSGAFC								
THGSGBFC								
MEHGSGAFC								
MEHGSGBFC								
CLSWEA								
SO4SWEA								
DOCSWEA								
TOCSWEA								
TPSWFB								
SRPSWFB								
FNNSWFB								
FNO3SWFB								
FNO2SWFB								
FNH4SWFB								
TNSWFB								
CHLASWFB								
H2SBWEE								
pHFCFS	1.000000							
H2OFCFS	-0.365866	1.000000						
ASHFCFS	0.650601	-0.699341	1.000000					
BDFCFS	0.383122	-0.970228	0.717492	1.000000				
TCFCFS	-0.608455	0.585557	-0.913081	-0.593050	1.000000			
TNFCFS	-0.601228	0.730606	-0.796422	-0.754037	0.723464	1.000000		
TPFCFB	-0.382090	0.405296	-0.553320	-0.391976	0.588696	0.445668	1.000000	
pHSDFS	0.788060	-0.520774	0.837214	0.546570	-0.780867	-0.647955	-0.478916	1.000000

	pHFCFS	H2OFCFS	ASHFCFS	BDFCFS	TCFCFS	TNFCFS	TPFCFB	pHSDFS
H2OSDFS	-0.514078	0.607376	-0.770291	-0.618715	0.761748	0.484587	0.461427	-0.662914
ASHSDFS	0.542881	-0.583931	0.808869	0.574256	-0.793690	-0.552471	-0.407438	0.734561
OMSDFS	-0.542881	0.583931	-0.808869	-0.574256	0.793690	0.552471	0.407438	-0.734561
BDSDFS	0.461928	-0.579421	0.741959	0.585465	-0.757217	-0.461786	-0.427927	0.634742
TCSDFS	-0.544178	0.477036	-0.787476	-0.519331	0.799862	0.525473	0.361250	-0.731512
TNSDFS	-0.448969	0.604728	-0.646098	-0.625273	0.590291	0.650802	0.132337	-0.568044
TPSDFB	0.038690	0.308436	-0.342440	-0.266667	0.383389	0.155161	0.553022	-0.286167
TCVGFS	-0.207977	0.077464	-0.203729	-0.129824	0.248259	0.269240	0.148331	-0.287624
TNVGFS	-0.168636	0.198959	-0.017741	-0.146315	-0.016558	0.104579	-0.210446	0.070954
TPVGFB	-0.275936	0.179716	-0.206982	-0.194317	0.254774	0.072073	0.178801	-0.149376
pHPBFS	0.734756	-0.639147	0.789634	0.670732	-0.715600	-0.844989	-0.640244	0.766980
H2OPBFS	-0.645263	0.877301	-0.703367	-0.856273	0.736196	0.640256	0.385323	-0.416019
ASHPBFS	0.823171	-0.856273	0.835366	0.865854	-0.819576	-0.826752	-0.567073	0.403190
BDPBFS	0.503049	-0.886854	0.689024	0.868902	-0.776762	-0.601826	-0.429878	0.366502
TCPBFS	-0.487691	0.798796	-0.978470	-0.814877	0.931929	0.972423	0.858090	-0.379426
TNPBFS	-0.487805	0.706425	-0.893293	-0.731707	0.807343	0.930095	0.713415	-0.361350
TPPBFB	-0.454268	0.418962	-0.625000	-0.457317	0.495415	0.699091	0.445122	-0.407329
pHPCFS	0.787875	-0.354873	0.609161	0.375380	-0.618476	-0.559427	-0.455302	0.757253
H2OPCFS	-0.546616	0.373487	-0.594610	-0.349317	0.490180	0.582359	0.374879	-0.510144
ASHPCFS	0.644620	-0.488294	0.865779	0.523404	-0.767489	-0.785949	-0.663743	0.675519
BDPCFS	0.475117	-0.372862	0.540005	0.371591	-0.447686	-0.573075	-0.396272	0.443480
TCPCFS	-0.624780	0.397239	-0.806370	-0.430762	0.731305	0.715201	0.594066	-0.640654
TNPCFS	-0.760934	0.388409	-0.733949	-0.379538	0.658492	0.716748	0.496461	-0.614739
TPPCFB	-0.717311	0.510258	-0.737336	-0.519689	0.630944	0.705558	0.469389	-0.598009
TEMP	0.361366	-0.318310	0.428280	0.278670	-0.409765	-0.268028	-0.419283	0.359591
COND	0.437107	-0.387793	0.679973	0.437454	-0.576931	-0.509289	-0.229841	0.344735
pH	0.654048	-0.558525	0.787594	0.571944	-0.768107	-0.615158	-0.600048	0.644332
TURB	-0.479788	0.247946	-0.308034	-0.263714	0.204559	0.267439	0.131834	-0.327617
DO	0.401967	-0.339656	0.436632	0.301696	-0.466890	-0.328086	-0.473755	0.408620
ORP	-0.101159	0.002882	-0.178486	-0.039342	0.194673	0.075102	0.101075	0.048022
WATDEPAV	-0.101816	0.302553	-0.295439	-0.318825	0.302101	0.272471	0.140777	-0.293047
SOILTHAV	-0.603158	0.256499	-0.589565	-0.301535	0.617167	0.338902	0.232734	-0.607042

	H2OSDFS	ASHSDFS	OMSDFS	BDSDFS	TCSDFS	TNSDFS	TPSDFB	TCVGFS
H2OSDFS	1.000000							
ASHSDFS	-0.883922	1.00000						
OMSDFS	0.883922	-1.00000	1.00000					
BDSDFS	-0.958789	0.83082	-0.83082	1.000000				
TCSDFS	0.840829	-0.91805	0.91805	-0.795805	1.000000			
TNSDFS	0.726816	-0.82264	0.82264	-0.671222	0.805213	1.000000		
TPSDFB	0.495397	-0.50347	0.50347	-0.521047	0.453685	0.456066	1.000000	
TCVGFS	0.241219	-0.27000	0.27000	-0.320295	0.381202	0.225922	0.154684	1.000000
TNVGFS	-0.123581	0.10299	-0.10299	0.123268	-0.196110	-0.094664	-0.249408	-0.379718
TPVGFB	0.179177	-0.08996	0.08996	-0.181462	0.118241	0.038649	0.330210	-0.049717
pHPBFS	-0.396585	0.18065	-0.18065	0.371757	-0.271108	-0.228306	-0.112828	-0.208578
H2OPBFS	0.824846	-0.70272	0.70272	-0.804189	0.832253	0.662618	0.437956	0.067554
ASHPBFS	-0.679301	0.83909	-0.83909	0.762924	-0.599419	-0.852769	-0.638780	-0.040608
BDPBFS	-0.768180	0.73284	-0.73284	0.804183	-0.808661	-0.717969	-0.500202	-0.124340
TCPBFS	0.650871	-0.73213	0.73213	-0.735889	0.571443	0.766113	0.620946	0.211182
TNPBFS	0.612724	-0.72951	0.72951	-0.709003	0.554951	0.777328	0.625379	0.332873
TPPBFB	0.389125	-0.46859	0.46859	-0.461531	0.308539	0.545473	0.407396	0.356244
pHPCFS	-0.446527	0.47294	-0.47294	0.449641	-0.465301	-0.401670	-0.246209	-0.185235
H2OPCFS	0.495894	-0.55329	0.55329	-0.433470	0.465774	0.548471	0.263885	0.182310
ASHPCFS	-0.617561	0.70466	-0.70466	0.581588	-0.653195	-0.657039	-0.501726	-0.185379
BDPCFS	-0.496235	0.53404	-0.53404	0.425137	-0.450207	-0.535577	-0.265587	-0.171881
TCPCFS	0.598140	-0.69322	0.69322	-0.555609	0.641874	0.635751	0.499176	0.093016
TNPCFS	0.600460	-0.65504	0.65504	-0.551746	0.587567	0.673207	0.417565	0.068481
TPPCFB	0.619037	-0.67672	0.67672	-0.561554	0.612826	0.686295	0.468963	0.045994
TEMP	-0.344679	0.32793	-0.32793	0.336636	-0.307413	-0.117755	-0.191848	-0.006333
COND	-0.198894	0.30447	-0.30447	0.180068	-0.265467	-0.246965	0.067140	-0.158657
pH	-0.599743	0.62402	-0.62402	0.575700	-0.567864	-0.417326	-0.359458	-0.137539
TURB	0.174783	-0.22748	0.22748	-0.150309	0.177564	0.104623	-0.078863	-0.042057
DO	-0.468121	0.46673	-0.46673	0.443559	-0.434012	-0.307406	-0.355715	-0.028275
ORP	-0.160594	0.11400	-0.11400	0.105585	-0.138555	-0.178448	-0.038448	-0.186241
WATDEPAV	0.548342	-0.57408	0.57408	-0.473240	0.597780	0.575720	0.229019	0.212737
SOILTHAV	0.714353	-0.73556	0.73556	-0.678998	0.748314	0.559368	0.286492	0.119785

	TNVGFS	TPVGFB	pHPBFS	H2OPBFS	ASHPBFS	BDPBFS	TCPBFS	TNPBFS
H2OSDFS								
ASHSDFS								
OMSDFS								
BDSDFS								
TCSDFS								
TNSDFS								
TPSDFB								
TCVGFS								
TNVGFS	1.000000							
TPVGFB	0.098153	1.000000						
pHPBFS	-0.082809	-0.454140	1.000000					
H2OPBFS	-0.257221	0.153291	-0.212076	1.000000				
ASHPBFS	-0.089110	-0.437053	0.308329	-0.590896	1.000000			
BDPBFS	0.141177	-0.444847	0.208224	-0.861612	0.646084	1.000000		
TCPBFS	-0.077687	0.342058	-0.348848	0.544496	-0.897280	-0.641063	1.000000	
TNPBFS	0.051260	0.346814	-0.393211	0.489674	-0.880041	-0.565837	0.940842	1.000000
TPPBFB	0.163818	0.275182	-0.505199	0.228225	-0.681277	-0.264578	0.709975	0.835169
pHPCFS	0.186189	-0.538611	0.799703	-0.200944	0.252788	0.087323	-0.271782	-0.288299
H2OPCFS	-0.191901	0.166609	-0.223361	0.682492	-0.674736	-0.655196	0.582079	0.644487
ASHPCFS	0.284415	-0.198571	0.260267	-0.662947	0.672115	0.683690	-0.793541	-0.821898
BDPCFS	0.261893	-0.219160	0.273182	-0.732669	0.712869	0.715818	-0.691059	-0.724494
TCPCFS	-0.209292	0.349252	-0.370521	0.817227	-0.899078	-0.763139	0.866922	0.853054
TNPCFS	-0.140267	0.264725	-0.294624	0.735190	-0.787691	-0.686324	0.798744	0.801363
TPPCFB	-0.144749	0.354545	-0.313012	0.772253	-0.810965	-0.755401	0.718225	0.721588
TEMP	0.270103	-0.241018	-0.202782	0.085676	-0.214453	-0.116113	0.249640	0.267440
COND	-0.074504	-0.125419	-0.023044	-0.213681	0.040650	0.186023	-0.117129	-0.176772
pH	0.023809	-0.324590	0.123135	0.067069	0.169860	0.032438	-0.163909	-0.112474
TURB	0.008825	-0.052535	0.117063	-0.381431	0.250704	0.234076	-0.237420	-0.346908
DO	0.222129	-0.414292	-0.010907	-0.155958	0.189066	0.229775	-0.209152	-0.129931
ORP	0.289938	-0.023605	0.179855	-0.210398	0.253869	0.154892	-0.329051	-0.337865
WATDEPAV	-0.042008	0.096098	-0.140431	0.824537	-0.633799	-0.775023	0.611661	0.571197
SOILTHAV	0.127064	0.268907	-0.269370	0.706533	-0.574730	-0.670067	0.553918	0.477682

	TPPBFB	pHPCFS	H2OPCFS	ASHPCFS	BDPCFS	TCPCFS	TNPCFS	TPPCFB
H2OSDFS								
ASHSDFS								
OMSDFS								
BDSDFS								
TCSDFS								
TNSDFS								
TPSDFB								
TCVGFS								
TNVGFS								
TPVGFB								
pHPBFS								
H2OPBFS								
ASHPBFS								
BDPBFS								
TCPBFS								
TNPBFS								
TPPBFB	1.000000							
pHPCFS	-0.452699	1.000000						
H2OPCFS	0.573859	-0.422298	1.000000					
ASHPCFS	-0.610245	0.600460	-0.711899	1.000000				
BDPCFS	-0.602940	0.416686	-0.943792	0.676439	1.000000			
TCPCFS	0.632503	-0.615999	0.670206	-0.957326	-0.641916	1.000000		
TNPCFS	0.515346	-0.623204	0.779220	-0.905016	-0.746952	0.909361	1.000000	
TPPCFB	0.552802	-0.634182	0.748864	-0.851962	-0.769610	0.860586	0.912075	1.000000
TEMP	0.217348	0.442323	-0.273831	0.378086	0.275686	-0.390782	-0.345618	-0.419323
COND	-0.130193	0.156047	-0.264702	0.274310	0.245925	-0.235143	-0.297980	-0.254192
pH	-0.152484	0.614715	-0.453621	0.662487	0.452003	-0.675358	-0.645896	-0.698709
TURB	-0.454450	-0.014140	0.132614	-0.021056	-0.142813	-0.007342	0.077215	0.117272
DO	-0.068367	0.564236	-0.432732	0.550775	0.463488	-0.602903	-0.556394	-0.631170
ORP	-0.285937	0.153310	-0.430263	0.143695	0.431367	-0.095207	-0.217697	-0.285608
WATDEPAV	0.322917	-0.177758	0.460358	-0.439070	-0.529879	0.417836	0.415291	0.476935
SOILTHAV	0.129276	-0.385430	0.379013	-0.481989	-0.371807	0.517824	0.484325	0.473872

	TEMP	COND	pH	TURB	DO	ORP	WATDEPAV	SOILTHAV
H2OSDFS								
ASHSDFS								
OMSDFS								
BDSDFS								
TCSDFS								
TNSDFS								
TPSDFB								
TCVGFS								
TNVGFS								
TPVGFB								
pHPBFS								
H2OPBFS								
ASHPBFS								
BDPBFS								
TCPBFS								
TNPBFS								
TPPBFB								
pHPCFS								
H2OPCFS								
ASHPCFS								
BDPCFS								
TCPCFS								
TNPCFS								
TPPCFB								
TEMP	1.000000							
COND	0.065171	1.000000						
pH	0.653927	0.403074	1.000000					
TURB	-0.169703	-0.242450	-0.350068	1.000000				
DO	0.799474	0.035334	0.765344	-0.197141	1.000000			
ORP	0.122894	-0.196519	0.051344	-0.045979	0.274479	1.000000		
WATDEPAV	-0.066067	0.085949	-0.207535	-0.000605	-0.265777	-0.428876	1.000000	
SOILTHAV	-0.248882	-0.120626	-0.511665	0.240057	-0.388811	-0.042487	0.544976	1.000000

END OF REPORT