Appendix 3-1: Annual Permit Report for the Everglades Stormwater Treatment Areas

Permit Report (May 1, 2010–April 30, 2011)

Guy Germain

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SUMMARY

As part of Everglades restoration, the construction and operation of six large freshwater treatment wetlands are mandated by the Everglades Forever Act (EFA) (Chapter 373.4592, Florida Statutes). These wetlands, known as the Everglades Stormwater Treatment Areas (STAs), have been constructed as part of the Everglades water quality restoration efforts (www.sfwmd.gov/sta). At present, approximately 52,000 acres of land south of Lake Okeechobee have been converted to STAs, yielding approximately 45,000 acres of effective treatment wetlands. Another approximately 12,000 acres of treatment wetlands are under construction and are scheduled to be fully operational in July 2012. The cumulative total area of the STAs, including infrastructure components, is around 65,000 acres. The STAs have been constructed south of Lake Okeechobee to remove excess total phosphorus (TP) from surface waters prior to entering the Everglades Protection Area (EPA) (**Figure 1**).

The six STAs [STA-1 East (STA-1E), STA-1 West (STA-1W), STA-2, STA-3/4, STA-5, and STA-6] (**Figure 2**) operate pursuant to EFA and National Pollutant Discharge Elimination System (NPDES) permits and their associated Administrative Orders (AOs). This appendix serves as the reporting mechanism for requirements contained within those permits and AOs related to the STAs during Water Year 2011 (WY2011) (May 1, 2010–April 30, 2011). The detailed annual report for the Everglades STAs is presented in Volume I, Chapter 5 and this appendix to Volume III. Based on Florida Department of Environmental Protection (FDEP) permit reporting guidelines, **Tables 1** through **6** list key permit-related information associated with this report for the six STAs. **Table 7** lists the attachments included with this report. In Attachment A, Tables A-1 through A-4 list the specific pages, tables, graphs, and attachments where project status and annual reporting requirements are addressed in Volumes I and III for the permit-specific conditions of each STA.

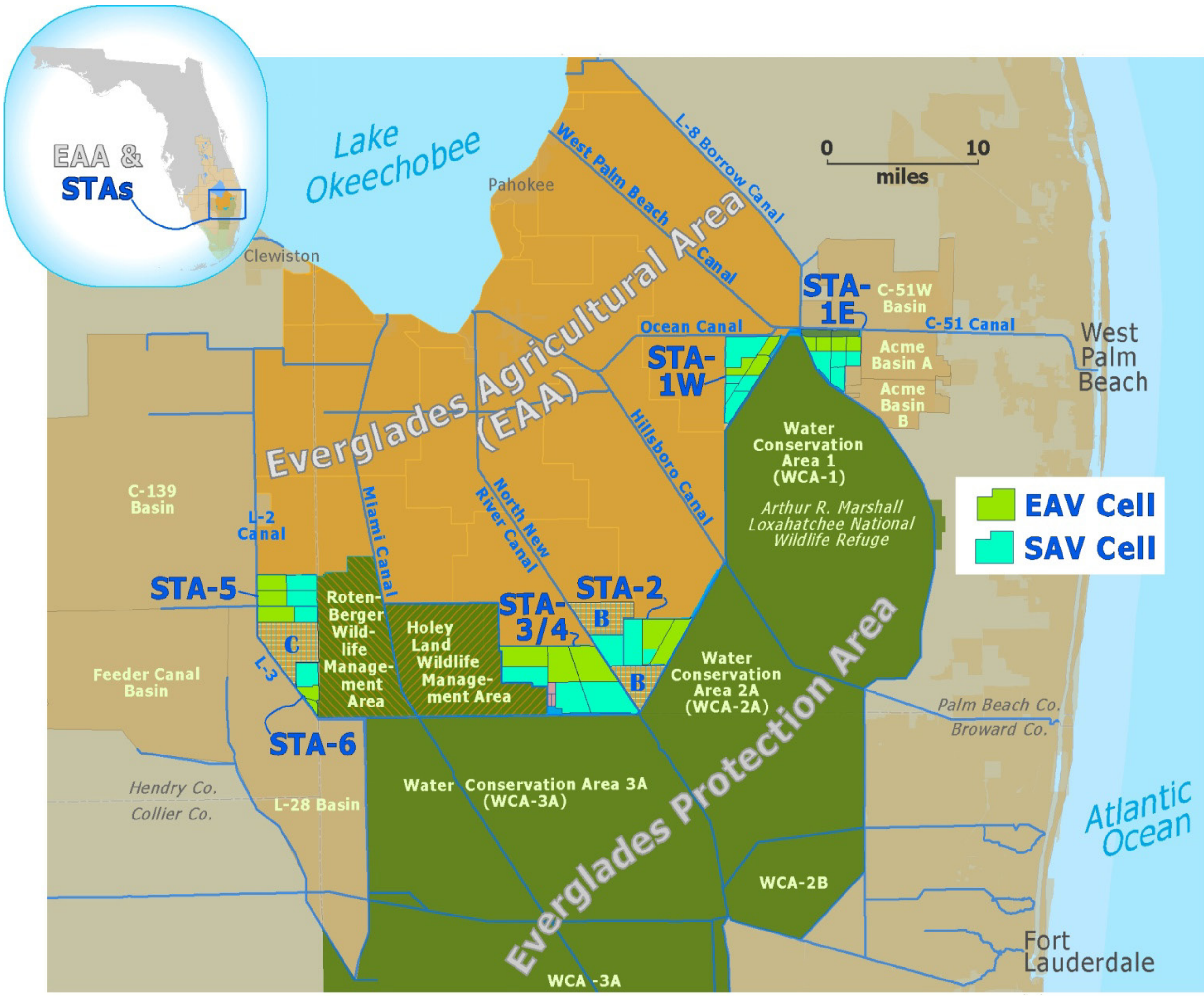

Figure 1. Location of the six Everglades Stormwater Treatment Areas (STAs) and the dominant vegetation community for each STA treatment cell [i.e., emergent aquatic vegetation (EAV) or submerged aquatic vegetation (SAV)]. [Note: STA-1E – STA-1 East; STA-1W – STA-1 West]

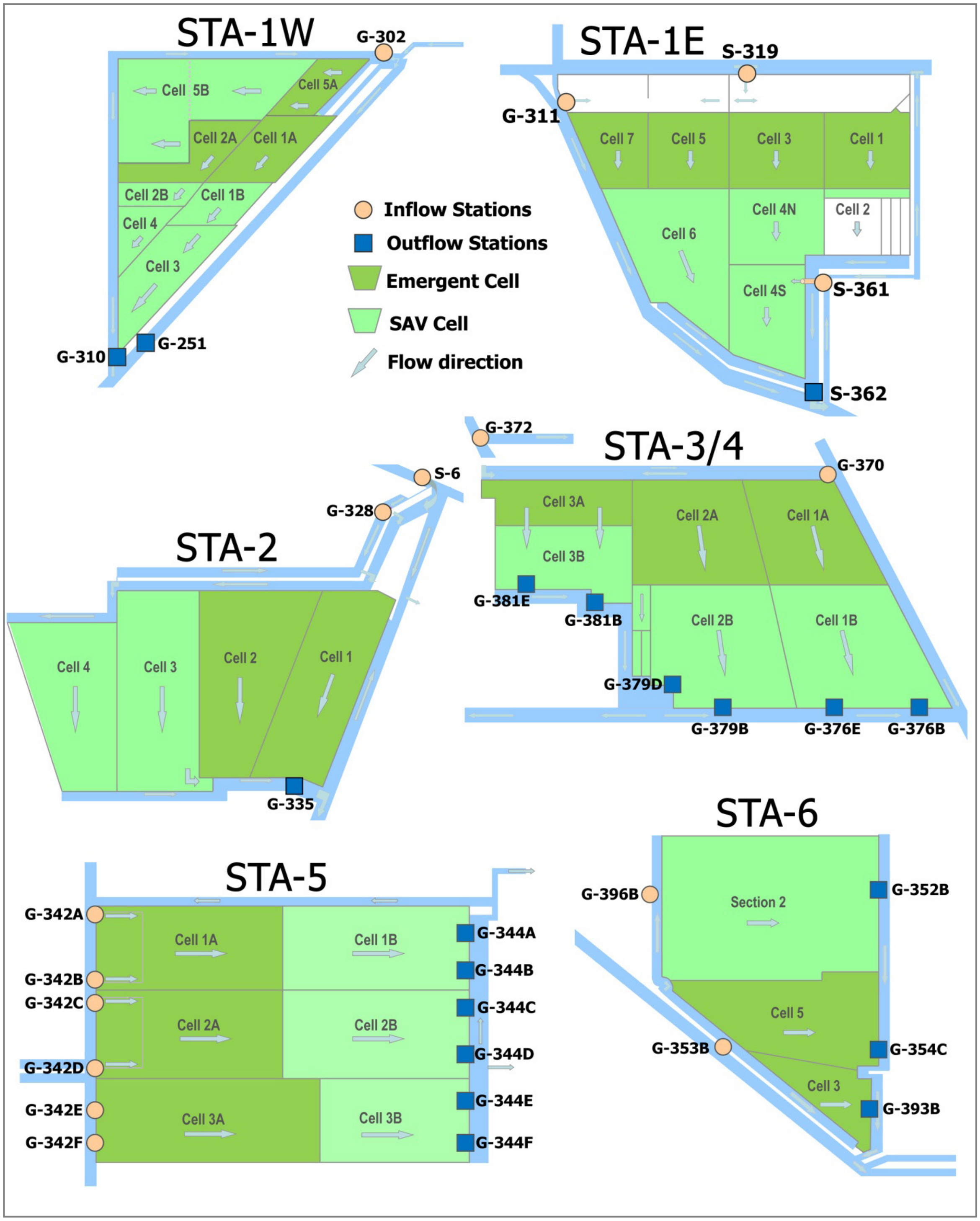

Figure 2. STA schematics showing configurations of the treatment cells, flow direction, dominant vegetation type, and locations of permitted inflow and outflow stations.

Table 1. Key permit-related information for Stormwater Treatment Area (STA) 1 East (STA-1E). [Note: EFA – Everglades Forever Act; NPDES – National Pollution Discharge Elimination System.]

Project Name	STA-1E
Permit Numbers	0279449 (EFA) FL0304549 (NPDES) Administrative Order-009 (NPDES)
Issue and Expiration Date	Issue: November 16, 2007 Expiration: November 15, 2012 (EFA) Issue: August 30, 2005 Expiration: August 30, 2010 (NPDES); NPDES permit is administratively extended
Project Phase	Stabilization
Permit Condition Requiring Annual Monitoring Report	Specific Condition 30 A-E
Relevant Period of Record	May 1, 2010–April 30, 2011
Report Generator	Guy Germain ggermain@sfwmd.gov 561-682-6732
Permit Coordinator	Holly Andreotta handreot@sfwmd.gov 561-242-5520 x3726

Table 2. Key permit-related information for STA-1 West (STA-1W).

Project Name	STA-1W
Permit Numbers	0279499 (EFA) FL0177962 (NPDES) Administrative Order-001(NPDES)
Issue and Expiration Date	Issue: November 16, 2007 Expiration: November 15, 2012 (EFA) Issue: May 11, 1999 Expiration: May 10, 2004 (NPDES); NPDES permit is administratively extended
Project Phase	Stabilization
Permit Condition Requiring Annual Monitoring Report	Specific Condition 30 A-E
Relevant Period of Record	May 1, 2010–April 30, 2011
Report Generator	Guy Germain ggermain@sfwmd.gov 561-682-6732
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Table 3. Key permit-related information for STA-2.

Project Name	STA-2
Permit Numbers	0126704 (EFA) FL0177946 (NPDES) Administrative Order-010 (EFA & NPDES)
Issue and Expiration Date	Issue: March 17, 2009 Expiration: March 17, 2014 (EFA) Issue: September 4, 2007 Expiration: September 4, 2012 (NPDES)
Project Phase	Stabilization
Permit Condition Requiring Annual Monitoring Report	Specific Condition 28 A-E
Relevant Period of Record	May 1, 2010–April 30, 2011
Report Generator	Guy Germain ggermain@sfwmd.gov 561-682-6732
Permit Coordinator	Holly Andreotta handreot@sfwmd.gov 561-242-5520 x3726

Table 4. Key permit-related information for STA-3/4.

Project Name	STA-3/4
Permit Numbers	0192895 (EFA) Administrative Order-008 (EFA) FL0300195 (NPDES) Administrative Order-007 (NPDES)
Issue and Expiration Date	Issue: January 9, 2004 Expiration: January 9, 2009 (EFA) Issue: January 9, 2004 Expiration: January 9, 2009 (NPDES); NPDES permit is administratively extended
Project Phase	Post-stabilization
Permit Condition Requiring Annual Monitoring Report	Specific Condition 30 A-F
Relevant Period of Record	May 1, 2010–April 30, 2011
Report Generator	Guy Germain ggermain@sfwmd.gov 561-682-6732
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Table 5. Key permit-related information for STA-5.

Project Name	STA-5
Permit Numbers	0131842 (EFA) FL0177954 (NPDES) Administrative Order-011 (EFA & NPDES)
Issue and Expiration Date	Issue: January 29, 2009 Expiration: January 29, 2014 (EFA) Issue: September 4, 2007 Expiration: September 4, 2012 (NPDES)
Project Phase	Stabilization
Permit Condition Requiring Annual Monitoring Report	Specific Condition 28 A-E
Relevant Period of Record	May 1, 2010–April 30, 2011
Report Generator	Guy Germain ggermain@sfwmd.gov 561-682-6732
Permit Coordinator	Holly Andreotta handreot@sfwmd.gov 561-242-5520 x3726

Table 6. Key permit-related information for STA-6.

Project Name	STA-6
Permit Numbers	0131842 (EFA) FL0473804 (NPDES) Administrative Order-011 (EFA) Administrative Order-012 (NPDES)
Issue and Expiration Date	Issue: January 29, 2009 Expiration: January 29, 2014 (EFA) Issue: September 4, 2007 Expiration: September 4, 2012 (NPDES)
Project Phase	Stabilization
Permit Condition Requiring Annual Monitoring Report	Specific Condition 28 A-E
Relevant Period of Record	May 1, 2010–April 30, 2011
Report Generator	Guy Germain ggermain@sfwmd.gov 561-682-6732
Permit Coordinator	Holly Andreotta handreot@sfwmd.gov 561-242-5520 x3726

Table 7. Attachments included with this report.

Attachment	Title
A	Specific Conditions and Cross-References
B	Supporting Information on Water Quality Data for the Everglades STAs and Downstream Transects for Water Year 2011
C	Annual Permit Compliance Monitoring Report for Mercury in the STAs
D	Rotenberger Wildlife Management Area Restoration and STA Downstream Transect Monitoring
E	STA Herbicide Application Summary for Water Year 2011

INTRODUCTION

In 1994 the Everglades Forever Act (EFA) authorized the Everglades Agricultural Area (EAA) Best Management Practices (BMPs) and the Everglades Stormwater Treatment Areas (STAs). As a major component of Everglades restoration, the STAs are intended to remove excess total phosphorus (TP) from surface waters prior to those waters entering the Everglades Protection Area (EPA). STAs are constructed wetlands that retain nutrients through several mechanisms including plant growth, accumulation of dead plant material in a layer of peat, settling and sorption, precipitation, and microbial activities.

This appendix reports on the permit compliance aspect of the six Everglades STAs: STA-1 East (STA-1E), STA-1 West (STA-1W), STA-2, STA-3/4, STA-5, and STA-6 (see **Figures 1** and **2**). The STAs operate under EFA and National Pollutant Discharge Elimination System (NPDES) permits and Administrative Orders (AOs). AOs, issued with each of the STA permits, establish a schedule for achieving compliance with the permit interim effluent limits (IELs). Varying in size, configuration, and period of operation, the STAs are shallow freshwater marshes divided into treatment cells by interior levees. Water flows through these systems via water control structures, such as pump stations, gates, or culverts. The dominant plant communities in the treatment cells are broadly classified as emergent aquatic vegetation (EAV), submerged aquatic vegetation (SAV), and floating aquatic vegetation (FAV). Both native and nonnative vegetation play a role in phosphorus removal in the STAs. Vegetation management activities include control of undesirable species that impact hydraulics.

This appendix summarizes STA performance during Water Year 2011 (WY2011) (May 1, 2010–April 30, 2011) to fulfill various permit reporting mandates and provides an evaluation of TP compliance with the IEL and other water quality parameters, including dissolved oxygen (DO), mercury (Hg), and other nutrients and major ions. Attachments A through E provide supplementary information for this report (**Table 7**).

STA PERFORMANCE

This section presents the annual data required by STA operating permits, AOs, and downstream monitoring. It also includes STA discharge monitoring in the downstream areas. A cross-reference listing for the permit reporting requirements is presented in Attachment A.

PERMIT STATUS AND REPORTING REQUIREMENTS

Permit Compliance for Phosphorus

The STAs operate under EFA and NPDES permits and AOs issued over a phased implementation schedule (**Table 8**). As part of the permit compliance for phosphorus, annual STA performance is evaluated in comparison to interim effluent limits and operational envelopes. The derivation of the IELs is found in the permit technical support documents, which also identify factors that may impact flows and TP loads associated with the treatment system. IELs are different concentrations for each STA, as defined by their respective operating permits, and are adjusted based on the amount of effective treatment area in operation for each STA (the effective treatment area of an STA may be temporarily reduced due to flow-ways being taken offline for rehabilitation or construction work) (see Table 5-4 in Volume I, Chapter 5 for more information about the operational status of the STAs). Several factors are taken into account when determining the IEL compliance status of an STA. These factors include (1) the operational phase of the STA, (2) rainfall conditions, and (3) rehabilitation or major construction activities. The operating permits also take into consideration that natural systems undergo maturity changes by categorizing STA operations into phases that depend on development and performance (**Table 9**). For more detailed information see Volume I, Chapter 5.

The permits for STA-1E, STA-1W, STA-2, STA-5, and STA-6 describe three operational phases: start-up, stabilization, and routine operations. During the initial start-up phase of a new treatment cell or new flow-way, phosphorus concentrations within the facility are monitored to demonstrate that the project is achieving a net reduction in phosphorus. Start-up phase operation and monitoring within the treatment area consists of the following criteria: (1) manage water depths in the treatment cells to facilitate the recruitment of marsh vegetation in accordance with the operations plan, (2) monitor TP weekly at the upstream side of a flow-way's inflow and outflow structures, (3) demonstrate that an individual flow-way or treatment cell, over a four-week period, is reducing phosphorus[1], and (4) discharge operations. Discharge operations, from an individual flow-way or treatment cell that has passed the phosphorus start-up test described in item 3, may commence once initial start-up phase documentation and all supporting data and analyses are submitted to the Florida Department of Environmental Protection (FDEP). For flow-ways or treatment cells that have not passed this test within six months after issuance of the permit, status updates regarding progress toward achieving and identifying strategies and timelines to achieve this requirement are necessary. The fifth criterion for start-up phase operations is referred to as initiation of individual flow-way (stabilization and routine operation) discharges and monitoring. Once flow-through discharges from a flow-way begin, routine water quality monitoring is initiated consistent with the monitoring program described in the permit.

[1] This net reduction is deemed to occur when the four-week geometric mean TP water column concentration from samples collected at the applicable outflow structures is less than the four-week geometric mean TP water column concentration collected at the applicable inflow structure(s).

Table 8. Current permit/Administrative Order (AO) reporting requirements used during Water Year 2011 (WY2011) (May 1, 2010–April 30, 2011) to assess STA phosphorus removal performance for EFA and NPDES permits and AOs.

STA Permit /AO Reporting Requirements	
STA-1E Permit Phase: Eastern Flow-way Restricted Operations; Central and Western Flow-ways in Stabilization Phase	
EFA permit 0279449-001-EM (issued November 16, 2007) is in effect.	The interim effluent limit (IEL) is applied as the annual phosphorus limitation for discharges under the current permit.
NPDES permit FL0304549 and AO-009-EV are in effect. Both were issued August 30, 2005.	These permits have the annual limit of 68 parts per billion (ppb) for each water year and a not-to-exceed limit of 50 ppb for three or more consecutive water years.
STA-1W Permit Phase: All Treatment Cells in Stabilization Phase	
EFA permit 0279449-001-EM (issued November 16, 2007) is in effect.	The IEL is applied as the annual phosphorus limitation for discharges under the current permit.
NPDES permit FL0177962-001 and AO-001-EV are in effect. Both were issued May 11, 1999	The NPDES and AO permits have an annual limit of 76 ppb for each water year and a not-to-exceed limit of 50 ppb for three or more consecutive water years.
STA-2 Permit Phase: Cells 1–4 in Stabilization Phase	
EFA permit 0126704-008-EM (issued March 17, 2009), NPDES permit FL0177946 (issued September 4, 2007), and AO-010-EV (issued March 17, 2009) are in effect. Note: AO authorizes conditional operations of the existing facility (Cells 1–4) and construction of Compartment B.	The IEL is applied as the annual phosphorus limitation for discharges under the current permit.
STA-3/4 Permit Phase: Post-Stabilization Phase (according to 2004-Issued Permit)	
EFA permit 0192895. NPDES permit FL0300195 and AO are in effect. All were issued on January 9, 2004.	These permits have the annual limit of 76 ppb for each water year and a not-to-exceed limit of 50 ppb for three or more consecutive water years.
STA-5 Permit Phase: North and Central flow-ways in Stabilization Phase, Southern Flow-way in Stabilization Phase	
EFA permit 0131842-009-EM (issued January 29, 2009), NPDES permit FL0177954 (issued September 4, 2007), and AO-011-EV (issued January 29, 2009) are in effect. Note: AO authorizes continued operation of the existing facility and conditional authorization of the construction of Compartment C.	The IEL is applied as the annual phosphorus limitation for discharges under the current permit.
STA-6 Permit Phase: Stabilization Phase	
EFA permit 0131842-009-EM and AO-011-EV (issued January 29, 2009) and NPDES permit FL0473804-001 and AO-012-EV (issued September 4, 2007) are in effect. Note: AO authorizes conditional operations of the existing facility (Sections 1 and 2) and construction of Compartment C.	The IEL is applied as the annual phosphorus limitation for discharges under the current permit.

Note: Refer to **Table 10** for the EFA and NPDES/AO outflow limits and status of applicability or compliance with the three-part test.

Table 9. Phases of each STA based on the conditions outlined in the EFA permits.

STA Permit Phase	Date Phase Entered	Expected Duration of Current Phase	Factors/Activities Impacting STA Treatment Capabilities: Long-Term Plan Enhancements	Recovery	Maintenance	Outside of Agency Control
STA-1E Stabilization Phase	WY2006	The South Florida Water Management District is continuing to coordinate with the Florida Department of Environmental Protection on these issues and will report the updated status in future South Florida Environmental Reports.		Recovery of submerged aquatic vegetation in Cell 6 continued in WY2011 following vegetation failure that occurred in WY2010.		The eastern flow-way remains in restricted flow conditions due to the United States Army Corps of Engineers' Periphyton-Based Stormwater Treatment Area (PSTA) Demonstration Project. Until the Comprehensive Everglades Restoration Plan (CERP) Loxahatchee River Watershed Project (L-8 Diversion Project) is complete, the status is expected to remain in the current phase. Poor vegetation conditions persisted in Cell 7 due to chronic deep water conditions. Anomalous low rainfall received in WY2011.
STA-1W Stabilization Phase	WY2000					
STA-2 Stabilization Phase	WY2008		Cell 4 was taken offline in November 2010 due to Compartment B construction and will remain offline until an operating permit is obtained.	Vegetation conversion initiated in WY2010 in Cell 2 continued in WY2011.		Cell 1 was recovering from dryout that occurred during WY2009 through May 2010, and dryout that occurred again in November 2010 to January 2011 as a result of drought. Anomalous low rainfall received in WY2011.
STA-3/4 Post-stabilization Phase	WY2005		Vegetation conversion continued in Cell 1B.	A temporary drawdown of Cell 1A was done beginning in May 2010, then again in March 2011 to June 2011 to allow for reestablishment of cattails impacted by chronic deep water conditions in the northern portion of the cell.		Anomalous low rainfall received in WY2011.
STA-5 Stabilization Phase	WY2000		The southern flow-way was taken offline in May 2010 related to Compartment C construction. This flow-way was brought back online with restrictions (for vegetation establishment) in September 2010 and continued to be on this status through the end of WY2011.			The northern flow-way was online with restrictions to protect Everglade snail kite (*Rostrhamus sociabilis plumbeus*) nests from the beginning of WY2011 until October 27, 2010. The central flow-way also had snail kite nests but operations were not impacted and restrictions were lifted on November 9, 2010. Due to anomalous low rainfall received in WY2011, Cells 1A, 2A, 3A, and 3B dried out beginning in December 2010 and remained dry for the remainder of the water year.
STA-6 Stabilization Phase	WY2008					Due to anomalous low rainfall received in WY2011, Cells 3 and 5 dried out by December 2010 and remained dry for the remainder of the water year.

During the stabilization phase (flow-through operations), the treatment vegetation will be maturing and STA performance will generally be improving toward achieving the IEL. An STA or flow-way may enter the stabilization phase after one of four conditions: (1) once flow-through operations begin following the initial start-up of a new treatment cell, (2) when a treatment cell is taken offline for implementation of the Long-Term Plan (LTP) for Achieving Water Quality Goals in the EPA enhancements that may have adverse impacts on STA performance, (3) when a treatment cell is taken offline for recovery activities associated with a major event that compromises structural integrity or performance, or (4) planned/unplanned maintenance activities that would cause adverse impacts to the STA's treatment capabilities (See Table 5-4 in Volume I, Chapter 5 for more information about operational status.). Once the facility achieves the IEL, it enters the routine operations phase and discharges from the STA must meet the related permit effluent limitations.

Compliance with the IEL is required once the facility enters flow-through operations, However, it is recognized that one or more of the aforementioned conditions may result in an observed excursion from the IEL. Such excursions do not immediately constitute noncompliance with the AO (and hence, the permit) as long as all the activities identified in the compliance schedules are being implemented, the reporting requirements are being met, any necessary recovery measures are being undertaken, and all other relevant conditions are in compliance. Annual maximum IELs for phosphorus are required by permits or AOs for all of the STAs except for STA-3/4. A two-part compliance test is required for STA-1E, STA-1W, and STA-3/4 in which the annual TP flow-weighted mean (FWM) concentration has to be less than the IEL for the reported water year or the TP FWM concentration has to be less than or equal to 50 parts per billion (ppb) for three or more consecutive years. All of the STAs except for STA-5 have met all appropriate criteria and were in compliance during WY2011. STA discharge concentrations are not compared to the relevant IEL in water years when rainfall in the source basins to the STAs is outside the South Florida Water Management Model (SFWMM) Simulation Rainfall Range (**Table 10**). Even though STA-1W and STA-6 were outside the simulation rainfall range, they met the IEL compliance criteria for WY2011 (see EFA Specific Conditions 23A for STA-1W and 21A for STA-6). STA-1E did not meet the IEL compliance criteria; however, since it was below the simulated rainfall range it is considered in compliance for WY2011 (see EFA Specific Conditions 23A for STA-1W and 21A for STA-6). STA-5 did not meet the IEL compliance criteria; however, according to Specific Conditions 18 and 21A of the EFA permit and Condition 18 of the AO, STA-5 is not required to meet the compliance criteria because of dryout conditions and the southern flow-way being off line due to the Compartment C build-out. Therefore, all the STAs were in compliance with their AOs and permits for WY2011 (**Table 10** and **Figure 3**).

In addition to IELs and operational envelopes (i.e., annual STA inflow volumes and TP loads compared to the 36-year daily simulated flows and TP loads), additional permit compliance is required. Operational envelopes are adjusted based on the amount of effective treatment area in operation for each STA. The effective treatment area of an STA may be temporarily reduced due to flow-ways being taken offline for rehabilitation or construction work. The operational envelope assessment is included in permits for all of the STAs except those for STA-3/4 to account for variable inflows received and requires annual comparison of the actual volumetric and TP loading to both the average and maximum annual loadings estimated in the operational envelope. STA-2 is only required to compare the maximum value to the operational envelope. STA-3/4 is operated under permits issued in calendar year 2004 prior to the development of operational envelopes. Once new permits for STA-3/4 are issued, it is anticipated that those permits will include operational envelope assessment requirements similar to the other STAs.

Information regarding the amount of water diverted around the STAs and received by the STAs from Lake Okeechobee as inflows during WY2011 can be found in **Table 11**.

Table 10. STA performance for WY2011 (May 1, 2010–April 30, 2011) and the period of record (POR) 1994–2011.

	STA-1E	STA-1W	STA-2	STA-3/4	STA-5	STA-6	All STAs
Effective Treatment Area in Permit (acres)	5,132	6,670	8,240	16,543	6,095	2,257	44,937
Adjusted Effective Treatment Area (acres)[a]	4,881	6,670	7,406	16,543	5,660	1,584	42,744
Rainfall							
Total Annual Rainfall (inches)	34.0[b]	35.0[b]	38.1	40.2	39.0	42.2[b]	38.1
South Florida Water Management Model (SFWMM) Simulation Rainfall Range (inches)	39.8–77.5	36.6–77.4	35.4–71.6	32.3–70.7	38.6–61.4	46.8–57.6	---
Inflow							
Total Inflow Volume [acre-feet (ac-ft)]	35,616	125,933	170,838	303,447	26,609	72,722	735,165
Total Inflow total phosphorus (TP) Load [metric ton (mt)]	4.955	23.461	15.248	26.208	5.258	10.141	85.271
Flow-weighted Mean (FWM) Concentration Inflow TP [parts per billion (ppb)]	113	151	72	70	160	113	94
Hydraulic Loading Rate (HLR) [centimeters per day (cm/d)[d]	0.61	1.58	1.93	1.53	0.39	3.83	1.44
TP Loading Rate (PLR) [grams per square meter per year ($g/m^2/yr$)][d]	0.25	0.87	0.51	0.39	0.23	1.58	0.49
Outflow							
Total Outflow Volume (ac-ft)	25,758	126,881	159,914	312,067	24,319	74,591	723,530
Total Outflow TP Load (mt)	0.691	3.990	3.049	6.305	1.420	2.317	17.772
FWM Concentration Outflow TP (ppb)	22	25	15	16	47	25	20
Outflow Plus Diversion Structures FWM TP (ppb)	22	25	15	17	47	25	20
Hydraulic Residence Time (days)	49	27	23	28	13	5	---
TP Retained (mt)	4.264	19.471	12.199	19.903	3.838	7.824	67.499
TP Removal Rate ($g/m^2/yr$)	0.22	0.72	0.41	0.30	0.17	1.22	0.39
Load Reduction (percent)	86%	83%	80%	76%	73%	77%	79%
Period of Record Performance							
Start Date	September 2004	October 1993	June 1999	October 2003	October 1999*	October 1997	1994–2011
Total Inflow Volume (ac-ft)	563,131	3,160,086	2,568,599	3,369,553	1,182,264	671,380	11,515,014
Total TP Load Retained to Date (mt)	84.469	465.434	250.619	400.612	205.029	64.132	1,470.296
FWM Concentration TP Outflow to Date (ppb)	62	52	23	17	95	33	38

[a] Adjusted effective treatment areas (AETA) reflect treatment cells temporarily off-line for plant rehabilitation, infrastructure repairs, or Long -Term Plan (LTP) enhancements (see Table 5-4 in Volume I, Chapter 5 for more information about the operational status of the STAs). AETA = days online/365 (for each flow-way or cell) * (effective treatment area for each flow-way or cell) then add them all together.

[b] The total annual rainfall received by the STA was below the range of values used to develop the IELs.

[c] SFWMM – South Florida Water Management Model.

[d] Inflow volume or TP load/adjusted effective treatment area.

* The Start Date for STA-5 was misreported as October 2099 and was corrected to October 1999 on April 2, 2012.

Table 10. Continued.

Required WY2011 Permit Reporting: EFA, NPDES, AO, and Interim Effluent Limit (IEL)							
	STA-1E	**STA-1W**	**STA-2**	**STA-3/4**	**STA-5**	**STA-6**	**All STAs**
Operational Permit Phase[e]	Stabilization	Stabilization	Stabilization	Post-Stabilization[f]	Stabilization	Stabilization	---
In Compliance with Permits?	Yes	Yes	Yes	Yes	Yes	Yes	---
Within Operational Envelope?							
Average (Flow/Load)	Yes/Yes	Yes/Yes	Yes/Yes	NA	Yes/Yes	No/No[j]	---
Maximum (Flow/Load)	Yes/Yes	Yes/Yes	Yes/Yes	NA	Yes/Yes	No/No[j]	---
Was EFA IEL Achieved?	No[b,g]	Yes	Yes	Yes	No[g]	Yes	---
Was NPDES/AO Annual IEL Achieved?[i]	Yes	Yes	Yes	Yes	No[g]	Yes	---
Was NPDES/AO 50 ppb Three-year Test Achieved?[i]	Yes	Yes	Not Applicable (NA)	Yes	NA	NA	---
Were There Any Water Quality (Other than Phosphorus) Excursions?	No	No	No	No	No	No	---
Was Dissolved Oxygen Site-specific Alternative Criteria (DO SSAC) Achieved?[h]	Yes	Yes	Yes	Yes	Yes	No	---
Permit Limits							
Operational Envelope[c]:							
Average Inflow volume (ac-ft)	198,924	206,987	307,049	NA	145,462	54,515	---
Maximum Inflow volume (ac-ft)	291,954	329,169	482,159	NA	194,327	66,135	---
Average Inflow TP load (mt)	32.261	44.303	38.726	NA	36.641	6.043	---
Maximum Inflow TP load (mt)	47.595	72.273	63.938	NA	59.366	7.519	---
Outflow EFA and NPDES/AO Limits:							
Outflow EFA IEL TP (ppb) Limit	20	27	21	76	40	28	---
Outflow NPDES/AO IEL TP (ppb) Limit	68	76	21	76	40	28	---

[e] See the *Permit Status and Reporting Requirements* section of this appendix.

[f] STA-3/4 is operated under permits issued in 2004 and is considered to be in the post-stabilization phase and the outflow water quality IEL is set at 76 ppb as defined in those permits. Operational envelope comparison is not applicable under the present permit.

[g] Excursions to the IEL are detailed further in the *STA Performance* section of this appendix.

[h] See the *Dissolved Oxygen* section of this appendix for details regarding the DO SSAC.

[i] The NPDES/AO permits for STA-1E, STA-1W, and STA-3/4 require a two-part test for phosphorus compliance. The two-part test states that the annual outflow TP FWM concentration has to be less than the IEL for the reported water year and the TP FWM concentration has to be less than or equal to 50 ppb for three or more consecutive years. For STA-2, STA-5, and STA-6, the NPDES/AO permits require only comparison of the annual outflow TP FWM concentration to the IEL for the reported water year.

[j] Section 2 received higher than anticipated inflow volume due to redirection of C139 basin runoff during a period when STA-5 had construction-related and snail kite-related restrictions, and Compartment C dewatering.

Notes: Flow-proportional auto-samplers are used to calculate TP loads and concentrations, if available. POR calculations include the amount of inflows and TP loads used to hydrate the STAs during start-up if those data are available. The data of PORs are appended from the *2011 South Florida Ecosystem Report* with WY2011 data. STA-1E flows and TP loads that occurred in WY2004 in response to regional flooding due to Hurricanes Francis and Jeanne are also included.

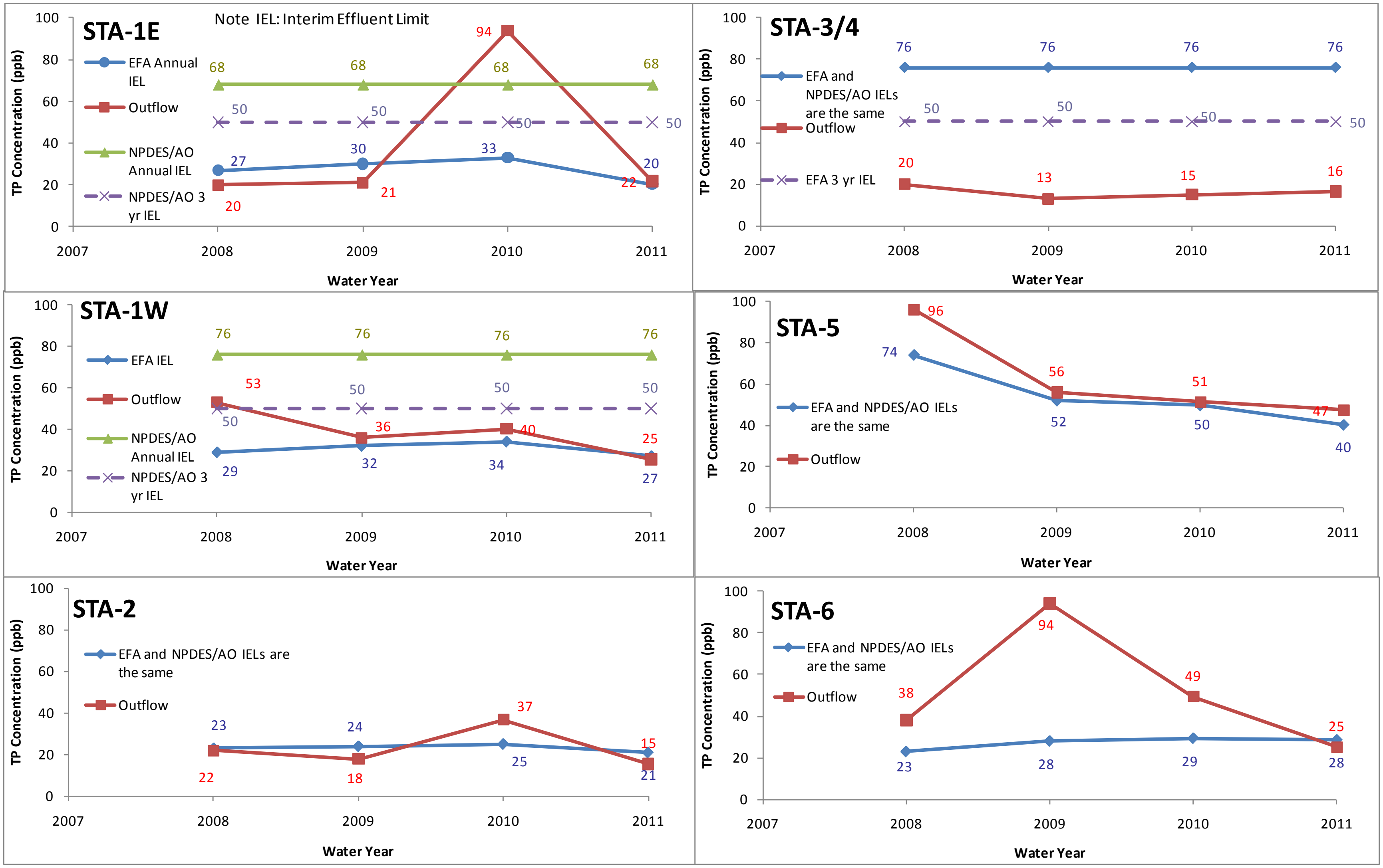

Figure 3. STA outflow total phosphorus (TP) concentrations in parts per billion (ppb) compared to Everglades Forever Act (EFA) and National Pollution Elimination System (NPDES)/Administrative Order (AO) interim effluent limits (IELs).

Table 11. Information fulfilling the permit-related reporting requirement for the amount of water diverted around the STAs and received by the STAs from Lake Okeechobee as inflows in WY2011.[a]

STA	STA Diversion Structure Flow							Inflows from Lake Okeechobee						
	STA Diversion				Water Supply, Gate Maintenance, etc.			Lake Flow-Through[e]				Supplemental Water to Maintain Vegetation[g]		
	Structure	Volume (ac-ft)	TP Load (mt)	FWM TP (ppb)[c]	Volume (ac-ft)	TP Load (mt)	FWM TP (ppb)	Structure	Volume (ac-ft)	TP Load (mt)	FWM TP (ppb)	Volume (ac-ft)	TP Load (mt)	FWM TP (ppb)
STA-1E	G300	----	----	----	0.1	<0.001	98	G-311	88	0.010	94			
								S-319[b]	8,273	1.171	115	611	0.087	115
	Total				**0.1**	**<0.001**	**98**	**Total**	**8,361**	**1.181**	**115**	**611**	**0.087**	**115**
STA-1W	G301	----	----	----	<0.1	<0.001	92	G-302	7,422	1.045	114	3,401	0.479	114
	Total				**<0.1**	**<0.001**	**92**	**Total**	**7,422**	**1.045**	**114**	**3,401**	**0.479**	**114**
STA-2	G338	----	----	----	<0.1	<0.001		S-6[d]	9,209	0.451	40	6,848	0.335	40
	G339				0.3	<0.001	38							
	Total				**0.3**	**<0.001**	**38**	**Total**	**9,209**	**0.451**	**40**	**6,848**	**0.335**	**40**
STA-3/4	G371	----	----	----	4,218	0.188	36	G-370	2,659	0.098	30	2,363	0.087	30
	G373	----	----	----	8,148	0.354	35	G-372	6,259	0.435	56	5,688	0.393	56
	Total				**12,366**	**0.541**	**35**	**Total**	**8,917**	**0.533**	**48**	**8,051**	**0.480**	**48**
STA-5	Not applicable	—	—	—	—	—	—	G-507[f]	1,084	0.045	33	1,084	0.044	33
								G-349B[f]	731	0.030	34	731	0.031	34
								G-350B[f]	995	0.029	24	995	0.029	24
	Total	**—**	**—**	**—**	**—**	**—**	**—**	**Total**	**2,810**	**0.104**	**30**	**2,810**	**0.104**	**30**
STA-6	G407	----	----	----	62	0.010	131		—	—	—	—	—	—
	Total				**62**	**0.010**	**131**	**Total**						
	All STAs Total				**12,429**	**0.551**	**36**	**All STAs Total**	**36,719**	**3.315**	**73**	**21,721**	**1.485**	**55**

mt – metric tons; ac-ft – acre-feet; FWM – flow-weighted mean; ppb – parts per billion

[a] Lake release details are illustrated in Figure 2-8 in Chapter 2, Volume I. Some numbers reported are estimated using Everglades Agricultural Area (EAA) model output. See also Appendix 3A-5, Volume I.

[b] Water was also delivered via the S-319 structure for the Periphyton Stormwater Treatment Area (PSTA) Implementation Project as requested by the United States Army Corps of Engineers.

[c] Concentrations expressed as parts per billion (ppb) are equal to micrograms per liter (µg/L).

[d] Some lake flow-through water at S-6 was for agricultural irrigation and was not routed to the STA-2 for supplemental water.

[e] Lake flow-through is a balance of Lake Okeechobee outflow into and discharges from EAA basins. Lake flow-through includes supplemental water to maintain vegetation, water released from Lake Okeechobee for EAA freeze protection operations, regulatory and environmental releases from Lake Okeechobee to the Everglades Protection Areas, and irrigation water not used in the EAA.

[f] Water was delivered via the G507, G349B and G350B structure for STA-5 rehydration was from mixed sources of Lake Okeechobee, STA-3/4 discharges, and STA-5 seepage return. TP loads and FWM TP concentration are calculated based on G507 monitoring data. The data presented here are from Lake Okeechobee only.

[g] Supplemental water volumes are calculated from December 8, 2010 to April 30, 2011.

In WY2011, all the STAs removed a significant amount of the inflow TP loads, ranging from 73 to 86 percent load reduction (**Table 10**). About 67.5 metric tons (mt) of TP that would have entered the Everglades was instead retained in the STAs. Since 1994, the total amount of TP retained in the STAs is about 1,470 mt.

Comparison of the outflow TP FWM concentration to the IEL shows that the 22 ppb outflow concentration measured at STA-1E did not meet the EFA permit IEL of 20 ppb, but did meet the NPDES/AO IEL. STA-1W, STA-2, STA-3/4, and STA-6 met both the EFA and NPDES/AO IELs. The 47 ppb annual FWM outflow concentration at STA-5 did not meet either the EFA or NPDES/AO IELs. Performance for all the STAs was compared to the EFA and NPDES/AO IELs for three water years, WY2009–WY2011, illustrating that STA-5 was the only STA not to be below the IEL (**Figure 3**). Even though some of the STAs did not meet the EFA or NPDES/AO criteria, they were all in compliance based on the explanations stated earlier on page App. 3-1-11.

Other Water Quality Permit Requirements

Water quality parameters with Florida Class III standards are identified in **Table 12**. Compliance with EFA permits is determined based on the following three-part assessment:

1. If the annual average outflow concentration does not cause or contribute to violations of applicable Class III water quality standards, then the STA shall be deemed in compliance.
2. If the annual average concentration at the outflow causes or contributes to violations of applicable Class III water quality standards, but does not exceed or is equal to the annual average concentration at the inflow stations, then the STA shall be deemed in compliance.
3. If the annual average concentration at the outflow causes or contributes to violations of applicable Class III water quality standards and also exceeds the annual average concentration at the inflow station, then the STA shall be deemed out of compliance.

The determination as to whether an STA is contributing to a violation for a specific parameter is a comparison of the average annual inflow concentration to the average annual outflow concentration relative to the three-part assessment. The South Florida Water Management District (District or SFWMD) has performed all sampling and analysis in compliance with Chapter 62-160, Florida Administrative Code (F.A.C.), and the District's Laboratory Quality Manual (SFWMD, 2010a) and Field Sampling Quality Manual (SFWMD, 2010b). The annual permit compliance monitoring report for mercury in the STAs is presented in Attachment C. Each STA has different permit reporting requirements for annual water quality constituents.

Compliance with the specific conductance (or conductivity) criteria for Class III fresh waters is described in Section 62-302.530, F.A.C., as measured values that are not more than 50 percent above background or do not exceed 1,275 microsiemens per centimeter (µS/cm) (whichever is greater). Because the samples are collected in freshwater systems, conductivities at STA inflows and outflows are typically lower than 1,275 µS/cm.

The Class III criterion for turbidity, as specified under Section 62-302.530, F.A.C., states that measured values shall not be more than 29 nephelometric turbidity units (NTUs) above natural background conditions. Under Chapter 62-303, F.A.C., natural background is defined as:

> "…the condition of waters in the absence of man-induced alterations based on the best scientific information available to the Department. The establishment of natural background for an altered water body may be based upon a similar unaltered water body or on historical pre-alteration data..."

Because the FDEP has not compiled any information on what it considers natural background, the District has determined that any measured value that is greater than 29 NTUs exceeds the turbidity criterion.

Table 12. Water quality parameters with Florida Class III criteria specified in Section 62-302.530, Florida Administrative Code.

Parameter	Units	Florida Class III Criteria[a]
Dissolved Oxygen[2]	mg/L	≥ 5.0 mg/L
Specific Conductance	µS/cm	Not > 50 percent of background or > 1,275 µS/cm, whichever is greater
pH	SU	Not < 6.0 or > 8.5
Turbidity	NTU	≤ 29 NTUs above background conditions
Un-ionized Ammonia	mg/L	≤ 0.02 mg/L
Alkalinity	mg $CaCO_3$/L	Not < 20 mg/L

mg/L – micrograms per liter; µS/cm – microsiemens per centimeter; SU – standard units; NTU – nephelometric turbidity units; mg CaCO3/L – milligrams calcium carbonate per liter

[a] Because the STAs are freshwater systems, the background concentration for specific conductance is assumed to be less than 1,275 µS/cm, and the background concentration for turbidity cannot exceed 29 NTUs.

[b] Permits for all STAs, except STA-3/4, require compliance with the site-specific alternative criteria (SSAC) for dissolved oxygen (Weaver, 2004).

Water Year 2011 Performance for Other Water Quality Parameters

For water quality parameters that do not have a Florida Class III standard, excursions are noted when the annual outflow FWM concentrations are higher than the annual inflow FWM concentrations. An STA may have individual excursions yet be in overall compliance if it meets the remaining components of the EFA three-part assessment.

WY2011 monitoring data for permitted water quality parameters at the STA inflows and outflows are presented in Attachment B. Annual FWM concentrations at inflows and outflows of the STAs, including excursion analysis, are summarized in **Table 13**, during WY2011 no excursions occurred at any of the STAs.

Pursuant to the EFA permits for each of the STAs (except STA-3/4), a statistical analysis is used to compare DO levels within the STA as set forth in the Everglades marsh DO site-specific alternative criteria (SSAC) to evaluate compliance annually. Additional details regarding the DO SSAC are presented in the *Dissolved Oxygen* section of this appendix.

Based on water quality data (excluding TP and DO) collected during WY2011, all the annual FWM concentrations measured at the outflows of each STA did not exceed the Class III criteria and were lower than annual FWM concentrations at the inflows to that STA (**Tables 12** and **13**).

Inflow and outflow FWM concentrations were compared statistically with a significance level (α) of 0.05. The Shapiro-Wilk test of normality was used to determine if datasets deviated significantly from normality. Those datasets that did not deviate significantly from a normal distribution (i.e., $p > 0.05$) were analyzed using the Student's t-test. Datasets that deviated significantly from normality ($p < 0.05$) were tested using the Mann-Whitney U test (a non-parametric equivalent of the Student's t-test).

During WY2011, 20 datasets did not deviate from normal distribution and 8 datasets did. Therefore, both the Mann-Whitney U and Student's t-test were used to compare the inflow and outflow FWM concentrations. These statistical comparisons are summarized in **Table 14** by parameter and STA. Of the 28 datasets evaluated, 9 comparisons exhibited statistically significant differences between inflow and outflow FWM concentrations. For each of those nine, inflow FWM concentrations were significantly higher than outflow FWM concentrations.

Table 13. Summary of annual FWM concentrations of parameters other than TP for inflow and outflow of the STAs during WY2011. [Note: n – sample size; Conc. – concentration]

Parameter	Annual Flow-Weighted Means[a]			
	Total Inflow		Total Outflow	
	n[b]	Conc.	n[b]	Conc.
STA-1E				
Sulfate (mg/L)	30 (74)	42.4	16 (25)	26.6
Alkalinity (mg $CaCO_3$/L)	31 (78)	178	17 (26)	141
Total Nitrogen (mg/L)	30 (76)	1.71	17 (26)	1.4
Nitrate + Nitrite as N (mg/L)	30 (76)	0.182	17 (26)	0.04
STA-1W				
Sulfate (mg/L)	5 (16)	75.9	15 (52)	73.6
Alkalinity (mg CaCO3/L)	6 (26)	261	15 (52)	185
Total Nitrogen (mg/L)	6 (26)	4.03	15 (51)	2.17
Nitrate + Nitrite as N (mg/L)	6 (26)	0.825	15 (51)	0.031
STA-2				
Sulfate (mg/L)	26 (73)	61.7	12 (26)	47.2
Total Nitrogen (mg/L)	30 (83)	3.44	12 (26)	2.31
Nitrate + Nitrite as N (mg/L)	30 (83)	0.839	12 (26)	0.042
STA-3/4				
Turbidity (NTU)	20 (52)	3.7	75 (156)	0.8
Soluble Reactive Phosphorus (mg/L)	31 (104)	0.033	143 (308)	0.002
Sulfate (mg/L)	20 (52)	71.8	75 (156)	58
Total Nitrogen (mg/L)	20 (52)	3.76	74 (155)	1.87
Nitrate + Nitrite as N (mg/L)	20 (52)	1.446	74 (155)	0.012
STA-5				
Sulfate (mg/L)	22 (98)	7.1	27 (127)	3.2
Total Nitrogen (mg/L)	22 (98)	1.73	27 (127)	1.29
Nitrate + Nitrite as N (mg/L)	22 (98)	0.042	27 (127)	0.006
STA-6				
Sulfate (mg/L)	24 (31)	9.4	31 (49)	6.8
Total Nitrogen (mg/L)	24 (31)	1.58	31 (49)	1.26
Nitrate + Nitrite as N (mg/L)	24 (31)	0.057	31 (49)	0.005

[a] Annual flow-weighted means are computed for inflows and outflows by combining the data from individual stations

[b] n: total number of samples collected with flow (total number of samples collected regardless of flow)

Table 14. Statistical comparison of monthly FWM concentrations at inflows and outflows of the STAs for other water quality parameters.

Parameter Name	Variable	Storm Water Treatment Areas					
		STA-1E	STA-1W	STA-2	STA-3/4	STA-5	STA-6
Specific Conductivity	p-Value[a]	0.676	0.761	0.088	0.294	0.565	0.067
	Structure[b]	Outflow	Outflow	Inflow	Inflow	Inflow	Inflow
	Statistical Test[c]	t Test	t Test	t Test	t Test	Mann-Whitney	t Test
Turbidity	p-Value[a]	NA	NA	NA	***0.027***	NA	NA
	Structure[b]	NA	NA	NA	***Inflow***	NA	NA
	Statistical Test[c]	NA	NA	NA	***t Test***	NA	NA
Alkalinity	p-Value[a]	0.170	0.163	NA	NA	NA	NA
	Structure[b]	Inflow	Inflow	NA	NA	NA	NA
	Statistical Test[c]	t Test	t Test	NA	NA	NA	NA
Sulfate	p-Value[a]	0.149	0.732	0.276	0.269	0.909	***0.024***
	Structure[b]	Inflow	Inflow	Inflow	Inflow	Outflow	***Inflow***
	Statistical Test[c]	t Test	t Test	t Test	t Test	t Test	***t Test***
Soluble Reactive Phosphorus	p-Value[a]	NA	NA	NA	0.317	NA	NA
	Structure[b]	NA	NA	NA	Inflow	NA	NA
	Statistical Test[c]	NA	NA	NA	Mann-Whitney	NA	NA
Nitrate + Nitrite	p-Value[a]	***0.014***	***0.007***	***0.001***	***<0.001***	0.116	***0.002***
	Structure[b]	***Inflow***	***Inflow***	***Inflow***	***Inflow***	Inflow	***Inflow***
	Statistical Test[c]	***Mann-Whitney***	***Mann-Whitney***	***Mann-Whitney***	***Mann-Whitney***	Mann-Whitney	***Mann-Whitney***
Total Nitrogen	p-Value[a]	0.712	0.106	***0.017***	0.151	0.385	***0.002***
	Structure[b]	Inflow	Inflow	***Inflow***	Inflow	Inflow	***Inflow***
	Statistical Test[c]	t Test	t Test	***t Test***	t Test	t Test	***t Test***

Note: NA indicates that data was not collected or there were insufficient data to perform the statistical analyses.

[a] Probability level (p-value) computed using appropriate comparison test. A significance level (α) of 0.05 was used. When p-value was less than 0.05, the parameter concentrations were significantly different between the inflow and outflow. Significant p-values are identified by shading and are presented in the table as italicized and bolded values.

[b] STA structure group (pooled inflow or pooled outflow) exhibiting higher parameter concentrations during the water year.

[c] Statistical test used to compare inflow and outflow water quality data. Choice of test was based on distributional assumptions. If the distribution of data did not significantly deviate from normality, the Student t test (t Test) was used. When the distribution of data deviated significantly from normality, the Mann-Whitney test (non-parametric equivalent) was used.

Dissolved Oxygen

DO concentrations below 5.0 milligrams per liter (mg/L) occur commonly throughout the Everglades Protection Area (EPA), including interior marsh sites minimally impacted by nutrient enrichment or cattail invasion. Frequent DO levels below 5.0 mg/L are typical in macrophyte-dominated wetlands where photosynthesis and respiration result in wide diel swings in DO levels. Because low DO concentrations often measured in the EPA represent natural variability in this type of ecosystem, the FDEP, pursuant to Chapter 62-302.800(1), F.A.C., has promulgated a SSAC for DO in the Everglades. This SSAC addresses the natural fluctuations that influence background DO levels. Weaver et al. (2008) explains the SSAC and its development and application in assessing DO excursions. The specific methods for determining compliance are set forth in the DO SSAC (Weaver and Payne, 2004), which was adopted by Secretarial Order on January 26, 2004, and approved by the U.S. Environmental Protection Agency (USEPA) as a revision to the State of Florida's water quality standards on June 16, 2004.

Previous reports (Jorge et al., 2002; Goforth et al., 2003, 2004, 2005; Pietro et al., 2006 and 2007) provided monitoring results, comparisons, and evaluations for diel DO in the STAs. These reports were used to assess the impact of STA discharges on the downstream Everglades ecological system or downstream water quality with respect to DO and pursuant to EFA permits and associated AOs for STA-1E, STA-1W, STA-2, STA-3/4, and STA-5. These reports also provided data to the FDEP for developing the DO SSAC. DO SSAC comparisons have been used to assess the STAs (except STA-6) since WY2007 (Pietro et al., 2008). STA-6 did not have a diel DO permit requirement when the DO SSAC was adopted.

The SSAC is now included in EFA permits and associated AOs of STA-1E, STA-1W, STA-2, STA-5, and STA-6 as a permit compliance criterion. The DO SSAC is also expected to be included in future STA permits for STA-3/4; the NPDES permit issued on January 9, 2004, for this STA stipulates that the permit shall be revised in the event that the State of Florida establishes a DO SSAC in the EPA.

EFA Permits and AOs issued for the six STAs require that the District provide the FDEP with an annual report consisting of an analysis demonstrating that DO levels in STA discharges do not adversely change the downstream Everglades ecology or the downstream water quality. As the DO SSAC has been adopted by the FDEP and formally approved by the USEPA, assessment on possible downstream impacts by the outflows from STAs during WY2011 was performed by applying the DO SSAC at the outflow stations.

Biweekly DO concentrations measured at STA discharge points during WY2011 are provided in Attachment B. A summary of annual DO levels at these permitted outflows and calculated DO SSAC for each STA are provided in **Table 15**. A comparison of the measured mean annual DO for an outflow station with the calculated mean annual SSAC determines compliance. When mean annual DO concentrations measured at the outflow stations are greater than the calculated mean annual concentration utilizing the SSAC equation, then the outflow values are in compliance with the permit.

During WY2011, three outflow stations at STA-6 (G352B, G354C and G393B) had mean annual DO levels lower than the SSAC (**Table 15**). These three stations were affected by extremely low water levels. Two of the stations (G352C and G393B) had no recorded flow from October 2010 through the end of April 2011. Station G354C had sporadic flow from October 2010 through April 2011. During this period, the total flow recorded was approximately 100 acre-feet over seven months. In addition, Section 2 of STA-6 was taken offline in November 2010 (**Table 11**). DO measurements at these three stations for WY2011 did not extend beyond December 2010. From May 2010 through September 2010, DO levels measured at the three outflow stations of STA-6 represented concentrations associated with the summer wet season when surface water temperatures are higher and solubility of oxygen is lower. In addition, productivity is also higher in the STA as more nutrients are introduced through rainfall and runoff. From October 2010 through December 2010, DO levels measured at the outflows from STA-6 did not reflect a normally operated system, but were more a reflection of a stagnant system. Average annual DO levels for Stations G352B, G354C, and G393B were 1.65, 1.59, and 1.84 mg/L, respectively. These annual concentrations were 0.5 to 1.0 mg/L lower than the SSAC (**Table 15**). It is important to note that DO levels reported for STA-6 outflows are not representative of a typical year of operation at this STA.

Table 15. Summary of WY2011 annual dissolved oxygen (DO) levels at outflow stations for each STA compared to the site-specific alternative criteria (SSAC).

STA	Outflow Station	Number of Samples	Mean[a]	Standard Deviation	Minimum	Maximum	Mean Annual SSAC Limit[b]	SSAC Limit Classification[c]
STA-1E	S362	50	5.92	1.80	2.63	9.82	1.94	Above
STA-1W	G251	48	2.99	1.66	0.27	6.57	2.16	Above
	G310	48	5.00	1.48	2.30	8.04	2.08	Above
STA-2	G335	52	5.17	1.59	2.10	8.79	2.34	Above
STA-3/4	G376B	50	4.91	2.02	1.05	9.39	2.53	Above
	G376E	50	4.89	1.87	1.99	11.50	2.67	Above
	G379B	50	4.32	1.98	0.42	10.10	2.92	Above
	G379D	50	5.76	2.84	2.08	15.80	3.03	Above
	G381B	50	5.45	2.28	1.20	12.10	3.32	Above
	G381E	50	6.10	2.80	2.23	13.60	3.45	Above
STA-5	G344A	48	4.43	2.31	0.97	9.34	2.27	Above
	G344B	48	3.85	2.08	0.67	11.20	2.51	Above
	G344C	45	4.00	2.20	1.14	10.90	2.59	Above
	G344D	45	4.36	2.82	0.62	10.80	2.78	Above
	G344E	25	2.79	2.35	0.45	7.60	2.46	Above
	G344F	24	3.14	2.20	0.21	7.41	2.41	Above
STA-6	***G352B***	***29***	***1.65***	***1.50***	***0.30***	***7.98***	***2.08***	***Below***
	G354C	***33***	***1.59***	***1.27***	***0.28***	***5.85***	***2.64***	***Below***
	G393B	***34***	***1.84***	***1.17***	***0.39***	***4.89***	***2.82***	***Below***

[a] Arithmetic mean

[b] Derived using the equation from Weaver (2004) that calculates the limit using water temperature and time of day data recorded at each monitoring location during each monitoring event.

[c] Indicates whether the mean annual DO level measured at an outflow station was above or below the SSAC limit. "Above" indicates that mean annual DO was equal to or greater than the mean annual SSAC limit.

Note: STA-1E and STA-1W, EFA permit number 0279499-001-EM

STA-2, EFA permit number 0126704-005-EM

STA-3/4, EFA permit number 0192895 and NPDES permit number FL0300195

STA-5, EFA permit number 0131842-006-GL

STA-6, EFA permit number 0236905-001 (PATS number 262918309)

In addition to assessing STA performance in WY2011 relative to the DO SSAC, a comparison of STA performance with the SSAC for the past four water years was also performed. **Figure 4** presents the mean annual residual DO levels for STA outflow for WY2007–WY2011. When mean annual DO levels are greater than the SSAC, the mean annual residuals (or difference between mean annual DO levels and SSAC) are positive (or greater than zero). All outflow stations at STA-1E, STA-2 and STA-3/4 and one outflow stations at STA-1W (e.g., G310) had positive residuals and exhibited continued improvement in DO levels since WY2007. In addition, outflow stations at STA-1W and STA-5 showed improved DO levels.

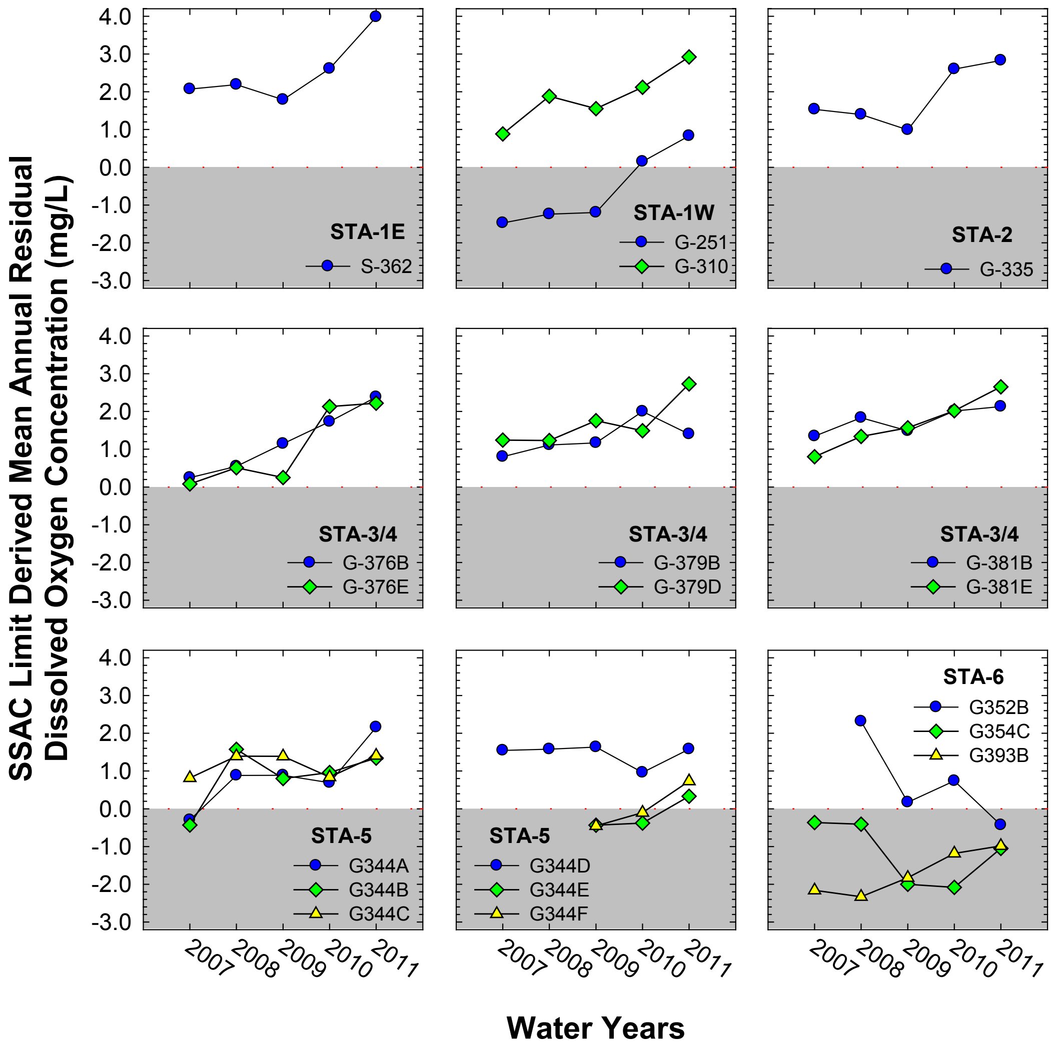

Figure 4. The mean annual residual DO plots at STA outflow stations for WY2007–WY2010. Mean annual residuals were computed as the difference between the mean annual DO and mean annual SSAC. Negative residuals indicate that an outflow station was below the SSAC limit, while positive residuals indicate that an outflow station was above the SSAC limit.

Compliance with the DO SSAC at marsh stations is analyzed in Chapter 3A of Volume I. A summary table for individual marsh stations in the Arthur R. Marshall Loxahatchee National Wildlife Refuge (Refuge), Water Conservation Areas (WCAs) 2 and 3, and Everglades National Park (ENP or Park) is provided in Appendix 3A-3 of Volume I. Based on the results of the SSAC analysis, six marsh stations did not pass the DO SSAC assessment. These stations are LOX16 and LOXA130 (Refuge), F1(WCA-2), CA316 and CA38 (WCA-3), and NE1 (ENP).

The two stations in the Refuge (LOX16 and LOXA130) that did not pass the DO SSAC assessment are shown in Chapter 3A, Figure 3A-1. Marsh station LOX16 is in the southern portion of the Refuge close to the S10A structure and 28 kilometers (km) from STA-1W and STA-1E discharges. The annual average DO concentrations for this station (mean = 2.1 mg/L) was lower than the annual SSAC limit by < 0.3 mg/L. Based on the DO levels of neighboring stations and its proximity to the STA-1W and STA-1E discharges (Chapter 3A, Figure 3A-1), it is not believed that the discharge from either STA resulted in the depressed DO levels observed at LOX16. Marsh station LOXA130 is located on the eastern side of the Refuge approximately 6.8 km from STA-1E (S362) and 0.5 km from the rim canal. Only two DO measurements were collected at LOXA130 during WY2011 (October 2010 and January 2011), probably due to drier than normal conditions in the Refuge. These two measured levels do not adequately reflect the DO regime for this marsh station. Further, stations located around LOXA130 exhibited higher annual DO concentrations and were in compliance with the SSAC limit. Station LOXA135 located in the L-40 canal immediately downstream of the STA-1E discharge exhibited an mean annual DO level of 5.7 mg/L. Based on this information, depressed DO levels measured at LOXA130 are not attributed to STA discharge.

Marsh station F1 in WCA-2 had a mean annual DO level of 2.7 mg/L (or 0.7 mg/L below the SSAC limit; see Appendix 3A-3). This marsh stations is 2 km downstream of the S-10C structure and 13 km east of the STA-2 discharge canal, L-6 (Chapter 3A, Volume I, Figure 3A-2). Based on the location of F1, it is evident that DO levels measured at this station were not influence by discharges from STA-2. The two marsh stations in WCA-3 (CA316 and CA38) are also not believed to have been influence by STA discharges. Both stations are approximately 20 km from the nearest STA discharge (see Chapter 3A, Volume I, Figure 3A-3). In addition, all other marsh stations located around these two marsh stations exhibited mean annual DO levels above the SSAC limit. The depressed DO levels may reflect natural processes as well as localized effects.

Mercury

During WY2011, there were no violations of the Florida Class III numerical water quality standard of 12 nanograms (ng) of total mercury per liter (THg/L) at any STA. The total outflow mercury load was lower than the inflow load. Currently, surface water samples are collected in STA-1E, STA-2, STA-5, and STA-6 for total mercury (THg) and methylmercury (MeHg) analysis. Surface water mercury monitoring within STA-3/4 and STA-1W has been terminated in accordance with the guidelines listed in the Protocol for Monitoring Mercury and Other Toxicants (SFWMD and FDEP, 2011) (see Attachment C). STA-1E is currently in Phase 2, Tier 1; STA-1W is in Phase 3, Tier 3; STA-2 is in Phase 2, Tier 1; STA-3/4 is in Phase 3, Tier 2; STA-5 northern and central flow-ways are in Phase 3, Tier 3; STA-5 Southern Flow-way is in Phase 2, Tier 1; STA-6, Cell 3 and Cell 5, are in Phase 3, Tier 3; and STA-6 Section 2 is in Phase 2, Tier 1.

During WY2011, the annual average mercury concentrations in mosquitofish (*Gambusia affinis*) and sunfish (*Lepomis* spp.) from all interior STA locations were similar to those in 2010. The lowest THg concentration in mosquitofish was found in STA-2 while the highest was found in STA-6. For sunfish, the lowest THg concentration was found in STA-1E and STA-2 and the highest was found in STA-5. For largemouth bass (LMB, *Micropterus salmoides*), similar to WY2010, sample collection was unsuccessful in STA-5 and STA-3/4 during the triennial collection phase. All STAs with available samples showed a decrease in Hg concentrations for age-standardized 2–3 year old bass [307–385 millimeters (mm) in length] with an average reduction of 47 percent from WY2010. The largest decrease in LMB THg concentration was observed in STA-1E, with a 65 percent reduction. Based on U.S. Fish and Wildlife Service (USFWS) and USEPA predator protection criteria, fish-eating wildlife foraging within all STAs appear to be at an overall moderate risk to mercury exposure. STA mercury performance criteria are evaluated on an annual basis. If respective action levels are exceeded, then corrective measures are taken in accordance with the FDEP-approved monitoring plans. Additional information on fish mercury concentrations, including spatial and temporal trends within and downstream of each STA, are presented in Attachment C of this volume.

Rotenberger Wildlife Management Area Restoration and STA Transect Monitoring

The District monitors adjacent wetland areas that receive discharges from the STAs, which include the Refuge (adjacent to STA-1E and STA-1W), WCA-2A (adjacent to STA-2), and the Rotenberger Wildlife Management Area (adjacent to STA-5) (**Figure 1**). Water and sediment quality, flow, stage and vegetation data are collected at inflow points and along prescribed transects to assess changes in conditions as water moves south. In accordance with the annual reporting requirements of related permits, these WY2011 data are provided in Attachment D.

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Attachment A: Specific Conditions and Cross-References

Tables A-1 through **A-4** provide specific conditions, actions taken, and cross-references for stormwater treatment areas constructed under the Everglades Forever Act (EFA). **Table A-1** provides this information for both STA 1 West (STA-1W) and STA 1 East (STA-1E), operation of which is authorized by Florida Department of Environmental Protection (FDEP) permit number 0279499-001-EM. STA-2 (FDEP permit 0126704-008-EM) and STA-3/4 (FDEP permit 0192895) information is provided in **Tables A-2** and **A-3**, respectively. **Table A-4** provides this information for both STA-5 and STA-6, which are authorized by FDEP permit 0131842-009-EM.

Table A-1. Specific conditions, actions taken, and cross-references presented in this report for Stormwater Treatment Area 1 West (STA-1W) and Stormwater Treatment Area 1 East (STA-1E), which are authorized under the Everglades Forever Act (EFA) and Florida Department of Environmental Protection (FDEP) permit 0279499-001-EM.

Specific Condition	Description	Applicable Phase	Action and Frequency	Reported in *2012 South Florida Environmental Report* (Note: "V1" = Volume 1, Chapter 5; "V3" = Volume 3, Appendix 3-1)			
				Table Number	Narrative (Page Number)	Figure Number	Attachment
6	Operational Improvements and Enhancements	Stabilization	None occurred during Water Year 2011 (WY2011) (May1, 2010–April 30, 2011)		V1: 59-62	V1: 32	
8	STA Operation Plan and Modifications	Stabilization	Upon completion of scheduled Long-Term Plan (LTP) enhancements and within 90 days of completion of additional LTP enhancements, submit revised operations plan (separate submittal). Submit data to justify modifications (as needed).				
8A	Minimum Water Level Targets to Avoid Dryout	Stabilization	See Volume 1, Chapter 5		V1: 57	V1: 30,31	
8B	Responding to Dryout Conditions	Stabilization	See Volume 1, Chapter 5		V3: 11 V1: 57	V1: 30,31	V3: C,D
8C	Maximum Water Level Targets	Stabilization	See Volume 1, Chapter 5				
8D	Operational Envelope	Stabilization	See Volume 1, Chapter 5	V3: 10	V3: 11 V1:4, 59		
8E	Phosphorus Removal Optimization	Stabilization	See Volume 1, Chapter 5		V1: 59		
8F	Hydropattern Restoration	Stabilization	See Volume 1, Chapter 5				V3: D
10A	Source Control Programs Implementation	Stabilization	See Volume II, Chapter 4 [Status of Source Controls in the Everglades Construction Project (ECP) Basins] and Volume II, Appendix 4-2				
10B	Source Control Programs Performance	Stabilization	See Volume II, Chapter 4 (Status of Source Controls in the ECP Basins) and Volume II, Appendix 4-2	V1: 1	V1: 10,12	V1: 4,6	
10C	Source Control Programs Improvements	Stabilization	Not applicable (NA)				
11	Water Quantity and Flooding Impacts	Stabilization	As needed				
12	Phosphorus Standard	Stabilization	In progress				

Table A-1. Continued.

Specific Condition	Description	Applicable Phase	Action and Frequency	Reported in 2012 SFER (Note: "V1" = Volume 1, Chapter 5; "V3" = Volume 3, Appendix 3-1)			
				Table Number	Narrative (Page Number)	Figure Number	Attachment
13	Start-Up Phase	Start-Up	NA		V3: 8,11		
13A	Establishment of Marsh Vegetation	Start-Up	NA				
13B	Start-Up Monitoring	Start-Up	NA				
13C	Phosphorus Start-Up Test	Start-Up	NA		V3: 8		
13D	Discharge Operation	Start-Up	NA		V3: 8		
13E	Initiation of Flow-Way (Stabilization and Routine Operation) and Discharge and Monitoring	Stabilization	NA				
14	Stabilization Phase	Stabilization	Submit strategies and timelines for corrective actions, as needed. Assess total phosphorus (TP) trends, annually. Remedial measures for no positive trend annually.		V1: 6,59	V1: 32	
15	Routine Operation Phase	NA	NA at this time				
16	Application of Interim Effluent Limit (IEL)	Stabilization		V3: 8,9, 10	V3: 8,11,16		
16A	Test compliance versus flow above specified minimum stages	Stabilization	Complied with in this report				
16B	IEL shall not apply during years with rain in excess of maximums	Stabilization	Complied with in this report				
16C	Deemed in compliance unless exceeds IEL as flow-weighted annual average	Stabilization	Complied with in this report	V3: 10			
17A	Internal	Stabilization	NA		V1: 20-22	V1: 11,12	
17A(1)	STA-1W Enhancements	Stabilization	NA		V1: 59	V1: 32	
17A(2)	STA-1E Enhancements	Stabilization	NA				

Table A-1. Continued.

Specific Condition	Description	Applicable Phase	Action and Frequency	Reported in 2012 SFER (Note: "V1" = Volume 1, Chapter 5; "V3" = Volume 3, Appendix 3-1)			
				Table Number	Narrative (Page Number)	Figure Number	Attachment
17B(1)	Convert STA1E to Flow-Through Operations	Stabilization	NA				
17B(2)	L-8 Diversion	Stabilization	NA at this time				
17B(3)	Additional Treatment Area	Stabilization	NA at this time				
17B(4)	Conveyance Improvements	Stabilization	NA at this time				
18	Water Quality-Based Effluent Limits (WQBEL)	Stabilization	Evaluate relationship twixt effluent load and Arthur R. Marshall Loxahatchee National Wildlife Refuge (Refuge) (TP) (separate submittal), one-time				
19	Operational Envelope	Stabilization	Compare actual to design inflow loads to evaluate effect on performance	V3: 10	V3: 11		
20	Comparison of Outflows to Inflows	Stabilization	In Volume I, Chapter 5 and Volume III, Appendix 3-1	V3: 10,13,14 V1: 1	V3: 16,20,21,60,100		V3: C,D
20A	If annual average outflow concentration does not cause Refuge > water quality standard (WQS), deemed in compliance	Stabilization			V3: 11,16		
20B	If not A but outflow < inflow, deemed in compliance	Stabilization		V3: 13,14	V3: 11,16		
20C	If not A or B, then deemed in non-compliance	Stabilization		V3: 13,14	V3: 11,16		
21	Dissolved Oxygen, evaluate compliance with site-specific alternative criteria on annual basis using statistics	Stabilization	In Volume III, Appendix 3-1	V3: 15	V3: 20–23	V3: 4	
22	Public Health, Safety or Welfare	Stabilization	NA				
23	Factors Outside of Permittee's Control	Stabilization	(Separate submittal)				
23A	Anomalous Rainfall	Stabilization	Dryout conditions occurred				
23B	Random Variation	Stabilization	None during WY2011				

Table A-1. Continued.

Specific Condition	Description	Applicable Phase	Action and Frequency	Reported in 2012 SFER (Note: "V1" = Volume 1, Chapter 5; "V3" = Volume 3, Appendix 3-1)			
				Table Number	Narrative (Page Number)	Figure Number	Attachment
23C	Other Factors	Stabilization	Lake Okeechobee and Water Conservation Area 3A were below regulation schedule				
23D	Emergency Conditions	Stabilization					
24	Turbidity Monitoring	Stabilization	Monitoring for Best Management Practices and WQS compliance (separate submittal), quarterly				
25	Monitoring Program	Stabilization					
25A	Long-Term Plan	Stabilization			V1: 71,72	V1: 35	V1: Appendix 5-5
25A(1)	Vegetation	Stabilization		V1: 12	V1: 51	V1: 27,28,29	V1: Appendix 5-3
25A(2)	Mercury	Stabilization	In Volume III, Appendix 3-1	V3: 7	V3: 23–24		V3: C
25A(3)	Routine Monitoring and Research	Stabilization		V1: 13	V1: 63		
26	Diversions	Stabilization	None occurred during WY2011				
26A	STA-1W Diversion Limit	Stabilization	None occurred during WY2011				
26B	STA-1E Diversion Limit	Stabilization	None occurred during WY2011				
27	Transects 1W	Stabilization			V1: 19,22	V1: 12	V3: D
28	Transects 1E	Stabilization					V3: D
29	Inspection Reports	Stabilization	Dike and pump inspections reports (semiannually). Levee and structure reports (annually). These reports are submitted under separate cover. The 2009 and 2010 annual levee and structure inspection reports were received by the FDEP. A revision to this report is being processed for signature at this time.				

Table A-1. Continued.

Specific Condition	Description	Applicable Phase	Action and Frequency	Reported in 2012 SFER (Note: "V1" = Volume 1, Chapter 5; "V3" = Volume 3, Appendix 3-1)			
				Table Number	Narrative (Page Number)	Figure Number	Attachment
30	Annual Monitoring Reports	Stabilization	Volume I, Chapter 5 and Volume III	V1: 1	V1: 9		
30A	Quality Assurance/Quality Control	Stabilization	Volume I, Chapter 5 and Volume III	V3: 7			V3: B
30B	Water Quality Data	Stabilization	Volume I, Chapter 5 and Volume III	V1: 1,7	V1: 10-13	V1: 4,6	V3: B
30C	Performance Evaluation	Stabilization	Volume I, Chapter 5 and Volume III	V3: 13,14 V1: 1	V3: 11,16–18 V1: 10,12	V1: 4,6	
30D	Herbicide and Pesticide Tracking	Stabilization	Volume I, Chapter 5 and Volume III	V3: 7	V1: 6,20		V3: E
30E	Implementation Schedules	Stabilization	NA	V1: 4	V1: 34	V1: 5,6	
31	Removal of Parameters	Stabilization	No parameters were removed during WY2011				
32	Addition of Parameters	Stabilization	No parameters were added during WY2011				
34	Emergency Suspension of Sampling	Stabilization	Suspended sampling for Cell 1A due to dryout conditions from March 17–August 18, 2011.				
35	Permit Renewal	Stabilization	NA for WY2011				
36	Permit Modification for STA Optimization	Stabilization	No permit modifications occurred during WY2011				

Table A-2. Specific conditions, actions taken, and cross-references presented for the STA-2 projects (EFA, FDEP permit 0126704-008-EM) in this report.

Specific Condition	Description	Applicable Phase	Action and Frequency	Reported in 2012 SFER (Note: "V1" = Volume 1, Chapter 5; "V3" = Volume 3, Appendix 3-1)			
				Table Number	Narrative (Page Number)	Figure Number	Attachment
3	Public Use	Stabilization	Not applicable (NA)		V1: 70		
5	Project Construction – Compartment B Build-Out	Stabilization	Currently under way	V1: 5,9	V1: 35,45,56	V1: 23,25	
6	Operation and Maintenance	Stabilization	NA				
9	Vegetation and Operational Enhancements	Stabilization		V3: 9	V3: 8,11 V1: 52,60	V1: 33	
11	STA Operation Plan and Modifications	Stabilization	Upon completion of scheduled Long-Term Plan (LTP) enhancements and within 90 days of completion of additional LTP enhancements, submit revised operations plan (separate submittal). Submit data to justify modifications (as needed).				
11A	Minimum Water Level Targets to Avoid Dryout	Stabilization	See Volume I, Chapter 5		V1: 57	V1: 30,31	
11B	Responding to Dryout Conditions	Stabilization	See Volume I, Chapter 5		V3: 11 V1: 43	V1: 30,31	V3: D
11C	Maximum Water Level Targets	Stabilization	See Volume I, Chapter 5				
11D	Operational Envelope	Stabilization	See Volume I, Chapter 5	V3: 10	V3: 11 V1: 4,59		
11E	Phosphorus Uptake Optimization	Stabilization	See Volume I, Chapter 5		V1: 59		
11F	Operational Plan Modification	Stabilization	Separate submittal				
12	Hydropattern Restoration	Stabilization	See Volume I, Chapter 5				V3: D
13A	Source Control Programs Implementation	Stabilization	See Volume II, Chapter 4 [Status of Source Controls in the Everglades Construction Project (ECP) Basins] and Volume II, Appendix 4-2				
13B	Source Control Programs Performance	Stabilization	See Volume II, Chapter 4 (Status of Source Controls in the ECP Basins) and Volume II, Appendix 4-2		V1: 14,22,23	V1: 7,13,14,15	

Table A-2. Continued.

Specific Condition	Description	Applicable Phase	Action and Frequency	Reported in 2012 SFER (Note: "V1" = Volume 1, Chapter 5; "V3" = Volume 3, Appendix 3-1)			
				Table Number	Narrative (Page Number)	Figure Number	Attachment
13C	Source Control Programs Improvements	Stabilization	NA				
14	Minimize Wetland Impacts	Stabilization					
15	Water Quantity and Flooding Impacts	Stabilization	As needed				
16	Phosphorus Standard	Stabilization	In progress				
17	Start-Up Phase	Start-Up	NA				
17A	Establishment of Marsh Vegetation	Start-Up	NA		V1: 60	V1: 33	
17B	Start-Up Monitoring	Start-Up	NA				
17C	Phosphorus Start-Up Test	Start-Up	NA		V3: 8		
17D	Discharge Operation	Start-Up	NA		V3: 8		
17E	Initiation of Flow-Way (Stabilization and Routine Operation) and Discharge and Monitoring	Stabilization	NA				
18	Stabilization Phase	Stabilization	Submit strategies and timelines for corrective actions as needed. Assess total phosphorus (TP) trends annually. Remedial measures for no positive trend annually		V1: 60	V1: 33	
19	Routine Operation Phase	NA	NA at this time				
20	Operational Envelope	Stabilization	Compare actual to design inflow loads to evaluate effect on performance	V3: 8	V3: 11		
21	Factors Outside of Permittee's Control	Stabilization					
21A	Anomalous Rainfall	Stabilization	Dryout conditions occurred				
21B	Random Variation	Stabilization	None during WY2011				

Table A-2. Continued.

Specific Condition	Description	Applicable Phase	Action and Frequency	Reported in 2012 SFER (Note: "V1" = Volume 1, Chapter 5; "V3" = Volume 3, Appendix 3-1)			
				Table Number	Narrative (Page Number)	Figure Number	Attachment
21C	Other Factors	Stabilization	Lake Okeechobee and Water Conservation Area 3A were below regulation schedule				
21D	Emergency Conditions	Stabilization					
22	Comparison of Outflows to Inflows	Stabilization	See Volume I, Chapter 5 and Volume III, Appendix 3-1	V3: 10,13,14, V1: 1	V3: 16,18,20,21		V3: C,D
22A	If annual average outflow concentration does not cause Arthur R. Marshall Loxahatchee National Wildlife Refuge > water quality standards (WQS), deemed in compliance	Stabilization			V3: 11,16		
22B	If not A but outflow < inflow, deemed in compliance	Stabilization		V3: 13,14	V3: 11,16		
22C	If not A or B, then deemed in non-compliance	Stabilization		V3: 13,14	V3: 11,16		
23	Dissolved Oxygen	Stabilization	See Volume III, Appendix 3-1	V3: 15	V3: 20–23		
24	Turbidity Monitoring	Stabilization	Monitoring for Best Management Practice and WQS compliance (separate submittal) quarterly				
25	Monitoring Program	Stabilization					
25A	Long-Term Plan	Stabilization			V1: 47,71,72	V1: 35	V1: Appendix 5-5
25A(1)	Aerial Vegetation Photographs and Mapping	Stabilization					V1: Appendix 5-3
25A(2)	Mercury Monitoring Program	Stabilization	See Volume III, Appendix 3-1	V3: 7	V3: 23–24		V3: C
25A(3)	Routine Monitoring and Research Program	Stabilization		V1: 13	V1: 63		
26	Diversions	Stabilization	No diversions occurred during WY2011				

Table A-2. Continued.

Specific Condition	Description	Applicable Phase	Action and Frequency	Reported in 2012 SFER (Note: "V1" = Volume 1, Chapter 5; "V3" = Volume 3, Appendix 3-1)			
				Table Number	Narrative (Page Number)	Figure Number	Attachment
27	Inspection Reports	Stabilization	Dike and pump inspections reports (semiannually). Levee and structure reports (annually). These reports are submitted under separate cover. The 2009 and 2010 annual levee and structure inspection reports were received by the FDEP on March 4 and April 6, 2011				
28	Annual Monitoring Reports	Stabilization	See Volume I, Chapter 5 and Volume III	V1: 1	V1: 9		
28A	Quality Assurance/ Quality Control	Stabilization	See Volume I, Chapter 5 and Volume III	V3: 7			V3: B
28B	Water Quality Data	Stabilization	See Volume I, Chapter 5 and Volume III	V1: 1,7	V1: 14,22,33	V1: 7,13,14,15	V3: B
28C	Performance Evaluation	Stabilization	See Volume I, Chapter 5 and Volume III	V3: 10,13,14	V3: 11,16–18 V1: 22,23	V1: 7,13,14,15	
28D	Herbicide and Pesticide Tracking	Stabilization	See Volume I, Chapter 5 and Volume III	V3: 7			V3: E
28E	Implementation Schedules	Stabilization		V1: 4	V1: 34	V1: 7	
29	Removal of Parameters	Stabilization	No parameters were removed during WY2011				
30	Addition of Parameters	Stabilization	No parameters were added during WY2011				
32	Emergency Suspension of Sampling	Stabilization	Suspended monitoring in Cell 1 due to dryout conditions from December 12, 2010 to June 29, 2011.				
33	Permit Renewal	Stabilization	NA for WY2011				
34	Permit Modification for STA Optimization	Stabilization	No permit modifications occurred during WY2011				

Table A-3. Specific conditions, actions taken, and cross-references presented for the STA-3/4 projects (EFA, FDEP Permit 0192895) in this report.

Specific Condition	Description	Applicable Phase	Action and Frequency	Reported in 2012 SFER (Note: "V1" = Volume 1, Chapter 5; "V3" = Volume 3, Appendix 3-1)			
				Table Number	Narrative (Page Number)	Figure Number	Attachment
10	STA Operation Plan and Modifications	Post Stabilization	Upon completion of scheduled Long-Term Plan (LTP) enhancements and within 90 days of completion of additional LTP enhancements, submit revised operations plan (separate submittal). Submit data to justify modifications as needed.		V1: 62		
10A	Minimum Water Level Targets to Avoid Dryout	Post Stabilization	See Volume I, Chapter 5		V1: 57	V1: 30,31	
10B	Responding to Dryout Conditions	Post Stabilization	See Volume I, Chapter 5		V1: 57 V3: 11	V1: 30,31	
10C	Maximum Water Level Targets	Post Stabilization	See Volume I, Chapter 5				
10D	Phosphorus Uptake Optimization	Post Stabilization	See Volume I, Chapter 5		V1: 59		
10E	Hydropattern Restoration	Post Stabilization	See Volume I, Chapter 5				
10E	Rotenberger Wildlife Management Area	Post Stabilization	Applicable STAs 3/4 and 5/6 only	V3: 7	V3: 24		V3: D
10F	Operations Plan Modification	Post Stabilization	Separate submittal				
11	Hydropattern Restoration	Post Stabilization	See Volume I, Chapter 5				
12A	Best Management Practices (BMP) Implementation and Monitoring	Post Stabilization	See Volume II, Chapter 4 [Status of Source Controls in the Everglades Construction Project (ECP) Basins] and Volume II, Appendix 4-2				
12B	BMP Fluctuations	Post Stabilization	See Volume II, Chapter 4 (Status of Source Controls in the ECP Basins) and Volume II, Appendix 4-2				
12C	BMP Performance	Post Stabilization	See Volume II, Chapter 4 (Status of Source Controls in the ECP Basins) and Volume II, Appendix 4-2				

Table A-3. Continued.

Specific Condition	Description	Applicable Phase	Action and Frequency	Reported in 2012 SFER (Note: "V1" = Volume 1, Chapter 5; "V3" = Volume 3, Appendix 3-1)			
				Table Number	Narrative (Page Number)	Figure Number	Attachment
13	Minimization of Wetland Impacts	Post Stabilization					
14	Water Quality and Flooding Impacts	Post Stabilization			V1: 7		
15	Structure Inspection Plan	Post Stabilization	Dike and pump inspections reports (semiannually). Levee and structure reports (annually). These reports are submitted under separate cover. The 2009 and 2010 annual levee and structure inspection reports were received by the FDEP on March 4 and April 6, 2011				
16	Start-Up Phase	Start-Up	Completed		V3: 8,11		
17	Stabilization Phase	Not Applicable (NA)	Submit strategies and timelines for corrective actions, as needed. Assess total phosphorus trends annually. Remedial measures for no positive trend annually				
18	Post-Stabilization/Normal Flow-Through Operation	Post-Stabilization					
19	Comparison of Outflows to Inflows	Post Stabilization	See Volume I, Chapter 5 and Volume III, Appendix 3-1	V3: 10,13,14 V1: 1	V3: 16,18,20,21 V1: 7		V3: C,D
19A	If annual average outflow concentration does not cause Arthur R. Marshall Loxahatchee National Wildlife Refuge > water quality standards, deemed in compliance	Post Stabilization		V3: 13,14	V3: 11,16		
19B	If not A but outflow < inflow, deemed in compliance	Post Stabilization		V3: 13,14	V3: 11,16		
19C	If not A or B, then deemed in non-compliance	Post Stabilization		V3: 13,14	V3: 11,16		
20	Dissolved Oxygen, evaluate compliance with site-specific alternative criteria on annual basis using statistics	Post Stabilization	See Volume III, Appendix 3-1	V3: 15	V3: 20–23	V3: 4	

Table A-3. Continued.

Specific Condition	Description	Applicable Phase	Action and Frequency	Reported in 2012 SFER (Note: "V1" = Volume 1, Chapter 5; "V3" = Volume 3, Appendix 3-1)			
				Table Number	Narrative (Page Number)	Figure Number	Attachment
22	Factors Outside of Permittee's Control	Post Stabilization					
22A	Anomalous Rainfall	Post Stabilization	Dryout conditions occurred				
22B	Natural Background	Post Stabilization					
22C	Random Variation	Post Stabilization	None during WY2011				
22D	Vegetation Conditions	Post Stabilization		V1: 12	V1: 52,61,62	V1: 27,28	V1: Appendix 5-3
22E	Other Factors	Post Stabilization	Lake Okeechobee and Water Conservation Area 3A were below regulation schedule				
23	Emergency Conditions	Post Stabilization					
25	Permit Modifications for Technological Advances	Post Stabilization	No permit modifications occurred during WY2011				
26	Permit Modifications for Design Changes	Post Stabilization	No permit modifications occurred during WY2011				
27	Permit Modifications for Long-Term Compliance	Post Stabilization	No permit modifications occurred during WY2011				
29	Monitoring Program	Post Stabilization					
29A	Aerial Vegetation Photographs and Mapping	Post Stabilization					
29B	Research and Monitoring Program	Post Stabilization		V1: 13	V1: 63		
30	Annual Monitoring Reports	Post Stabilization	See Volume I, Chapter 5 and Volume III	V1: 1			
30A	Quality Assurance/Quality Control	Post Stabilization	See Volume I, Chapter 5 and Volume III	V3: 7			V3: B
30B	Water Quality Data	Post Stabilization	See Volume I, Chapter 5 and Volume III	V1: 1 V3: 7	V1: 15,16	V1: 8	V3: B

Table A-3. Continued.

Specific Condition	Description	Applicable Phase	Action and Frequency	Reported in 2012 SFER (Note: "V1" = Volume 1, Chapter 5; "V3" = Volume 3, Appendix 3-1)			
				Table Number	Narrative (Page Number)	Figure Number	Attachment
30C	Hydraulic Retention Time	Post Stabilization	See Volume I, Chapter 5 and Volume III	V1: 1	V1: 7		
30D	Performance Evaluation	Post Stabilization	See Volume I, Chapter 5 and Volume III	V3: 13 V1: 1	V3: 11,16–18 V1: 15,16	V1: 8	
30E	Herbicide and Pesticide Tracking	Post Stabilization	See Volume I, Chapter 5 and Volume III	V3: 7			V3: E
30F	Implementation Schedules	Post Stabilization	NA	V1: 4	V1: 34	V1: 8	
31	Removal of Parameters	Post Stabilization	No parameters were removed during WY2011				
32	Addition of Parameters	Post Stabilization	No parameters were added during WY2011				
34	Emergency Suspension of Sampling	Post Stabilization	Suspension of sampling at Cell 1A due to dryout from March, 21–June 28, 2011.				

Table A-4. Specific conditions, actions taken, and cross-references presented for the STA-5/6 projects (EFA, permit 0131842-009-EM) in this report.

Specific Condition	Description	Applicable Phase	Action and Frequency	Reported in 2012 SFER (Note: "V1" = Volume 1, Chapter 5; "V3" = Volume 3, Appendix 3-1)			
				Table Number	Narrative (Page Number)	Figure Number	Attachment
3	Public Use	Stabilization			V1: 70		
4	Project Construction - Compartment C	Stabilization	Currently under way	V1: 5,11	V1: 35,47,56	V1: 24,26	
5	Operation and Maintenance	Stabilization			V1: 20		
8	Vegetation and Operational Enhancements	Stabilization		V3: 9 V1: 12	V3: 11,16–18 V1: 51-53	V1: 28	
10	STA Operation Plan and Modifications	Stabilization	Upon completion of scheduled Long-Term Plan (LTP) enhancements and within 90 days of completion of additional LTP enhancements, submit revised operations plan (separate submittal). Submit data to justify modifications (as needed).				
10A	Minimum Water Level Targets to Avoid Dryout	Stabilization	See Volume I, Chapter 5		V1: 58,59	V1: 30,31	
10B	Responding to Dryout Conditions	Stabilization	See Volume I, Chapter 5		V3: 11 V1: 58,59	V1: 30,31	V3: D
10C	Maximum Water Level Targets	Stabilization	See Volume I, Chapter 5		V1: 27		
10D	Operational Envelope	Stabilization	See Volume I, Chapter 5	V3: 10	V3: 11 V1: 4,59		
10E	Phosphorus Uptake Optimization	Stabilization	See Volume I, Chapter 5		V1: 59		
10F	Operations Plan Modifications	Stabilization	See Volume I, Chapter 5				
11	Hydropattern Restoration	Stabilization	See Volume I, Chapter 5				V3: D
12	Rotenberger Wildlife Management Area Restoration	Stabilization	Applicable STAs 3/4 and 5/6 only	V3: 7	V3: 24		V3: D
13	Implementation of Source Control Programs	Stabilization	Not applicable (NA)				
13A	Implementation	Stabilization	See Volume II, Chapter 4 [Status of Source Controls in the Everglades Construction Project (ECP) Basins] and Volume II, Appendix 4-2		V1: 59		

Table A-4. Continued.

Specific Condition	Description	Applicable Phase	Action and Frequency	Reported in 2012 SFER (Note: "V1" = Volume 1, Chapter 5; "V3" = Volume 3, Appendix 3-1)			
				Table Number	Narrative (Page Number)	Figure Number	Attachment
13B	Performance	Stabilization	See Volume II, Chapter 4 (Status of Source Controls in the ECP Basins) and Volume II, Appendix 4-2	V1: 1	V1: 9	V1: 9,10	
13C	Improvements	Stabilization	NA				
14	Minimization of Wetlands Impacts	Stabilization					
15	Water Quantity and Flooding Impacts	Stabilization	As needed				
16	Phosphorus Standard	Stabilization					
17	Start-Up Phase	Start-Up	NA		V3: 8,11		
17A	Establishment of Marsh Vegetation	Start-Up	NA		V1: 59		
17B	Start-Up Monitoring	Start	NA				
17C	Phosphorus Start-Up Test	Start	NA		V3: 8		
17D	Discharge Operation		NA		V3: 8		
17E	Initiation of Flow-Way (Stabilization and Routine Operation) and Discharge and Monitoring	Stabilization	NA				
18	Stabilization Phase	Stabilization Phase	Submit strategies and timelines for corrective actions, as needed. Assess total phosphorus (TP) trends annually. Remedial measures for no positive trend annually			V1: 9,10	
19	Routine Operation Phase	NA	NA at this time				
20	Operational Envelope	Stabilization	Compare actual to design inflow loads to evaluate effect on performance annually	V3: 10	V3: 11		
21	Factors Outside of Permittee's Control	Stabilization					

Table A-4. Continued.

Specific Condition	Description	Applicable Phase	Action and Frequency	Reported in 2012 SFER (Note: "V1" = Volume 1, Chapter 5; "V3" = Volume 3, Appendix 3-1)			
				Table Number	Narrative (Page Number)	Figure Number	Attachment
21A	Anomalous Rainfall	Stabilization	Dryout conditions occurred				
21B	Random Variation	Stabilization	None during WY2011				
21C	Other Factors	Stabilization	Lake Okeechobee and Water Conservation Area 3A were below regulation schedule				
21D	Emergency Conditions	Stabilization	Dryout conditions occurred				
22	Comparison of Outflows to Inflows	Stabilization	See Volume I, Chapter 5 and Volume III, Appendix 3-1	V3: 10,13,14 V1: 1	V3: 16,18,20,21 V1: 7		V3: C,D
22A	If annual average outflow conc. does not cause Arthur R. Marshall Loxahatchee National Wildlife Refuge > water quality standards (WQS), deemed in compliance	Stabilization		V3: 12,13	V3: 11,16		
22B	If not A but outflow < inflow, deemed in compliance	Stabilization		V3: 13	V3: 11,16		
22C	If not A or B, then deemed in non-compliance	Stabilization		V3: 13	V3: 11,16		
23	Dissolved Oxygen	Stabilization	See Volume III, Appendix 3-1	V3: 15	V3: 20–23		
24	Turbidity Monitoring	Stabilization	Monitoring for Best Management Practice and WQS compliance (separate submittal) quarterly				
25	Monitoring Program	Stabilization					
25A	Long-Term Plan	Stabilization			V1: 71,72	V1: 35	
25A(1)	Aerial Vegetation Photographs and Mapping	Stabilization					
25A(2)	Mercury Monitoring Program	Stabilization	See Volume III, Appendix 3-1	V3: 7	V3: 23–24		V3: C
25A(3)	Routine Monitoring and Research Program	Stabilization		V1: 13	V1: 63		
26	Diversions	Stabilization					

Table A-4. Continued.

Specific Condition	Description	Applicable Phase	Action and Frequency	Reported in 2012 SFER (Note: "V1" = Volume 1, Chapter 5; "V3" = Volume 3, Appendix 3-1)			
				Table Number	Narrative (Page Number)	Figure Number	Attachment
27	Inspection Reports	Stabilization	Dike and pump inspections reports (semiannually). Levee and structure reports (annually). These reports are submitted under separate cover. The 2009 and 2010 annual levee and structure inspection reports were received by the FDEP on March 4 and April, 2011				
28	Annual Monitoring Reports	Stabilization	See Volume I, Chapter 5 and Volume III	V1: 1	V1: 6,7	V1: 16,17	
28A	Quality Assurance/Quality Control	Stabilization	See Volume I, Chapter 5 and Volume III	V3: 7			V3: B
28B	Water Quality Data	Stabilization	See Volume I, Chapter 5 and Volume III		V1: 6,7,26	V1: 16,17	V3: B
28C	Performance Evaluation	Stabilization	See Volume I, Chapter 5 and Volume III	V3: 13 V1: 1	V3: 11,16–18 V1: 26	V1: 16,17	
28D	Herbicide and Pesticide Tracking	Stabilization	See Volume I, Chapter 5 and Volume III	V3: 7			V3: E
28E	Implementation Schedules	Stabilization				V1: 9,10	
29	Removal of Parameters	Stabilization	No parameters were removed during WY2011				
30	Addition of Parameters	Stabilization	No parameters were added during WY2011				
32	Emergency Suspension of Sampling	Stabilization	Suspension of sampling for STA-5 for Cells 1A, 2A, 2B, 3A and 3B and STA-6 Cells 3 and 5 due to dryout. STA-6 offline due to construction of Compartment C.				
33	Permit Renewal	Stabilization	NA for WY2011				
34	Permit Modification for STA Optimization	Stabilization	No permit modifications occurred during WY2011				

Attachment B: Supporting Information on Water Quality Data for the Everglades STAs and Downstream Transects for Water Year 2011

Contact: Guy Germain

This project information is required by Specific Conditions 27, 28, and 30(b) for Stormwater Treatment Area (STA) 1 West (STA-1W), STA-1 East (STA-1E), and STA-3/4, and Specific Conditions 25(b)3 and 28(b) for STA-2, STA-5, and STA-6 for the Everglades Forever Act permits and the Administrative Order for STA-5 and STA-6 under the Findings of Fact Number 20 for each of the above-mentioned STAs. This information is available upon request.

Attachment C: Annual Permit Compliance Monitoring Report for Mercury in the STAs

Ben Gu and Nicole Howard

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In addition to the information provided in this attachment, additional supplemental information is required by Specific Conditions 27, 28, and 30(b) for Stormwater Treatment Area (STA) 1 West (STA-1W), STA-1 East (STA-1E), and STA-3/4, and Specific Conditions 25(b)3 and 28(b) for STA-2, STA-5, and STA-6 for the Everglades Forever Act permits and the Administrative Order for STA-5 and STA-6 under the Findings of Fact Number 20 for each of the above-mentioned STAs. This supporting information is available upon request.

KEY FINDINGS AND OVERALL ASSESSMENT

This report summarizes data from compliance monitoring of mercury (Hg) storage, reduction, release, and biomagnification in the Stormwater Treatment Areas (STAs) for Water Year 2011 (WY2011) (May 1, 2010–April 30, 2011). Key findings are as follows:

1. **All STAs:** There were no violations of the Florida Class III numerical water quality standard of 12 nanograms (ng) of total mercury per liter (THg/L) during the reporting year at any of the STAs and the projects have met all action level requirements listed in the Protocol for Monitoring Mercury and Other Toxicants (SFWMD and FDEP, 2011). With the exception of three specimens of sunfish from STA-1E, total mercury concentrations in mosquitofish, sunfish, and largemouth bass in STA interior stations for WY2011 did not exceed U.S. Fish and Wildlife Service (USFWS) and U.S. Environmental Protection Agency (USEPA) predator protection criteria.
2. **STA-1W:** Since its start as the Everglades Nutrient Removal project in 1994, methylmercury (MeHg) biomagnification in resident large-bodied fish such as sunfish (*Lepomis* spp.) and largemouth bass (*Micropterus salmoides*) in STA-1W has remained relatively constant over the monitoring period at levels almost an order of magnitude lower than those observed in fish from downstream Everglades sites and lower than the other STAs. Mercury levels in STA-1W in fish across trophic levels did not pose a threat to fish-eating wildlife based on USFWS and USEPA predator protection criteria. Consistent with the Protocol for Monitoring Mercury and Other Toxicants (SFWMD and FDEP, 2011), all mercury monitoring was terminated in STA-1W in 2009 (see the *Phase 3: Operational Monitoring* section of this Attachment).

[2] Contributed as SFWMD staff during the draft SFER production cycle.

3. **STA-1E:** During WY2011, surface water total mercury (THg) and MeHg inflow and outflow concentrations were comparatively moderate in STA-1E. THg and MeHg loads in outflow were less than inflow. Mercury levels in mosquitofish (*Gambusia holbrooki*) from the interior marshes were the third lowest of all STAs. Sunfish showed the highest mercury levels among STAs due to a single high value. Mercury levels in largemouth bass were one of the lowest. Regarding risks to fish-eating wildlife, mosquitofish (trophic level 2 or 3) from the interior locations did not exceed the USEPA's 77 nanograms per gram (ng/g) predator protection criterion; however, mosquitofish from the downstream locations did exceed the criterion in three of four quarters. Most sunfish from the interior marsh of STA-1E had mercury concentrations below both USFWS (100 ng/g) and USEPA (77 ng/g) criteria for trophic level (TL) 3 fish. However, nearly all downstream sunfish assayed had concentrations greater than 77 ng/g. The average THg level in largemouth bass from the interior marsh did not exceed the USEPA criterion (346 ng/g) for TL 4 fish species. However, the only specimen collected from downstream showed THg level twice as high as the USEPA criterion.

4. **STA-2:** During WY2011 in STA-2, both THg and MeHg were among the lowest concentrations in both inflow and outflow relative to other STAs. Although THg and MeHg were at the highest loading rates among STAs, STA-2 displayed the highest MeHg load reduction. The THg level in mosquitofish from STA-2 marsh interior and was the lowest among actively monitored STAs. Similarly, sunfish and largemouth bass THg concentrations from interior cells were also the lowest among the STAs. All mosquitofish within and downstream of STA-2 contained mercury levels less than both the USFWS and USEPA predator protection criteria for TL 3 species. Similarly, THG levels in all sunfish and largemouth bass from the interior and downstream locations were below the USFWS criterion of 100 ng/g for TL 2 or TL 3 species and 346 ng/g for TL 4 fish species, respectively.

5. **STA-3/4:** In WY2011, tissue Hg levels in mosquitofish from STA-3/4 were the same as STA-2 and the lowest among STAs and lower than the USEPA criterion (77 ng/g). There are no data to report for sunfish and largemouth bass for WY2011 since large-bodied fish in STA-3/4 are collected on a triennial basis. The next large-bodied fish collection is scheduled for WY2012. Consistent with the Protocol for Monitoring Mercury and Other Toxicants (SFWMD and FDEP, 2011), THg and MeHg surface water sampling is no longer conducted in STA-3/4.

6. **STA-5:** Water-column concentrations of both THg and MeHg were comparatively moderate for the inflows and outflows of STA-5 during WY2011. The inflow loading for THg and MeHg were the lowest among STAs. At the outflow, there was a net reduction of THg but not for MeHg due to a single high MeHg concentration. Mosquitofish in the interior marsh and at the downstream site had low THg levels. In contrast with previous years, sunfish had the highest THg levels for both the interior and downstream site. Only one sunfish (bluegill, *Lepomis macrochirus*) was collected from the interior marsh and it had THg level below the USFWS criterion of100 ng/g. However, all five sunfish samples from the downstream site were warmouth sunfish (*Lepomis gulosus*) with a THg level 1.5 times greater than the USFWS criterion of 100 ng/g. Similar to WY2010, despite a concerted collection effort, no largemouth bass were caught.

7. **STA-6:** THg and MeHg concentration in the STA-6 inflow were moderate, but the loads were the second highest among STA inflows. However, load reductions for both THg and MeHg were among the greatest compared to other STAs. Overall, this STA continues to have some of the highest THg levels in all fish species. Mosquitofish from the interior and downstream locations did not exceed the 77 ng/g TL 2-3 USEPA criterion. Sunfish from the interior marsh did not exceed the USEPA TL 3 criterion and sunfish from the downstream

site marginally exceeded the USFWS 100 ng/g criterion. Largemouth bass from the interior marsh did not exceed USEPA criterion for TL 4 fish species (346 ng/g), but those collected at the downstream site were above the criterion.

INTRODUCTION

This attachment contains the annual permit compliance monitoring report for mercury (Hg) in the Everglades Stormwater Treatment Areas (STAs) by the South Florida Water Management District (District or SFWMD) and summarizes the mercury-related reporting requirements of Florida Department of Environmental Protection (FDEP) permit number 0279499-001-EM [STA 1 West (STA-1W) and STA 1 East (STA-1E)], 0126704-008-EM (STA-2), 192895 (STA-3/4) and 0131842-009-EM (STA-5/6 and Compartment C) under the Everglades Forever Act (EFA) [Chapter 373.4592, Florida Statutes (F.S.)].

This report summarizes the results of monitoring in Water Year 2011 (WY2011) (May 1, 2010–April 30, 2011) for surface water and fish in STA-1E, STA-1W, STA-2, STA-3/4, STA-5, and STA-6. The results of mercury monitoring at far-field sites downstream of the STAs in accordance with these permits, as well as non-Everglades Construction Project (non-ECP) discharge structures (permit number 06.502590709), are reported separately in Appendix 3-2, Attachment F of this volume.

This report consists of key findings and overall assessment, an introduction and background, a summary of the Mercury Monitoring and Assessment Program (MMAP), and monitoring results. The background section briefly summarizes previously identified and published concerns regarding possible impact of STA operations on South Florida's mercury problem. The following sections summarize MMAP, quality assurance/quality control (QA/QC), and statistical applications, followed by a summary and discussion of monitoring results. The monitoring results section comprises the bulk of new discussion. The last section of this attachment provides updates on mercury monitoring network optimization in each STA.

BACKGROUND

STAs are constructed wetlands designed to remove phosphorus from stormwater runoff originating from upstream agricultural areas and other areas, including Lake Okeechobee releases. The original six STAs, totaling over 65,000 acres and approximately 45,000 acres of effective treatment area, were built as part of the Everglades Construction Project (ECP) authorized under the EFA (Chapter 373.4592, F.S.).

Even before passage of the EFA in 1994, concerns were being raised that attempts to reduce downstream eutrophication could inadvertently aggravate the mercury problem known to be present in the Everglades (Ware et al., 1990; Mercury Technical Committee, 1991). These concerns stemmed from studies in other areas that showed flooded soils in new impoundments were sources of inorganic mercury (Cox et al., 1979). Of greater concern, studies also showed wetlands to be a significant site of mercury methylation.

Methylmercury (MeHg) is more bioaccumulative and toxic than the inorganic or elemental form of mercury (St. Louis et al., 1994; Rudd, 1995). Decomposition of flooded terrestrial vegetation and soil carbon in new reservoirs was reported to stimulate the sulfate-reducing bacteria that methylate inorganic mercury (Kelly et al., 1997; Paterson et al., 1998). Environments that favor methylation also drive bioaccumulation. For example, Paterson et al. (1998) found that annual fluxes of MeHg increased 10 to 100 times through a zooplankton community after impoundment.

Newly created reservoirs were also found to contain fish with elevated mercury levels (Abernathy and Cumbie, 1977; Bodaly et al., 1984; Bodaly and Fudge, 1999). This so-called “reservoir effect” can persist for several decades after initial soil flooding (Bodaly et al., 1984; Verdon et al., 1991; Fink et al., 1999). For instance, Verdon et al. (1991) reported that total mercury levels in northern pike (*Esox lucius*) increased from 0.61 to 2.99 parts per million (ppm or milligrams per liter) and continued to increase nine years after the initial soil flooding. Given these observations, Kelly et al. (1997) recently recommended that in siting a new reservoir total land area flooded should be minimized and flooding wetlands, which contain more organic carbon than uplands, should be avoided.

However, applying these recommendations directly to the Everglades is problematic because most of the observations were made in deepwater lakes or reservoirs in temperate regions. In a report to the SFWMD on the potential impact of nutrient removal on the Everglades mercury problem, Watras (1993) stated that “the boreal and temperate watersheds, wetlands and reservoirs studied to date are very different geologically, hydrologically, meteorologically and ecologically from the subtropical systems in the Everglades.” Watras recommended monitoring and integrating mass balance and process-oriented studies to understand how this subtropical system would behave. Such studies were initiated in 1994 with the start-up of the prototype STA, the Everglades Nutrient Removal (ENR) Project (later incorporated within Stormwater Treatment Area 1 West). Baseline collections at the ENR Project found no evidence of MeHg spikes in either surface water (PTI, 1994 attributed to KBN, 1994a; Watras, 1993 and 1994) or resident fish [mosquitofish (*Gambusia holbrooki*) and largemouth bass (*Micropterus salmoides*)] (PTI, 1994 attributed to KBN, 1994b].

During the first two years of operation, median concentrations of total mercury (THg) and MeHg in unfiltered surface water were reported to be 0.81 and 0.074 nanograms per liter (ng/L), respectively (Miles and Fink, 1998). These low levels persisted in later years: from January 1998 through April 1999, median water-column concentrations in the interior marsh (i.e., excluding inflows and outflows) were 0.81 ng THg/L and 0.04 ng MeHg/L (Rumbold and Fink, 2002b). Resident fish also continued to have only low mercury levels: 8–75 nanograms per gram (ng/g) in mosquitofish, and 100–172 ng/g largemouth bass age-standardized to three years (age-3) (Miles and Fink, 1998; SFWMD, 1999a; Lange et al., 1999). Finally, a mass balance assessment found the ENR Project to be a net sink for both THg and MeHg, removing approximately 70 percent of the inflow mass (Miles and Fink, 1998). Nonetheless, to provide continuing assurance that EFA implementation does not exacerbate the mercury problem, the FDEP construction and operating permits issued for the STAs require the SFWMD to monitor levels of THg and MeHg in various abiotic (e.g., surface water and sediment) and biotic (e.g., fish and bird tissues) media, both within STAs and the downstream receiving waters (see also Appendix 3-2, Attachment F of this volume).

Results from monitoring programs at STAs constructed and operated since 1999 (after the ENR Project) have revealed transitory spikes in MeHg production (see previous reports published by the SFWMD, including Rumbold and Fink, 2002b). Combined with the results of a 1999 field study on the effect that drought and muck fires had on mercury cycling in the Everglades (Krabbenhoft and Fink, 2001), these monitoring results demonstrated that spikes can sometimes occur following dryout and rewetting. Accumulating evidence suggests that oxidation of sulfide pools in the sediments (e.g., organic sulfide, disulfides, acid volatile sulfides) during dryout can lead to increased methylation upon rewetting of the marsh either by providing free sulfate, which stimulates sulfate-reducing bacteria or, in highly sulfidic areas, by reducing porewater sulfide, which can inhibit methylation (Benoit et al., 1999a and b).

SUMMARY OF THE MERCURY MONITORING AND ASSESSMENT PROGRAM

The following section provides information on current monitoring and reporting activities used for the District's Mercury Monitoring and Assessment Program (MMAP) (SFWMD, 1999c). The MMAP was initially developed for the Everglades Construction Project, the Central and Southern Florida Project, and the Everglades Protection Area (EPA). The SFWMD developed and submitted a plan to the FDEP, the U.S. Environmental Protection Agency (USEPA), and the U.S. Army Corps of Engineers (USACE) in compliance with the permit requirements (SFWMD, 1999b) and was later approved. Details on the procedures for ensuring the quality of and accountability for data generated under this monitoring program were set forth in the SFWMD's Quality Assurance Project Plan (QAPP) for the Mercury Monitoring and Assessment Program (SFWMD, 1999c), which was also approved on issuance of the FDEP permit. QAPP revisions were approved by the FDEP on June 7, 1999.

On February 13, 2006, a revised sampling protocol was approved by the FDEP and the District which was entitled A Protocol for Monitoring Mercury and Other Toxicants (Protocol). Adapted from Rumbold and Pfeuffer (2005), this new plan was developed to replace the initial plan developed under the MMAP. The primary drivers of the Protocol are to (1) streamline sampling procedures, (2) eliminate the need for extended, open-ended sampling activities, and (3) phase out surface water sampling. The Protocol continues to use the QAPP modified in 1999. As of May 16, 2008, all mercury monitoring within each STA follows the Protocol. On September 29, 2009, additional modifications to the Protocol were approved by FDEP that involved altering the fish collection length for largemouth bass to the current range of 307–385 millimeters (mm). The Protocol was formally updated in April 2011 (SFWMD and FDEP, 2011) to reflect the agreed-upon change in the size of fish collected for analysis and is in agreement with CERP Guidance Memorandum 42 on the same subject. The change in size reflects a more appropriate age for evaluating contaminant concentrations.

PROTOCOL FOR MONITORING MERCURY AND OTHER TOXICANTS

Phase 1: Baseline Collection and Assessment

Phase 1 baseline collection and assessment is meant to provide information regarding the likelihood that a constructed facility under an EFA project may exacerbate or create a mercury (or other toxicant) problem. Identifying problematic areas will allow managers to avoid sites or areas that may present risk.

Phase 1 is operated under three levels: Tier 1 (Compilation and Review of Available Data), Tier 2 (Field Sampling), and Tier 3 (Bioaccumulation Tests and Dynamic Modeling).

Under Tier 1, the Environmental Site Assessment (ESA) is evaluated to determine (1) if any corrective actions were taken during the ESA, (2) there was potential for contamination, and/or (3) the time interval between the ESA and project construction. If information data gaps exist, or where the preponderance of baseline data demonstrates a potential problem, then Phase 1, Tier 2 or Tier 3 is initiated.

Under Phase 1, Tier 2, five representative soil/sediment cores are collected and analyzed from five locations within each operable unit (i.e., OU- each independently operated treatment train) or each 1,000 acre parcel, whichever is smaller, At each location, three cores from the 0-to-4 cm horizon are collected and composited as a single soil sample and analyzed for several constituents that help evaluate MeHg production and mercury bioaccumulation. **Figure C-1** summarizes sediment collection under Phase 1 to date. Along with sediment, mosquitofish and large-bodied fish are collected and analyzed for THg within the same operating unit (OU). The methods used for fish and sediment collection are described below.

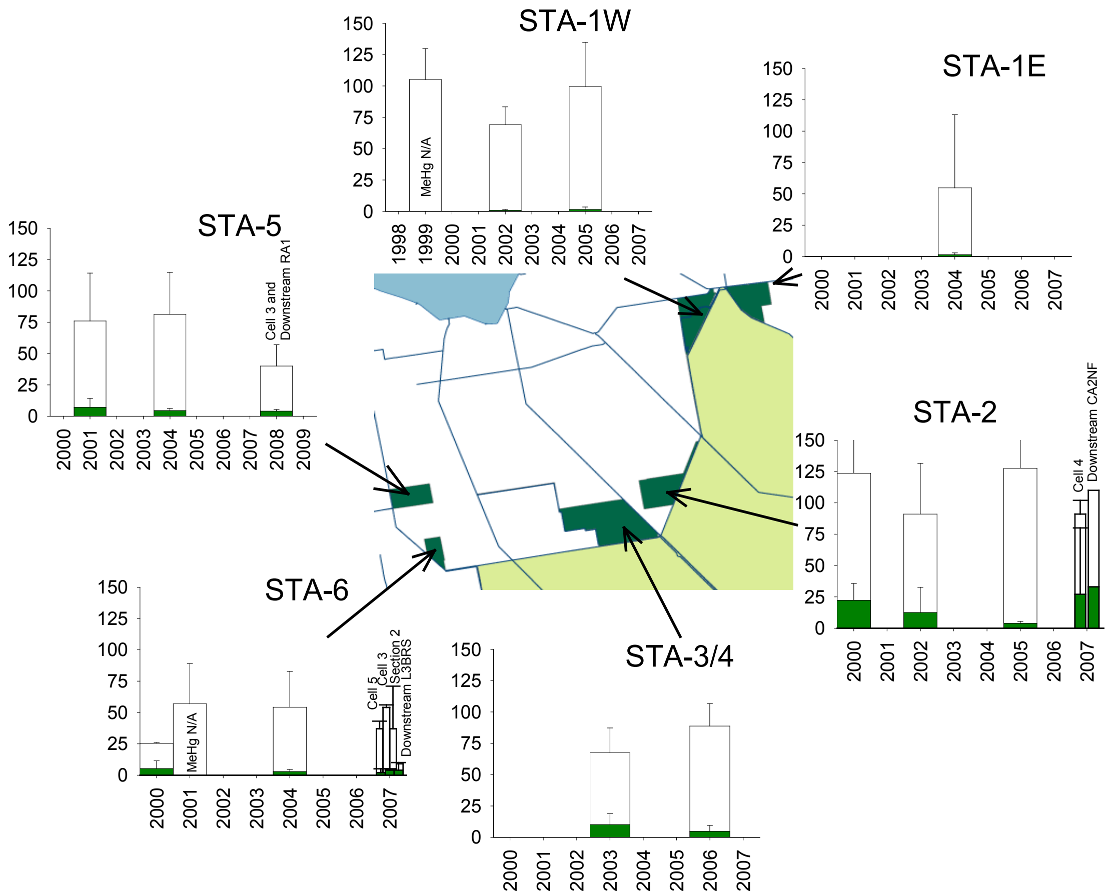

Figure C-1. Mean concentration [+1 standard deviation (SD); dry-weight basis] of total mercury (THg) in nanograms per gram (ng/g) and methylmercury (MeHg) (10x ng/g) in sediment cores (n = 5 per cell/section; 0–10 centimeters deep) collected from each stormwater treatment area (STA) to start-up. Crossed-hatched columns indicate collections following the mercury monitoring program (SFWMD and FDEP, 2011). These are the most recent datasets on THg and MeHg for sediment collections in the STAs.

Phase 1, Tier 3 is initiated if at least one of the following occurs: (1) absolute concentrations of MeHg or average percent MeHg in sediments/soils from an OU exceeds the 90 percent upper confidence level of the basin average or, if not available, the 75th percentile concentration (percent MeHg) for all basins; or (2) ambient fish collected with the project boundary demonstrate excessive bioaccumulation that exceeds the 90 percent upper confidence level of the basinwide average or, if that value is not available, the 75th percentile concentration for all basins. Phase 1, Tier 3 is used to evaluate extending uncertainties surrounding mercury bioaccumulation. This is accomplished through the use of bioaccumulation testing and modeling.

Phase 2: Monitoring During Three-Year Stabilization Period

If Phase 1 monitoring is not necessary, then Phase 2, Tier 2 monitoring can occur following OU flow-through. Under Phase 2, Tier 1, one surface water sample is collected and analyzed for THg and MeHg on a quarterly basis at inflow and outflow structures. Additionally, at least 100 mosquitofish are collected quarterly from multiple locations within each OU to be composited and analyzed for THg. Sunfish (*Lepomis* spp.) and largemouth bass (LMB) ($n \geq 5$) are collected and analyzed for THg annually.

Six criteria are used to evaluate the performance of each OU with respect to mercury bioaccumulation and enhancement (SFWMD and FDEP, 2011). These criteria are related to long-term trends in fish tissue concentrations, surface water THg/MeHg loading, and water quality standards.

If any of the action criteria is exceeded, then Phase 2, Tier 2 is triggered. Tier 2 sequentially involves (1) notifying the permitting authority, (2) resampling the media that triggered Tier 2 monitoring, (3) evaluating the spatial and temporal extent of the mercury bioaccumulation/enhancement accompanied with bioaccumulation modeling, and (4) developing an adaptive management plan.

Phase 3: Operational Monitoring

If after the first three years of monitoring, neither downstream loading nor residue levels in fish have exceeded action levels in the two years prior, then the project can move into Phase 3, Tier 1. Under Phase 3, Tier 1, (1) surface water sampling is discontinued, (2) the frequency of mosquitofish collection is reduced to semiannually, and (3) the frequency of large-bodied fish collection is reduced to one collection every three years. If the conditions are not met within the first three years, then criteria can be reevaluated annually based on the preceding two-year period.

Phase 3, Tier 2 is triggered if (1) the annual average THg levels in mosquitofish progressively increase over time, (2) any semiannual mosquitofish composite exceeds the 90 percent upper confidence level of the basin-wide annual average (or, if basin-specific data are lacking, exceeds the 75th percentile concentration for the period of record for all basins), or (3) if triennial monitoring of large-bodied fish (i.e., in years 6–9) reveal tissue mercury levels have statistically increased over time (i.e., over two or more years) or have become elevated to the point of exceeding the 90 percent upper confidence level of the basinwide annual average (or if basin-specific data are lacking, exceeds the 75th percentile for the period of record for all basins).

If fish under Phase 3 operational monitoring have not exceeded action levels by the ninth year, project-specific mercury monitoring can be moved into Phase 3, Tier 3. Under Phase 3, Tier 3, all of the project's mercury-related monitoring is discontinued; however, project managers are cautioned that action levels may be revised in the future.

QUALITY ASSURANCE MEASURES

Quality assurance and quality control (QA/QC) are integral to all monitoring programs. A stringent QA/QC program is especially critical when dealing with ultra-trace concentrations of analytes in natural and human-impacted environments. Quality assurance includes design, planning, and management activities conducted prior to implementing the project to ensure that the appropriate types and quantities of data will be collected with the required representativeness, accuracy, precision, reliability, and completeness. The goals of QA are to ensure (1) standard collection, processing, and analysis techniques will be applied consistently and correctly, (2) the number of lost, damaged, and uncollected samples will be minimized, (3) the integrity of the data will be maintained and documented from sample collection to entry into the data record, and (4) data are usable based on project objectives.

Quality assurance measures are incorporated during the sample collection and laboratory analysis to evaluate the quality of the data. These measures give an indication of measurement error and bias (or accuracy and precision). Aside from using these results to indicate data quality, an effective QA program must utilize QC results to determine areas of improvement and implement corrective measures. QC measures include both internal and external checks. Typical internal QC checks include replicate measurements, internal test samples, method validation, blanks, and the use of standard reference materials. Typical external QC checks include split and blind studies, independent performance audits, and periodic proficiency examinations. Data comparability is a primary concern because mercury-related degradation of water quality is defined here as relative to baseline data generated by one or more laboratories. It is important to establish and maintain comparability of the performance and results among participating laboratories assessing the reporting units and calculations, database management processes, and interpretative procedures. Comparability of laboratory performance must be ensured if the overall goals of the monitoring program are to be realized.

Laboratory Quality Control

Data for this program was generated by the District and the FDEP, both of which are certified by the Florida Department of Health under the National Environmental Laboratory Accreditation Program. The following methods were utilized when analyzing samples for THg and MeHg during WY2011: FDEP–USEPA Method 1631E (Mercury in Water by Oxidation, Purge and Trap, and Cold Vapor Atomic Fluorescence Spectrometry); USEPA Draft Method 1630 (Methylmercury in Water and Tissues by Distillation, Extraction, Aqueous Phase Ethylation, Purge and Trap, Isothermal GC Separation, Cold Vapor Atomic Fluorescence Spectrometry); USEPA Method 245.6 [Mercury in Tissues by Cold Vapor AAS (uses liquid digestion)]; EPA 7471A [Mercury in Solids by Cold Vapor AAS (uses liquid digestion)]; District–EPA 7473 [Mercury in Solids and Tissues by Direct Thermal Decomposition, Amalgamation and AA (does not incorporate liquid digestion)]. All of these methods use performance-based standards employing the appropriate levels of QA/QC required by the National Environmental Laboratory Accreditation Conference (NELAC), the specific reference method, and the Protocol.

Field Quality Control Samples

For WY2011, 30 field QC samples, including field kit prep blanks (FKPB), equipment blanks [both laboratory-cleaned equipment blanks (EB) and field-cleaned equipment blanks (FCEB)], replicate samples (RS), and trip blanks (TB), were collected for both THg and MeHg surface water samples at STA-1W, STA-1E, STA-2, STA-3/4, STA-5, and STA-6. These field QC check samples represented approximately 48 percent of the 162 water samples collected during this reporting period. The results of the field QC blanks are summarized in **Table C-1**. An FKPB is a sample of the deionized distilled water (DDW) for field QC that remains at the lab to monitor low-level background inorganic mercury contamination of the laboratory DDW system, which can vary over time. An EB is collected at the beginning of every sampling event, and an FCEB is collected at the end of the event. A TB is a blank sample (DDW) that is used to identify potential contamination during field transport. For this field collection blank, DDW is carried through the field collection trip, remains sealed in a container, and is then analyzed with all other samples at the FDEP laboratory.

For WY2011, there were no flagged QA/QC samples for THg and MeHg samples. Trip blanks were temporally implemented into MMAP to assess contamination associated with MeHg. The TBs indicated that some element of contamination was occurring between the points of preparation and shipment back to the laboratory. Measures are currently being taken to determine the source of contamination.

Table C-1. Field quality control (QC) blanks from Stormwater Treatment Area (STA) 1 West (STA-1W), STA 1 East (STA-1E), STA-2, STA-5, and STA-6 for Water Year 2011 (WY2011) (May 1, 2010–April 30, 2011). Method detection limits (MDLs) are 0.1 nanograms per liter (ng/L) for total mercury (THg) and 0.022 ng/L for methylmercury (MeHg).

Field QC[a]	THg						MeHg					
	Sample Size (n)[b]	Collection Frequency (%)	Mean (ng/L)[c]	n>MDL	n Flagged	% Flagged[d]	Sample Size (n)[b]	Collection Frequency (%)	Mean (ng/L)[c]	n>MDL	n Flagged	% Flagged[d]
FKPB	4	0.11	-0.10	0	0	0	4	0.11	-0.022	0	0	0
EB	3	0.08	-0.10	0	0	0	3	0.08	-0.022	0	0	0
FCEB	4	0.11	-0.10	0	0	0	4	0.11	-0.022	0	0	0
TB	4	0.11	-0.10	0	0	0	4	0.11	-0.022	0	0	0

[a] FKPB – field kit preparation blank; EB – lab-cleaned equipment blank; FCEB – field-cleaned equipment blank; TB – trip blank

[b] Total number (n) of respective quality assurance/quality control (QA/QC) samples

[c] Mean concentration of quality control (QC) samples

[d] Percentage of all (QA/QC+ monitoring) samples collected for WY2011 (n = 37 for THg and n = 37 for MeHg)

The sample corrective action criterion for FCEBs and EBs is currently 10x the FCEB/EB level. All routine samples associated with an FCEB or EB are flagged if its value is less than 10x the method detection limit of 0.1 ng/L for THg or 0.022 ng/L for MeHg.

Analytical and Field Sampling Precision

Field replicates samples (RS) are collected from the same source as the routine sample using the same sampling equipment. The resulting data are compared to the results of routine samples to evaluate sampling precision

Laboratory replicates are aliquots of the same sample that are prepared and analyzed within the same run. The results from duplicate analyses are used to evaluate analytical precision.

WATER SAMPLES

To assess the precision of field collection and analysis, 18 replicate, unfiltered surface water samples (9 THg and 9 MeHg) collected at STA-1E, STA-2, and STA-5 were processed during WY2011. **Table C-2** reflects the results of sample analyses. Two replicate samples were matched with one surface water sample. For WY2011, all the THg and MeHg relative standard deviations were below the required 20 percent QA/QC precision level.

Table C-2. Relative standard deviations (RSD) for samples collected within STA-1E, STA-2, and STA-5 during WY2011.

Media	Sample Size (n)	% Relative Standard Deviation*		
		Minimum	Maximum	Mean
Surface Water THg	9	1.6	36.5	7.6
Surface Water MeHg	9	0.0	49.3	9.6
Mosquitofish THg	10	0.0	31.5	12.0

* RSD = standard deviation/average x 100

MOSQUITOFISH COMPOSITE SAMPLES

To monitor spatial and temporal patterns in mercury residues in small-bodied fish, mosquitofish (at least 100 individuals) are collected at various locations in the STAs, ECP, and non-ECP marshes. These individuals are then composited for each site. Composite sampling can increase sensitivity by increasing the amount of material available for analysis, reduce inter-sample variance effects, and dramatically reduce analytical costs. However, subsampling from a composite introduces uncertainty if homogenization is incomplete. Since 1999, the District has used a Polytron homogenizer to homogenate composited mosquitofish. Until late 2001, the homogenate was subsampled in quintuplicate and each subsample analyzed for THg. Based on the apparent degree of homogenization as evidenced by the low relative standard deviation (RSD) among aliquots reported in the *2002 Everglades Consolidated Report*, the District revised its standard operating procedure after consultation with and approval by the FDEP, reducing subsampling of the homogenate from five to three. In 2007, replicates were further reduced from three to one homogenate [This reduction was approved by the FDEP in 2007 and documented in the *2009 South Florida Environmental Report (SFER) – Volume 1*, Appendix 5-4, page 7 under the heading Prey Fish]. Laboratory replicates of mosquitofish were processed by the SFWMD and analyzed for THg. For WY2011, the mean percent RSD between replicate and routine samples for the 30 aliquots was 12 percent (Table C-2) which is similar to Calendar Year 2009 (CY2009) (mean of 11.7 percent). Only one RSD was greater than the required 20 percent QA/QC precision level.

SEDIMENT COMPOSITE SAMPLES

For WY2010 and WY2011, no sediment samples were collected for THg/MeHg analysis for any of the STAs because no new cells came online and no extended sediment monitoring was needed.

Inter-laboratory Comparability Studies

To ensure further reproducibility between ongoing mercury sampling initiatives and to evaluate the performance of contract laboratories used for mercury analysis, round-robin studies for water, fish, and sediment are routinely initiated. These studies are performed by the District and contracted laboratories (Battelle et al., 2011; Wageningen Evaluating Programmes for Analytical Laboratories, 2011).

SURFACE WATER AND FISH

As in previous years, inter-laboratory studies were initiated by the FDEP to assess the comparability of THg and MeHg analysis in water for several laboratories. Participating laboratories receive nine samples of ambient water from the Everglades for analysis of THg and/or MeHg. In CY2010, the District participated in the Quality Assurance of Information for Marine Environmental Monitoring in Europe (QUASIMEME) study to assess their performance in quantifying mercury in fish and improve the laboratory's data quality.

SEDIMENT

In CY2010, the District participated in two performance testing (PT) studies to assess the ability of the District's laboratory to generate acceptable analytical data for THg in sediment/soil. NELAC certification requires participation in PT studies every six months.

STATISTICAL METHODS

The proper interpretation of residue levels in tissues can sometimes prove problematic due to the confounding influences of age or species of collected animals. For comparison, special procedures are used to normalize the data (Wren and MacCrimmon, 1986; Hakanson, 1980). To be consistent with the reporting protocol used by the Florida Fish and Wildlife Conservation Commission (FWC) (Lange et al., 1998 and 1999), mercury concentrations in LMB were standardized to an expected mean concentration in three-year-old fish at a given site by regressing mercury against age (EHg3). Currently, the FWC targets LMB between lengths of 307–385 mm, which includes age-3 fish. This length range is targeted to eliminate the need for fish aging. Sunfish were not aged. Instead, arithmetic means were reported. Additionally, the distribution of the different species of sunfish [warmouth (*Lepomis gulosus*), spotted sunfish (*L. punctatus*), bluegill (*L. macrochirus*), and redear sunfish (*L. microlophus*)] that were collected during electroshocking was also qualitatively considered as a potential confounding influence on mercury concentrations prior to each comparison. The target sunfish species is bluegill.

Where appropriate, analysis of covariance (ANCOVA) using the SAS General Linear Model procedure was used to evaluate spatial and temporal differences in mercury concentrations, with age of LMB or weight of sunfish as a covariate. However, use of ANCOVA is predicated on the following critical assumptions (Zar, 1996): (1) regressions are simple linear functions, (2) regressions are statistically significant (i.e., nonzero slopes), (3) covariate is a random, fixed variable, (4) both the dependent variable and residuals are independent and normally distributed, and (5) slopes of regressions are homogeneous (parallel, i.e., no interactions). Regressions also require that collected samples exhibit a relatively wide range of covariate — that is, that fish from a given site are not all the same age or weight. Where these assumptions were not met, ANCOVA was inappropriate. Instead, standard analysis of variance [ANOVA ($n > 2$ groups)] or Student's t-tests ($n \leq 2$ groups) were used.

Possible covariates were considered separately and often qualitatively. The assumptions of normality and equal variance were tested by the Kolmorogov-Smirnov and Levene Median tests, respectively. Datasets that either lacked homogeneity of variance or departed from normal distribution were natural-log transformed and reanalyzed. If transformed data met the assumptions, then they were used in ANOVA. If multi-group null hypotheses were rejected under ANOVA, then the group was compared using either the Tukey Honestly Significant Difference (for equal-sized datasets), the Tukey-Kramer (for unequal-sized datasets), or the Holm-Sidak test.

If the group did not meet any of these assumptions, then raw datasets were evaluated using nonparametric tests such as the Kruskal-Wallis ANOVA on ranks ($n > 2$ groups) or the Mann-Whitney Rank sum test ($n \leq 2$ groups). If the multi -group null hypothesis was rejected, then the groups were compared using either the Nemenyi test (for equal-sized datasets) or Dunn's Method (for unequal-sized datasets). The Pearson Product moment (or the non-parametric equivalent Spearman Rank Order) was used to evaluate the relationship between two parameters. Linear regression was used to develop a line of best fit (linear model) between parameters.

SITE DESCRIPTIONS

Site descriptions and operational plans for STA-1W, STA-1E, STA-2, STA-3/4, STA-5, and STA-6 are published elsewhere (SFWMD, 2007a-d; 2009). Maps of selected monitoring locations are given with the data for each STA in the *Monitoring Results* section of this Attachment.

MONITORING RESULTS

STA-1W

In 2000, STA-1W subsumed the ENR Project (Cells 1 through 4, **Figure C-2**), which had been in operation since 1994. STA-1W surface water passed start-up criteria during the week of January 17, 2000, and flow-through operations began in early February 2000. Formal monitoring of mercury levels in STA-1W surface water began on February 16, 2000 (for discussion of results observed prior to WY2009, see Rumbold and Rawlik, 2000; Rumbold et al., 2001, 2006; Rumbold and Fink, 2002a, 2003a; Rumbold, 2004, 2005, Gabriel et al., 2007). In 2007, Phase 3, Tier 1 (SFWMD and FDEP, 2011) conditions were approved and implemented and therefore surface water monitoring for THg and MeHg was terminated. After the first quarterly mosquitofish collection in 2009, Phase 3, Tier 3 monitoring was implemented and all remaining monitoring under the Protocol was discontinued.

Concentrations of THg in mosquitofish in CY2009 are summarized in **Table C-3** and graphically presented in **Figure C-3**. Mosquitofish from STA-1W continued to have very low mercury levels particularly from the interior sampling sites. These levels were similar to previous conditions when the area was operated as the ENR project (Rumbold and Fink, 2002b). Furthermore, mercury levels in STA-1W mosquitofish continued to be lower than levels currently observed in fish from other areas of the Everglades. Mosquitofish in STA-1W have consistently exhibited a negative percent change in tissue mercury levels since this STA was put into operation (**Table C-3**). The slope of this decreasing trend is close to zero, likely indicating that the internal mercury biogeochemical cycle has reached a minimum in fish THg concentration [see

2010 SFER – Volume I, Appendix 5-6]. This pattern was also observed in sunfish and largemouth bass for previous collections. In 2008, the outflow data for G310 and ENR012 were combined with downstream location ST1WLX, resulting in overall higher levels as downstream marsh locations typically contain higher fish mercury concentrations. In CY2009, only ST1WLX data was available. The average annual total mercury mosquitofish composite concentration for CY2009, including all individual mosquitofish composites within STA-1W, did not exceed the period of record (POR) 75th percentile for all Everglades downstream receiving water sampling locations.

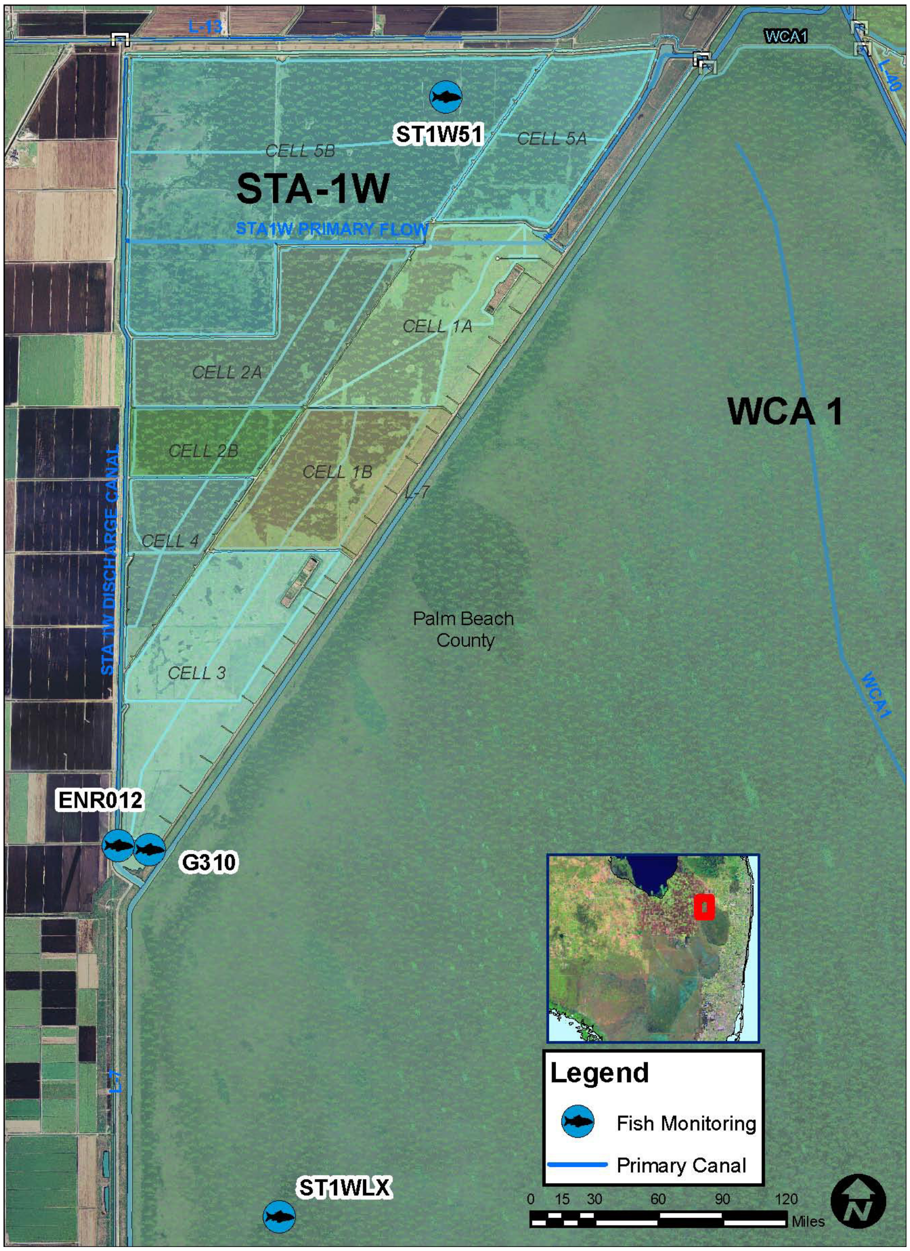

Figure C-2. STA 1 West (STA-1W) showing calendar year 2009 mercury monitoring sites.

Table C-3. Concentration of THg [nanograms per grams (ng/g), wet weight] in mosquitofish (*Gambusia holbrooki*) composite samples from STAs during WY2011.

STA	Quarterly Collection	Interior Fish	Outflow/ Downstream Fish
STA-1W	Monitoring terminated		
STA-1E	July 2010	17	93
	October 2010	9	111
	January 2011	10	95
	April 2011	22	57
	WY2011 mean	14	89
STA-2	August 2010	8	21
	October 2010	7	26
	February 2011	7	27
	WY2011 mean	7	25
STA-3/4	September 2010	7	19
	WY2011 mean	7	19
STA-5	May 2010	10	41
	August 2010	18	27
	October 2010	19	16
	WY2011 mean	16	28
STA-6	May 2010	50	66
	August 2010	24	27
	October 2010	10	10
	January 2011	18	17
	April 2011	26	29
	WY2011 mean	25	30

Contrary to other areas of the Everglades, fish-eating wildlife foraging preferentially at STA-1W are not at risk from mercury exposure. STA-1W mosquitofish (see previous SFERs)

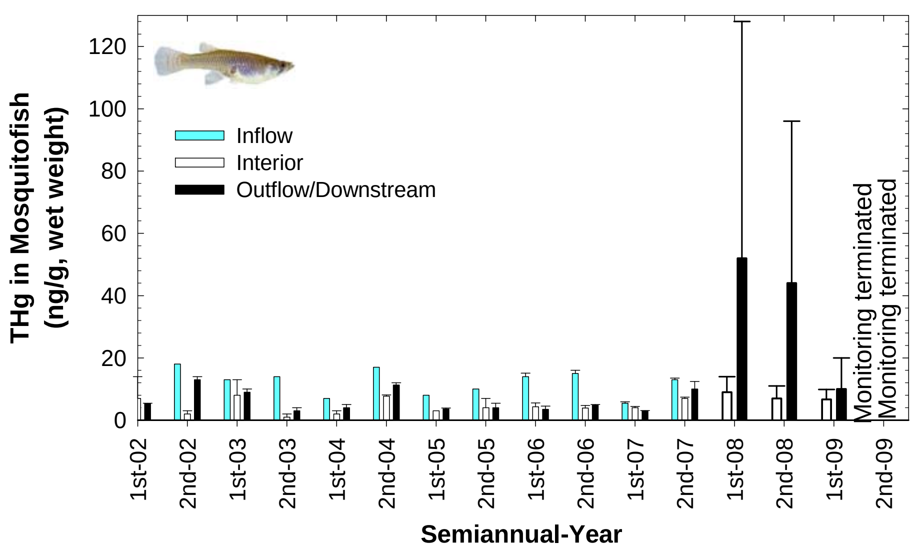

Figure C-3. THg concentrations (ng/g, wet weight) in mosquitofish composites have some of the lowest tissue-Hg levels in South Florida — well below both USEPA and USFWS guidance levels for predator protection (Eisler, 1987; USEPA, 1997). Historical data on mercury concentrations in fish from STA-1W are presented in previous SFERs.

STA-1E

Monitoring water-column concentrations of THg and MeHg began in January 2005 at STA-1E. Both the central flow-way (Cells 3, 4N, and 4S) and the westernmost flow-way (Cells 5–7) met the start-up criteria, as specified in EFA permit number 0195030-001-GL. The USACE constructed a Periphyton-Based Stormwater Treatment Area (PSTA) Demonstration Project in the easternmost flow-way (Cells 1 and 2) of STA-1E. The most recent eastern flow-way passed start-up in 2007. Currently, STA-1E is under Phase 2, Tier 1 monitoring (**Figure C-4**).

In WY2011, STA-1E displayed moderate surface water THg and MeHg concentrations at inflow and outflow locations in comparison to all other STAs (**Figures C-5** and **C-6**). All THg levels were below the Florida Class III numerical water quality standard of 12 ng/L (**Figure C-7**). Both THg and MeHg loads at the outflow were less than inflow (**Table C-4**).

Quarterly collection of mosquitofish from STA-1E sites at interior marshes (in each cell) and the single downstream site (ST1ELX) began during the third quarter of 2005. As shown in **Table C-3**, annual mean mercury level in mosquitofish from the interior marsh in WY2011 was 14 ng/g. Average annual mosquitofish composites for the interior of STA-1E, including all mosquitofish composites, did not exceed the POR 75th percentile for all Everglades downstream sampling locations during WY2011. However, the downstream mosquitofish contained an annual average level (89 ng/g) that exceeded the USEPA trophic level (TL) 2 and 3 criterion (77 ng/g), but did not exceed USFWS criterion of 100 ng/g. The elevated mosquitofish THg concentration may be related enhanced mercury methylation at the downstream marsh in the ARM Loxahatchee National Wildlife Refuge where the high sulfate concentration is likely diluted by marsh water to reach the optimal range for methylation.

Surface water sulfate, water level, and rainfall for STA-1E are presented in **Figure C-8**. Water levels within the cells of this STA typically do not fall below mean cell bottom elevation. Sulfate levels at the inflow and outflow locations are comparable to other STAs and there does not appear to be any seasonal trend in sulfate concentration.

Mercury levels in sunfish collected in the marsh interior on October 2010 were marginally above USFWS TL 2 and 3 criterion (**Table C-5**). This is influenced by a single bluegill sunfish with a THg level of 717 ng/g. Average THg level without this fish was 53 ng/g. Sunfish of 4-7 inches or 102-178 mm are targeted. This bluegill had the total length of 102 mm and is the smallest individual collected at this site in WY2011. Individual preference on feeding habits, habitat heterogeneity or fish movement are likely major factors contributing to the variation in fish THg level.

Levels in sunfish from the near-field downstream site (ST1ELX) were comparable to the THg level from nearby LOXF4 and displayed a three-year consecutive decline (**Figure C-9**).

For WY2011, largemouth bass were collected from the STA-1E interior site, but only one fish was available at the downstream site (**Table C-6**). For the interior site all LMB were within the 307–385 mm range. The average annual LMB THg concentration for interior and downstream locations did not exceed the POR 75th percentile for all Everglades downstream receiving water sampling locations in WY2011.

The LMB from the interior cells (ST1EC2A, ST1EC4SA, and ST1EC6A) in WY2011 displayed the lowest THg level for the POR (**Figure C-9**). No LMB sample in the downstream site was available for WY2010 and only one fish was caught in WY2011. This sample, however, exhibited a very high level of THg.

Regarding risks to fish-eating wildlife, interior mosquitofish (TL 2 or 3) did not exceed the USEPA's 77 ng/g criterion; however, the mosquitofish from the downstream location did exceed this criterion for the first three quarters. Unlike in 2010, all resident interior and downstream sunfish within STA-1E were above the USFWS criterion of 100 ng/g for TL 2 or 3 fish. All downstream sunfish were above the USEPA's 77 ng/g and USFWS 100 ng/g criteria. With the exception of the single sample from the downstream site, the THg level for LMB STA-1E did not exceed the USEPA criterion of 346 ng/g for TL 4 fish species.

Table C-4. THg and MeHg inflow and outflow loadings in grams for WY2011.

	Inflow Load		Outflow Load		% Difference[a]	
STA	THg	MeHg	THg	MeHg	THg	MeHg
STA-1E[b]	45.2	7.0	21.6	5.2	-52.3	-25.9
STA-2[c]	115.9	34.8	107.5	11.8	-7.2	-66.0
STA-5[d]	28.9	3.9	22.6	4.7	-21.6	18.8
STA-6[e]	103.2	33.2	34.0	17.3	-67.0	-47.9

[a] (outflow–inflow/inflow)*100

[b] S-319 (inflow), S-361 (outflow), S-362 (outflow)

[c] Includes stations S6, G328 (inflow) and G335 (outflow)

[d] Includes stations G342E, G342F (inflow, Flow-way 3) and G344E, G344F (outflow, Flow-way 3)

[e] Includes stations G600, G396B (inflow) and stations G354, G393, G354C, G393B, and G352B (outflow)

Note: surface water THg/MeHg monitoring was terminated in STA-3/4 and STA-1W

Table C-5. Concentration of THg (ng/g, wet weight) in sunfish collected from STAs in WY2011 (sample size in parentheses).

STA	Interior Fish	Outflow/Downstream Fish
STA-1W	Monitoring terminated	
STA-1E	109±196 (12[a])	120±57 (5)
Cumulative mean	88	160
STA-2	21±10 (10)	85±67(20)
Cumulative mean	74	117
STA-3/4	TRI[c]	TRI[c]
Cumulative mean	75[b]	70
STA-5	93 (1)	278±27 (5)
Cumulative mean	78	106
STA-6	72±33 (5)	101±16 (5)
Cumulative mean	76	99

[a] Where n > 5, multiple sites were sampled and pooled, i.e., multiple interior or outflows (see the *Protocol for Monitoring Mercury and Other Toxicants* section of this appendix).

[b] Cumulative through WY2008 data

[c] TRI = Triennial fish collection

Table C-6. Largemouth bass THg concentrations (ng/g, wet weight) collected in the STAs between lengths 307–385 millimeters (mm) for WY2011. In parentheses all data is presented, which includes data within and outside of the 307–385 mm range. Cumulative mean includes all fish within and outside the 307–385 mm range for the period of record. All data show arithmetic mean ± 1 standard deviation (SD).

STA	Interior Fish	Outflow/Downstream Fish
STA-1W	Monitoring terminated	
STA-1E	53±32, 10	649, 1
Cumulative mean	175	(350±226, 12)
STA-2	43±7, 5	297±42, 6 (303±249, 20)
Cumulative mean	251	297
STA-3/4	TRI[c]	TRI[c]
Cumulative mean	313	423
STA-5	NA	NA
Cumulative mean	327	362
STA-6	121±27, 3	467±316, 3 (470±258, 4)
Cumulative mean	244	473

[a] Where n > 5, multiple sites were sampled and pooled, i.e., multiple interior or outflows (see the *Protocol for Monitoring Mercury and Other Toxicants* section of this appendix).

[b] Cumulative through WY2008 data

[c] TRI = Triennial fish collection

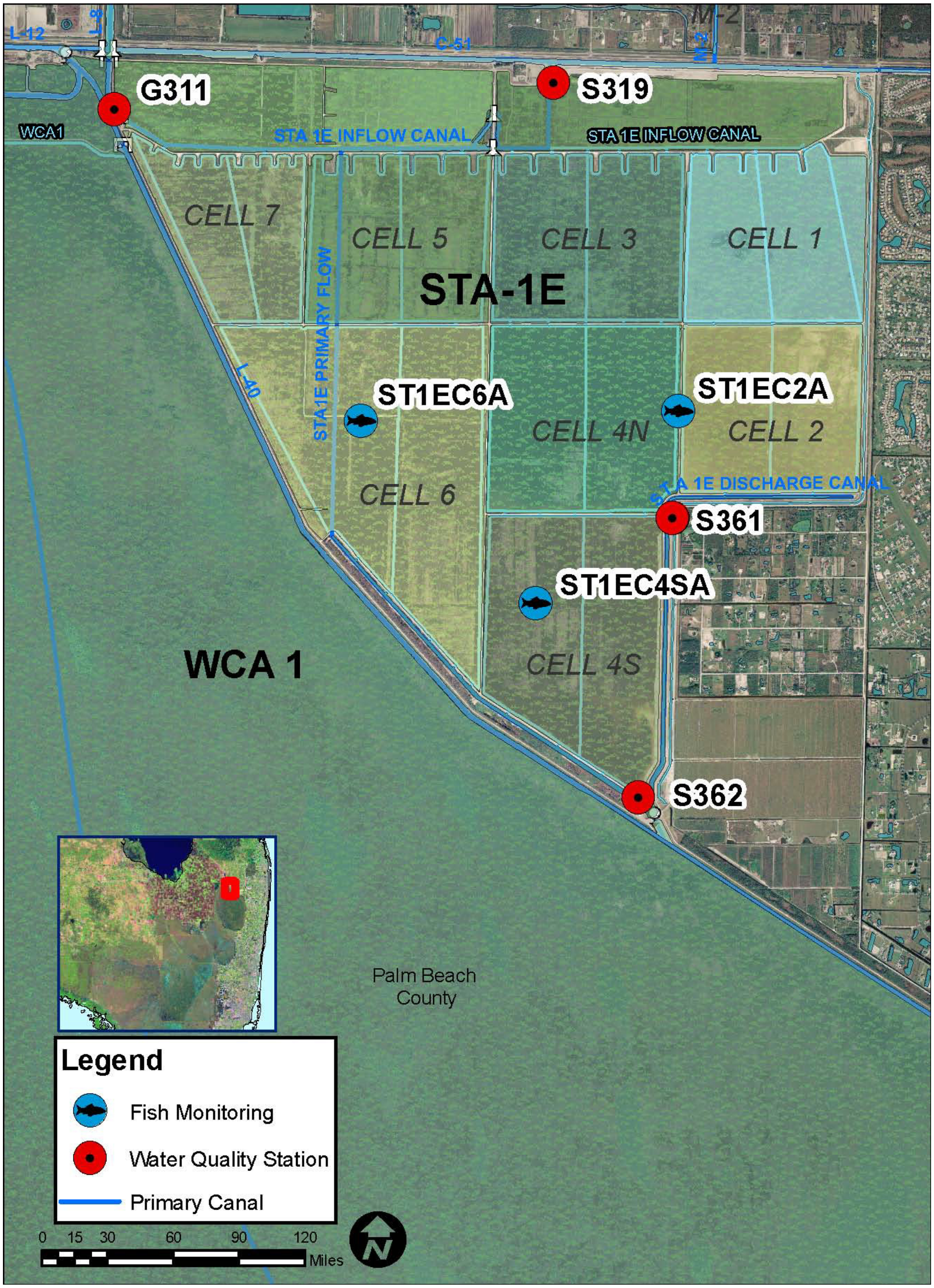

Figure C-4. Map of STA 1 East (STA-1E) showing selected mercury monitoring sites. Mosquitofish are collected downstream of STA-1E at ST1ELX and within each cell of the STA, and submitted as one composite sample per flow-way.

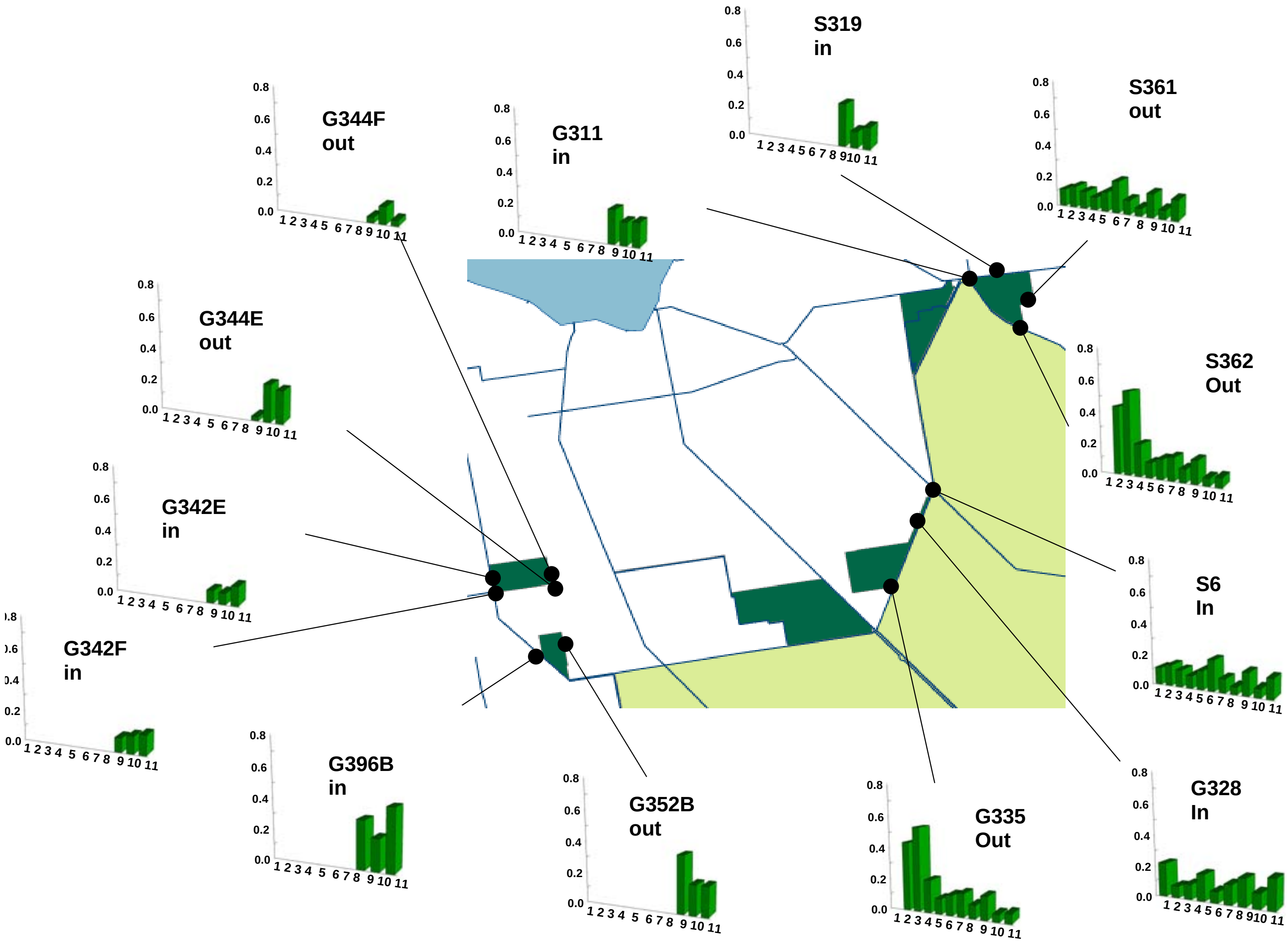

Figure C-5. Annual median THg concentrations in monitored surface waters [nanograms per liter (ng/L)] for the STAs from Water Year 2002 (WY2002) (May 1, 2001–April 30, 2002) through WY2011.

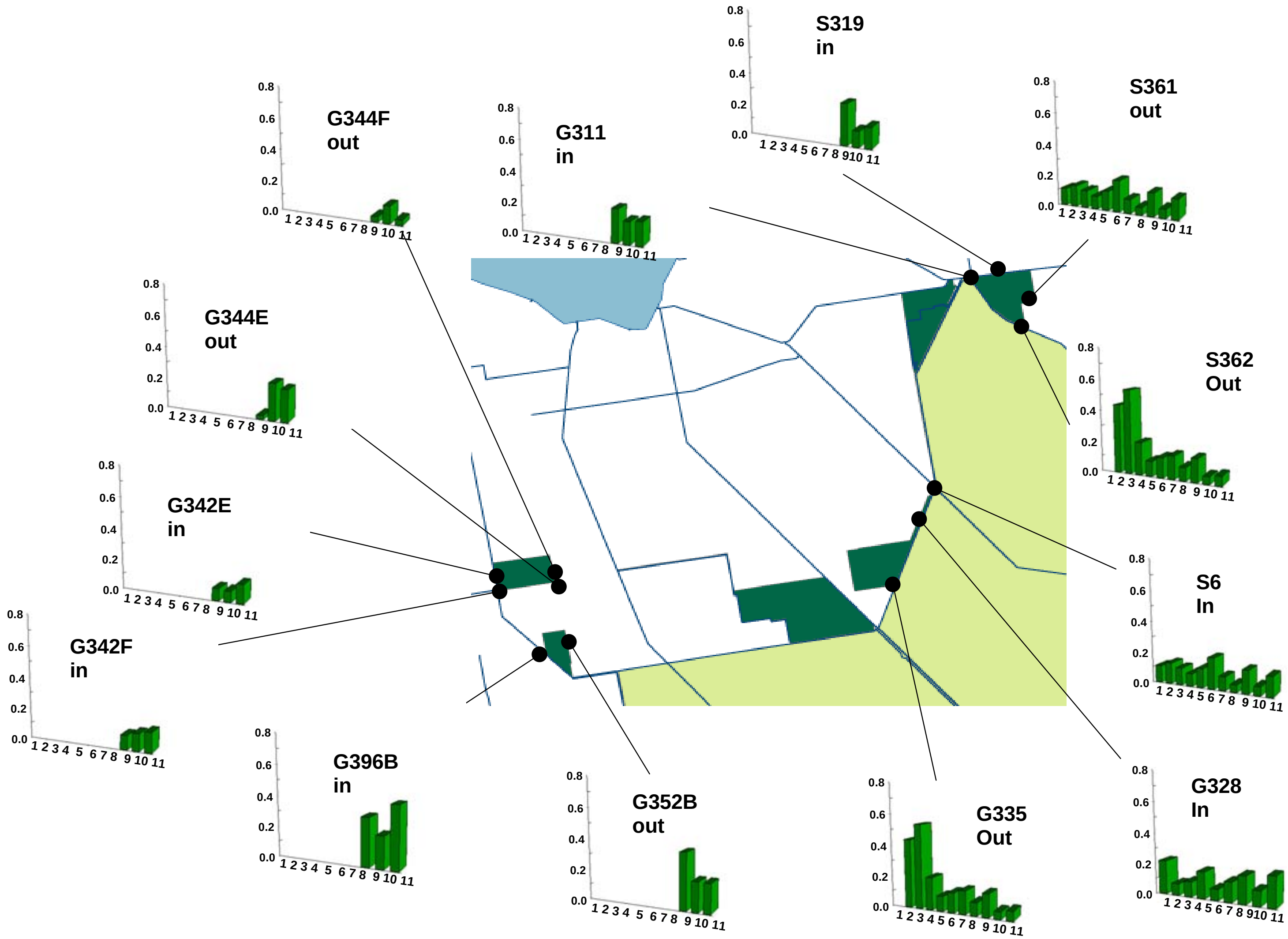

Figure C-6. Annual median MeHg concentrations in monitored surface waters (ng/L) for the STAs through WY2011.

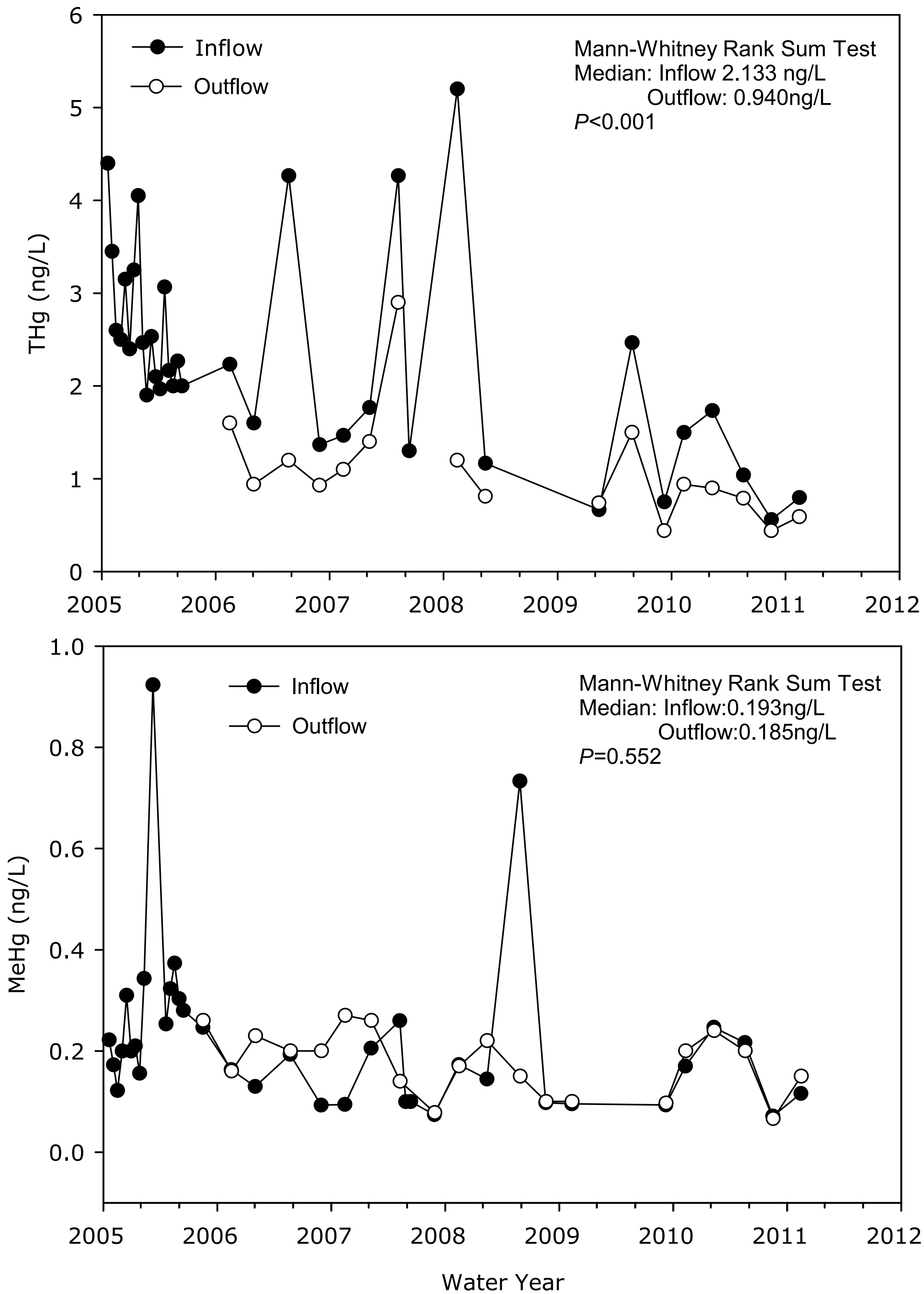

Figure C-7. Concentrations of THg (top) and MeHg (bottom) in unfiltered surface water collected at STA-1E.

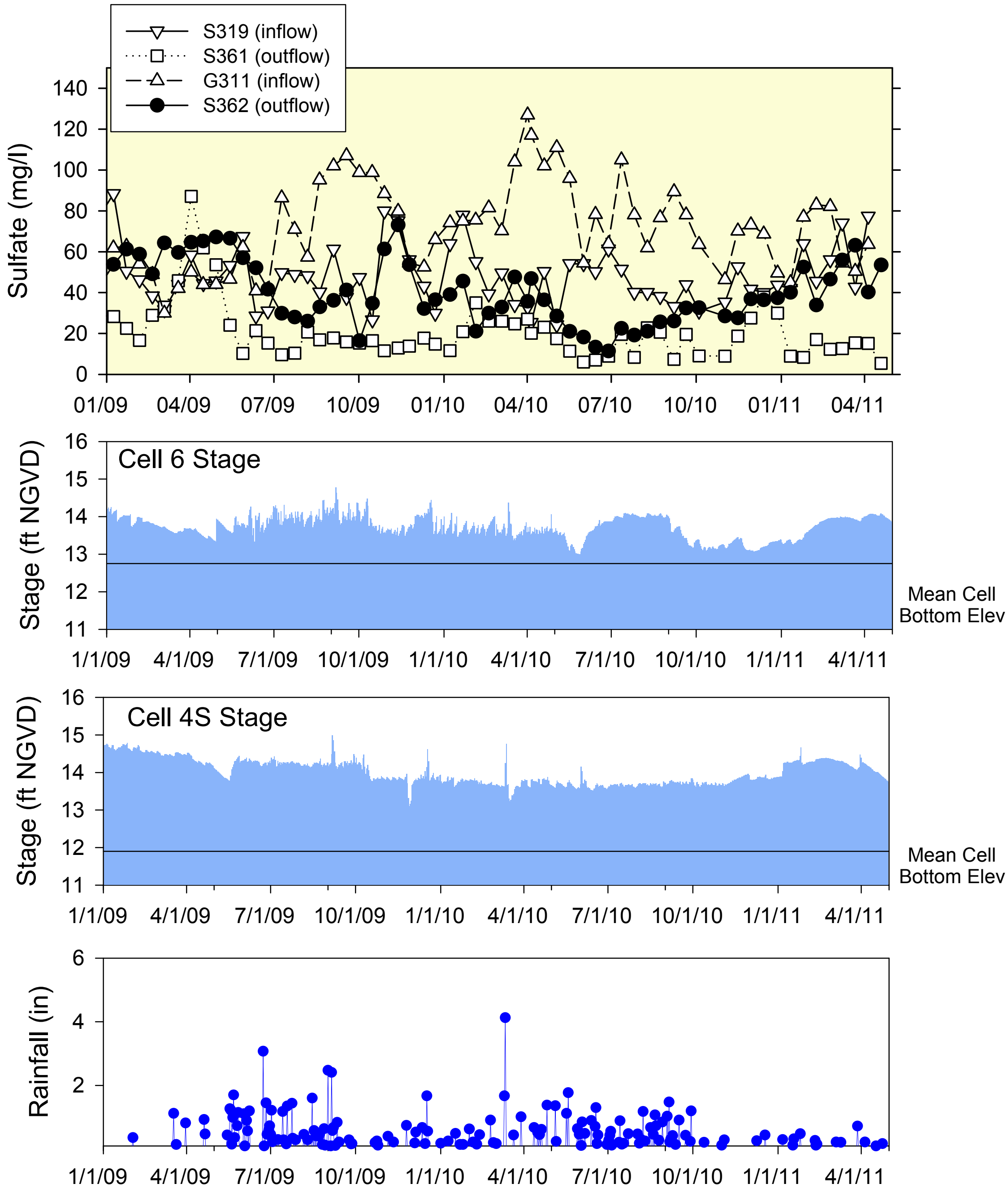

Figure C-8. Water-column sulfate, stage (recorded immediately upstream of outflow culvert of cell), and rainfall at STA-1E. [Note: mg/L – milligrams per liter; ft NGVD – feet National Geodetic Vertical Datum; in – inches; Elev – elevation]

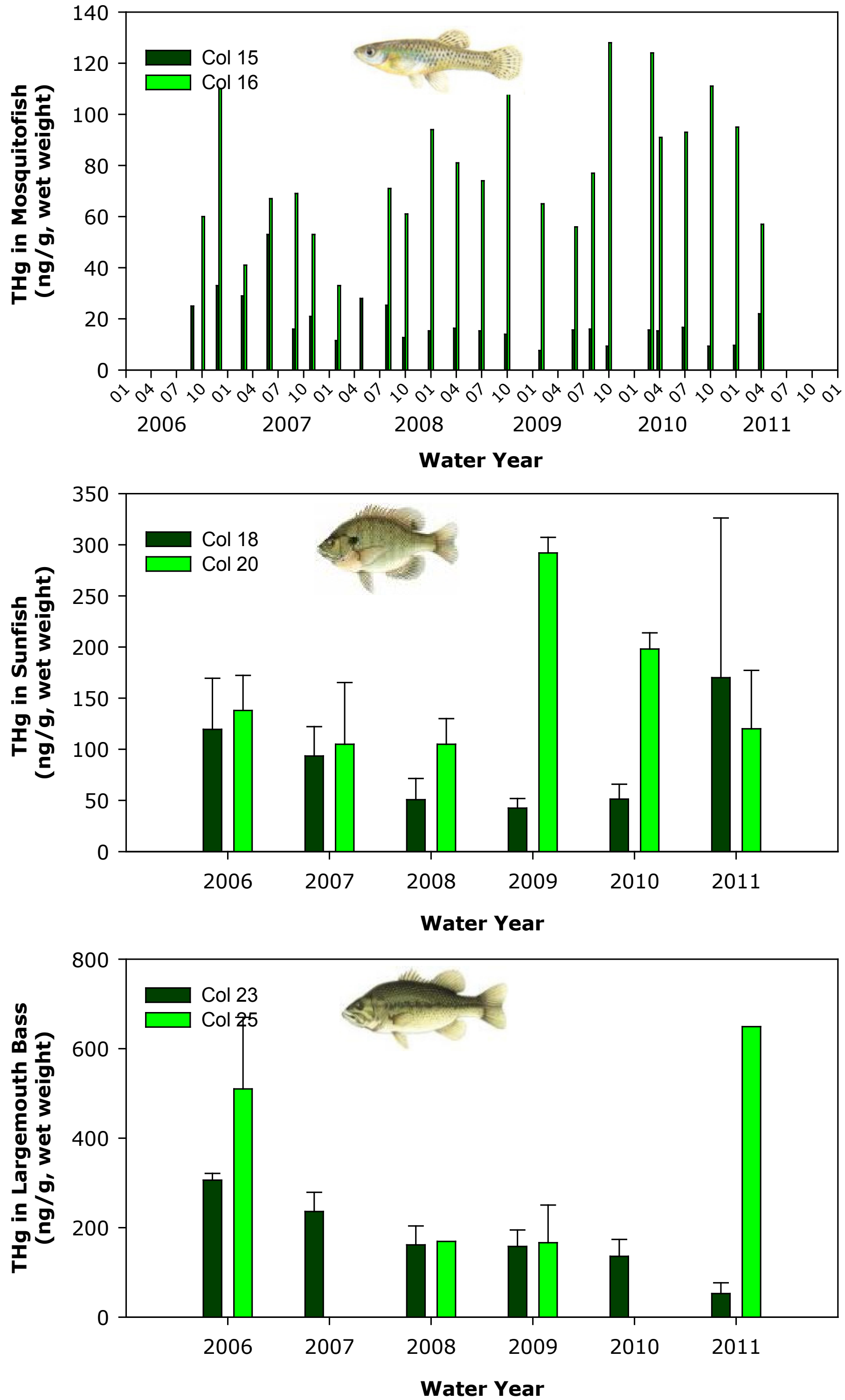

Figure C-9. Total mercury concentrations (ng/g, wet weight) in mosquitofish composites (± SD) (top), whole sunfish (± SD) (middle), and fillets of largemouth bass (arithmetic mean, ± SD) (bottom) collected at STA-1E.

STA-2

STA-2, Cells 2 and 3, met mercury start-up criteria in September 2000 and November 2000, respectively. In August 2001, flow-though operation of Cell 1 was approved under a permit modification. Cell 1 met start-up criteria in November 26, 2002. Operational monitoring for mercury at STA-2 began during the third quarter of 2001 after completion of the S-6 connection (Rumbold and Fink, 2002b, 2003b; Rumbold 2004, 2005; Rumbold et al., 2006). The most recently developed area, Cell 4, passed mercury start-up criteria and flow-through began in 2007. Currently, all of STA-2 is under Phase 2, Tier 1 monitoring (**Figure C-10**).

Results from monitoring mercury concentrations in surface water at STA-2 (**Figure C-11**) show THg concentration in inflow and outflow did not exceed the Florida Class III numerical water quality standard of 12 ng/L during WY2011. Both MeHg, which has no numerical water quality standard, and THg remained at low concentrations in the outflow. A high value of THg (12 ng/L) was observed at the outflow site on December 2001. The high THg level was associated with the dryout and reflooding events that occurred in STA-2 Cell 1 and has been reported by Rumbold and Fink (2005). Outflow loads of THg and MeHg were both less than inflow (**Table C-4**). Load reduction for THg was the least and one of the highest for MeHg among STAs. A drop in water level below mean cell bottom elevation is a common occurrence in this STA. In WY2011, the drop in water level for Cell 1 (**Figure C-12**) may have triggered increased THg levels that hampered the load reduction.

Table C-3 and **Figure C-13** summarize results from operational monitoring of mercury concentrations in STA-2 mosquitofish for WY2011. The THg level in mosquitofish from the STA-2 marsh interior and was the lowest among actively monitored STAs. In WY2011, the average mosquitofish composite and each individual mosquitofish composite for the interior and downstream locations did not exceed the POR 75th percentile for the downstream Everglades sampling locations.

Sunfish from STA-2 interior sampling locations (STA2C4A and STA2C1X) show the lowest THg level in WY2011 (**Table C-5** and **Figure C-13**). The downstream site (CA2NF) displays a three-year consecutive decline in THg. In WY2011, the average annual sunfish concentration for all STA-2 interior locations and downstream did not exceed the POR 75th percentile for all downstream Everglades sampling locations.

Concentrations of THg in fillets of resident largemouth bass from STA-2 (**Table C-6** and **Figure C-13**) in the length range of 307–385 mm reflect an overall average of 47 ± 7 ng/g collected across Cell 4, which is the lowest of all interior STA sites. The same finding was also reported for 2010. Historically, fish THg levels within this STA have been high compared with the other STAs, which may be related to the previous land use within this area. Annual LMB concentration for all STA-2 locations did not exceed the POR 75th percentile for all Everglades downstream receiving water sampling locations (see Appendix 3-2, Attachment F of this volume). Regarding risk to fish-eating wildlife, in WY2011 no mosquitofish composite from the interior and downstream site and sunfish from the interior marsh contained mercury levels greater than the USEPA predator protector criteria of 77 ng/g for TL 2 or TL 3 species or the USFWS criteria of 100 ng/g. In contrast, several sunfish from the downstream locations did exceed the USEPA or USFWS predator protector criteria for TL 2 or TL 3 species. There was no exceedance of the USEPA criterion of 346 ng/g for TL 4 fish species in LMB within STA-2 although THg level in the downstream site was high. Overall, fish-eating wildlife foraging preferentially within and downstream of STA-2 continue to appear to have an overall moderate risk of mercury exposure

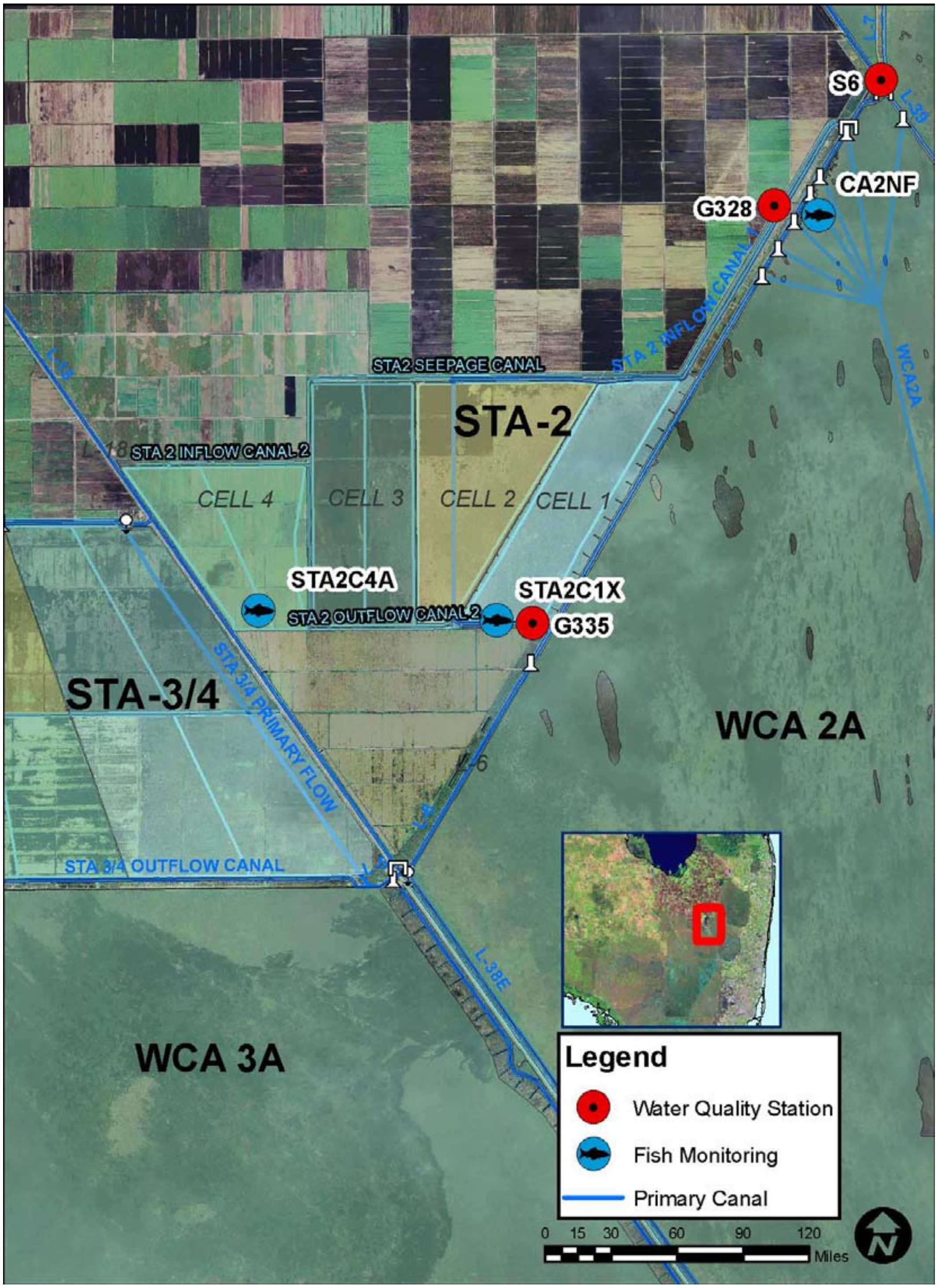

Figure C-10. Map of STA-2 showing current mercury monitoring sites. Mosquitofish samples are collected from downstream station CA2NF and in each cell then submitted as a composite for each flow-way.

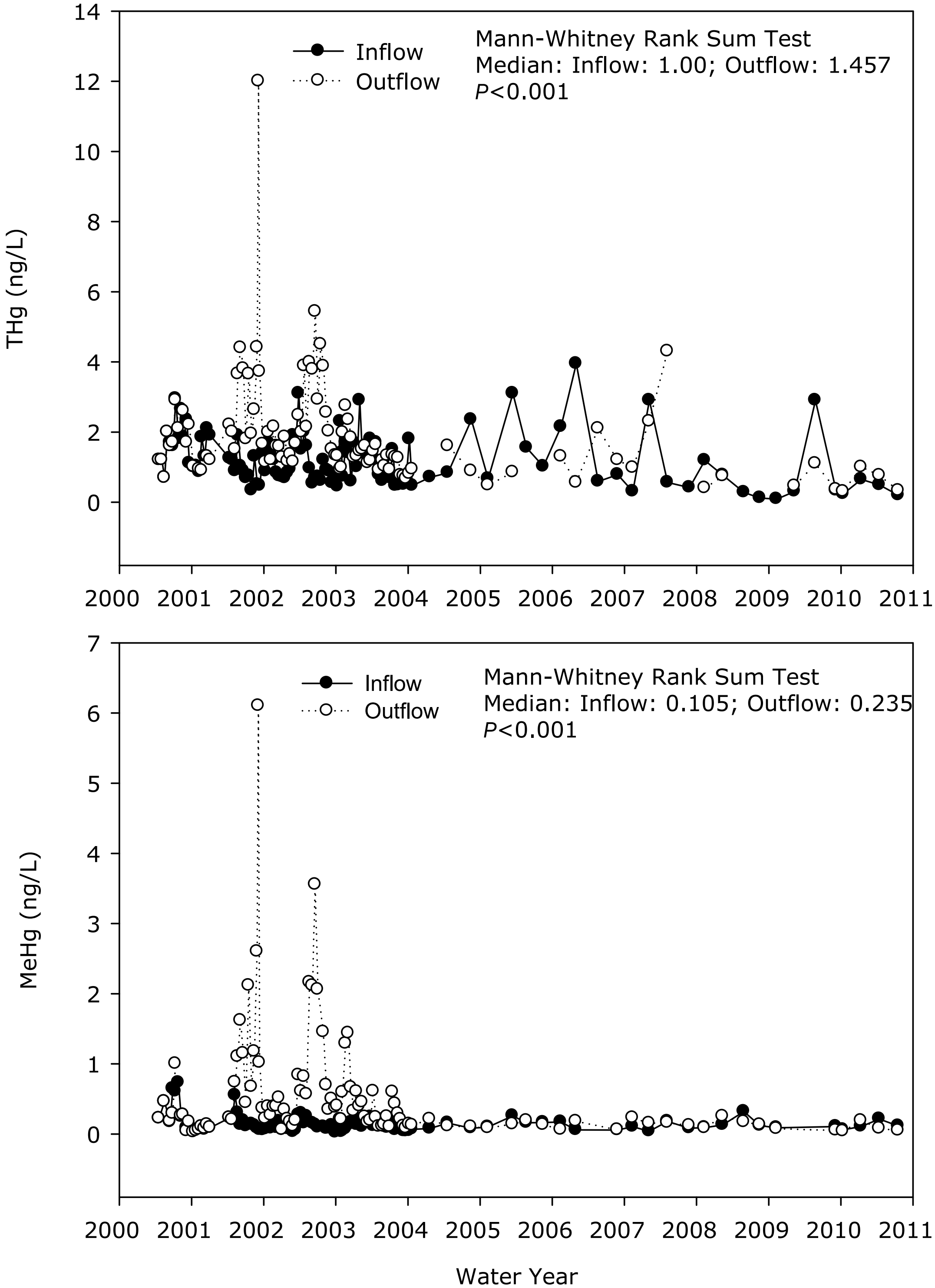

Figure C-11. Concentrations of THg (top) and MeHg (bottom) in unfiltered surface water collected at STA-2.

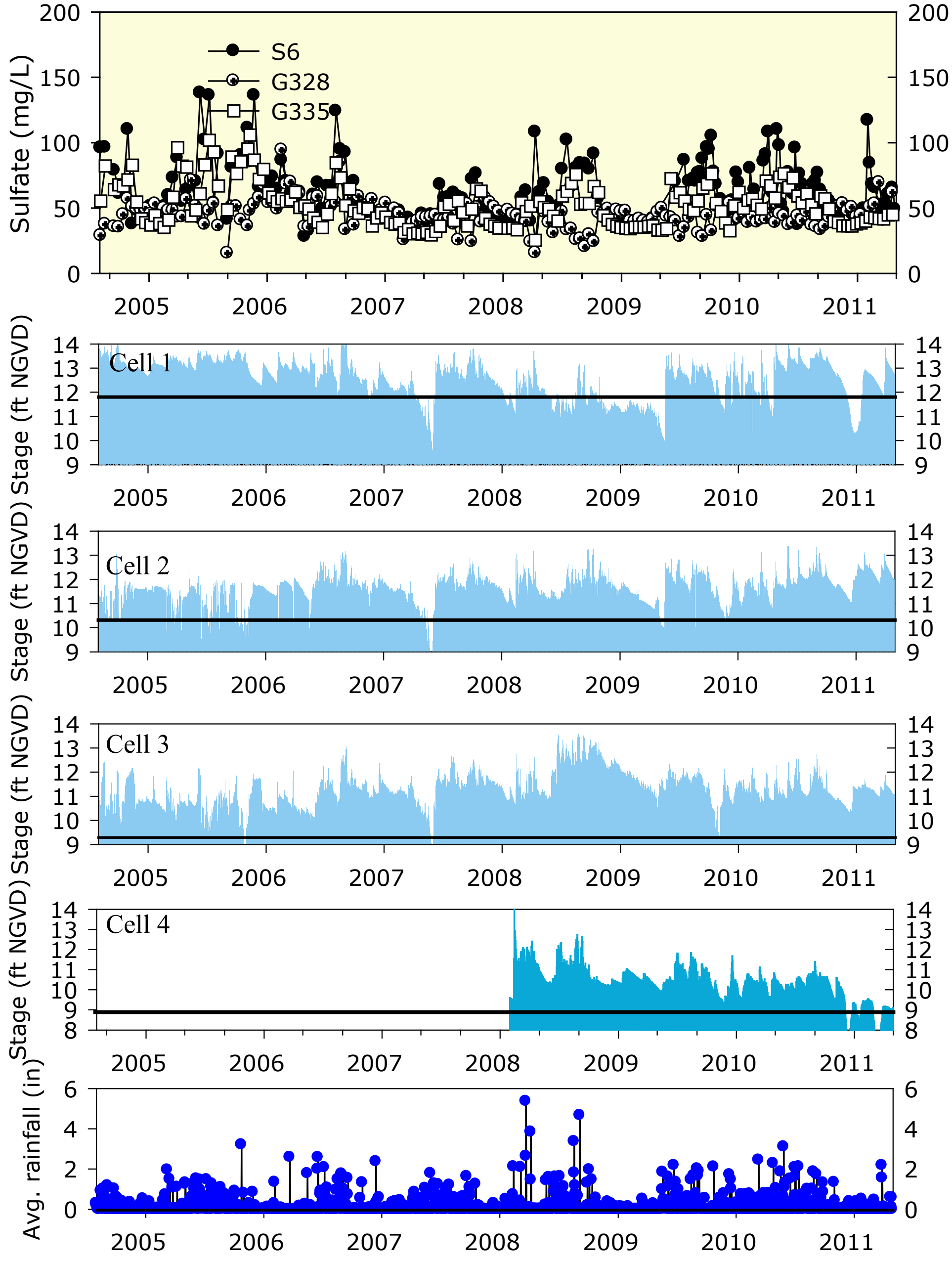

Figure C-12. Water-column sulfate, stage (recorded immediately upstream of outflow culvert of cell), and rainfall totals at STA-2.

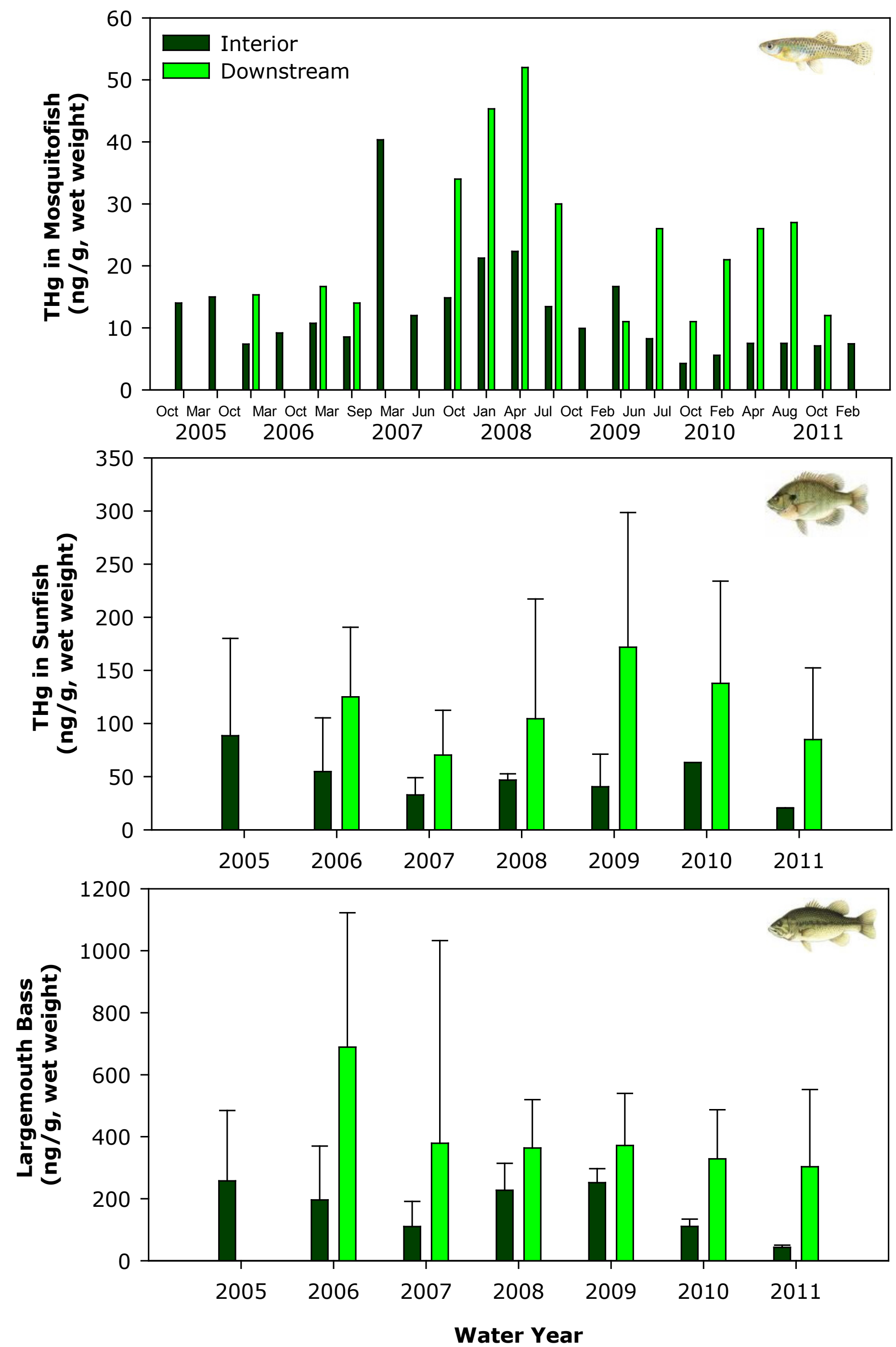

Figure C-13. Mercury concentrations (ng/g, wet weight) in mosquitofish composites (± SD) (STA2C4A and STA2C1X) (top), whole sunfish (±SD) (middle), and fillets of largemouth bass (arithmetic mean, ± SD) (bottom) collected at STA-2. An asterisk indicates an arithmetic mean of all available largemouth bass.

STA-3/4

STA-3/4, Cell 1, satisfied start-up criteria for mercury in January 2004; the first discharges of treated water from this STA were in February 2004. Accordingly, routine operational monitoring of this flow-way began during the first quarter of 2004. STA-3/4, Cell 3, satisfied start-up criteria for mercury in June 2004 and Cell 2 passed in August 2004; with consensus from the FDEP in September 2004, discharges began (for discussion of results observed prior to 2005, see Rumbold et al., 2006). In 2007, all mercury monitoring was moved into Phase 3, Tier 1 of the Protocol (SFWMD and FDEP, 2011). Therefore, surface water monitoring for THg and MeHg was terminated and the last surface water dataset was collected in March 2008. Information on THg and MeHg for STA-3/4 is presented in previous SFERs. **Figure C-15** shows current mercury monitoring locations for concentrations in resident fish at TL 2 through 4.

Concentrations of THg in mosquitofish are summarized in **Table C-3** and **Figure C-14**. For WY2011, mosquitofish from STA-3/4 had the lowest levels among the STAs, which is consistent with past years. The average annual composite for WY2011 and each individual mosquitofish composite within STA-3/4 did not exceed the POR 75th percentile for all downstream receiving water sampling Everglades locations during the year.

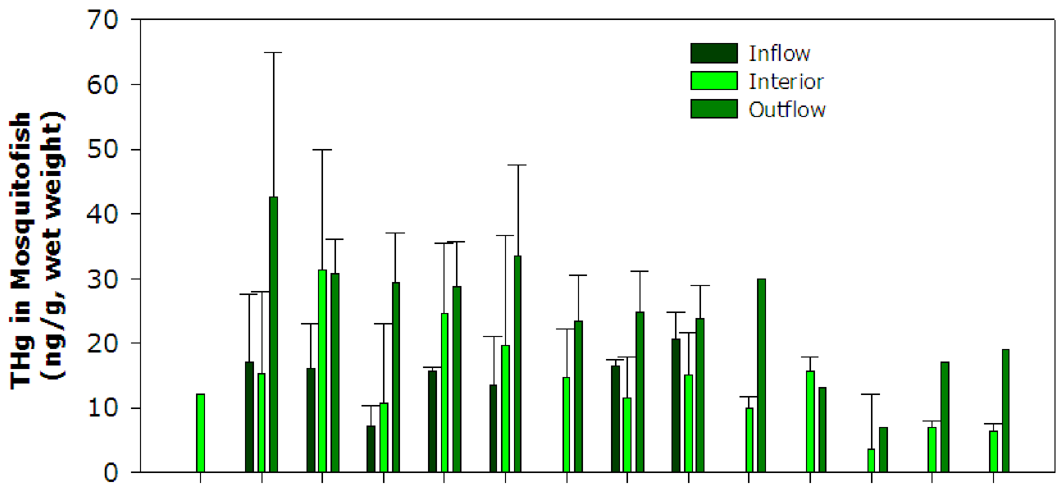

Figure C-14. Mercury concentrations (ng/g, wet weight) in mosquitofish composites (± SD) collected at STA-3/4.

Surface water sulfate, water level, and precipitation for STA-3/4 are presented in **Figure C-16**. Water levels within the cells of this STA typically do not fall below mean cell bottom elevation. Sulfate levels at the inflow and outflow locations are comparable to other STAs and there does not appear to be any seasonal trend in sulfate concentration.

No sunfish or largemouth bass collections were made for WY2011 due to the triennial sampling schedule in effect under Phase 3 monitoring. The next collection will be in late Calendar Year 2011.

Regarding the risk to fish-eating wildlife, all resident mosquitofish within the marsh of STA-3/4 contain mercury levels below the USEPA criterion of 77 ng/g for TL 2–3 fish species. Based on the available mosquitofish data, fish-eating wildlife foraging preferentially within the interior marsh and downstream of STA-3/4 appear to be at low risk from mercury exposure.

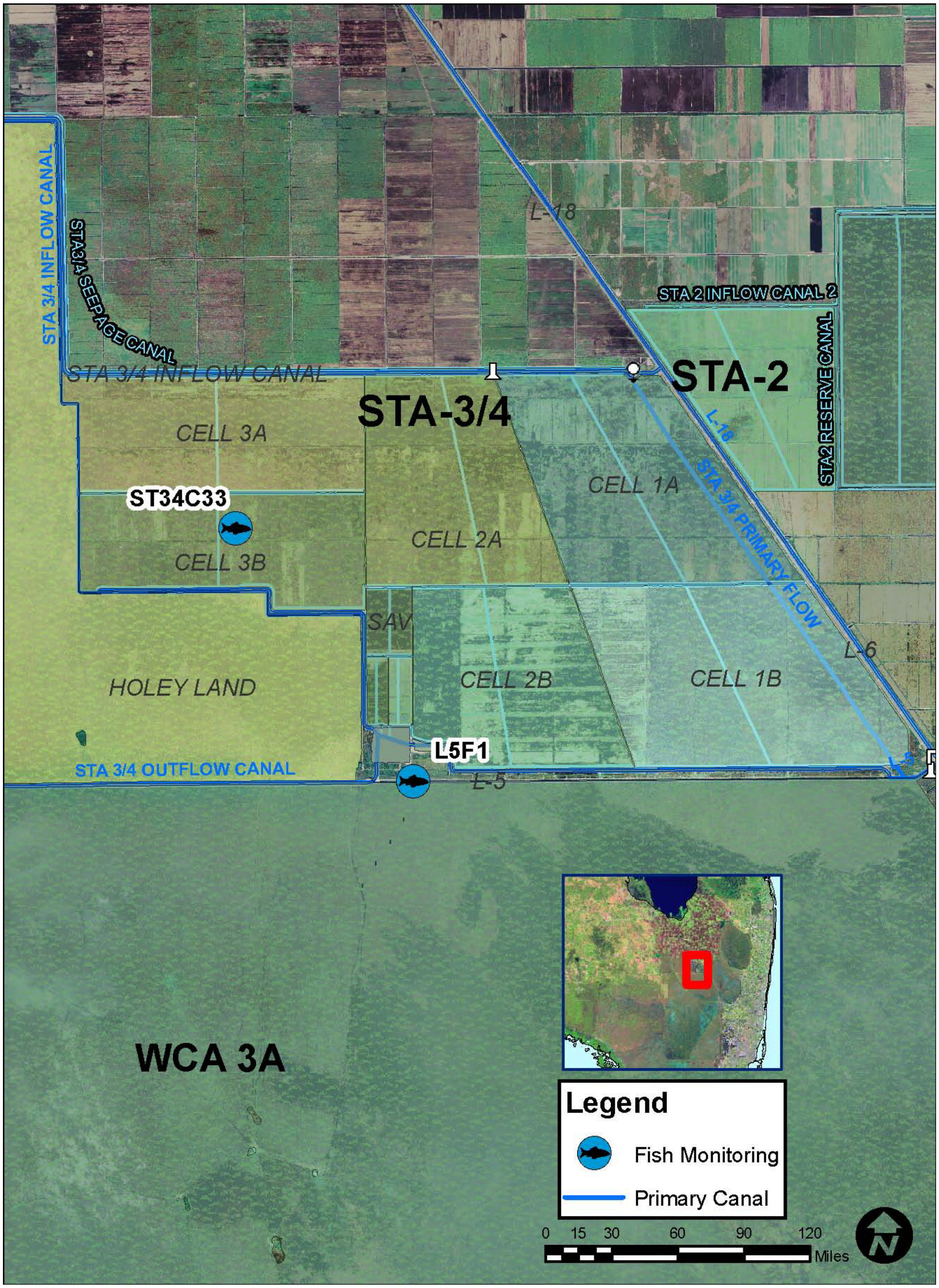

Figure C-15. Map of STA-3/4 showing current mercury monitoring sites.

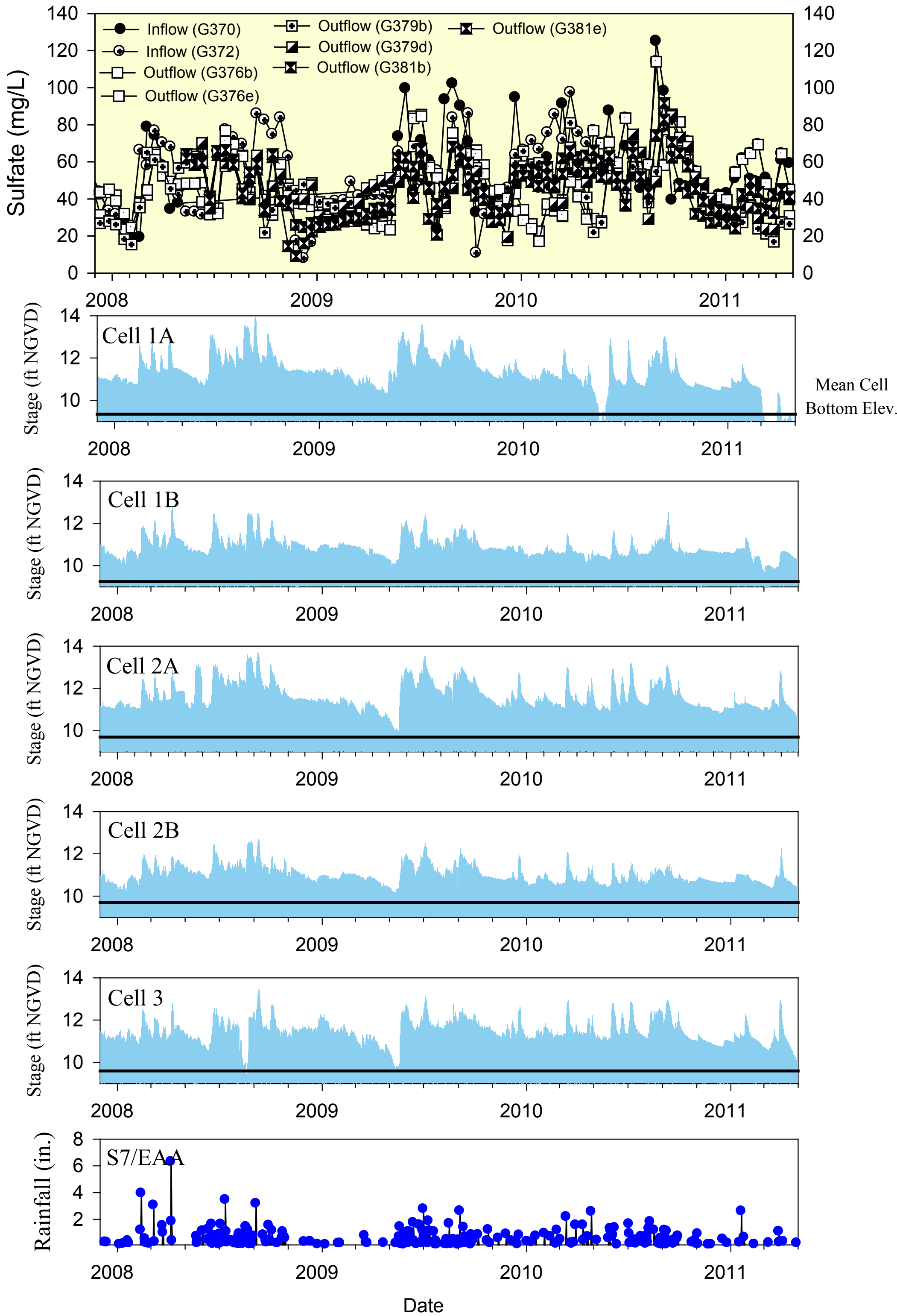

Figure C-16. Water-column sulfate, stage (recorded immediately upstream of outflow culvert of cell), and rainfall at STA-3/4.

STA-5

STA-5 met start-up criteria for mercury in September 1999. However, because of drought conditions and the detection of high phosphorus concentrations at the outflows, STA-5 did not begin flow-through until July 2000 (for discussion of results observed prior to 2005, see Rumbold and Rawlik, 2000; Rumbold et al., 2001 and 2006; Rumbold and Fink, 2002a and 2003a; Rumbold, 2004 and 2005). The new section, Flow-way 3, is under Phase 2, Tier 1 monitoring and Flow-ways 1 and 2 are under Phase 3, Tier 3 monitoring (**Figure C-17**). On December 31, 2009, the FDEP approved the District's request to move mercury monitoring in Flow-ways 1 and 2 from Phase 3, Tier 1 to Phase 3, Tier 3. This implemented termination of all site-specific mercury monitoring in those flow-ways.

As shown in **Figure C-18**, water-column concentrations of THg and MeHg in WY2011 remained low in STA-5. No THg sample was above the 12 ng/L water quality standard. On January 1, 2009, surface water sampling was temporarily suspended due to dryout conditions. The consistent dryout and rewetting has likely created the elevated surface water sulfate concentrations (**Figure C-19**). An increasing/decreasing trend in surface water sulfate occurred, which, likely also results from the frequent dryout and rewet processes (**Figure C-19**). For WY2011, outflow loading of MeHg was about 20 percent greater than the inflow (**Table C-6**). This is in contrast to the previous year that showed the largest difference in MeHg inflow versus outflow loading in STA-5 compared to all other STAs. The negative reduction on MeHg was due to a low value of MeHg at the inflow and only two sampling events available for load calculation.

Mosquitofish collected from STA-5 in WY2011 contained moderate annual mean mercury levels (**Figure C-20**), compared to the other STAs (**Table C-3**). The average annual mosquitofish composite for WY2011 and each individual mosquitofish composite for all locations within STA-5 did not exceed the POR 75th percentile for all downstream Everglades sampling locations during 2009. Since 2009, mosquitofish THg level at outflow decreased steadily while THg at the interior marsh fluctuated at a moderately low level.

In contrast to WY2010 when sunfish collected from the interior marsh and downstream contained the lowest levels of mercury compared to the other STAs, sunfish collected at the downstream site displayed high THg level (**Table C-5**). However, all five sunfish were warmouth while all sunfish collected at the downstream site were bluegill in WY2010. Only one sunfish (bluegill) was collected in the interior marsh in WY2011 and it had a moderately low THg level.

As in previous years, the FWC (under contract to the District to collect large-bodied fish for mercury monitoring) encountered difficulties in filling sample quotas for STA-5. As shown in **Table C-6**, no LMB were available. For information on LMB within STA-5 refer to previous SFER appendices.

Regarding the risk to fish-eating wildlife, all resident mosquitofish within and downstream from STA-5 contained mercury levels below the USEPA criterion of 77 ng/g for TL 2 or 3 fish species and all fish were below the USFWS criterion of 100 ng/g. For sunfish in WY2011, all sunfish from the downstream site exceed USFWS criterion of 100 ng/g. The single specimen at the interior marsh exceeded the USEPA criterion of 77 ng/g, but not the USFWS criterion of 100 ng/g. Largemouth bass samples collected between WY2006 and WY2009 did not exceed the USEPA criterion of 346 ng/g for TL 4 fish species. Therefore, based on the available mosquitofish and sunfish data, fish-eating wildlife foraging preferentially from the interior marsh of STA-5 appears to be at low to moderate risk from mercury exposure. The warmouth at the downstream site served as trophic level 4 fish but with a THg level below USEPA criterion of 346 ng/g for TL 4 fish. Further sampling and analysis are needed to assess if the high THg level still exists in the next water year.

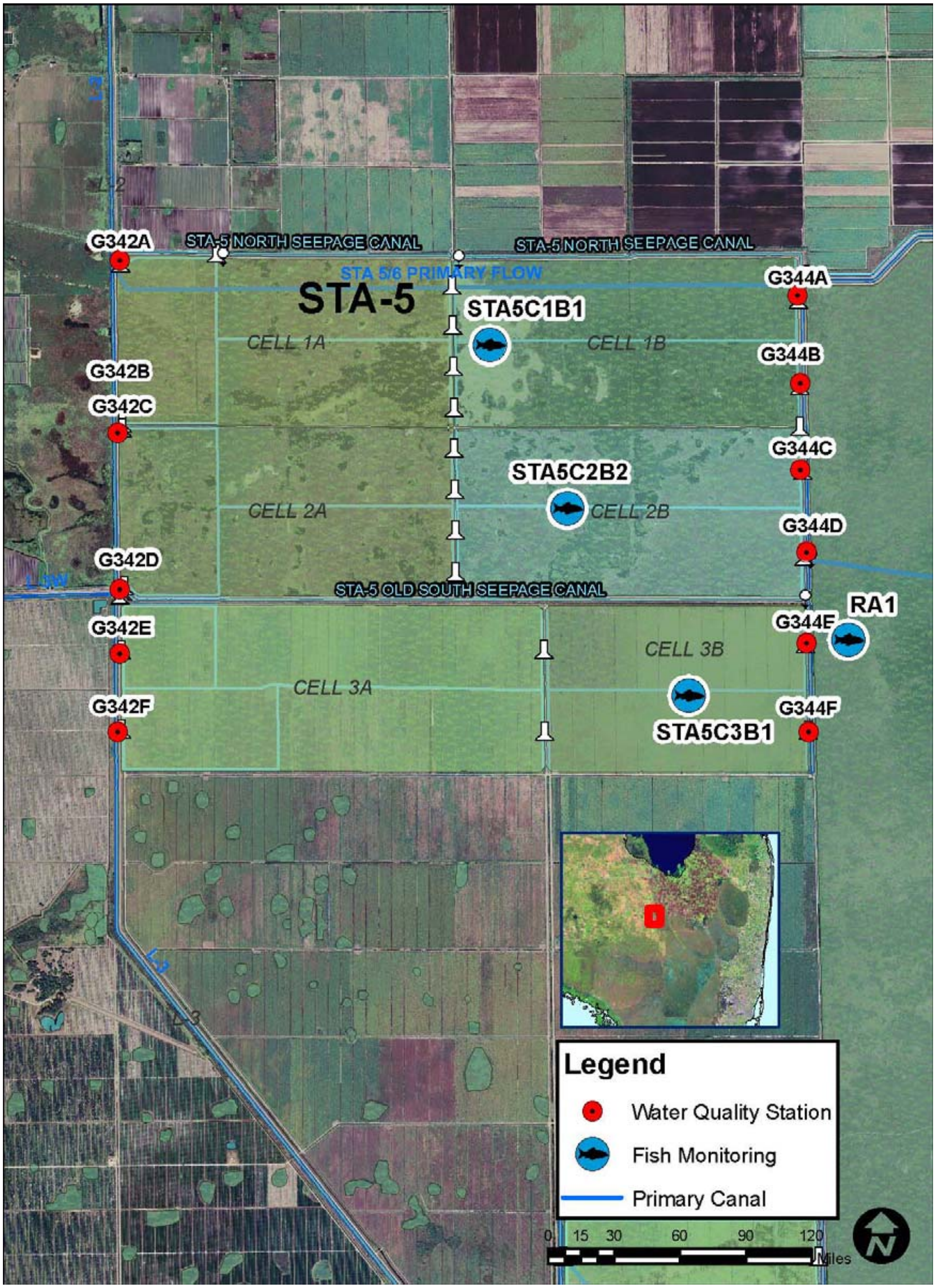

Figure C-17. Map of STA-5 showing current and historical mercury monitoring sites. Mosquitofish composite samples are collected for each flow-way and composited, and one mosquitofish sample is collected downstream (RA1). Currently, only Flow-way 3 is being monitored for fish collection.

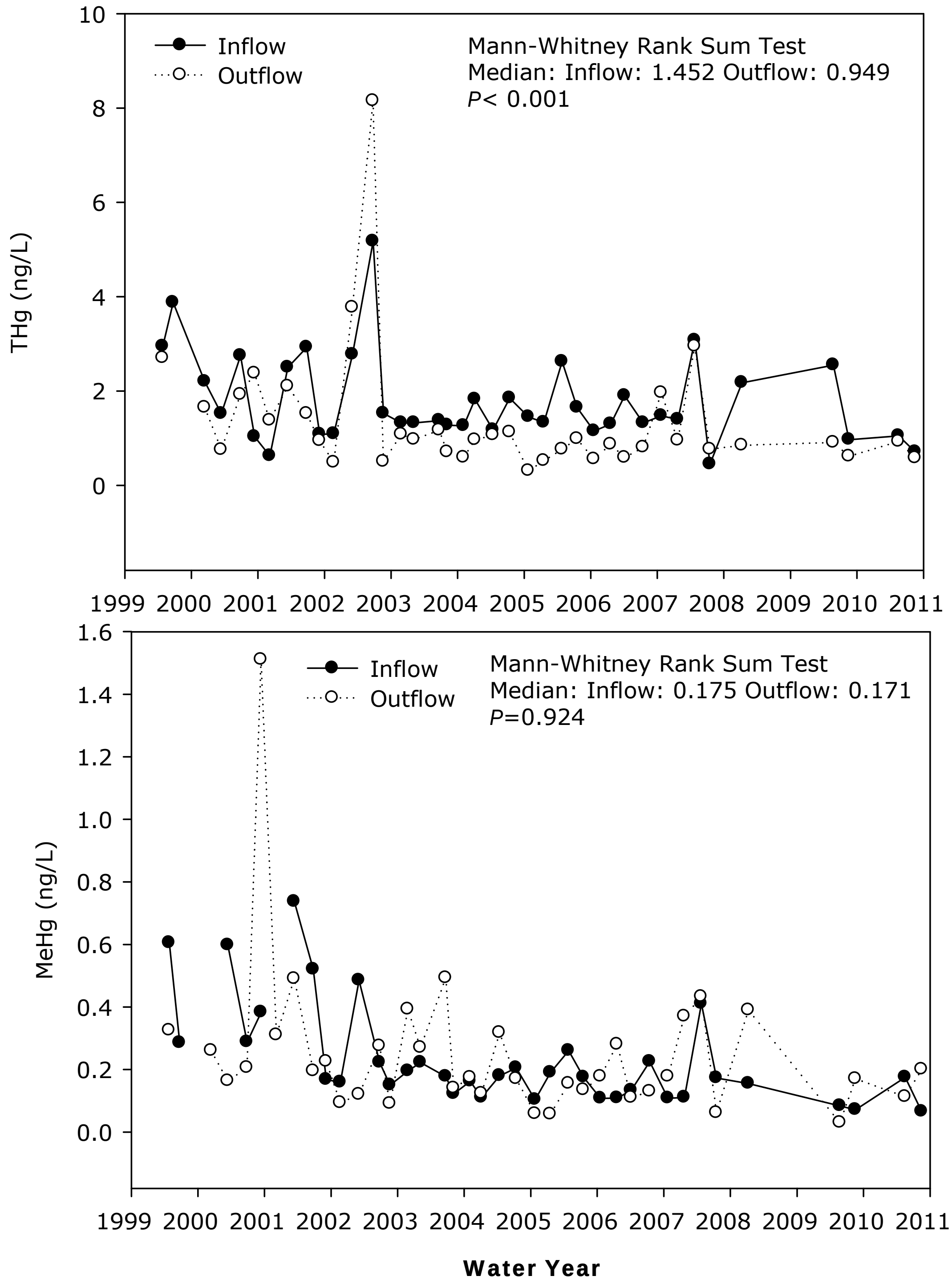

Figure C-18. Concentrations of THg (top) and MeHg (bottom) in unfiltered surface water collected at STA-5.

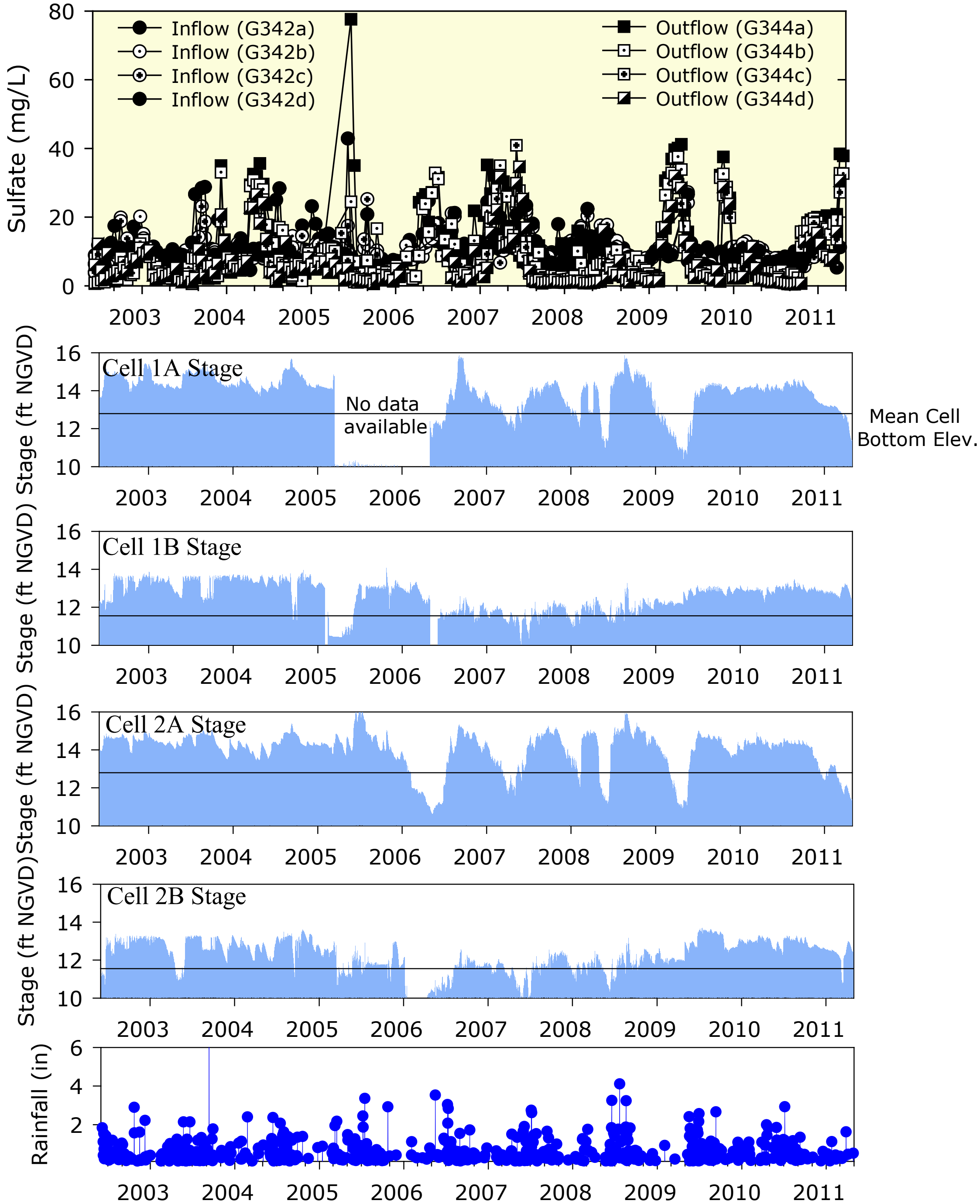

Figure C-19. Concentrations of sulfate, stage in the two cells (recorded immediately upstream of the outflow culvert), and rainfall at STA-5.

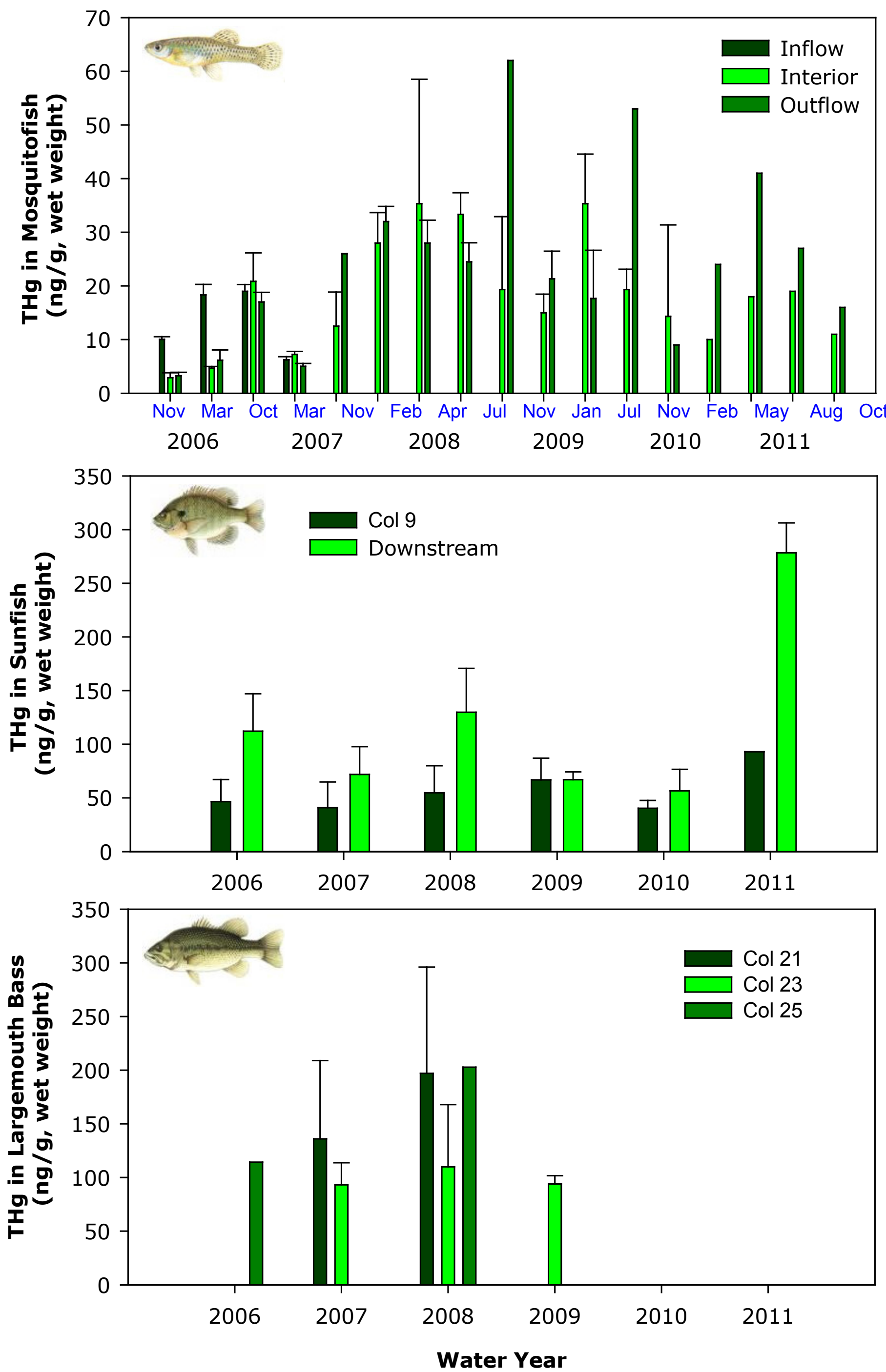

Figure C-20. Mercury concentrations (ng/g, wet weight) in mosquitofish composites (± SD) (top), whole sunfish (± SD) (middle), and fillets of largemouth bass (arithmetic mean, ± SD) (bottom) collected at STA-5. All sunfish at the downstream site were warmouth sunfish and only one fish (bluegill) was collected from the interior marsh.

STA-6

Start-up mercury monitoring occurred in the new part of STA-6, Section 2, on July 25, 2007. Currently, STA-6, Section 2, is under Phase 2, Tier 1 monitoring (**Figure C-21**) as reported in this section. The remainder of STA-6 (Cells 3 and 5) is in Phase 3, Tier 3, so monitoring has been terminated. Monitoring results prior to May 2004 are reported elsewhere (SFWMD, 1998 and 1999d; Rumbold and Rawlik, 2000; Rumbold et al., 2001; Rumbold and Fink, 2002a; Rumbold and Fink, 2003a; Rumbold, 2004 and 2005; Rumbold et al., 2006).

THg concentrations at the inflows and outflows of STA-6, Section 2, were fairly low throughout WY2011 (**Figure C-22**) and remained relatively low compared to previous spikes. MeHg remained at very low concentrations throughout the year. No THg sample was above the Florida Class III numerical water quality standard of 12 ng/L. All cells dried down during WY2010 for a period of approximately three months each (**Figure C-23**). These dryout periods could have created the high surface water sulfate level observed. The relatively low THg and MeHg concentrations in the outflow appear incongruous with hypotheses previously offered regarding dryout and rewetting effects on sediment oxidation, sulfur biogeochemistry, and stimulation of methylation by sulfate-reducing bacteria (Rumbold et al., 2006). Nonetheless, it is reasonable to assume that the dryout and rewetting of this rain-driven STA has some part in higher tissue-mercury levels in large-bodied fish. For WY2010, inflow loading of THg and MeHg were both greater than outflow (**Table C-4**).

Concentrations of THg in mosquitofish are summarized in **Table C-3** and **Figure C-24**. Levels of mercury in mosquitofish from the interior of STA-6 for WY2011 were the highest of all STAs; however, these levels were lower compared to previous years within STA-6. The persistent high levels in STA-6 are inconsistent with the historically low surface water percent MeHg levels, leading to the speculation that food chain dynamics enhance mercury bioaccumulation in STA-6. However, potential changes in porewater MeHg may also be a factor. The average annual composite for WY2011 and each individual mosquitofish composite for all locations within STA-6 did not exceed the POR 75th percentile for all downstream Everglades sampling locations.

As shown in **Table C-5** and **Figure C-24**, STA-6 sunfish from the interior marsh for WY2011 had mercury levels greater than those observed in sunfish at all other STAs, with the exception of locations within the Everglades and downstream monitoring locations. This has been the scenario since STA-6 started operations. The average annual sunfish Hg concentration for the interior marsh of STA-6 did not exceed the 75th percentile for the POR for all receiving waters sampled in downstream Everglades locations during WY2011.

Similar to sunfish, largemouth bass (**Table C-6**) at the interior site (STA6S2) had the highest THg concentration compared to all other STAs in WY2011 (**Figure C-24**). The interior concentrations show a decreasing trend over the POR and WY2011 levels are the lowest for the POR. The average annual LMB collected for WY2011 in STA-6 did not exceed the POR 75th percentile for all downstream Everglades sampling locations.

Regarding risks to fish-eating wildlife, mosquitofish from the interior and downstream locations did not exceed the 77 ng/g TL 2 or 3 USEPA criterion in WY2011. For sunfish, 80 percent of the catch from the interior marsh exceeded the USEPA TL 3 criterion and 40 percent exceeded the USFWS 100 ng/g criterion. All sunfish from the downstream site exceeded the TL 3 criterion and all but one sunfish sample exceeded the USFWS criterion. Fifty percent of all largemouth bass (whole-body concentration estimated from fillet concentration) from the interior marsh of STA-6 were above the USFWS criterion (100 ng/g), but none were above the USEPA criterion of TL 4 species (346 ng/g). Therefore, the risk of mercury exposure to fish-eating wildlife foraging preferentially at interior and downstream locations within STA-6 remains moderate to high.

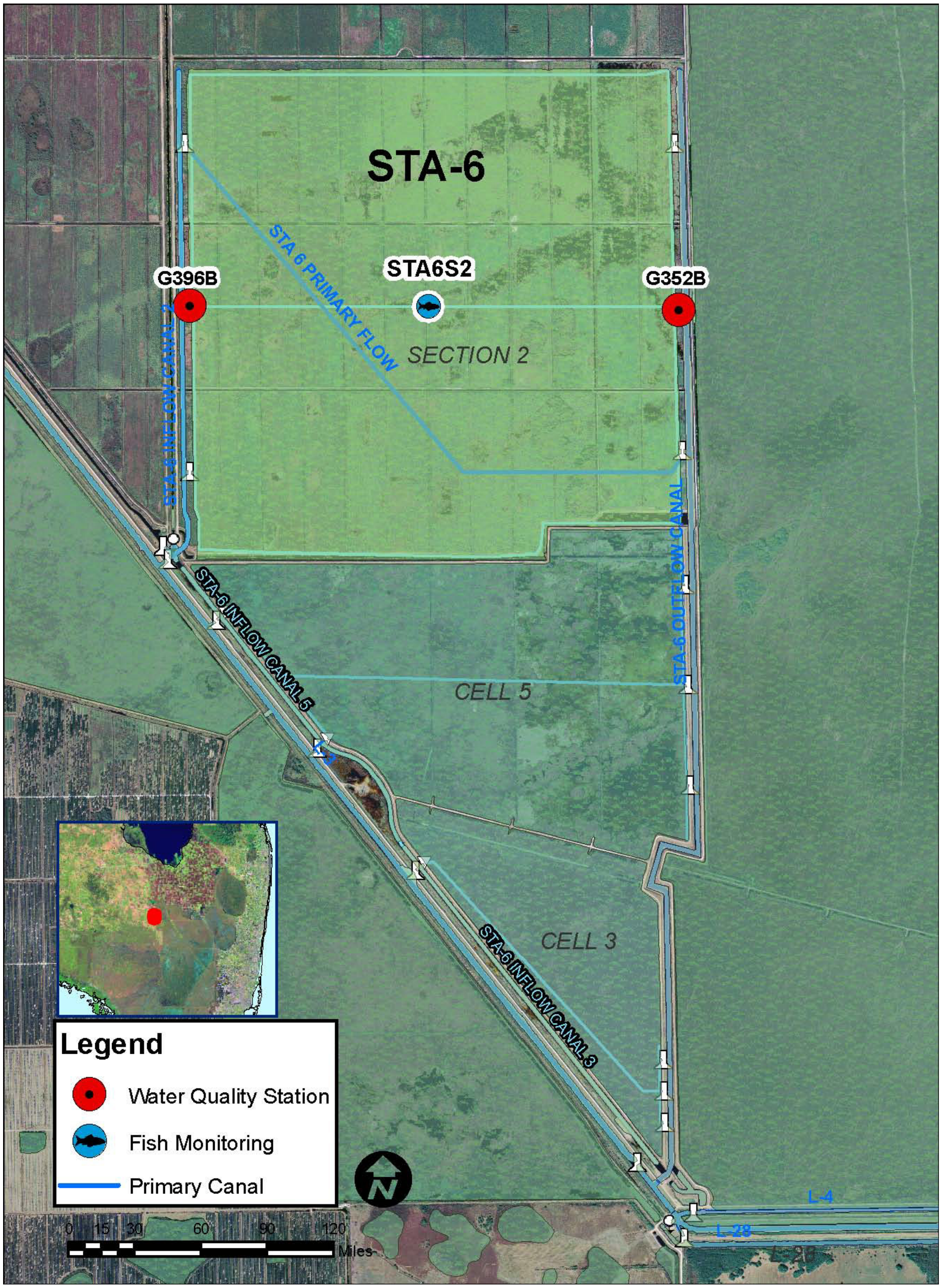

Figure C-21. Map of STA-6 showing current mercury monitoring sites. A mosquitofish composite sample is collected for STA-6, Section 2, and a single mosquitofish sample is collected downstream (STA6DC).

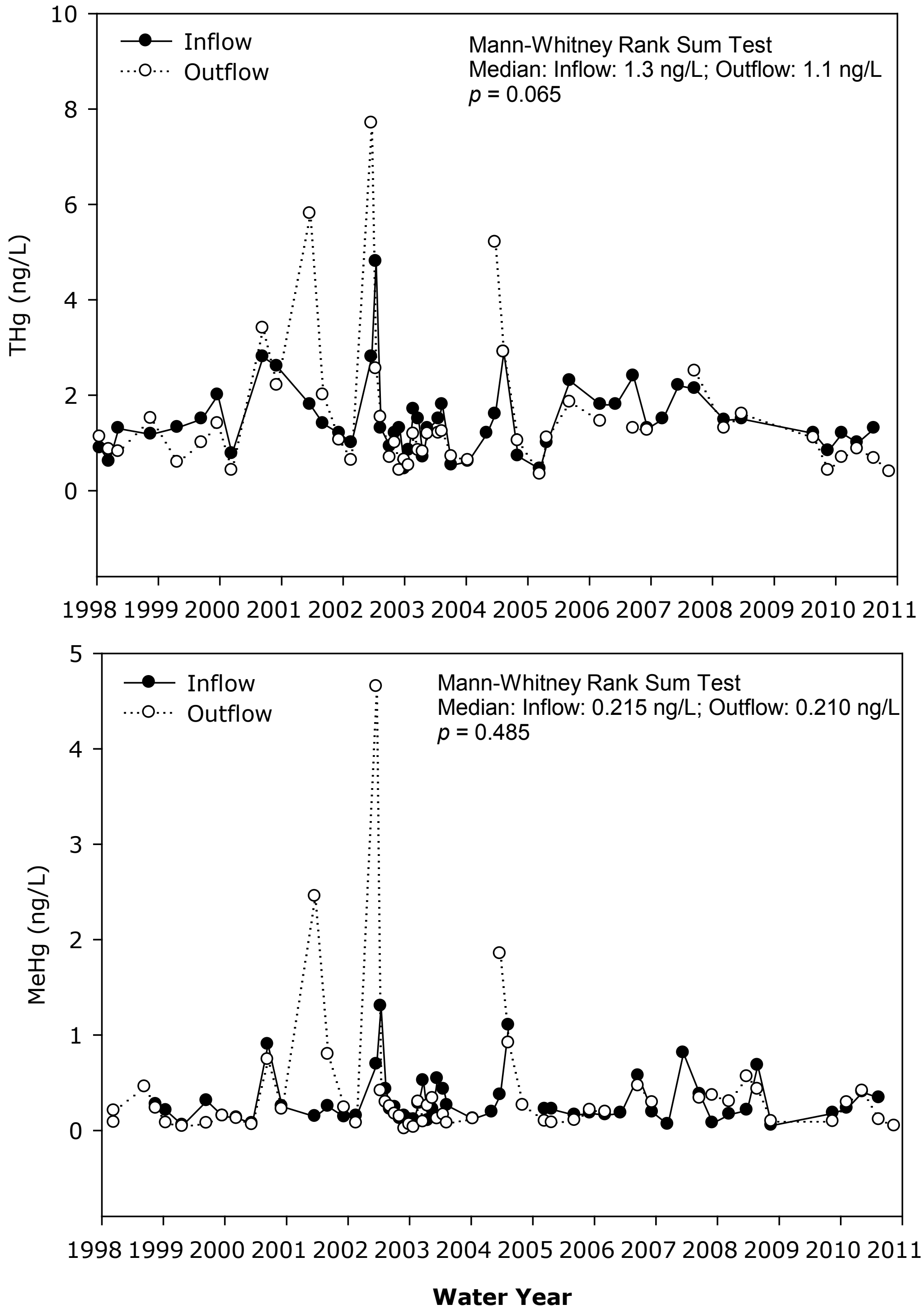

Figure C-22. Concentrations of (A) THg and (B) MeHg (ng/L) in unfiltered surface water collected at STA-6.

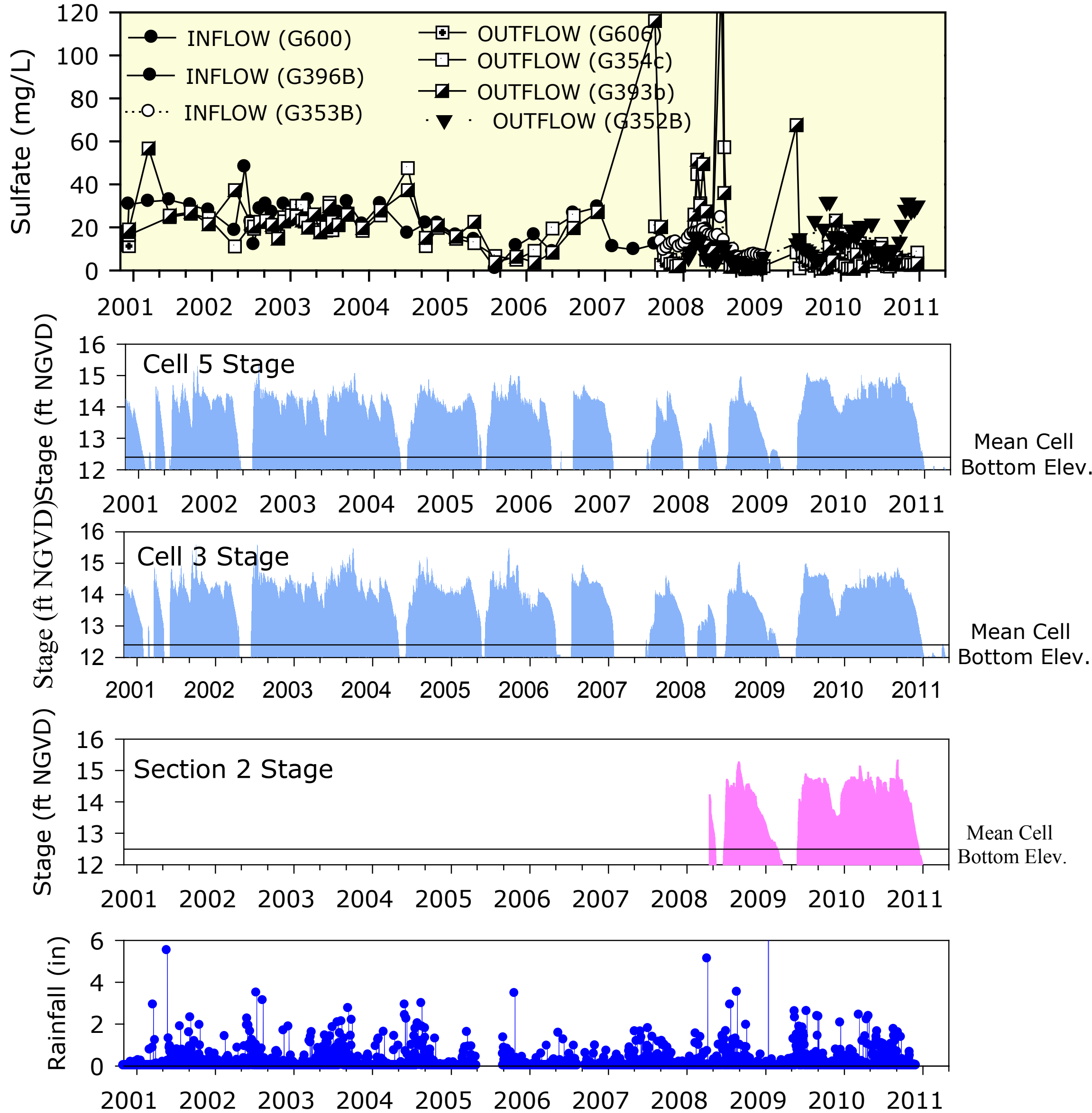

Figure C-23. Concentrations of sulfate, stage, and rainfall for STA-6.

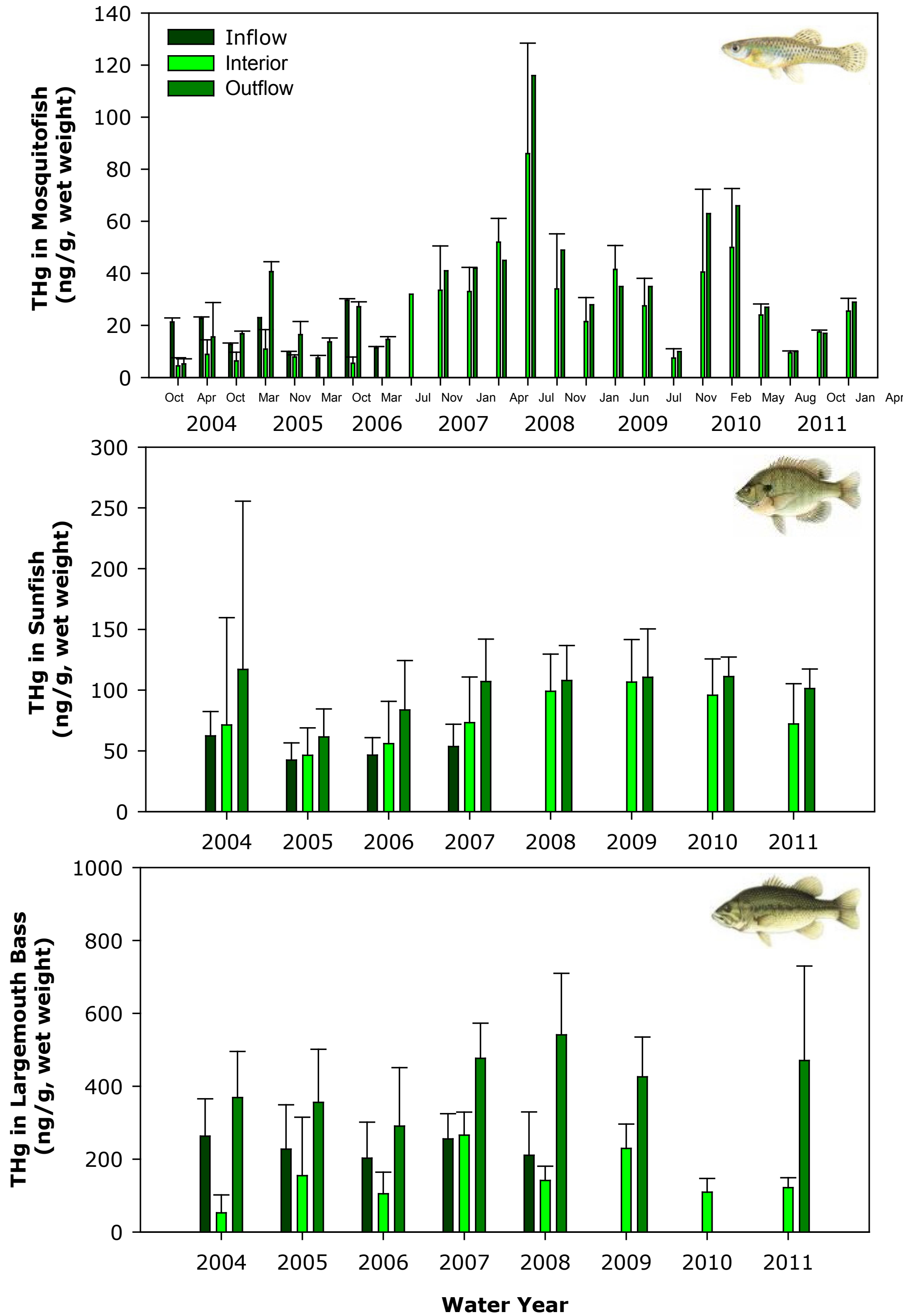

Figure C-24. Mercury concentrations (ng/g, wet weight) in mosquitofish composites (± SD)(top), whole sunfish (± SD)(middle), and fillets of largemouth bass (arithmetic mean, ± SD)(bottom) collected at STA-6.

MERCURY MONITORING NETWORK OPTIMIZATIONS

The summaries below provide information on the current mercury monitoring phase for each STA. These phases are concurrent with guidance contained in the MMAP.

STA-1W

Mercury monitoring in STA-1W is currently in Phase 3, Tier 3. The permit modification for moving from Phase 3, Tier 1 to Phase 3, Tier 3 was issued August 21, 2009. Phase 3 terminates all mercury monitoring in STA-1W (mosquitofish stations ST1W13COM, ST1W24COM, ST1WC5COM, ENR012, G310, ST1WLX; bass and sunfish stations ST1W51, ENR012, G310, ST1WLX).

STA-1E

Mercury monitoring in STA-1E is currently in Phase 2, Tier 1. Evaluations to move to Phase 3, Tier 1 are under way.

STA-2

Mercury monitoring in STA-2 is currently in Phase 2, Tier 1. Evaluations to move to Phase 3, Tier 3 are under way for Flow-ways 1, 2, and 3. Cell 4 was constructed and came online after the other cells and mercury monitoring did not begin until 2007, so monitoring in that cell is not eligible to move to Phase 3, Tier 3.

STA-3/4

Mercury monitoring in STA-3/4 is currently in Phase 3, Tier 1. A permit modification issued June 6, 2008, moved monitoring from Phase 2. Under this modification, Hg monitoring through mosquitofish was terminated at G383, G370, ST34C1B1, ST34C2B4, G376B, G376E, G379B, G379D, G381B, and G381E; largemouth bass and sunfish monitoring was ended at G383, G370, ST34C1B1, and ST34C2B4. Mosquitofish monitoring continues semiannually at cell flow-ways and downstream station L5F1. Largemouth bass and sunfish collections are triennial, with the next collection and results anticipated to be reported in the 2013 SFER.

STA-5

Mercury monitoring in STA-5, Flow-ways 1 and 2, is currently in Phase 3, Tier 3. The recently constructed Flow-way 3 is in Phase 2, Tier 1. The permit modification issued June 6, 2008, made these phase adjustments, terminating mosquitofish monitoring at G344B and G344D, largemouth bass and sunfish monitoring at G344D, and added mosquitofish station ST5C3COM and largemouth bass and sunfish collection station STA5C3B1.

STA-6

STA-6 (Cells 3 and 5) is in Phase 3, Tier 3 and mercury monitoring has been terminated in these areas. The relatively new Section 2 of STA-6 is in Phase 2, Tier 1 monitoring, which includes surface water and fish data. The permit modification issued June 6, 2008, made these phase adjustments, terminated mosquitofish monitoring at STA6C3COM and STA6C5COM, and terminated largemouth bass and sunfish monitoring at STA6C32.

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Attachment D: Rotenberger Wildlife Management Area Restoration and STA Downstream Transect Monitoring

Tom Dreschel

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In addition to the information provided in this attachment, additional supplemental information is required by Specific Conditions 27, 28, and 30(b) for Stormwater Treatment Area (STA) 1 West (STA-1W), STA-1 East (STA-1E), and STA-3/4, and Specific Conditions 25(b)3 and 28(b) for STA-2, STA-5, and STA-6 for the Everglades Forever Act permits and the Administrative Order for STA-5 and STA-6 under the Findings of Fact Number 20 for each of the above-mentioned STAs. This supporting information is available upon request.

HYDROPATTERN RESTORATION AND STA DISCHARGE MONITORING ON THE DOWNSTREAM AREAS

This section presents results from monitoring conducted in the areas downstream of the Stormwater Treatment Areas (STAs), including the Arthur R. Marshall Loxahatchee National Wildlife Refuge (Refuge), Water Conservation Area (WCA) 2A, and the Rotenberger Wildlife Management Area (RWMA). Everglades Forever Act (EFA) permit 0279449 for STA 1 West (STA-1W) and STA 1 East (STA-1E) and Administrative Order (AO) AO-010-EV for STA-2 and AO-011-EV for STA-5 requires the characterization of the effects of STA discharges on adjacent marsh areas. This characterization is based on monthly samples collected for specific conductance (conductivity) and total phosphorus (TP). Water quality monitoring stations in the marsh areas have been chosen along a transect from the discharge points and are categorized as "impacted" or "unimpacted" based on sediment TP levels. Those transect stations in areas where sediment TP levels are greater than 500 milligrams per kilogram (mg/kg) are identified as impacted. Monitoring data for each transect are provided in Attachment B. A summary of specific conductance and TP collected for these transects is provided in **Tables D-1** and **D-2**, respectively. These water quality data are also graphically presented as notched box-and-whisker plots along with the results of the monitoring conducted as part of the hydropattern restoration monitoring, which includes vegetation and water level.

Table D-1. Summary statistics for specific conductance in microsiemens per centimeter (µS/cm) measurements collected during Water Year 2011 (WY2011) (May 1, 2010–April 30, 2011) at transect stations from STA outflows.
[Note: km – kilometers]

STA Transects	Station Information: Name	Station Information: Category[1]	Distance from Canal (km)	Number of Samples	Mean	Standard Deviation	Minimum	Percentiles: 25th	Percentiles: 50th[2]	Percentiles: 75th	Maximum
STA-1W	LOXA104	Rim Canal	0.0	12	879	175	536	776	879	1,016	1,119
	LOXA104.5	Impacted	0.4	9	767	218	316	655	792	900	1,024
	LOXA105	Impacted	0.8	9	530	223	240	347	557	662	878
	LOXA106	Impacted	1.1	7	401	175	186	255	393	501	693
	LOXA107	Impacted	2.2	4	198	30	159	177	201	219	230
	LOXA107U	Unimpacted	3.4	5	144	11	134	134	139	155	156
	LOXA108	Unimpacted	4.1	7	140	20	115	126	141	150	174
STA-1E	LOXA135	Rim Canal	0.0	12	768	123	565	677	761	858	962
	LOXA136	Impacted	0.6	8	384	197	146	167	444	535	638
	LOXA137	Impacted	1.1	10	248	106	109	157	258	298	424
	LOXA138	Unimpacted	2.1	8	141	24	95	132	140	162	166
	LOXA139	Unimpacted	4.0	8	98	30	62	80	93	110	158
STA-2 (Transect 1)	2AN.25	Impacted	0.2	9	1,102	154	833	1,000	1,139	1,251	1,270
	2AN1	Impacted	0.9	7	1,020	204	698	872	1,055	1,144	1,304
	2AN2	Impacted	1.9	5	1,033	124	851	954	1,034	1,134	1,168
	2AN4	Impacted	3.7	6	1,036	152	845	864	1,071	1,160	1,205
	2AC4	Unimpacted	6.8	5	963	198	671	827	983	1,126	1,169
STA-2 (Transect 2)	2AFS.25	Impacted	0.4	8	1,024	136	848	921	991	1,151	1,215
	FS1	Impacted	1.0	7	1,007	99	881	940	995	1,077	1,168
	FS3	Impacted	3.1	8	912	255	380	809	1,003	1,071	1,152
	CA29	Unimpacted	5.6	9	921	132	658	880	920	978	1,156
STA-5	ROTC1	Impacted	0.2	7	549	140	283	497	557	664	686
	ROTC2	Impacted	2.3	6	395	126	192	307	432	494	516
	ROTC3	Impacted	4.2	6	308	106	188	209	293	426	439

[1]Categories of "impacted and "unimpacted" refer to station identification based on sediment phosphorus concentrations, Impacted stations have sediment total phosphorus concentrations of 500 milligrams per kilogram.

[2] Median = 50th percentile.

Table D-2. Summary statistics for total phosphorus (TP) in micrograms per liter (μg/L) measurements collected during WY2011 at transect stations from STA outflows.

STA Transects	Station Information: Name	Station Information: Category[1]	Distance from Canal (km)	Number of Samples	Mean	Standard Deviation	Minimum	Percentiles: 25th	Percentiles: 50th[2]	Percentiles: 75th	Maximum
STA-1W	LOXA104	Rim Canal	0.0	12	26	9	15	18	24	33	43
	LOXA104.5	Impacted	0.4	9	18	6	9	13	18	24	25
	LOXA105	Impacted	0.8	9	14	5	7	11	14	16	24
	LOXA106	Impacted	1.1	7	9	3	5	8	9	9	14
	LOXA107	Impacted	2.2	4	8	6	3	5	7	12	16
	LOXA107U	Unimpacted	3.4	5	7	2	5	5	6	8	9
	LOXA108	Unimpacted	4.1	7	7	3	3	5	8	8	11
STA-1E	LOXA135	Rim Canal	0.0	12	39	19	15	23	30	57	68
	LOXA136	Impacted	0.6	8	17	6	5	14	17	21	27
	LOXA137	Impacted	1.1	10	12	7	4	10	11	12	30
	LOXA138	Unimpacted	2.1	8	7	2	4	5	8	9	9
	LOXA139	Unimpacted	4.0	8	7	2	4	6	7	9	9
STA-2 (Transect 1)	2AN.25	Impacted	0.2	8	19	7	12	14	17	25	29
	2AN1	Impacted	0.9	7	18	6	12	14	16	20	29
	2AN2	Impacted	1.9	5	14	3	10	12	14	17	18
	2AN4	Impacted	3.7	6	7	1	6	6	7	8	8
	2AC4	Unimpacted	6.8	5	6	1	4	5	6	6	7
STA-2 (Transect 2)	2AFS.25	Impacted	0.4	8	23	19	10	14	18	21	69
	FS1	Impacted	1.0	7	14	3	10	12	15	17	19
	FS3	Impacted	3.1	8	6	1	5	6	6	7	8
	CA29	Unimpacted	5.6	9	5	1	4	4	5	6	7
STA-5	ROTC1	Impacted	0.2	7	29	18	10	16	29	36	64
	ROTC2	Impacted	2.3	6	13	5	7	11	12	13	23
	ROTC3	Impacted	4.2	6	12	4	6	9	12	13	18

[1] Categories of "impacted" and "unimpacted" refer to station identification based on sediment phosphorus concentrations. Impacted stations have sediment TP concentrations greater than or equal to 500 milligrams per kilogram.

[2] Median = 50th percentile.

Transects in the Refuge exhibited a substantial decrease in both specific conductance and TP concentrations within 1 km of the rim canal (**Figure D-2**). Specific conductance measured in the western transect (downstream of STA-1W outflows) decreased, on average, by 40 percent or 478 microsiemens per centimeter (µS/cm) and TP concentrations decreased by approximately 66 percent or 17 micrograms per liter [(µg/L) or parts per billion (ppb)], and within 1 km of the rim canal station. The eastern transect (downstream of the STA-1E outflow) exhibited a decrease of approximately 68 percent or 520 µS/cm in specific conductance and 69 percent or 27 ppb in TP within 1 km of the rim canal. Stations on both transects more than 1 km from the rim canal had mean TP concentrations ranging from 7 to 8 ppb and mean specific conductance values from 98 to 198 µS/cm (**Tables 1** and **2**). All specific conductance levels measured at Refuge transect stations were below the Class III criterion of 1,275 µS/cm.

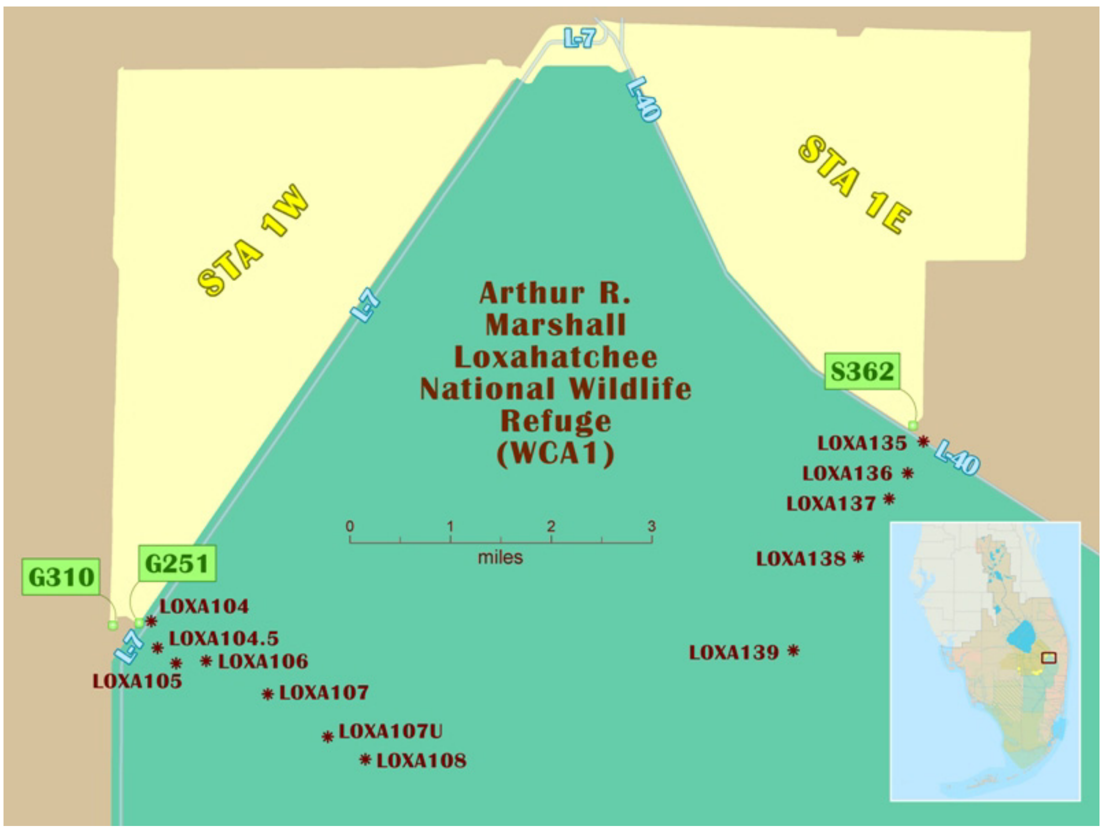


Figure D-1. Locations of marsh transect stations in the Arthur R. Marshall Loxahatchee National Wildlife Refuge (Refuge) and outflow structures from Stormwater Treatment Area (STA) 1 West (STA-1W) and STA 1 East (STA-1E).

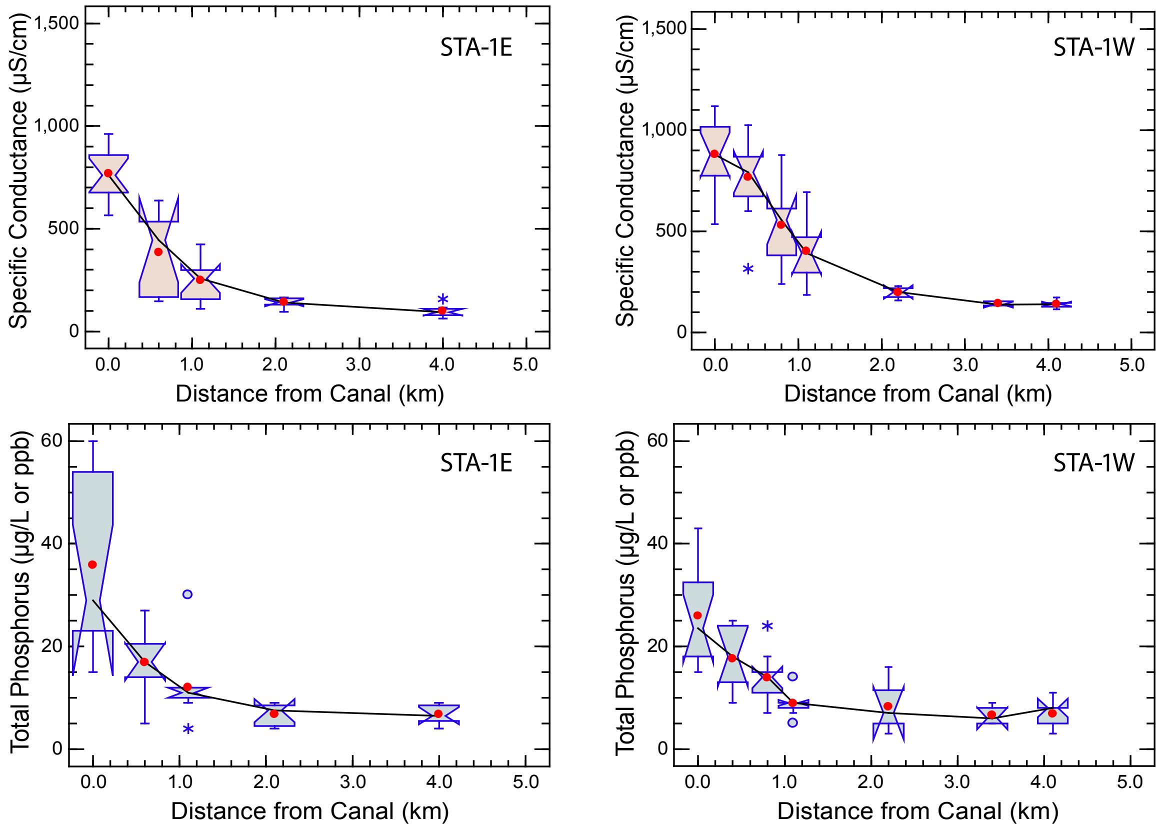


Figure D-2. Notched box-and-whisker plots of specific conductance and total phosphorus (TP) measured at transect stations downstream of STA-1W and STA-1E during Water Year 2011 (WY2011) (May 1, 2010–April 30, 2011). The notch on a box plot represents the 95 percent confidence interval (C.I.) about the median, which is represented by the narrowest part of the notch. The top and bottom of the box represent the 75th and 25th percentiles, respectively. The whiskers represent the highest and lowest data values that are within two standard deviations (SD) of the median. Values above and below the whiskers are greater than two SD from the median. Notches that do not overlap indicate that the data represented by the boxes being compared are significantly different at the 95 percent C.I.
[Note: km – kilometers)

The average specific conductance levels for STA-1W and STA-1E transects were 446 ± 343 µS/cm (median = 446) and 446 ± 317 µS/cm (median = 382) for Water Year 2010 (WY2010) (May 1, 2009–April 30, 2010) and WY2011, respectively. A Mann-Whitney test indicated there was no statistical difference in specific conductance between the two water years (p-value = 0.96, n = 215). The average TP concentration from both transects was 19 ± 20 µg/L (median = 11) for WY2010 and 16 ± 13 µg/L (median = 12) for WY2011 with no statistically significant difference in TP concentrations exhibited between the two water years (Mann-Whitney test, p-value = 0.82, n = 225), although concentrations in the rim canal adjacent to the STA-1E discharge were higher in WY2010 than in WY2011. Additional statistical summaries for these two transects are provided in **Table D-3**.

Sediments sampled in August 2010 for WCA-1 (**Table D-4**) showed impacts at the stations closest to the rim canal, and as expected, sediments considered unimpacted by TP are found at the sites farther from the canals (LOXA-107U, LOXA-108, LOXA-138, and LOXA-139).

Table D-3. Comparisons of the surface water mean [±1 standard deviation (SD)] specific conductance in µS/cm and TP concentration in or parts per billion (ppb) between WY2010 and WY2011 at the permit compliance stations in Water Conservation Area (WCA) 1.

STA Transects	Station	Specific Conductance (µS/cm)		Total Phosphorus (µg/L or ppb)	
		WY2010	WY2011	WY2010	WY2011
STA-1W	LOXA104	886 ± 197	879 ± 175	36 ± 10	26 ± 9
	LOXA104.5	824 ± 236	767 ± 218	26 ± 15	18 ± 6
	LOXA105	673 ± 268	530 ± 223	13 ± 5	14 ± 5
	LOXA106	423 ± 222	401 ± 175	10 ± 4	9 ± 3
	LOXA107	173 ± 24	198 ± 30	9 ± 5	8 ± 6
	LOXA107U	146 ± 25	144 ± 11	8 ± 2	7 ± 2
	LOXA108	146 ± 34	140 ± 20	8 ± 2	7 ± 3
STA-1E	LOXA135	819 ± 220	768 ± 123	62 ± 34	39 ± 19
	LOXA136	310 ± 178	384 ± 197	20 ± 15	17 ± 6
	LOXA137	215 ± 118	248 ± 106	12 ± 8	12 ± 7
	LOXA138	136 ± 41	141 ± 24	7 ± 2	7 ± 2
	LOXA139	101 ± 15	98 ± 30	9 ± 3	7 ± 2

Table D-4. Mean floc and soil TP concentrations with SD to a depth of 10 centimeters (cm). Soil TP concentrations above 500 milligrams per kilogram (mg/kg) are considered impacted.

SITE	FLOC TP (mg/kg)	SEDIMENT TP (mg/kg)
LOXA-104.5	1880 ± 289	1012 ± 112
LOXA-105	1150 ± 230	634 ± 185
LOXA-106	792 ± 102	529 ± 18
LOXA-107		559 ± 46
LOXA-107U	438 ± 21	386 ± 60
LOXA-108	436 ± 95	322 ± 38
LOXA-136	1320 ± 289	922 ± 147
LOXA-137	858 ± 207	746 ± 68
LOXA-138	293 ± 27	279 ± 3
LOXA-139	366 ± 52	276 ± 39

NORTHWESTERN WATER CONSERVATION AREA 2A

WCA-2A Monitoring Objectives

In accordance with the EFA, the South Florida Water Management District (District or SFWMD) has been monitoring the effect of water discharged from STA-2 into the northwestern region of WCA-2A. These releases are intended to restore the hydropattern and ecological functionality of the marshes downstream of STA-2. The STA-2 EFA permit requires that the District implement a monitoring and assessment program to monitor and evaluate ecological changes associated with STA-2 discharges into the area. This annual report addresses the (1) beneficial environmental effects, including changes in water quality, soil, vegetative conditions, inundation, and timing of discharges, and (2) any adverse environmental effects, including imbalances in natural populations of flora or fauna, changes in periphyton communities, or other undesirable consequences of the hydropattern restoration.

WCA-2A Configuration

STA-2 primarily discharges into WCA-2A through six culverts (G-336A–F structures) (**Figure D-3**). STA-2 discharges are also released through G-336G into the discharge canal south of STA-2. Approximately 1 km northeast of the S-7 pump station, the levee separating this discharge canal from WCA-2A is degraded, allowing discharge passing through G-336G to passively enter WCA-2A. Three transects (N-, C-, and S-transects) were established in 1998 to monitor environmental and ecological changes in the area. In 2005, a new transect (FS-transect) was established to monitor the STA-2 discharges through the degraded levee northeast of S-7. The FS-transect includes locations at 0.25, 1, 2, and 3 km from the degraded levee. There are two EFA permit compliance monitoring transects that consist of selected stations from the N-, C-, and FS-transects and also include station CA29.

WCA-2A Hydropattern Restoration

Hydropattern improvements resulting from STA-2 discharges are presented in Pietro et al. (2009) and Garrett and Ivanoff (2008). Permanent stage recorders were installed at WC2AN1 and WC2AS1 (**Figure D-3**) stations in WY2009 and both gauges began recording data in June 2009. Stage data were available for WY2010 and WY2011 for sites WC2AN1 and WC2AS. Water depths were determined by subtracting estimated ground elevation from the stages. Results showed that in WY2011, the north station site was inundated 77 percent of the time and the south station site was inundated 55 percent of the time (**Figure D-4**). Mean water depth when the water level was above ground was 15.4 inches (in) at WC2AN1 and 5.3 in at WC2AS1. Compared to WY2010, depths and number of inundation days were lower due to drought conditions. Water depths at the north station fluctuated widely between 10 inches and 35 inches during the wet season and dryout occurred in the early part of the dry season. Water depth continued declining from October 2010 to February 2011.

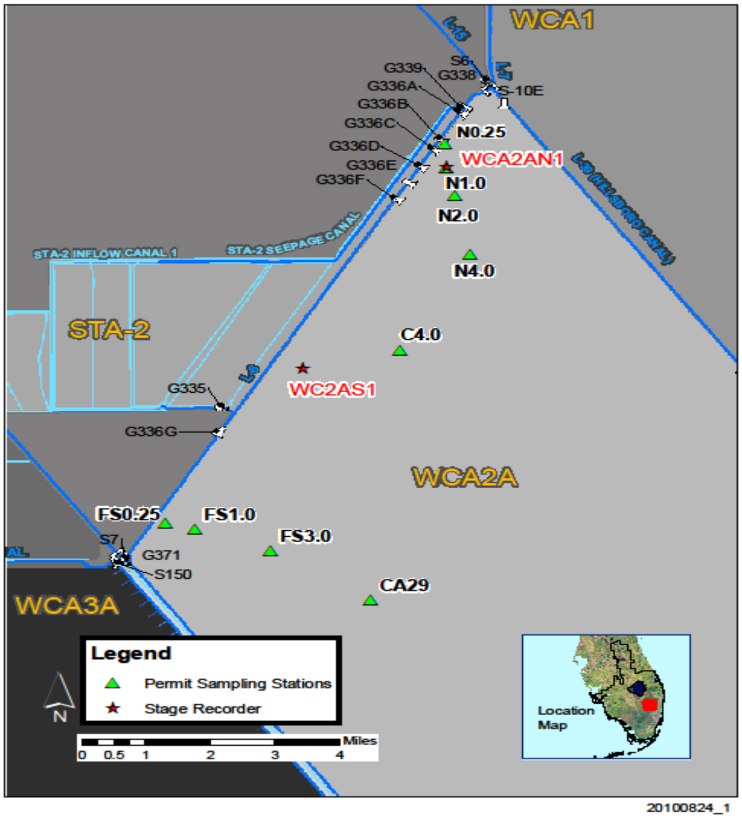


Figure D-3. Location of STA-2 discharge structures, including the G-336A–G discharge culverts in relation to sampling stations along transects in the northwestern section of Water Conservation Area (WCA) 2A.

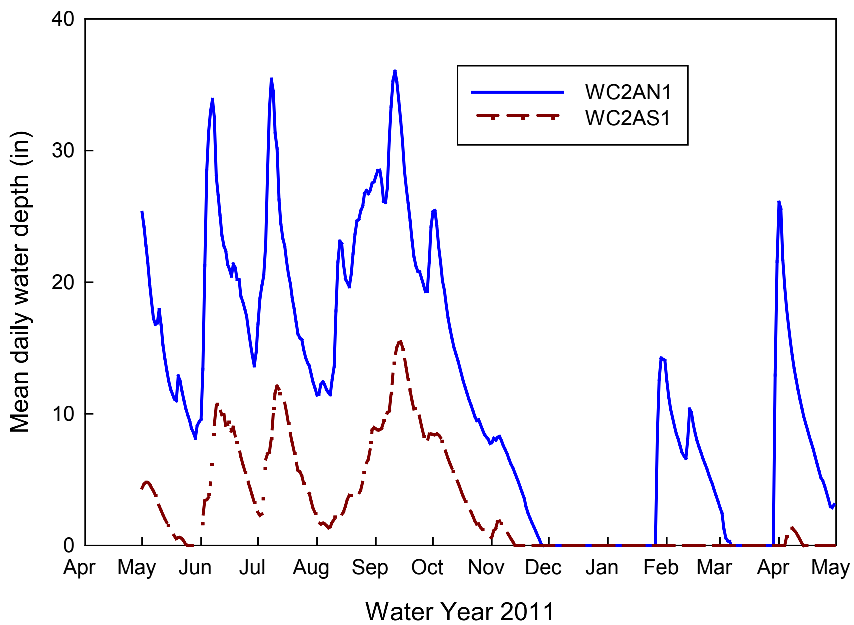


Figure D-4. Mean daily water depths for WY2011 derived from two stage recorders deployed along the northwest region of WCA-2A.

EFA Permit Compliance Transect Total Phosphorus and Specific Conductance at STA-2 Downstream Area (WCA-2A)

Two EFA permit compliance transects are downstream of the STA-2 discharge. These transects are monitored to characterize the effects of STA-2 discharges on the marsh. They are in the western part of the WCA, with Transect 1 in the northern portion and Transect 2 in the southern portion (**Figure D-3**). Transect 1 is near the G-336A-G structure and consists of five marsh monitoring stations (N0.25, N1.0, N2.0, N4.0, and C4.0) extending approximately 7 km into the WCA. Transect 2 is downstream of the G-336G structure and consists of four marsh monitoring stations (FS0.25, FS1.0, FS3.0, and CA29) extending approximately 6 km into WCA-2A.

Mean specific conductance during WY2011 ranged from 912 to 1,102 µS/cm for both transects (**Table D-5**). Specific conductance levels along the northern transect between 0.25 and 4 km from L-6 ranged from similar (1,020 to 1,102 µS/cm) and decreased to 963 µS/cm at 7 km into the marsh (**Figure D-5**). Average specific conductance levels had little change along the southern transect during WY2011, ranging from 912 to 1024 µS/cm (**Table D-5**). One measurement along the northern transect exceeded the Class III criterion of 1,275 µS/cm. A measured specific conductance value of 1,304 µS/cm was reported at marsh station N1.0 in April 2011 during the peak of the drought and probably resulted from evaporative processes. No statistically significant difference was observed between specific conductance measure in WY2010 and WY2011 (Mann-Whitney p-value = 0.32, n = 157).

Mean TP concentrations in WY2011 ranged from 5 to 23 µg/L for both transects with stations located closer to the canal exhibiting higher TP concentrations (**Table D-5**). By 4 km from the canal, TP concentrations for both transects were below 10 µg/L (**Figure D-5**). TP concentrations in the northern transect decreased from a mean concentration of 19 µg/L at N0.25 to 6 ppb at 7 km from the discharge point. Along the southern transect, the mean TP concentration near the inflow averaged 23 µg/L and decreased to 5 ppb approximately 6 km into the marsh. Both transects exhibited a significant reduction in TP concentrations at 1 to 2 km from the inflow.

A Mann-Whitney test was used to determine if a statistically significant difference existed for TP data between WY2010 and WY2011. Based on the analysis, a statistically significant difference (p-value = 0.006, n = 152) was observed for TP data with the WY2010 data (median = 16 µg/L) being significantly higher than the WY2011 data (median = 12 µg/L). Higher canal concentrations during WY2010 contributed to the observed differences.

Sediments sampled in WCA-2A in 2010 are compared to concentrations obtained in 2008 in **Table D-6**. For the measurements reported, there is a general trend toward increasing TP but due to the generally high variability of the sediment TP, no substantial changes in soils TP are reported, except at site FS3.0. Further, a statistical comparison between WY2008 and WY2010 sediment TP concentrations found no statistically significant difference (2-sample t-test p-value = 0.91; Mann-Whitney p-value = 0.61).

Table D-5. Comparisons of the surface water mean (±1 SD) specific conductance and TP concentration between WY2010 and WY2011 at the permit compliance stations in WCA-2.

STA Transects	Station	Specific Conductance (µS/cm)		Total Phosphorus (µg/L or ppb)	
		WY2010	WY2011	WY2010	WY2011
STA-2 (Transect 1)	N0.25	1,063 ± 131	1,102 ± 154	30 ± 24	19 ± 7
	N1.0	1,063 ± 145	1,020 ± 204	26 ± 21	18 ± 6
	N2.0	1,019 ± 146	1,033 ± 124	19 ± 6	14 ± 3
	N4.0	1,038 ± 164	1,036 ± 152	11 ± 8	7 ± 1
	C4.0	783 ± 322	963 ± 198	7 ± 1	6 ± 1
STA-2 (Transect 2)	FS0.25	1,088 ± 120	1,024 ± 136	42 ± 40	23 ± 19
	FS1.0	1,067 ± 112	1,007 ± 99	27 ± 21	14 ± 3
	FS3.0	997 ± 131	912 ± 255	11 ± 9	6 ± 1
	CA29	1,009 ± 107	921 ± 132	5 ± 1	5 ± 1

Table D-6. Mean soil TP concentrations with SD measured in March 2008 and March–April 2010. Each value is the mean of three soil cores collected to a depth of 10 cm. Soil TP concentrations above 500 mg/kg are considered impacted.

Station	2008 Mean Soil TP (mg/kg)	2010 Mean Soil TP (mg/kg)
C4.0*	476 ± 37	444 ± 40
CA29*		363 ± 48
FS0.25*	1134 ± 95	1241 ± 15
FS1.0*	892 ± 150	992 ± 102
FS3.0*	500 ± 8	611 ± 8
N0.25*	835 ± 32	854 ± 52
N1.0*	713 ± 63	802 ± 96
N2.0*	675 ± 170	681 ± 57
N4.0*	518 ± 58	475 ± 47

Asterisk (*) indicates permit compliance station.

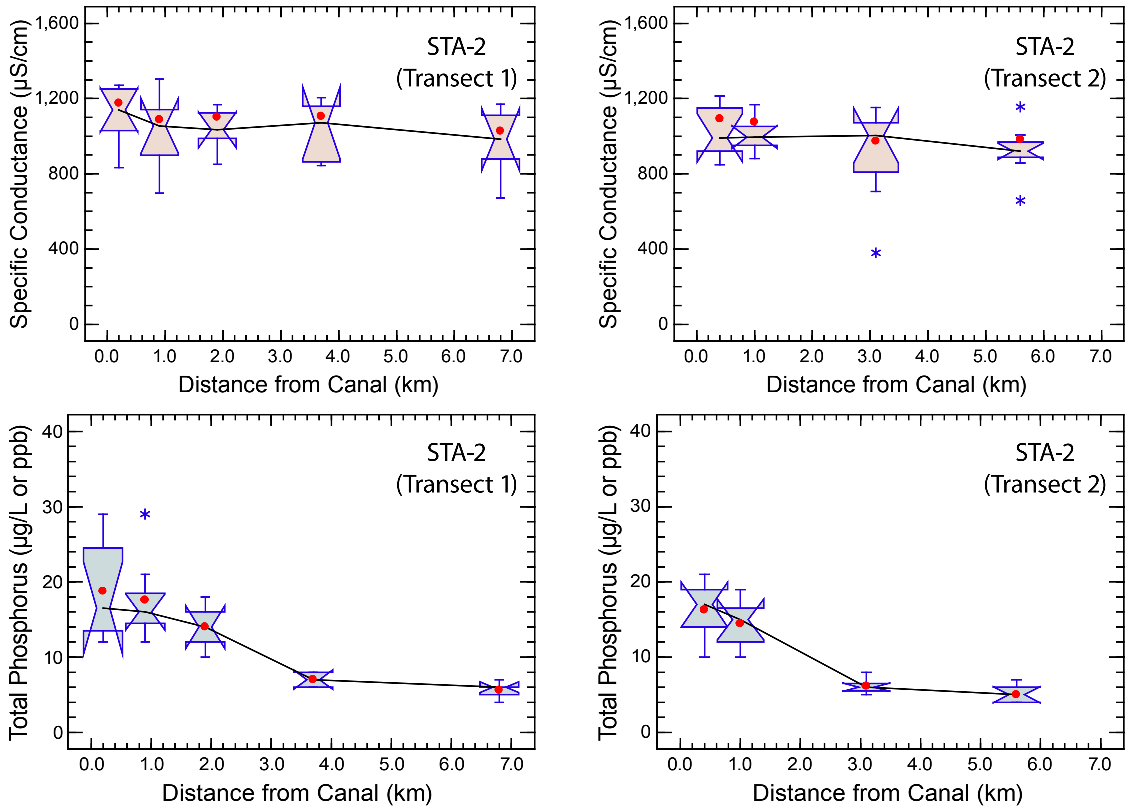


Figure D-5. Notched box-and-whisker plots of specific conductance and TP levels measured at transect stations downstream of STA-2 during WY2011. See Figure D-2 for information on notched box-and-whisker plots.

WCA-2A Macrophyte Composition along the Permit Compliance Transects

The areal coverage of several dominant macrophyte species was measured along fixed transects each year from 2005 through 2010. Using point-intercept survey methodology, the presence of sawgrass (*Cladium jamaicense*) and cattail (*Typha* spp.) at one-meter intervals along 10 m transects was recorded. Only data from the permit compliance sites are presented in this report. **Tables D-7** and **D-8** show the frequency of occurrence of cattail and sawgrass along each transect. At the northern transect, site N0.25 (0.25 km from the nearest G-336 discharge point), was dominated by cattail with little sawgrass present. Sawgrass has been the dominant vegetation at 1 to 4 km from the inflow over the survey period except for site N1.0 (**Table D-7**). N1.0 displayed increases in both sawgrass and cattail presence in the most recent survey. The cause is not clear. No cattail was present at sites 2 to 4 km from the inflow over the survey period.

At the southern transect, both sawgrass and cattail were present in FS0.25 and FS1.0 while only sawgrass was present in FS3.0 (**Table D-8**). Sawgrass and cattail presence increased at FS0.25 since 2007. However, sawgrass decreased its presence at FS1.0 since the April 2010 sampling. It is important to note that transect poles had to be moved in November 2008 at several sites (N1.0, N2.0, N4.0, FS0.25, and FS1.0) was due to the impact of drift from an herbicide application to clear helicopter landing areas for safe access to sites. In addition, one transect (N2.0) was relocated in April 2006 because trails worn next to it affected the vegetation along the transect. In each of these cases, transect poles were moved to the closest possible location away from the disturbance that had the same vegetation communities. These distances varied between 15 and 30 meters from the original location.

Table D-7. Number of points (out of 10 possible points at one-meter intervals along each transect) at the northern transect locations of WCA-2A where sawgrass (Saw) or cattail (Cat) was present.

Date	N0.25		N1.0		N2.0		N4.0		C4.0	
	Saw	Cat	Saw	Cat	Saw	Cat	Saw	Cat	Saw	Cat
April 2005	1	10	10	0	10	0	10	0	10	0
October 2005	1	10	9	0	10	0	10	0	10	0
April 2006	1	10	9	0	10[W]	0[W]	10	0	10	0
November 2006	1	10	10	5	9	0	1[F]	0[F]	10	0
April 2007	1	10	10	9	10	0	6	0	10	0
October 2007	0	9	10	2	10	0	2	0	10	0
March 2008	0	10	10	0	10	0	4	0	10	0
October 2008	1	10	5	2	10	0	8	0	10	0
April 2009	1	10	10[S]	4[S]	10[S]	0[S]	9[S]	0[S]	10	0
October 2009	1	10	10	9	9	0	10	0	10	0
April 2010	0	9	0	9	8[A]	0[A]	10	0	9[A]	0[A]
October 2010	2	10	9	10	10	0	10	0	10	0

[S] Transect was moved due to herbicide overspray

[W] Transect was moved due to worn trail next to transect

[F] Fire occurred at site

[A] Transect was moved due to airboat damaging vegetation on transect

Table D-8. Number of points (out of 10 possible points at one-meter intervals along each transect) at the southern transect locations of WCA-2A where sawgrass (Saw) or cattail (Cat) was present.

Date	FS0.25		FS1.0		FS3.0	
	Saw	Cat	Saw	Cat	Saw	Cat
April 2005	7	8	7	0	10	0
October 2005	3	9	3	3	10	0
April 2006	7	4	7	6	10	0
November 2006	8	5	8	7	10	0
April 2007	8	5	8	8	9	0
October 2007	8	2	8	5	10	0
March 2008	8	4	8	8	10	0
October 2008	6	6	6	5	10	0
April 2009	8[S]	4[S]	8[S]	2[S]	10	0
October 2009	6	8	10	8	10	0
April 2010	6	10	10	9	10	0
October 2010	10	10	3	10	10	0

[S] indicates that transect was moved due to herbicide overspray

ROTENBERGER WILDLIFE MANAGEMENT AREA

Restoration and Monitoring Objectives

The Rotenberger Hydropattern Restoration Project is a component of the District's Everglades restoration efforts. The project goal is to slow, alter, and eventually reverse the ecosystem degradation within the RWMA (**Figure D-6**), primarily by restoring a more natural hydropattern. The degradation was caused by overly dry conditions that have resulted in repeated peat fires, soil oxidation and compaction, nutrient release from surface soils, and conversion of obligate wetland vegetative communities to upland-type communities. Anticipated benefits of the restoration efforts include the preservation and encouragement of additional desirable wetland vegetation species and the initiation of peat formation. The WY2011 restoration activities included completion of the design of a supplemental pump station to deliver water to the area.

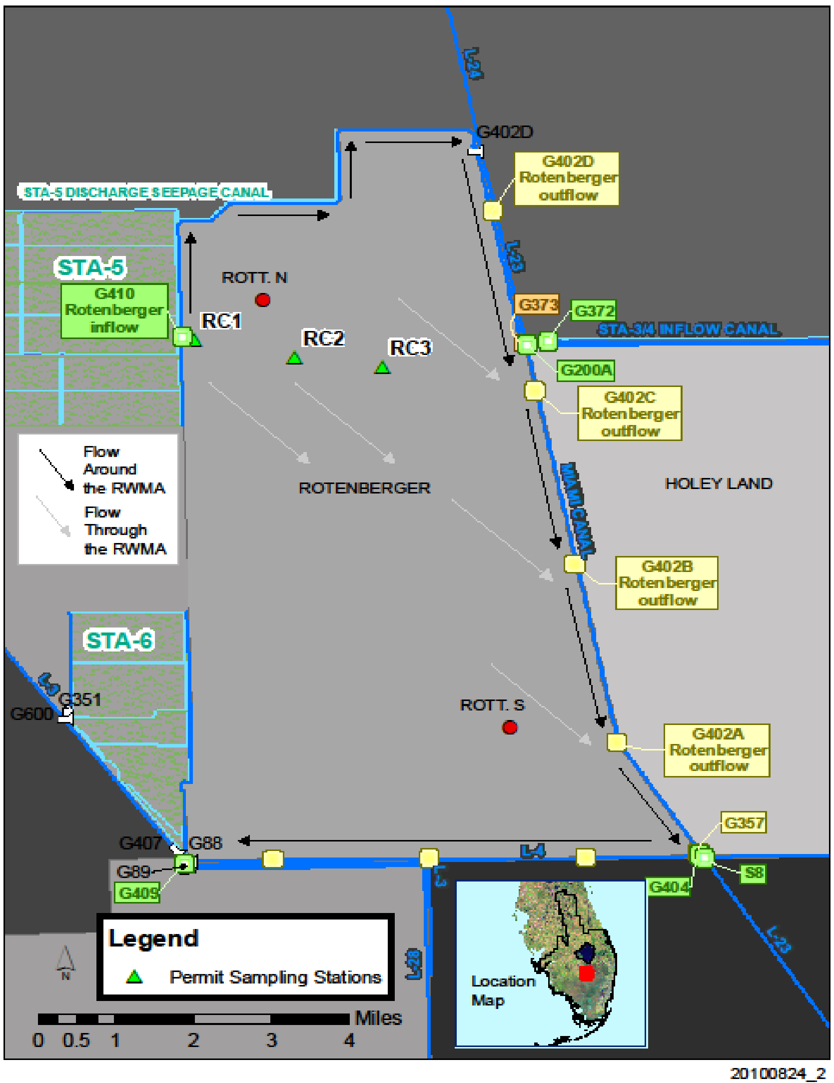


Figure D-6. Map of the Rotenberger Wildlife Management Area (RWMA) showing major structures and monitoring transect RC (permit compliance monitoring transect). Rott.N and Rott.S are the locations of the permanent stage recorders and newly installed groundwater wells.

Configuration

Project features include a 240 cubic foot per second (cfs) electric pump station (G-410) to withdraw treated water from the STA-5 discharge canal for release into the RWMA. This pump station distributes water through a 10-mile spreader canal located parallel to the west perimeter levee of the area. Surface water that is released out of the RWMA goes into the Miami Canal (L-28 canal) through four gated culverts (G-402A through G-402D) along the eastern boundary of the RWMA. There is a quarter-mile collection canal upstream of each outlet structure.

The RC1, RC2, and RC3 stations are EFA permit compliance locations within the RWMA. Monitoring data for the stations downstream of STA-5 can be located within two District databases, ERDP and DBHYDRO. Water levels have historically been monitored at the Rott.N and Rott.S stage gauges.

Water Budget

Annual water budgets from 2003 through 2011 are presented in **Table D-9**. Of the inflow, 79 percent is attributed to rainfall and 86 percent of the outflow is attributed to evapotranspiration (ET). Both rainfall and inflow through G-410 decreased significantly in WY2011 compared to WY2010. Outflows remained about the same but ET increased significantly in WY2011 reflecting the drought conditions. Seepage values were not accounted for in these calculations. Errors include seepage losses or gains and measurement errors. Also, due to the drought when water level receded further below ground ET will be lower than the potential ET. That could account for part of the water budget errors.

Table D-9. Water budgets calculated for WY2003–WY2011. Inflows in acre-feet (ac-ft) represent discharges into the RWMA from the G-410 structure and outflows represent water releases from the G-402A–D structures.
[Note: ET – evapotranspiration.]

Water Year	Inflow (ac-ft)	Rainfall (ac-ft)	Total Inflow (ac-ft)	Outflow (ac-ft)	ET (ac-ft)	Total Outflow (ac-ft)	Change in storage (ac-ft)	Error %
2003	54,306	111,179	165,485	25,312	125,410	150,722	70	-9.3
2004	16,849	114,620	131,469	352	123,546	123,898	-20	-5.9
2005	44,414	113,868	158,282	33,788	123,847	157,635	33	-0.4
2006	29,886	114,605	144,491	54,648	124,451	179,099	-792	20.9
2007	16,195	85,538	101,733	4,630	123,403	128,033	-731	22.3
2008	11,646	108,725	120,371	0	124,900	124,900	11,431	13.0
2009	32,297	102,125	134,422	25,126	128,177	153,303	-11,187	5.3
2010	40,582	152,423	193,005	21,295	125,578	146,873	1,018	-26.5
2011	17,922	116,675	134,597	21,622	138,200	159,822	-13,365	8.1
Total	264,097	1,019,758	1,283,855	186,773	1,137,512	1,324,285	-13,543	2.1
Percent of inflow	G-410 Inflow	Rainfall				Percent of Outflow	G-402 Outflow	ET
	21%	79%					14%	86%

Hydrologic and Total Phosphorus Loads

In WY2011, approximately 17,922 acre-feet (ac-ft) of STA-5 water were discharged into the RWMA through the G-410 structure (**Figure D-7**). This volume is approximately 23,000 ac-ft less than the WY2010 discharge. An estimated TP load of 0.41 metric tons (mt) was exported to the RWMA during WY2011, yielding an inflow flow-weighted mean (FWM) TP of 18.6 ppb. Both the TP load and FWM concentration in WY2011 were considerably lower than those reported in WY2010 (TP load = 1.41 mt; TP FWM = 28.1 ppb). A simple regression analysis of FWM TP concentrations with time exhibited a statistically significant decreasing trend in WY2011 (r = -0.80, p-value = 0.003). A similar analysis for TP load indicated that while loads had a decreasing trend, the slope of the line was not statistically different from zero (r = -0.26; p-value = 0.41).

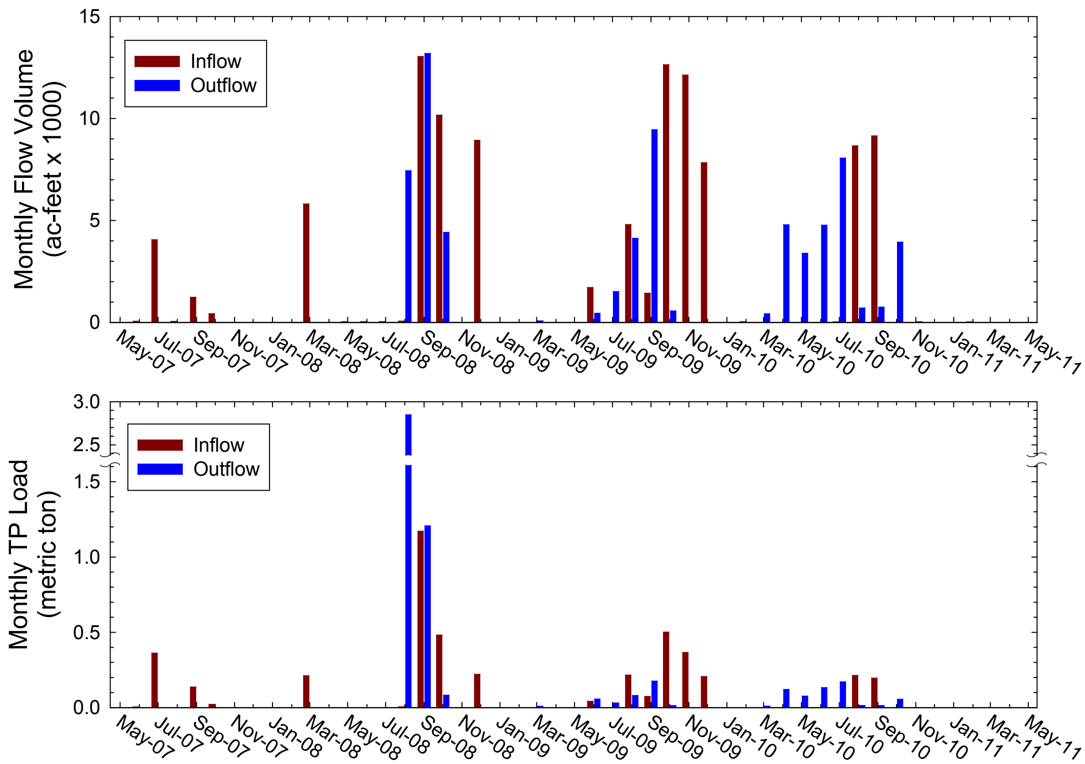


Figure D-7. Monthly flow volumes (top) and TP loads (bottom) for inflow and outflow structures at the RWMA for WY2008 through WY2011. [Note the scale break in the bottom plot.]

Approximately 21,621 ac-ft of water was released through the G-402A–C structures during WY2011, approximately 321 ac-ft more than in WY2010. The total load of TP released from the RWMA through the structures during WY2011 was 0.46 mt, or 0.05 mt higher than discharged to the wildlife management area. The resulting annual FWM TP concentration at the RWMA outflow was 17.3 ppb (**Figure D-8**). Both the outflow load and FWM concentration for WY2011 were lower than WY2010 (TP Load = 0.48 mt; FWM TP = 18.5 ppb). Additionally, outflow loads and FWM TP concentrations exhibited a statistically significant decrease during WY2011 based on a simple regression of each parameter with time (r = -0.73 for TP load and r = -0.89 for FWM TP; p-value = 0.007 for both).

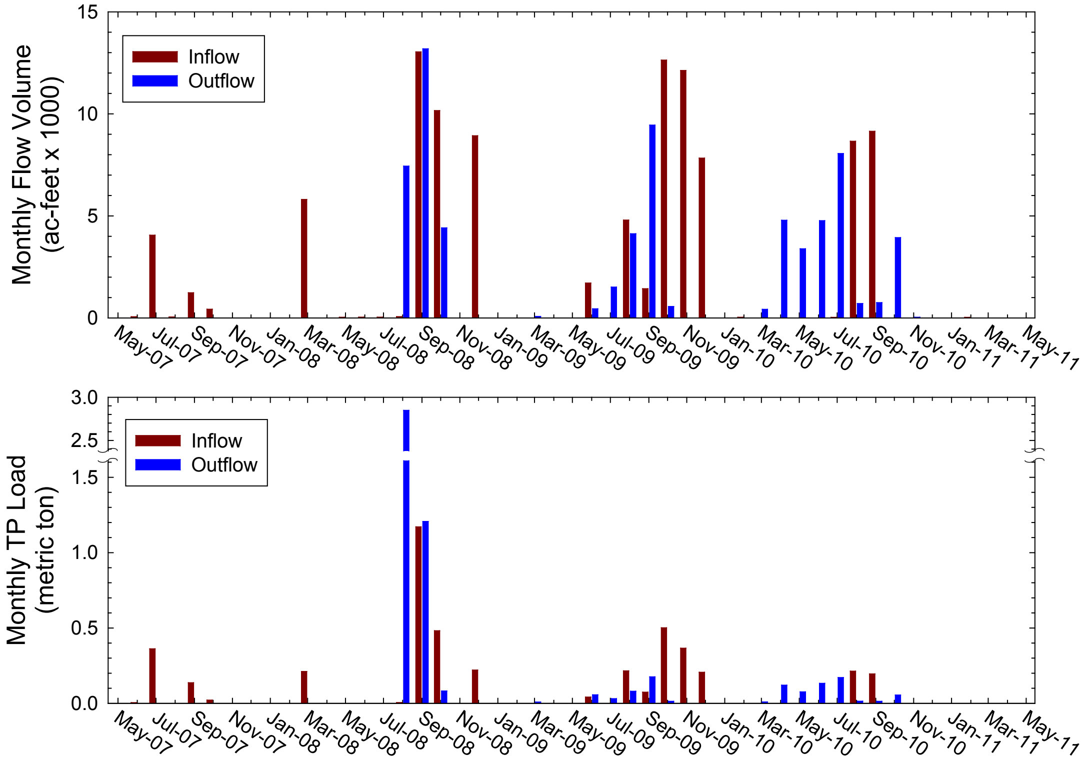


Figure D-8. Comparison of monthly flow-weighted mean TP concentrations with the 12-month moving average of the flow-weighted means for the RWMA inflow (top) and outflow (bottom) structures during WY2008 through WY2011. [Note the scale break in the bottom plot (outflow).]

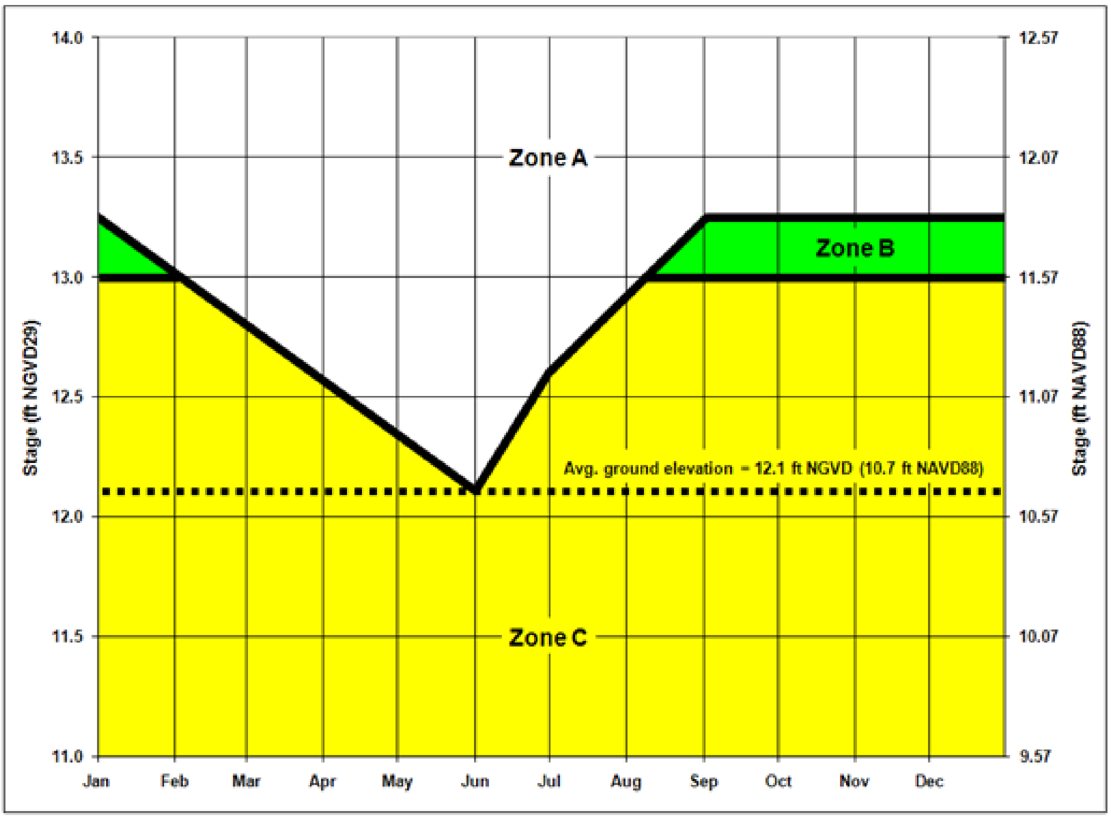
Although the annual outflow FWM TP concentration from the RWMA was lower than the annual inflow concentration to the RWMA, the outflow TP load during WY2011 was higher by 0.05 mt. The higher load out of the RWMA probably resulted from an excess of 4,000 ac-ft discharge through the G-402A-C structures than flowed into the system from the G-410 structure. Atmospheric input (i.e., rainfall) most likely accounted for the excess outflows. In fact, the southern flow-way of STA-5 was offline due to Compartment C build-out, and dryout conditions causing the STA to retain as much water as possible, thus there was less water available to discharge into the Rotenberger through G-410.

Hydropattern Restoration

Starting in June 2008, the District began meeting with the Florida Fish and Wildlife Conservation Commission (FWC) and the Florida Department of Environmental Protection (FDEP) to review the RWMA Operational Plan (SFWMD, 2004) and revise and improve the interim regulation schedule to better achieve the project's hydropattern restoration goals. An initial step in the process was to obtain an updated survey of the RWMA, which was completed in December 2008. The calculated ground elevation from the 2008 survey was 12.14 feet in relation to the National Geodetic Vertical Datum 1929 (ft NGVD 29).

The daily target stages for the RWMA in the previous years were set based on the District's Natural System Model (NSM) values plus 0.25 ft. The 0.25 ft was added to minimize the potential for excessive dryout during the dry season. In April 2009, consensus was reached on a modified interim regulation schedule that attempts to maintain the hydropattern restoration goals while also addressing the diverse biological needs of the RWMA and minimizing the risk of muck and/or peat fires. The biological needs considered were those of tree islands, native open-marsh vegetation [e.g., sawgrass and maidencane (*Panicum hemitomon*)], periphyton, wading birds, aquatic macrofauna [e.g., crayfish (*Procambarus alleni*)], and upland faunal species (e.g., mammals). It is recognized that during severe droughts when no supplemental water is available, the RWMA will dry out.

In the modified regulation schedule (**Figure D-9**), when water levels are within either Zone A or Zone C and regional water conditions allow, Rotenberger inflow and outflow structures will be managed in an effort to return water levels to the regulation schedule or Zone B. The District will continue to communicate all water management actions with the FWC (SFWMD, 2010).



Zone	Operational Direction
A	Manage inflows (G-410) and/or outflows (G-402A, G-402B, G-402C, and G-402D) to return to regulation schedule or Zone B.
B	Discretionary Zone: manage inflows and/or outflows to maintain water levels within Zone B if possible, based on an assessment of historical, climatic, and regional water conditions. Coordination with FWC required.
C	If regional water conditions allow, manage inflows and/or outflows to return to regulation schedule or Zone B.

Figure D-9. Modified interim regulation schedule for RWMA.

The average of stage values measured at ROTT.N (ROTTN-L) and ROTT.S (ROTTS-L) should be used with the modified interim regulation schedule. ROTTNGW can be substituted for ROTT.N if ROTT.N is unavailable or the water level at ROTT.N is at or below the ground surface (11.24 ft NGVD29). ROTTSGW can be substituted for ROTT.S if ROTT.S is unavailable or the water level at ROTT.S is at or below the ground surface (11.70 ft NGVD29). Based on data from these sites, WY2010 and WY2011 daily average RWMA stages, average ground elevation, and the interim operation plan target stages are depicted in **Figure D-10**. In WY2011 stages dropped to as much as 2 ft below the ground elevation by April 30, 2011. The stage decline started in March 2011.

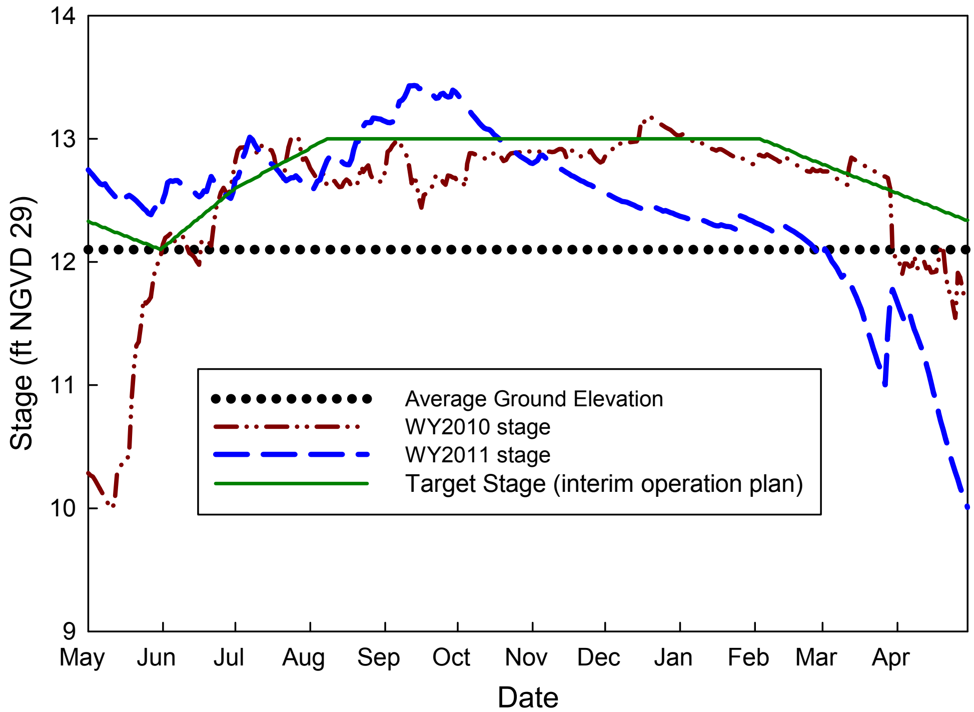


Figure D-10. Daily mean RWMA stages, average ground elevation, and interim operation plan target stages.

EFA Permit Compliance Transect Total Phosphorus and Specific Conductance at STA-5 Downstream Area

As previously mentioned, the RWMA EFA permit compliance transect comprises three monitoring stations (RC-1, RC-2, and RC-3) that extend approximately 4 km downstream of pump station G-410 (**Figure D-6**). All stations along this transect are identified as impacted.

All specific conductance levels measured along the RWMA transect were well below the 1,275 µS/cm for Class III waters (**Table D-10**). Specific conductance levels in WY2011 changed by approximately 44 percent along the RWMA transect. TP concentrations exhibited a decrease of approximately 60 percent from 29 µg/L at the inflow to 12 µg/L at a distance of 4 km from the canal (**Figure D-11**).

A statistically significant difference was observed between specific conductance data from WY2010 and WY2011 (Mann-Whitney p-value = 0.010, n = 49). Specific conductance in WY2010 (median = 651 µS/cm) was higher than in WY2011 (median = 439 µS/cm). No statistically significant difference was observed between TP data for WY2010 and WY2011 (p-value = 0.90) with concentrations for both years being similar (median = 13 µg/L).

Table D-10. Comparison of the surface water mean (± 1 SD) specific conductance and TP concentration between WY2010 and WY2011 at the permit compliance stations in the RWMA.

STA Transects	Station	Specific Conductance (µS/cm)		Total Phosphorus (µg/L or ppb)	
		WY2010	WY2011	WY2010	WY2011
STA-5	ROTC1	670 ± 195	549 ± 140	36 ± 21	29 ± 18
STA-5	ROTC2	593 ± 246	395 ± 126	11 ± 3	13 ± 5
STA-5	ROTC3	522 ± 264	308 ± 106	10 ± 3	12 ± 4

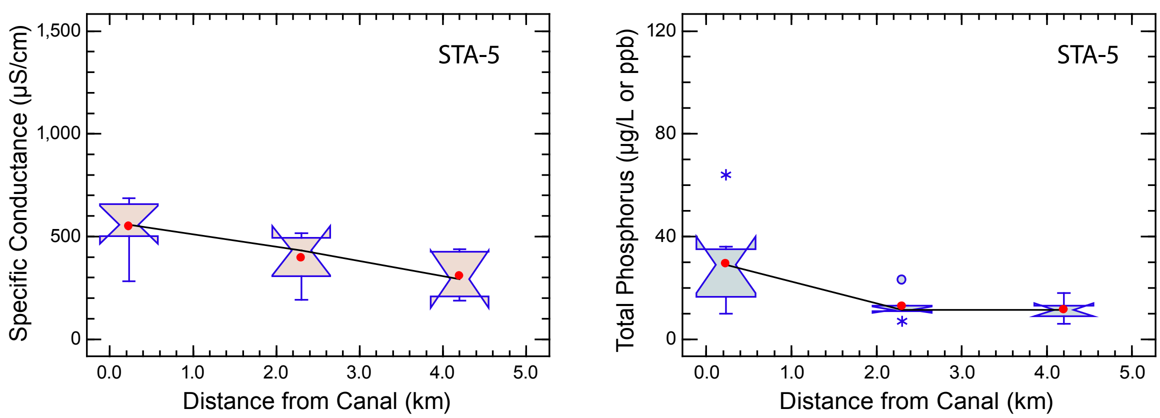


Figure D-11. Notched box-and-whisker plots of specific conductance and TP levels measured at transect stations downstream of STA-5 during WY2011. See Figure D-2 for information on notched box-and-whisker plots.

MACROPHYTE COVERAGE

Using point intercept survey methodology, the areal coverage of dominant macrophyte species has been surveyed at three permit-mandated stations along fixed 10-meter transects twice a year (dry and wet seasons) since 2005. The presence of sawgrass and cattail at 1-meter intervals was recorded (**Table D-11**). Sawgrass coverage remained stable and cattail coverage increased at the RC1 station during the previous four-year survey period. Sawgrass was the dominant macrophyte in RC2 and RC3 where surface water TP concentrations were also low (**Table D-10**). A large scale fire occurring in May 2006 likely had a strong effect on the vegetative change at RC1. This site is located in an area that experienced peat fires, and nearly all the vegetation along the transect was removed in the fire. In addition, the RC1 site was flooded to suppress these peat fires, while the other two sites remained dry for several months after the fire. Cattail coverage at the RC2 and RC3 sites increased in the October 2010 survey but then decreased again in spring 2011.

Table D-11. Number of points (out of 10 possible points at one-meter intervals along each transect) where sawgrass (Saw) or cattail (Cat) was present. Surveys were not completed at RC3 in October 2007 due to site inaccessibility.

Date	RC1		RC2		RC3	
	Saw	Cat	Saw	Cat	Saw	Cat
April 2005	9	4	7	6	10	0
November 2005	9	0	10	6	10	0
April 2006	9	0	10	6	10	0
October 2006	3	4	5	2	10	1
April 2007	3	3	7	4	10	4
October 2007	2	1	9	3	-[b]	-[b]
April 2008	4	1	9	1	10	0
October 2008	5	5	9	0	10	1
April 2009	3	7	10	0	10	1
October 2009	2	9	10	0	10	2
May 2010	6	7	9[a]	3[a]	10	1
October 2010	6	10	10	6	10	5
March 2011	5	10	9	3	10	0

[a] Transect was moved due to swamp buggy damaging vegetation.

[b] Surveys not completed at RC3 in October 2007 due to site inaccessibility.

Vegetation Surveys

Qualitative vegetation surveys have been conducted biannually from 1998 through 2007 as part of a long-term monitoring effort in the RWMA and are described in detail by Garrett and Ferree (2010). Plant species were observed at monitoring locations within the marsh and were identified and recorded. Three hydrologic periods were identified: the dry pre-discharge period (1998–2001), the wet post-discharge period (2002–2005), and the post-discharge drought period (2006–2007). The overall species composition in the RWMA changed following the initiation of STA discharges into the area: the relative abundance of obligate wetland species increased and the relative abundance of facultative upland species decreased. Several obligate wetland species notably increased, including *Sagittaria lancifolia*, *Proserpinaca palustris*, *Ludwigia repens*, *Pontederia cordata*, and *Salix caroliniana*. In addition, several facultative and facultative upland species notably decreased during this time, including *Solidago leavenworthii*, *Eupatorium capillifolium*, and *Erigeron quercifolius*.

During the drought period (2006–2007), the relative abundance of obligate wetland species decreased in both sampling periods, although a larger decrease was noted in the spring. Several notable obligate wetland species decreased in frequency during the drought period, such as *P. palustris* and *L. repens*. The relative abundance of facultative upland species increased in the drought period, with a larger increase also noted in the spring. *E. capillifolium* displayed a particularly large increase during the drought period, becoming the dominant species at several locations. The drastic increase of *E. capillifolium* showed how rapidly the area can revert back to an upland community when the increased hydroperiod is not maintained. Examining vegetative community changes in the RWMA has provided useful information on the vegetative response to hydropattern restoration through the use of STA-5.

Restoration Activities

Final design of a second inflow pump station (G-708) into the RWMA has been completed. This pump station will deliver treated STA water to augment the existing G-410 inflow pump station. Environmental permit authorizations for this pump station have not been issued and construction of G-708 is delayed.

The District, in cooperation with the FWC is restoring approximately 19 acres of tree islands in the southwest corner of the RWMA. Invasive Brazilian pepper (*Schinus terebinthifolius*) and primrose-willow (*Ludwigia peruviana*) were removed by cutting and applying herbicide. In 2009, 3,000 native trees and shrubs were planted with the majority of this vegetation surviving to date.

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Attachment E: STA Herbicide Application Summary for Water Year 2011

Louis Toth

Table E-1 summarizes herbicide treatments (acres treated and volumes of herbicides used) in the Everglades Stormwater Treatment Areas (STAs) during Water Year 2011 (WY2011) (May 1, 2010–April 30, 2011). No pesticides were applied within the Everglades STAs during WY2011.

Herbicides were used to control three species of floating plants: water lettuce (*Pistia stratiotes*), water hyacinth (*Eichhornia crassipes*), and crested floating heart (*Nymphoides cristata*); five species of emergents: cattail (*Typha domingensis* and *Typha latifolia*), giant bulrush (*Schoenoplectus californicus*), torpedo grass (*Panicum repens*), and pennywort (*Hydrocotyle umbellata*); and three species of shrubs: Brazilian pepper (*Schinus terebinthifolius*), primrose willow (*Ludwigia peruviana*), and Carolina willow (*Salix caroliniana*). The largest herbicide treatments occurred in Cell 1B of STA-3/4 where 784 acres of cattail were treated for the conversion to submerged aquatic vegetation (SAV) and in Cell 2A of STA-5 where 475 acres of primrose willow were treated to enhance cover of cattail.

<u>Application Rate</u>: Water lettuce and water hyacinth were treated with diquat dibromide (37.3 percent solution) at a rate of one quart per acre. Brazilian pepper was controlled by a basal bark treatment of 10 percent triclopyr solution. Pennywort, cattails, and giant bulrush were treated with glyphosate (53.8 percent) at a rate of 6–7.5 pints per acre or with a mix of glyphosate and imazapyr (28.7 percent). The glyphosate/imazapyr mix also was used to treat torpedograss, Carolina willow, and primrose willow. Some primrose willow was treated with 2,4 D (46.3 percent) at a rate of 2 gallons per acre.

<u>Application Certification Statement</u>: The South Florida Water Management District ensures that all herbicide applications are carried out in accordance with the manufacturer's guidelines.

Table 1. Acres of vegetation treated with herbicides during Water Year 2011 (May 1, 2010 to April 30,2011).

STA	Cell	Acres	Diquat (gallons)	Imazpyr (gallons)	Glyphosate (gallons)	2,4 D (gallons)	Triclopyr (gallons)
STA-1E	1	0	0	0	0	0	0
	2	0	0	0	0	0	0
	3	90.5	12.3	0	5.6	7	0
	4N	131.9	9.3	1.9	14.1	2.5	5
	4S	160.4	0.25	7.3	54.4	3.3	0
	5	49	7.3	0	8.5	9.4	0
	6	0	0	0	0	0	0
	7	50.3	9	0	5.6	10.4	0
STA-1W	1A	58.6	13.3	4.2	9.1	0	2.5
	1B	78.4	8	0	37.1	4	0
	2A	50	6.3	0.4	13.3	4.5	0
	2B	157.4	2.3	0	58.3	2	0
	3	112.6	0	30.2	179	0	0
	4	274	0	0	157.7	1.5	0
	5A	170.8	7.6	11	59	3.3	0
	5B	132.7	29.3	0	0	21	0
STA-2	1	6.5	2	0	0	0	0
	2	120.2	1.5	5.7	67.5	9	0
	3	5.6	1.8	0	0	0	0
	4	7.2	2.4	0.1	0.9	0	0
STA-3/4	1A	24.5	5.8	0	0	0	0
	1B	785.8	0.3	400	750	0	0
	2A	7.8	2.8	0	0	0	0
	2B	2.7	0.5	0	0	0	0
	3A	15.6	4.8	0	0	0	0
STA 5	1A	45.6	2.5	6.3	24.1	2.5	0
	1B	82.7	15	3	12	0	0
	2A	608.2	3	52	214.4	0	0
	2B	48.8	9.5	0	0	0	0
	3A	0	0	0	0	0	0
	3B	0	0	0	0	0	0
STA 6	3	1.8	0	0.8	0.3	0	0
	5	0	0	0	0	0	0
	Section 2	0	0	0	0	0	0