Appendix 5-3: Rotenberger Wildlife Management Area Restoration and STA Downstream Transect Monitoring

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HYDROPATTERN RESTORATION AND STA DISCHARGE MONITORING OF 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 2A (WCA-2A), and the Rotenberger Wildlife Management Area (RWMA). Everglades Forever Act (EFA) [Section 373.4592(13), Florida Statutes] permit 0279499-001-EM for STA-1W and STA-1E and Administrative Order 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 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 Appendix 5-4. A summary of conductivity and TP collected for these transects is provided in **Tables 1** and **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 1. Summary statistics for conductivity (in microsiemens per centimeter, or µS/cm) measurements collected during WY2010 at transect stations from STA outflows.

STA Transects	Station Information		Distance from Canal (km)	Number of Samples	Mean	Standard Deviation	Minimum	Percentiles			Maximum
	Name	Category[1]						25th	50th[2]	75th	
STA-1W	LOXA104	Rim Canal	0.0	12	886	197	490	826	908	1,039	1,126
	LOXA104.5	Impacted	0.4	11	824	236	271	735	855	993	1,085
	LOXA105	Impacted	0.8	11	673	268	221	427	700	911	979
	LOXA106	Impacted	1.1	11	423	222	183	221	325	580	796
	LOXA107	Impacted	2.2	6	173	24	128	166	180	190	193
	LOXA107U	Unimpacted	3.4	9	146	25	107	130	149	157	194
	LOXA108	Unimpacted	4.1	9	146	34	99	124	140	161	214
STA-1E	LOXA135	Rim Canal	0.0	11	819	220	455	701	754	933	1,315
	LOXA136	Impacted	0.6	11	310	178	182	211	237	353	811
	LOXA137	Impacted	1.1	10	215	118	140	148	178	233	536
	LOXA138	Impacted	2.1	8	136	41	85	118	123	149	222
	LOXA139	Impacted	4.0	7	101	15	81	85	106	115	118
STA-2 (Transect 1)	2AN.25	Impacted	0.2	10	1,063	132	886	947	1,066	1,197	1,231
	2AN1	Impacted	0.9	10	1,063	145	897	913	1,067	1,209	1,232
	2AN2	Impacted	1.9	8	1,019	146	854	909	955	1,185	1,200
	2AN4	Impacted	3.7	7	1,038	165	795	930	992	1,161	1,275
	2AC4	Unimpacted	6.8	5	783	322	245	657	864	955	1,106
STA-2 (Transect 2)	2AFS.25	Impacted	0.4	11	1,088	120	926	967	1,122	1,170	1,259
	FS1	Impacted	1.0	11	1,067	112	920	991	1,070	1,156	1,256
	FS3	Impacted	3.1	11	997	131	753	905	1,020	1,108	1,163
	CA29	Unimpacted	5.6	10	1,009	107	756	953	1,055	1,071	1,129
STA-5	ROTC1	Impacted	0.2	11	671	195	371	464	746	827	927
	ROTC2	Impacted	2.3	10	593	246	242	366	604	823	918
	ROTC3	Impacted	4.2	9	522	264	217	256	537	783	871

[1] Categories of "impacted" and "unimpacted" refer to station identification based on sediment phosphorus concentrations. Impacted stations have sediment TP concentration ≥500 mg/Kg.

Table 2. Summary statistics for TP (in micrograms per liter, or µg/L) measurements collected during WY2010 at transect stations from STA outflows.

STA Transects	Station Information		Distance from Canal (km)	Number of Samples	Mean	Standard Deviation	Minimum	Percentiles			Maximum
	Name	Category[1]						25th	50th[2]	75th	
STA-1W	LOXA104	Rim Canal	0.0	12	36	10	22	31	32	40	59
	LOXA104.5	Impacted	0.4	11	26	15	10	16	20	35	61
	LOXA105	Impacted	0.8	11	13	5	7	9	13	15	25
	LOXA106	Impacted	1.1	11	10	4	6	7	9	9	22
	LOXA107	Impacted	2.2	7	9	5	6	6	8	11	19
	LOXA107U	Unimpacted	3.4	10	8	2	6	6	7	8	13
	LOXA108	Unimpacted	4.1	11	8	2	6	7	7	11	11
STA-1E	LOXA135	Rim Canal	0.0	12	62	34	19	43	46	79	145
	LOXA136	Impacted	0.6	11	20	15	9	11	14	20	62
	LOXA137	Impacted	1.1	11	12	8	4	9	10	13	36
	LOXA138	Unimpacted	2.1	10	7	2	4	6	6	8	9
	LOXA139	Unimpacted	4.0	9	9	3	7	8	8	9	16
STA-2 (Transect 1)	2AN.25	Impacted	0.2	11	30	24	14	18	19	35	96
	2AN1	Impacted	0.9	11	26	21	11	17	20	27	87
	2AN2	Impacted	1.9	9	19	6	10	15	16	25	28
	2AN4	Impacted	3.7	8	11	8	7	8	8	11	31
	2AC4	Unimpacted	6.8	6	7	1	5	6	7	8	8
STA-2 (Transect 2)	2AFS.25	Impacted	0.4	11	42	40	16	18	25	45	140
	FS1	Impacted	1.0	11	27	21	13	15	19	25	73
	FS3	Impacted	3.1	11	11	9	4	7	8	10	38
	CA29	Unimpacted	5.6	11	5	1	4	4	5	5	7
STA-5	ROTC1	Impacted	0.2	11	36	21	16	24	26	44	91
	ROTC2	Impacted	2.3	10	11	3	8	9	10	12	17
	ROTC3	Impacted	4.2	9	10	3	7	8	9	13	15

[1] Categories of "impacted" and "unimpacted" refer to station identification based on sediment phosphorus concentrations. Impacted stations have sediment TP concentration ≥500 mg/Kg.

Arthur R. Marshall Loxahatchee National Wildlife Refuge

Discharges from STA-1W and STA-1E are released into the rim canal surrounding the Refuge. These discharges enter the rim canal from the northwestern (STA-1W) and northeastern (STA-1E) quadrants of the Refuge. Marsh transects downstream from both discharges extend approximately 4 kilometers (km) into the area (**Figure 1**). Impacted stations extend approximately 2 km (downstream of STA-1W) and 1 km (downstream of STA-1E) into the marsh (**Tables 1** and **2**). A total of 12 stations are monitored in the Refuge, with seven stations along the western transect and five stations along the eastern transect. One station from each transect is monitored in the rim canal.

Transects in the Refuge exhibited a substantial decrease in both conductivity and TP concentrations within 1 km from the rim canal (**Figure 2**). Conductivity measured in the western transect (downstream of STA-1W outflows) decreased, on average, by 50 percent or 463 microSiemens per centimeter (µS/cm) and total phosphorus (TP) concentrations decreased by approximately 70 percent or 26 parts per billion (ppb) [or micrograms per liter (µg/L)], and within 1 km from the rim canal station. The eastern transect (downstream of the STA-1E outflow) exhibited a decrease of approximately 74 percent or 604 µS/cm in conductivity and 80 percent or 50 ppb in TP within the first kilometer from the rim canal. Stations on both transects located at a distance greater than 1 km from the rim canal had mean TP concentrations ranging from 6 to 8 ppb. Mean conductivity values for these stations ranged from 101 to 146 µS/cm (**Tables 1** and **2**). All conductivity levels measured at Refuge transect stations were below the Class III criterion of 1,275 µS/cm.

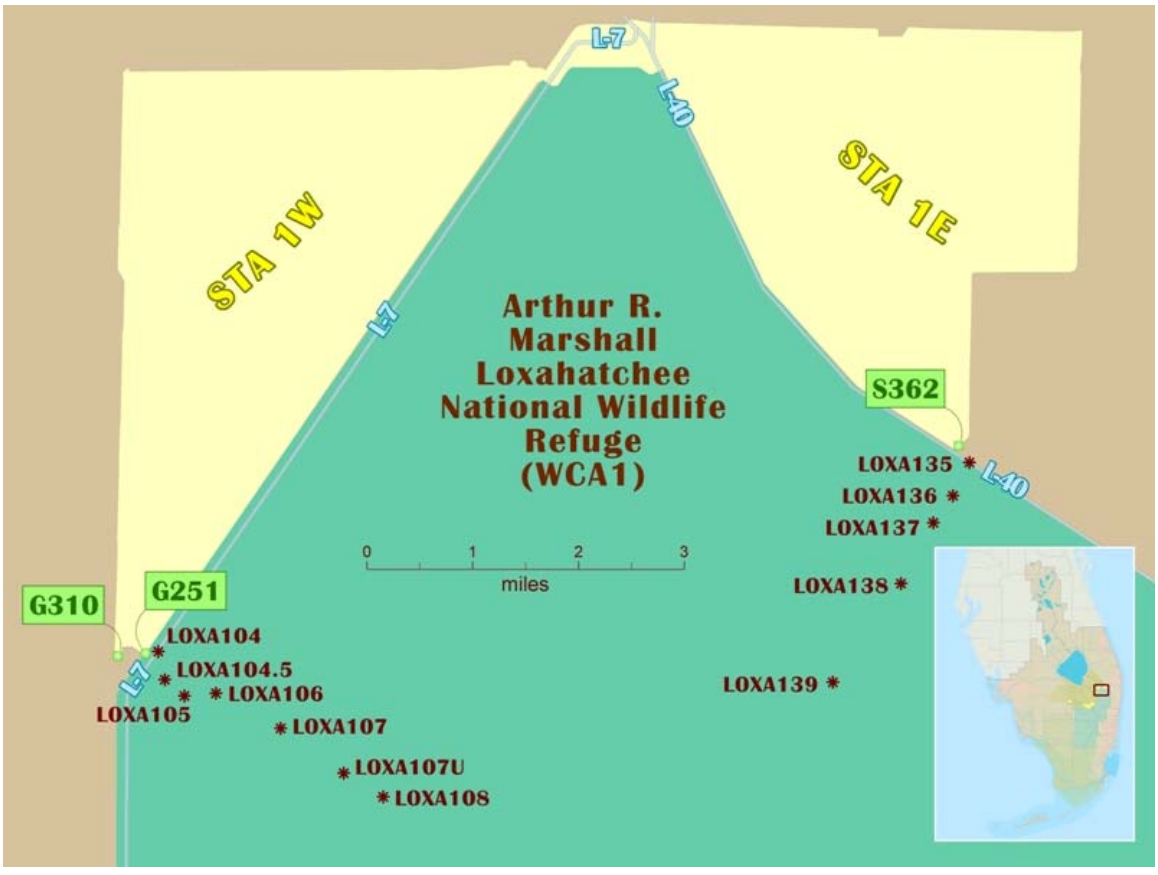

Figure 1. Locations of marsh transect stations in the Arthur R. Marshall Loxahatchee National Wildlife Refuge (Refuge) and outflow structures from STA-1W and STA-1E.

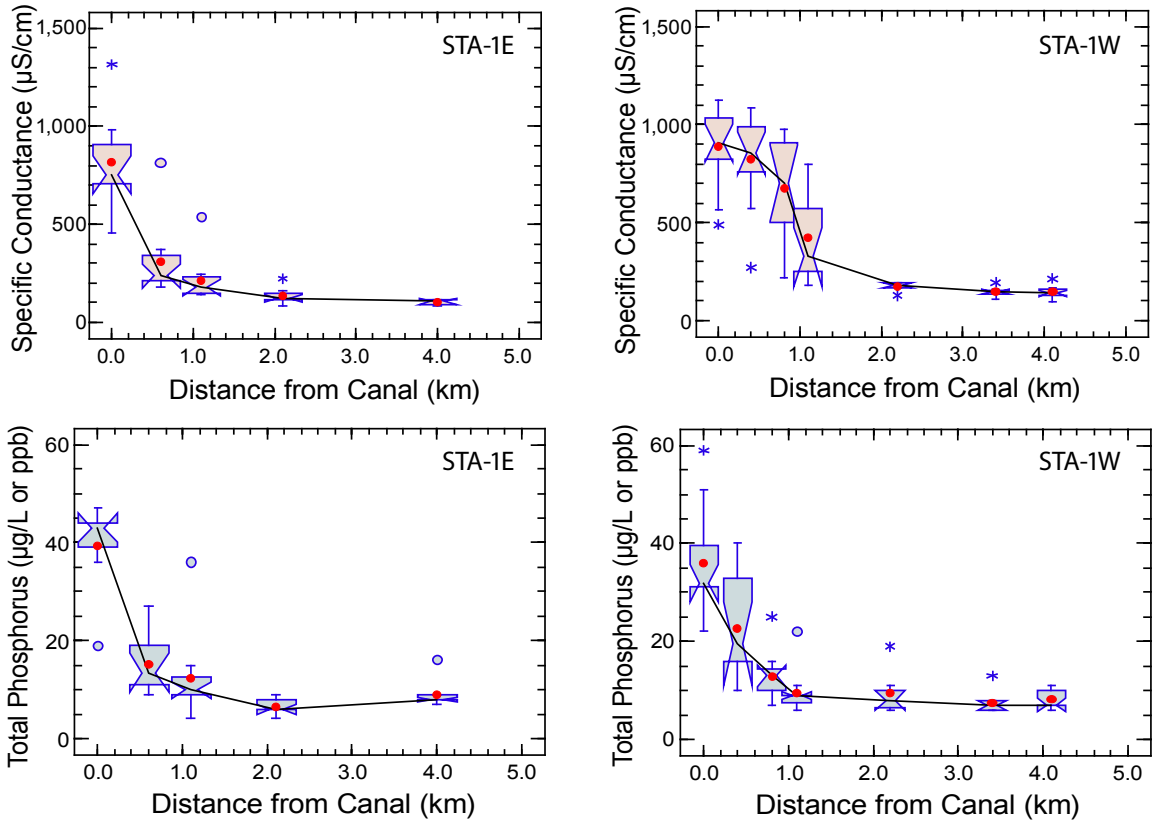

Figure 2. Notched box-and-whisker plots of conductivity and total phosphorus levels measured at transect stations downstream of STA-1W and STA-1E during WY2010.

Note: The notch on a box plot represents the 95% 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 of the median. Values above and below the whiskers are greater than two standard deviations from the median. Notches that do not overlap indicate that the data represented by the boxes being compared are significantly different at the 95% confidence interval.

The average conductivity from STA-1W and STA-1E transects was 382 ± 222 µS/cm for Water Year 2009 (WY2009) (May 1, 2008–April 30, 2009) WY2009 and 404 ± 308 µS/cm for Water Year 2010 (WY2010) (May 1, 2009–April 30, 2010) (**Table 3**) and was not significantly different between the two water years (paired t-test, p = 0.50, n = 12). The average TP concentration from both transects was 17 ± 12 µg/L for WY2009 and 18 ± 16 µg/L for WY2010 (**Table 3**) and was also not significantly different (paired t-test, p = 0.50, n = 12) although the STA-1E discharge had considerably higher TP concentration in WY2010 than in WY2010.

Table 3. Comparisons of the surface water mean (±1 standard deviation) conductivity and TP concentration between WY2009 and WY2010 at the permit compliance stations in Water Conservation Area 1 (WCA-1).

STA Transects	Station	Conductivity (µS/cm)		TP (µg/L)	
		WY2009	WY2010	WY2009	WY2010
STA-1W	LOXA104	652±168	886±197	32±13	36±10
	LOXA104.5	607±198	824±236	39±54	26±15
	LOX105	510±229	673±268	12±6	13±5
	LOX106	378±190	423±222	10±6	10±4
	LOX107	203±134	173±24	7±2	9±5
	LOX107U	119±25	146±25	6±1	8±2
	LOX108	111±21	146±34	10±3	8±2
STA-1E	LOX135	710±126	819±220	36±19	62±34
	LOX136	548±163	310±178	21±22	20±15
	LOX137	367±203	215±118	12±11	12±8
	LOX138	279±119	136±41	7±2	7±2
	LOX139	98±32	101±15	7±2	9±3

Northwestern Water Conservation Area 2A

WCA-2A Monitoring Objectives

In accordance with the EFA, the District 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. The annual report addresses the following issues: (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 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 stations in WY2009 and both gauges began recording data in June 2009. Stage data for WY2010 were only available for 347 and 332 days for WC2AN1 and WC2AS1, respectively. Water depths were determined by subtracting the ground elevation from the stage. Results showed that 99 percent of time at the north station and 86 percent of time at the south station were inundated (**Figure 4**). Mean water depth ranged from 50 centimeters (cm) at WC2AN1 to 17 cm at WC2AS1. Water depths at the north station fluctuated greatly with several peaks at approximately 100 cm during the wet season and dryout in early May. Stage data for May 2009 are not available at WC2AS1. The water depth was highest at this location between July and September and later experienced a dryout between November 2009 and January 2010.

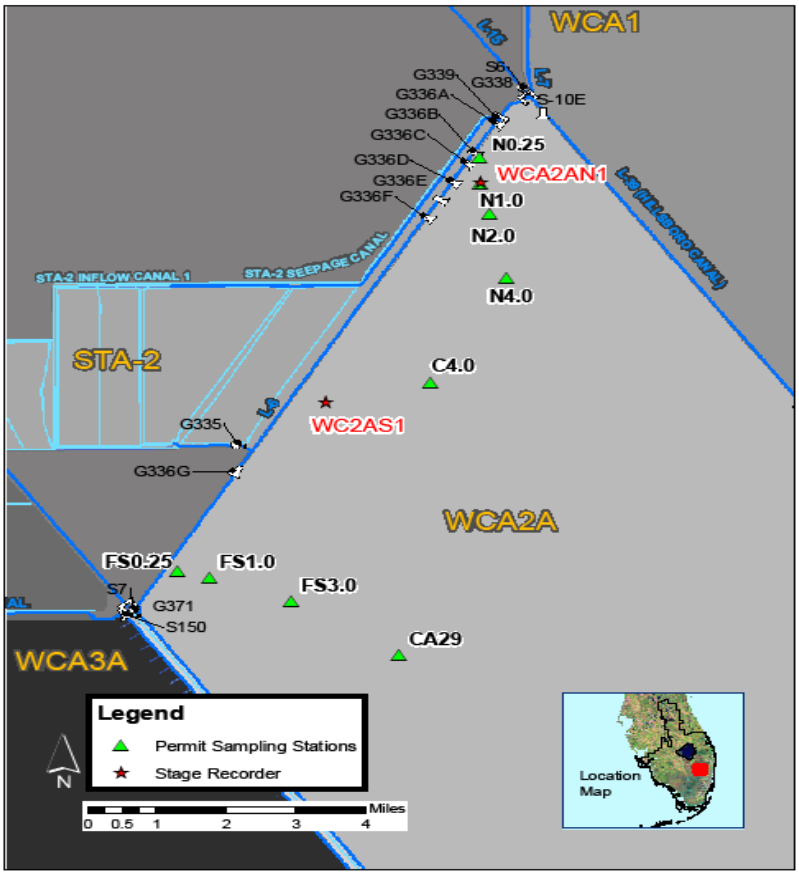

Figure 3. Location of STA-2 discharge structures, including the G-336A–G discharge culverts in relation to sampling stations along transects in the northwestern section of Water Conservation Area 2A (WCA-2A).

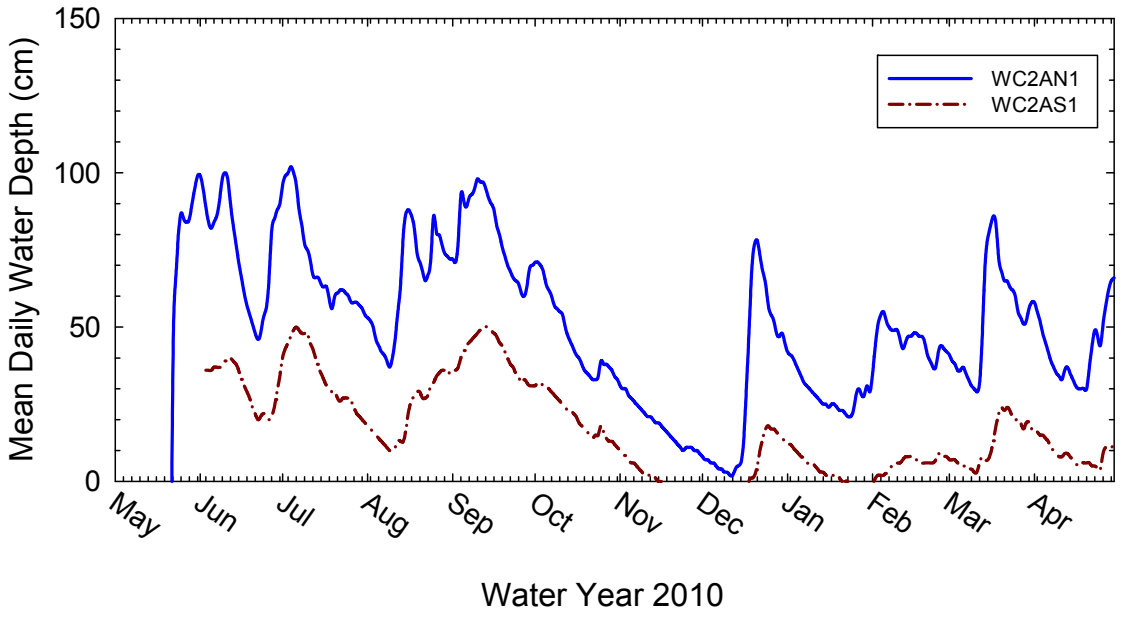

Figure 4. Mean daily water depths for WY2010 derived from two stage recorders deployed along the northwest region of WCA-2A. See Figure 5-3 for the location of these stations.

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

There are two EFA permit compliance transects. Transect 1 near the G-336A-G structures consists of N0.25, N1.0, N2.0, N4.0, and C4.0. Transect 2 downstream of the G-336G structure consists of FS0.25, FS1.0, FS3.0, and CA29. The EFA permit compliance transects are monitored to characterize the effects of STA-2 discharges on the marsh and are located in the western portion of the WCA, with one transect located in the northern portion and the other in the southern portion (**Figure 3**). The northern transect comprises five monitoring stations extending approximately 7 km. The southern transect extends approximately 6 km into WCA-2A and contains four monitoring stations.

Mean conductivity ranged from 783 to 1,088 µS/cm at both transects (**Table 1**). Conductivity levels along the northern transect between 0.25 and 4 km from L-6 were similar (1,019 to 1,063 µS/cm) and decreased to 783 µS/cm at 7 km into the marsh (**Figure 5**). Conductivity levels displayed little change at the southern transect, ranging from 997 to 1,088 µS/cm (**Table 1**). No conductivity measured along the northern or southern transect exceeded the Class III criterion of 1,275 µS/cm.

Mean TP concentrations ranged from 5 to 42 ppb at both transects with high concentrations near the canal and low concentrations in the interior marshes (**Table 2**) and displayed continuous decline along the transects. At the northern transect, mean TP decreased consistently along points on the transect, from 30 ppb at site N0.25 (a northern transect site 0.25 km from the nearest G-336 discharge point) from km to 7 ppb at 7 km from the discharge point (**Figure 5**). At the southern transect, the mean TP concentration near the inflow was high (42 ppb), but decreased to 5 ppb at approximately 6 km into the marsh. Both transects began dramatic TP reduction at 1 to 2 km from the inflow.

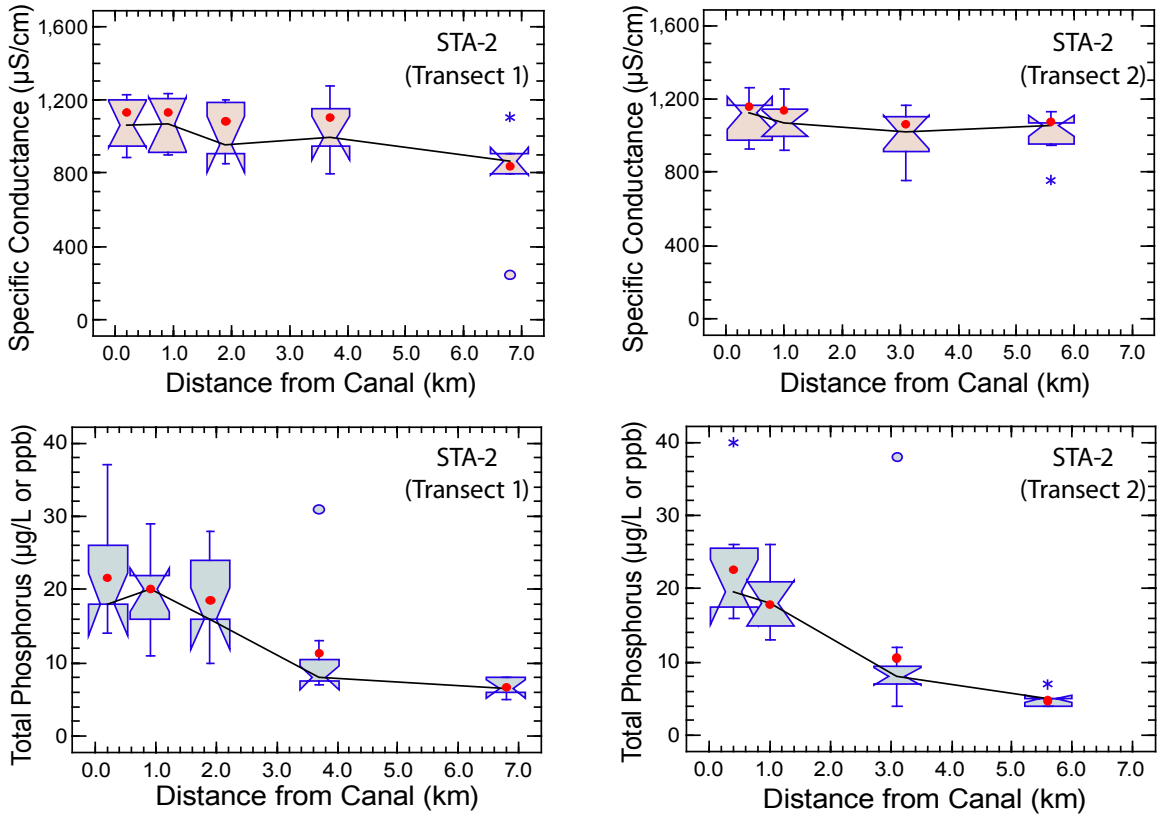

Figure 5. Notched box-and-whisker plots of conductivity and total phosphorus levels measured at transect stations downstream of STA-2 during WY2010.

The average conductivity from the two STA-2 transects was 1,054 ± 67 µS/cm for WY2009 and 1,014 ± 92 µS/cm for WY2010 (**Table 4**) and was not significantly different (paired t-test, $p = 0.20$, $n = 9$). The average TP concentration from both transects was 12 ± 7 µg/L for WY2009 and 20 ± 12 µg/L for WY2010 (**Table 4**) and was significantly different (paired t-test, $p = 0.008$, $n = 9$). This is apparently attributed to the considerably higher TP concentrations from the G-336 culverts that elevated the TP concentrations of the surface water along the transects during WY2010.

Table 4. Comparisons of the surface water mean (± 1 standard deviation) conductivity and TP concentration between WY2009 and WY2010 at the permit compliance stations in Water Conservation Area 2 (WCA-2).

STA Transects	Station	Conductivity (µS/cm)		TP (µg/L)	
		WY2009	WY2010	WY2009	WY2010
STA-2 (Transect 1)	N0.25	1,123±76	1,063±132	24±12	30±24
	N1.0	1,081±91	1,063±145	15±8	26±21
	N2.0	1,054±89	1,019±146	10±3	19±6
	N4.0	1,054±106	1,038±165	7±2	11±8
	C4.0	1,014±108	783±322	5±1	7±1
STA-2 (Transect 2)	FS0.25	1,112±70	1,088±120	18±5	42±40
	FS1.0	1064±57	1,067±112	14±3	27±21
	FS3.0	1,087±139	997±131	7±3	11±8
	CA29	899±153	1,009±107	5±1	7±1

WCA-2A Macrophyte Composition Along Permit Compliance Transects

The areal coverage of several dominant macrophyte species has been measured along fixed transects twice a year (dry season and wet season) since 2005. Using point-intercept survey methodology, the presence of sawgrass and/or cattail at one-meter intervals along 10-meter (m) transects was recorded. These surveys were performed at 19 locations (all stations except CA29, see **Figure 3**); only data from the permit compliance sites are presented in this report. **Tables 5** and **6** show the frequency of occurrence of cattail and sawgrass along each transect. The northern transect site, N0.25, was dominated by cattail (*Typha* spp.) with little sawgrass (*Cladium jamaicense*) presence. Sawgrass has been the dominant vegetation at the 1-to-4 km interval from the inflow over the survey period except for N1 (**Table 5**). Site N1.0 displayed decreases in both sawgrass and cattail presence in the most recent survey. The cause is not clear. No cattail was present at sites 2–4 km from the inflow over the survey period. Although sawgrass coverage at site N4.0 decreased for several years thereafter, complete recovery was observed at pre-fire conditions by the time of second survey in 2009.

At the southern transect, both sawgrass and cattail were present in FS0.25 and FS1.0 while only sawgrass was present at FS3.0 (**Table 6**). Cattail presence increased at FS0.25 since 2007 while sawgrass had little change during the same time period. However, both sawgrass and cattail have increased at FS1.0 since 2008. 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). This was due to the impact of drift from an herbicide application to clear helicopter landing areas for safe access to sites. In addition, one site (N2.0) was relocated in April 2006 due to trails worn next to it which 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 to 30 meters away from the original location.

Table 5. Number of points (out of 10 possible points at 1-meter intervals along each line transect) at the northern transect locations of WCA-2A where sawgrass or cattail was present. Surveys were completed during the dry and wet seasons each year.

Date	N0.25		N1.0		N2.0		N4.0		C4.o	
	Saw	Cat	Saw	Cat	Saw	Cat	Saw	Cat	Saw	Cat
Apr 2005	1	10	10	0	10	0	10	0	10	0
Oct 2005	1	10	9	0	10	0	10	0	10	0
Apr 2006	1	10	9	0	10[W]	0[W]	10	0	10	0
Nov 2006	1	10	10	5	9	0	1[F]	0[F]	10	0
Apr 2007	1	10	10	9	10	0	6	0	10	0
Oct 2007	0	9	10	2	10	0	2	0	10	0
Mar 2008	0	10	10	0	10	0	4	0	10	0
Oct 2008	1	10	5	2	10	0	8	0	10	0
Apr 2009	1	10	10[S]	4[S]	10[S]	0[S]	9[S]	0[S]	10	0
Oct 2009	1	10	10	9	9	0	10	0	10	0
Apr 2010	0	9	0	4	8[A]	0[A]	10	0	9[A]	0[A]

[S] indicates that transect was moved due to herbicide overspray
[W] indicates that transect was moved due to worn trail next to transect
[F] indicates a fire occurred at site
[A] indicates that transect was moved due to airboat damaging vegetation on transect

Table 6. Number of points (out of 10 possible points at 1-meter intervals along each line transect) of WCA-2A at the southern transect locations where sawgrass (*Cladium jamaicense*) or cattail (*Typha* spp.) was present. Surveys were completed during the dry and wet seasons each year.

Date	FS0.25		FS1.0		FS3.0	
	Saw	Cat	Saw	Cat	Saw	Cat
Apr 2005	7	8	7	0	10	0
Oct 2005	3	9	3	3	10	0
Apr 2006	7	4	7	6	10	0
Nov 2006	8	5	8	7	10	0
Apr 2007	8	5	8	8	9	0
Oct 2007	8	2	8	5	10	0
Mar 2008	8	4	8	8	10	0
Oct 2008	6	6	6	5	10	0
Apr 2009	8[S]	4[S]	8[S]	2[S]	10	0
Oct 2009	6	8	10	8	10	0
Apr 2010	6	10	10	9	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 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 FY2010 restoration activities include an update of the operation plan and the design of a supplemental pump station to deliver water to the area.

Configuration

Project features include a 240 cubic feet 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-long 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 2003–2010 are presented in **Table 7**. Seventy-nine percent and 86 percent of the inflows and outflows in each water budget were attributed to rainfall and evapotranspiration (ET). Both rainfall and inflow through G-410 increased significantly in WY2010. Seepage values were not accounted for in these calculations. Errors noted on WY2006 and WY2007 budgets could have been due to the large-scale fire that occurred in 2006, which resulted in losses of surface vegetation in sizable portions of the area.

Hydrologic and Total Phosphorus Loads

In WY2010, approximately 40,582 acre-feet (ac-ft) of STA-5 water was discharged into the RWMA through the G-410 structure (**Figure 7**) which is about 8,000 ac-ft more than in WY2009. The inflow flow-weighted mean (FWM) TP concentration was 26 ppb, yielding an inflow TP load of about 1.41 metric tons (mt). Both inflow FWM TP concentration and load were considerably lower than those (47 ppb as FWM TP concentration and 1.88 mt as TP load) in WY2009. In fact, there is a significant trend of reductions in both FWM TP concentration ($r = -0.41$, $p < 0.05$) and monthly TP load ($r = -0.25$, $p < 0.05$) to the RWMA.

Approximately 21,295 ac-ft of water was released through the G-402A–C structures, which is about 4,000 ac-ft less than WY2009. The outflow FWM TP concentration was 28 ppb and outflow TP load was about 0.49 mt (**Figure 8**). This is compared to outflow FWM TP concentration of 69 ppb and TP load of 2.15 mt in WY2009. The outflow FWM TP concentration was higher than the inflow FWM TP concentration, but the outflow TP load was less than inflow TP load. This indicates that the RWMA served as a net storage for TP. No trend analysis was conducted due to frequent lack of outflow.

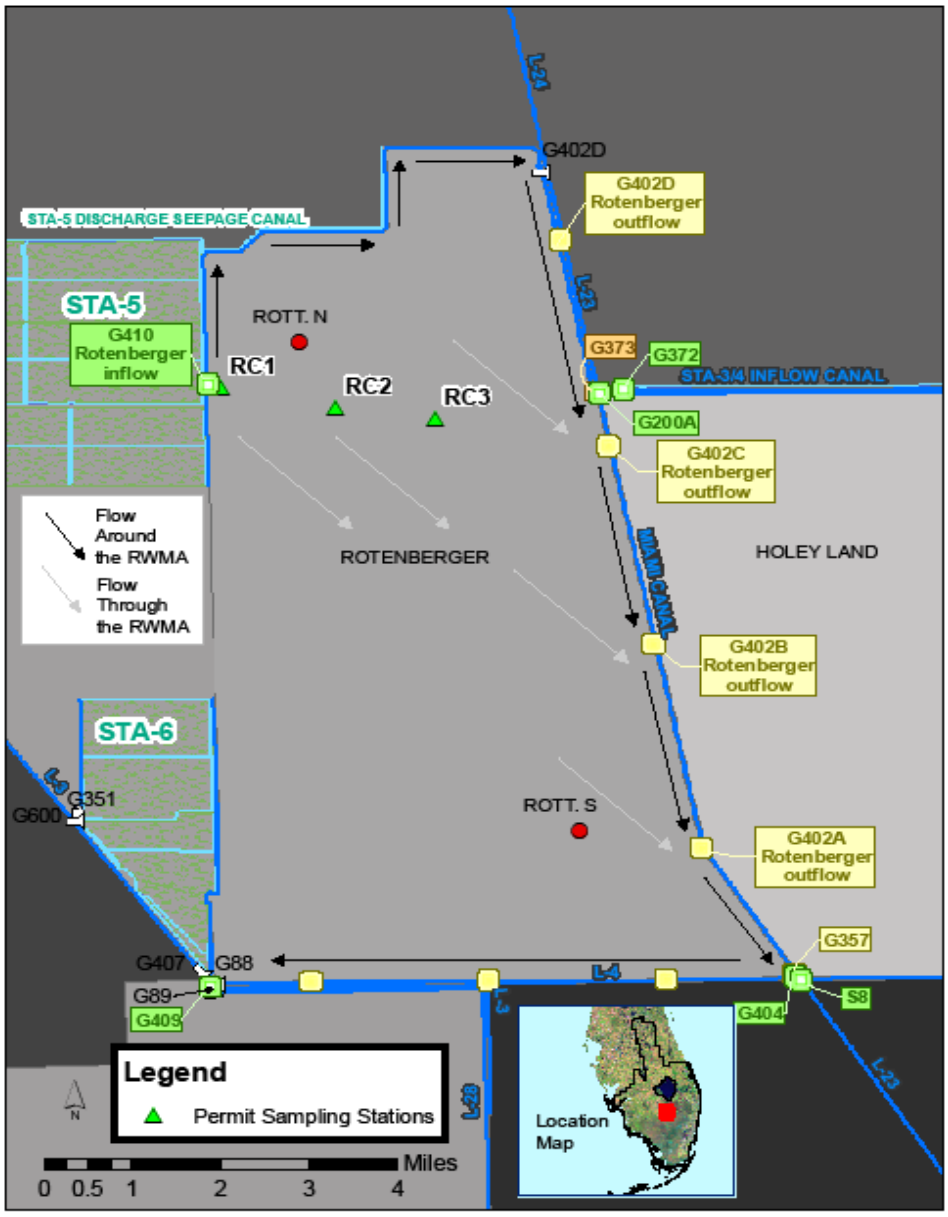

Figure 6. Rotenberger Wildlife Management Area's (RWMA) major structures and monitoring transect RC (permit compliance monitoring transect). Site Rott.N, and Rott.S are the locations of the permanent stage recorders and newly installed groundwater wells.

Table 7. Water budgets calculated for WY2003 through WY2010. Inflows (acre-feet) represent discharges into the RWMA from the G-410 structure and outflows represent water releases from the G-402A–D structures. ET is evapotranspiration.

Water Year	Inflow (ac-ft)	Rainfall (ac-ft)	Total Inflow (ac-ft)	Outflow (ac-ft)	ET	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	123,897	-20	-5.9
2005	44,414	113,868	158,281	33,788	123,847	157,634	33	-0.4
2006	29,886	114,605	144,491	54,648	124,451	179,100	-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	152423	193,005	21,295	125,578	146,873	1,018	-26.5
Total	**246,175**	**903,083**	**1,149,257**	**165,151**	**999,312**	**1,164,462**	**-178**	**2.4**

	G-410 Inflow	Rainfall
% of inflow	21%	79%

	G-402 Outflow	ET
% of Outflow	14%	86%

Note: Errors include unaccounted flows as seepage and measurement errors

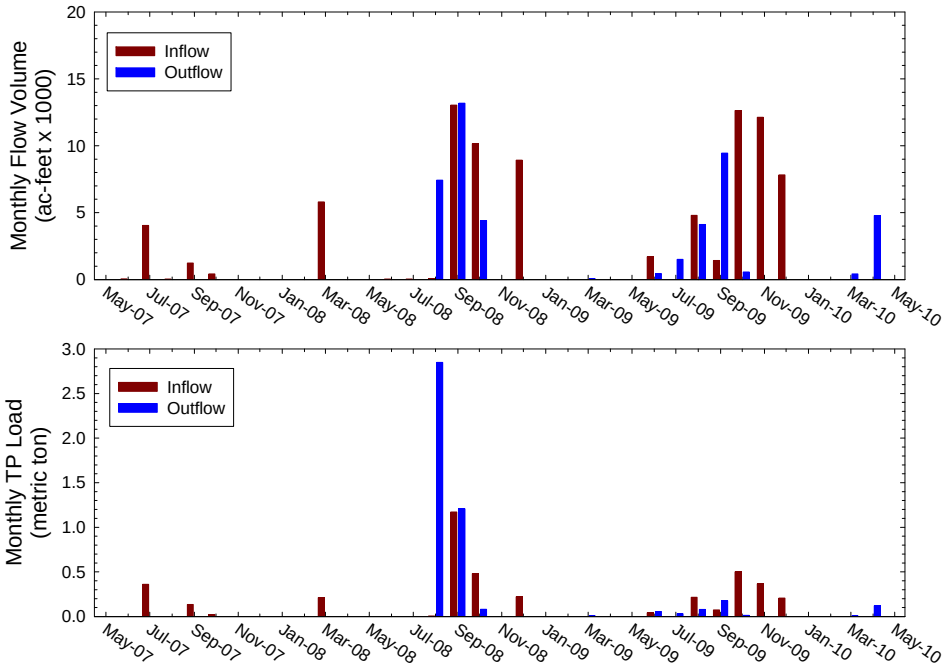

Figure 7. Monthly flow volumes (top) and TP loads (bottom) for inflow and outflow structures at the RWMA for WY2008 through WY2010.

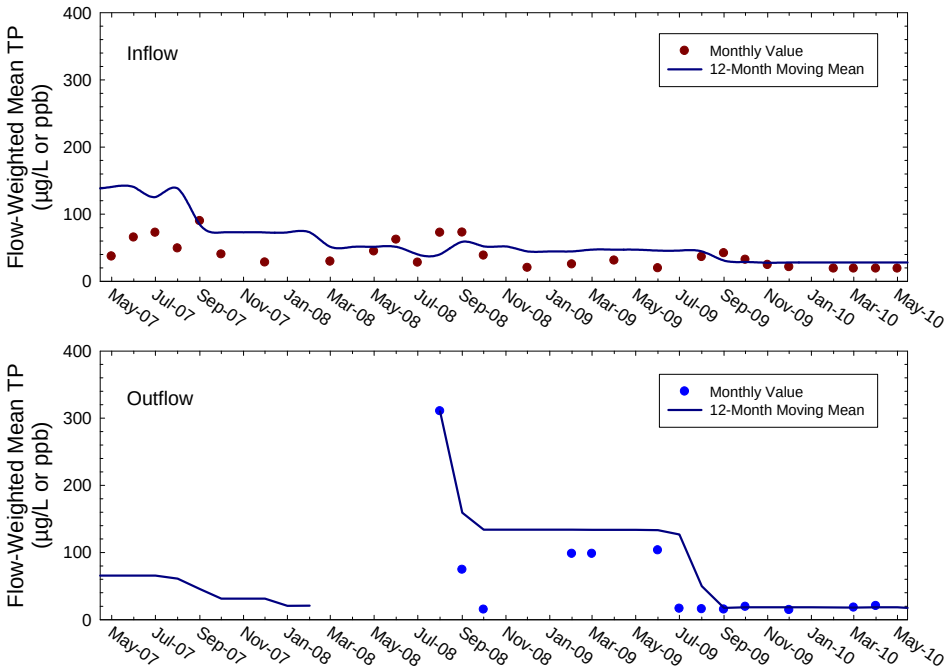

Figure 8. Comparison of monthly flow-weighted mean TP concentrations with the 12-month moving average of the flow-weighted means for the RWMA inflow (top) and outflow (bottom) structures during WY2008 through WY2010.

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 Operation Plan (SFWMD, 2004) and revise and improve the interim regulation schedule in an effort to better achieve the hydropattern restoration goals for the RWMA. An initial step in the process was to obtain an updated survey of the RWMA, which was completed in December 2008. The RWMA was surveyed in 2004 and 2008. The calculated ground elevation from the 2008 survey was 12.14 feet 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 (**Figure 9**). The revised average stage (12.88 ft) remained similar to the average stage (12.93 ft) of the previous schedule (**Figure 9**).

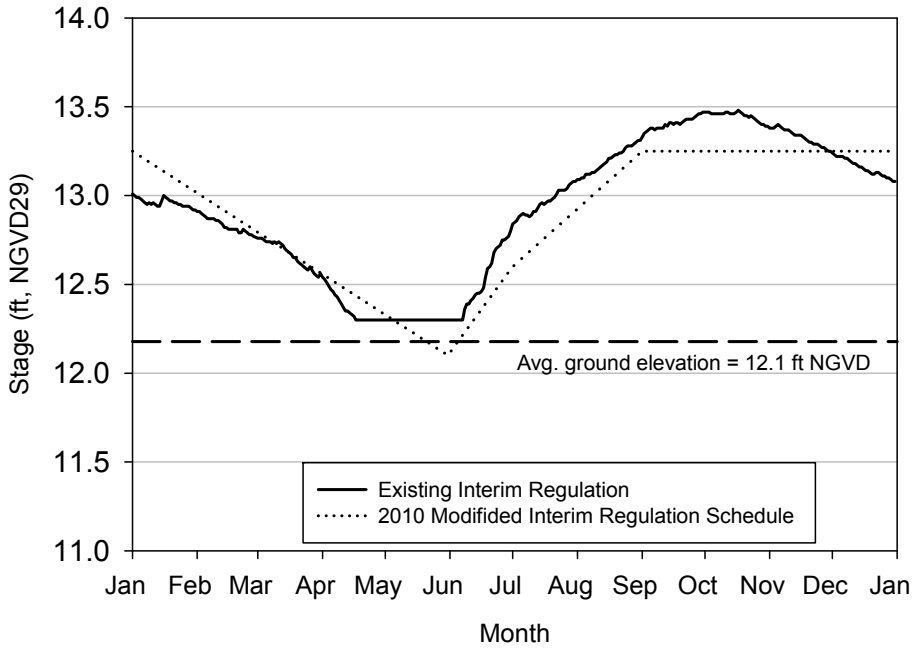

Figure 9. Existing and modified 2010 interim regulation schedule for RWMA stage.

Stage dropped to as much as 2 ft below the ground elevation in May 2009 and then increased above the average ground elevation once the wet season began. The stage fluctuated within 0.5–1 foot above ground elevation for the majority of WY2010 then dropped slightly below the average ground elevation from April through May 2010. Average stages were approximately 3 inches below the target stage set for 2010 schedule (**Figure 10**).

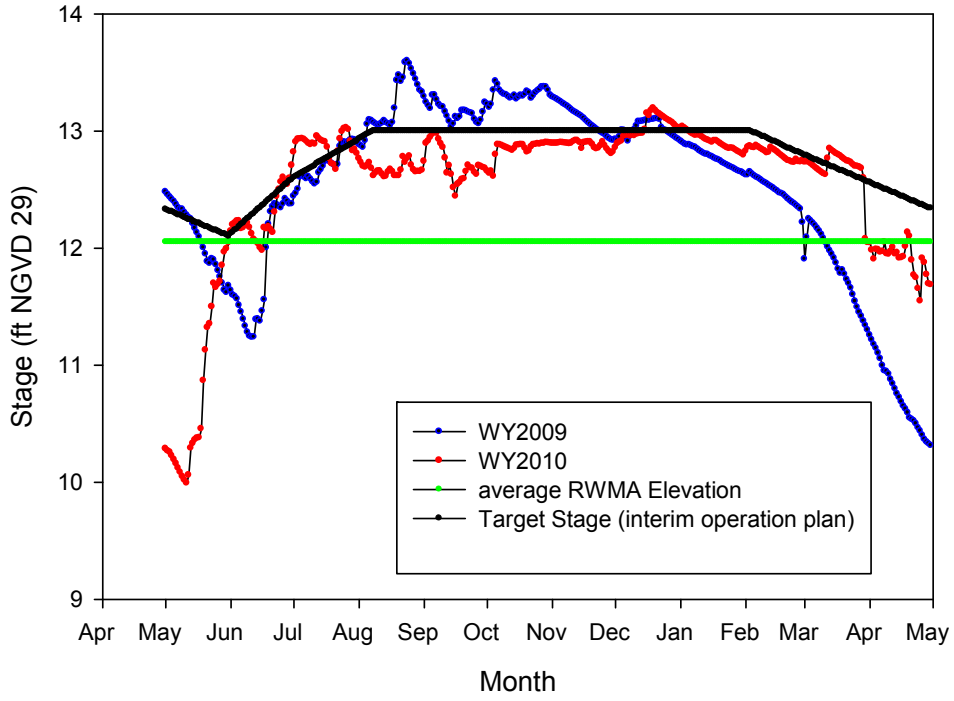

Figure 10. Daily target stage levels and mean daily stage readings (average of Rott.N and Rott.S stages) in the RWMA for WY2009 and WY2010. The average ground elevation is also displayed. Erroneous readings due to gauge failure were excluded. Target stages were based on the revised interim operation plan schedule (SFWMD, 2010).

EFA Permit Compliance Transect Total Phosphorus and Conductivity 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 6**). All stations along this transect are identified as impacted.

All specific conductivity levels along the RWMA transect were well below the 1,275 µS/cm for Class III waters (**Table 1**). While conductivity levels did not change substantially along the RWMA transect, TP concentrations decreased from 36 ppb at inflow to 10 ppb 4 km from the canal (**Figure 11**).

The average conductivity from the three permit compliance stations in RWMA for both WY2009 and 2010 was similar at 524±73µS/cm for WY2009 and 594±74µS/cm for WY2010 (**Table 8**). The average TP concentration was also similar at 17±8µg/L for WY2009 and 19±15µg/L for WY2010 (**Table 8**).

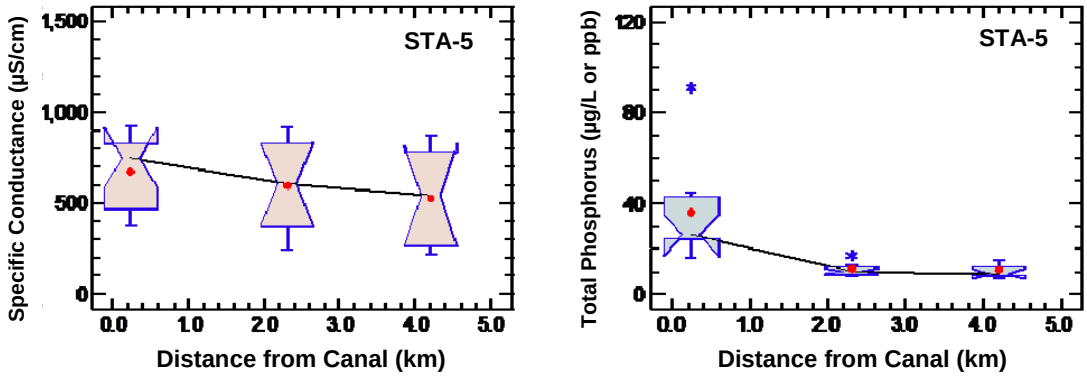

Figure 11. Notched box-and-whisker plots of conductivity and total phosphorus levels measured at transect stations downstream of STA-5.

Table 8. Comparisons of the surface water mean (± 1 standard deviation) conductivity and TP concentration between WY2009 and WY2010 at the permit compliance stations in Rotenberger Wildlife Management Area (RWMA).

Station	Conductivity (µS/cm)		TP (µg/L)	
	WY2009	WY2010	WY2009	WY2010
RC1	607±199	670±195	26±9	36±21
RC2	500±180	592±245	12±3	11±3
RC3	467±206	522±264	14±7	10±3

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 long transects twice a year (dry and wet seasons) since 2005. The presence of sawgrass and/or cattail at 1-meter intervals was recorded (**Table 9**). Sawgrass coverage decreased and cattail coverage increased at the RC1 station during the previous 4-year survey period. However, a significant increase in sawgrass presence and a moderate decrease in cattail presence were observed during the May 2010 survey. Sawgrass was the dominant macrophyte in RC2 and RC3 where surface water TP concentrations were also low (**Table 2**). 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. Sawgrass and cattail coverage at the RC3 site remained fairly constant over the survey period.

Table 9. Number of points along a fixed transect with three permit compliance stations where sawgrass or cattail was present, out of 10 possible points. Each point represents a distance of 1 meter. Surveys were completed twice, once during the dry season (November–May) and once during the wet season (June–October) each year. Surveys were not completed at RC3 in October 2007 due to site inaccessibility.

	RC1		RC2		RC3	
Date	**Saw**	**Cat**	**Saw**	**Cat**	**Saw**	**Cat**
Apr 2005	9	4	7	6	10	0
Nov 2005	9	0	10	6	10	0
Apr 2006	9	0	10	6	10	0
Oct 2006	3	4	5	2	10	1
Apr 2007	3	3	7	4	10	4
Oct 2007	2	1	9	3	-	-
Apr 2008	4	1	9	1	10	0
Oct 2008	5	5	9	0	10	1
Apr 2009	3	7	10	0	10	1
Oct 2009	2	9	10	0	10	2
May 2010	6	7	9*	3*	10	1

* indicates that transect was moved due to swamp buggy damaging vegetation on transect