Appendix 5-4: Annual Permit Report for the Holey Land Wildlife Management Area

Permit Report (October 1, 2010–September 30, 2011)
Permit Numbers: 06,500809209 and 06,501191549

Cheol Mo

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SUMMARY

Based on Florida Department of Environmental Protection (FDEP) permit reporting guidelines, **Table 1** lists key permit-related information associated with this report. **Table 2** lists the attachments included with this report. **Table A-1** in Attachment A list specific pages, tables, and graphs where project status and annual reporting requirements are addressed. This annual report satisfies the reporting requirements specified in the permits. In accordance with the permits, data presented in this annual report covers the federal Water Year 2011 (October 1, 2010–September 30, 2011) reporting period.

Table 1. Key permit-related information.

Project Name	Holey Land
Permit Numbers	06,500809209 and 06,501191549
Issue and Expiration Dates 06,500809209 06,501191549	 Issued: 10/1/1984; Expires: N/A (in Operation Phase) Issued: 9/5/1986; Expires: N/A (in Operation Phase)
Project Phase	Operation
Permit Condition Requiring Annual Monitoring Report	Specific conditions listed on permit pages 8-11
Relevant Period of Record	October 1, 2010–September 30, 2011
Report Lead	Cheol Mo cmo@sfwmd.gov 561-682-2106
Permit Coordinator	John Shaffer jshaffe@sfwmd.gov 561-682-6308

Table 2. Attachments included with this report.

Attachment	Title
A	Specific Conditions and Cross-References
B	Water Quality and Sediment Data
C	Hydrologic Data
D	Holey Land Wildlife Management Area 2011 Annual Cattail Monitoring Report

INTRODUCTION

The Holey Land Wildlife Management Area (WMA) is a 35,350-acre (14,140-hectare) impoundment located in the southwest corner of Palm Beach County, Florida. In 1989, the South Florida Water Management District (SFWMD or District) started collecting water samples at the inflow structure (G-200A), outflow structures (G-204, G-205, and G-206), and interior stations (**Figure 1**). In 1991, the Florida Fish and Wildlife Conservation Commission began conducting annual cattail surveys. In October 2005, Hurricane Wilma severely damaged the inflow pump station (G-200A) as inoperable. Due to high cost and the fact that the pump station was outdated, it was not repaired. To date, this pump station has not been replaced. Since October 2005, limited surface water inflow capacity has been available through the G-372HL box culvert. For practicality, reporting of inflow data was switched to G-372HL, which has been the only source for surface water inflow to the Holey Land WMA since G-200A was damaged.

Although G-200A has been inoperable, water quality grab samples are collected at the site (currently known as G-200). No water quality samples are collected from G-372HL. The three outflow structures (G-203, G-204 and G-205) are monitored quarterly.

Since April 2008, there has been no surface water inflow to the Holey Land WMA, and no outflows have occurred since January 2006. Essentially, the Holey Land WMA has become rainfall-driven and no longer functions as a flow-through system. The area dries out routinely, and re-wets depending on rainfall amounts.

The initial water regulation schedule called for water levels varying from 11.5 to 13.5 feet National Geodetic Vertical Datum of 1992 (NGVD29) and permit requirements stated that a minimum water level of 9 feet, NGVD29 must be maintained in the seepage ditches of the Holey Land WMA. However, there have been subsequent revisions of the water schedules to the lower levels and the seepage canal on the north and northeast sides of the Holey Land WMA were widened and deepened to become the inflow canal for Stormwater Treatment Area 3/4 (STA-3/4) in 2005. The only remaining seepage ditch structure for the Holey Land WMA is G-203D, which is located on the southeast side, adjacent to STA-3/4.

More background information and the current status of the Holey Land WMA water regulation schedules are presented in the 2011 Annual Cattail Monitoring Report (Attachment D).

SURFACE WATER QUALITY DATA

During the reporting period, quarterly water quality grab samples were collected at the upstream of G-200 site (in Miami Canal) and at the upstream the three outflow structures (G-203, G-204, and G-205) (**Figure 1**). Water quality data for federal Water Year 2011 (October 1, 2010–September 30, 2011) is summarized in **Tables 3** through **6**. Individual water quality monitoring measurements are included in Attachment B. Overall, there were no exceedances for parameters with Class III standards (specific conductance and pH) at the four monitoring sites.

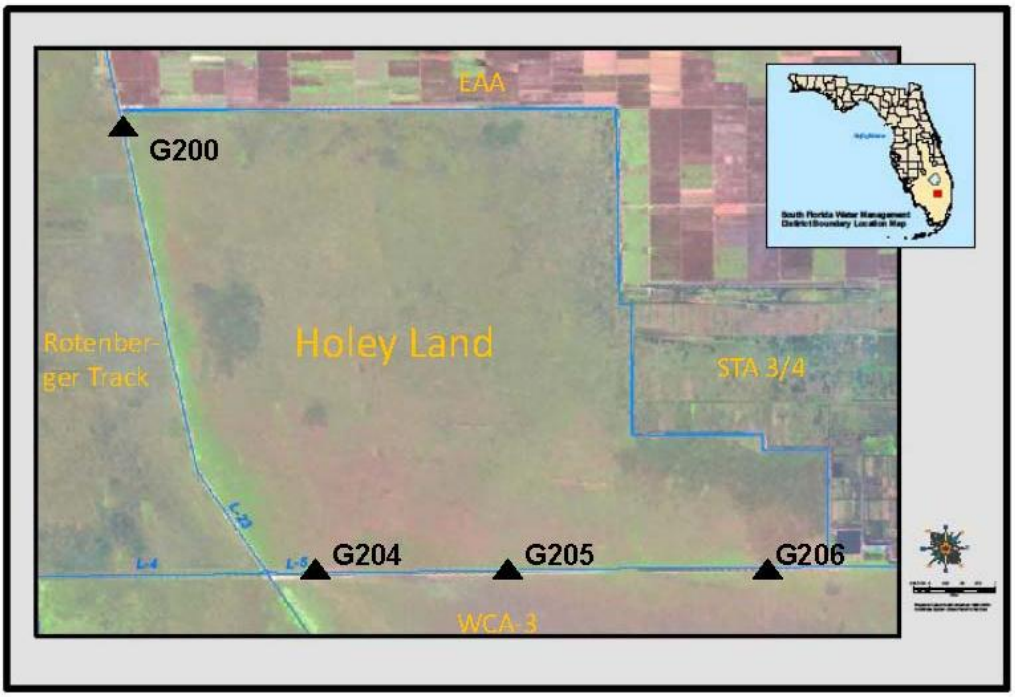

Figure 1. Holey Land Wildlife Management Area (WMA) water quality monitoring locations.

Observed total phosphorous levels at the upstream inflow monitoring station (G200) were generally lower than levels observed within the Holey Land WMA at the outflow structures. Higher nutrient levels were observed at G204, which dries out more frequently than G205 and G206, due to the higher topography of the location. At this station, median TP levels were above 100 ppb.

Table 3. Summary of water quality data at G-200 from October 1, 2010–September 30, 2011.

Parameter	Sample Type	First Datum	-	Last Datum	Sample Number	Minimum	Maximum	Median	Average	Standard Deviation
PHYSICAL										
Water Temperature (ºC)	field	10/28/10	-	08/31/11	4	16.4	30.2	27.4	25.4	6.1
Specific Conductance (µmhos/cm)	field	10/28/10	-	08/31/11	4	463.0	794.0	560.1	594.3	141.1
pH (SU)	field	10/28/10	-	08/31/11	4	7.30	8.00	7.45	7.55	0.31
NUTRIENTS										
Total Nitrogen (mg/L)	grab	10/28/10	-	08/31/11	4	1.274	1.911	1.593	1.593	0.260
Total Kjeldahl Nitrogen (mg/L)	grab	10/28/10	-	08/31/11	4	1.190	1.780	1.560	1.523	0.246
Nitrate/Nitrite (as N mg/L)	grab	10/28/10	-	08/31/11	4	0.017	0.131	0.067	0.070	0.049
Total Phosphorus (mg/L)	grab	10/28/10	-	08/31/11	4	0.020	0.032	0.024	0.025	0.005

ºC – degrees Celsius
mg/L – milligrams per liter
SU – standard units
µmhos/cm – micromhos per centimeter

Table 4. Summary of water quality data at G-204 from October 1, 2010–September 30, 2011.

Parameter	Sample Type	First Datum	-	Last Datum	Sample Number	Minimum	Maximum	Median	Average	Standard Deviation
PHYSICAL										
Water Temperature (ºC)	field	10/28/10	-	08/31/11	4	14.3	30.1	26.1	24.1	6.9
Specific Conductance (µmhos/cm)	field	10/28/10	-	08/31/11	4	477.0	873.0	594.1	634.6	168.7
pH (SU)	field	10/28/10	-	08/31/11	4	7.00	7.80	7.30	7.35	0.33
NUTRIENTS										
Total Nitrogen (mg/L)	grab	10/28/10	-	08/31/11	4	2.084	5.076	3.183	3.381	1.368
Total Kjeldahl Nitrogen (mg/L)	grab	10/28/10	-	08/31/11	4	2.040	5.060	3.180	3.365	1.376
Nitrate/Nitrite (as N mg/L)	grab	10/28/10	-	08/31/11	4	<0.005	0.044	0.006	0.016	0.020
Total Phosphorus (mg/L)	grab	10/28/10	-	08/31/11	4	0.048	0.206	0.108	0.117	0.079

Table 5. Summary of water quality data at G-205 from October 1, 2010–September 30, 2011.

Parameter	Sample Type	First Datum	-	Last Datum	Sample Number	Minimum	Maximum	Median	Average	Standard Deviation
PHYSICAL										
Water Temperature (ºC)	field	10/28/10	-	08/31/11	4	16.3	30.0	26.3	24.7	5.9
Specific Conductance (µmhos/cm)	field	10/28/10	-	08/31/11	4	263.0	884.0	571.4	572.5	253.6
pH (SU)	field	10/28/10	-	08/31/11	4	6.80	7.70	7.40	7.33	0.41
NUTRIENTS										
Total Nitrogen (mg/L)	grab	10/28/10	-	08/31/11	4	1.223	2.376	2.118	1.958	0.509
Total Kjeldahl Nitrogen (mg/L)	grab	10/28/10	-	08/31/11	4	1.220	2.350	2.115	1.950	0.503
Nitrate/Nitrite (as N mg/L)	grab	10/28/10	-	08/31/11	4	<0.005	0.026	<0.005	0.008	0.012
Total Phosphorus (mg/L)	grab	10/28/10	-	08/31/11	4	0.030	0.072	0.045	0.048	0.019

Table 6. Summary of water quality data at G-206 from October 1, 2010–September 30, 2011.

Parameter	Sample Type	First Datum	-	Last Datum	Sample Number	Minimum	Maximum	Median	Average	Standard Deviation
PHYSICAL										
Water Temperature (ºC)	field	10/28/10	-	08/31/11	4	15.2	30.0	26.5	24.5	6.4
Specific Conductance (µmhos/cm)	field	10/28/10	-	08/31/11	4	91.4	876.0	640.0	561.8	338.4
pH (SU)	field	10/28/10	-	08/31/11	4	6.10	7.70	7.20	7.05	0.70
NUTRIENTS										
Total Nitrogen (mg/L)	grab	10/28/10	-	08/31/11	4	1.165	1.873	1.572	1.545	0.355
Total Kjeldahl Nitrogen (mg/L)	grab	10/28/10	-	08/31/11	4	1.150	1.870	1.550	1.530	0.350
Nitrate/Nitrite (as N mg/L)	grab	10/28/10	-	08/31/11	4	<0.005	0.041	0.005	0.015	0.018
Total Phosphorus (mg/L)	grab	10/28/10	-	06/22/11	3	0.012	0.031	0.028	0.024	0.010

SEDIMENT QUALITY DATA

During the reporting period, sediment quality samples were collected at four interior marsh locations (HOLEYSD1, HOLEYSD2, HOLEYSD3, and HOLEYSD4) (**Figure 2**). Annual sediment data for Federal Water Year 2011 (October 1, 2010–September 30, 2011) is summarized in **Table 7**. Individual sediment quality monitoring measurements are included in Attachment B.

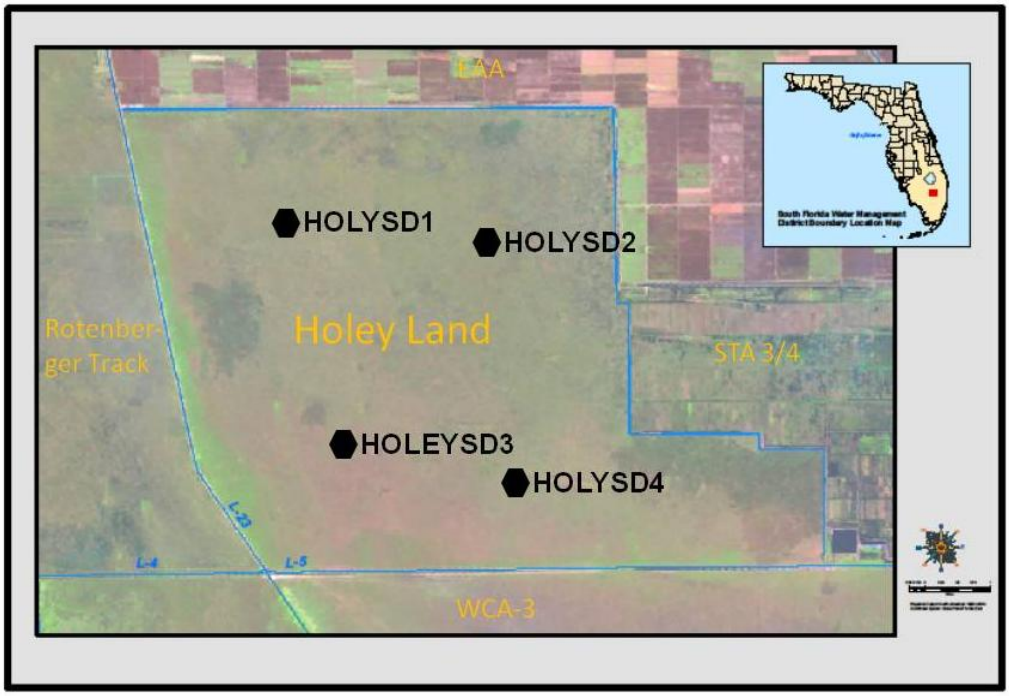

Figure 2. Holey Land WMA sediment monitoring locations.

Table 7. Summary of Holey Land WMA sediment data from October 1, 2010–September 30, 2011.

Parameter	Units	Sampling Date	Monitoring Station			
			HOLYSD1	HOLYSD2	HOLYSD3	HOLYSD4
Antimony	mg/kg	5/24/11	<0.24	<0.24	0.27	<0.25
Arsenic	mg/kg	5/24/11	5.11	4.27	5.84	3.77
Beryllium	mg/kg	5/24/11	0.11	0.10	0.12	0.15
Cadmium	mg/kg	5/24/11	0.11	0.11	0.14	0.13
Chromium	mg/kg	5/24/11	3.46	3.41	3.96	4.65
Copper	mg/kg	5/24/11	5.89	6.07	6.24	6.35
Lead	mg/kg	5/24/11	6.9	9.0	13.0	15.1
Mercury	mg/kg	5/24/11	0.12	0.13	0.11	0.18
Nickel	mg/kg	5/24/11	3.44	3.20	3.52	4.03
Selenium	mg/kg	5/24/11	2.28	2.33	2.25	2.40
Silver	mg/kg	5/24/11	0.018	0.024	0.020	0.024
Thallium	mg/kg	5/24/11	<0.048	<0.048	<0.048	<0.050
Zinc	mg/kg	5/24/11	5.1	5.3	7.2	6.0

mg/kg – milligrams per kilogram

FLOW DATA

In 1989, the SFWMD started collecting water samples at the inflow structure (G-200A), outflow structures (G-204, G-205, and G-206), and interior stations. In October 2005, Hurricane Wilma severely damaged the inflow pump station (G-200A) and rendered it inoperable. Since that time, only limited surface water inflow capacity has been available through the G-372HL box culvert (**Figure 3**). Since April 2008, there has been no surface water inflow at G-372HL. During the reporting period, gate opening records indicate that G-372HL was not opened. There have been no outflows since January 2006, and there was no flow at the outflow structures during the reporting period.

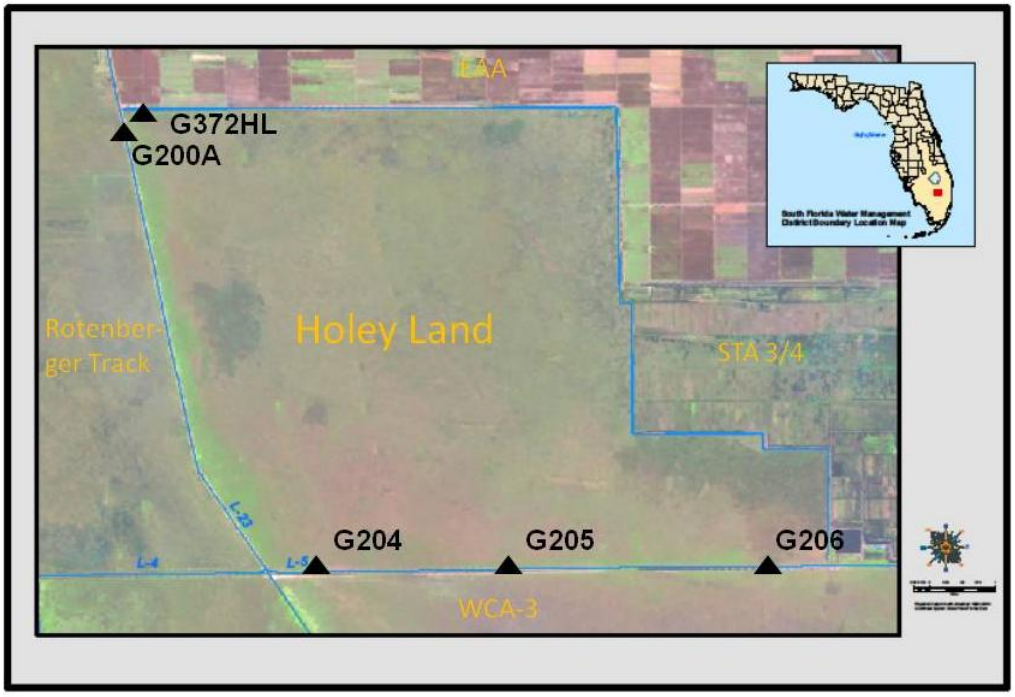

Figure 3. Holey Land WMA flow monitoring locations at the inflow and outflow sites.

STAGE DATA

Within the Holey Land WMA, water levels were monitored at two marsh stations (HOLEY1 and HOLEY2), one ground water monitoring station (HOLEY_G), one interior perimeter canal station on the eastern side (G203D), and on the upstream side of the outflow structures (G204_H, G205_H, and G206_H)(**Figure 4**).

The permit specifies that "for operational decisions, the average stage in the Holey Land will be defined as the water level in the interior pond at station G-203, located on the eastern boundary of Holey Land, 4 miles south of the north levee." The intention of this location was to measure stage at a location that was far enough away from the inlet and outlets that it would not be significantly influenced by changes in the inlet or outlet operations. Because the Holey Land WMA has become rainfall-driven and no longer functions as a flow-through system, water levels fluctuate naturally with rainfall events.

All stage data collected at the stations shown in **Figure 4** are summarized in **Table 8**. Additional information about the stage data is included in Attachment C.

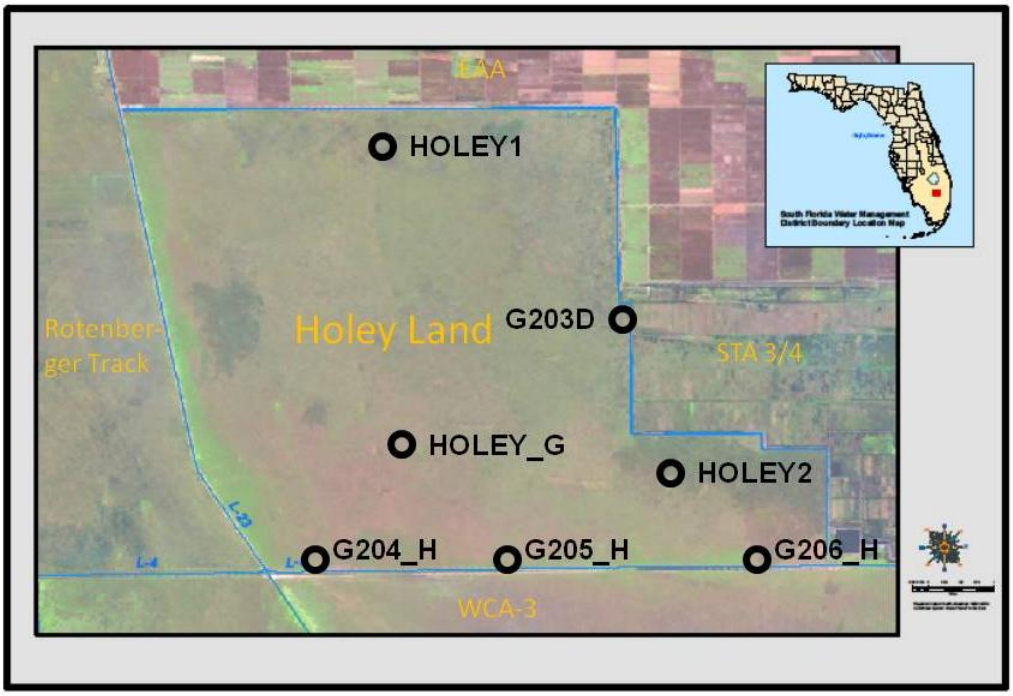

Figure 4. Holey Land WMA stage monitoring locations.

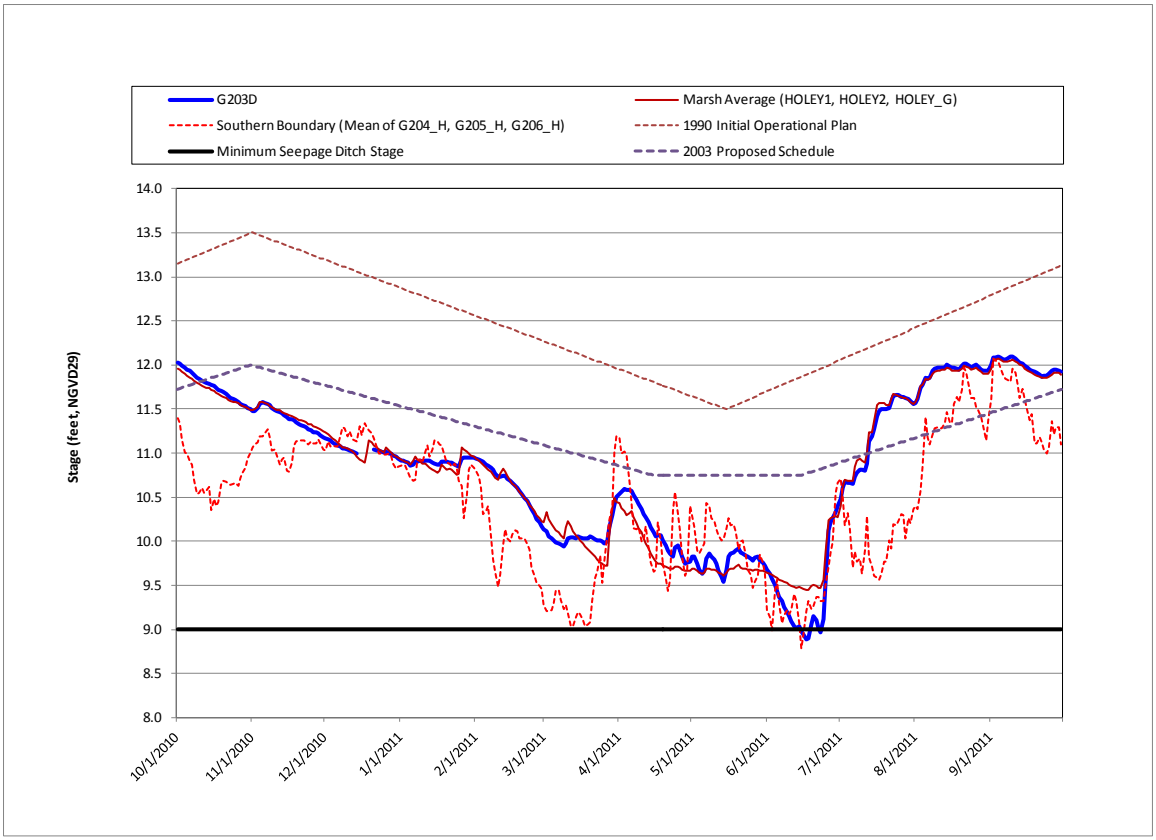

Figure 5. Daily stages in the Holey Land WMA from October 1, 2010–September 30, 2011.

Table 8. Summary of daily mean stage data (feet, NGVD29) from the Holey Land WMA from October 1, 2010–September 30, 2011.

Site	Statistics	Oct. 2010	Nov. 2010	Dec. 2010	Jan. 2011	Feb. 2011	Mar. 2011	Apr. 2011	May. 2011	Jun. 2011	Jul. 2011	Aug. 2011	Sep. 2011	WY2011 Total
G203D	Maximum	12.03	11.58	11.17	10.95	10.94	10.50	10.59	9.92	10.40	11.66	12.01	12.10	12.10
	Mean	11.75	11.39	11.04*	10.90	10.64	10.06	10.16	9.78	9.38	11.20	11.92	11.99	10.83
	Minimum	11.50	11.18	10.94	10.85	10.17	9.94	9.75	9.54	8.88	10.48	11.57	11.87	8.88
HOLEY_G	Maximum	12.09	11.79	11.48	11.32	11.03	10.91	10.73	10.03	10.03	11.88	12.05	12.16	12.16
	Mean	11.85	11.64	11.28	11.03	10.77	<10.47	<10.22	<10.03	<10.03	<11.09	11.99	12.03	11.51
	Minimum	11.67	11.50	11.07	10.84	10.45	<10.03	<10.03	<10.03	<10.03	<10.03	11.76	11.92	10.45
HOLEY1	Maximum	11.92	11.52	11.14	11.01	10.90	10.56	10.39	9.49	10.35	11.61	11.91	12.00	12.00
	Mean	11.66	11.36	10.93	10.81	10.59	<9.88	<9.75	<9.49	9.64	11.31	11.81	11.88	11.11
	Minimum	11.44	11.16	10.76	10.65	10.15	<9.49	<9.49	<9.49	9.48	10.49	11.44	11.78	9.48
HOLEY2	Maximum	11.81	11.44	11.16	10.98	10.87	10.22	10.06	9.49	10.55	11.62	12.01	12.06	12.06
	Mean	11.56	11.32	10.96	10.78	10.55	<9.81	<9.59	<9.39	<9.58	11.38	11.87	11.94	11.30
	Minimum	11.36	11.17	10.85	10.64	10.13	<9.39	<9.38	<9.38	<9.38	10.58	11.55	11.81	10.13
G204_H	Maximum	12.03	11.22	11.28	11.10	10.76	11.00	11.12	10.42	10.49	10.50	12.01	12.17	12.17
	Mean	11.23	11.02	11.06	10.81	9.95	9.45	10.07	9.95	9.34	9.92	11.76	11.98	10.55
	Minimum	10.59	10.70	10.79	10.21	9.41	8.99	9.39	9.43	8.74	9.53	10.33	11.85	8.74
G205_H	Maximum	11.81	11.30	11.38	11.19	10.84	11.20	11.22	10.48	10.66	10.71	12.06	12.14	12.14
	Mean	10.62	11.11	11.15	10.90	10.03	9.54	10.17	10.02	9.42	10.03	11.26	11.55	10.48
	Minimum	9.89	10.82	10.87	10.30	9.49	9.06	9.47	9.51	8.80	9.60	10.39	10.65	8.80
G206_H	Maximum	11.01	11.28	11.34	11.15	10.80	11.36	11.33	10.40	10.89	10.92	11.83	11.92	11.92
	Mean	10.38	11.09	11.12	10.87	10.01	9.52	10.18	9.98	9.40	10.07	10.98	11.05	10.39
	Minimum	9.87	10.85	10.82	10.27	9.47	9.04	9.43	9.48	8.79	9.56	10.36	10.22	8.79

* Six daily values missing. All data reported in feet National Geodetic Vertical Datum of 1929.

RAINFALL AND EVAPORATION DATA

Rainfall was measured at G200_R and adjacent stations (S3_R and S8_R), along with the pan evaporation measurements at S7_E **(Figure 6)**.

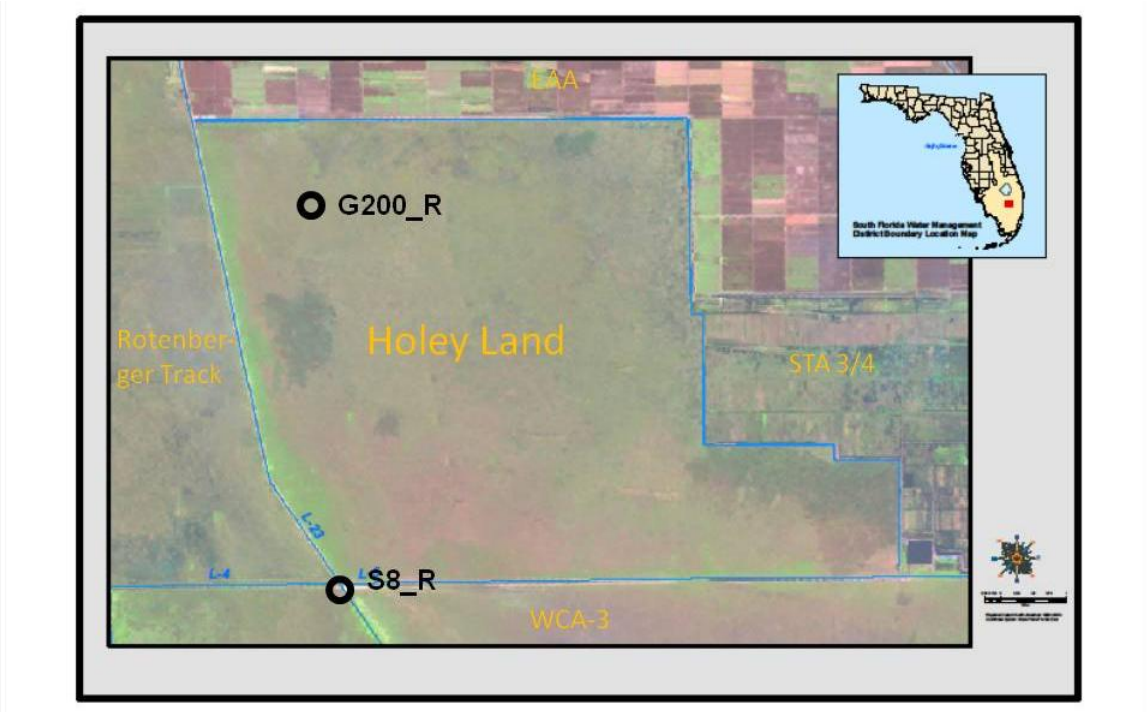

Figure 6. Holey Land rainfall/evaporation monitoring locations.
(Not shown: Station S3_R, which is located at the S3 pump station, about 19 miles north of G200_R, and S7_E, which is located about 15 miles east of S8_R.)

Comparison of monthly total rainfall and monthly total evaporation is presented in **Figure 7** to show the seasonal patterns. Monthly total rainfall data is summarized in **Table 9**, and monthly total evaporation data is summarized in **Table 10**. Additional information on the rainfall data is included in Attachment C.

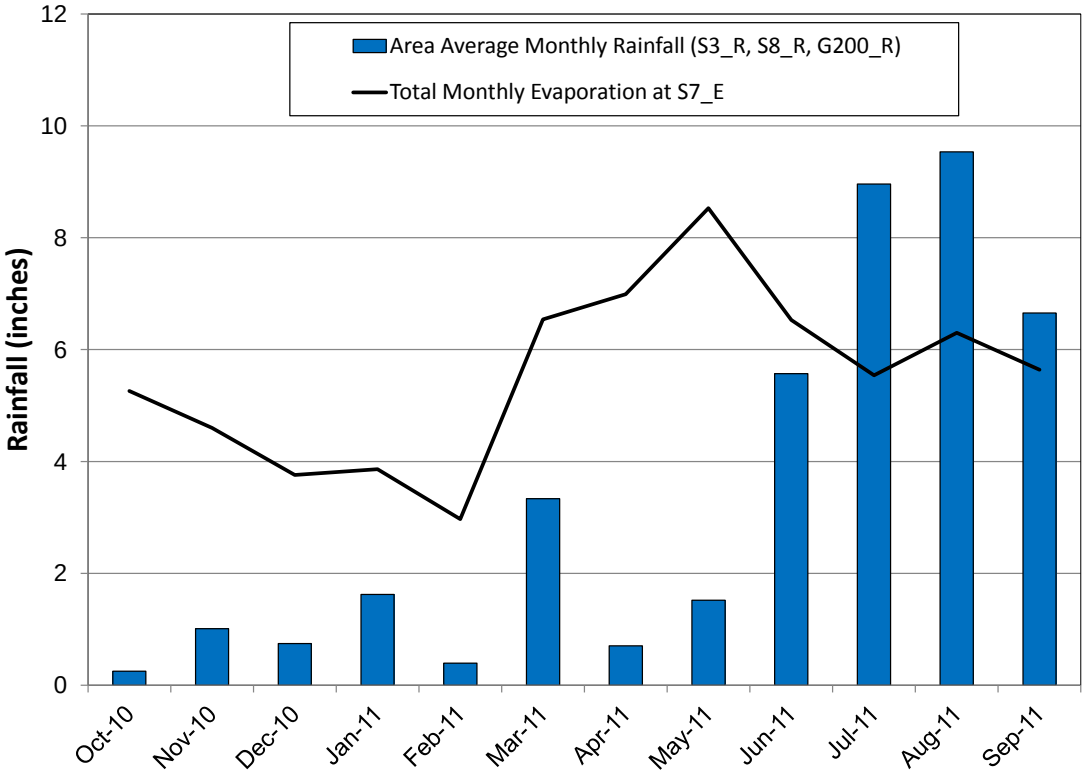

Figure 7. Average monthly rainfall in the Holey Land WMA (average of S3_R, S8_R, and G200_R) compared to monthly evaporation at S7_E.

Table 9. Summary of daily rainfall data and monthly sums (inches) in the Holey Land WMA from October 1, 2010–September 30, 2011.

Site	Statistics	Oct. 2010	Nov. 2010	Dec. 2010	Jan. 2011	Feb. 2011	Mar. 2011	Apr. 2011	May. 2011	Jun. 2011	Jul. 2011	Aug. 2011	Sep. 2011	WY2011 Total
S3_R	Maximum	0.15	0.35	0.19	0.70	0.20	2.45	0.25	0.71	1.29	1.79	2.00	0.96	2.45
	Mean	0.01	0.02	0.02	0.07	0.01	0.11	0.01	0.07	0.15	0.24	0.27	0.15	0.09
	Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Sum	0.22	0.54	0.47	2.00	0.36	3.33	0.33	2.03	4.43	7.39	8.41	4.34	33.85
S8_R	Maximum	0.15	0.83	0.75	0.81	0.16	1.56	0.18	0.34	1.12	1.69	2.26	3.73	3.73
	Mean	0.01	0.06	0.04	0.04	0.01	0.12	0.01	0.03	0.15	0.26	0.27	0.30	0.11
	Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
	Sum	0.24	1.65	1.11	1.15	0.33	3.71	0.39	0.66*	4.42	8.18	8.43	8.97	38.58
G200_R	Maximum	0.11	0.39	0.52	0.87	0.24	1.48	0.50	0.77	2.27	2.41	1.71	0.00**	2.41
	Mean	0.01	0.03	0.02	0.06	0.02	0.10	0.05	0.06	0.26	0.37	0.38	0.00**	0.12
	Minimum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00**	0.00
	Sum	0.29	0.84	0.65	1.71	0.49	2.96	1.39	1.87	7.86	11.31	11.77	0.00**	41.14

* 8 daily values were missing
** 29 daily values were missing

Table 10. Summary of daily pan evaporation data and monthly sums (inches) in the Holey Land WMA from October 1, 2010–September 30, 2011.

Site	Statistics	Oct. 2010	Nov. 2010	Dec. 2010	Jan. 2011	Feb. 2011	Mar. 2011	Apr. 2011	May. 2011	Jun. 2011	Jul. 2011	Aug. 2011	Sep. 2011	WY2011 Total
S7_E	Maximum*	0.64	0.56	0.73	0.53	0.80	1.04	1.07	1.15	1.19	0.78	1.09	0.57	1.19
	Mean*	0.21	0.24	0.19	0.22	0.16	0.34	0.41	0.43	0.38	0.23	0.30	0.23	0.28
	Minimum*	0.06	0.07	-0.03	0.06	0.00	0.12	0.16	0.21	0.11	0.06	0.03	0.08	-0.03
	Sum	5.26	4.60	3.76	3.86	2.97	6.54	6.99	8.53	6.53	5.54	6.30	5.64	66.52

* Cumulative values from one to five days

Attachment A: Specific Conditions and Cross-References

Table A-1. Specific conditions, actions taken, and cross-references presented for the Holey Land WMA (Environmental Resource Permits: 06,500809209 and 06,501191549*) in this report.

Specific Condition	Description	Applicable Phase	Action Taken	Reported in the 2013 SFER in: *(All references are to Volume III, unless otherwise noted)*			
				Narrative (page #'s)	**Figure**	**Table**	**Attachment**
5	Maintain normal water level in seepage ditches (no lower than +9 ft. NGVD)	Operation	N/A (Seepage ditches were extensively modified and water regulation schedules were changed). Daily stages monitored and reported	3, 10	5	8	C
6	Turbidity control	Construction	N/A (No construction occurred during this reporting period)				
Page 8 of 11 in permit	Long-term water quality monitoring**	Operation	Quarterly water quality monitoring conducted and reported	3, 4		3 - 6	B
Page 9 of 11 in permit	Sediment monitoring**	Operation	Annual sediment sampling conducted and reported	7		7	B
Page 10 of 11 in permit	Vegetation monitoring***	Operation	Annual vegetation monitoring conducted and reported	3			D
Page 10 of 11 in permit	Report volume of rainfall	Operation	Rainfall monitored and reported	3, 13	7	9 - 10	C
Page 10 of 11 in permit	Report volume of water pumped	Operation	Flow monitored and reported	3, 9		N/A (no flow)	C

* All conditions required for permit 06,500809209 also apply to permit 06,501191549.
** For revised monitoring plan changes from FDEP, see minor permit modification document, dated September 20, 2005.
*** For vegetation reporting requirements see "Exhibit C" of the agreement between South Florida Water Management District and the Florida Game and Fresh Water Fish Commission, dated June 28, 1990.

Attachment B:
Water Quality and Sediment Data

This project information is required by the Holey Land Wildlife Management Area permits (06,500809209 and 06,501191549), and is available upon request.

Attachment C: Hydrologic Data

This project information is required by the Holey Land Wildlife Management Area permits (06,500809209 and 06,501191549), and is available upon request.

Attachment D: Holey Land Wildlife Management Area 2011 Annual Cattail Monitoring Report

Note: This project information is required by the Holey Land Wildlife Management Area permits (06,500809209 and 06,501191549). This document, dated June 17, 2012, was provided to the South Florida Water Management District by the Florida Fish and Wildlife Conservation Commission.

HOLEY LAND WILDLIFE MANAGEMENT AREA
2011 ANNUAL CATTAIL MONITORING REPORT

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INTRODUCTION

Holey Land Wildlife Management Area (WMA) is a 35,350 acre wetland in the southwest corner of Palm Beach County, Florida. The area was originally a marsh of dense sawgrass with scattered shrubs and sloughs (Davis 1943); however, unnatural alteration of the area's hydropattern began when the Miami Canal was excavated (1907-1917) along the western border of the area. After the authorization of the Central and Southern Florida Project for Flood Control and Other Purposes in 1948, the canal was deepened and the L-5 levee was constructed creating the southern border of Holey Land and blocking sheetflow to the south (Light and Dineen 1994). By the late 1960s, these changes, in combination with the conversion of marsh to farmland in the north and east, had altered the area's hydropattern and caused significant changes in the plant communities (Cornwell and Hutchinson 1974).

In 1968 the area was leased to the Florida Fish and Wildlife Conservation Commission (FWC) for fish and wildlife management purposes. Pursuant to that objective, from 1974 to 1975, 54 artificial islands 0.3 to 0.5 has in size were created by dredging muck from the marsh, leaving behind a small pond adjacent to each island. This was part of an Everglades-wide program, initiated by sportsman Francis "Franny"

Taylor to mitigate for the loss of tree island habitat caused by muck fires (Shortemeyer 1980).

A 1983 interagency agreement between FWC, the South Florida Water Management District (SFWMD), and the Florida Department of Environmental Regulation identified hydropattern improvement as a goal for restoration in Holey Land. Subsequently, in the late 1980's a system of levees, canals, and pumps was built that allowed managers to pump water from the Miami Canal into the area to achieve desired water levels. This system was fully functional by 1990 and the initial water schedule, which called for water levels varying from 11.5-13.5 feet above mean sea level (MSL), was achieved in June 1991. A topographic survey performed in 1992 revealed that the average elevation was 11.1 ft MSL, 0.4 ft lower than the previous estimate of 11.5 ft MSL prompting managers to lower the water regulation schedule to 11.0-13.0 ft MSL in July 1993. The elevation in Holey Land also ranges as much as four feet, a result of muck fires burning away organic soil during extreme dry periods. Extended high water levels in Holey Land can drown out typical marsh species in these deep pockets, creating an opening in the landscape susceptible to invasion by cattail (Newman et al. 1998). In early 1995, the schedule was dropped to 10.5-12.0 ft. MSL in an attempt to slow the proliferation of cattail.

Both of the major changes in the schedule were done informally and a revised schedule similar to that adopted in 1995 is under review by the FWC and SFWMD, as is a formal Memorandum of Understanding. Conforming to a revised schedule has been hindered by the fact that the G200A pump station is no longer functioning, restricting the ability to deliver clean water to Holey Land.

METHODS

The cattail survey method used from 1992-2003 was initiated after an attempt to use color infrared photography failed due to a combination of low cattail density and poor survey timing (Gilbert 1991). Two separate surveys conducted via helicopter were used to determine cattail coverage by first delineating boundaries of cattail monocultures and then sampling these areas to determine aerial percent cattail coverage. Cattail stands were first located by systematically traversing the entire area. Global Positioning System (GPS) readings were taken at all extensive areas of cattail growth. After completing this initial survey, each of the areas of extensive cattail growth previously located were revisited and mapped by taking GPS readings along their perimeters.

The second phase employed an aerial point-sampling scheme that utilized a 4 x 5 grid of crosshairs to systematically select 20 sample points. This grid was copied onto an 8.5" x 11" sheet of clear plastic and provided to two biologists observing out of either side of the helicopter. Sampling was conducted at different altitudes, depending on the size of the area sampled (e.g., observations were made at lower altitudes in areas with smaller cattail stands to ensure that samples were taken within the boundaries of the area surveyed), by holding the grid at arm's-length (as nearly parallel to the ground as possible given the configuration of the helicopter) and recording the number of points where the cross-hairs landed on the various vegetation types surveyed. The vegetation types were classified as cattail, sawgrass, brush, open water, or other. Each biologist took 10 sets of 20 sample points totaling 400 sample points in each area (200 sample points per biologist). The number of points landing on cattail, divided by the total number of sample points, provided the percent aerial cattail coverage in each sampling

area. The field map produced using the GPS coordinates recorded along the boundary of each sampling area was transformed into an area layer that provided measurements of total acreage within each area. The total cattail coverage in Holey Land WMA was the sum of the resulting estimates of cattail coverage in the individual sampling areas. Estimates of cattail coverage were computed using the 35,350 acre base map.

In 2004 the point intercept method was adopted in an effort to obtain more accurate and less subjective data (Owensby 1973). The survey involves two biologists, one on each side of the helicopter, selecting a specific point on the helicopter skid and looking directly down past that point at the vegetation below at 369 evenly spaced points. The surveys are performed in May and involve flying 12 transects, collecting data at all 369 points for a total of 738 data entries. At each point the observer records one of five different categories: cattail, sawgrass, brush, open water, and other. These categories were changed in 2005 to cattail, wax myrtle, Brazilian pepper, red maple, sawgrass, willow, and other. In 2007 a "burned" category was added to account for a 13,395 acre wildfire that occurred on April 1, 2007, one month before the survey. The helicopter is flown at an altitude of 200 feet and at a speed of approximately 80 miles/hour. The number of points where cattail is observed is divided by the total number of points and multiplied by 100 to provide a percent coverage of cattail. The percentage is multiplied by the total acres surveyed to calculate total acres of cattail.

In 2005, the FWC contracted Florida Natural Areas Inventory (FNAI) to conduct a vegetation survey of Holey Land WMA (Figure 1) via remote sensing of aerial photographs. They digitized as many community types as possible and ground-truthed each polygon identified during their remote sensing. They found 25.5% (9,025.22 acres)

of the area to be cattail monoculture, which is consistent with the results of our sampling from 2004-2006.

RESULTS

The results of the 2011 survey estimate that 17.8% of the area is covered by cattail (Table 1; see Figure 1 for sample locations and results). The acreage covered by cattail was calculated to be 6,297 acres. This indicates an increase in estimated cattail coverage from 2010 (10.5%), however, it is still significantly less than what was estimated in 2004 (27.0%).

DISCUSSION

Cattail coverage increased rapidly over the course of the initial hydrological restoration of Holey Land, aided by the higher water regime schedules. During this time, cattail invaded sloughs and open-water areas that were created when muck fires burned the peat and sawgrass rootstock. These muck fires also released large amounts of nutrients. Sawgrass can survive total submergence for up to six weeks, but is adversely affected by high water and a combination of increased water depth, extended hydropatterns, and increased nutrients will promote the growth of cattail over sawgrass (Newman et al. 1998).

Determining the cattail coverage from the air continues to be subjective due to different biologists participating in the surveying each year and the varying appearance of cattail throughout the area and years, e.g., the area's soil moisture at any given time and location can affect the "greenness" and detectability of cattail. The survey does show a

clear trend of decreasing cattail coverage in Holey Land WMA (Figure 2). This could be attributed to the lowered water schedule, the overall reduction in water deliveries after the G200A pump station was decommissioned, and the periodic drought conditions that have occurred during recent years. The increase in cattail coverage observed from 2010 (10.5%) to 2011 (17.8%) may be a short-term phenomenon attributable to the high water levels present during much of 2010 (Figure 3).

Cattail would be expected to spread again and possibly encroach into the dominant sawgrass expanse in Holey Land WMA if extreme high water levels or extremely long hydroperiods are adopted (Newman et al. 1998). Because regular water deliveries have not been made, Holey Land has generally had lower than normal water levels. This has allowed shrub encroachment over much of the area and one reason for the decrease in cattail may be replacement by Carolina willow. These dry conditions also increase the probability of muck fires which could create more suitable conditions for cattail expansion. The FWC is working with the South Florida Water Management District to ensure that the primary focus in Holey Land is to restore water levels and hydroperiods that are closer to historic levels in order to achieve a healthier natural community.

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Table 1. Cattail surveys in the Holey Land WMA, 1991-2010.

Year	Actual Acres Surveyed	Cattail Acres (95% C.I.)	Estimated % of Cattail Coverage in WMA
1991 [1]	N/A	538	N/A
1992	4,640	1,456 (990-1920)	4.1
1993	12,814	3,838 (2,890-4,823)	10.9
1994	19,460	5,434 (3,928-6,961)	15.4
1995	19,253	6,534 (5,321-7,731)	18.5
1996	19,657	6,706 (5,064-8,346)	19.0
1997 [2]	21,987	9,092 (7,398-10,772)	25.7
1998 [2]	20,937	9,987 (7,935-11,208)	28.3
1999 [2]	21,850	10,392 (7,377-13,401)	29.4
2000	22,442	11,195 (10,750-13,804)	31.7
2004	35,350	9,545 (8,484-10,605)	27.0
2005	35,350	7,848 (6,514-9,182)	22.2
2006	35,350	8,060 (6,999-9,120)	22.8
2007	35,350	6,850 (5,819-7,897)	19.4
2008	35,350	5,508 (4,596-6,434)	15.6
2009	35,350	6,108 (5,142-7,074)	17.3
2010	35,350	3,706 (2,928-4,484)	10.5
2011	35,350	6,297 (5,323-7,271)	17.8

[1] Visual estimates of cattail given in Gilbert (1991).
[2] Cattail surveys performed in the fall rather than in the spring.

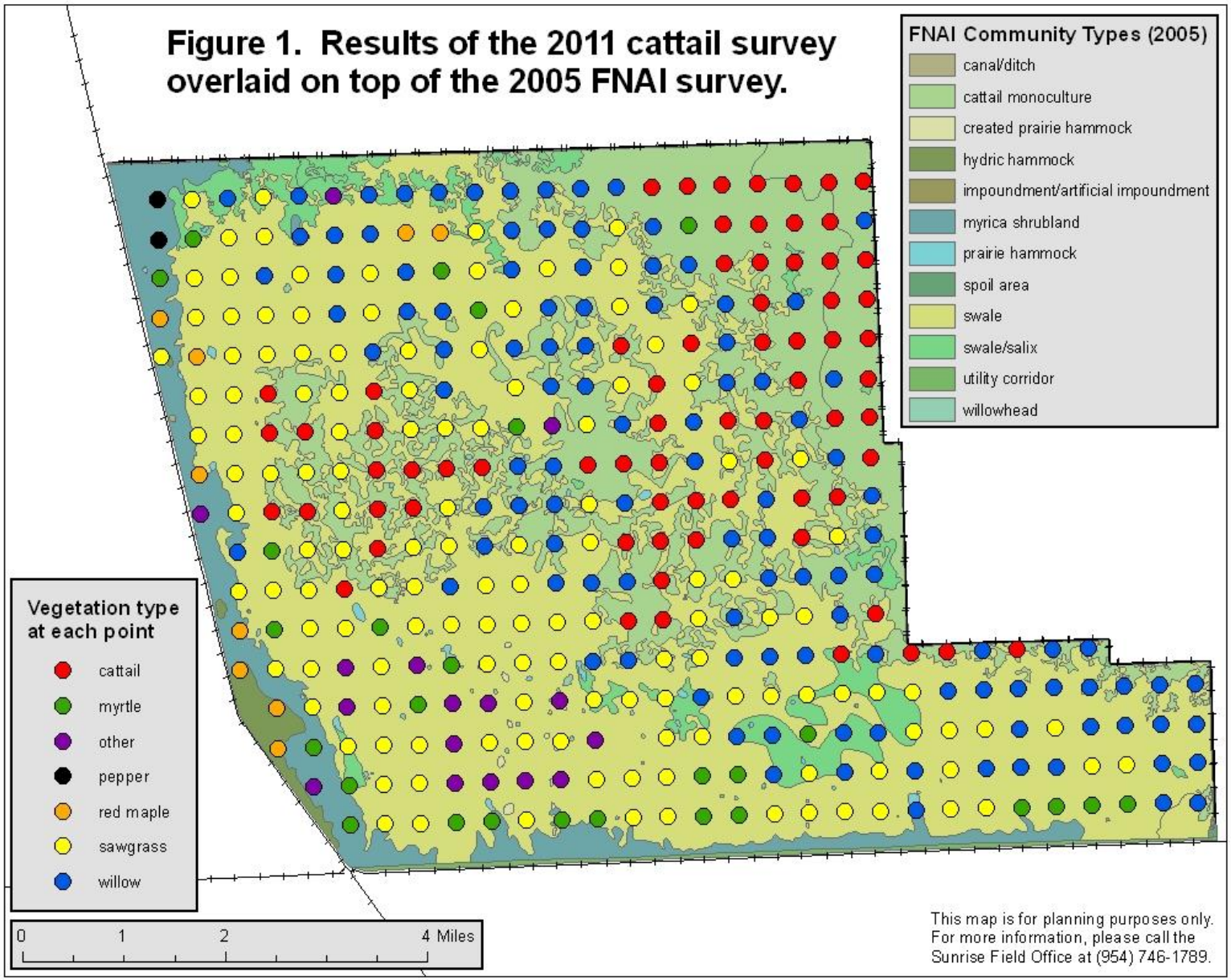
Figure 1. Results of the 2011 cattail survey overlaid on top of the 2005 FNAI survey.
FNAI Community Types (2005)
canal/ditch
cattail monoculture
created prairie hammock
hydric hammock
impoundment/artificial impoundment
myrica shrubland
prairie hammock
spoil area
swale
swale/salix
utility corridor
willowhead
Vegetation type at each point
cattail
myrtle
other
pepper
red maple
sawgrass
willow
0
1
2
4 Miles
This map is for planning purposes only.
For more information, please call the
Sunrise Field Office at (954) 746-1789.

Figure 2. Cattail Coverage in Holey Land WMA

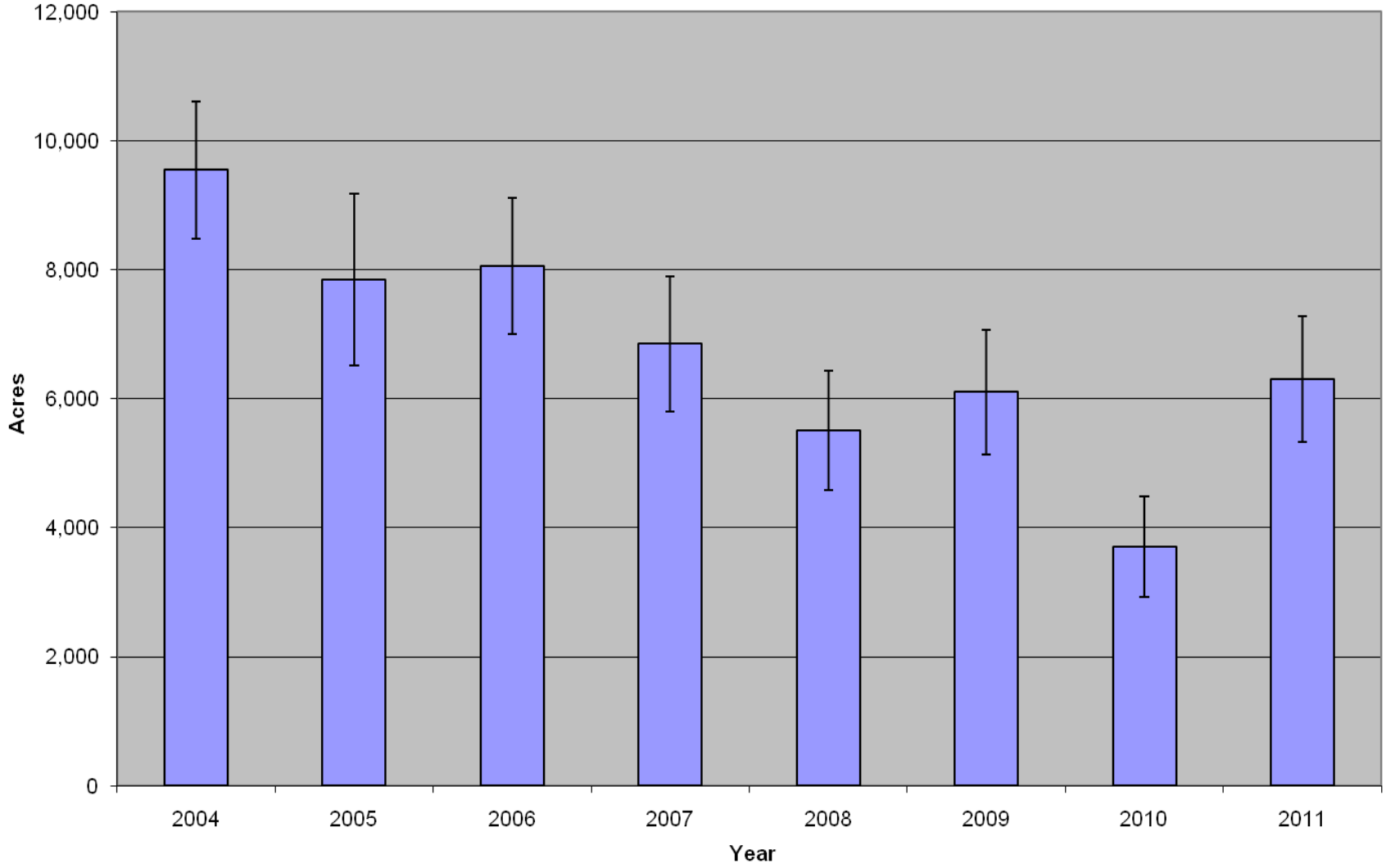

Figure 3. Holey Land WMA stage level (G203) water levels from 2010 and 2011, average weekly water levels for 1990-2010, average ground elevation, closure criteria and the schedule.