# Appendix 2-3: Annual Permit Report for the Biscayne Bay Coastal Wetlands – L-31 East Culverts and Deering Estate Flow-way

**Permit Report (May 1, 2012–April 30, 2013)**
**Permit Number: 0271729**

Bahram Charkhian

Contributors: Dallas Hazelton[1], Stephen Blair[2], Josh Mahoney[2], Jennifer Possley[3], Gregory Garis[4], Lucia Baldwin, Ben Gu, Leslye Waugh, and Richard Pfeuffer

## 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 lists specific pages, tables, graphs, and attachments where project status and annual reporting requirements are addressed. This annual report satisfies the reporting requirements specified in the permit.

[1] Miami-Dade County, Natural Areas Management, Parks, Recreation, and Open Spaces Department
[2] Miami-Dade County, Department of Regulatory and Economic Resources, Environmental Resources Management, Restoration and Enhancement Section
[3] Fairchild Tropical Botanic Garden
[4] Biscayne National Park Resource Management, U.S. National Park Service

**Table 1.** Key permit-related information.

| | |
|---|---|
| **Project Name:** | Biscayne Bay Coastal Wetlands –<br>L-31 East Culverts and Deering Estate Flow-way |
| **Permit Number:** | 0271729-006 |
| **Issue and Expiration Dates:** | Issued: 4/18/2013; Expires: 4/18/2018 |
| **Project Phase:** | Operations |
| **Permit Specific Condition Requiring Annual Report:** | 26 |
| **Reporting Period:** | May 1, 2012–April 30, 2013 |
| **Report Lead:** | Bahram Charkhian<br>bcharkh@sfwmd.gov<br>561-682-2284 |
| **Permit Coordinator:** | Leslye Waugh<br>lwaugh@sfwmd.gov<br>561-682-6483 |

**Table 2.** Attachments included with this report.

| Attachment | Title |
|---|---|
| **A** | Specific Conditions and Cross-References |
| **B** | Water Quality Data |
| **C** | Hydrologic Data |
| **D** | Biscayne Bay Coastal Wetlands L-31E Culverts Annual Mitigation Monitoring Report |
| **E** | Biscayne Bay Coastal Wetlands Deering Estate Flow-way Annual Mitigation Monitoring Report |

# INTRODUCTION

The Comprehensive Everglades Restoration Plan (CERP) Biscayne Bay Coastal Wetlands (BBCW) Project includes three components: (1) the Deering Estate Flow-way, (2) the L-31E Culverts, and (3) the proposed Cutler Wetlands Flow-way (**Figure 1**). The projects are essential to achieving restoration of tidal wetlands and nearshore habitats within Biscayne Bay, including Biscayne National Park. CERPRA permit 0271729, which was issued by the FDEP to the South Florida Water Management District (District or SFWMD), authorized the District to construct and operate two components of the BBCW Project—the L-31 East (L-31E) Culverts (**Figure 2**) and Deering Estate Flow-way (**Figure 3**).

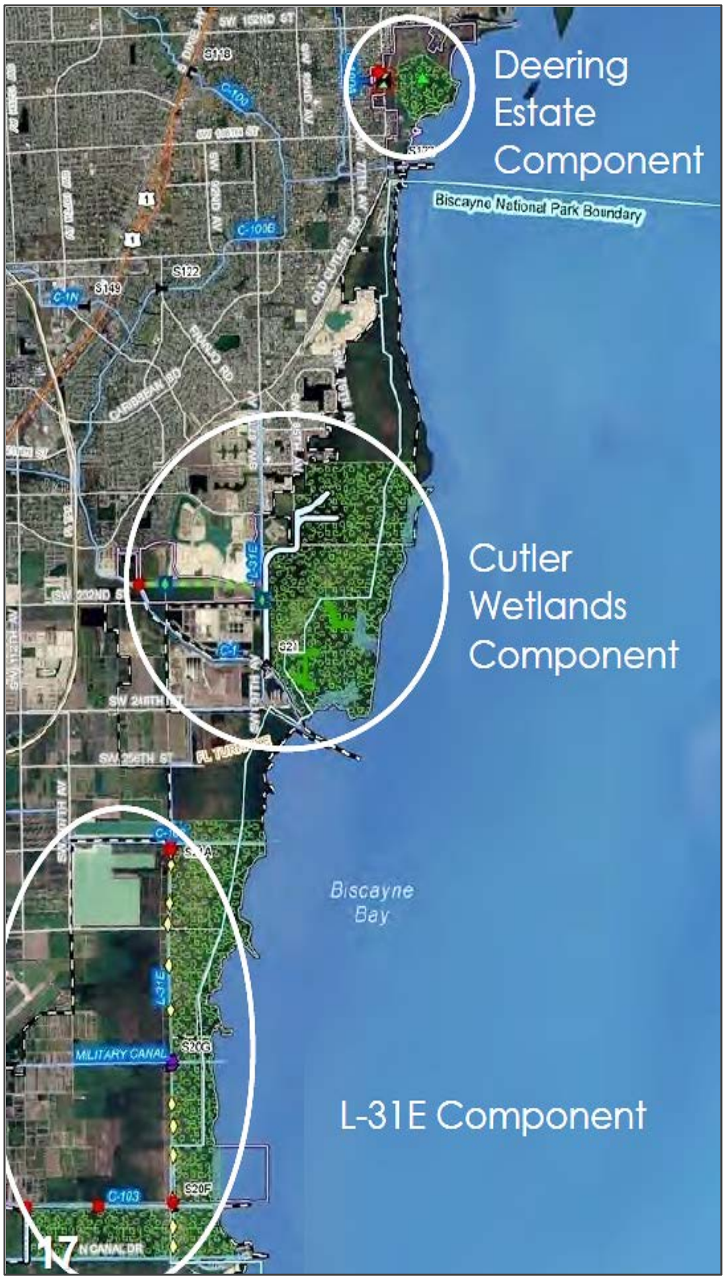


**Figure 1.** Biscayne Bay Coastal Wetlands (BBCW) project components.


**Figure 2.** BBCW Project L-31 East (L-31E) culverts.


**Figure 3.** BBCW Project Deering Estate Flow-way component features.

This report satisfies Specific Condition 26 of the permit, which requires the District to submit an annual report to FDEP detailing the progress of the BBCW Project, and to incorporate the annual monitoring report into the South Florida Environmental Report. This document also serves as a comprehensive reference for water quality monitoring needed to evaluate the L-31E Culverts and Deering Estate Flow-way components' performance toward meeting the planned restoration goals, and to satisfy the water quality monitoring requirements of the CERPRA permit.

## L-31E CULVERTS

The L-31E Culverts component is located in Miami-Dade County between the C-102 and C-103 canals (Sections 4, 9, 28, 33, and Township 56 South Range 40 East and 57 South Range 40 East). The component's goal is to reestablish, at least in part, historical sheetflow and wetland hydroperiods downstream of the project area. This component may also provide the additional benefit of mitigating impacts of discharging fresh water via the existing canals. The component is expected to achieve its objectives by redirecting flow that was historically discharged through structures S-21A, S-20F, and S-20G. This flow is now discharged into the coastal wetlands east of the L-31E levee, along Biscayne Bay, via four flap-gated culverts: S-23A, S-23B, S-23C, and S-23D (**Figure 2**). Construction for the culverts began on January 11, 2010, and was completed on June 10, 2010. The baseline monitoring event was conducted in August 2010 and was followed by monthly monitoring events. SFWMD completed the first annual mitigation monitoring event in January 2012.

To evaluate the performance of the L-31E Culverts, Specific Condition 20 of the CERPRA permit requires monitoring of the following:

- Monthly collection of water quality samples for turbidity, ammonia, total suspended solids (TSS), color, total phosphorous (TP), nitrate + nitrite ($NO_x$), and physiochemical data for specific conductance, dissolved oxygen (DO), pH, temperature, and salinity (calculated) at monitoring stations MI01, BB53, PR01, and MW01
- Monthly water level using stage gauges upstream and downstream of water control structures S-21A, S-20G, and S-20F
- Monthly calculated flow through culverts S-23A, S-23B, S-23C, and S-23D
- Mercury and other toxicants monitoring according to Specific Condition 22 of the permit

Water quality samples for the L-31E Culverts were analyzed by Miami-Dade County's Department of Regulatory and Economic Resources laboratory, under contract with the District, utilizing quantitative analytical methods approved by the FDEP. The Miami-Dade lab is accredited under the National Environmental Laboratory Accreditation Program (NELAP).

## DEERING ESTATE FLOW-WAY

The Deering Estate Flow-way component is located in southeastern Miami-Dade County at 1580 Old Cutler Road, Palmetto Bay, Florida (**Figure 3**). This component included construction of a 500-foot extension of a spur canal off the C-100A canal, a 100 cubic feet per second (cfs) pump station with associated discharge piping, and an outlet spreader structure. Excluding the spreader structure, these components were constructed on a 9.7-acre tract referred to as the "Powers Addition Parcel", located west of, and adjacent to, the Deering Estate.

The Deering Estate Flow-way will redirect up to 100 cfs of water from the C-100A canal system, through the C-100A spur canal into the Cutler Drain on the component site, and within the Deering Estate Flow-way, thus restoring a portion of the historic freshwater flow through the flow-way and into Biscayne Bay (**Figure 3**). SFWMD completed construction of this component in April 2012, and water quality monitoring was initiated in May 2012. The project became operational in November 2012.

Miami-Dade County and the District are cooperating on this component with the following goals:

- Redirect up to 100 cfs of the existing point-source discharge from the S-123 structure by optimizing the capture and conveyance of fresh water from the C-100A spur canal to the coastal wetlands in the immediate vicinity of the Cutler Drain, east of Old Cutler Road
- Rehydration of the wetland region east of Old Cutler Road, and restoration of a more natural freshwater flow regime
- Establishment of an educational wetland on the Power's Addition Parcel

To evaluate performance of the Deering Estate Flow-way component, Specific Condition 20 of the CERPRA permit requires monitoring of the following:

- Biweekly collection (when pumps are operated) of water quality samples for turbidity, ammonia, TP, $NO_x$, total Kjeldahl nitrogen (TKN), and physiochemical data for specific conductance, DO, pH, and temperature at Deering Estate pump station S-700
- Daily water level using a stage recorder upstream of Deering Estate pump station S-700
- Daily calculated flow through pump station S-700
- Mercury and other toxicants monitoring according to Specific Condition 22 of the permit

## CUTLER WETLANDS FLOW-WAY

The proposed Cutler Wetlands Flow-way (**Figure 1**) will consist of a pump station on the C-1 canal, a lined conveyance canal, a spreader canal system, box culverts under roadways, and the plugging of mosquito control ditches. The pump station will deliver water to the spreader canal located in the saltwater wetlands via a lined conveyance canal. The proposed Cutler Wetlands Flow-way is currently under permit review with regulatory agencies. Funding for initiating District-expedited components of Cutler Flow-way is subject to District Governing Board approval.

## PERMIT HISTORY

The original CERPRA permit and all modifications issued to SFWMD are as follows:

- 0271729-001, issued September 10, 2007, with an expiration date of September 10, 2012, was the original permit for the L-31E Culverts.
- 0271729-002, issued May 23, 2008, with an expiration date of May 23, 2013, to include the Deering Estate Flow-Way component of BBCW.
- 0271729-005, issued June 8, 2012, with an expiration date of May 23, 2013, to modify the water quality monitoring plan for the Deering Estate Flow-Way.
- 0271729-006, issued April 18, 2013, with an expiration date of April 18, 2018, to renew the permit for five years.

# WATER QUALITY MONITORING SUMMARY

## L-31E CULVERTS

Monthly water quality samples collected at stations BB53, MI01, MW01, and PR01 (**Figure 4**) were collected and analyzed for Water Year 2013 (WY2013) (May 1, 2012–April 30, 2013) and compared to data collected and analyzed the previous two water years. Two types of water quality parameters were analyzed: (1) profile parameters measured along water depth at the surface, the middle, and the bottom, and (2) surface parameters measured close to the water surface at approximately 0.5 meter depth.

There are statistically significant changes for all surface water parameters. The most important change observed for profile parameters is the statistically significant decrease in salinity and specific conductivity at stations BB53, MW01, and PR01 during WY2013, especially when compared to WY2012. The differences are the result of climatological (e.g., rainfall) and operational effects, with the former providing the most prominent impacts. Most of the parameters decreased during WY2013. Color decreased at MW01. Dissolved ammonia decreased at MW01 and PR01. TSS decreased at the BB53 and MW01. Turbidity decreased at MI01 and PR01. TP values are already quite low (near the detection limits of the analytical methods), and have shown only minor variability. Although statistically significant differences were observed, due to their low concentrations (near the analytical method detection limit), the differences are considered environmentally insignificant. During WY2013, the only parameter that increased in concentration is $NO_x$, for which there was a statistically significant increase in concentration at MW01 and PR01.

Summary statistics for the two types of water quality parameters by station, and relative water depth, where applicable, for WY2013 are presented in **Tables 3** and **4**. These tables also include Class III criteria standards for marine or brackish waters corresponding to the listed parameters, as well as the number of excursions during WY2013.

There were no Class III criteria excursions at the four monitoring stations for any analyzed parameters, except DO. Measured DO values fell below the Class III threshold of 4 milligrams per liter (mg/L) for about 9 to 27 percent of the sampling events, depending on the stations and water depth. These excursion frequencies represent an improvement compared to the historical values. **Table 5** lists the total number of DO measurements, as well as total excursions, and frequency of excursions by station and water year for May 1, 1979 to April 30, 2013. There were no sampling events between May 1, 2003 and April 30, 2009.

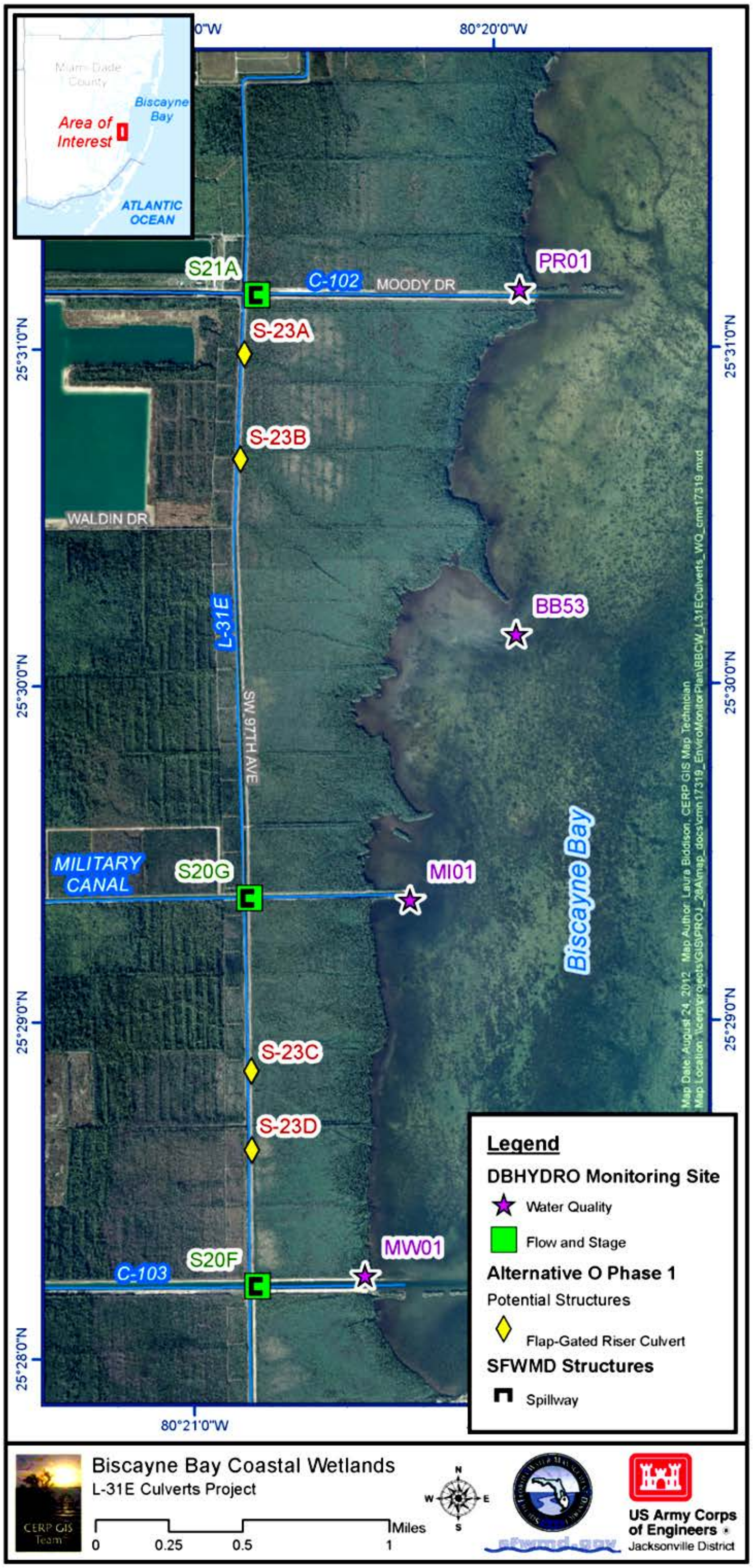


**Figure 4.** Location of L-31E culverts and related flow, stage, and water quality monitoring stations.

**Table 3.** Summary statistics of profile water quality parameters for WY2013 for the L-31 East (L-31E) Culverts.

| Parameter | Units[a] | Depth[b] | Class III Standard for Marine Waters | Period of Record | Number of Samples | Mean | Standard Deviation | Minimum | Q25[c] | Median | Q75[d] | Maximum | Number Below Detection Limit | Number of Excursions | Percent Excursions |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***STATION: BB53*** | | | | | | | | | | | | | | | |
| Dissolved Oxygen | mg/L | S | ≥ 4.0 mg/L | 5/9/2012–2/6/2013 | 9 | 7.8 | 1.6 | 5.88 | 6.5 | 7.1 | 9.2 | 10.69 | NA[e] | 0 | 0.00% |
| | | M | ≥ 4.0 mg/L | 5/9/2012–2/6/2013 | 7 | 7.6 | 1.7 | 5.84 | 6.1 | 7.1 | 9.2 | 10.08 | NA | 0 | 0.00% |
| | | B | ≥ 4.0 mg/L | 5/9/2012–2/6/2013 | 9 | 6.2 | 2.1 | 2.24 | 5.1 | 6.5 | 7.4 | 9.24 | NA | 1 | 11.11% |
| pH | | S | 6.5 ≤ pH ≤ 8.5 | 5/9/2012–2/6/2013 | 10 | 8.06 | 0.14 | 7.86 | 7.95 | 8.04 | 8.18 | 8.3 | NA | 0 | 0.00% |
| | | M | 6.5 ≤ pH ≤ 8.5 | 5/9/2012–2/6/2013 | 8 | 8.05 | 0.16 | 7.86 | 7.91 | 8.06 | 8.16 | 8.3 | NA | 0 | 0.00% |
| | | B | 6.5 ≤ pH ≤ 8.5 | 5/9/2012–2/6/2013 | 10 | 8 | 0.17 | 7.70 | 7.93 | 7.98 | 8.09 | 8.34 | NA | 0 | 0.00% |
| Salinity | PSU | S | None | 5/9/2012–2/6/2013 | 10 | 15.2 | 5.9 | 6.98 | 11.8 | 13.1 | 20.9 | 26.93 | NA | NA | NA |
| | | M | None | 5/9/2012–2/6/2013 | 8 | 18 | 6.5 | 11.41 | 11.7 | 17.6 | 23.7 | 26.79 | NA | NA | NA |
| | | B | None | 5/9/2012–2/6/2013 | 10 | 16.8 | 6.7 | 7.02 | 11.7 | 15 | 21.2 | 26.73 | NA | NA | NA |
| Specific Conductivity | µS/cm | S | None | 5/9/2012–2/6/2013 | 10 | 24,884 | 8,821 | 12,251 | 19,922 | 21,830 | 33,433 | 41,966 | NA | NA | NA |
| | | M | None | 5/9/2012–2/6/2013 | 8 | 29,081 | 9,578 | 19,331 | 19,791 | 28,517 | 37,464 | 41,774 | NA | NA | NA |
| | | B | None | 5/9/2012–2/6/2013 | 10 | 27,168 | 9,865 | 12,320 | 19,760 | 24,721 | 33,900 | 41,,693 | NA | NA | NA |
| Temperature | ºC | S | None | 5/9/2012–2/6/2013 | 10 | 26.8 | 2.9 | 21.92 | 24.8 | 27.6 | 29.1 | 30.59 | NA | NA | NA |
| | | M | None | 5/9/2012–2/6/2013 | 8 | 26.5 | 3.2 | 21.93 | 23.9 | 26.9 | 29.2 | 30.59 | NA | NA | NA |
| | | B | None | 5/9/2012–2/6/2013 | 10 | 26.7 | 2.9 | 21.93 | 24.6 | 27.6 | 29.2 | 30.59 | NA | NA | NA |

a. Key to units: mg/L – milligrams per liter; PSU – practical salinity units; µS/cm – microsiemens per centimeter; ºC – degrees Celsius.
b. Key to depth descriptions: S – surface; M – middle; B - bottom.
c. Q25 – 25$^{th}$ percentile.
d. Q75 – 75$^{th}$ percentile.
e. NA – not applicable.

**Table 3.** Continued.

| Parameter | Units[a] | Depth[b] | Class III Standard for Marine Waters | Period of Record | Number of Samples | Mean | Standard Deviation | Minimum | Q25[c] | Median | Q75[d] | Maximum | Number Below Detection Limit | Number of Excursions | Percent Excursions |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***STATION: MI01*** | | | | | | | | | | | | | | | |
| Dissolved Oxygen | mg/L | S | ≥ 4.0 mg/L | 5/9/2012–2/6/2013 | 11 | 6 | 1.7 | 3.3 | 4.3 | 6 | 7.2 | 8.49 | NA[e] | 3 | 27.27% |
| | | M | ≥ 4.0 mg/L | 5/9/2012–4/3/2013 | 11 | 6 | 1.4 | 3.97 | 5 | 5.7 | 7 | 8.61 | NA | 1 | 9.09% |
| | | B | ≥ 4.0 mg/L | 5/9/2012–4/3/2013 | 11 | 5.7 | 2.1 | 1.24 | 4.8 | 5.4 | 6.8 | 9.54 | NA | 1 | 9.09% |
| pH | | S | 6.5 ≤ pH ≤ 8.5 | 5/9/2012–4/3/2013 | 12 | 7.73 | 0.2 | 7.47 | 7.59 | 7.68 | 7.86 | 8.08 | NA | 0 | 0.00% |
| | | M | 6.5 ≤ pH ≤ 8.5 | 5/9/2012–4/3/2013 | 12 | 7.82 | 0.21 | 7.55 | 7.7 | 7.75 | 7.96 | 8.31 | NA | 0 | 0.00% |
| | | B | 6.5 ≤ pH ≤ 8.5 | 5/9/2012–4/3/2013 | 12 | 7.8 | 0.32 | 7.27 | 7.59 | 7.84 | 7.99 | 8.33 | NA | 0 | 0.00% |
| Salinity | PSU | S | NONE | 5/9/2012–4/3/2013 | 12 | 12.1 | 11.8 | 0.4 | 1.5 | 7.5 | 24.5 | 28.18 | NA | NA | NA |
| | | M | NONE | 5/9/2012–4/3/2013 | 12 | 13.1 | 11.6 | 0.43 | 2.4 | 10.3 | 25.7 | 28.16 | NA | NA | NA |
| | | B | NONE | 5/9/2012–4/3/2013 | 12 | 18.4 | 8.9 | 0.47 | 14 | 18.6 | 27.1 | 28.85 | NA | NA | NA |
| Specific Conductivity | µS/cm | S | NONE | 5/9/2012–4/3/2013 | 12 | 19,304 | 18,217 | 811 | 2,875 | 12,754 | 38,597 | 43,640 | NA | NA | NA |
| | | M | NONE | 5/9/2012–4/3/2013 | 12 | 20,897 | 17,782 | 885 | 4,455 | 17,296 | 40,191 | 43,618 | NA | NA | NA |
| | | B | NONE | 5/9/2012–4/3/2013 | 12 | 29,412 | 13,428 | 954 | 23,204 | 30,405 | 42,265 | 44,557 | NA | NA | NA |
| Temperature | ºC | S | NONE | 5/9/2012–4/3/2013 | 12 | 26 | 3 | 21.08 | 24.1 | 25.4 | 29 | 29.92 | NA | NA | NA |
| | | M | NONE | 5/9/2012–4/3/2013 | 12 | 25.9 | 3 | 20.98 | 23.9 | 25.6 | 28.8 | 29.86 | NA | NA | NA |
| | | B | NONE | 5/9/2012–4/3/2013 | 12 | 26.1 | 3.3 | 19.74 | 23.8 | 26.3 | 29 | 29.92 | NA | NA | NA |

a. Key to units: mg/L – milligrams per liter; PSU – practical salinity units; µS/cm – microsiemens per centimeter; ºC – degrees Celsius.
b. Key to depth descriptions: S – surface; M – middle; B - bottom.
c. Q25 – 25th percentile.
d. Q75 – 75th percentile.
e. NA – not applicable.

**Table 3.** Continued.

| Parameter | Units[a] | Depth[b] | Class III Standard for Marine Waters | Period of Record | Number of Samples | Mean | Standard Deviation | Minimum | Q25[c] | Median | Q75[d] | Maximum | Number Below Detection Limit | Number of Excursions | Percent Excursions |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***STATION: MW01*** | | | | | | | | | | | | | | | |
| Dissolved Oxygen | mg/L | S | ≥ 4.0 mg/L | 5/9/2012–4/3/2013 | 11 | 6.1 | 1.6 | 3.98 | 4.8 | 5.5 | 7 | 8.96 | NA[e] | 1 | 9.09% |
| | | M | ≥ 4.0 mg/L | 5/9/2012–4/3/2013 | 11 | 6.1 | 1.7 | 3.7 | 4.7 | 5.7 | 6.9 | 9.13 | NA | 1 | 9.09% |
| | | B | ≥ 4.0 mg/L | 5/9/2012–4/3/2013 | 11 | 5.6 | 2 | 2.15 | 4.3 | 5.3 | 6.6 | 9.18 | NA | 1 | 9.09% |
| pH | | S | 6.5 ≤ pH ≤ 8.5 | 5/9/2012–4/3/2013 | 12 | 7.73 | 0.25 | 7.43 | 7.52 | 7.71 | 7.86 | 8.22 | NA | 0 | 0.00% |
| | | M | 6.5 ≤ pH ≤ 8.5 | 5/9/2012–4/3/2013 | 12 | 7.83 | 0.26 | 7.46 | 7.65 | 7.79 | 7.95 | 8.35 | NA | 0 | 0.00% |
| | | B | 6.5 ≤ pH ≤ 8.5 | 5/9/2012–4/3/2013 | 12 | 7.94 | 0.24 | 7.58 | 7.8 | 7.92 | 8.07 | 8.36 | NA | 0 | 0.00% |
| Salinity | PSU | S | NONE | 5/9/2012–4/3/2013 | 12 | 10.3 | 6.1 | 1.84 | 6.7 | 9.5 | 14.3 | 24.08 | NA | NA | NA |
| | | M | NONE | 5/9/2012–4/3/2013 | 12 | 13.4 | 8.4 | 1.91 | 7.3 | 14.1 | 18 | 30.67 | NA | NA | NA |
| | | B | NONE | 5/9/2012–4/3/2013 | 12 | 23.2 | 6.2 | 14.04 | 18.7 | 21.9 | 29.2 | 32.18 | NA | NA | NA |
| Specific Conductivity | µS/cm | S | NONE | 5/9/2012–4/3/2013 | 12 | 17,278 | 9,396 | 3,520 | 11,812 | 16,188 | 23,589 | 37,871 | NA | NA | NA |
| | | M | NONE | 5/9/2012–4/3/2013 | 12 | 21,952 | 12,774 | 3,638 | 12,777 | 23,290 | 29,090 | 47,079 | NA | NA | NA |
| | | B | NONE | 5/9/2012–4/3/2013 | 12 | 36,518 | 8,771 | 23,319 | 30,187 | 34,984 | 45,033 | 49,151 | NA | NA | NA |
| Temperature | ºC | S | NONE | 5/9/2012–4/3/2013 | 12 | 26 | 2.7 | 21.19 | 24 | 26.3 | 28.1 | 30.15 | NA | NA | NA |
| | | M | NONE | 5/9/2012–4/3/2013 | 12 | 26 | 2.8 | 21.01 | 24 | 26.1 | 28.1 | 30.15 | NA | NA | NA |
| | | B | NONE | 5/9/2012–4/3/2013 | 12 | 26.2 | 3.3 | 20.48 | 23.6 | 26.6 | 29 | 30.32 | NA | NA | NA |

a. Key to units: mg/L – milligrams per liter; PSU – practical salinity units; µS/cm – microsiemens per centimeter; ºC – degrees Celsius.
b. Key to depth descriptions: S – surface; M – middle; B - bottom.
c. Q25 – 25th percentile.
d. Q75 – 75th percentile.
e. NA – not applicable.

**Table 3.** Continued.

| Parameter | Units[a] | Depth[b] | Class III Standard for Marine Waters | Period of Record | Number of Samples | Mean | Standard Deviation | Minimum | Q25[c] | Median | Q75[d] | Maximum | Number Below Detection Limit | Number of Excursions | Percent Excursions |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***STATION: PR01*** | | | | | | | | | | | | | | | |
| Dissolved Oxygen | mg/L | S | ≥ 4.0 mg/L | 5/9/2012–4/3/2013 | 11 | 5.6 | 1.4 | 3.39 | 4.7 | 5.4 | 6.2 | 8.35 | NA[e] | 2 | 18.18% |
| | | M | ≥ 4.0 mg/L | 5/9/2012–4/3/2013 | 11 | 5.6 | 1.4 | 3.42 | 4.8 | 5.5 | 6.1 | 8.56 | NA | 1 | 9.09% |
| | | B | ≥ 4.0 mg/L | 5/9/2012–4/3/2013 | 11 | 6 | 1.8 | 3.5 | 4.7 | 6.1 | 6.8 | 9.9 | NA | 2 | 18.18% |
| pH | | S | 6.5 ≤ pH ≤ 8.5 | 5/9/2012–4/3/2013 | 12 | 7.58 | 0.21 | 7.43 | 7.46 | 7.49 | 7.61 | 8.06 | NA | 0 | 0.00% |
| | | M | 6.5 ≤ pH ≤ 8.5 | 5/9/2012–4/3/2013 | 12 | 7.68 | 0.18 | 7.53 | 7.55 | 7.62 | 7.71 | 8.08 | NA | 0 | 0.00% |
| | | B | 6.5 ≤ pH ≤ 8.5 | 5/9/2012–4/3/2013 | 12 | 7.88 | 0.25 | 7.48 | 7.65 | 7.88 | 8.04 | 8.36 | NA | 0 | 0.00% |
| Salinity | PSU | S | NONE | 5/9/2012–4/3/2013 | 12 | 5.3 | 7 | 0.37 | 0.6 | 2.7 | 6.8 | 24.34 | NA | NA | NA |
| | | M | NONE | 5/9/2012–4/3/2013 | 12 | 7 | 9.1 | 0.41 | 0.6 | 3.1 | 10.2 | 24.71 | NA | NA | NA |
| | | B | NONE | 5/9/2012–4/3/2013 | 12 | 15.2 | 9.4 | 0.73 | 8.2 | 15.2 | 25 | 26.31 | NA | NA | NA |
| Specific Conductivity | µS/cm | S | NONE | 5/9/2012–4/3/2013 | 12 | 8,906 | 11,043 | 767 | 1,127 | 5,039 | 11,879 | 38,239 | NA | NA | NA |
| | | M | NONE | 5/9/2012–4/3/2013 | 12 | 11,514 | 14,277 | 840 | 1,110 | 5,718 | 17,219 | 38,791 | NA | NA | NA |
| | | B | NONE | 5/9/2012–4/3/2013 | 12 | 24,522 | 14,306 | 1,461 | 14,223 | 24,983 | 39,299 | 41,053 | NA | NA | NA |
| Temperature | ºC | S | NONE | 5/9/2012–4/3/2013 | 12 | 25.6 | 2.1 | 20.83 | 24.7 | 26.1 | 27.1 | 28.03 | NA | NA | NA |
| | | M | NONE | 5/9/2012–4/3/2013 | 12 | 25.5 | 2.2 | 20.74 | 24.7 | 25.8 | 27 | 27.98 | NA | NA | NA |
| | | B | NONE | 5/9/2012–4/3/2013 | 12 | 25.9 | 2.9 | 20.71 | 23.7 | 26 | 28.7 | 29.16 | NA | NA | NA |

a. Key to units: mg/L – milligrams per liter; PSU – practical salinity units; µS/cm – microsiemens per centimeter; ºC – degrees Celsius.
b. Key to depth descriptions: S – surface; M – middle; B - bottom.
c. Q25 – 25$^{th}$ percentile.
d. Q75 – 75$^{th}$ percentile.
e. NA – not applicable.

**Table 4.** Summary statistics of surface water quality parameters for WY2013 for the L-31E Culverts.

| Parameter | Units[a] | Lab Method | Class III Standard for Marine Waters | Period of Record | Number of Samples | Mean | Standard Deviation | Minimum | Q25[b] | Median | Q75[c] | Maximum | Number Below Detection Limit | Number of Excursions | Percent Excursions |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | ***STATION: BB53*** | | | | | | | | |
| Color | PCU | EPA 110.2 | NONE | 5/9/2012–2/6/2013 | 10 | 21 | 5 | 12 | 18 | 21 | 25 | 25 | 0 | NA[d] | NA |
| Dissolved Ammonia | mg/L | EPA 350.1 | NONE | 5/9/2012–2/6/2013 | 9 | 0.07 | 0.04 | 0.02 | 0.06 | 0.07 | 0.09 | 0.14 | 0 | NA | NA |
| Nitrate + Nitrite | mg/L | EPA 353.2 | NONE | 5/9/2012–2/6/2013 | 9 | 0.49 | 0.444 | 0.1 | 0.13 | 0.25 | 0.82 | 1.23 | 0 | NA | NA |
| Total Phosphorous | mg/L | EPA 365.1 | NONE | 5/9/2012–2/6/2013 | 10 | 0.005 | 0.0005 | 0.004 | 0.004 | 0.005 | 0.01 | 0.01 | 0 | NA | NA |
| Total Suspended Solids | mg/L | EPA 160.2 | NONE | 5/9/2012–2/6/2013 | 10 | 37.1 | 14.4 | 15 | 28 | 35.5 | 42 | 60 | 0 | NA | NA |
| Turbidity | NTU | EPA 180.1 | ≤ 29 NTU | 5/9/2012–2/6/2013 | 10 | 0.8 | 0.3 | 0.6 | 0.7 | 0.8 | 0.9 | 1.5 | 0 | 0 | 0.00% |
| | | | | | | | ***STATION: MI01*** | | | | | | | | |
| Color | PCU | EPA 110.2 | NONE | 5/9/2012–4/3/2013 | 11 | 21 | 4 | 15 | 20 | 22 | 24 | 30 | 0 | NA | NA |
| Dissolved Ammonia | mg/L | EPA 350.1 | NONE | 5/9/2012–4/3/2013 | 12 | 0.1 | 0.05 | 0.06 | 0.07 | 0.09 | 0.1 | 0.24 | 0 | NA | NA |
| Nitrate + Nitrite | mg/L | EPA 353.2 | NONE | 5/9/2012–4/3/2013 | 12 | 0.483 | 0.352 | 0.03 | 0.115 | 0.635 | 0.77 | 0.94 | 0 | NA | NA |
| Total Phosphorous | mg/L | EPA 365.1 | NONE | 5/9/2012–4/3/2013 | 12 | 0.008 | 0.002 | 0.005 | 0.006 | 0.007 | 0.01 | 0.01 | 0 | NA | NA |
| Total Suspended Solids | mg/L | EPA 160.2 | NONE | 5/9/2012–4/3/2013 | 12 | 31.6 | 23.2 | 6 | 9.5 | 27 | 56.5 | 61 | 0 | NA | NA |
| Turbidity | NTU | EPA 180.1 | ≤ 29 NTU | 5/9/2012–4/3/2013 | 12 | 0.6 | 0.2 | 0.4 | 0.5 | 0.6 | 0.8 | 0.9 | 0 | 0 | 0.00% |

a. Key to units: PCU – photo conductor units; mg/L – milligrams per liter; NTU – nephelometric turbidity units.
b. Q25 – 25th percentile.
c. Q75 – 75th percentile.
d. NA – not applicable.

**Table 4.** Continued.

| Parameter | Units[a] | Lab Method | Class III Standard for Marine Waters | Period of Record | Number of Samples | Mean | Standard Deviation | Minimum | Q25[b] | Median | Q75[c] | Maximum | Number Below Detection Limit | Number of Excursions | Percent Excursions |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| ***STATION: MW01*** | | | | | | | | | | | | | | | |
| Color | PCU | EPA 110.2 | NONE | 5/9/2012–4/3/2013 | 12 | 17 | 4 | 10 | 14 | 18 | 19 | 25 | 0 | NA[d] | NA |
| Dissolved Ammonia | mg/L | EPA 350.1 | NONE | 5/9/2012–4/3/2013 | 12 | 0.06 | 0.02 | 0.02 | 0.04 | 0.06 | 0.07 | 0.09 | 0 | NA | NA |
| Nitrate + Nitrite | mg/L | EPA 353.2 | NONE | 5/9/2012–4/3/2013 | 12 | 0.664 | 0.243 | 0.32 | 0.475 | 0.645 | 0.8 | 1.12 | 0 | NA | NA |
| Total Phosphorous | mg/L | EPA 365.1 | NONE | 5/9/2012–4/3/2013 | 9 | 0.006 | 0.001 | 0.005 | 0.005 | 0.006 | 0.01 | 0.01 | 0 | NA | NA |
| Total Suspended Solids | mg/L | EPA 160.2 | NONE | 5/9/2012–4/3/2013 | 12 | 28.1 | 12.9 | 6 | 20.5 | 28 | 38.5 | 47 | 1 | NA | NA |
| Turbidity | NTU | EPA 180.1 | ≤ 29 NTU | 5/9/2012–4/3/2013 | 12 | 0.6 | 0.1 | 0.4 | 0.5 | 0.6 | 0.6 | 0.8 | 0 | 0 | 0.00% |
| ***STATION: PR01*** | | | | | | | | | | | | | | | |
| Color | PCU | EPA 110.2 | NONE | 5/9/2012–4/3/2013 | 12 | 14 | 4 | 10 | 10 | 13 | 19 | 20 | 0 | NA | NA |
| Dissolved Ammonia | mg/L | EPA 350.1 | NONE | 5/9/2012–4/3/2013 | 12 | 0.09 | 0.04 | 0.03 | 0.07 | 0.08 | 0.11 | 0.18 | 0 | NA | NA |
| Nitrate + Nitrite | mg/L | EPA 353.2 | NONE | 5/9/2012–4/3/2013 | 12 | 2.684 | 1.342 | 0.08 | 2.125 | 3.075 | 3.61 | 4.12 | 0 | NA | NA |
| Total Phosphorous | mg/L | EPA 365.1 | NONE | 5/9/2012–4/3/2013 | 11 | 0.007 | 0.002 | 0.004 | 0.005 | 0.006 | 0.01 | 0.01 | 0 | NA | NA |
| Total Suspended Solids | mg/L | EPA 160.2 | NONE | 5/9/2012–4/3/2013 | 12 | 17.3 | 20.6 | 6 | 6 | 9 | 13.5 | 67 | 5 | NA | NA |
| Turbidity | NTU | EPA 180.1 | ≤ 29 NTU | 5/9/2012–4/3/2013 | 12 | 0.8 | 0.3 | 0.4 | 0.6 | 1 | 1 | 1.1 | 0 | 0 | 0.00% |

a. Key to units: mg/L – milligrams per liter; PSU – practical salinity units; µS/cm – microsiemens per centimeter; ºC – degrees Celsius.
b. Key to depth descriptions: S – surface; M – middle; B - bottom.
c. Q25 – 25th percentile.
d. Q75 – 75th percentile.
e. NA – not applicable.

**Table 5.** Number of DO measurements and excursions, and annual average salinity by water year for the L-31E Culverts.

| Water Year | Number of Valid DO Measurements | | | | Number of DO Values Less Than 4 mg/L | | | | Percent of DO Values Greater Than 4 mg/L | | | | Annual Average Salinity | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | BB53 | MI01 | MW01 | PR01 | BB53 | MI01 | MW01 | PR01 | BB53 | MI01 | MW01 | PR01 | BB53 | MI01 | MW01 | PR01 |
| 1980 | | | 6 | | | | 1 | | | | 16.7% | | | | 25.2 | |
| 1981 | | | 8 | | | | 4 | | | | 50.0% | | | | 25.0 | |
| 1982 | | | 7 | | | | 1 | | | | 14.3% | | | | 29.9 | |
| 1983 | | | 7 | | | | 0 | | | | 0.0% | | | | 16.2 | |
| 1984 | | | 5 | | | | 1 | | | | 20.0% | | | | 21.9 | |
| 1985 | | | 6 | | | | 2 | | | | 33.3% | | | | 28.6 | |
| 1986 | | | 8 | | | | 2 | | | | 25.0% | | | | 22.7 | |
| 1987 | | | 8 | | | | 2 | | | | 25.0% | | | | 26.8 | |
| 1988 | | | 18 | | | | 3 | | | | 16.7% | | | | 30.3 | |
| 1989 | | | 29 | | | | 0 | | | | 0.0% | | | | 20.0 | |
| 1990 | | | 27 | | | | 3 | | | | 11.1% | | | | 30.3 | |
| 1991 | | | 21 | 27 | | | 1 | 3 | | | 4.8% | 11.1% | | | 26.1 | 20.2 |
| 1992 | | | 27 | 24 | | | 2 | 4 | | | 7.4% | 16.7% | | | 22.4 | 14.1 |
| 1993 | | | 35 | 36 | | | 6 | 9 | | | 17.1% | 25.0% | | | 18.0 | 14.3 |
| 1994 | | | 36 | 33 | | | 4 | 3 | | | 11.1% | 9.1% | | | 20.0 | 12.5 |
| 1995 | | | 36 | 34 | | | 9 | 8 | | | 25.0% | 23.5% | | | 18.6 | 10.2 |
| 1996 | | | 34 | 32 | | | 7 | 4 | | | 20.6% | 12.5% | | | 16.6 | 10.8 |
| 1997 | | | 21 | 22 | | | 2 | 4 | | | 9.5% | 18.2% | | | 16.0 | 12.3 |
| 1998 | | | 5 | 5 | | | 0 | 1 | | | 0.0% | 20.0% | | | 19.2 | 10.9 |
| 1999 | | | 14 | 15 | | | 3 | 9 | | | 21.4% | 60.0% | | | 29.1 | 25.1 |
| 2000 | 2 | 3 | 29 | 29 | | 1 | 6 | 4 | 0.0% | 33.3% | 20.7% | 13.8% | 25.9 | 27.6 | 17.8 | 12.1 |
| 2001 | 24 | 36 | 36 | 33 | | 17 | 6 | 7 | 0.0% | 47.2% | 16.7% | 21.2% | 23.8 | 22.5 | 22.6 | 17.2 |
| 2002 | 17 | 27 | 27 | 25 | | 6 | 6 | 5 | 0.0% | 22.2% | 22.2% | 20.0% | 22.4 | 17.1 | 20.3 | 12.7 |
| 2003 | 15 | 24 | 24 | 24 | | 15 | 8 | 12 | 0.0% | 62.5% | 33.3% | 50.0% | 23.5 | 20.7 | 23.8 | 16.8 |
| 2010 | 21 | 21 | 21 | 21 | | 6 | 4 | 3 | 0.0% | 28.6% | 19.0% | 14.3% | 20.8 | 20.2 | 18.3 | 12.0 |
| 2011 | 31 | 36 | 36 | 33 | | 5 | 7 | 5 | 0.0% | 13.9% | 19.4% | 15.2% | 21.2 | 16.1 | 20.8 | 14.8 |
| 2012 | 33 | 36 | 36 | 36 | 3 | 7 | 9 | 5 | 9.1% | 19.4% | 25.0% | 13.9% | 23.7 | 21.3 | 24.5 | 19.1 |
| 2013 | 25 | 30 | 30 | 30 | 1 | 4 | 3 | 5 | 4.0% | 13.3% | 10.0% | 16.7% | 16.6 | 13.4 | 15.0 | 8.6 |

The graph in **Figure 5** represents the percentage of DO values smaller than 4 mg/L by water year for May 1, 1979 to April 30, 2013. The historical percentage of DO values smaller than 4 mg/L is quite high due to high water temperatures and high salinity in the area. Note that beginning in 2010, when fresh water started being added into the system, the frequency of measurements with DO less than 4 mg/L decreased at stations MI01, MW01, and PR01. At station BB53, there were no measured DO values smaller than 4 mg/L before May 1, 2011. During the last two water years, WY2012 and WY2013, there was a low frequency (under 10 percent) of such occurrences. Nevertheless, the system spanned by all four monitoring stations seems to have a lower incidence of DO values less than 4 mg/L after WY2010. It seems that the fresh water input into the system has lowered the average salinity, which, in return, has increased DO values.

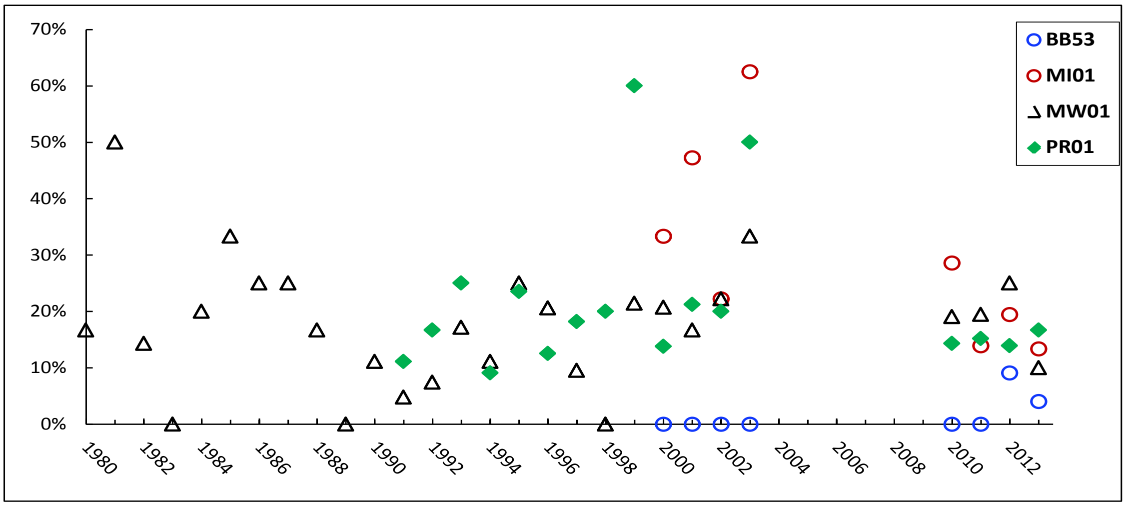


**Figure 5.** Percentage of DO values less than 4 mg/L at stations BB53, MI01, MW01, and PR01.

The second part of the analysis focuses on comparing water quality data measured during WY2013 and the corresponding data measured during WY2011 and WY2012. Comparison between water years has been done by comparing central tendencies for each parameter by site and water depth, where applicable. The student t-test was used to assess the statistical significance of differences between arithmetic means, and the Mann Whitney U test was used to assess the statistical significance of differences between medians. The non-parametric Mann Whitney U test was added to the analysis due to its proficiency in comparing non-normally distributed data sets. Comparison between arithmetic means based on Student t-test are appropriate only for normally distributed data sets, while comparison between medians based on the Mann Whitney U test does not require normality of the underlining distributions. The statistical significance $\alpha$ was chosen to be 0.05 for both tests. Hence, a probability value smaller than, or equal to, 0.05 signals a statistically significant difference between the compared entities. For ease of readability, such p-values have been listed in **bold underlined** characters in the tables below. Both tests provide similar conclusions, therefore, checking the normality of the underlining distributions was not relevant. Results of the comparison between WY2013 and the previous two water years are presented in **Table 6** for profile parameters, and **Table 7** for surface parameters. These tables list the number of samples, arithmetic means, and medians of the compared data sets, as well as the corresponding p-values generated by the student t-test (for arithmetic mean comparisons) and Mann Whitney U test (for median comparisons).

**Table 6.** Comparison of profile water quality parameters by station for WY2011, WY2012, and WY2013 for the L-31E Culverts. [Note: a probability value smaller than, or equal to, 0.05 indicates a statistically significant difference between the compared entities. For ease of readability, such p-values are shown in **bold, underlined** type.]

| Profile Parameter | Relative Depth | Period | N | | | | Arithmetic Mean | | | | Median | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | BB53 | MI01 | MW01 | PR01 | BB53 | MI01 | MW01 | PR01 | BB53 | MI01 | MW01 | PR01 |
| Dissolved Oxygen | Surface | WY2011 | 11 | 11 | 11 | 11 | 7.7 | 5.7 | 5.9 | 5.4 | 7.3 | 5.8 | 5.7 | 5.4 |
| | | WY2012 | 12 | 12 | 12 | 12 | 6.8 | 5.8 | 5.3 | 4.9 | 7.9 | 6.0 | 5.7 | 5.0 |
| | | WY2013 | 9 | 11 | 11 | 11 | 7.8 | 6.0 | 6.1 | 5.6 | 7.1 | 6.0 | 5.5 | 5.4 |
| | | p-value for comparison WY2013 to WY2011 | | | | | 0.824 | 0.635 | 0.707 | 0.810 | 0.820 | 0.533 | 0.669 | 0.922 |
| | | p-value for comparison WY2013 to WY2012 | | | | | 0.241 | 0.783 | 0.340 | 0.315 | 0.434 | 0.829 | 0.424 | 0.310 |
| | Middle | WY2011 | 8 | 11 | 11 | 11 | 8.1 | 5.5 | 5.5 | 5.4 | 7.7 | 5.6 | 5.2 | 5.0 |
| | | WY2012 | 9 | 12 | 12 | 12 | 6.5 | 5.5 | 5.1 | 5.0 | 7.6 | 6.2 | 5.5 | 5.2 |
| | | WY2013 | 7 | 11 | 11 | 11 | 7.6 | 6.0 | 6.1 | 5.6 | 7.1 | 5.7 | 5.7 | 5.5 |
| | | p-value for comparison WY2013 to WY2011 | | | | | 0.527 | 0.438 | 0.397 | 0.694 | 0.418 | 0.450 | 0.491 | 0.694 |
| | | p-value for comparison WY2013 to WY2012 | | | | | 0.328 | 0.537 | 0.271 | 0.308 | 0.491 | 0.853 | 0.498 | 0.295 |
| | Bottom | WY2011 | 10 | 11 | 11 | 11 | 7.4 | 5.8 | 5.1 | 5.3 | 7.1 | 6.2 | 5.6 | 4.7 |
| | | WY2012 | 12 | 12 | 12 | 12 | 6.4 | 4.9 | 5.2 | 5.3 | 6.5 | 4.8 | 5.3 | 5.8 |
| | | WY2013 | 9 | 11 | 11 | 11 | 6.2 | 5.7 | 5.6 | 6.0 | 6.5 | 5.4 | 5.3 | 6.1 |
| | | p-value for comparison WY2013 to WY2011 | | | | | 0.210 | 0.920 | 0.600 | 0.350 | 0.253 | 0.974 | 0.768 | 0.430 |
| | | p-value for comparison WY2013 to WY2012 | | | | | 0.898 | 0.310 | 0.644 | 0.362 | 0.887 | 0.295 | 1.000 | 0.389 |
| pH | Surface | WY2011 | 11 | 11 | 11 | 11 | 8.08 | 7.72 | 7.79 | 7.56 | 8.06 | 7.74 | 7.83 | 7.55 |
| | | WY2012 | 12 | 12 | 12 | 12 | 8.11 | 7.96 | 8.00 | 7.72 | 8.13 | 8.01 | 8.00 | 7.70 |
| | | WY2013 | 10 | 12 | 12 | 12 | 8.06 | 7.73 | 7.73 | 7.58 | 8.04 | 7.68 | 7.71 | 7.49 |
| | | p-value for comparison WY2013 to WY2011 | | | | | 0.728 | 0.896 | 0.606 | 0.816 | 0.647 | 0.902 | 0.441 | 0.689 |
| | | p-value for comparison WY2013 to WY2012 | | | | | 0.569 | **0.030** | 0.051 | 0.226 | 0.598 | 0.060 | **0.046** | 0.093 |
| | Middle | WY2011 | 8 | 11 | 11 | 11 | 8.09 | 7.74 | 7.85 | 7.69 | 8.05 | 7.76 | 7.95 | 7.63 |
| | | WY2012 | 9 | 12 | 12 | 12 | 8.04 | 8.00 | 8.04 | 7.83 | 8.11 | 8.08 | 8.02 | 7.89 |
| | | WY2013 | 8 | 12 | 12 | 12 | 8.05 | 7.82 | 7.83 | 7.68 | 8.06 | 7.75 | 7.79 | 7.62 |
| | | p-value for comparison WY2013 to WY2011 | | | | | 0.630 | 0.408 | 0.801 | 0.886 | 0.674 | 0.735 | 0.559 | 0.497 |
| | | p-value for comparison WY2013 to WY2012 | | | | | 0.894 | 0.095 | 0.117 | 0.186 | 0.923 | 0.141 | 0.094 | 0.069 |
| | Bottom | WY2011 | 10 | 11 | 11 | 11 | 8.06 | 7.86 | 7.83 | 7.89 | 8.05 | 7.80 | 7.91 | 7.92 |
| | | WY2012 | 12 | 12 | 12 | 12 | 8.06 | 7.89 | 8.08 | 7.97 | 8.05 | 7.88 | 8.10 | 7.94 |
| | | WY2013 | 10 | 12 | 12 | 12 | 8.00 | 7.80 | 7.94 | 7.88 | 7.98 | 7.84 | 7.92 | 7.88 |
| | | p-value for comparison WY2013 to WY2011 | | | | | 0.420 | 0.661 | 0.294 | 0.884 | 0.520 | 0.758 | 0.579 | 0.829 |
| | | p-value for comparison WY2013 to WY2012 | | | | | 0.524 | 0.576 | 0.190 | 0.340 | 0.575 | 0.623 | 0.260 | 0.326 |

**Table 6.** Continued.

| Profile Parameter | Relative Depth | Period | N | | | | Arithmetic Mean | | | | Median | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | BB53 | MI01 | MW01 | PR01 | BB53 | MI01 | MW01 | PR01 | BB53 | MI01 | MW01 | PR01 |
| Salinity | Surface | WY2011 | 11 | 11 | 11 | 11 | 20.6 | 13.7 | 17.1 | 10.5 | 23.0 | 14.7 | 17.3 | 7.1 |
| | | WY2012 | 12 | 12 | 12 | 12 | 23.6 | 17.8 | 22.6 | 15.6 | 21.5 | 12.5 | 21.9 | 9.8 |
| | | WY2013 | 10 | 12 | 12 | 12 | 15.2 | 12.1 | 10.3 | 5.3 | 13.1 | 7.5 | 9.5 | 2.7 |
| | | p-value for comparison WY2013 to WY2011 | | | | | 0.127 | 0.709 | 0.099 | 0.141 | 0.105 | 0.580 | 0.110 | 0.131 |
| | | p-value for comparison WY2013 to WY2012 | | | | | **0.014** | 0.262 | **0.007** | **0.028** | **0.010** | 0.184 | **0.024** | **0.009** |
| | Middle | WY2011 | 8 | 11 | 11 | 11 | 20.3 | 15.4 | 19.6 | 14.0 | 21.8 | 15.8 | 24.4 | 14.6 |
| | | WY2012 | 9 | 12 | 12 | 12 | 22.7 | 20.2 | 23.4 | 17.4 | 20.4 | 18.1 | 22.8 | 16.9 |
| | | WY2013 | 8 | 12 | 12 | 12 | 18.0 | 13.1 | 13.4 | 7.0 | 17.6 | 10.3 | 14.1 | 3.1 |
| | | p-value for comparison WY2013 to WY2011 | | | | | 0.611 | 0.584 | 0.170 | 0.096 | 0.600 | 0.498 | 0.218 | 0.140 |
| | | p-value for comparison WY2013 to WY2012 | | | | | 0.236 | 0.146 | **0.029** | **0.032** | 0.211 | 0.248 | **0.043** | **0.021** |
| | Bottom | WY2011 | 10 | 11 | 11 | 11 | 20.5 | 21.0 | 23.2 | 20.0 | 21.5 | 22.4 | 27.7 | 21.3 |
| | | WY2012 | 12 | 12 | 12 | 12 | 24.4 | 26.0 | 27.5 | 24.3 | 21.5 | 23.3 | 25.2 | 22.6 |
| | | WY2013 | 10 | 12 | 12 | 12 | 16.8 | 18.4 | 23.2 | 15.2 | 15.0 | 18.6 | 21.9 | 15.2 |
| | | p-value for comparison WY2013 to WY2011 | | | | | 0.327 | 0.454 | 0.993 | 0.238 | 0.326 | 0.667 | 0.712 | 0.310 |
| | | p-value for comparison WY2013 to WY2012 | | | | | **0.041** | 0.051 | 0.174 | **0.013** | **0.041** | 0.065 | 0.184 | **0.038** |
| Specific Conductivity | Surface | WY2011 | 10 | 10 | 10 | 10 | 31,362 | 21,062 | 25,587 | 17,733 | 32,512 | 21,814 | 26,480 | 14,377 |
| | | WY2012 | 12 | 12 | 12 | 12 | 37,118 | 28,209 | 35,305 | 24,809 | 34,240 | 20,943 | 34,826 | 16,739 |
| | | WY2013 | 10 | 12 | 12 | 12 | 24,884 | 19,304 | 17,278 | 8,906 | 21,830 | 12,754 | 16,188 | 5,039 |
| | | p-value for comparison WY2013 to WY2011 | | | | | 0.217 | 0.802 | 0.173 | 0.129 | 0.174 | 0.644 | 0.187 | 0.147 |
| | | p-value for comparison WY2013 to WY2012 | | | | | **0.013** | 0.244 | **0.007** | **0.022** | **0.010** | 0.184 | **0.024** | **0.009** |
| | Middle | WY2011 | 7 | 10 | 10 | 10 | 30,110 | 23,588 | 29,481 | 21,270 | 28,630 | 22,834 | 37,319 | 22,049 |
| | | WY2012 | 9 | 12 | 12 | 12 | 35,842 | 31,865 | 36,455 | 27,555 | 32,632 | 29,558 | 36,013 | 27,476 |
| | | WY2013 | 8 | 12 | 12 | 12 | 29,081 | 20,897 | 21,952 | 11,514 | 28,517 | 17,296 | 23,290 | 5,718 |
| | | p-value for comparison WY2013 to WY2011 | | | | | 0.878 | 0.693 | 0.282 | 0.145 | 0.908 | 0.553 | 0.323 | 0.187 |
| | | p-value for comparison WY2013 to WY2012 | | | | | 0.234 | 0.134 | **0.030** | **0.028** | 0.211 | 0.248 | **0.043** | **0.021** |
| | Bottom | WY2011 | 9 | 10 | 10 | 10 | 30,886 | 32,315 | 34,607 | 30,434 | 28,312 | 35,154 | 40,500 | 32,830 |
| | | WY2012 | 12 | 12 | 12 | 12 | 38,238 | 40,424 | 42,554 | 38,194 | 34,207 | 36,744 | 39,499 | 35,844 |
| | | WY2013 | 10 | 12 | 12 | 12 | 27,168 | 29,412 | 36,518 | 24,522 | 24,721 | 30,405 | 34,984 | 24,983 |
| | | p-value for comparison WY2013 to WY2011 | | | | | 0.506 | 0.590 | 0.728 | 0.347 | 0.514 | 0.895 | 0.895 | 0.510 |
| | | p-value for comparison WY2013 to WY2012 | | | | | **0.039** | 0.051 | 0.174 | **0.012** | **0.041** | 0.065 | 0.184 | **0.038** |

**Table 7.** Comparison of surface water quality parameters by station for WY2011, WY2012, and WY2013 for the L-31E Culverts. [Note: a probability value smaller than, or equal to, 0.05 signals a statistically significant difference between the compared entities. For ease of readability, such p-values are shown in **bold, underlined** type.]

| Parameter | Period | N | | | | Arithmetic Mean | | | | Median | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | BB53 | MI01 | MW01 | PR01 | BB53 | MI01 | MW01 | PR01 | BB53 | MI01 | MW01 | PR01 |
| Color | WY2011 | 11 | | | | 17 | | | | 18 | | | |
| | WY2012 | 12 | 11 | 11 | 11 | 17 | 25 | 24 | 16 | 18 | 25 | 25 | 18 |
| | WY2013 | 10 | 11 | 12 | 12 | 21 | 21 | 17 | 14 | 21 | 22 | 18 | 13 |
| | Compare | WY2013 to WY2011 | | | | 0.075 | | | | 0.074 | | | |
| | Compare | WY2013 to WY2012 | | | | 0.147 | 0.100 | **0.008** | 0.282 | 0.129 | 0.177 | **0.015** | 0.337 |
| Dissolved Ammonia | WY2011 | 10 | 11 | 11 | 10 | 0.11 | 0.11 | 0.08 | 0.14 | 0.09 | 0.10 | 0.08 | 0.13 |
| | WY2012 | 12 | 12 | 12 | 12 | 0.10 | 0.10 | 0.09 | 0.13 | 0.08 | 0.11 | 0.08 | 0.12 |
| | WY2013 | 9 | 12 | 12 | 12 | 0.07 | 0.10 | 0.06 | 0.09 | 0.07 | 0.09 | 0.06 | 0.08 |
| | Compare | WY2013 to WY2011 | | | | 0.256 | 0.802 | 0.117 | **0.038** | 0.264 | 0.190 | 0.163 | 0.079 |
| | Compare | WY2013 to WY2012 | | | | 0.165 | 0.897 | **0.022** | 0.155 | 0.159 | 0.977 | 0.076 | 0.323 |
| Nitrite Plus Nitrate | WY2011 | 11 | 11 | 11 | 11 | 0.417 | 0.430 | 0.578 | 1.475 | 0.230 | 0.480 | 0.300 | 1.430 |
| | WY2012 | 12 | 12 | 12 | 12 | 0.294 | 0.314 | 0.308 | 1.638 | 0.145 | 0.290 | 0.175 | 1.435 |
| | WY2013 | 9 | 12 | 12 | 12 | 0.490 | 0.483 | 0.664 | 2.684 | 0.250 | 0.635 | 0.645 | 3.075 |
| | Compare | WY2013 to WY2011 | | | | 0.730 | 0.716 | 0.670 | **0.028** | 0.470 | 0.558 | 0.218 | **0.027** |
| | Compare | WY2013 to WY2012 | | | | 0.266 | 0.196 | **0.005** | 0.098 | 0.154 | 0.193 | **0.015** | 0.094 |
| Total Phosphorous | WY2011 | 11 | 10 | 7 | 11 | 0.004 | 0.008 | 0.008 | 0.007 | 0.004 | 0.008 | 0.007 | 0.006 |
| | WY2012 | 12 | 12 | 10 | 12 | 0.006 | 0.007 | 0.007 | 0.008 | 0.005 | 0.007 | 0.007 | 0.008 |
| | WY2013 | 10 | 12 | 9 | 11 | 0.005 | 0.008 | 0.006 | 0.007 | 0.005 | 0.007 | 0.006 | 0.006 |
| | Compare | WY2013 to WY2011 | | | | 0.083 | 0.829 | 0.071 | 0.709 | 0.064 | 0.613 | **0.015** | 0.569 |
| | Compare | WY2013 to WY2012 | | | | 0.183 | 0.915 | 0.089 | 0.260 | 0.461 | 0.659 | 0.101 | 0.213 |
| Total Suspended Solids | WY2011 | | | | | | | | | | | | |
| | WY2012 | 11 | 10 | 10 | 10 | 59.4 | 37.2 | 48.0 | 34.4 | 52.0 | 35.5 | 52.5 | 36.0 |
| | WY2013 | 10 | 12 | 12 | 12 | 37.1 | 31.6 | 28.1 | 17.3 | 35.5 | 27.0 | 28.0 | 9.0 |
| | Compare | WY2013 to WY2011 | | | | | | | | | | | |
| | Compare | WY2013 to WY2012 | | | | **0.010** | 0.542 | **0.010** | 0.084 | 0.011 | 0.428 | **0.032** | 0.072 |
| Turbidity | WY2011 | 9 | 9 | 9 | 9 | 0.8 | 0.9 | 0.9 | 1.1 | 0.8 | 0.8 | 0.7 | 1.1 |
| | WY2012 | 12 | 12 | 12 | 12 | 0.9 | 0.9 | 0.7 | 0.9 | 0.9 | 0.9 | 0.6 | 0.9 |
| | WY2013 | 10 | 12 | 12 | 12 | 0.8 | 0.6 | 0.6 | 0.8 | 0.8 | 0.6 | 0.6 | 1.0 |
| | Compare | WY2013 to WY2011 | | | | 0.970 | **0.025** | 0.166 | **0.041** | 0.934 | **0.034** | 0.095 | **0.012** |
| | Compare | WY2013 to WY2012 | | | | 0.739 | **0.016** | 0.173 | 0.457 | 0.920 | **0.025** | 0.193 | 0.663 |

All surface water parameters had statistically significant changes. Most of the parameters decreased during WY2013. Color decreased at the station MW01; dissolved ammonia decreased at stations MW01 and PR01; TSS decreased at stations BB53 and MW01; and turbidity decreased at stations MI01 and PR01. The most important change noticed for profile parameters is the statistically significant decrease in salinity and specific conductivity at stations BB53, MW01, and PR01 during WY2013, especially when compared to WY2012.

TP values are already low, and have a small variability. Their decrease, even when it seems statistically significant, has the order of magnitude of the laboratory method detection limit, and therefore is environmentally insignificant.

A visualization of the comparison between parameter data sets is provided in the box plots in **Figures 6**, **7**, and **8** for the L-31E Culverts. These graphs allow a comparison between the central tendencies as well as between the variability of the data sets. During WY2013, the only parameter that encountered increased concentration is $NO_x$. There is a statistically significant increase in $NO_x$ concentration at stations MW01 and PR01 (**Figure 8**).

Total suspended solids (TSS) for the L-31E Culverts have been measured at the stations BB53, MI01, MW01, and PR01 during WY2012 and WY2013. More information about TSS is provided below:

- No TSS measurements were taken during WY2011.
- TSS summary statistics for WY2013 by station are listed in **Table 4**.
- A comparison between WY2011, WY2012, and WY2013 is presented in **Table 7**. Results show a decrease of mean and median TSS at all stations. Using Student t-test and Mann Whitney U test with a significance level of $\alpha=0.05$, the decrease was found to be statistically significant at the stations BB53 and MW01.
- Box plots of TSS by station and water year, for WY2011 through WY2013, are presented in **Figure 8**.

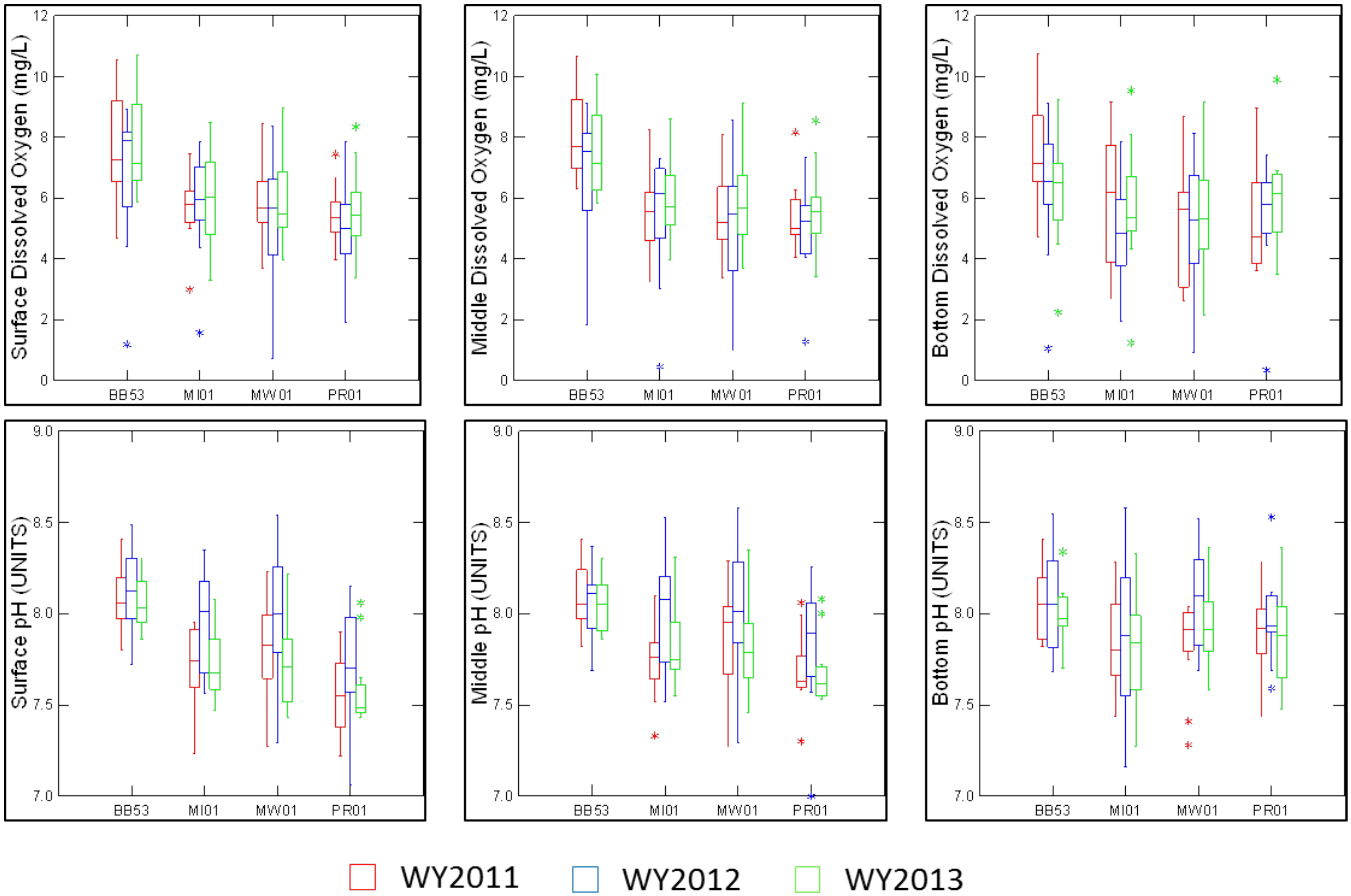


**Figure 6.** Box plots showing DO and pH measured along water depth at the surface, middle, and bottom of the BBCW L -31E Culverts.

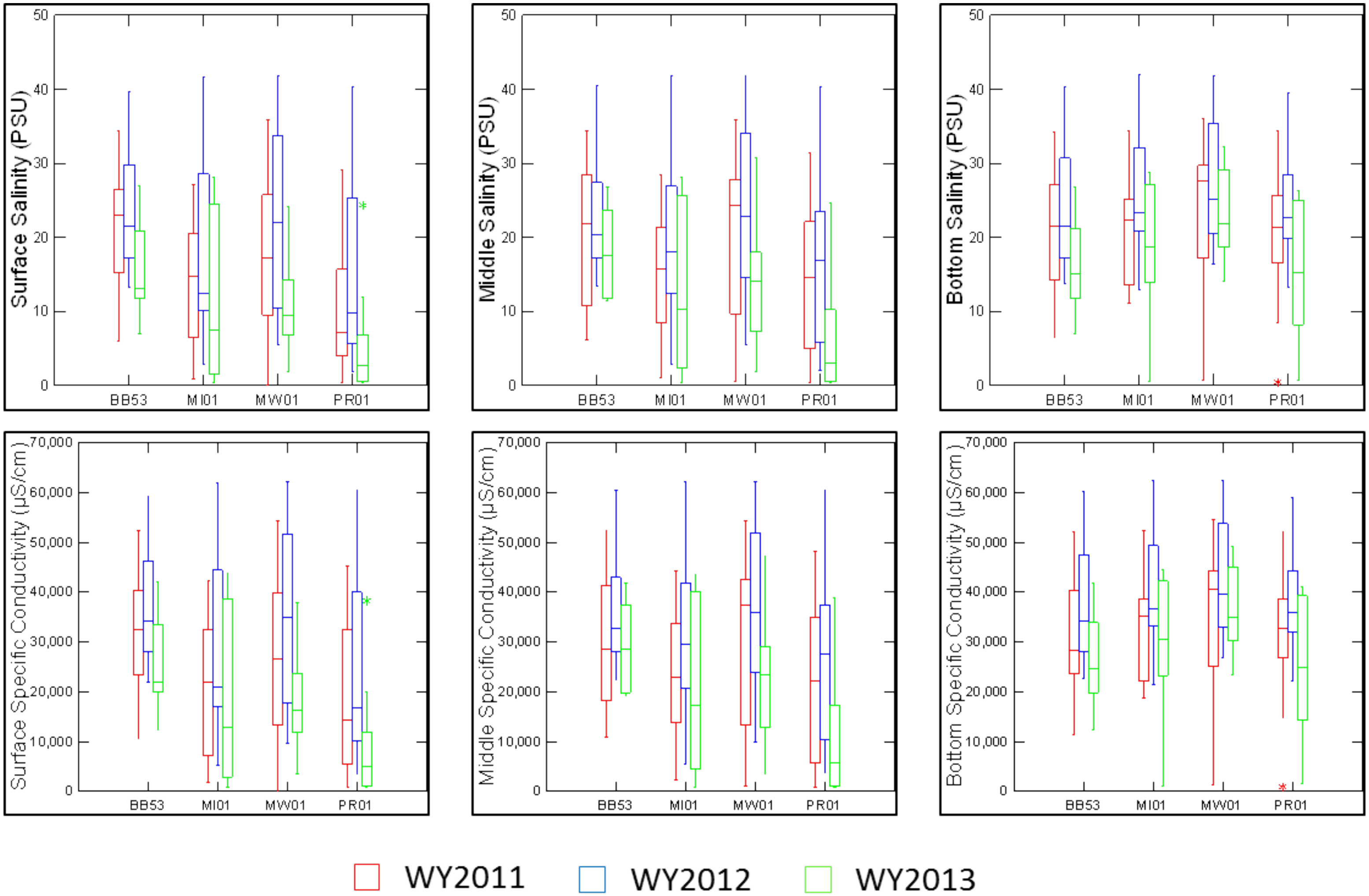


**Figure 7.** Box plots showing salinity in practical salinity units (PSU) and specific conductivity in microsiemens per centimeter (µS/cm) measured along water depth at the surface**,** the middle, and the bottom of the BBCW L-31E Culverts.

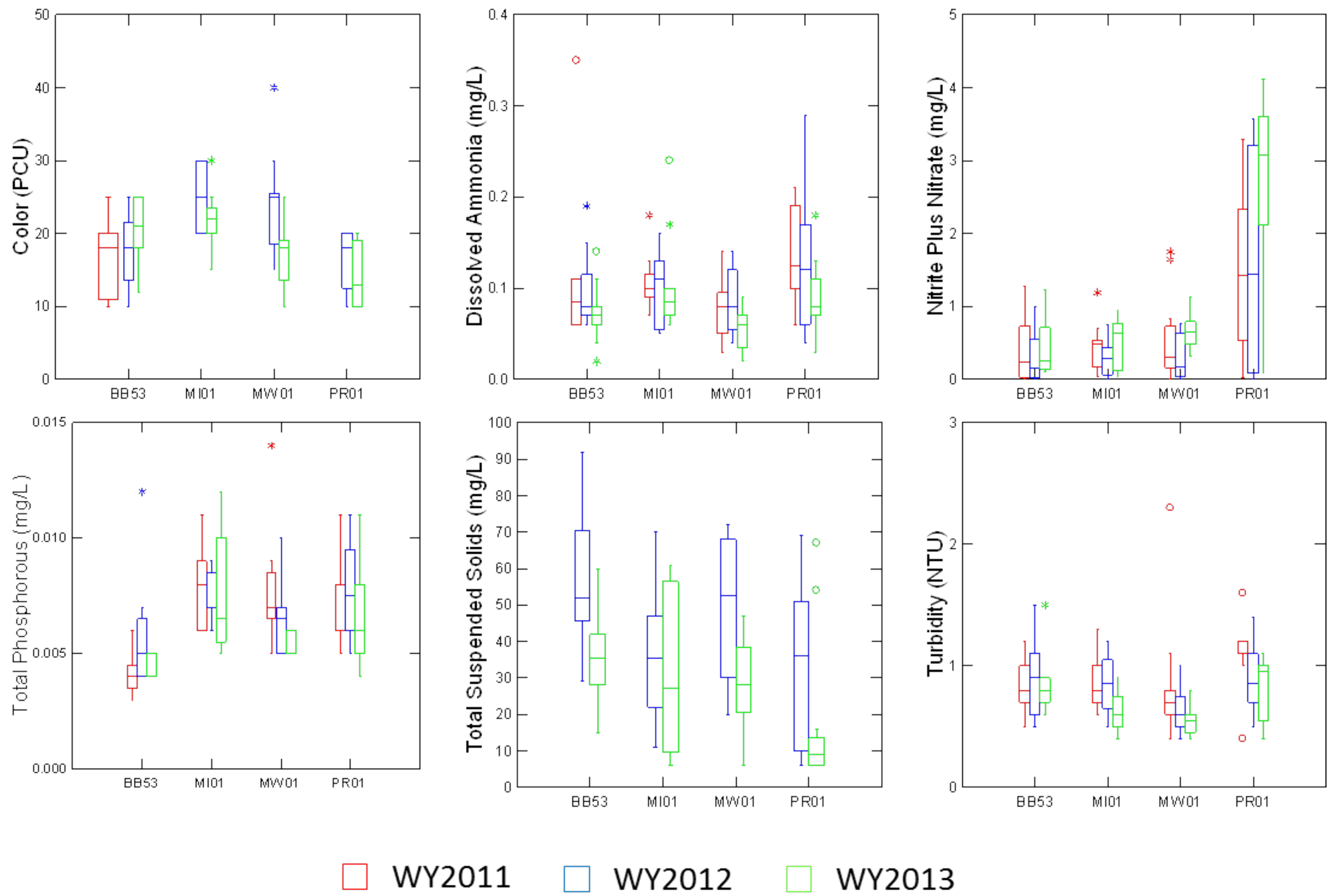


**Figure 8.** Box plots showing color in photo conductor units (PCU), dissolved ammonia in mg/L, nitrite + nitrate in mg/L, total phosphorus in mg/L, TSS in mg/L, and turbidity in nephelometric turbidity units (NTU) measured at the surface of the BBCW L-31E Culverts.

## DEERING ESTATE FLOW-WAY

Water quality sample collection at pump station S-700 began on May 24, 2012, in accordance with Specific Condition 20 of FDEP Permit Number 0271729-006 for Deering Estate. In order to establish the state of the system for WY2013, Class III criteria for fresh waters were monitored (**Table 8**). Excursions of Class III freshwater criteria occurred for two of the analyzed parameters: DO and specific conductivity. In South Florida, due to high water temperatures, the amount of DO tends to be low in many freshwater bodies. Such was the case for measurements taken at pump station S-700, where, during WY2013, all measured water temperatures were above 22 degrees Celsius, and 20 percent of DO measurements were less than 5 mg/L. During WY2013, measured specific conductivity exceeded the accepted freshwater criteria once, on November 27, 2012. This happened during the dry season, when a long period of no flow occurred. No water quality samples were taken before May 24, 2012, at pump station S-700. Therefore, at this stage, no comparisons with previous water years can be made.

**Table 8.** Summary statistics of water quality parameters measured at pump station S-700 in the Deering Estate during WY2013.

| Parameter | Units[a] | Class III Criteria for Fresh Waters | Period of Record | Number of Samples | Mean | Standard Deviation | Minimum | Q25[b] | Median | Q75[c] | Maximum | Number Below Detection Limit | Number of Excursions | Percent Excursions |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Dissolved oxygen | mg/L | ≥5.0 mg/L | 5/24/2012–4/29/2013 | 20 | 6.3 | 2 | 2.65 | 5.1 | 6.3 | 7.5 | 9.59 | NA[d] | 4 | 20.00% |
| Dissolved Ammonia | mg/L | None | 5/24/2012–4/29/2013 | 18 | 0.04 | 0.03 | 0.01 | 0.02 | 0.03 | 0.06 | 0.09 | 2 | NA | NA |
| Nitrate Plus Nitrite | mg/L | None | 5/24/2012–4/29/2013 | 20 | 0.173 | 0.06 | 0.04 | 0.15 | 0.17 | 0.2 | 0.29 | 0 | NA | NA |
| pH | | 6 < pH ≤ 8.5 | 5/24/2012–4/29/2013 | 20 | 7.53 | 0.18 | 7.2 | 7.4 | 7.5 | 7.6 | 7.9 | NA | 0 | 0.00% |
| Specific Conductivity | µS/cm | <1,275 µS/cm | 5/24/2012–4/29/2013 | 20 | 634 | 190 | 513 | 558 | 582 | 597 | 1,322 | NA | 1 | 5.00% |
| Temperature | ºC | None | 5/24/2012–4/29/2013 | 20 | 25.8 | 2.8 | 22.4 | 23.2 | 25.2 | 28.8 | 30.1 | NA | NA | NA |
| Total Kjeldahl Nitrogen | mg/L | None | 5/24/2012–4/29/2013 | 20 | 0.4 | 0.2 | 0.23 | 0.3 | 0.3 | 0.6 | 0.66 | 0 | NA | NA |
| Total Phosphorus | mg/L | None | 5/24/2012–4/29/2013 | 20 | 0.015 | 0 | 0.01 | 0.01 | 0.014 | 0.02 | 0.02 | 0 | NA | NA |

a. Key to units: mg/L – milligrams per liter; µS/cm – microsiemens per centimeter; ºC – degrees Celsius
b. Q25 – 25th percentile
c. Q75 – 75th percentile
d. NA – not applicable

**Table 9** summarizes monthly TP and total nitrogen (TN) loads discharged from pump station S-700 during WY2013. Due to the short period of record, which includes only four complete months during the dry season, and two complete months during the wet season, any estimation of nutrient load temporal trends may be premature. The variability of the data could be caused by seasonal changes rather than project related effects. While a minimum of a second year of monitoring data is necessary to evaluate temporal trends, and a minimum of five complete years of data are required for a rigorous seasonal Kendall tau test, it should be noted that the concentrations of these nutrients in the inflow waters are low (≤ 0.005 mg/L TP; ≤ 0.5 mg/L TN), and consistent with concentrations noted in other non-impacted canals within Miami-Dade County.

**Table 9.** Summary of monthly flow, and monthly loads for $NO_x$, ammonia ($NH_4$), TKN, TN, total organic nitrogen (TORGN), and TP in kilograms (kg) discharged from pump station S-700 during WY2013.

| Month | Flow | | Load | | | | | |
|---|---|---|---|---|---|---|---|---|
| | (cfs) | (acre-feet) | $NO_X$ (kg) | $NH_4$ (kg) | TKN (kg) | TN (kg) [a] | TORGN(kg) [b] | TP (kg) |
| Dec. 2012 | 230.85 | 457.88 | 95.30 [c] | 16.31 [c] | 143.19 [c] | 238.49 [c] | 126.88 [c] | 7.39 [c] |
| Jan. 2013 | 743.7 | 1,475.13 | 287.37 | 144.78 | 970.13 | 1,257.50 | 825.35 | 26.78 |
| Feb. 2013 | 782.48 | 1,552.04 | 404.54 | 122.01 | 1,081.22 | 1,485.76 | 959.21 | 29.21 |
| Mar. 2013 | 295.28 | 585.68 | 140.04 | 43.77 | 423.15 | 563.18 | 379.37 | 10.2 |
| Apr. 2013 | 789.82 | 1,566.61 | 249.96 | 56.12 | 1,150.36 | 1,400.32 | 1,094.24 | 27.05 |
| **Total** | **2,842.13** | **5,637.34** | **1,081.91** | **366.68** | **3,624.86** | **4,706.76** | **3,258.17** | **93.24** |

a. TN load = TKN load + $NO_x$ load
b. TORGN load = TKN load + $NH_4$ load
c. Month is incomplete; flow data start on December 2012.

## MERCURY MONITORING

In accordance with Specific Condition 22, the District is mandated to implement mercury monitoring and evaluation in specific media in restoration projects that may potentially discharge water with negative impacts to the downstream receiving waters. The FDEP and the District have developed a systematic approach (Phase/Tier) using *A Protocol for Monitoring Mercury and Other Toxicants* (Protocol) (FDEP and SFWMD, 2011) to evaluate the status of mercury and other toxicants in the BBCW Project area.

During WY2013, the mercury monitoring program was in the first year of monitoring required for Phase 2 – Tier 1: Routine Monitoring during Three-Year Stabilization Period. During this period, the Protocol requires that surface water samples at inflow and outflow structures be collected quarterly; mosquitofish (*Gambusia holbrooki*) composite samples at the inflow and outflow structures be collected quarterly; and sunfish (*Lepomis sp.*) and largemouth bass (*Micropterus salmoides*), which are together referred to as "large-bodied fish", be collected annually.

## ACTION LEVEL CRITERIA

Action level criteria described in the Protocol for Phase 2 – Tier 1: Routine Monitoring during Three-Year Stabilization Period that are appropriate for a single water year evaluation are as follows:

- If a water quality standard (WQS) [in Chapter 62-302, Florida Administrative Code (F.A.C.)] is exceeded; or
- If annual outflow loads of total mercury (THg) or methyl mercury (MeHg) are determined to be significantly greater than inflow loads (i.e., based on an uncertainty analysis of loading estimates, e.g., precision in measuring analytes and flow, interpolation over quarter); or
- If THg in any (quarterly) mosquitofish composite exceeds the 90 percent upper confidence level of the basinwide average, or if basin-specific data are lacking, exceeds the 75$^{th}$ percentile concentration for the period of record for all basins; or
- If annual average THg levels in a given fish species become elevated to the point of exceeding the 90$^{th}$ upper confidence level of the basinwide average, or if basin-specific data are lacking, exceeding the 75$^{th}$ percentile concentration for the period of record for all basins.

## ACTION LEVEL CRITERIA ASSESSMENT

The following sections provide assessments of the action criteria listed above for surface water and fish.

### Surface Water Assessment

The first evaluation criterion for THg in surface water is listed as, "If a WQS (in Chapter 62-302, F.A.C.) is exceeded". The Florida Class III water quality standard for mercury in surface water is 12 nanograms per liter (ng/L). Surface water samples were collected quarterly at pump station S-700 (inflow) for THg and MeHg analysis (**Table 10**). No outflow samples were taken because the outflow stations (S-701 and GL03) are located in a downstream area that has not been constructed. The mercury concentration varied from 0.240 to 0.670 ng/L for THg, and 0.034 to 0.240 ng/L for MeHg. The THg concentration is well below the U.S. Environmental Protection Agency (USEPA) standard of 12 ng/L. Therefore, this criterion was not violated. Because no outflow data were collected, an evaluation for mercury load reduction is not possible.

**Table 10.** Quarterly surface water THg and MeHg concentrations, in ng/L, collected at pump station S-700 in the BBCW project area during WY2013.

| Date | THg | MeHg |
|---|---|---|
| 7/10/2012 | 0.670 | 0.240 |
| 10/11/2012 | 0.450 | 0.089 |
| 1/16/2013 | 0.240 | 0.052 |
| 4/16/2013 | 0.700 | 0.034 |
| ***Average*** | ***0.515*** | ***0.104*** |

## Fish Assessment

The evaluation criterion for mosquitofish is if mercury in any (quarterly) mosquitofish composite exceeds the 90 percent upper confidence level of the basinwide average, or, if basin-specific data are lacking, exceeds the $75^{th}$ percentile concentration for the period of record for all basins. Mosquitofish samples, which consisted of approximately 100 individuals as a composite sample, were collected quarterly from station S700 during WY2013. USEPA recommended MeHg fish tissue criterion of 77 nanograms per gram (ng/g) for Trophic Level III fish. **Table 11** shows that the THg concentration in mosquitofish from the BBCW Project area is well below the $75^{th}$ percentile of THg concentration of mosquitofish from the Water Conservation Areas, Everglades National Park, and the USEPA standard. Therefore, this criterion was not violated.

The evaluation criterion for large-bodied fish is if annual average THg levels in a given fish species become elevated to the point of exceeding the $90^{th}$ upper confidence level of the basinwide average, or if basin specific data are lacking, exceeding the $75^{th}$ percentile concentration for the period of record for all basins. **Table 11** shows that THg concentrations in sunfish and largemouth bass from the BBCW Project area are well below the $75^{th}$ percentile of the THg concentration in the Water Conservation Areas, Everglades National Park, and the USEPA standard. Therefore, this criterion was not violated.

**Table 11.** THg concentrations, in ng/g, in fish of different trophic levels collected at the inflow structure (S-700) of the BBCW Project area during WY2013.

| Date | Species | THg | Number of Samples [a] | Reference Value [b] | USEPA Criterion |
|---|---|---|---|---|---|
| 7/2/2012 | Mosquitofish | 37 | 1 | 100 | 77 |
| 10/2/2012 | Mosquitofish | 36 | 1 | 100 | 77 |
| 1/15/2013 | Mosquitofish | 34 | 1 | 100 | 77 |
| 4/11/2013 | Mosquitofish | 10 | 1 | 100 | 77 |
| 10/11/2012 | Sunfish[c] | 33 | 3 | 240 | 77 |
| 10/11/2012 | Largemouth Bass | 157 | 1 | 678 | 346 |

a. For large bodied fish, it is the number of individual fish. For mosquitofish, it is the number of composite samples consisting of greater than or equal to 100 individuals.

b. $75^{th}$ percentile from the Everglades Protection Area for the period of record (1998-2013).

c. Samples consisted of two bluegill (*Lepomis macrochirus*) and one redear sunfish (*Lepomis microlophus*).

## Summary

In summary, mercury concentrations in surface water and fish (mosquitofish and large-bodied fish) were determined for the project Phase 2 – Tier 1 Routine Monitoring during Three-Year Stabilization Period during WY2013. THg and MeHg concentrations in the surface water were below 75 percent (all basins) and the USEPA criterion. THg concentrations in mosquitofish and large-bodied fish were well below the $75^{th}$ percentile of THg concentrations for respective species from the Water Conservation Areas and Everglades National Park.

# OTHER TOXICANTS MONITORING

Initial other toxicants monitoring in sediment, surface water, and fish was started for the BBCW project in 2012, at pump station S-700, following the FDEP permit requirements. Parameters identified in **Table 12** were analyzed in each of the specified matrices. Routine monitoring during the stabilization period for surface water and fish began in April 2012. Evaluations were performed to determine if Phase 2 – Tier 1 Routine Monitoring during Three-Year Stabilization Period criteria for fish and surface water have been met.

Sections 2.1a and 2.1.c of the Protocol make the following recommendations:

- If, after one year of sampling, action level criteria are met, then surface water sampling would be discontinued.
- If levels of other toxicants in tissues do not exceed recognized background tissue concentrations, or benchmarks established in ecological risk assessments completed as part of the environmental site assessment (ESA), then sampling would be discontinued.

**Table 12.** Toxicant parameters measured in the BBCW Project area.

| Analyte | Surface Water | Sediment | Fish Tissue |
|---|---|---|---|
| o,p'_DDD (ortho, para dichlorodiphenyldichloroethane) | - | - | X |
| p,p'_DDD (para, para dichlorodiphenyldichloroethane) | X | X | X |
| o,p'_DDE (ortho, para dichlorodiphenyldichloroethylene) | - | - | X |
| p,p'_DDE (para, para dichlorodiphenyldichloroethylene) | X | X | X |
| o,p'_DDT (ortho, para dichlorodiphenyltrichloroethane) | - | - | X |
| p,p'_DDT (p,p'-DDT – para, para dichlorodiphenyltrichloroethane) | X | X | X |
| chlordane | X | X | X |
| cis-chlordane | - | - | X |
| trans-chlordane | - | - | X |
| cis-nonachlor | - | - | X |
| trans-nonachlor | - | - | X |
| alpha endosulfan | X | X | X |
| beta endosulfan | X | X | X |
| endosulfan sulfate | X | X | X |

- "X" indicates that a parameter was analyzed in the matrix listed in the heading of the column in which it appears.
- "-" indicates that a parameter was not analyzed in the matrix listed in the heading of the column in which it appears.

## ACTION LEVEL CRITERIA

Action level criteria described in the Protocol for Phase 2 – Tier 1: Routine Monitoring during Three-Year Stabilization Period for toxicants are as follows:

- If water-column concentrations of other toxicants do not exceed the water quality standard in Chapter 62-302, F.A.C., or
- If levels of other toxicants in tissues do not exceed recognized background tissue concentrations or benchmarks established in ecological risk assessments completed as part of the ESA

## ACTION LEVEL CRITERIA ASSESSMENT

The following sections provide assessments of the action criteria listed above for surface water and fish.

## SURFACE WATER ASSESSMENT

Surface water samples for the Phase 2 – Tier 1: Routine Monitoring during Three-Year Stabilization Period were collected on April 17, July 10, and October 11, 2012, and January 16 and April 16, 2013. None of the samples had any detectable pesticide concentrations. Therefore, the critical evaluation or Action Level Criteria were met.

## FISH ASSESSMENT

Mosquitofish samples for the routine monitoring during stabilization period were collected on July 2 and October 2, 2012, as well as on January 15 and April 11, 2013. The only compounds detected were in the January sampling event, at which the concentrations were below levels of concern (**Table 13)**.

Pesticides detected in the annual large-bodied fish collection, which occurred on October 11, 2012, were below any levels of concern (**Table 13**). Therefore, the critical evaluation or Action Level Criteria were met.

**Table 13.** Summary of fish pesticide analysis for the BBCW Project area.

| Sampling Date | Station Fish | DDTr (µg/kg wet weight) (includes o,p'-DDD, p,p'-DDD, o,p'-DDE, p,p'-DDE, o,p'-DDT, p,p'-DDT) [a] | Total Chlordane (µg/kg wet weight) (includes sum of cis- and trans chlordane and nonachlor, and oxychlordane | Criteria | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | p,p'-DDE[b] (µg/Kg wet weight) (Newfields 2006) | | | | | Whole Fish Benchmark for Protection of Fish Eating Wildlife (Newell et. al 1987) | Whole Fish Total DDTr (µg/Kg dry weight; tissue residue)(Environment Canada 1999) | | Recreational Fishers Screening Value (USEPA 2000) | |
| | | | | Bald Eagle | Great Blue Heron | Little Blue Heron | White Pelican | Wood Stork | Whole Fish Total DDTr (µg/kg wet weight) | Fish Consuming Birds Protection | Available Tissue Residue for Human Health Protection | Total DDTr (µg/kg dry weight) | Total Chlordane (µg/kg dry weight) |
| 10/11/2012 | S700 bluegill | 7 I[c] | 65 | 14,700 | 10,000 | 5,200 | 12,200 | 10,100 | 200 | 1,000 | 320 | 117 | 114 |
| 1/15/2013 | S700 Mosquitofish | 2 I | 1.4 I | 14,700 | 10,000 | 5,200 | 12,200 | 10,100 | 200 | 1,000 | 320 | 117 | 114 |

a. µg/kg – micrograms per kilograms.
Definitions of DDTr terms are as follows:
- o,p'-DDD: ortho, para dichlorodiphenyldichloroethane
- p,p'-DDD: para, para dichlorodiphenyldichloroethane
- o,p'-DDE: ortho, para dichlorodiphenyldichloroethylene
- p,p'-DDE: para, para dichlorodiphenyldichloroethylene
- o,p'-DDT: ortho, para dichlorodiphenyltrichloroethane
- p,p'-DDT: para, para dichlorodiphenyltrichloroethane

b. Screening levels correspond to exposure equal to no observed adverse effects levels, wet weight basis, for overall receptor diet.

c. I – value reported is less than the practical quantification limit, and greater than or equal to the method detection limit.

# OPERATION

## L-31E CULVERTS

The L-31E culverts are passive, flap-gated devices designed to divert available fresh water from the L-31E canal into adjacent wetlands. Because of their more frequent stage measurements (and close proximity), daily flow rates for culverts S-23A and S-23B were based on mean daily stages at structure S-21A, while daily flow rates for culverts S-23C and S-23D were based on mean daily stages at structure S-20F. More specifically, the mean daily flow rates at each of the four culverts were derived by manually entering the mean daily stage at the physically closest structure (S-21A or S-20F) into the design rating curve (**Figure 9**) and identifying the corresponding flow rate.

During the first annual reporting period, South Florida experienced extreme drought conditions. Beginning in October 2010, water levels along the transect downstream of culvert S-23A fell below the minimum level required for sampling, and remained at or below this level through June 2011. From December 2010 through June 2011, November 2011 through December 2012, and November 2012 through March 2013, water levels along the transect downstream of culvert S-23D fell below the minimum level required for sampling. Once water began to flow, in July 2011 through September 2011, and in May 2012 through October 2012, inundations were observed along the entire length of the transects, with water depths approximately 12 to 24 inches along the transect downstream of culvert S-23D, and 6 to 12 inches along the transect downstream of culvert S-23A. From November 2012 through February 2013, the District diverted water to Biscayne Bay through spillway S-21A and S-20F within the vicinity of the L-31E Culverts, and water levels along the transects fell below the minimum level required for sampling (**Table 14**).

**Table 14.** Monthly mean stage in feet National Geodetic Vertical Datum of 1929 (ft NGVD29) for the L-31E Culverts.

| Date | Stage S-20F Headwater (ft NGVD29) | Stage S-20F Tailwater (ft NGVD29) | Stage S-21A Headwater (ft NGVD29) | Stage S21A Tailwater (ft NGVD29) |
|---|---|---|---|---|
| May 2012 | 1.93 | 0.93 | 1.93 | 0.98 |
| Jun. 2012 | 1.50 | 1.05 | 1.59 | 1.10 |
| Jul. 2012 | 1.66 | 0.84 | 1.72 | 0.87 |
| Aug. 2012 | 1.84 | 0.94 | 1.87 | 0.98 |
| Sep. 2012 | 1.83 | 0.97 | 1.86 | 0.98 |
| Oct. 2012 | 1.64 | 1.43 | 1.67 | 1.38 |
| Nov. 2012 | 1.50 | 1.61 | 1.52 | 1.57 |
| Dec. 2012 | 1.33 | 1.02 | 1.32 | 1.01 |
| Jan. 2013 | 1.29 | 0.83 | 1.50 | 0.78 |
| Feb. 2013 | 1.26 | 0.73 | 1.85 | 0.65 |
| Mar. 2013 | 1.30 | 0.89 | 1.89 | 0.80 |
| Apr. 2013 | 1.28 | 0.77 | 1.84 | 0.71 |

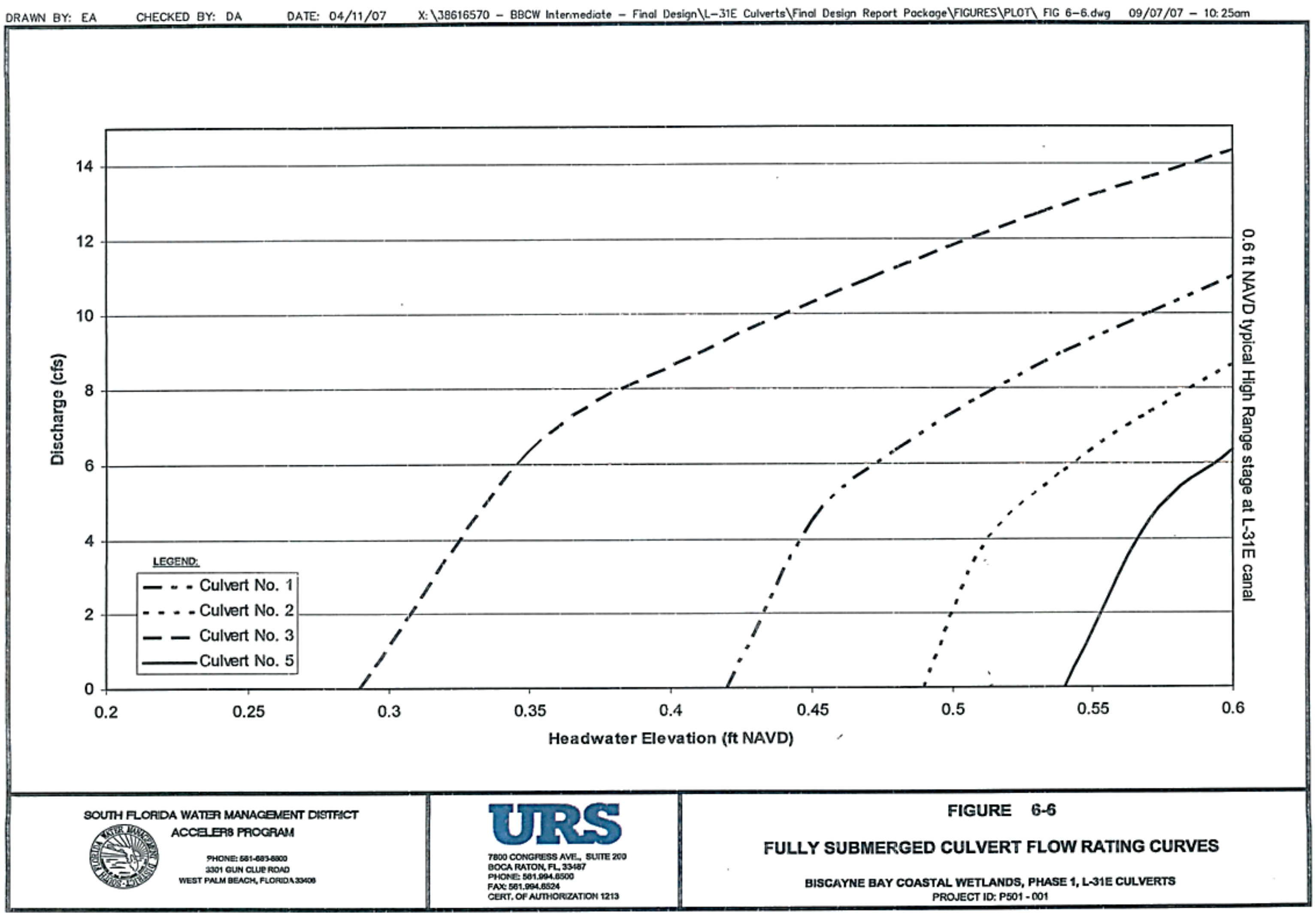


**Figure 9.** Fully submerged culvert flow rating curves for the L31E Culverts. Headwater elevation from structures S-21A, S-20G, and S-20F were utilized. [Note: SFWMD consultant mislabeled the culverts S-23B and S-23C in the design rating curve document for the L-31E culverts. Corrections have been made.]

In accordance with Special Condition 10C of U.S. Army Corps of Engineers (USACE) Permit Number SAJ-2007-1994-1327(IP-TKW) for the L-31E Culverts, the project was able to meet or exceed its 4 percent diversion target during six months of the last two water years (**Figures 10** and **11**, and **Tables 15** through **18**), but was only able to divert 3 percent in WY2012, and 2 percent in WY2013, of all the water available for the diversion. Although the 4 percent overall target was not reached for each water year, it is important to recognize that 5,110 acre-feet of fresh water in WY2012, and 4,705 acre-feet in WY2013, was diverted through the L-31E Culverts to wetlands east of the L-31E levee.

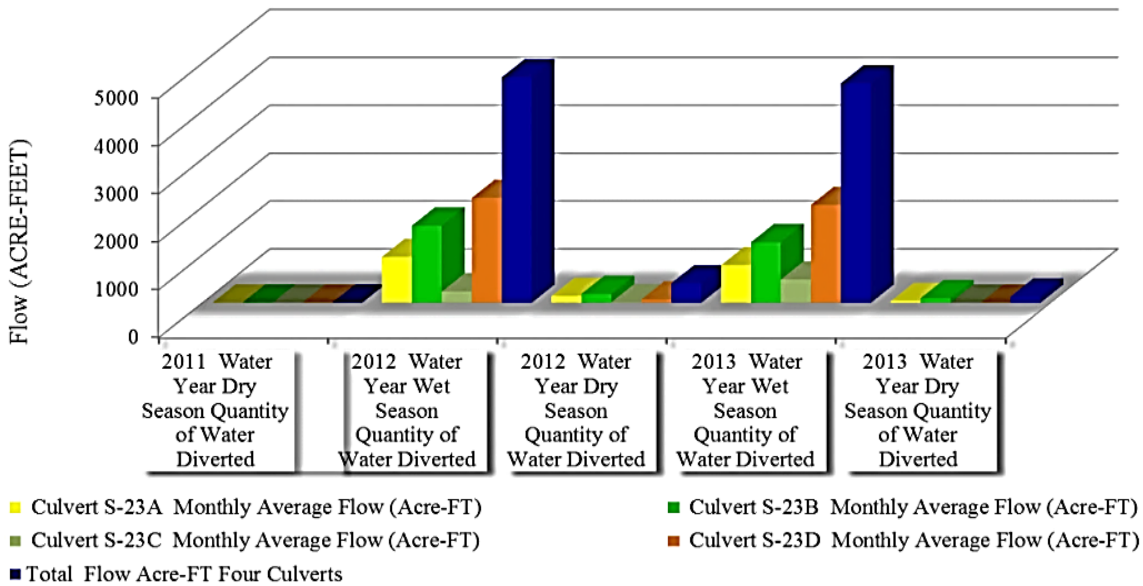


**Figure 10.** Comparison of fresh water in acre-feet (ACRE-FEET or Acre-FT) diverted from the L-31E canal through the L-31E Culverts to wetlands east of the L-31E levee.

**Table 15.** Fresh water in acre-feet diverted from the L-31E canal through the L-31E Culverts to wetlands east of the L-31E levee.

| Culvert | Monthly Average Flow of Water Diverted (acre-feet) | | | | |
|---|---|---|---|---|---|
| | WY2011 | WY2012 | | WY2013 | |
| | Dry Season | Wet Season | Dry Season | Wet Season | Dry Season |
| S-23A | 0.00 | 956.52 | 140.53 | 784.59 | 32.34 |
| S-23B | 0.00 | 1,609.94 | 182.87 | 1,264.59 | 93.13 |
| S-23C | 0.00 | 231.67 | 12.54 | 487.26 | 0.00 |
| S-23D | 0.00 | 2,189.99 | 70.36 | 2,043.30 | 0.00 |
| **Total Flow** | **0.00** | **4,704.12** | **406.31** | **4,579.74** | **125.47** |

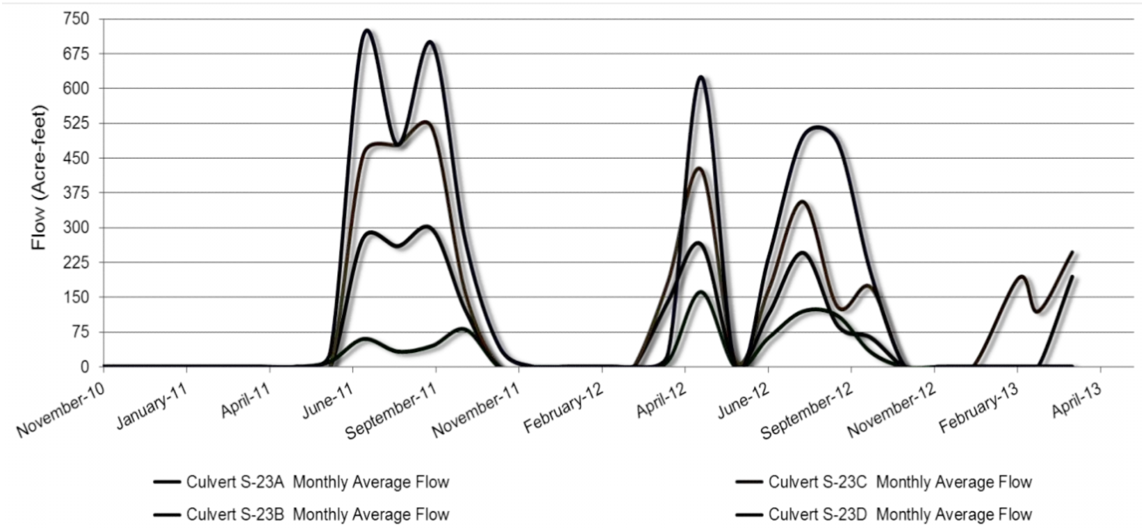


**Figure 11.** Comparison of monthly average fresh water in acre-feet diverted from the L-31E canal through the L-31E Culverts to wetlands east of the L-31E levee.

**Table 16.** Monthly average flow in cfs for the L-31E Culverts during WY2011.

| Period | Month | Flow S-23A | Flow S-23B | Flow S-23C | Flow S-23D | Total Flow Four Culverts | Flow S-20F | Flow S-21A | Total Flow S-21A and S-20F | Total Flow S-20F, S-21A, and Four Culverts | Available Water Diverted | Percent Water Diverted |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| WY2011 Dry Season | Nov. 2010 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 8,610.13 | 4,030.55 | 12,730.14 | 12,730.14 | 0.00 | 0.00% |
| | Dec. 2010 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 3,880.65 | 2,156.71 | 6,037.36 | 6,037.36 | 0.00 | 0.00% |
| | Jan. 2011 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 5,329.27 | 3,048.85 | 8,378.12 | 8,378.12 | 0.00 | 0.00% |
| | Feb. 2011 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2,073.58 | 1,355.05 | 3,428.63 | 3,428.63 | 0.00 | 0.00% |
| | Mar. 2011 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | Not Available |
| | Apr. 2011 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | Not Available |
| WY2011 Total (in cfs) | | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 19,893.63 | 10,591.16 | 30,574.25 | 30,574.25 | 0.00 | 0.00 |
| WY2011 Total (in acre-feet) | | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 38,991.51 | 20,758.67 | 59,925.53 | 59,925.53 | 0.00 | |

**Table 17.** Monthly average flow in cfs for the L-31E Culverts in WY2012.

| Period | Month | Flow S-23A | Flow S-23B | Flow CFS S-23C | Flow S-23D | Total Flow Four Culverts | Flow S-20 F | Flow S-21A | Total Flow S-21A and S-20F | Total Flow S-20F, S-21A, and Four Culverts | Available Water Diverted | Percent Water Diverted |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| WY2012 Wet Season | May 2011 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | Not Available |
| | Jun. 2011 | 0.00 | 6.00 | 0.00 | 15.40 | 21.40 | 0.00 | 0.00 | 0.00 | 21.40 | 0.00 | 0.00% |
| | Jul. 2011 | 141.48 | 30.80 | 233.20 | 363.76 | 769.24 | 5,673.54 | 2,662.06 | 8,335.6 | 9,104.84 | 0.10 | 10.12% |
| | Aug. 2011 | 132.45 | 17.00 | 243.60 | 243.98 | 637.03 | 10,065.07 | 5,237.11 | 15,302.18 | 15,939.21 | 0.04 | 4.00% |
| | Sep. 2011 | 151.29 | 23.10 | 262.50 | 355.40 | 792.29 | 7,370.02 | 4,356.82 | 11,726.84 | 12,519.13 | 0.06 | 6.33% |
| | Oct. 2011 | 62.80 | 41.30 | 82.10 | 138.80 | 180.10 | 20,442.16 | 7,601.49 | 28,043.65 | 28,368.65 | 0.03 | 2.72% |
| WY2012 Dry Season | Nov. 2011 | 0.00 | 0.00 | 0.00 | 21.50 | 21.50 | 7,763.53 | 3,485.14 | 11,248.67 | 11,270.17 | 0.00 | 0.23% |
| | Dec. 2011 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 5,197.46 | 2,552.78 | 7,750.24 | 7,750.24 | 0.00 | 0.00% |
| | Jan. 2012 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 3,851.93 | 255.66 | 4,107.59 | 4,107.59 | 0.00 | 0.00% |
| | Feb. 2012 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7,247.49 | 0.00 | 7,247.49 | 7,247.49 | 0.00 | 0.00% |
| | Mar. 2012 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1,950.02 | 0.00 | 1,950.02 | 1,950.02 | 0.00 | 0.00% |
| | Apr. 2012 | 71.70 | 6.40 | 93.30 | 14.40 | 185.80 | 4,238.83 | 0.00 | 4,238.83 | 4,424.63 | 0.02 | 2.00% |
| WY2012 Total (in cfs) | | 559.72 | 124.60 | 914.70 | 1,153.24 | 2,607.36 | 73,800.05 | 26,151.06 | 99,951.11 | 102,703.37 | 0.03 | 3.00% |
| WY2012 Total (in acre-feet) | | 1,097.05 | 244.22 | 1,792.81 | 2,260.35 | 5,110.43 | 144,648.10 | 51,256.08 | 19,5904.18 | 201,298.61 | | |

**Table 18.** Monthly average flow in cfs for the L-31E Culverts component in WY2013[a].

| Period | Month | Flow S-23A | Flow S-23B | Flow S-23C | Flow S-23D | Total Flow Four Culverts | Flow S-20 F | Flow S-21A | Total Flow S-21A and S-20F | Total Flow S-20F, S-21A and Four Culverts | Available Water Diverted | Percent Water Diverted |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| WY 2013 Wet Season | May 2012 | 134.40 | 82.40 | 216.70 | 318.40 | 751.90 | 8286.67 | 0.00 | 8,286.67 | 9,038.57 | 0.18 | 18.40% |
| | Jun. 2012 | 3.80 | 0.00 | 7.80 | 0.00 | 11.60 | 12,041.31 | 2,669.42 | 14,710.73 | 14,722.33 | 0.00 | 0.13% |
| | Jul. 2012 | 58.40 | 32.20 | 85.10 | 120.55 | 296.25 | 10,405.42 | 5,897.29 | 16,302.71 | 16,598.96 | 0.04 | 4.04% |
| | Aug. 2012 | 125.30 | 61.20 | 181.40 | 253.10 | 621.00 | 13,281.23 | 6,386.70 | 19,667.93 | 19,578.06 | 0.07 | 7.26% |
| | Sep. 2012 | 45.90 | 56.40 | 66.50 | 247.15 | 415.95 | 9,304.24 | 4,935.51 | 14,239.75 | 14,655.70 | 0.05 | 4.56% |
| | Oct. 2012 | 32.50 | 16.40 | 87.70 | 103.30 | 239.90 | 7,704.00 | 4,158.00 | 11,232.00 | 11,472.00 | 0.02 | 2.00% |
| WY2013 Dry Season | Nov. 2012 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 6,016.00 | 3,482.00 | 9,498.00 | 9,498.00 | 0.00* | 0.00%* |
| | Dec. 2012 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 6,617.00 | 2,997.00 | 8,614.00 | 8,614.00 | 0.00* | 0.00%* |
| | Jan. 2013 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 3,517.00 | 1,512.00 | 5,046.00 | 5,046.00 | 0.00* | 0.00%* |
| | Feb. 2013 | 0.00 | 0.00 | 98.10 | 0.00 | 98.10 | 3,623.00 | 309.00 | 3,932.00 | 4,031.00 | 0.02* | 2.43%* |
| | Mar. 2013 | 0.00 | 0.00 | 61.00 | 0.00 | 61.00 | 3,236.00 | 138.00 | 3,374.00 | 3,435.00 | 0.02* | 1.80%* |
| | Apr. 2013 | 99.00 | 0.00 | 126.00 | 0.00 | 225.00 | 6,941.00 | 2,501.00 | 9,442.00 | 9,667.00 | 0.02* | 2.30%* |
| WY2013 Total (in cfs) | | 499.30 | 248.60 | 930.30 | 1042.50 | 2,720.70 | 90,972.87 | 34,985.92 | 12,4345.79 | 12,6356.62 | 0.02 | 2.00%* |
| WY2013 Total (in acre-feet) | | 978.63 | 487.26 | 1,823.39 | 2,043.30 | 5,332.57 | 17,8306.83 | 68,572.40 | 24,3717.75 | 24,7658.98 | | |

a. During the WY2013 dry season, the stage in the L-31E Canal was low, and fresh water was diverted from the C-102 and C-103 canals through the S-21A and S-20F spillways to test the effectiveness of passing supplemental water flow into central Biscayne Bay (Pilot Project Tests for Supplemental Water Deliverables to Biscayne Bay).

## DEERING ESTATE FLOW-WAY

The District submitted the final version of the Preliminary Project Operating Manual for the Deering Estate Flow-way component of the BBCW Project to the FDEP on March 6, 2012. Construction was completed on March 26, 2012, and the District completed testing and certification of the pump station in March 2012.

Based on a review of the monitoring data collected during the first year of ecological monitoring and a comparison of this data to baseline data, the project appears to be meeting project objectives by diverting approximately 5,571 acre-feet of fresh water from the C-100 canal through pump station S-700 to historic remnant wetlands near Cutler Creek east of Old Cutler Road from December 2012 through April 30, 2013. During this reporting period, 98 percent of the total available fresh water from the C-100A canal was diverted from S-700 to wetlands east of Old Cutler Road. The remaining 2 percent (100 acre-feet) was diverted through the S-123 spillway to Biscayne Bay. **Figure 12** shows flow and stage at S-700 and S-123, respectively. Rainfall monitoring station S-123 recorded 6.4 inches from December 20, 2012 through April 30, 2013 (**Figure 13**).

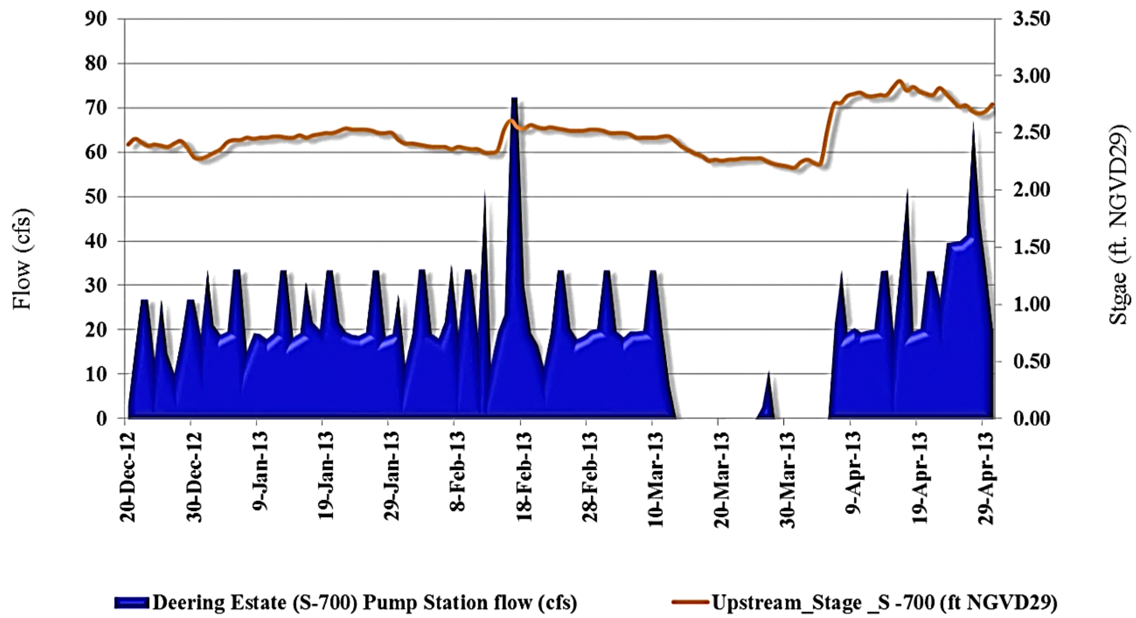


**Figure 12.** Comparison of flow and stage for pump station S-700.

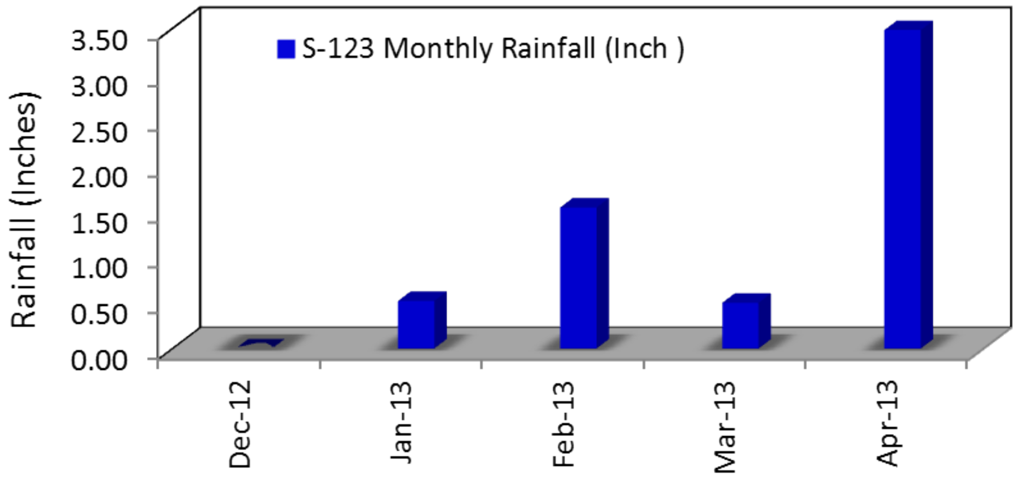


**Figure 13.** S-123 monthly rainfall (inches).

# ECOLOGICAL MONITORING

## L-31E CULVERTS

In accordance with Specific Conditions 9(a) and 9(b) of USACE permit SAJ-1994-1327 (IP-TKW), and Specific Condition 26B (5) of FDEP permit 0271729-006, the District performed ecological monitoring of project benefits at two of the four culvert (S-23A and S-23D) locations, including the mitigation enhancement areas. The project area is anticipated to be enhanced by water deliverables (salinity concentrations, water stage, wetland vegetation, and algal compositions). In accordance with Specific Conditions 11(a) and 11(b) of USACE permit SAJ 1994-1327 (IP-TKW), the District completed routine mitigation compliance monitoring on June 30, 2013. The latest *Biscayne Bay Coastal Wetlands L-31E Culverts Annual Mitigation Monitoring Report* was submitted by the District to the USACE on July 21, 2013, and is provided in this report as Attachment D.

### Aquatic Food Web Monitoring

During the last two annual reporting periods, wetland periphyton communities were not observed within the vicinity of culverts S-23A and S-23D. However, various species of birds, amphibians, invertebrates, fish, and reptiles were observed within the vicinity of culverts S-23A and S-23D (**Table 19**).

**Table 19.** List of species observed within the vicinity of culverts S-23A and S-23D during the first and second year of routine ecological monitoring.

| Type | First Year | | Second Year | |
|---|---|---|---|---|
| | **Species** | **Common Name** | **Species** | **Common Name** |
| **Culvert S-23A** | | | | |
| Invertebrates | *Cardisoma guanhumi* | blue land crab | *Cardisoma guanhumi* | blue land crab |
| | *Gonatista grisea* | grizzled mantid | | |
| Amphibians | *Osteopilus septentrionalis* | Cuban tree frog | *Osteopilus septentrionalis* | Cuban tree frog |
| Reptiles | *Nerodia fasciata* | banded water snake | *Nerodia fasciata* | banded water snake |
| | | | *Agkistrodon piscivorus* | water moccasin |
| Birds | *Butorides virescens* | little green heron | *Butorides virescens* | little green heron |
| | *Dumetella carolinensis* | gray catbird | *Dumetella carolinensis* | gray catbird |
| Fish | | | *Caranx hippos* | crevalle jack |
| **Culvert S-23D** | | | | |
| Invertebrates | *Callinectes sapidus* | blue crab | *Callinectes sapidus* | blue crab |
| Reptiles | *Nerodia fasciata* | banded water snake | *Nerodia fasciata* | banded water snake |
| | | | *Kinosternon baurii* | striped mud turtle |
| | | | *Agkistrodon piscivorus* | water moccasin |
| Birds | *Ardea alba* | great egret | *Ardea alba* | great egret |
| | *Ardea Herodias* | great blue heron | *Ardea Herodias* | great blue heron |
| | *Butorides virescens* | little green heron | *Butorides virescens* | little green heron |
| Fish | *Cichla ocellaris* | butterfly peacock bass | *Cichla cellaris* | butterfly peacock bass |
| | *Cichlasoma urophthalmus* | Mayan cichlid | *Cichlasoma urophthalmus* | Mayan cichlid |
| | *Eucinostomus californiensis* | graceful mojarra | *Eucinostomus californiensis* | graceful mojarra |
| | *Eucinostomus melanopterus* | flagfin mojarra | *Eucinostomus melanopterus* | flagfin mojarra |
| | *Gambusia holbrooki* | eastern mosquitofish | *Gambusia holbrooki* | eastern mosquitofish |
| | *Poecilia latipinna* | sailfin molly | *Poecilia latipinna* | sailfin molly |
| | | | *Centropomus undecimalis* | common snook |
| | *Floridichthys carpio* | goldspotted killifish | *Floridichthys carpio* | goldspotted killifish |
| | *Mugil curema* | white mullet | *Mugil curema* | white mullet |
| | *Strongylura marina* | Atlantic needlefish | *Strongylura marina* | Atlantic needlefish |

## Vegetation Monitoring

Vegetation monitoring was implemented to detect changes in the composition of vegetation in response to increased freshwater flows from the L-31E Culverts to the BBCW Project area. The project area is also monitored for Category I and II invasive exotic plant species. The District conducted monthly vegetation monitoring, since spring 2011, along two 100-meter transects downstream of culverts S-23A and S-23D (**Figure 14** and Attachments C and D) to document the composition and coverage of vascular plant species found in the groundcover and canopy strata.

The line-intercept method was used to document all vascular plant species along a 100-meter transect in the canopy (greater than 4.5 feet) and the groundcover (less than or equal to 4.5 feet) strata within the transitional mangrove forest located downstream of culvert S-23A (Attachment D: Tables 3 through 7 and Figure 3 through 7). The canopy stratum consists primarily of *R. mangle*, *Conocarpus erectus* (buttonwood), *Laguncularia racemosa* (white mangrove), *Annona glabra* (pond apple), and *Rhabdadenia biflora* (mangrovevine). The groundcover stratum is dominated by *Acrostichum aureum* (golden leather fern) and *R. mangle*. The combination of shading by moderate to dense canopy cover combined with dense cover by *A. aureum* in the groundcover appears to preclude the development of a wetland graminoid or herbaceous community in the monitoring area. *Bacopa monnieri* (smooth water hyssops), a herbaceous wetland plant, was observed during several events but its distance from the culvert and ephemeral presence at the monitoring site appear to indicate a more random occurrence rather than a result of recently modified hydrology (Attachment D).

The above-referenced methodology was also used to document plant species and species cover in the scrub *R. mangle* habitat located downstream of culvert S-23D (Attachment D: Tables 8 and 9). This system is comprised almost entirely (approximately 78 percent) of dwarf *R. mangle* with occasional *L. racemosa* and *Utricularia foliosa* (leafy bladderwort) near the S-23D culvert basin. Percent vegetation coverage and the height of *R. mangle* trees are monitored on a monthly basis along transect S-23D. There was a slight decrease in percent vegetation coverage of *R. mangle*, possibly due to freezing and cold temperatures within vegetation transect S-23D in winter 2011 (Attachment D, Figure C-12). Statistical analysis of monitoring data collected indicates no change in the height of the ten *R. mangle* individuals located at each of the following locations: start (5 meters), middle (50 meters), and end (100 meters), along vegetation transect S-23D (Attachment D: Figures 8 through 10). Overall, after two years of data collection, no major changes were observed in the vegetation community within the S-23D transect.

Within vegetation transect S-23A, which is downstream of culvert S-23A, monthly monitoring is conducted for percent vegetation coverage and percent canopy coverage. Statistical analysis of the monitoring data indicates a slight decrease in percent vegetation coverage of *R. mangle*, and a slight increase in percent canopy coverage of *R. mangle*. The *R. mangle* trees within this transect vary widely in size, and range from seedlings approximately 15 centimeters tall to mature trees upwards of 15 meters tall. Given the variability in *R. mangle* height and the feasibility of obtaining accurate height measurements of mature trees within a forested system, the data collected may not provide useful insight or a basis for comparison between S-23D and S-23A (Attachment D).

Based on field observations and review of the monitoring data collected during the last two years of ecological monitoring, there has not been a major change in the composition and coverage of vascular plants downstream of the S-23A and S-23D culverts. A comparison of two years of vegetation data is shown in Attachment D (Tables 3 through 9, and Figures 3 through 10).

## Sawgrass Mapping

In April 2012, the project team initiated field mapping of *Cladium jamaicense* (sawgrass) communities within a 370-acre area in the vicinity of the L-31E culverts. The objective of this task was to create a baseline map showing the distribution and relative abundance of *C. jamaicense* within the effective area of culverts S-23A and S-23B (**Figure 15**). During this reporting period, forty-two acres of patchy and scattered sawgrass communities were detected within the area of surface water redistribution and removal of exotic plants (northern culverts).

## Nearshore Salinity Monitoring

Continuous salinity monitoring has been conducted since 2006, in the coastal region near the L-31E culverts, along the shore between Turkey Point and the C-1 canal. Salinity stations used for the L-31E Culverts component nearshore region are 14, 22, 28, 44, A8, and B4 in **Figure 16**. Salinity is collected near the bottom at these stations at 15-minute intervals within 500 meters of the shore. For WY2013, salinity exhibited similar conditions for this region as it has during the period of record. Specifically, dry season salinity showed a higher average salinity with a narrower range of conditions than wet season, at 29.21 ± 2.10 relative to 21.80 ± 3.84, respectively. No statistically significant difference in the salinity ranges or seasonal patterns was observed in 2013, relative to the previous two years. Recent apparent trends downward in the mean and median salinity are a reflection of the return of relatively normal precipitation, compared to the drier periods observed in the 2011 dry season and 2012 wet season. Note that wet and dry season average salinities were above the CERP Restoration Coordination and Verification Program salinity performance measure target of 20 (http://www.evergladesplan.org/pm/recover/perf_se.aspx). More detailed analysis of the factors influencing salinity, including an examination of how water management in the coastal zone is influencing salinity, is necessary to interpret these differences and to ascertain any ecologically significant trends.

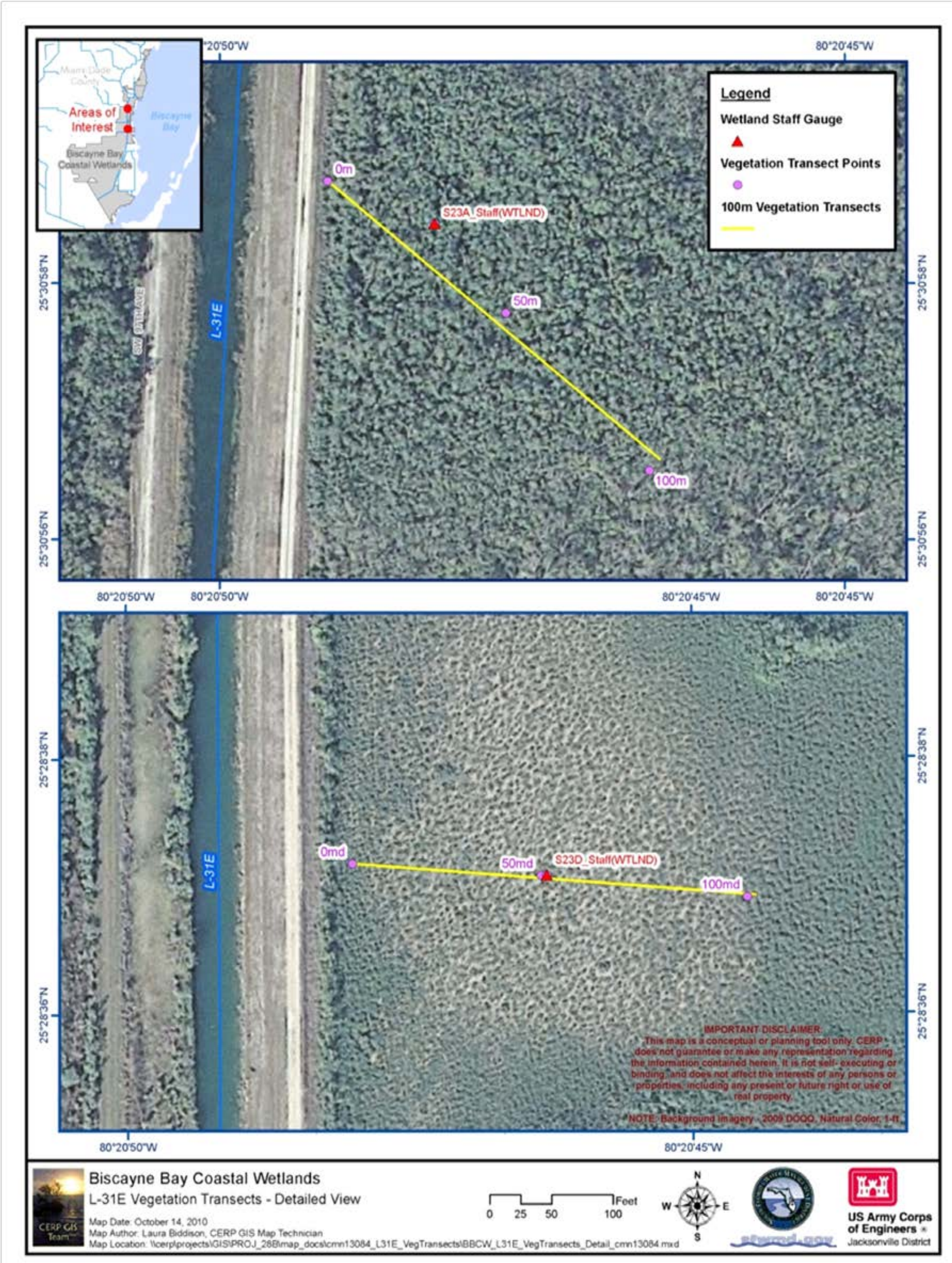


**Figure 14.** Location of 100-meter transects east of the levee at culverts S23-A (top) and S-23D (bottom).


**Figure 15.** April 2013 *Cladium jamaicense* (sawgrass) survey.

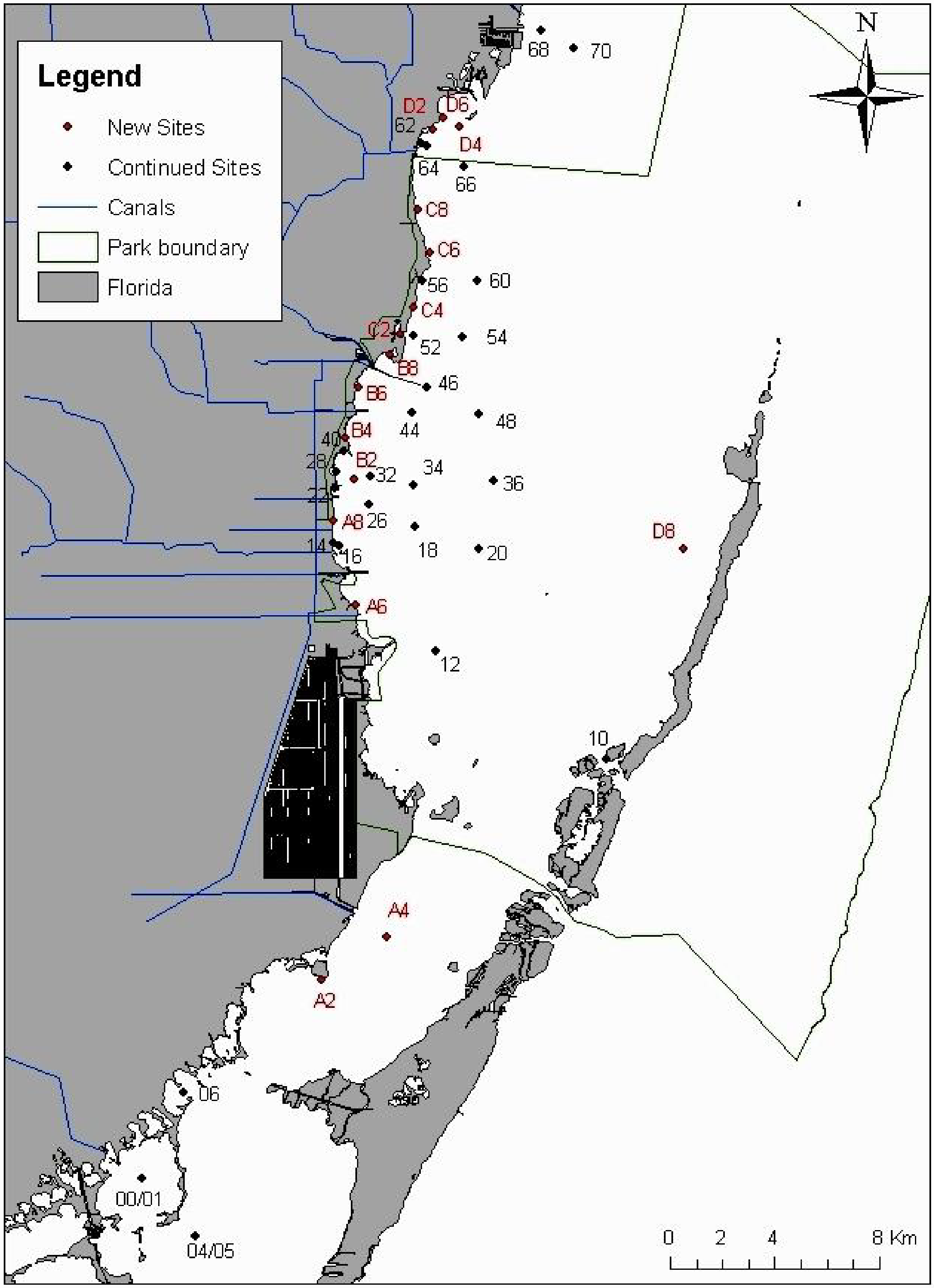


**Figure 16.** CERP Restoration Coordination and Verification Program and Biscayne National Park Nearshore Salinity Monitoring Network.

## DEERING ESTATE FLOW-WAY

In accordance with Special Conditions 11 and 12 of USACE permit SAJ-2007-139 (IP-AAZ, and Specific Condition 26B (5) of FDEP permit 0271729-006, ecological monitoring events are conducted by the District and Miami-Dade County Permitting, Environmental, and Regulatory Affairs staff. This monitoring will evaluate the performance of the Deering Estate Flow-way, which is anticipated to result in higher water levels in Cutler Creek and wetlands within the Deering Estate. The increased water levels are the result of operation of constructed features of the project. Monitoring will be conducted for at least three years after completion of construction of the pump station, and annual reports will be submitted to the USACE.

In accordance with Special Conditions 11 and 12 of USACE permit SAJ-2007-139 (IP-AAZ), and the *Ecological Monitoring Plan for Deering Estate Flow-way*, dated February 7, 2010, the District completed the baseline monitoring event and submitted the report to the USACE on March 2012. The first annual report was completed and submitted to the USACE by the District in August 2013, and is provided in Attachment E.

Four monitoring stations are used for Deering Estate Flow-way water level/flow monitoring (**Table 20** and **Figure 17**). Stations 1 and 3 are wetland staff gauges, and stations 2 and 5 are groundwater monitoring wells (**Figure 17**).

**Table 20.** Locations of ecological monitoring stations for the Deering Estate Flow-way.

| Station Name | Area Description | New/ Existing | Latitude Approximate X Coordinates | Longitude Approximate Y Coordinates | Function and/or Description | Monitoring Well Information: Top of Casing Elevation (feet NGVD29)[a] | Monitoring Well Information: Rim (feet) |
|---|---|---|---|---|---|---|---|
| Station 1 | Within the Rehydration Area | Existing | 885124.742 | 469012.886 | Staff Gauge | Not applicable (NA) | NA |
| Station 3 | | | 885363.133 | 468759.938 | | NA | NA |
| Station 5 | Within the Rehydration Area | Existing | 885729.49 | 468718.07 | Groundwater Monitoring Well | 8.53 | 8.78 |
| Station 2 | | | 883587.85 | 469241.68 | | 10.3 | 10.61 |

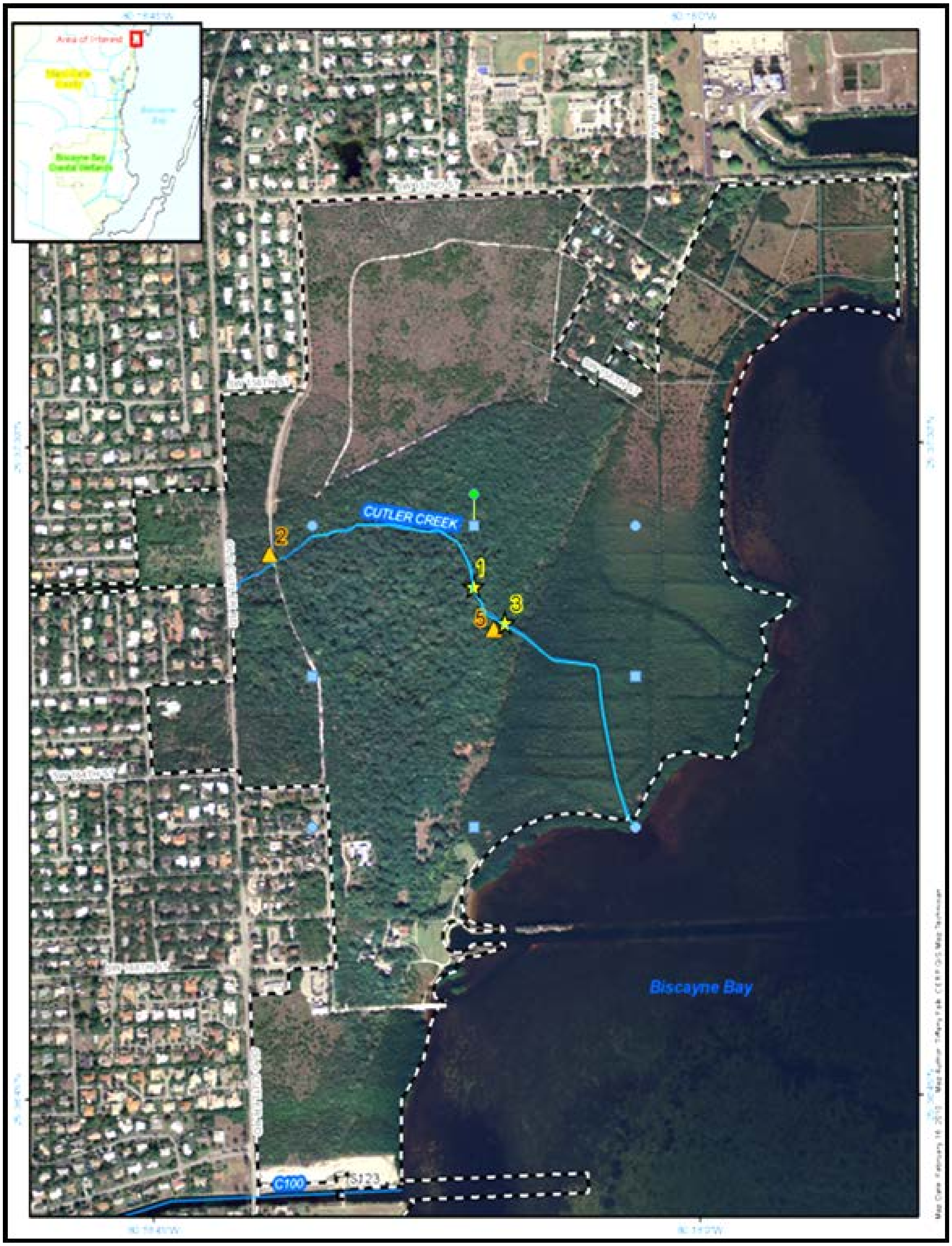


**Figure 17.** Ecological monitoring stations for the Deering Estate Flow-way.

Surface water level within the wetlands increased at the two wetland staff gauges (**Figure 18**). The greatest increase in water level occurred at staff gauge 1, an average stage of about 2.16 feet. Since operation of the S-700 pump station commenced, surface water levels within the slough show an increasing trend through the period of record ending in late April 2013. Statistical analyses of surface water level data from staff gauge monitoring stations 1 and 3 were not performed due to the short period of record.

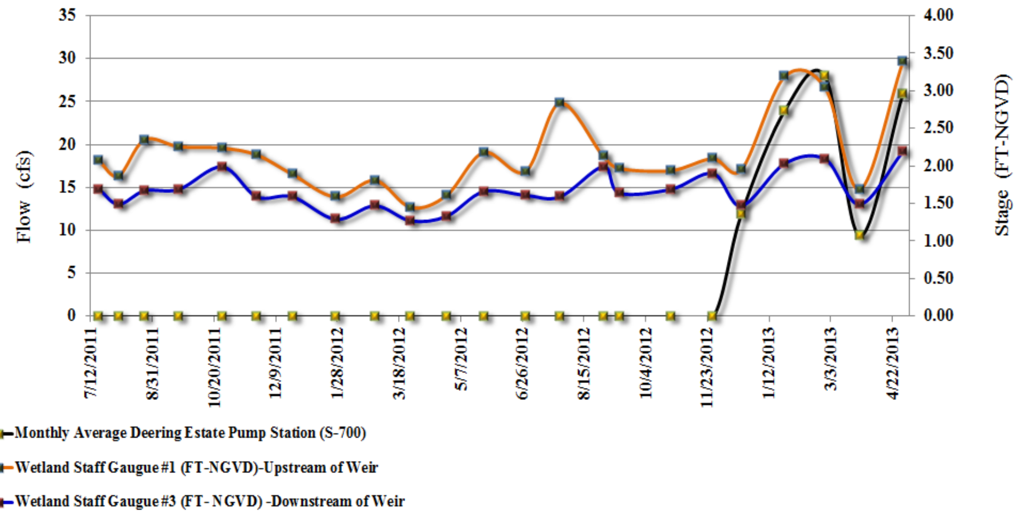


**Figure 18.** Comparison of water levels at Deering Estate staff gauges 1 and 3 versus pump station S-700 daily flow.

The groundwater response became progressively muted as distance from the diversion point (S-700) increased. Monitoring station 2 is located about 360 feet downstream of the pump station S-700 discharge (**Figure 19**). Statistical analyses indicated high correlations between groundwater levels and S-700 flow. Analyses also revealed low correlations between groundwater levels and rainfall, between groundwater salinity and S-700 flow, and between groundwater salinity and rainfall.

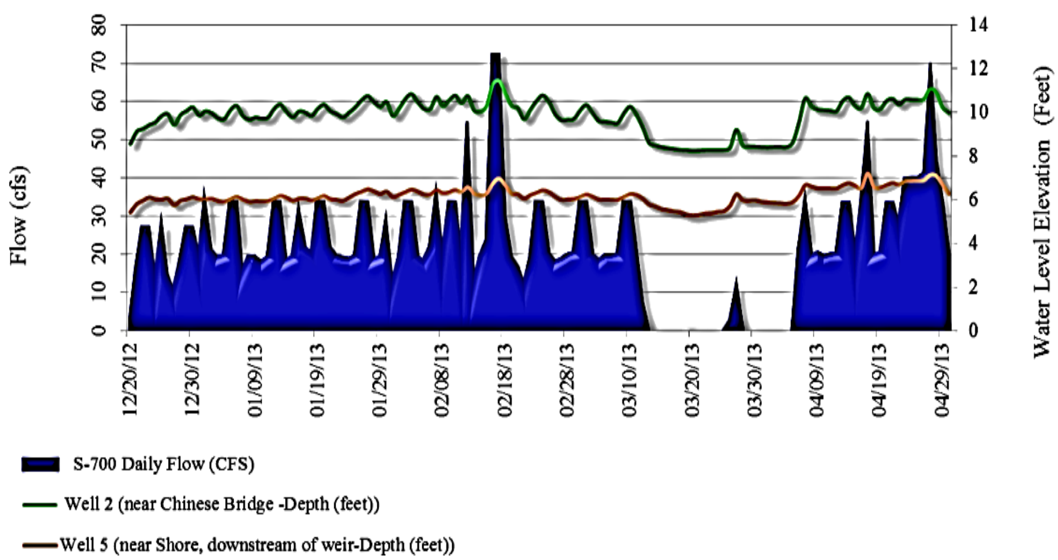


**Figure 19.** Comparison of groundwater levels within the vicinity of historic remnant wetlands of Deering Estate.

## Wetland Inundation

In accordance with Special Conditions 11 and 12 of USACE permit SAJ-2007-139 (IP-AAZ), and Specific Condition 26B (5) of FDEP permit 0271729-006, between January and February 2013, the spatial extent of wetland inundation (**Figure 20**) within the slough under various pumping rates was determined via Global Positioning System (GPS)- based mapping of inundated wetlands under varied rates of water diversion (i.e., 25, 50, 75, and 100 cfs). **Table 21** shows the estimated acreage of impounded surface water within the Deering Estate under different flow rates. For more information, see Attachment E, "Wetland Inundation" section.

**Table 21.** Estimated acreage of impounded surface water under different pumping/flow rates within the Deering Estate.

| Pumping Rate (cfs) | Duration of Testing (hours) | Estimated Acres of Impounded Surface Water | Percentage of Inundated Historic Remnant Wetlands within Cutler Creek During 5 Hours Testing |
|---|---|---|---|
| 0 | 5 | 0 | 0% |
| 25 | 5 | 19 | 58% |
| 50 | 5 | 25 | 76% |
| 75 | 5 | 27 | 82% |
| 100 | 5 | 31 | 94% |

## Salinity Monitoring

Continuous salinity monitoring in the coastal region near Deering Estate, along the shore of Biscayne Bay north of the S-123 spillway, has been conducted at site 62 since 2004, and was augmented with two additional nearshore stations, sites D2 and D6, in late 2010. The location of the sites is shown in **Figure 16**. Bottom salinity is collected at 15-minute intervals at these stations located within 500 meters of the shore.

Salinity along the shore in the Deering Estate region was lower than it has been for previous years, but was statistically within the range of the longer-term time series. No discernible trend was observed in salinity in recent years, even though there were periods of higher salinity, such as from the 2011 dry season into the 2012 wet season, and slightly lower periods in WY2013. These year-to-year variations are a result of variations in precipitation in the region, but may also have water management related influences. The analysis is limited to a brief statistical summary of conditions at sites 62, D2, and D6.

For WY2013, dry season salinity was 27.43 ± 3.84, while wet season salinity was 20.98 ± 5.19. S-700 operations began during the WY2013 dry season, but occurred during periods where additional water was also being moved from Water Conservation Area 3A toward the east coast. Dry season salinity was similar to the 26.58 ± 4.38 observed in WY2012, and within the range of salinity observed in this region over the period of record for continuous salinity observations. The wet season values were appreciably lower than the 33.64 ± 5.80 observed in the WY2012 wet season, likely due to differences in precipitation.

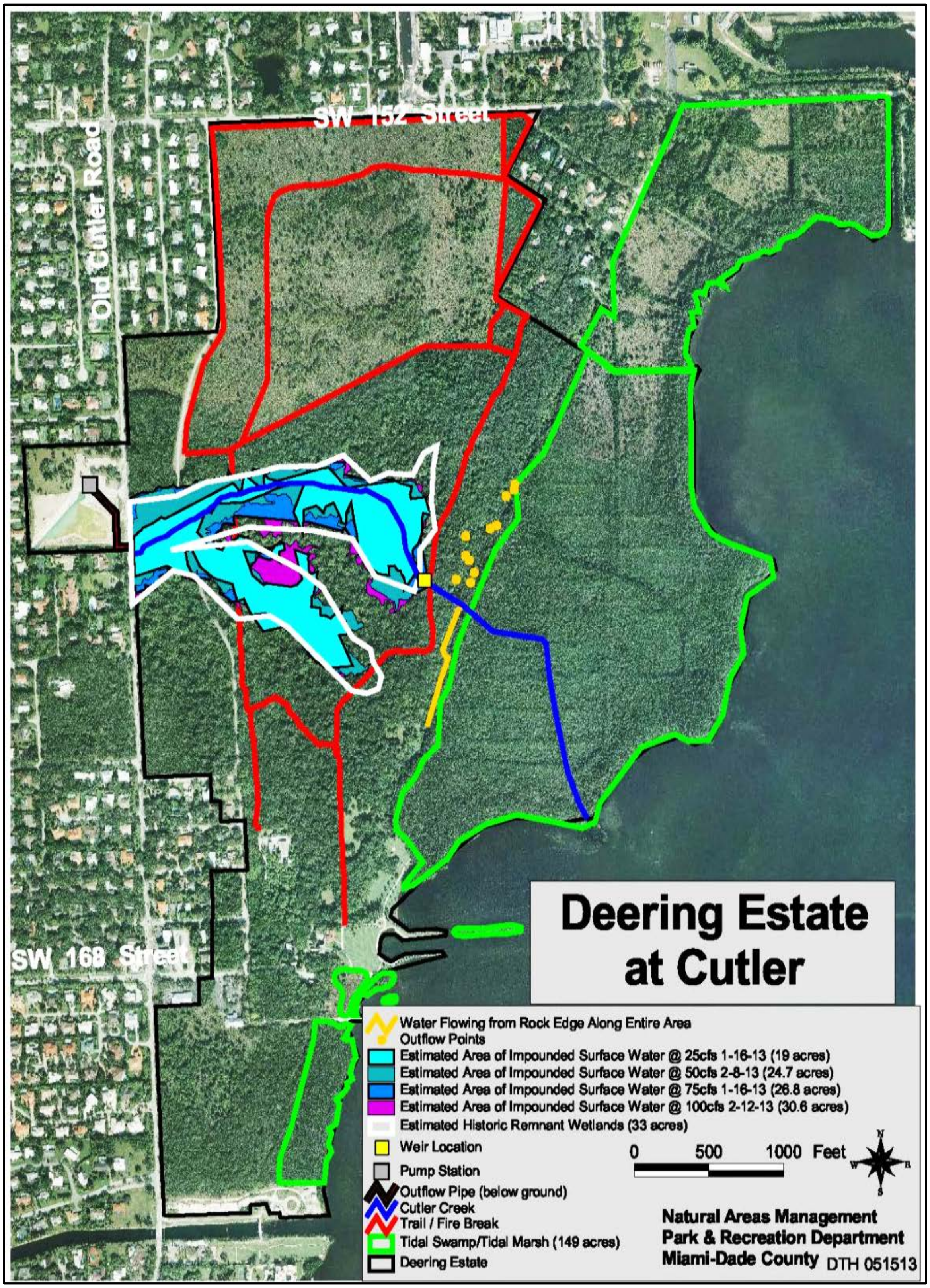


**Figure 20.** Delineation of the historical freshwater wetland slough in Deering Estate and areas of inundation at different pump rates.

## Surface Water Level within Cutler Creek

Surface water salinity responded to the pumped inputs of fresh water from pump station S-700 into the historic remnant wetlands within the vicinity of Cutler Creek (**Figure 21**). Salinity at both wetland staff gauges 1 and 3 decreased to less than 1 approximately six weeks after pumping had been initiated. Salinities remained at or near zero through most of the period of record after late January. The only exception was an increase to about 3 at staff gauge 3 in late March, which is likely in response to the cessation of S-700 pumping during that time.

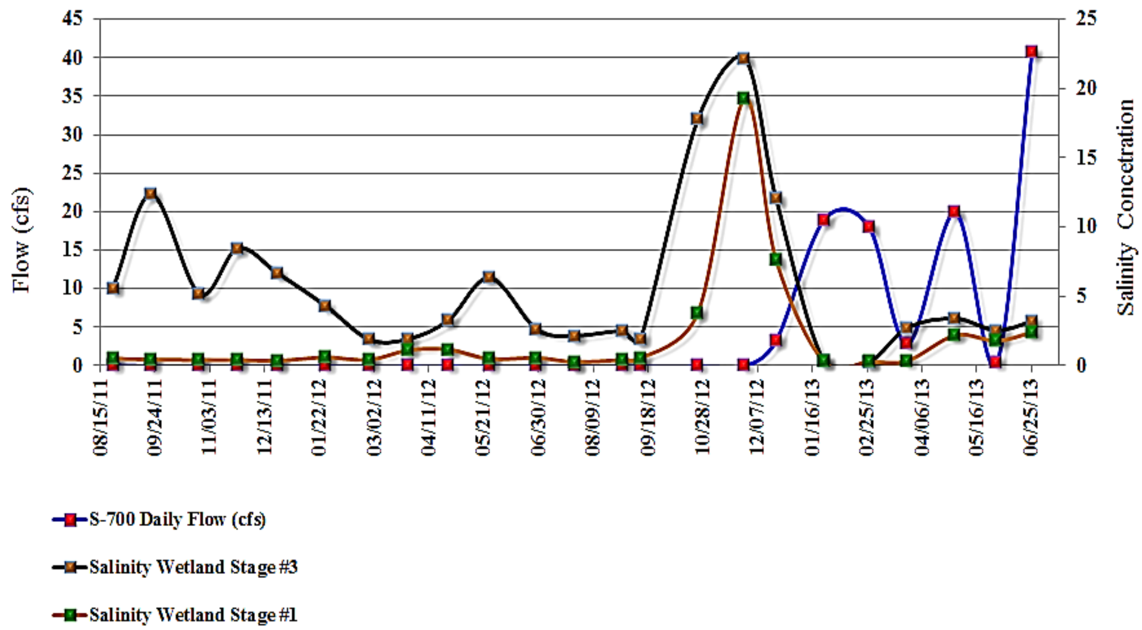


**Figure 21.** Surface water salinity concentration at staff gauges 1 and 3, upstream of the weir.

## Vegetation Monitoring within Cutler Creek

Changes have occurred in the vegetation communities within the historic remnant wetlands near Cutler Creek in the Deering Estate. Upland trees that had grown into the historic wetlands over the past several decades are beginning to die back (**Figure 22** and Attachment E: "Vegetation Changes" section). Some species, like Trema, Mastic, and Lancewood, appear to be dying quickly, while others are persisting, but in a weakened state and susceptible to pathogens.

Now that the rehydration project is bringing increased water levels back to the historic wetlands, a shift in vegetation is anticipated, with upland species being displaced by wetland species. The project team is in the process of establishing fixed photographic stations to document changes in vegetation communities in the vicinity of the historic remnant wetlands.

**Figure 22.** Changes in the vegetation communities and the beginnings of dieback of upland trees in the historic remnant wetlands within the vicinity of Cutler Creek in the Deering Estate in July 2013.

# HERBICIDE AND PESTICIDE TRACKING

## L-31E CULVERTS

Exotic plant species within the L-31E Culverts component were treated chemically (herbicides) and mechanically. During the reporting period, exotic vegetation within approximately 291 acres in the vicinity of the S-23A, S-23B, S-23C, and S-23D culverts were treated with herbicides, including Impel RED 15/85 (1.75 gallons), Aquapro (0.183 gallon), Terramark Blue Dye (0.026 gallon), and Subenergy (0.025 gallon). The dominant exotic species removed or treated were Australian pine (*Casuarina equisetifolia*), Brazilian pepper (*Schinus terebinthifolius*), day jessamine (*Cestrum diurnum*), and shoebutton ardisia (*Ardisia elliptica*). The application of herbicides was successful, and the District will continue to treat and manage exotic vegetation within the L-31E Culverts area.

## DEERING ESTATE FLOW-WAY

Exotic plant species within the Deering Estate historic wetland within the vicinity of Cutler Creek were treated chemically (herbicides) and mechanically. During the reporting period, exotic vegetation within approximately 33 acres in the vicinity of Cutler Creek were treated with herbicides, including Renovate mixed at 50 percent, 5 gallons.

# IMPLEMENTATION SCHEDULE

The L-31E Culverts and Deering Estate Flow-way are expedited components of the larger BBCW Project, which requires congressional authorization, anticipated to occur in or after 2015.

# PROBLEMS ENCOUNTERED

## L-31E CULVERTS

### Inlet and Outlet Issues

During routine maintenance inspections of the L-31E culverts in WY2012, it was determined that performance was being hindered by aquatic vegetation clogging the manatee barrier upstream of the culverts, and by accumulated sediment and silt blocking the flap gate downstream of the culverts.

### Freshwater Delivery through L-31E Culverts to Wetlands East of L-31E Canal

In delivering adequate fresh water to wetlands east of L-31E canal through the L-31E culverts, the project was able to meet or exceed its 4 percent diversion target during 6 months of the last two water years, but only able to divert a total of 2 percent in WY2013, of all the water available for diversion. Although the 4 percent overall target was not reached each water year, it is important to recognize that 5,110 acre-feet in WY2012, and 4,705 acre-feet in WY2013, of fresh water was diverted through the L-31E culverts to wetlands east of the L-31E levee.

## DEERING ESTATE FLOW-WAY

SFWMD initiated operation of the Deering Estate Pump Station (S-700) in March 2012, and then began the operational testing and monitoring phase. An evaluation of stage data upstream of S-700 indicated that it did not reach or exceed the original Pump-ON trigger [3.0 feet National

Geodetic Vertical Datum of 1929 (NGVD29)] during the initial 9 months of the operational testing and monitoring phase. As a result, the pump station operated infrequently, and did not meet the criteria of the preliminary operating manual (POM), dated February 2012.

The Deering Estate (S-700) upstream stage did not reach or exceed 3.0 feet NGVD29 daily average during this period, which supports the revisions of the Interim POM to lower the Pump-ON stage to 2.6 feet NGVD29 daily average.

# ACTION TAKEN TO ADDRESS PROBLEMS

## L-31E CULVERTS

### Inlet and Outlet Improvements

To resolve the inlet and outlet issues described earlier, and using the adaptive management concept for CERP projects, the District removed accumulated downstream sediment, ensured that the depth of each downstream sump relative to each pipe invert closely matches the depths depicted in the permitted design cross-sections, and installed floating debris barriers across the mouth of each culvert inlet channel. In May 2012, the District acquired approval from the USACE [BBCW-L-31E Culverts Maintenance Work-As-Built Certification Permit SAJ-1994-01327 (NW-AAZ)] and FDEP to initiate these activities, and completed them in August 2012.

### Freshwater Delivery through L-31E Culverts to Wetlands East of L-31E Canal

To deliver adequate fresh water through the L-31E culverts to wetlands east of the L-31E levee and meet the project's requirements, the District has identified four project features that could be implemented. These features are combined into three projects named Projects A, B, and C, and were presented to the District's Governing Board for approval in July 2013. Due to the limited funding source, the District may initiate any or all of these projects. Descriptions of the projects are as follows:

- **Project A: Rehydration of Wetlands East of L-31E Canal.** This project involves diverting fresh water from the C-103 canal to the L-31E canal south of the C-103 canal through two new 30-inch corrugated metal pipe culverts to saltwater wetlands east of the L-31E canal. Components include the installation of a permanent 40-cfs pump with concrete housing and supervisory control and data acquisition (SCADA) telemetry and temporary plugs in the L-31E canal at the C-103 and North canals.

- **Project B: Rehydration of Wetlands East of L-31E Canal.** This project involves diverting fresh water from the C-103 canal to the L-31E canal north of the C-103 canal through four existing flap-gated culverts to saltwater wetlands east of the L-31E canal. Components include the installation of a permanent 40-cfs pump with concrete housing and SCADA telemetry and a temporary plug in the L-31E canal at the C-103 canal.

- **Project C: Rehydration of Wetlands East of L-31E Canal.** This project involves diverting fresh water from the C-102 canal through a 40-cfs pump and then through existing culverts to saltwater wetlands east of the L-31E canal. Components include the installation of a permanent 40-cfs pump with concrete housing and SCADA telemetry and a temporary plug in the L-31E Canal at the C-102 canal and one plug south of the C-102 canal at Waldin Drive.

## DEERING ESTATE

During the 2012–2013 dry season, and parallel to the operational testing and monitoring phase, SFWMD conducted two experimental operational pilot projects in southern Miami-Dade County to test the effectiveness of passing supplemental water flows into central Biscayne Bay through the C-1 and C-100 canals. A portion of the increased flow through the C-100 system was diverted to the coastal wetlands via the Deering Estate flow-way. Objectives of the tests were to assess the feasibility and effectiveness of rerouting water flows among the basins, and to gauge the effects on salinity in the nearshore waters of Biscayne Bay, as well as on coastal groundwater. Additional freshwater inflows to Biscayne Bay have the potential to lower or maintain salinity within a range that is healthy for the nearshore ecosystem.

Based on the results of the experimental operational pilot projects, and in an effort to meet the goals and objectives of the project, operational changes were made by lowering the Pump-ON stage at S-700 from 3.0 feet NGVD29 to 2.6 feet NGVD29. The District will submit to FDEP revision 2 of the BBCW Deering Estates Revised Interim 2014 Project Operating Manual, Deering Estate Flow-way Component of the Biscayne Bay Coastal Wetlands Project (permit 0271729-006).

# REFERENCES

Environment Canada. 1999. A Compendium of Environmental Quality Benchmarks. Environment Canada, Vancouver, British Columbia.

FDEP and SFWMD. 2011. A Protocol for Monitoring Mercury and Other Toxicants. Florida Department of Environmental Protection, Tallahasee, FL, and South Florida Water Management District, West Palm Beach, FL.

Newell, A.J., D.W. Johnson, and L.K. Allen. 1987. Niagara River biota contamination project-fish flesh criteria for piscivorous wildlife. Technical Report 87-3, New York State Department of Environmental Conservation, Division of Fish and Wildlife, Bureau of Environmental Protection, Albany, NY.

Newfields. 2006. Risk Based Screening Levels for Select Organochlorine Pesticides in Sediment and Fish Tissue. Prepared for South Florida Water Management District, West Palm Beach, FL.

USEPA. 2000. Guidance for Assessing Chemical Contaminant Data for Use in Fish Advisories, Volume 1: Fish Sampling and Analysis, (3rd edition). EPA 823-B-00-007, Office of Water, U.S. Environmental Protection Agency, Washington, DC.

# Attachment A:
# Specific Conditions and Cross-References

**Table A-1.** Specific conditions, actions taken, and cross-references presented in this report for the BBCW–L-31 E Culverts and Deering Estate Flow-way project (CERPRA permit 0271729-006).

| Specific Condition | Description | Applicable Phase | Action Taken | Included In This Report As: Narrative (page #s) | Figure | Table | Attachment |
|---|---|---|---|---|---|---|---|
| **15** | Operation of Passive Structures | Operation | Operation of passive structures was conducted as required | 33–41 | 9–13 | 14–17 | |
| **16** | Pump Station Operation | Operation | No action needed | 40 | 12–13 | | |
| **17** | Pump Station Testing and Maintenance | Operation | Done as required | | | | |
| **18** | Culvert Testing and Maintenance | Operation | Done as required | 56 | | | |
| **19** | Public Health, Safety, and Welfare | Operation | Discharges did not pose a serious danger to public health/safety/welfare | | | | |
| **20** | Water Quality Monitoring Program | Operation | Water quality monitoring plan submitted within 90 days before starting flow; water quality monitoring program conducted as required | 8–27 | 3–8 | 3–8 | B |
| **20A** | Quality Assurance and Quality Control | Operation | Done as required | 6 | | | B |
| **20B** | Method Detection Limits | Operation | Done as required | | | | B |
| **22** | Mercury & Other Toxicants: Monitoring Plan | Operation | Monitoring plan completed and submitted, and baseline data collected and evaluated, as required | 27–32 | | 10–13 | B |
| **23** | Removal of Parameters | Operation | No action needed | | | | |
| **24** | Addition of Parameters | Operation | No action needed | | | | |
| **26** | Annual Reports | Operation | Annual report completed and submitted as required | All | All | All | All |
| **26A** | Water Quality Data | Operation | Records include all required details | 8–32 | 3–8 | 3–13 | B |
| **26B** | Performance Evaluation | Operation | Annual performance evaluated and reported as required | All | All | All | All |
| **26C** | Annual Herbicide and Pesticide Tracking | Operation | Use of herbicides and pesticides tracked and reported as required | 55 | | | |
| **26D** | Implementation Schedules | All | No action needed | | | | |
| **27** | Permit Modifications | Operation | The FDEP approved modification 0271729-006 on 4/18/2013, which extended the permit expiration date to 4/18/2018. | | | 2 | |
| **28** | Permit Renewal | Operation | The FDEP approved modification 0271729-006 on 4/18/2013, which extended the permit expiration date to 4/18/2018. | | | 2 | |
| **29** | Department Review and Approval | Operation | No action needed | | | | |

# Attachment B: Water Quality Data

This project information is required by Specific Conditions 26A and 26C of the Biscayne Bay Coastal Wetlands – L-31 East Culverts and Deering Estate Flow-way permit (0271729-006), and is available upon request.

# Attachment C: Hydrologic Data

This project information is required by Specific Conditions 26A and 26B of the Biscayne Bay Coastal Wetlands – L-31 East Culverts and Deering Estate Flow-way permit (0271729-006), and is available upon request.

# Attachment D: Biscayne Bay Coastal Wetlands L-31E Culverts Annual Mitigation Monitoring Report

# SOUTH FLORIDA WATER MANAGEMENT DISTRICT

**Ref. No. 08212013-03**

August 21, 2013

Mr. Robert Kirby
Enforcement Section
U.S. Army Corps of Engineers
9900 SW 107th Ave, Suite 203
Miami, FL 33176

Dear Mr. Kirby:

**Subject: Biscayne Bay Coastal Wetland Project-L-31E Culverts**
**Permit No. SAJ-1994-1327 (IP-TKW) - 2nd Annual Mitigation Monitoring Report**

The U.S. Army Corps of Engineers issued the above referenced permit to the South Florida Water Management District on May 2, 2008, for the L-31E Culverts Project, a component of the Biscayne Bay Coastal Wetlands. In accordance with Special Condition 11(d), please find enclosed the 2nd Annual Mitigation Monitoring Report for Biscayne Bay Coastal Wetlands, L-31E Culverts.

If you have questions or need additional information, please contact Leslye Waugh at (561) 682-6483 or via email at lwaugh@sfwmd.gov.

Sincerely,

Nimmy S. Jeyakumar

Nimmy Jeyakumar
Section Administrator
Permit Acquisition & Compliance Section
Office of Everglades Policy & Coordination

NJ/am
Enclosure

c: Bahram Charkhian, SFWMD
Richard Fike, FWS
Jorge Jaramillo, SFWMD
Leslye Waugh, SFWMD

# Second Annual Mitigation Monitoring Report for Biscayne Bay Coastal Wetlands Project L-31E Culverts

USACE Permit Number: SAJ-1994-1327 (IP-TRW)

Prepared for

U. S. Army Corps of Engineers
Enforcement Section
P.O. Box 4970
Jacksonville, FL 33401

July 26, 2013

Prepared by


Bahram Charkhian

South Florida Water Management District
3301 Gun Club Road
West Palm Beach, Florida 33406

**Table 1.** Key permit-related information.

| | |
|---|---|
| **Project Name** | **Biscayne Bay Coastal Wetlands Project L-31E Flow-way** |
| **Permit Number** | **SAJ-1994-1327 (IP-TRW)** |
| **Issue Date** | May 2, 2008 |
| **Expiration Date for Construction** | November 13, 2012 |
| **Project Phase** | Operations |
| **Relevant Permit Conditions** | Special Conditions 9,10,11 and 12 |
| **Relevant Period of Record** | Second Annual Monitoring Report |
| **Report Generator** | **Bahram Charkhian**<br>561-682-2284<br>bcharkh@sfwmd.gov |
| **Permit Coordinator** | **Leslye Waugh**<br>561-682-6483<br>lwaugh@sfwmd.gov |
| **Permittee's Consultants** | Miami-Dade County Permitting, Environmental and Regulatory Affairs<br>**Stephen Blair and Josh Mahoney**<br>Miami-Dade County Park & Natural Areas Management and Open Spaces<br>**Dallas Hazelton** |
| **Directions to Project Site** | L-31E Culverts. Take FL-821S toward Homestead; take Exit 2 for NE 8th St/Campbell Dr. east. Turn right onto SW 137th Ave, turn left onto N Canal Dr. Turn left onto L-31E Levee at entrance to Biscayne National Park. |

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# LIST OF ATTACHMENTS

# PROJECT OVERVIEW

The U.S. Army Corps of Engineers (USACE) issued Permit Number SAJ-1994-1327 (IP-TKW) on May 15, 2008 to the South Florida Water Management District (SFWMD). The permit authorizes SFWMD to construct four flap-gated culverts collectively known as the L-31 East (L-31E) culverts (**Figure 1**), an early work element of the Biscayne Bay Coastal Wetlands (BBCW) Project, which is a component of the Comprehensive Everglades Restoration Plan (CERP).

The project is located along the L-31E canal, east of the L-31E levee, within the coastal wetlands of Biscayne Bay, in Sections 28 and 33, Township 56 south, Range 40 east, and in Sections 4, 9 and 16, Township 57 south, Range 40 east, in southeastern Miami-Dade County. The project site is bordered by Biscayne Bay to the east, the L-31E levee and canal to the west, C-102 canal to the north, and the C-103 canal to the south (**Figure 1**).

The L-31E culverts, in conjunction with future implementation of the L-31E flow-way, are intended to achieve several of the CERP objectives. The culverts and flow-way will improve distribution of fresh water to Biscayne Bay and Biscayne National Park, improve freshwater and estuarine habitat, improve salinity distribution within Biscayne Bay, and reestablish productive nursery habitat along the bay shoreline. The project's goal is to reestablish, at least in part, historical sheet flow and wetland hydroperiods downstream of the project area with the installation of flap-gated culverts at four locations along the L-31E canal.

It was anticipated that the project would result in 0.33 acres of impact to jurisdictional waters of the United States. Once construction was completed, only 0.03 acres of wetlands were actually impacted. According to Special Condition 9, these wetland impacts were to be offset by project benefits, which included enhancement to salinity concentrations, water stages, wetland vegetation, and algal composition within the wetland area affected by culvert water deliveries. This "mitigation enhancement area" is estimated to be about 1 acre for each culvert, 4 acres total for the project.

Construction of the culverts began on January 11, 2010, and was completed on June 10, 2010. Ecological monitoring commenced within 60 days of completion of the culverts in accordance with Special Condition 11 and the approved Ecological Monitoring Plan for the L-31E Project dated May 5, 2008. The baseline monitoring event was conducted in August 2010 and was followed by monthly monitoring events. The SFWMD completed the first annual mitigation monitoring event in January 2012. The monitoring events were conducted by SFWMD and Miami-Dade County Permitting, Environmental and Regulatory Affairs staff.


**Figure 1.** BBCW Project L-31E culverts.

# REQUIREMENTS

In accordance with Special Conditions 10 and 11 of USACE Permit Number SAJ-1994-1327 (IP-TKW) and the Ecological Monitoring Plan for the L-31E Project dated May 5, 2008, SFWMD will perform monthly monitoring events and report annually on the L-31E Project benefits based on the following performance standards:

- **Aquatic Food Web Monitoring:** Improvement of the aquatic food web, including establishment of appropriate wetland periphyton communities that reflect an increasing salinity gradient from the culverts eastward to the shoreline. No increase in pollution tolerant plant species, or elimination or reduction of existing desirable species.
- **Vegetation Monitoring:** Less than 5 percent cover of Category I and II invasive exotic plant species, pursuant to the most current list established by the Florida Exotic Pest Plant Council, within the mitigation enhancement areas.
- **Water Level and Flow Monitoring:** Hydrologic enhancement by redirecting flow from coastal canals to the coastal wetlands at the culvert delivery points. The project is anticipated to capture approximately 4 percent of the available water from the major conveyance canals (C-102 and C-103) and redistribute the water at the culvert locations, thereby recreating/restoring remnant tidal creeks or portions of these creeks or associated wetland areas.
- **Water Physiochemical Monitoring:** Improvement of salinity concentrations in coastal wetlands so they become more suitable and hypersaline zones are reduced. The direction and movement of the salinity gradient of restored tidal creeks in interior wetlands will be measured for characteristics of an estuarine system.

To evaluate project performance, the following data will be collected on a monthly basis:

- Water quality samples and physiochemical data (specific conductance, dissolved oxygen, pH, temperature, and [calculated] salinity) collected at eight locations:
    - Upstream of culvert S-23A
    - Immediately downstream of culvert S-23A
    - 50 meters downstream of culvert S-23A
    - 100 meters downstream of culvert S-23A
    - Upstream of culvert S-23D
    - Immediately downstream of culvert S-23D
    - 50 meters downstream of culvert S-23D
    - 100 meters downstream of culvert S-23D
- Water level (stage gauges) monitoring at the following locations:
    - Upstream and downstream of water control structures S-21A, S-20G and S-20F
    - Upstream and downstream of culverts S-23A and S-23D
    - 100 meters downstream of culverts S-23A and S-23D
- Calculated flow through culverts S-23A, S-23B, S-23C and S-23D.
- Vegetation cover by species along 100-meter transects east of the levee at culverts S-23A and S-23D, and height of 10 dwarf *Rhizophora mangle* (red mangrove) trees along transect S-23D.

# SUMMARY DATA

## Aquatic Food Web Monitoring

During the last two annual reporting periods, pollution tolerant plant species did not increase nor were desirable species eliminated or reduced. Wetland periphyton communities were not observed within the vicinity of culverts S-23A and S-23D. However, various species of birds, amphibians, invertebrates, fish and reptiles were observed within the vicinity of culverts S-23A and S-23D (**Table 2**).

**Table 2.** List of species observed within the vicinity of culverts S-23A and S-23D during the first and second year of routine ecological monitoring.

| Location | First Year | | Second Year | |
|---|---|---|---|---|
| | Species | Common Name | Species | Common Name |
| **Culvert S-23A** | | | | |
| Invertebrates | *Cardisoma guanhumi* | blue land crab | *Cardisoma guanhumi* | blue land crab |
| | *Gonatista grisea* | grizzled mantid | | |
| Amphibians | *Osteopilus septentrionalis* | Cuban tree frog | *Osteopilus septentrionalis* | Cuban tree frog |
| Reptiles | *Nerodia fasciata* | banded water snake | *Nerodia fasciata* | banded water snake |
| | | | *Agkistrodon piscivorus* | water moccasin |
| Birds | *Butorides virescens* | little green heron | *Butorides virescens* | little green heron |
| | *Dumetella carolinensis* | gray catbird | *Dumetella carolinensis* | gray catbird |
| Fish | | | *Caranx hippos* | crevalle jack |
| **Culvert S-23D** | | | | |
| Invertebrates | *Callinectes sapidus* | blue crab | *Callinectes sapidus* | blue crab |
| Reptiles | *Nerodia fasciata* | banded water snake | *Nerodia fasciata* | banded water snake |
| | | | *Kinosternon baurii* | striped mud turtle |
| | | | *Agkistrodon piscivorus* | water moccasin |
| Birds | *Ardea alba* | great egret | *Ardea alba* | great egret |
| | *Ardea Herodias* | great blue heron | *Ardea Herodias* | great blue heron |
| | *Butorides virescens* | little green heron | *Butorides virescens* | little green heron |
| Fish | *Cichla ocellaris* | butterfly peacock bass | *Cichla cellaris* | butterfly peacock bass |
| | *Cichlasoma urophthalmus* | Mayan cichlid | *Cichlasoma urophthalmus* | Mayan cichlid |
| | *Eucinostomus californiensis* | graceful mojarra | *Eucinostomus californiensis* | graceful mojarra |
| | *Eucinostomus melanopterus* | flagfin mojarra | *Eucinostomus melanopterus* | flagfin mojarra |
| | *Gambusia holbrooki* | eastern mosquitofish | *Gambusia holbrooki* | eastern mosquitofish |
| | *Poecilia latipinna* | sailfin molly | *Poecilia latipinna* | sailfin molly |
| | | | *Centropomus undecimalis* | common snook |
| | *Floridichthys carpio* | goldspotted killifish | *Floridichthys carpio* | goldspotted killifish |
| | *Mugil curema* | white mullet | *Mugil curema* | white mullet |
| | *Strongylura marina* | Atlantic needlefish | *Strongylura marina* | Atlantic needlefish |

## Vegetation Monitoring

Vegetation monitoring was implemented to detect changes in the composition of vegetation in response to increased freshwater flows from the culverts to the coastal wetlands. The project area is also monitored for Category I and II invasive exotic plant species. The SFWMD conducted monthly vegetation monitoring, between October 2010 and June 2013, along two 100-meter transects downstream of culverts S-23A and S-23D (**Figure 2**) to document the composition and coverage of vascular plant species found in the groundcover (**Table 3** and **Figures 3** and **4**) and canopy (**Tables 4** through **12** and **Figures 5** through 7) strata.

The line-intercept method was used to document all vascular plant species along a 100-meter transect in the canopy (greater than 4.5 feet) and the groundcover (less than or equal to 4.5 feet) strata within the transitional mangrove forest located downstream of culvert S-23A (**Tables 3** through **7** and **Figure 3** through **7**). The canopy stratum consists primarily of *R. mangle*, *Conocarpus erectus* (buttonwood), *Laguncularia racemosa* (white mangrove), *Annona glabra* (pond apple), and *Rhabdadenia biflora* (mangrovevine). The groundcover stratum is dominated by *Acrostichum aureum* (golden leather fern) and *R. mangle*. The combination of shading by moderate to dense canopy cover combined with dense cover by *A. aureum* in the groundcover appears to preclude the development of a wetland graminoid or herbaceous community in the monitoring area. *Bacopa monnieri* (smooth water hyssops), a herbaceous wetland plant, was observed during several events but its distance from the culvert and ephemeral presence at the monitoring site appear to indicate a more random occurrence rather than a result of recently modified hydrology.

The above referenced methodology was also used to document plant species and species cover in the scrub *R. mangle* habitat located downstream of culvert S-23D (**Tables 8** and **9**). This system is comprised almost entirely (approximately 78 percent) of dwarfed *R. mangle* with occasional *L. racemosa* and *Utricularia foliosa* (leafy bladderwort) near the culvert basin. Monitoring data collected during the last two years indicate a slight decrease ($R^2$=0.414) in areal coverage of *R. mangle*, possible due to freezing and cold temperature in winter 2011 (**Attachment C**, **Figure C-12**), and a slight decrease in percentage of vegetation coverage of *R. mangle* within vegetation transect S-23A, which is downstream of culvert S-23A. No changes were observed in percentage of canopy coverage of vegetation downstream of culvert S-23A except for a slight increase in percentage of canopy coverage of *R. mangle*. No changes were observed in the vegetation community within the S-23D transect, which is downstream of the S-23D culvert, after two years of data collection. No change was expected in this area.

In addition to vegetation percent cover, the height of dwarf *R. mangle* trees along transect S-23D are monitored on a monthly basis. Statistical analysis of monitoring data collected indicates no change in the height of the ten *R. mangle* individuals located at each of the following locations—start (5 meters), middle (50 meters), and end (100 meters) along vegetation transect S-23D (**Figures 8** through **10**).

Based on field observations and review of the monitoring data collected during the last two years of ecological monitoring, there has not been a major change in the composition and coverage of vascular plants downstream of the S-23A and S-23D culverts. The comparison of two years of vegetation data is shown in (**Tables 3** through **9** and **Figures 3** through **10**).

During this reporting period, the percent of coverage of Category I and II invasive plant species based on the Florida Exotic Pest Plant Council's 2009 List of Invasive Plant Species was less than 5 percent. Additionally, chemical and mechanical treatment of exotic plant species was conducted over the past two years within approximately 291 acres of the project site (**Table 10** and **Figure 11**).

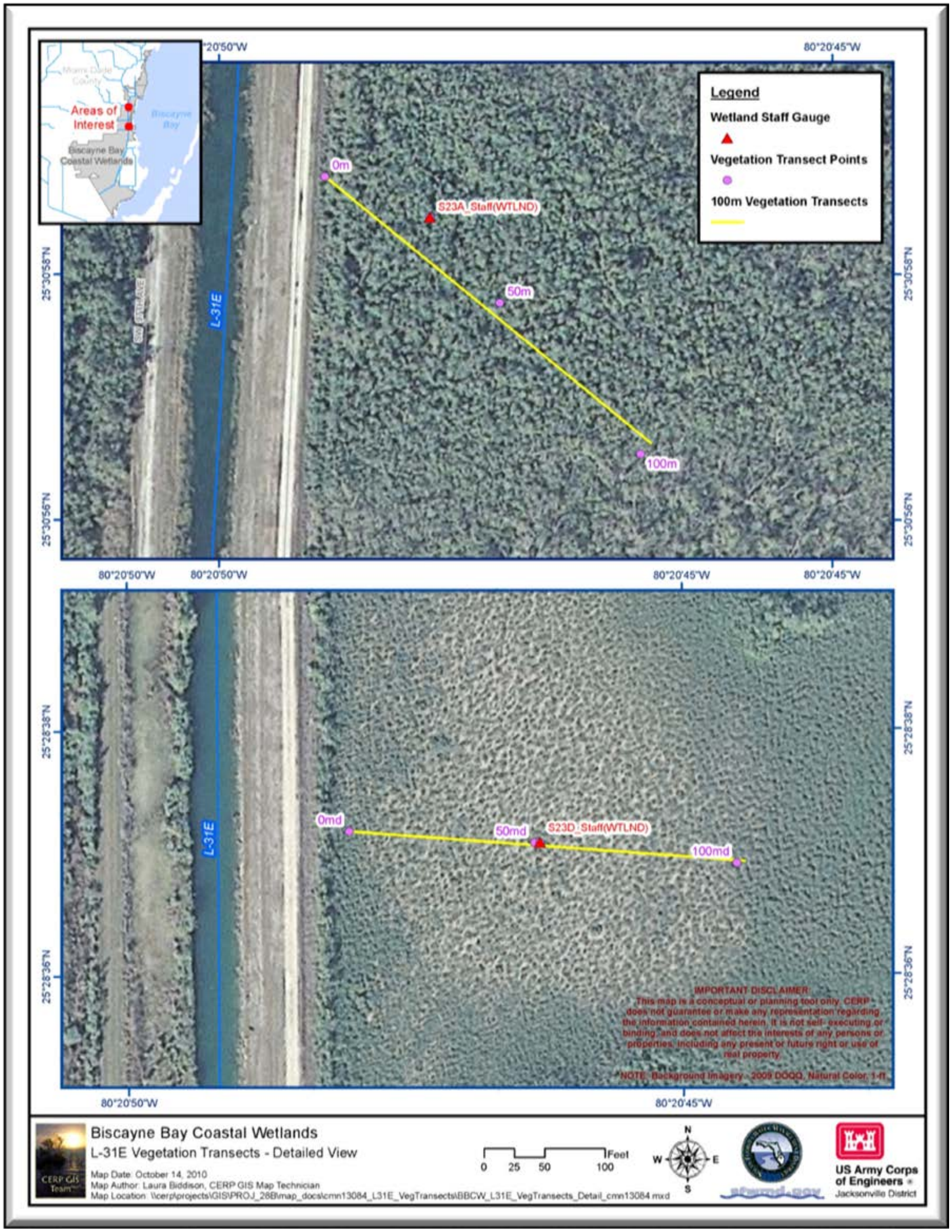


**Figure 2.** Location of 100-meter transects east of the levee at culverts S23-A (top) and S-23D (bottom).

**Table 3.** Comparison of *A. glabra* percent groundcover vegetation within transect S-23A

| Descriptive Statistics | S-23A Vegetation Transect *A. glabra* Percent Canopy Coverage | | | | |
|---|---|---|---|---|---|
| | Water Year 2011 | Water Year 2012 | | Water Year 2013 | |
| | Dry Season | Wet Season | Dry Season | Wet Season | Dry Season |
| | 3.80% | 2.80% | 4.60% | 2.80% | 3.30% |
| | 3.60% | 2.70% | 5.30% | 8.20% | 4.50% |
| | 2.80% | 0.60% | 3.80% | 4.80% | 0.80% |
| | 3.20% | 2.70% | 3.30% | 3.10% | 1.20% |
| | 1.40% | 3.00% | 1.50% | 4.30% | 3.70% |
| | 2.90% | 2.50% | 2.90% | 3.00% | 1.70% |
| Mean | 2.95% | 2.38% | 3.57% | 4.37% | 2.53% |
| Standard Deviation | 0.85% | 0.89% | 1.34% | 2.04% | 1.50% |
| 1st Quartile | 2.68% | 2.34% | 2.78% | 2.98% | 1.17% |
| Median | 3.05% | 2.70% | 3.55% | 3.70% | 2.50% |
| 3rd Quartile | 3.62% | 2.82% | 4.66% | 5.08% | 3.77% |
| Interquartile Range | 0.93% | 0.48% | 1.88% | 2.10% | 2.60% |

**Table 4.** Comparison of *C. erectus* percent canopy coverage within transect S-23A.

| Descriptive Statistics | S-23A Vegetation Transect *C. erectus* Percent Canopy Coverage | | | | |
|---|---|---|---|---|---|
| | Water Year 2011 | Water Year 2012 | | Water Year 2013 | |
| | Dry Season | Wet Season | Dry Season | Wet Season | Dry Season |
| | 74.90% | 65.40% | 49.50% | 65.40% | 59.30% |
| | 72.10% | 33.80% | 53.80% | 62.70% | 55.40% |
| | 73.00% | 47.50% | 62.30% | 57.30% | 45.70% |
| | 73.40% | 63.10% | 55.00% | 68.10% | 53.30% |
| | 59.60% | 47.50% | 59.70% | 68.00% | 57.70% |
| | 67.70% | 63.20% | 60.30% | 59.00% | 73.90% |
| Mean | 70.12% | 53.42% | 56.77% | 63.42% | 57.55% |
| Standard Deviation | 5.70% | 12.55% | 4.83% | 4.57% | 9.31% |
| 1st Quartile | 67.03% | 46.36% | 53.44% | 58.86% | 52.67% |
| Median | 72.55% | 55.30% | 57.35% | 64.05% | 56.55% |
| 3rd Quartile | 73.53% | 63.38% | 60.47% | 68.01% | 60.52% |
| Interquartile Range | 6.50% | 17.03% | 7.03% | 9.15% | 7.85% |

**Table 5.** Comparison of *L. racemosa* percent canopy vegetation within transect S-23A.

| Descriptive Statistics | S-23A Vegetation Transect *L. racemosa* Percent Canopy Coverage | | | | |
|---|---|---|---|---|---|
| | Water Year 2011 | Water Year 2012 | | Water Year 2013 | |
| | Dry Season | Wet Season | Dry Season | Wet Season | Dry Season |
| | 33.70% | 47.40% | 54.30% | 47.40% | 48.30% |
| | 31.80% | 61.90% | 16.70% | 56.80% | 40.50% |
| | 28.30% | 27.40% | 38.10% | 37.40% | 52.90% |
| | 29.10% | 44.50% | 59.30% | 52.50% | 42.00% |
| | 37.60% | 50.10% | 51.40% | 51.90% | 46.50% |
| | 42.80% | 52.20% | 52.30% | 37.80% | 37.70% |
| Mean | 33.88% | 47.25% | 45.35% | 47.30% | 44.65% |
| Standard Deviation | 5.51% | 11.39% | 15.70% | 8.08% | 5.61% |
| 1st Quartile | 29.03% | 43.08% | 36.32% | 37.77% | 40.27% |
| Median | 32.75% | 48.75% | 51.85% | 49.65% | 44.25% |
| 3rd Quartile | 38.03% | 53.01% | 54.72% | 52.86% | 48.68% |
| Interquartile Range | 9.00% | 9.93% | 18.40% | 15.09% | 8.42% |

**Table 6.** Comparison of *R. mangle* percent canopy vegetation within transect S-23A.

| Descriptive Statistics | S-23A Vegetation Transect *R. mangle* Percent Canopy Coverage | | | | |
|---|---|---|---|---|---|
| | Water Year 2011 | Water Year 2012 | | Water Year 2013 | |
| | Dry Season | Wet Season | Dry Season | Wet Season | Dry Season |
| | 74.90% | 73.80% | 83.90% | 73.80% | 72.90% |
| | 72.10% | 76.50% | 78.10% | 75.40% | 76.40% |
| | 73.00% | 73.40% | 74.50% | 71.90% | 70.40% |
| | 73.40% | 76.30% | 69.80% | 74.60% | 75.90% |
| | 59.60% | 69.40% | 74.10% | 75.80% | 73.20% |
| | 67.70% | 76.00% | 74.60% | 74.50% | 70.30% |
| Mean | 70.12% | 74.23% | 75.83% | 74.33% | 73.18% |
| Standard Deviation | 5.70% | 2.71% | 4.75% | 1.39% | 2.60% |
| 1st Quartile | 67.03% | 73.07% | 73.74% | 73.64% | 70.39% |
| Median | 72.55% | 74.90% | 74.55% | 74.55% | 73.05% |
| 3rd Quartile | 73.53% | 76.32% | 78.58% | 75.43% | 75.94% |
| Interquartile Range | 6.50% | 3.25% | 4.84% | 1.79% | 5.55% |

**Table 7.** Comparison of *R. biflora* percent canopy vegetation within transect S-23A.

| Descriptive Statistics | S-23A Vegetation Transect *R. biflora* Percent Canopy Coverage | | | | |
|---|---|---|---|---|---|
| | Water Year 2011 | Water Year 2012 | | Water Year 2013 | |
| | Dry Season | Wet Season | Dry Season | Wet Season | Dry Season |
| | 4.80% | 3.10% | 5.00% | 3.10% | 8.00% |
| | 3.50% | 0.20% | 0.70% | 4.60% | 6.30% |
| | 3.00% | 0.00% | 3.00% | 4.30% | 7.10% |
| | 2.00% | 3.10% | 9.40% | 6.40% | 0.00% |
| | 5.20% | 2.10% | 6.30% | 4.20% | 0.00% |
| | 4.00% | 4.10% | 13.00% | 5.70% | 0.00% |
| Mean | 3.75% | 2.10% | 6.23% | 4.72% | 3.57% |
| Standard Deviation | 1.18% | 1.67% | 4.44% | 1.17% | 3.94% |
| 1st Quartile | 2.92% | 0.18% | 2.81% | 4.11% | 0.00% |
| Median | 3.75% | 2.60% | 5.65% | 4.45% | 3.15% |
| 3rd Quartile | 4.83% | 3.18% | 9.70% | 5.76% | 7.18% |
| Interquartile Range | 1.92% | 3.00% | 6.89% | 1.65% | 7.18% |

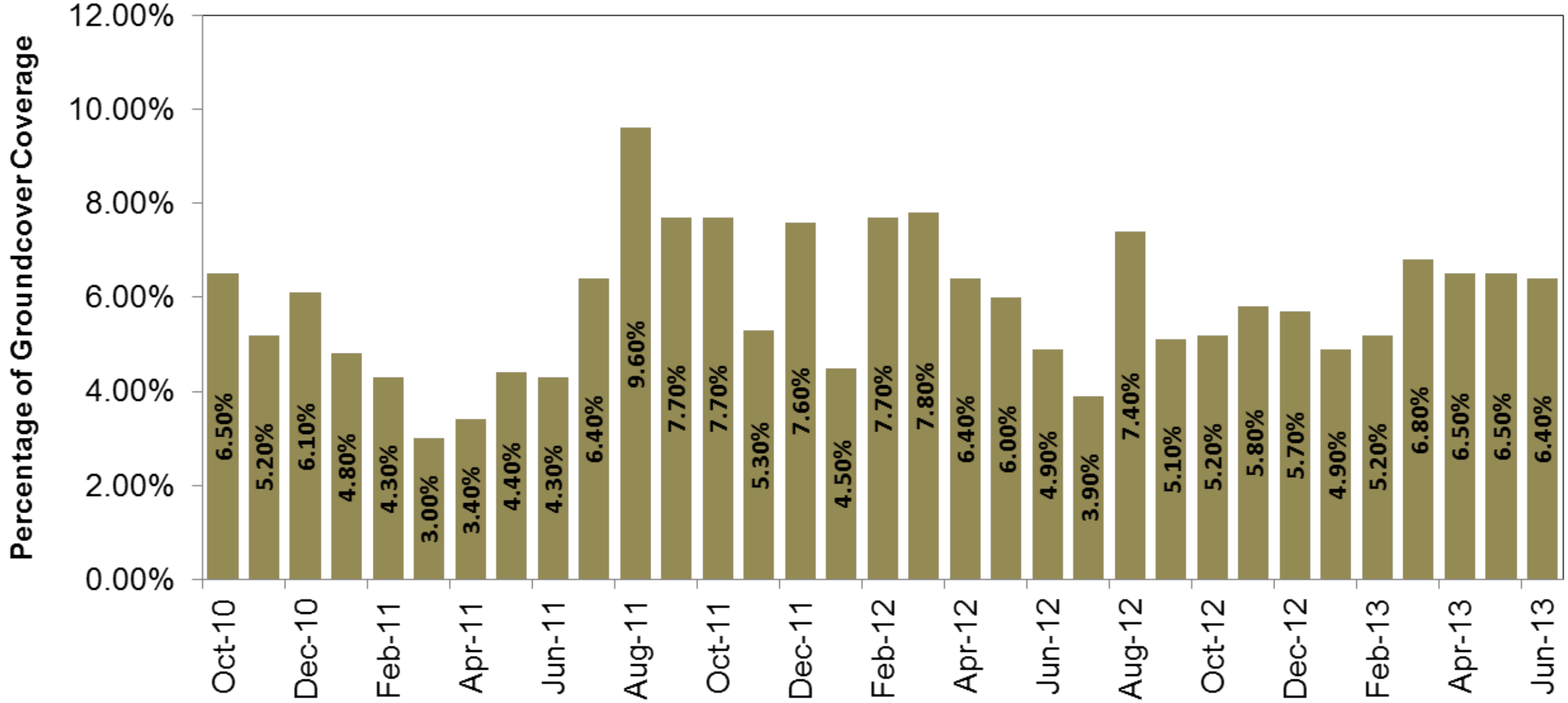


**Figure 3.** *C. erectus* percentage of ground cover within the vicinity of transect S-23A.

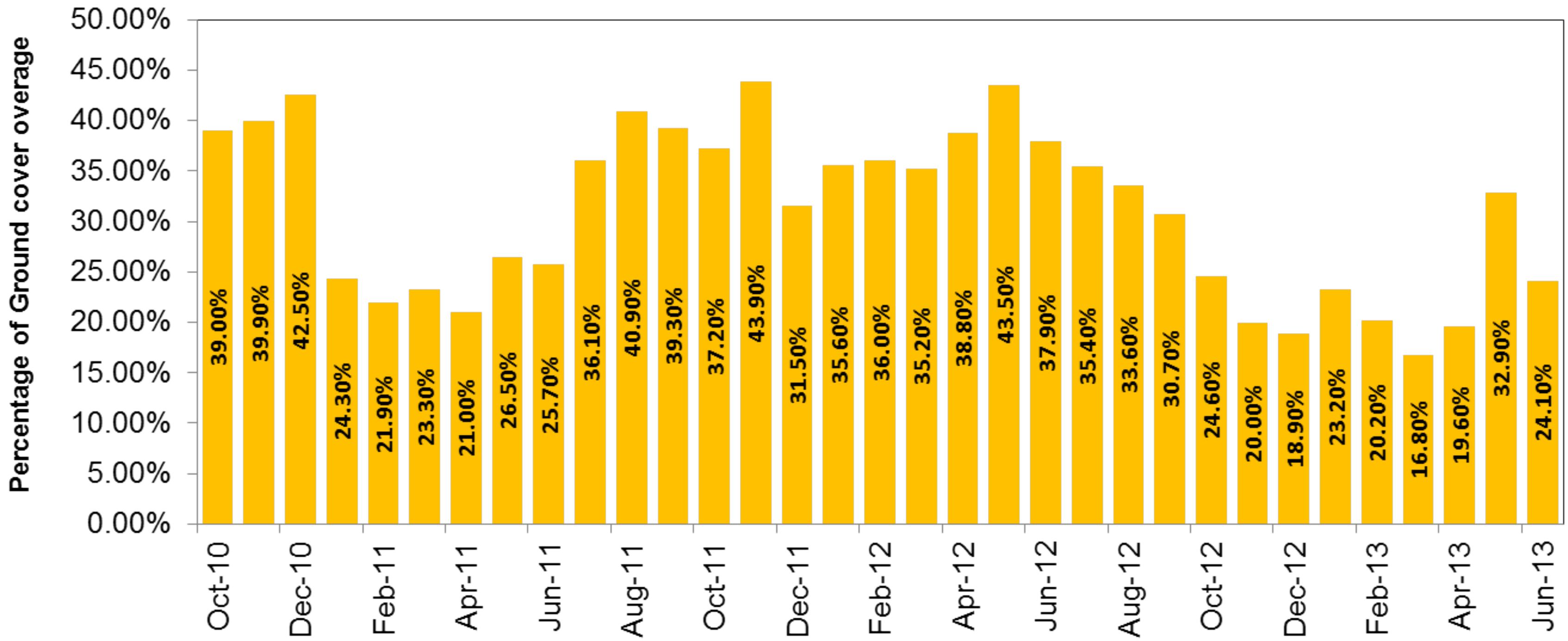


**Figure 4.** *A. glabra* percentage of groundcover cover within the vicinity of transect S-23A.

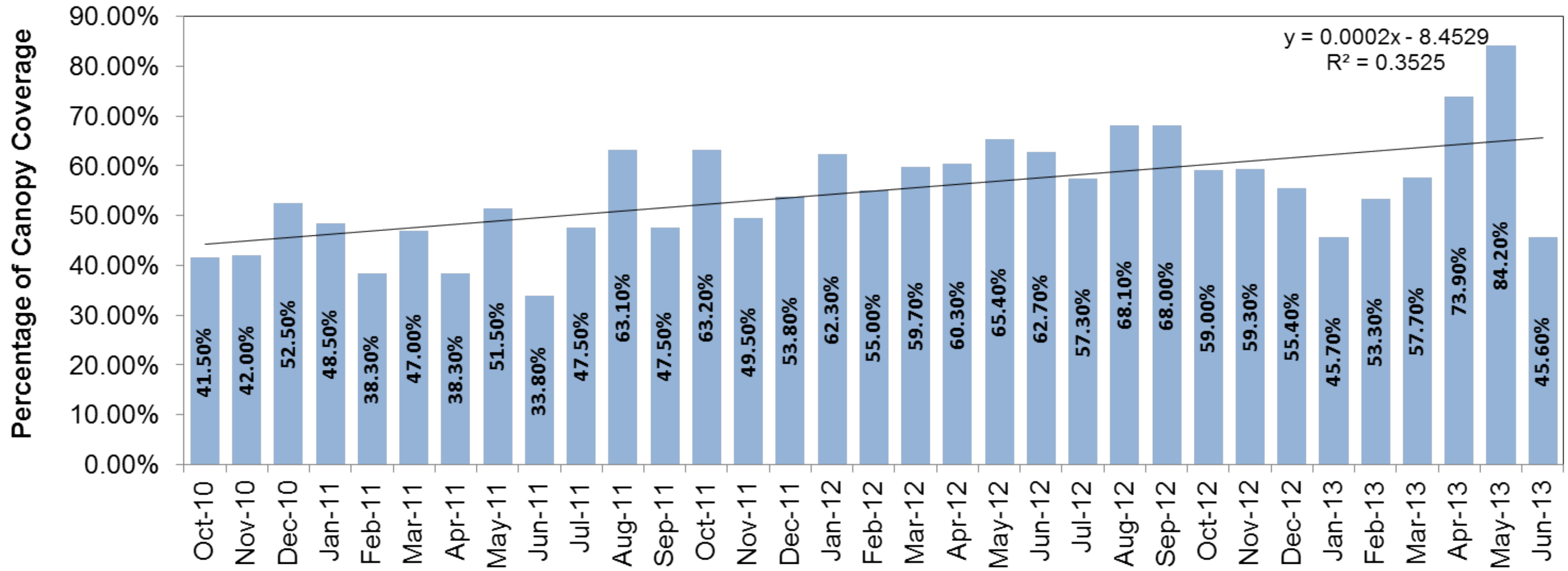


**Figure 5.** *C. erectus* percentage of canopy coverage within the vicinity of transect S-23A.

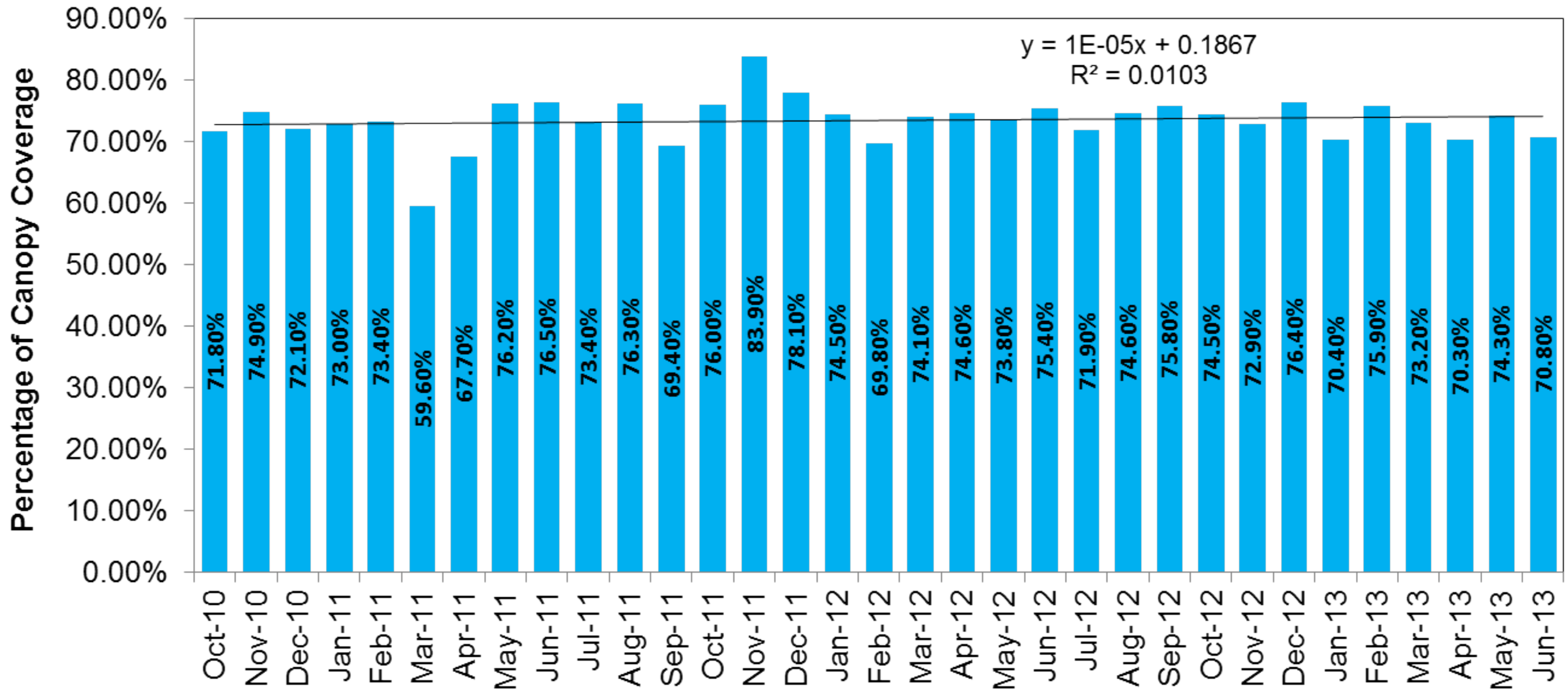


**Figure 6.** *R. mangle* percentage of canopy coverage within the vicinity of transect S-23A.

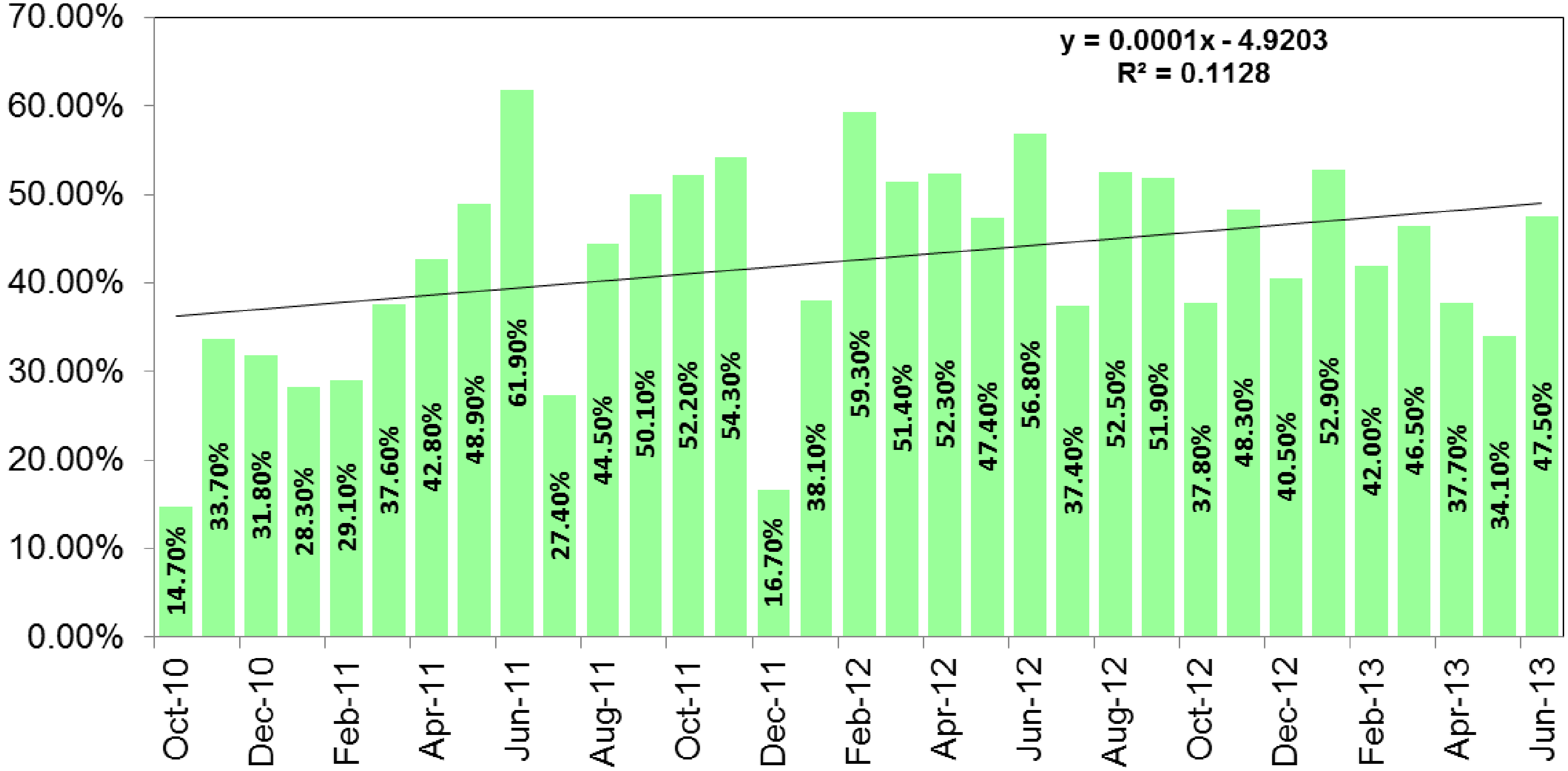


**Figure 7.** *L. racemosa* percentage of canopy coverage within the vicinity of transect S-23A.

**Table 8.** Comparison of *R. mangle* percent canopy vegetation within transect S-23D.

| Descriptive Statistics | S-23A Vegetation Transect *R. mangle* Percent Canopy Coverage | | | | |
|---|---|---|---|---|---|
| | Water Year 2011 | Water Year 2012 | | Water Year 2013 | |
| | Dry Season | Wet Season | Dry Season | Wet Season | Dry Season |
| | 81.00% | 84.00% | 67.30% | 74.60% | 72.80% |
| | 79.60% | 74.30% | 71.90% | 72.80% | 70.10% |
| | 78.20% | 74.60% | 71.30% | 72.40% | 60.80% |
| | 80.90% | 71.00% | 74.40% | 72.90% | 76.90% |
| | 80.40% | 75.40% | 72.10% | 71.20% | 70.00% |
| | 76.80% | 75.60% | 72.20% | 60.80% | 65.00% |
| Mean | 0.79 | 0.76 | 0.72 | 0.71 | 0.69 |
| Standard Deviation | 0.02 | 0.04 | 0.02 | 0.05 | 0.06 |
| 1st Quartile | 0.78 | 0.74 | 0.71 | 0.7 | 0.65 |
| Median | 0.8 | 0.75 | 0.72 | 0.73 | 0.7 |
| 3rd Quartile | 0.81 | 0.76 | 0.72 | 0.73 | 0.73 |
| Interquartile Range | 0.03 | 0.02 | 0.01 | 0.03 | 0.08 |

**Table 9.** Comparison of *L. racemosa* percent canopy vegetation within transect S-23D.

| Descriptive Statistics | S-23A Vegetation Transect *L. racemosa* Percent Canopy Coverage | | | | |
|---|---|---|---|---|---|
| | Water Year 2011 | Water Year 2012 | | Water Year 2013 | |
| | Dry Season | Wet Season | Dry Season | Wet Season | Dry Season |
| | 0.00% | 0.00% | 0.20% | 0.20% | 0.20% |
| | 0.00% | 0.00% | 0.00% | 0.00% | 0.20% |
| | 0.00% | 0.20% | 0.30% | 0.00% | 0.00% |
| | 0.00% | 0.20% | 0.20% | 0.00% | 0.10% |
| | 0.40% | 0.30% | 0.20% | 0.00% | 0.00% |
| | 0.40% | 0.20% | 0.20% | 0.20% | 0.00% |
| Mean | 0 | 0 | 0 | 0 | 0 |
| Standard Deviation | 0 | 0 | 0 | 0 | 0 |
| 1st Quartile | 0 | 0 | 0 | 0 | 0 |
| Median | 0 | 0 | 0 | 0 | 0 |
| 3rd Quartile | 0 | 0 | 0 | 0 | 0 |
| Interquartile Range | 0 | 0 | 0 | 0 | 0 |

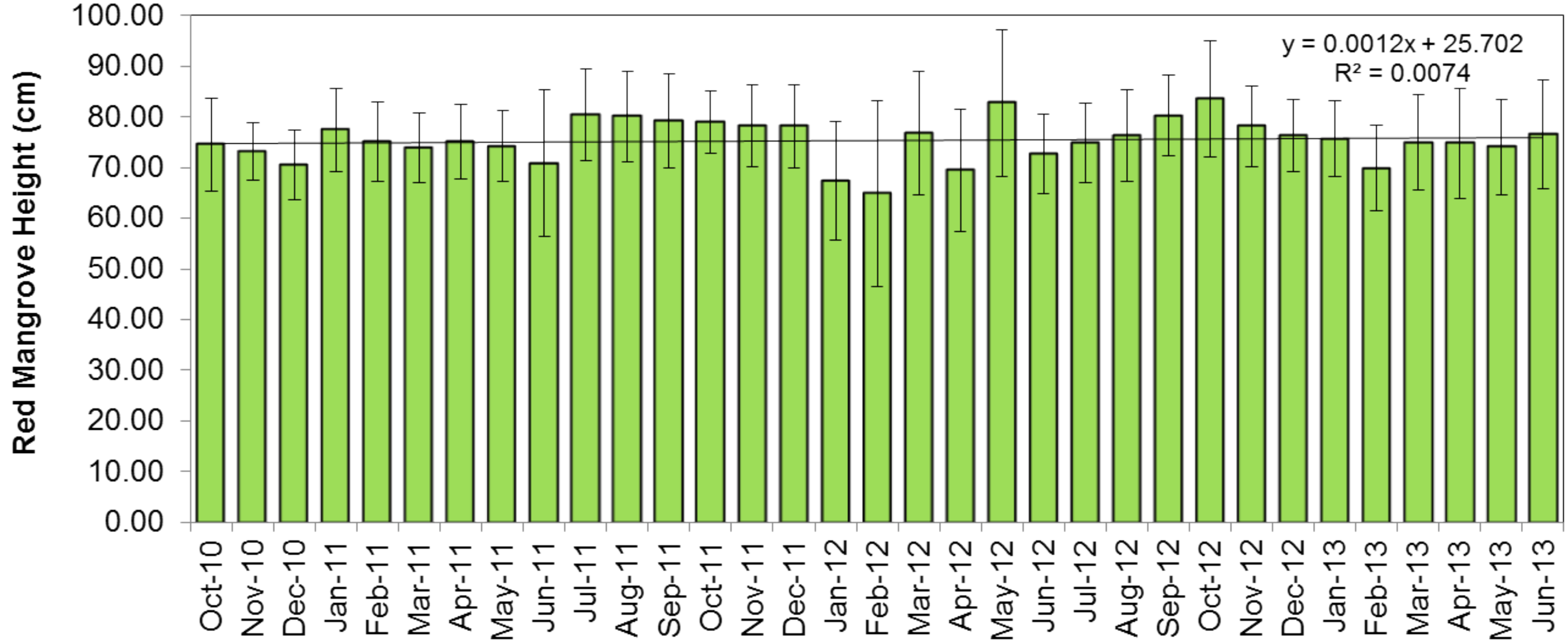


**Figure 8.** Average height in centimeters (cm) of *R. mangle* 5 meters downstream of culvert S-23D.

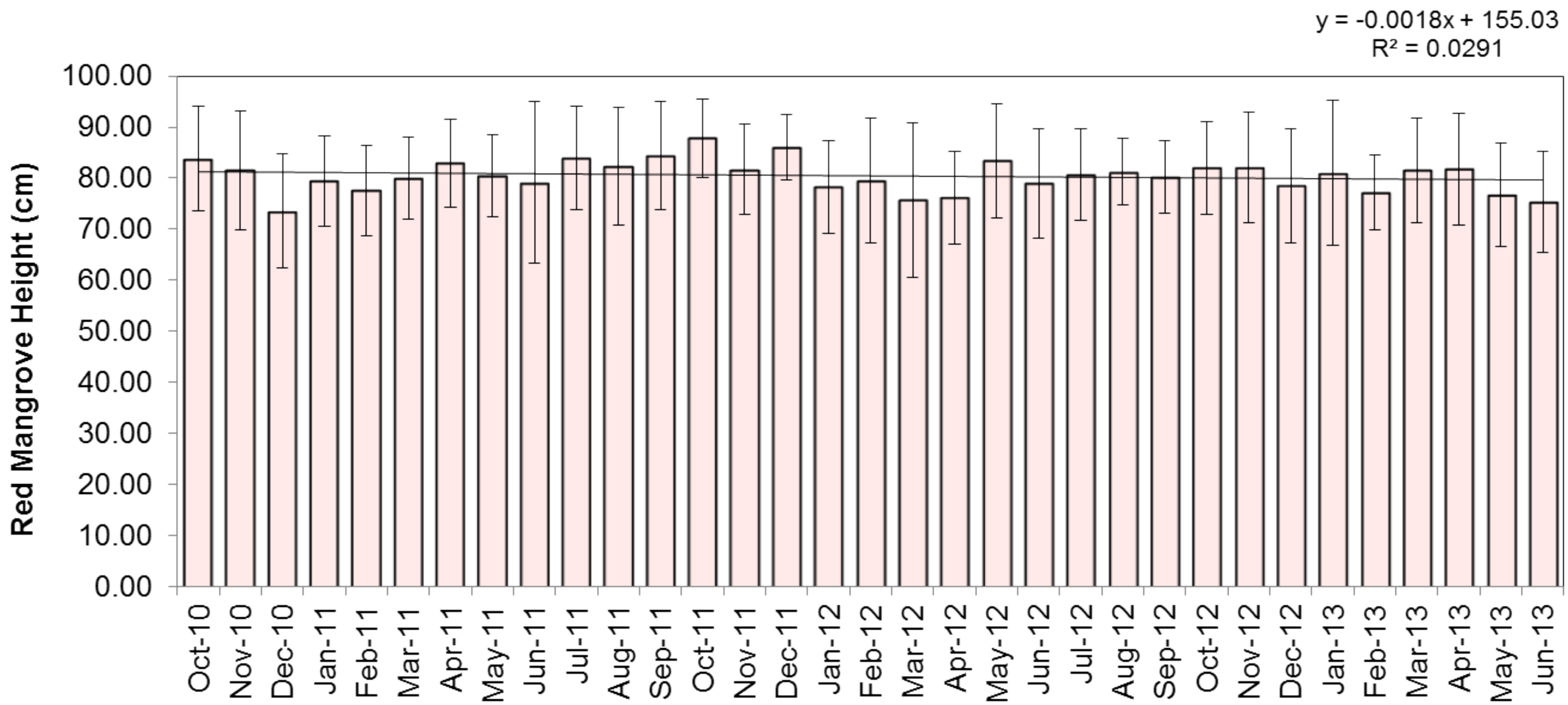


**Figure 9.** Average height of *R. mangle* 50 meters downstream of culvert S-23D.

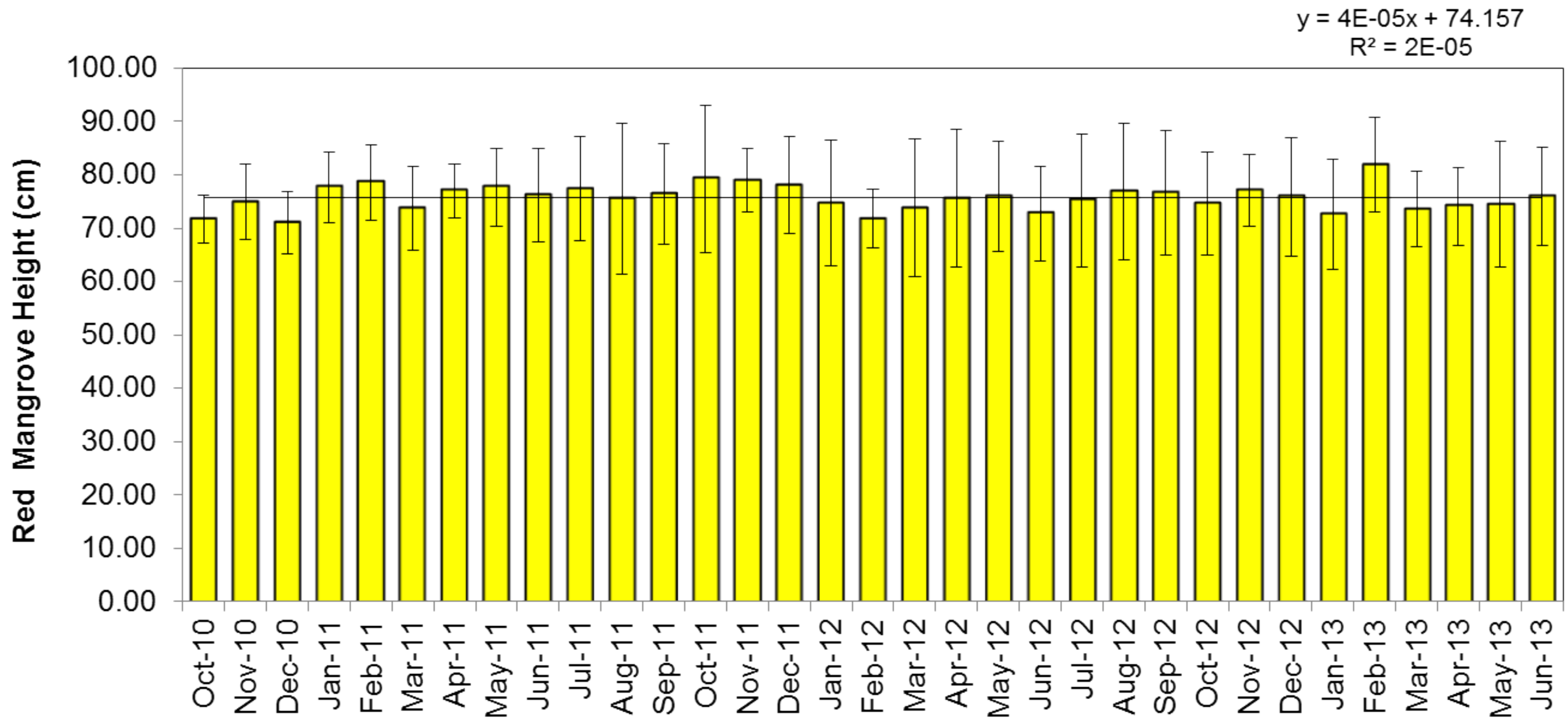


**Figure 10.** Average height of *R. mangle* 100 meters downstream of culvert S-23D.

**Table 10.** Summary of total acres of chemical and mechanical treatment of exotic plant species within the vicinity of the L-31E flow-way.

| Date | Total Acres of Chemical and Mechanical Treatment of Exotic Plant Species | Dominant Exotic Species Removed |
|---|---|---|
| 2011 | 27 | *Ardisia elliptica* (Shoebutton ardisia)<br>*Casuarina equisetifolia* (Australian pine)<br>*Lygodium microphyllum* (Old World climbing fern)<br>*Cestrum diurnum* (Day-blooming jasmine)<br>*Schinus terebinthifolia* (Brazilian pepper) |
| 2012 | 239 | |
| 2013 | 25 | |
| **Total** | **291** | |

**Figure 11.** Chemical and mechanical treated area within the vicinity of the northern L-31E culverts.

## Water Level and Flow Monitoring

The L-31E culverts are passive structures intended to redirect flow from the L-31E canal and provide hydrologic enhancement to the adjacent BBCW. Beginning in August 2010, water levels were recorded on a monthly basis upstream and downstream of the S-23A and S-23D culverts, as well as at 100 meters downstream of the culverts along the wetland transects (**Tables 11** and **12**).

Special condition 10(C) of the USACE permit states that "the project is anticipated to capture approximately 4% of the available water from the main conveyance canals (C-102 and C-103)". The *percent capture*, is essentially the percentage of the total *available water* that has been diverted into the four project culverts (S-23A, S-23B, S-23C and S-23D) during any particular period of interest. *Available water* is limited to the water that would have historically been discharged via structures S-21A and S-20F, and is now equivalent to the sum of the discharges at S-21A, S-20F, and the four project culverts.

Because of their more frequent stage measurements (and close proximity), daily flow rates for culverts S-23A and S-23B were based on mean daily stages at structure S-21A, while daily flow rates for culverts S-23C and S-23D were based on mean daily stages at structure S-20F. More specifically, the mean daily flow rates at each of the four culverts were derived by manually entering the mean daily stage at the physically closest structure (S-21A or S-21F) into the design rating curve (**Attachment D**) and identifying the corresponding flow rate.

During the first annual reporting period, South Florida experienced extreme drought conditions. Beginning in October 2010, water levels along the transect downstream of culvert S-23A fell below the minimum level required for sampling and remained at or below this level through June 2011. From December 2010 through June 2011, November 2011 through December 2012, and November 2012 through March 2013, water levels along the transect downstream of culvert S-23D fell below the minimum level required for sampling. Once water began to flow in July 2011 through September 2011 and May 2012 through October 2012 inundations were observed along the entire length of the transects with water depths approximately 12 to 24 inches along the transect downstream of culvert S-23D and 6 to 12 inches along the transect downstream of culvert S-23A (**Tables 11** and **12**, and **Figures 12** and **13**). The fluctuations in water levels do correspond to wet and dry season conditions.

From November 2012 through February 2013, the SFWMD diverted water to Biscayne Bay through spillway S-21A and S-20F within the vicinity of the BBCW Project L-31E culverts and water levels along the transects fell below the minimum level required for sampling. The optimum water level to divert adequate fresh water from the L-31E canal through the L-31E culverts to wetlands east of the L-31E levee is 0.6 feet North American Vertical Datum (ft NAVD).

The project was able to meet or exceed its 4 percent diversion target during 6 month of the last two water years in what water was available for diversion, but only able to divert a total of 3 percent in Water Year (WY) 2012, May 1, 2011-April 30, 2012, and 2 percent in WY 2013, May 1, 2012-April 30, 2013, of all water was available for the diversion (**Table 13**). Although the 4 percent overall target was not reached for each water year, it is important to recognize that 5,110 acre-feet in WY 2012 and 5,333 acre-feet in WY 2013 of fresh water was diverted through the L-31E culverts to wetlands east of the L-31E levee (**Table 13** and **Figure 14**).

**Table 11.** Summary of water levels recorded at the staff gauges near culvert S-23A.

| Period | Date | Stage Upstream of S-23A (ft NAVD) | Stage Downstream of S-23A (ft NAVD) | Stage 100 Meters Downstream of S-23A (ft NAVD) |
|---|---|---|---|---|
| WY 2011 Dry Season | 11/22/2010 | 0.00 | 0.00 | 0.00 |
| | 12/20/2010 | 0.00 | 0.00 | 0.00 |
| | 1/24/2011 | 0.00 | 0.00 | 0.00 |
| | 2/24/2011 | 0.15 | 0.15 | 0.00 |
| | 3/25/2011 | 0.04 | 0.04 | 0.00 |
| | 4/25/2011 | 0.00 | 0.00 | 0.00 |
| | Average | 0.03 | 0.03 | 0.00 |
| WY 2012 Wet Season | 5/26/2011 | 0.00 | 0.00 | 0.00 |
| | 7/25/2011 | 0.00 | 0.00 | 0.00 |
| | 8/25/2011 | 0.47 | 0.47 | 0.50 |
| | 9/14/2011 | 0.60 | 0.60 | 0.60 |
| | 10/25/2011 | 0.68 | 0.64 | 0.70 |
| | Average | 0.35 | 0.34 | 0.36 |
| WY 2012 Dry Season | 11/22/2011 | 0.13 | 0.12 | 0.00 |
| | 12/21/2011 | 0.08 | 0.06 | 0.00 |
| | 1/24/2012 | 0.00 | 0.00 | 0.00 |
| | 2/24/2012 | 0.20 | 0.20 | 0.00 |
| | 3/28/2012 | 0.00 | 0.00 | 0.00 |
| | 4/24/2012 | 0.10 | 0.10 | 0.00 |
| | Average | 0.09 | 0.08 | 0.00 |
| WY 2013 Wet Season | 5/24/2012 | 0.52 | 0.53 | 0.65 |
| | 5/24/2012 | 0.51 | 0.58 | 0.50 |
| | 6/29/2012 | 0.20 | 0.30 | 0.00 |
| | 7/25/2012 | 0.60 | 0.59 | 0.60 |
| | 8/28/2012 | 0.50 | 0.50 | 0.60 |
| | 9/13/2012 | 0.68 | 0.68 | 0.58 |
| | 10/25/2012 | 0.57 | 0.78 | 0.80 |
| | Average | 0.51 | 0.57 | 0.53 |
| WY 2013 Dry Season | 11/26/2012 | 0.20 | 0.18 | 0.60 |
| | 12/19/2012 | 0.00 | 0.00 | 0.00 |
| | 1/23/2013 | 0.29 | 0.28 | 0.00 |
| | 2/25/2013 | 0.40 | 0.42 | 0.60 |
| | 3/25/2013 | 0.40 | 0.40 | 0.60 |
| | Average | 0.26 | 0.26 | 0.36 |

**Table 12.** Summary of water levels recorded at staff gauges near culvert S-23D.

| Period | Date | Stage Upstream of S-23D (ft NAVD) | Stage Downstream of S-23D (ft NAVD) | Stage 100 Meters Downstream of S-23D (ft NAVD) |
|---|---|---|---|---|
| WY 2011 Dry Season | 11/22/2010 | 0.00 | 0.00 | 0.20 |
| | 12/20/2010 | 0.00 | 0.00 | 0.00 |
| | 1/24/2011 | 0.00 | 0.00 | 0.00 |
| | 2/24/2011 | 0.15 | 0.05 | 0.00 |
| | 3/25/2011 | 0.00 | 0.00 | 0.00 |
| | 4/25/2011 | 0.00 | 0.00 | 0.00 |
| | Average | 0.03 | 0.01 | 0.03 |
| WY 2012 Wet Season | 5/26/2011 | 0.00 | 0.00 | 0.00 |
| | 6/24/2011 | 0.00 | 0.00 | 0.00 |
| | 7/25/2011 | 0.34 | 0.21 | 0.00 |
| | 8/25/2011 | 0.60 | 0.60 | 0.60 |
| | 9/14/2011 | 0.37 | 0.20 | 0.20 |
| | 10/25/2011 | 0.42 | 0.54 | 0.60 |
| | Average | 0.29 | 0.26 | 0.23 |
| WY 2012 Dry Season | 11/22/2011 | 0.00 | 0.16 | 0.20 |
| | 12/21/2011 | 0.00 | 0.12 | 0.20 |
| | 1/24/2012 | 0.00 | 0.00 | 0.00 |
| | 2/24/2012 | 0.00 | 0.00 | 0.00 |
| | 3/28/2012 | 0.05 | 0.00 | 0.00 |
| | 4/24/2012 | 0.00 | 0.00 | 0.00 |
| | Average | 0.01 | 0.05 | 0.07 |
| WY 2013 Wet Season | 5/24/2012 | 0.60 | 0.35 | 0.61 |
| | 6/29/2012 | 0.00 | 0.00 | 0.00 |
| | 7/25/2012 | 0.60 | 0.48 | 0.60 |
| | 8/28/2012 | 0.10 | 0.00 | 0.20 |
| | 9/13/2012 | 0.64 | 0.50 | 0.48 |
| | 10/25/2012 | 0.52 | 0.79 | 0.85 |
| | Average | 0.41 | 0.35 | 0.46 |
| WY 2013 Dry Season | 11/26/2012 | 0.22 | 0.22 | 0.60 |
| | 12/19/2012 | 0.00 | 0.00 | 0.00 |
| | 1/23/2013 | 0.29 | 0.28 | 0.00 |
| | 2/25/2013 | 0.40 | 0.42 | 0.60 |
| | 3/25/2013 | 0.40 | 0.40 | 0.60 |
| | Average | 0.26 | 0.26 | 0.36 |

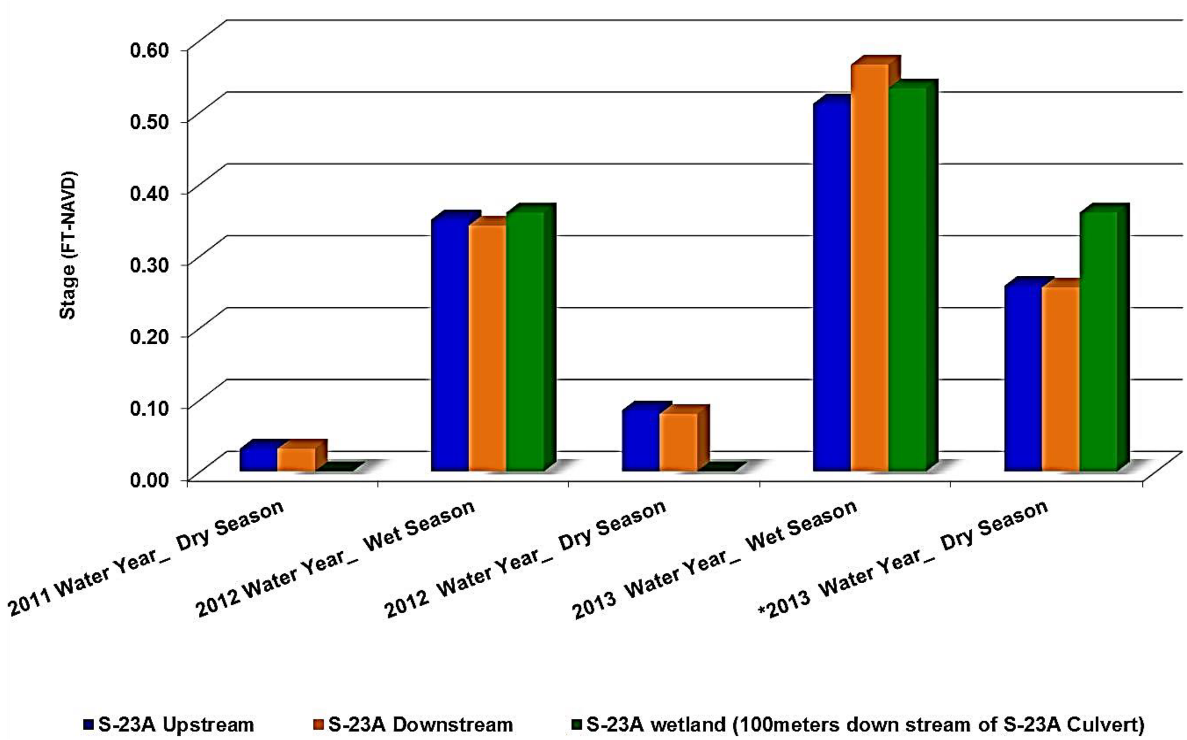


**Figure 12.** Comparison of water levels of wet and dry seasons for each water year at staff gauges near culvert S-23A.

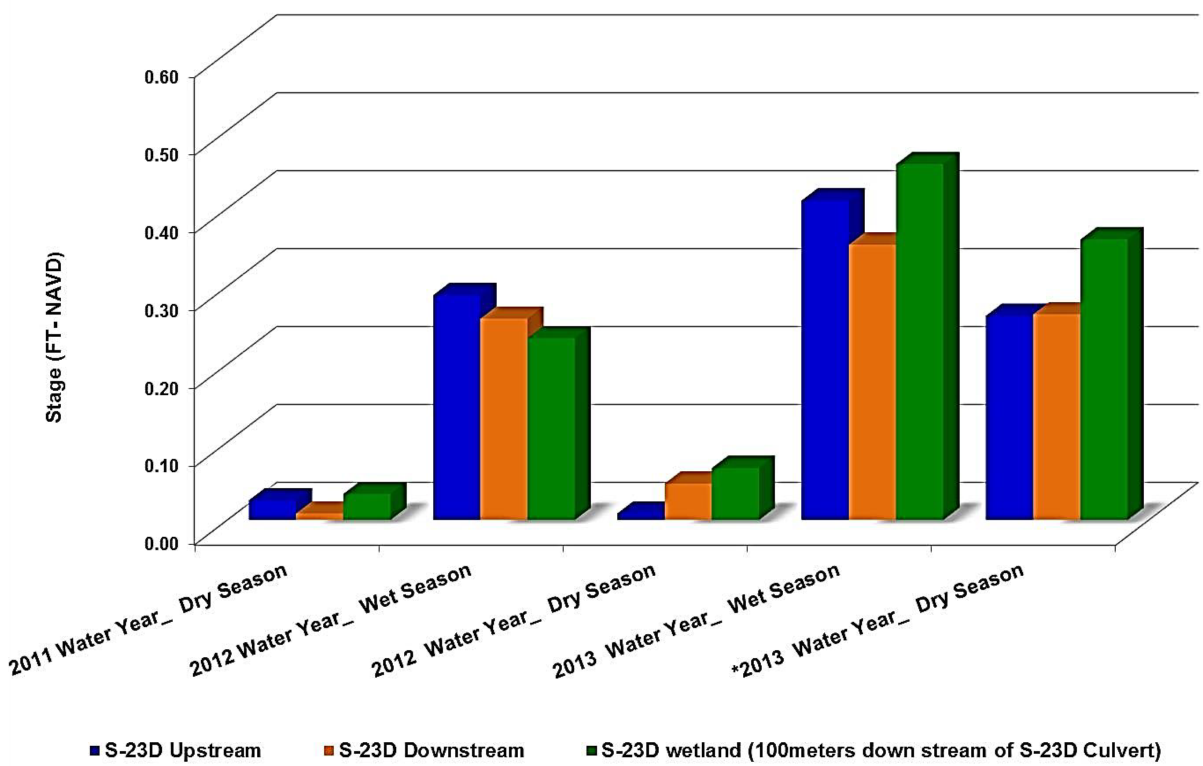


**Figure 13.** Comparison of water levels of wet and dry seasons for each water year at staff gauges near culvert S-23D.

Table 13. Percentage of available fresh water diverted through the L-31E flow-way during the dry season of WY 2011 and the wet and dry seasons of WY 2012 and WY 2013.

| Period | Month | Flow (cfs) | | | | | | | | | Available Water Diverted (cfs) | Percent Water Diverted |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | S-23A | S-23B | S-23C | S-23D | Total for 4 Culverts (S-23A+S-23B+ S-23C+S-23D) | S-20F | S-21A | Total for S-21A and S-20F | Total for S-20F, S-21A and 4 Culverts | | |
| WY 2011 Dry Season | November-10 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 8610.13 | 4030.55 | 12730.14 | 12730.14 | 0.00 | 0.00% |
| | December-10 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 3880.65 | 2156.71 | 6037.36 | 6037.36 | 0.00 | 0.00% |
| | January-11 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 5329.27 | 3048.85 | 8378.12 | 8378.12 | 0.00 | 0.00% |
| | February-11 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 2073.58 | 1355.05 | 3428.63 | 3428.63 | 0.00 | 0.00% |
| | March-11 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | Not Available |
| | April-11 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | Not Available |
| WY 2011 Total (cfs) | | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 19893.63 | 10591.16 | 30574.25 | 30574.25 | 0.00 | 0.00% |
| WY 2011 Total (acre-ft) | | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 38991.51 | 20758.67 | 59925.53 | 59925.53 | 0.00 | |
| WY 2012 Wet Season | May-11 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | Not Available |
| | June-11 | 0.00 | 0.00 | 6.00 | 15.40 | 21.40 | 0.00 | 0.00 | 0.00 | 21.40 | 0.00 | 0.00% |
| | July-11 | 141.48 | 233.20 | 30.80 | 363.76 | 769.24 | 5673.54 | 2662.06 | 8335.6 | 9104.84 | 0.10 | 10.12% |
| | August-11 | 132.45 | 243.60 | 17.00 | 243.98 | 637.03 | 10065.07 | 5237.11 | 15302.18 | 15939.21 | 0.04 | 4.00% |
| | September-11 | 151.29 | 262.50 | 23.10 | 355.40 | 792.29 | 7370.02 | 4356.82 | 11726.84 | 12519.13 | 0.06 | 6.33% |
| | October-11 | 62.80 | 82.10 | 41.30 | 138.80 | 180.10 | 20442.16 | 7601.49 | 28043.65 | 28368.65 | 0.03 | 2.72% |
| WY 2012 Dry Season | November-11 | 0.00 | 0.00 | 0.00 | 21.50 | 21.50 | 7763.53 | 3485.14 | 11248.67 | 11270.17 | 0.00 | 0.23% |
| | December-11 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 5197.46 | 2552.78 | 7750.24 | 7750.24 | 0.00 | 0.00% |
| | January-12 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 3851.93 | 255.66 | 4107.59 | 4107.59 | 0.00 | 0.00% |
| | February-12 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 7247.49 | 0.00 | 7247.49 | 7247.49 | 0.00 | 0.00% |
| | March-12 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 1950.02 | 0.00 | 1950.02 | 1950.02 | 0.00 | 0.00% |
| | April-12 | 71.70 | 93.30 | 6.40 | 14.40 | 185.80 | 4238.83 | 0.00 | 4238.83 | 4424.63 | 0.02 | 2.00% |
| WY 2012 Total (cfs) | | 559.72 | 914.70 | 124.60 | 1153.24 | 2607.36 | 73800.05 | 26151.06 | 99951.11 | 102703.37 | 0.03 | 3.00% |
| WY 2013 Total (acre-feet) | | 1097.05 | 1792.81 | 244.22 | 2260.35 | 5110.43 | 144648.10 | 51256.08 | 195904.18 | 201298.61 | | |

**Table 13.** Continued.

| Period | Month | Flow (cfs) | | | | | | | | | Available Water Diverted (cfs) | Percent Water Diverted |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | S-23A | S-23B | S-23C | S-23D | Total for 4 Culverts (S-23A+S-23B+ S-23C+S-23D) | S-20F | S-21A | Total for S-21A and S-20F | Total for S-20F, S-21A, and 4 Culverts | | |
| WY 2013 Wet Season | May-12 | 134.40 | 216.70 | 82.40 | 318.40 | 751.90 | 8286.67 | 0.00 | 8286.67 | 9038.57 | 0.18 | 18.40% |
| | June-12 | 3.80 | 7.80 | 0.00 | 0.00 | 11.60 | 12041.31 | 2669.42 | 14710.73 | 14722.33 | 0.00 | 0.13% |
| | July-12 | 58.40 | 85.10 | 32.20 | 120.55 | 296.25 | 10405.42 | 5897.29 | 16302.71 | 16598.96 | 0.04 | 4.04% |
| | August-12 | 125.30 | 181.40 | 61.20 | 253.10 | 621.00 | 13281.23 | 6386.70 | 19667.93 | 19578.06 | 0.07 | 7.26% |
| | September-12 | 45.90 | 66.50 | 56.40 | 247.15 | 415.95 | 9304.24 | 4935.51 | 14239.75 | 14655.70 | 0.05 | 4.56% |
| | October-12 | 32.50 | 87.70 | 16.40 | 103.30 | 239.90 | 7704.00 | 4158.00 | 11232.00 | 11472.00 | 0.02 | 2.00% |
| WY 2013 Dry Season | November-12 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 6016.00 | 3482.00 | 9498.00 | 9498.00 | 0.00* | 0.00%* |
| | December-12 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 6617.00 | 2997.00 | 8614.00 | 8614.00 | 0.00* | 0.00%* |
| | January-13 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 3517.00 | 1512.00 | 5046.00 | 5046.00 | 0.00* | 0.00%* |
| | February-13 | 0.00 | 98.10 | 0.00 | 0.00 | 98.10 | 3623.00 | 309.00 | 3932.00 | 4031.00 | 0.02* | 2.43%* |
| | March-13 | 0.00 | 61.00 | 0.00 | 0.00 | 61.00 | 3236.00 | 138.00 | 3374.00 | 3435.00 | 0.02* | 1.80%* |
| | April-13 | 99.00 | 126.00 | 0.00 | 0.00 | 225.00 | 6941.00 | 2501.00 | 9442.00 | 9667.00 | 0.02* | 2.30%* |
| WY 2012 Total (cfs) | | 499.30 | 930.30 | 248.60 | 1042.50 | 2720.70 | 90972.87 | 34985.92 | 124345.79 | 126356.62 | 0.02 | 2.00%* |
| WY 2013 Total (acre-feet) | | 978.63 | 1823.39 | 487.26 | 2043.30 | 5332.57 | 178306.83 | 68572.40 | 243717.75 | 247658.98 | | |

* From November 2012 through February 2013, the SFWMD diverted water to Biscayne Bay through spillways S-21A and S-20F within the vicinity of the BBCW L-31E Culverts Project and water levels along the transect fell below the minimum level required.

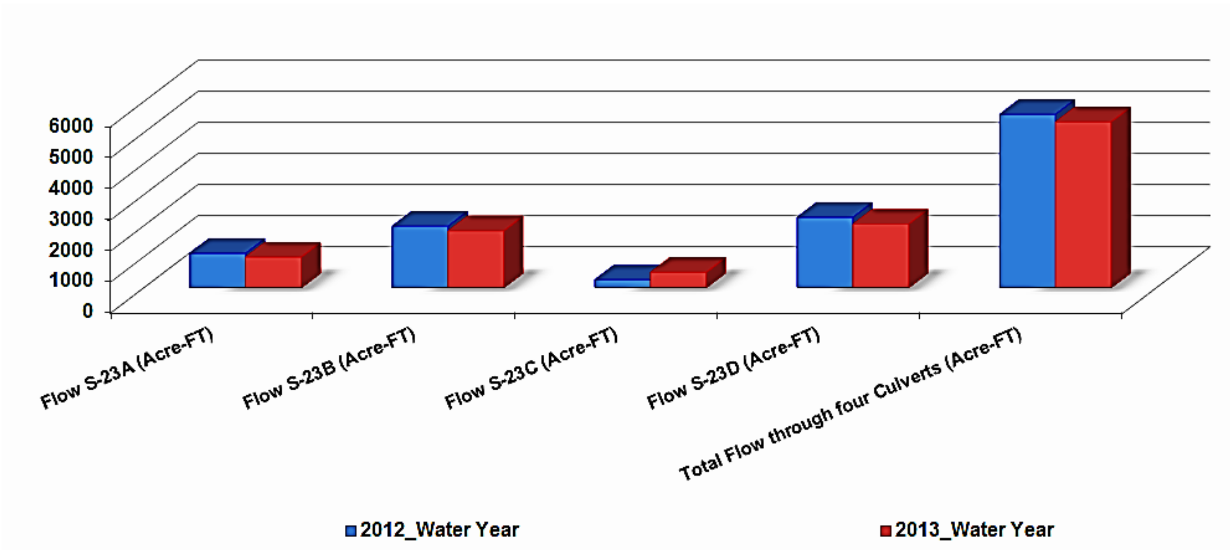


**Figure 14.** Comparison of fresh water in acre-feet (Acre-FT) diverted from the L-31E canal through the L-31E flow-way to wetlands east of the L-31E levee.

## Water Physiochemical Monitoring

By diverting fresh water from the L-31E canal into the BBCW, salinity concentrations should become more suitable, hypersaline zones reduced, and estuarine habitat improved. Over the last year, SFWMD conducted monthly surface water sampling at the two monitored culverts (S-23A and S-23D) at four locations: (1) directly upstream of the culvert, (2) directly downstream of the culvert, (3) 50 meters downstream of the culvert along the monitoring transect, and (4) 100 meters downstream of the culvert along the monitoring transect. Temperature, conductivity, salinity, dissolved oxygen, and pH were recorded at each station using a calibrated YSI multi-parameter water quality monitoring instrument.

**Tables A-1** through **A-10** in **Attachment A** provide descriptive statistics of monthly value data sets for physiochemical parameters. Due to the lack of availability of fresh water, salinity, specific conductivity (field), pH, and dissolved oxygen data were not recorded 50 and 100 meters downstream of culvert S-23A during all three dry seasons.

Based on field observations and a review of the monitoring data collected during the last two years of ecological monitoring, the following were noted:

- No noticeable change was recorded in monthly temperature along transects S-23A and S-23D.
- Slight increases and decreases of monthly specific conductivity (field) were recorded along transects S-23A and S-23D.
- No noticeable change was recorded in monthly pH along transects S-23A and S-23D.
- Slight increases and decreases of monthly dissolved oxygen (field) were recorded along transects S-23A and S-23D.
- No noticeable change was recorded in monthly salinity (field) results along the vegetation transect S-23A.
- No noticeable change was recorded in monthly salinity (field) results during the WY 2011 dry season and the WY 2012 wet season.

- There were noticeable changes in monthly salinity (field) results during WY 2013 dry and wet seasons along transect S-23A at 50 and 100 meter locations downstream of culvert S-23A. This is due to the tidal influence during this period.

# ENHANCING REHYDRATION OF WETLANDS EAST OF L-31E CANAL

## L-31E Flow-way Inlet and Outlet Improvement

During routine maintenance inspections of the L-31E culverts, it was determined that component performance was being hindered by aquatic vegetation clogging the manatee barrier upstream of the culverts, and by accumulated sediment and silt blocking the flap gate downstream of the culverts. To resolve these issues, and using the adaptive management concept for CERP projects, the SFWMD will remove accumulated downstream sediment; ensure that the depth of each downstream sump, relative to each pipe invert, closely matches the depths depicted in the permitted design cross-sections; and will install floating debris barriers across the mouth of each culvert inlet channel. The SFWMD acquired approval from the USACE [BBCW-L-31E Culverts Maintenance Work-As-Built Certification Permit Number SAJ-1994-01327 (NW-AAZ)] and the Florida Department of Environmental Protection to initiate this activity in May 2012. It was completed by August 2012 (**Attachment C**, **Figures C-1** through **C-4**).

# MAPPING SAWGRASS

In April 2012, the project team initiated field mapping of *Cladium jamaicense* (sawgrass) communities within vicinity of the BBCW Project L-31E flow-way within an area of 370 acres. The objective of this task is to create a baseline map showing the distribution and relative abundance of *C jamaicense* with the effective area of culverts S-23A and S-23B (**Figure 15**). During this reporting period, forty-two acres of patchy and scattered sawgrass communities were detected within the area of surface water redistribution and removal of exotic plants (northern culverts).

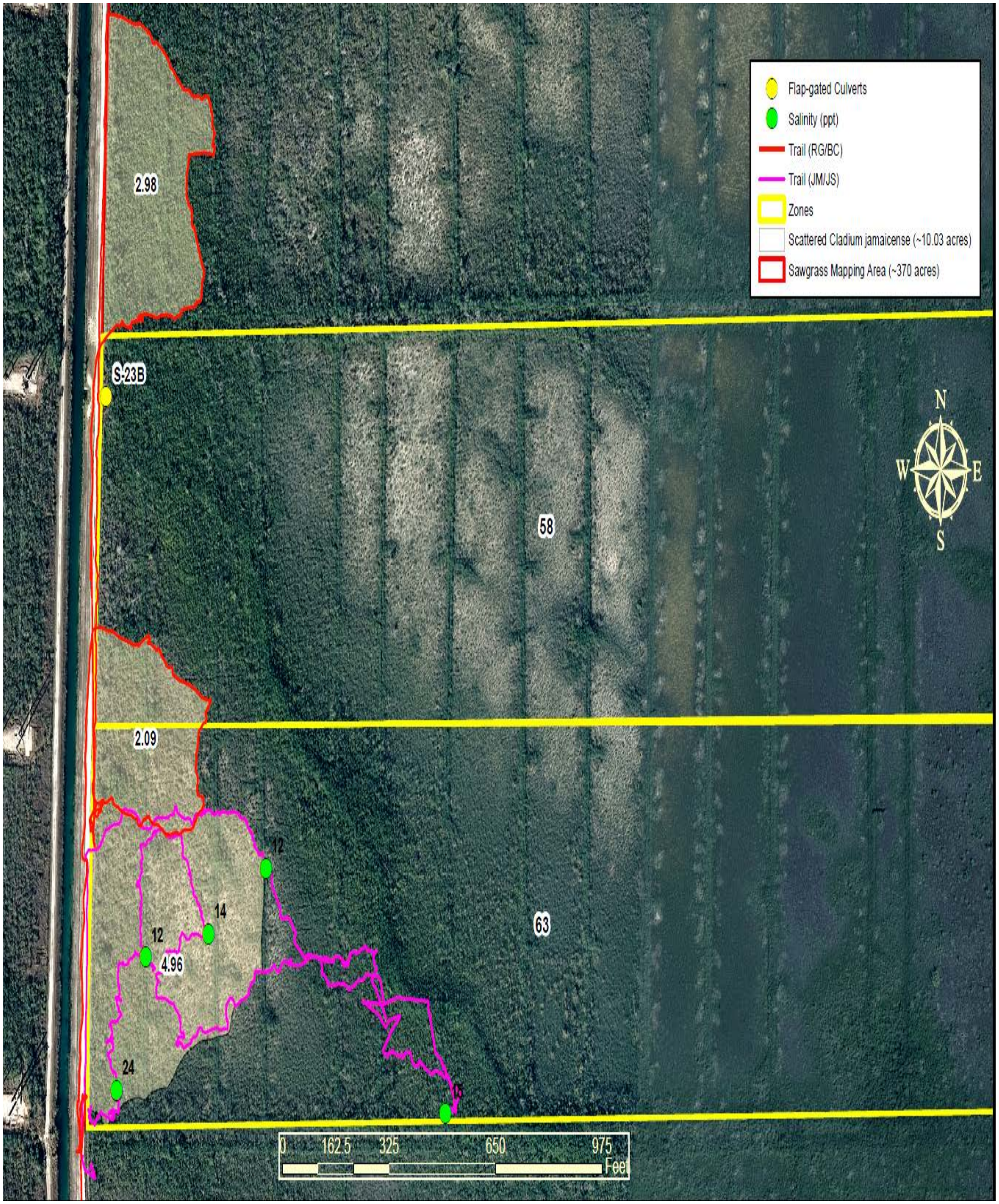


**Figure 15.** BBCW Project L-31E flow-way April 2013 *C. jamaicense* survey.

# CONCLUSIONS

The L-31E culverts are passive, flap-gated structures designed to divert available fresh water from the L-31E canal into the adjacent coastal wetlands. Ecological monitoring has been conducted over the last two years to document project benefits and performance. The project is anticipated to provide improvements to salinity concentrations, water stages, wetland vegetation, and algal composition within the wetland area affected by culvert water deliveries.

Overall, following the first two years of monitoring, the project is trending towards success by diverting approximately 5,110 acre-ft in WY 2012 and 5,333 acre-feet in WY 2013 of fresh water through the L-31E culverts to wetlands east of the L-31E levee. The project was able to meet or exceed its 4 percent diversion target during 6 months of last two years in what water was available for diversion, but only able to divert a total of 3 percent in WY 2012 and 2 percent in WY 2013 of all water available for diversion.

During the first annual reporting period, South Florida experienced extreme drought conditions. Beginning in October 2010, water levels along the transect downstream of culvert S-23A fell below the minimum level required for sampling and remained at or below this level through June 2011. From December 2010 through June 2011, November 2011 through December 2012, and November 2012 through March 2013, water levels along the transect downstream of culvert S-23D fell below the minimum level required for sampling. Once water began to flow in July 2011 through September 2011 and May 2012 through October 2012, inundations were observed along the entire length of the transects with water depths approximately 12 to 24 inches along the transect downstream of culvert S-23D and 6 to 12 inches along the transect downstream of culvert S-23A.

From November 2012 through February 2013, the SFWMD diverted water to Biscayne Bay through spillways S-21A and S-20F within the vicinity of the BBCW L-31E Culverts Project and water levels along the transect fell below the minimum level required. The optimum water level to divert adequate fresh water from the L-31E canal through the L-31E culverts to wetlands east of L-31E levee is 0.6 ft-NAVD.

During the last two annual reporting periods, wetland periphyton communities were not observed within the vicinity of culverts S-23A and S-23D. However, various species of birds, amphibians, invertebrates, fish and reptiles were observed.

Vegetation monitoring data collected during the last two years indicate the following: (1) a slight decrease in areal coverage of *R. mangle*, possible due to freezing and cold temperature in winter 2011; (2) a slight decrease in percentage of vegetation coverage of *R. mangle* within transect S-23A downstream of culvert S-23A; (3) no change in the percentage of canopy coverage of vegetation downstream of culverts S-23A except a slight increase in the percentage of canopy coverage of *R. mangle*; (4) no other changes downstream of culvert S-23A; and (5) no changes in the vegetation community within transect S-23D downstream of culvert S-23D after two years of data collection (no change was expected in this area). In addition to vegetation percent cover, the height of dwarf *R. mangle* along transect S-23D are monitored on a monthly basis. Statistical analysis of monitoring data collected indicates no change in the height of the 10 *R. mangle* individuals located at in the vicinity of culvert S-23D. Based on field observations and review of the monitoring data collected during the last two years, there has not been a major change in the composition and coverage of vascular plants downstream of culverts S-23A and S-23D.

During this reporting period, the percent of coverage of Category I and II invasive plant species based on the Florida Exotic Pest Plant Council's 2009 List of Invasive Plant Species was less than 5 percent. Chemical and mechanical treatment of exotic plant species was conducted over the past two years within approximately 291 acres of the project site.

# Attachment A:
# Summary of Monthly Results and Statistical Descriptive Analysis of Water Physiochemical Monitoring

**Table A-1.** Summary of monthly temperature in degrees Celsius (°C) and statistical descriptive analysis along transect S-23A.

| Descriptive Statistics | Water Year 2011 Dry Season S-23A Salinity | | | |
|---|---|---|---|---|
| | S-23A Upstream | S-23A Downstream | S-23A Downstream 50 Meter | S-23A Downstream 100 Meter |
| | 0.53 | 0.61 | * | * |
| | 0.44 | 0.36 | * | * |
| | 0.43 | 0.44 | * | * |
| | 0.29 | 0.29 | * | * |
| | 0.30 | 0.30 | * | * |
| | 0.59 | 0.55 | * | * |
| Mean | 0.43 | 0.43 | * | * |
| SD | 0.12 | 0.13 | * | * |
| 1st Quartile | 0.30 | 0.30 | * | * |
| Median | 0.44 | 0.40 | * | * |
| 3rd Quartile | 0.54 | 0.56 | * | * |
| IQR | 0.24 | 0.26 | * | * |

| Descriptive Statistics | Water Year 2012 Wet Season S-23A Salinity | | | | Water Year 2012 Dry Season S-23A Salinity | | | |
|---|---|---|---|---|---|---|---|---|
| | S-23A Upstream | S-23A Downstream | S-23A Downstream 50 Meter | S-23A Downstream 100 Meter | S-23A Upstream | S-23A Downstream | S-23A Downstream 50 Meter | S-23A Downstream 100 meter |
| | 1.06 | 0.78 | * | * | 0.60 | 1.44 | * | * |
| | 1.10 | 0.97 | * | * | 0.57 | 1.38 | * | * |
| | 0.46 | 0.45 | 0.29 | 0.61 | 0.31 | 0.32 | * | * |
| | 0.40 | 0.40 | 0.45 | * | 0.60 | 0.57 | * | * |
| | 0.35 | 0.35 | 0.25 | 0.20 | 0.36 | 0.34 | * | * |
| | 0.53 | 0.49 | * | * | 0.38 | 0.38 | 0.71 | 0.78 |
| Mean | 0.65 | 0.57 | 0.17 | 0.14 | 0.47 | 0.74 | * | * |
| SD | 0.34 | 0.25 | 0.19 | 0.25 | 0.13 | 0.53 | * | * |
| 1st Quartile | 0.40 | 0.40 | 0.00 | 0.00 | 0.36 | 0.34 | * | * |
| Median | 0.50 | 0.47 | 0.13 | 0.00 | 0.48 | 0.48 | * | * |
| 3rd Quartile | 1.06 | 0.80 | 0.30 | 0.23 | 0.60 | 1.39 | * | * |
| IQR | 0.67 | 0.40 | 0.30 | 0.23 | 0.24 | 1.05 | * | * |

| Descriptive Statistics | Water Year 2013 Wet Season S-23A Salinity | | | | Water Year 2013 Dry Season Salinity | | | |
|---|---|---|---|---|---|---|---|---|
| | S-23A Upstream | S-23A Downstream | S-23A Downstream 50 Meter | S-23A Downstream 100 Meter | S-23A Upstream | S-23A Downstream | S-23A Downstream 50 Meter | S-23A Downstream 100 Meter |
| | 0.36 | 0.33 | 0.34 | 0.30 | 1.27 | 21.22 | 21.79 | 13.93 |
| | 0.47 | 0.52 | * | * | 1.44 | 1.60 | * | * |
| | 0.40 | 0.40 | 0.63 | 0.46 | 0.35 | 0.38 | * | * |
| | 0.30 | 0.33 | 0.84 | 0.79 | 0.30 | 0.30 | * | * |
| | 0.31 | 0.31 | 0.45 | 0.69 | 0.31 | 0.40 | 10.06 | 7.65 |
| | 0.39 | 1.69 | 6.94 | 7.79 | | | * | * |
| Mean | 0.37 | 0.60 | 1.53 | 1.67 | 0.61 | 3.98 | * | * |
| SD | 0.06 | 0.54 | 2.66 | 3.01 | 0.59 | 8.46 | * | * |
| 1st Quartile | 0.31 | 0.33 | 0.31 | 0.28 | 0.28 | 0.28 | * | * |
| Median | 0.38 | 0.37 | 0.54 | 0.58 | 0.33 | 0.39 | * | * |
| 3rd Quartile | 0.41 | 0.62 | 1.35 | 1.37 | 1.28 | 3.23 | * | * |
| IQR | 0.10 | 0.29 | 1.04 | 1.10 | 1.01 | 2.96 | * | * |

*** No data**

**SD – standard deviation**

**IQR – interquartile range**

**Table A-2.** Summary of monthly temperature in °C and statistical descriptive analysis along transect S-23D.

| Descriptive Statistics | Water Year 2011 Dry Season S-23D Temperature | | | |
|---|---|---|---|---|
| | S-23D Upstream | S-23D Downstream | S-23D Downstream 50 Meter | S-23D Downstream 100 meter |
| | 24.57 | 24.49 | 25.69 | 25.30 |
| | 19.00 | 18.92 | * | * |
| | 20.13 | 19.48 | * | * |
| | 24.23 | 24.45 | * | * |
| | 25.04 | 24.13 | * | * |
| | 27.42 | 27.51 | * | * |
| Mean | 23.40 | 23.16 | * | * |
| SD | 3.19 | 3.31 | * | * |
| 1st Quartile | 20.04 | 19.43 | * | * |
| Median | 24.40 | 24.29 | * | * |
| 3rd Quartile | 25.24 | 24.74 | * | * |
| IQR | 5.20 | 5.31 | * | * |

| Descriptive Statistics | Water Year 2012 Wet Season S-23D Specific Temperature | | | | Water Year 2012 Dry Season S-23D Temperature | | | |
|---|---|---|---|---|---|---|---|---|
| | S-23D Upstream | S-23D Downstream | S-23D Downstream 50 Meter | S-23D Downstream 100 meter | S-23D Upstream | S-23D Downstream | S-23D Downstream 50 Meter | S-23D Downstream 100 meter |
| | 27.01 | 27.54 | * | * | 25.63 | 25.36 | 26.21 | 26.17 |
| | 31.21 | 30.55 | * | * | 22.49 | 21.76 | 22.60 | 22.84 |
| | 30.00 | 29.79 | 31.78 | 32.47 | 23.23 | 22.95 | * | * |
| | 28.37 | 28.39 | 27.98 | 27.75 | 25.07 | 29.10 | 29.21 | 28.98 |
| | 28.64 | 28.50 | 30.18 | 30.40 | 25.36 | 25.35 | 24.08 | 24.00 |
| | 23.84 | 24.08 | 23.50 | 22.65 | 24.96 | 24.21 | 29.63 | 28.16 |
| Mean | 28.18 | 28.14 | 28.36 | 28.32 | 24.46 | 24.79 | 26.35 | 26.03 |
| SD | 2.57 | 2.26 | 3.60 | 4.24 | 1.28 | 2.53 | 3.09 | 2.62 |
| 1st Quartile | 26.75 | 27.25 | 25.37 | 24.78 | 23.17 | 22.85 | 23.59 | 23.61 |
| Median | 28.51 | 28.45 | 29.08 | 29.08 | 25.02 | 24.78 | 26.21 | 26.17 |
| 3rd Quartile | 30.10 | 29.85 | 31.11 | 31.61 | 25.38 | 25.67 | 29.35 | 28.43 |
| IQR | 3.36 | 2.60 | 5.75 | 6.83 | 2.21 | 2.82 | 5.76 | 4.82 |

| Descriptive Statistics | Water Year 2012 Wet Season S-23D Temperature | | | | Water Year 2013 Dry Season S-23D Temperature | | | |
|---|---|---|---|---|---|---|---|---|
| | S-23D Upstream | S-23D Downstream | S-23D Downstream 50 Meter | S-23D Downstream 100 meter | S-23D Upstream | S-23D Downstream | S-23D Downstream 50 Meter | S-23D Downstream 100 Meter |
| | 26.30 | 26.29 | 26.06 | 25.31 | 20.37 | 18.39 | 19.83 | 19.56 |
| | 30.99 | 31.13 | 31.12 | 31.63 | 23.51 | 22.10 | 23.33 | 23.72 |
| | 29.53 | 29.34 | 31.74 | 32.90 | 22.28 | 19.18 | 20.03 | 20.41 |
| | 27.25 | 27.41 | 30.25 | 31.75 | 25.26 | 26.21 | 0.00 | 0.00 |
| | 28.65 | 28.70 | 28.02 | 27.80 | 25.91 | 25.66 | 26.66 | 25.62 |
| | 26.03 | 24.53 | 25.04 | 25.23 | * | * | * | * |
| Mean | 28.13 | 27.90 | 28.71 | 29.10 | 23.47 | 22.31 | 17.97 | 17.86 |
| SD | 1.95 | 2.34 | 2.77 | 3.43 | 2.25 | 3.59 | 10.43 | 10.28 |
| 1st Quartile | 26.28 | 26.14 | 25.98 | 25.30 | 21.64 | 18.92 | 13.22 | 13.04 |
| Median | 27.95 | 28.06 | 29.14 | 29.72 | 23.51 | 22.10 | 20.03 | 20.41 |
| 3rd Quartile | 29.65 | 29.49 | 31.17 | 31.85 | 25.48 | 25.84 | 24.44 | 24.35 |
| IQR | 3.37 | 3.35 | 5.20 | 6.54 | 3.83 | 6.93 | 11.22 | 11.31 |

*** No data**

**SD – standard deviation**

**IQR – interquartile range**

**Table A-3.** Summary of monthly specific conductivity in microsiemens per centimeter (µS/cm) and statistical descriptive analysis along transect S-23A.

| Descriptive Statistics | Water Year 2011 Dry Season S-23A Specific Conductivity (Field)_umhos/cm | | | |
|---|---|---|---|---|
| | S-23A Upstream | S-23A Downstream | S-23A Downstream 50 Meter | S-23A Downstream 100 meter |
| | 1066 | 1236 | * | * |
| | 885 | 784 | * | * |
| | 877 | 884 | * | * |
| | 607 | 598 | * | * |
| | 617 | 614 | * | * |
| | 1189 | 1108 | * | * |
| Mean | 873.50 | 870.67 | * | * |
| SD | 233.90 | 259.89 | * | * |
| 1st Quartile | 616.17 | 612.67 | * | * |
| Median | 881.00 | 834.00 | * | * |
| 3rd Quartile | 1076.25 | 1118.67 | * | * |
| IQR | 460.08 | 506.00 | * | * |

| Descriptive Statistics | Water Year 2012 Wet Season S-23A Specific Conductivity (Field)_umhos/cm | | | | Water Year 2012 Dry Season S-23A Specific Conductivity (Field)_ umhos/cm | | | |
|---|---|---|---|---|---|---|---|---|
| | S-23A Upstream | S-23A Downstream | S-23A Downstream 50 Meter | S-23A Downstream 100 Meter | S-23A Upstream | S-23A Downstream | S-23A Downstream 50 Meter | S-23A Downstream 100 Meter |
| | 2088 | 1552 | * | * | 1202 | 2772 | * | * |
| | 2177 | 1921 | * | * | 1151 | 2678 | * | * |
| | 952 | 913 | 608 | 1238 | 634 | 651 | * | * |
| | 817 | 823 | 921 | * | 1211 | 1150 | * | * |
| | 733 | 730 | 523 | 410 | 744 | 708 | * | * |
| | 1072 | 994 | * | * | 774 | 773 | 1416 | 1546 |
| Mean | 1306.50 | 1155.50 | 342.00 | * | 952.67 | 1455.33 | * | * |
| SD | 650.80 | 473.22 | 397.40 | * | 262.77 | 999.28 | * | * |
| 1st Quartile | 810.00 | 815.25 | 0.00 | * | 734.83 | 703.25 | * | * |
| Median | 1012.00 | 953.50 | 261.50 | * | 962.50 | 961.50 | * | * |
| 3rd Quartile | 2095.42 | 1582.75 | 634.08 | * | 1202.75 | 2685.83 | * | * |
| IQR | 1285.42 | 767.50 | 634.08 | * | 467.92 | 1982.58 | * | * |

| Descriptive Statistics | Water Year 2013 Wet Season S-23A Specific Conductivity (Field)_ umhos/cm | | | | Water Year 2013 Dry Season Specific Conductivity (Field)_ umhos/cm | | | |
|---|---|---|---|---|---|---|---|---|
| | S-23A Upstream | S-23A Downstream | S-23A Downstream50 Meter | S-23A Downstream 100 Meter | S-23A Upstream | S-23A Downstream | S-23A Downstream50 Meter | S-23A Downstream 100 Meter |
| | 740 | 689 | 706 | 622 | 2452 | 33760 | 34581 | 22977 |
| | 961 | 1063 | * | * | 2780 | 3060 | * | * |
| | 823 | 832 | 1270 | 912 | 718 | 770 | * | * |
| | 615 | 674 | 1665 | 1578 | 628 | 623 | * | * |
| | 634 | 637 | 928 | 1387 | 648 | 827 | 17078 | 13255 |
| | 802 | 3290 | 1212 | 13509 | * | * | * | * |
| Mean | 762.50 | 1197.50 | 963.50 | 3001.33 | 1204.33 | 6506.67 | * | * |
| SD | 129.15 | 1037.02 | 573.36 | 5178.37 | 1128.54 | 13392.13 | * | * |
| 1st Quartile | 632.42 | 670.92 | 647.17 | 570.17 | 575.67 | 571.08 | * | * |
| Median | 771.00 | 760.50 | 1070.00 | 1149.50 | 683.00 | 798.50 | * | * |
| 3rd Quartile | 834.50 | 1248.58 | 1302.92 | 2572.25 | 2479.33 | 5618.33 | * | * |
| IQR | 202.08 | 577.67 | 655.75 | 2002.08 | 1903.67 | 5047.25 | * | * |

*** No data**

**SD – standard deviation**

**IQR – interquartile range**

**Table A-4.** Summary of monthly specific conductivity in µS/cm and statistical descriptive analysis along transect S-23D.

| Descriptive Statistics | Water Year 2011 Dry Season S-23D Specific Conductivity (Field) -umhos/cm | | | |
|---|---|---|---|---|
| | S-23D Upstream | S-23D Downstream | S-23D Downstream 50 Meter | S-23D Downstream 100 Meter |
| | 2017.00 | 27886.00 | 32907.00 | 31706.00 |
| | 1245.00 | 1733.00 | * | * |
| | 1100.00 | 1131.00 | * | * |
| | 946.00 | 955.00 | * | * |
| | 1178.00 | 1221.00 | * | * |
| | 1088.00 | 1116.00 | * | * |
| Mean | 2350.50 | 2817.33 | * | * |
| SD | 2006.11 | 2764.54 | * | * |
| 1st Quartile | 910.67 | 951.92 | * | * |
| Median | 1342.00 | 1478.50 | * | * |
| 3rd Quartile | 4245.08 | 4705.33 | * | * |
| IQR | 3334.42 | 3753.42 | * | * |

| Descriptive Statistics | Water Year 2012 Wet Season S-23D Specific Conductivity (Field) - umhos/cm | | | | Water Year 2012 Dry Season S-23D Specific Conductivity (Field) - umhos/cm | | | |
|---|---|---|---|---|---|---|---|---|
| | S-23D Upstream | S-23D Downstream | S-23D Downstream 50 Meter | S-23D Downstream 100 meter | S-23D Upstream | S-23D Downstream | S-23D Downstream 50 Meter | S-23D Downstream 100 meter |
| | 4126.00 | 4430.00 | * | * | 1433.00 | 22739.00 | 21755.00 | 12760.00 |
| | 5555.00 | 7734.00 | * | * | 1627.00 | 23614.00 | 26528.00 | 25061.00 |
| | 919.00 | 964.00 | 1140.00 | 1062.00 | 678.00 | 713.00 | 0.00 | 0.00 |
| | 973.00 | 1017.00 | 11037.00 | 12257.00 | 1246.00 | 27405.00 | 28994.00 | 28159.00 |
| | 819.00 | 819.00 | 868.00 | 1173.00 | 1342.00 | 1335.00 | 1541.00 | 2204.00 |
| | 1711.00 | 1940.00 | 19637.00 | 27309.00 | 2837.00 | 6240.00 | 14802.00 | 14700.00 |
| Mean | 8170.50 | 10450.25 | 1262.33 | 5673.67 | 1527.17 | 13674.33 | 15603.33 | 13814.00 |
| SD | 8989.84 | 12405.49 | 383.08 | 10885.01 | 716.79 | 12206.73 | 12476.83 | 11487.29 |
| 1st Quartile | 981.33 | 1108.25 | 1076.17 | 1102.58 | 1198.67 | 1283.17 | 1412.58 | 2020.33 |
| Median | 6088.50 | 6715.00 | 1139.00 | 1176.00 | 1387.50 | 14489.50 | 18278.50 | 13730.00 |
| 3rd Quartile | 16053.67 | 21037.33 | 1309.33 | 3912.42 | 1727.83 | 23929.92 | 26733.50 | 25319.17 |
| IQR | 15072.33 | 19929.08 | 233.17 | 2809.83 | 529.17 | 22646.75 | 25320.92 | 23298.83 |

| Descriptive Statistics | Water Year 2013 Wet Season S-23D Specific Conductivity (Field) - umhos/cm | | | | Water Year 2013 Dry Season S-23D Specific Conductivity (Field) - umhos/cm | | | |
|---|---|---|---|---|---|---|---|---|
| | S-23D Upstream | S-23D Downstream | S-23D Downstream 50 Meter | S-23D Downstream 100 meter | S-23D Upstream | S-23D Downstream | S-23D Downstream 50 Meter | S-23D Downstream 100 meter |
| | 664.00 | 662.00 | 2530.00 | 727.00 | 8033.00 | 40256.00 | 36238.00 | 38356.00 |
| | 3572.00 | 3114.00 | 10221.00 | 16011.00 | 2759.00 | 20874.00 | 32117.00 | 31184.00 |
| | 1142.00 | 1096.00 | 1687.00 | 1424.00 | 1737.00 | 33152.00 | 37392.00 | 36924.00 |
| | 716.00 | 830.00 | 6339.00 | 6533.00 | 966.00 | 1361.00 | * | * |
| | 662.00 | 661.00 | 810.00 | 6061.00 | 2293.00 | 3222.00 | 44412.00 | 30233.00 |
| | 5257.00 | 19551.00 | 22243.00 | 23116.00 | * | * | * | * |
| Mean | 3157.60 | 19773.00 | 37539.75 | 34174.25 | 2002.17 | 4319.00 | 7305.00 | 8978.67 |
| SD | 2806.12 | 17411.92 | 5110.46 | 4062.97 | 1951.37 | 7520.39 | 8113.29 | 8820.15 |
| 1st Quartile | 1480.00 | 2601.67 | 33834.08 | 30629.25 | 663.83 | 661.92 | 1613.92 | 1365.92 |
| Median | 2293.00 | 20874.00 | 36815.00 | 34054.00 | 929.00 | 963.00 | 4434.50 | 6297.00 |
| 3rd Quartile | 4517.00 | 35520.00 | 41487.00 | 37759.33 | 3712.42 | 4483.75 | 11222.83 | 16603.08 |
| IQR | 3037.00 | 32918.33 | 7652.92 | 7130.08 | 3048.58 | 3821.83 | 9608.92 | 15237.17 |

*** No data**

**SD – standard deviation**

**IQR – interquartile range**

**Table A-5.** Summary of monthly pH and statistical descriptive analysis along transect S-23A.

| Descriptive Statistics | Water Year 2011 Dry Season S-23A pH (Field) | | | |
|---|---|---|---|---|
| | S-23A Upstream | S-23A Downstream | S-23A Downstream 50 Meter | S-23A Downstream 100 Meter |
| | 7.55 | 7.40 | * | * |
| | 7.96 | 7.76 | * | * |
| | 7.71 | 7.52 | * | * |
| | 7.67 | 7.59 | * | * |
| | 7.77 | 7.73 | * | * |
| | 7.86 | 7.74 | * | * |
| Mean | 7.75 | 7.62 | * | * |
| SD | 0.14 | 0.15 | * | * |
| 1st Quartile | 7.66 | 7.51 | * | * |
| Median | 7.74 | 7.66 | * | * |
| 3rd Quartile | 7.87 | 7.74 | * | * |
| IQR | 0.21 | 0.23 | * | * |

| Descriptive Statistics | Water Year 2012 Wet Season S-23A_ pH (Field) | | | | Water Year 2012 Dry Season S-23A_ pH (Field) | | | |
|---|---|---|---|---|---|---|---|---|
| | S-23A Upstream | S-23A Downstream | S-23A Downstream 50 Meter | S-23A Downstream 100 Meter | S-23A Upstream | S-23A Downstream | S-23A Downstream 50 Meter | S-23A Downstream 100 Meter |
| | 7.73 | 7.57 | * | * | 7.37 | 7.27 | * | * |
| | 7.86 | 7.61 | * | * | 7.44 | 7.30 | * | * |
| | 7.38 | 7.22 | 7.20 | 7.28 | 7.58 | 7.49 | * | * |
| | 7.53 | 7.44 | 7.24 | 0.00 | 7.30 | 7.29 | * | * |
| | 7.75 | 7.65 | 7.38 | 7.64 | 7.71 | 7.61 | * | * |
| | 7.52 | 7.37 | * | * | 7.78 | 7.76 | 7.56 | 7.65 |
| Mean | 7.63 | 7.48 | 7.27 | * | 6.37 | 7.55 | * | * |
| SD | 0.18 | 0.16 | 0.09 | * | 2.96 | 0.14 | * | * |
| 1st Quartile | 7.51 | 7.36 | 7.21 | * | 6.72 | 7.44 | * | * |
| Median | 7.63 | 7.51 | 7.24 | * | 7.55 | 7.53 | * | * |
| 3rd Quartile | 7.76 | 7.61 | 7.36 | * | 7.61 | 7.69 | * | * |
| IQR | 0.25 | 0.26 | 0.15 | * | 0.89 | 0.25 | * | * |

| Descriptive Statistics | Water Year 2013 Wet Season S-23A_ pH (Field) | | | | Water Year 2013 Dry Season S-23A_ pH (Field) | | | |
|---|---|---|---|---|---|---|---|---|
| | S-23A Upstream | S-23A Downstream | S-23A Downstream50 Meter | S-23A Downstream 100 meter | S-23A Upstream | S-23A Downstream | S-23A Downstream50 Meter | S-23A Downstream 100 meter |
| | 7.58 | 7.55 | 7.08 | 7.61 | 7.48 | 6.72 | 6.41 | 6.47 |
| | 7.53 | 7.44 | * | * | 7.33 | 7.29 | * | * |
| | 7.30 | 7.38 | 7.01 | 7.48 | 7.88 | 7.21 | * | * |
| | 7.56 | 7.50 | 7.19 | 7.14 | 7.71 | 7.64 | * | * |
| | 7.90 | 7.68 | 7.04 | 7.19 | 7.84 | 7.74 | 7.01 | 7.52 |
| | 0.33 | 7.75 | 7.32 | 7.49 | * | * | * | * |
| Mean | 6.37 | 7.55 | 7.13 | 7.38 | 7.65 | 7.32 | * | * |
| SD | 2.96 | 0.14 | 0.13 | 0.21 | 0.24 | 0.40 | * | * |
| 1st Quartile | 6.72 | 7.44 | 7.03 | 7.17 | 7.43 | 7.05 | * | * |
| Median | 7.55 | 7.53 | 7.08 | 7.48 | 7.71 | 7.29 | * | * |
| 3rd Quartile | 7.61 | 7.69 | 7.23 | 7.53 | 7.85 | 7.67 | * | * |
| IQR | 0.89 | 0.25 | 0.20 | 0.36 | 0.42 | 0.63 | * | * |

*** No data**

**SD – standard deviation**

**IQR – interquartile range**

**Table A-6.** Summary of monthly pH and statistical descriptive analysis along transect S-23D.

| Descriptive Statistics | Water Year 2011 Dry Season S-23D pH (Field) | | | |
|---|---|---|---|---|
| | S-23D Upstream | S-23D Downstream | S-23D Downstream 50 Meter | S-23D Downstream 100 Meter |
| | 7.36 | 7.27 | 7.52 | 7.41 |
| | 7.07 | 7.38 | * | * |
| | 7.47 | 7.35 | * | * |
| | 7.88 | 7.79 | * | * |
| | 7.99 | 7.82 | * | * |
| | 7.78 | 7.64 | * | * |
| Mean | 7.59 | 7.54 | * | * |
| SD | 0.35 | 0.24 | * | * |
| 1st Quartile | 7.34 | 7.34 | * | * |
| Median | 7.63 | 7.51 | * | * |
| 3rd Quartile | 7.89 | 7.79 | * | * |
| IQR | 0.55 | 0.45 | * | * |

| Descriptive Statistics | Water Year 2012 Wet Season S-23D pH (Field) | | | | Water Year 2012 Dry Season S-23D pH (Field) | | | |
|---|---|---|---|---|---|---|---|---|
| | S-23D Upstream | S-23D Downstream | S-23D Downstream 50 Meter | S-23D Downstream 100 Meter | S-23D Upstream | S-23D Downstream | S-23D Downstream 50 Meter | S-23D Downstream 100 meter |
| | 7.20 | 7.11 | * | * | 7.45 | 7.45 | 7.55 | 7.57 |
| | 7.82 | 7.61 | * | * | 7.46 | 7.28 | 7.43 | 7.33 |
| | 7.23 | 7.28 | 7.44 | 7.81 | 7.46 | 7.40 | * | * |
| | 7.66 | 7.52 | 7.13 | 7.15 | 6.96 | 7.54 | 7.50 | 7.54 |
| | 7.55 | 7.44 | 7.69 | 7.60 | 8.11 | 8.18 | 8.12 | 8.08 |
| | 7.20 | 7.18 | 7.10 | 7.14 | 7.71 | 7.83 | 7.63 | 7.74 |
| Mean | 7.44 | 7.36 | 7.34 | 7.43 | 7.53 | 7.61 | 7.65 | 7.65 |
| SD | 0.27 | 0.20 | 0.28 | 0.33 | 0.38 | 0.33 | 0.27 | 0.28 |
| 1st Quartile | 7.20 | 7.17 | 7.11 | 7.14 | 7.41 | 7.39 | 7.48 | 7.47 |
| Median | 7.39 | 7.36 | 7.29 | 7.38 | 7.46 | 7.50 | 7.55 | 7.57 |
| 3rd Quartile | 7.67 | 7.53 | 7.59 | 7.72 | 7.74 | 7.86 | 7.79 | 7.85 |
| IQR | 0.47 | 0.35 | 0.47 | 0.58 | 0.33 | 0.47 | 0.32 | 0.38 |

| Descriptive Statistics | Water Year 2013 Wet Season S-23D pH (Field) | | | | Water Year 2013 Dry Season S-23D pH (Field) | | | |
|---|---|---|---|---|---|---|---|---|
| | S-23D Upstream | S-23D Downstream | S-23D Downstream 50 Meter | S-23D Downstream 100 meter | S-23D Upstream | S-23D Downstream | S-23D Downstream 50 Meter | S-23D Downstream 100 meter |
| | 7.84 | 7.80 | 7.32 | 7.90 | 7.29 | 7.02 | 7.35 | 7.10 |
| | 7.60 | 7.54 | 7.48 | 7.45 | 7.39 | 7.28 | 7.69 | 7.51 |
| | 7.11 | 7.29 | 7.57 | 7.84 | 7.56 | 7.15 | 7.49 | 7.50 |
| | 7.28 | 7.30 | 7.05 | 7.40 | 7.74 | 7.68 | * | * |
| | 7.81 | 7.77 | 7.73 | 7.38 | 7.91 | 7.60 | 7.60 | 7.57 |
| | 7.65 | 7.77 | 7.77 | 7.73 | * | * | * | * |
| Mean | 7.55 | 7.58 | 7.49 | 7.62 | 7.58 | 7.35 | 7.53 | 7.42 |
| SD | 0.29 | 0.24 | 0.27 | 0.23 | 0.25 | 0.29 | 0.15 | 0.22 |
| 1st Quartile | 7.27 | 7.30 | 7.30 | 7.40 | 7.36 | 7.11 | 7.41 | 7.27 |
| Median | 7.63 | 7.66 | 7.53 | 7.59 | 7.56 | 7.28 | 7.55 | 7.51 |
| 3rd Quartile | 7.81 | 7.77 | 7.73 | 7.85 | 7.80 | 7.63 | 7.65 | 7.55 |
| IQR | 0.55 | 0.47 | 0.44 | 0.45 | 0.44 | 0.52 | 0.24 | 0.28 |

*** No data**

**SD – standard deviation**

**IQR – interquartile range**

**Table A-7.** Summary of monthly dissolved oxygen in milligrams per liter (mg/L) and statistical descriptive analysis along transect S-23A.

| Descriptive Statistics | Water Year 2011 Dry Season S-23A Dissolved Oxygen (Fld) _ mg/L | | | |
|---|---|---|---|---|
| | S-23A Upstream | S-23A Downstream | S-23A Downstream 50 Meter | S-23A Downstream 100 Meter |
| | 6.12 | 5.12 | * | * |
| | 6.35 | 6.35 | * | * |
| | 6.37 | 6.55 | * | * |
| | 8.72 | 7.30 | * | * |
| | 8.93 | 7.55 | * | * |
| | 7.48 | 6.90 | * | * |
| Mean | 7.33 | 6.63 | * | * |
| SD | 1.25 | 0.86 | * | * |
| 1st Quartile | 6.33 | 6.25 | * | * |
| Median | 6.93 | 6.73 | * | * |
| 3rd Quartile | 8.74 | 7.32 | * | * |
| IQR | 2.41 | 1.07 | * | * |

| Descriptive Statistics | Water Year 2012 Wet Season S-23A Dissolved Oxygen (Fld) _ mg/L | | | | Water Year 2012 Dry Season S-23A Dissolved Oxygen (Fld) _ mg/L | | | |
|---|---|---|---|---|---|---|---|---|
| | S-23A Upstream | S-23A Downstream | S-23A Downstream 50 Meter | S-23A Downstream 100 Meter | S-23A Upstream | S-23A Downstream | S-23A Downstream 50 Meter | S-23A Downstream 100 meter |
| | 8.31 | 4.89 | * | * | 5.03 | 3.49 | * | * |
| | 6.22 | 2.95 | * | * | 6.57 | 4.51 | * | * |
| | 4.80 | 3.98 | 2.59 | 1.98 | 7.94 | 7.04 | * | * |
| | 4.82 | 5.10 | 3.70 | * | 7.24 | 5.80 | * | * |
| | 5.38 | 5.65 | 3.71 | 3.17 | 6.44 | 6.42 | * | * |
| | 2.47 | 2.86 | * | * | 6.97 | 8.23 | 3.06 | 4.05 |
| Mean | 5.33 | 4.24 | 3.33 | * | 6.70 | 5.92 | * | * |
| SD | 1.92 | 1.17 | 0.64 | * | 0.98 | 1.72 | * | * |
| 1st Quartile | 4.61 | 2.94 | 2.78 | * | 6.32 | 4.43 | * | * |
| Median | 5.10 | 4.44 | 3.70 | * | 6.77 | 6.11 | * | * |
| 3rd Quartile | 6.39 | 5.15 | 3.71 | * | 7.30 | 7.14 | * | * |
| IQR | 1.79 | 2.20 | 0.93 | * | 0.98 | 2.71 | * | * |

| Descriptive Statistics | Water Year 2013 Wet Season S-23A Dissolved Oxygen (Fld) _ mg/L | | | | Water Year 2013 Dry Season S-23A Dissolved Oxygen (Fld) _ mg/L | | | |
|---|---|---|---|---|---|---|---|---|
| | S-23A Upstream | S-23A Downstream | S-23A Downstream50 Meter | S-23A Downstream 100 meter | S-23A Upstream | S-23A Downstream | S-23A Downstream50 Meter | S-23A Downstream 100 meter |
| | 5.16 | 5.17 | 2.28 | 4.52 | 6.62 | 5.20 | 3.74 | 3.55 |
| | 4.86 | 5.66 | * | * | 4.66 | 4.90 | * | * |
| | 5.29 | 5.48 | 0.65 | 2.08 | 7.01 | 6.39 | * | * |
| | 4.91 | 5.09 | 2.81 | 2.72 | 7.45 | 6.22 | * | * |
| | 5.38 | 6.81 | 1.27 | 1.47 | 7.44 | 6.83 | 0.91 | 3.90 |
| | 6.68 | 5.42 | 2.66 | 3.67 | * | * | * | * |
| Mean | 5.38 | 5.61 | 1.93 | 2.89 | 6.64 | 5.91 | * | * |
| SD | 0.67 | 0.63 | 0.94 | 1.22 | 1.16 | 0.82 | * | * |
| 1st Quartile | 4.91 | 5.16 | 1.06 | 1.88 | 5.97 | 5.10 | * | * |
| Median | 5.23 | 5.45 | 2.28 | 2.72 | 7.01 | 6.22 | * | * |
| 3rd Quartile | 5.49 | 5.76 | 2.71 | 3.95 | 7.44 | 6.54 | * | * |
| IQR | 0.58 | 0.59 | 1.65 | 2.08 | 1.48 | 1.44 | * | * |

*** No data**

**SD – standard deviation**

**IQR – interquartile range**

**Table A-8.** Summary of monthly dissolved oxygen in mg/L and statistical descriptive analysis along transect S-23D.

| Descriptive Statistics | Water Year 2011 Dry Season S-23D Dissolved Oxygen (Fld)_ mg/L | | | |
|---|---|---|---|---|
| | S-23D Upstream | S-23D Downstream | S-23D Downstream 50 Meter | S-23D Downstream 100 Meter |
| | 6.37 | 3.52 | 2.60 | 4.98 |
| | 2.74 | 7.95 | * | * |
| | 4.90 | 5.24 | * | * |
| | 9.58 | 8.52 | * | * |
| | 8.49 | 7.75 | * | * |
| | 6.54 | 5.64 | * | * |
| Mean | 6.44 | 6.44 | * | * |
| SD | 2.46 | 1.95 | * | * |
| 1st Quartile | 4.72 | 5.10 | * | * |
| Median | 6.46 | 6.70 | * | * |
| 3rd Quartile | 8.58 | 8.00 | * | * |
| IQR | 3.86 | 2.90 | * | * |

| Descriptive Statistics | Water Year 2012 Wet Season S-23D Dissolved Oxygen (Fld)_ mg/L | | | | Water Year 2012 Dry Season S-23D Dissolved Oxygen (Fld)_ mg/L | | | |
|---|---|---|---|---|---|---|---|---|
| | S-23D Upstream | S-23D Downstream | S-23D Downstream 50 Meter | S-23D Downstream 100 Meter | S-23D Upstream | S-23D Downstream | S-23D Downstream 50 Meter | S-23D Downstream 100 Meter |
| | 5.18 | 4.44 | * | * | 7.33 | * | * | * |
| | 6.71 | 3.65 | * | * | 7.30 | 3.55 | 4.31 | 4.87 |
| | 5.15 | 4.75 | 6.61 | 9.20 | 8.39 | 4.78 | * | * |
| | 4.32 | 4.69 | 3.29 | 2.44 | 7.65 | 8.07 | 4.90 | 6.52 |
| | 4.22 | 3.78 | 7.19 | * | 8.69 | 9.24 | 7.40 | 6.39 |
| | 1.29 | 4.04 | 4.12 | 4.27 | 5.71 | 6.63 | 3.17 | 2.92 |
| Mean | 4.48 | 4.23 | 5.30 | 5.30 | 7.51 | 6.45 | 4.95 | 5.18 |
| SD | 1.80 | 0.47 | 1.89 | 3.50 | 1.05 | 2.33 | 1.79 | 1.68 |
| 1st Quartile | 3.98 | 3.77 | 3.64 | 2.75 | 7.17 | 4.37 | 3.65 | 3.73 |
| Median | 4.74 | 4.24 | 5.37 | 4.27 | 7.49 | 6.63 | 4.61 | 5.63 |
| 3rd Quartile | 5.31 | 4.70 | 6.95 | 8.38 | 8.42 | 8.46 | 6.36 | 6.47 |
| IQR | 1.33 | 0.93 | 3.31 | 5.63 | 1.25 | 4.09 | 2.71 | 2.73 |

| Descriptive Statistics | Water Year 2013 Wet Season S-23D Dissolved Oxygen (Fld)_ mg/L | | | | Water Year 2013 Dry Season S-23D Dissolved Oxygen (Fld)_ mg/L | | | |
|---|---|---|---|---|---|---|---|---|
| | S-23D Upstream | S-23D Downstream | S-23D Downstream 50 Meter | S-23D Downstream 100 meter | S-23D Upstream | S-23D Downstream | S-23D Downstream 50 Meter | S-23D Downstream 100 meter |
| | 6.12 | 6.12 | 0.66 | 5.95 | 4.01 | 5.96 | 6.07 | 5.28 |
| | 5.32 | 5.78 | 1.14 | 3.28 | 5.74 | 4.50 | 5.53 | 5.54 |
| | 5.02 | 5.46 | 2.58 | 3.90 | 7.32 | 6.26 | 5.49 | 5.50 |
| | 5.72 | 6.09 | 4.41 | 4.84 | 7.55 | 6.44 | * | * |
| | 6.76 | 6.72 | 4.07 | 5.39 | 7.64 | 6.69 | 3.09 | 2.73 |
| | 1.54 | 5.31 | 3.44 | 13.93 | * | * | * | * |
| Mean | 5.08 | 5.91 | 2.72 | 6.22 | 6.45 | 5.97 | 5.05 | 4.76 |
| SD | 1.84 | 0.51 | 1.55 | 3.90 | 1.57 | 0.86 | 1.33 | 1.36 |
| 1st Quartile | 4.73 | 5.45 | 1.10 | 3.85 | 5.16 | 5.47 | 4.09 | 3.79 |
| Median | 5.52 | 5.94 | 3.01 | 5.12 | 7.32 | 6.26 | 5.51 | 5.39 |
| 3rd Quartile | 6.17 | 6.17 | 4.10 | 6.62 | 7.58 | 6.52 | 5.85 | 5.52 |
| IQR | 1.44 | 0.72 | 3.00 | 2.77 | 2.42 | 1.05 | 1.76 | 1.73 |

*** No data**

**SD – standard deviation**

**IQR – interquartile range**

**Table A-9.** Summary of monthly salinity and statistical descriptive analysis along transect S-23A

| Descriptive Statistics | Water Year 2011 Dry Season S-23A Salinity | | | |
|---|---|---|---|---|
| | S-23A Upstream | S-23A Downstream | S-23A Downstream 50 Meter | S-23A Downstream 100 Meter |
| | 0.53 | 0.61 | * | * |
| | 0.44 | 0.36 | * | * |
| | 0.43 | 0.44 | * | * |
| | 0.29 | 0.29 | * | * |
| | 0.30 | 0.30 | * | * |
| | 0.59 | 0.55 | * | * |
| Mean | 0.43 | 0.43 | * | * |
| SD | 0.12 | 0.13 | * | * |
| 1st Quartile | 0.30 | 0.30 | * | * |
| Median | 0.44 | 0.40 | * | * |
| 3rd Quartile | 0.54 | 0.56 | * | * |
| IQR | 0.24 | 0.26 | * | * |

| Descriptive Statistics | Water Year 2012 Wet Season S-23A Salinity | | | | Water Year 2012 Dry Season S-23A Salinity | | | |
|---|---|---|---|---|---|---|---|---|
| | S-23A Upstream | S-23A Downstream | S-23A Downstream 50 Meter | S-23A Downstream 100 Meter | S-23A Upstream | S-23A Downstream | S-23A Downstream 50 Meter | S-23A Downstream 100 Meter |
| | 1.06 | 0.78 | * | * | 0.60 | 1.44 | * | * |
| | 1.10 | 0.97 | * | * | 0.57 | 1.38 | * | * |
| | 0.46 | 0.45 | 0.29 | 0.61 | 0.31 | 0.32 | * | * |
| | 0.40 | 0.40 | 0.45 | * | 0.60 | 0.57 | * | * |
| | 0.35 | 0.35 | 0.25 | 0.20 | 0.36 | 0.34 | * | * |
| | 0.53 | 0.49 | * | * | 0.38 | 0.38 | 0.71 | 0.78 |
| Mean | 0.65 | 0.57 | 0.17 | 0.14 | 0.47 | 0.74 | * | * |
| SD | 0.34 | 0.25 | 0.19 | 0.25 | 0.13 | 0.53 | * | * |
| 1st Quartile | 0.40 | 0.40 | 0.00 | 0.00 | 0.36 | 0.34 | * | * |
| Median | 0.50 | 0.47 | 0.13 | 0.00 | 0.48 | 0.48 | * | * |
| 3rd Quartile | 1.06 | 0.80 | 0.30 | 0.23 | 0.60 | 1.39 | * | * |
| IQR | 0.67 | 0.40 | 0.30 | 0.23 | 0.24 | 1.05 | * | * |

| Descriptive Statistics | Water Year 2013 Wet Season S-23A Salinity | | | | Water Year 2013 Dry Season Salinity | | | |
|---|---|---|---|---|---|---|---|---|
| | S-23A Upstream | S-23A Downstream | S-23A Downstream 50 Meter | S-23A Downstream 100 Meter | S-23A Upstream | S-23A Downstream | S-23A Downstream 50 Meter | S-23A Downstream 100 Meter |
| | 0.36 | 0.33 | 0.34 | 0.30 | 1.27 | 21.22 | 21.79 | 13.93 |
| | 0.47 | 0.52 | * | * | 1.44 | 1.60 | * | * |
| | 0.40 | 0.40 | 0.63 | 0.46 | 0.35 | 0.38 | * | * |
| | 0.30 | 0.33 | 0.84 | 0.79 | 0.30 | 0.30 | * | * |
| | 0.31 | 0.31 | 0.45 | 0.69 | 0.31 | 0.40 | 10.06 | 7.65 |
| | 0.39 | 1.69 | 6.94 | 7.79 | * | * | * | * |
| Mean | 0.37 | 0.60 | 1.53 | 1.67 | 0.61 | 3.98 | * | * |
| SD | 0.06 | 0.54 | 2.66 | 3.01 | 0.59 | 8.46 | * | * |
| 1st Quartile | 0.31 | 0.33 | 0.31 | 0.28 | 0.28 | 0.28 | * | * |
| Median | 0.38 | 0.37 | 0.54 | 0.58 | 0.33 | 0.39 | * | * |
| 3rd Quartile | 0.41 | 0.62 | 1.35 | 1.37 | 1.28 | 3.23 | * | * |
| IQR | 0.10 | 0.29 | 1.04 | 1.10 | 1.01 | 2.96 | * | * |

*** No data**

**SD – standard deviation**

**IQR – interquartile range**

**Table A-10.** Summary of monthly salinity and statistical descriptive analysis along transect S-23D

| Descriptive Statistics | Water Year 2011 Dry Season S-23D Salinity (Field) | | | |
|---|---|---|---|---|
| | S-23D Upstream | S-23D Downstream | S-23D Downstream 50 Meter | S-23D Downstream 100 Meter |
| | 1.03 | 17.16 | 20.58 | 19.73 |
| | 0.62 | 0.88 | * | * |
| | 0.55 | 0.56 | * | * |
| | 0.47 | 0.47 | * | * |
| | 0.58 | 0.61 | * | * |
| | 0.54 | 0.55 | * | * |
| Mean | 0.63 | 3.37 | * | * |
| SD | 0.20 | 6.76 | * | * |
| 1st Quartile | 0.53 | 0.54 | * | * |
| Median | 0.57 | 0.59 | * | * |
| 3rd Quartile | 0.65 | 2.24 | * | * |
| IQR | 0.12 | 1.69 | * | * |

| Descriptive Statistics | Water Year 2012 Wet Season S-23D Salinity (Field) | | | | Water Year 2012 Dry Season S-23D Salinity (Field) | | | |
|---|---|---|---|---|---|---|---|---|
| | S-23D Upstream | S-23D Downstream | S-23D Downstream 50 Meter | S-23D Downstream 100 Meter | S-23D Upstream | S-23D Downstream | S-23D Downstream 50 Meter | S-23D Downstream 100 meter |
| | 2.18 | 2.35 | 0.00 | 0.00 | 0.72 | 13.70 | 13.72 | 11.85 |
| | 2.97 | 4.24 | 0.00 | 0.00 | 0.82 | 14.34 | 16.28 | 15.29 |
| | 0.45 | 0.47 | 0.56 | 0.49 | 0.33 | 0.35 | * | * |
| | 0.48 | 0.50 | 6.24 | 7.09 | 0.62 | 16.74 | 17.81 | 17.27 |
| | 0.40 | 0.40 | 0.42 | 0.58 | 0.67 | 0.67 | 0.77 | 1.13 |
| | 0.86 | 0.99 | 11.69 | 16.79 | 1.47 | 3.40 | 8.54 | 8.53 |
| Mean | 1.22 | 1.49 | 3.15 | 4.16 | 1.04 | 2.47 | 4.69 | 5.18 |
| SD | 1.09 | 1.53 | 4.83 | 6.77 | 1.06 | 4.51 | 5.25 | 5.35 |
| 1st Quartile | 0.45 | 0.46 | 0.00 | 0.00 | 0.32 | 0.32 | 0.81 | 0.67 |
| Median | 0.67 | 0.75 | 0.49 | 0.54 | 0.45 | 0.47 | 2.40 | 3.42 |
| 3rd Quartile | 2.25 | 2.51 | 6.69 | 7.90 | 1.94 | 2.44 | 9.11 | 9.67 |
| IQR | 1.80 | 2.04 | 6.69 | 7.90 | 1.62 | 2.12 | 8.30 | 9.00 |

| Descriptive Statistics | Water Year 2013 Wet Season S-23D Salinity (Field) | | | | Water Year 2013 Dry Season S-23D Salinity (Field) | | | |
|---|---|---|---|---|---|---|---|---|
| | S-23D Upstream | S-23D Downstream | S-23D Downstream 50 Meter | S-23D Downstream 100 Meter | S-23D Upstream | S-23D Downstream | S-23D Downstream 50 Meter | S-23D Downstream 100 Meter |
| | 0.32 | 0.32 | 1.30 | 0.35 | 4.47 | 25.75 | 22.94 | 24.43 |
| | 1.86 | 1.61 | 8.72 | 9.28 | 1.43 | 12.69 | 20.05 | 19.40 |
| | 0.56 | 0.54 | 0.85 | 0.70 | 0.88 | 20.85 | 23.79 | 23.41 |
| | 0.34 | 0.40 | 3.49 | 3.53 | 0.47 | 0.68 | * | * |
| | 0.32 | 0.32 | 0.39 | 3.30 | 1.17 | 1.70 | 28.64 | 18.81 |
| | 2.82 | 11.61 | 13.38 | 13.93 | * | * | * | * |
| Mean | 0.77 | 8.20 | 11.42 | 10.81 | 1.68 | 12.33 | 23.86 | 21.51 |
| SD | 0.38 | 7.51 | 6.92 | 6.36 | 1.60 | 11.20 | 3.57 | 2.82 |
| 1st Quartile | 0.60 | 0.64 | 5.95 | 6.06 | 0.74 | 1.36 | 21.25 | 19.06 |
| Median | 0.70 | 8.55 | 13.72 | 11.85 | 1.17 | 12.69 | 23.37 | 21.41 |
| 3rd Quartile | 0.87 | 14.54 | 16.79 | 15.95 | 2.44 | 22.48 | 26.62 | 24.01 |
| IQR | 0.28 | 13.90 | 10.84 | 9.89 | 1.70 | 21.12 | 5.37 | 4.95 |

*** No data**

**SD – standard deviation**

**IQR – interquartile range**

# Attachment B:

# Maps

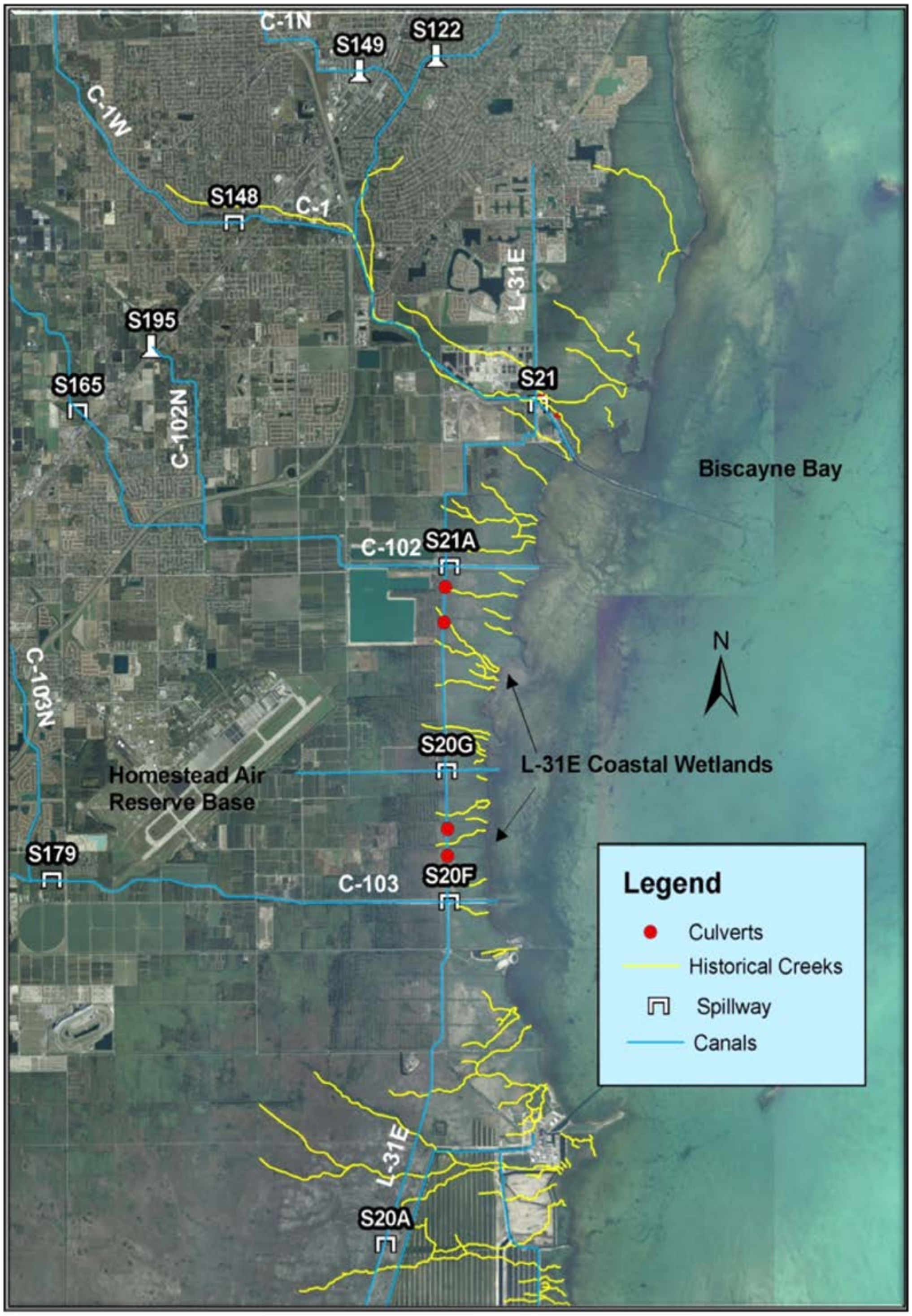


**Figure B-1.** Location of the BBCW and the L-31E Culverts (red dots) in Miami-Dade County. The L-31E Culverts are east of the levee between the C-102 and C-103 canals.


**Figure B-2.** BBCW L-31E culverts project area (green pattern) and monitoring structures.

# Attachment C:

# Photographs


**Figure C-1.** Upstream L-31E culverts before repairs.


**Figure C-2.** Upstream L-31E culverts after repairs.

**Figure C-3.** Downstream L-31E culverts before repairs.


**Figure C-4.** Downstream L-31E culverts after repairs.


**Figure C-5.** Staff gauge upstream of culvert S-23A.


**Figure C-6.** Staff gauge downstream of culvert S-23A.


**Figure C-7.** Transect S-23A at 50 meters downstream and looking northwest.


**Figure C-8.** Transect S-23A at 100 meters downstream and looking northwest.


**Figure C-9.** Staff gauge upstream of culvert S-23D.

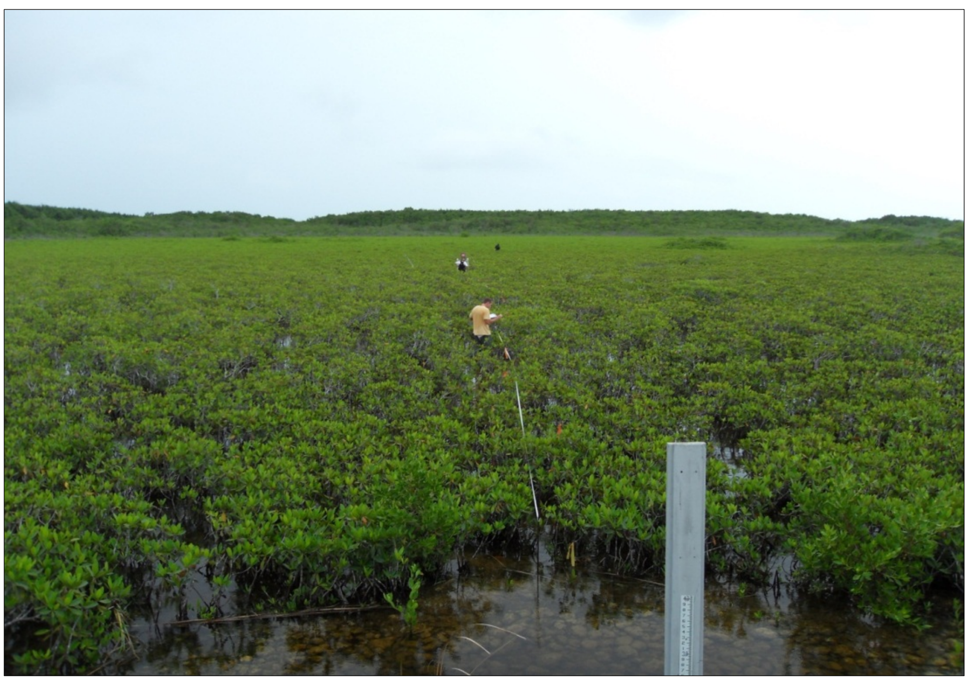

**Figure C-10.** Staff gauge downstream of culvert S-23D.


**Figure C-11.** Transect S-23D at 50 meters downstream and looking west.

**Figure C-12.** Cold weather damaged mangroves from winter 2010 within the BBCW L-31E culverts project area.

# Attachment D:

# L-31E Culverts Flow Rating Curves

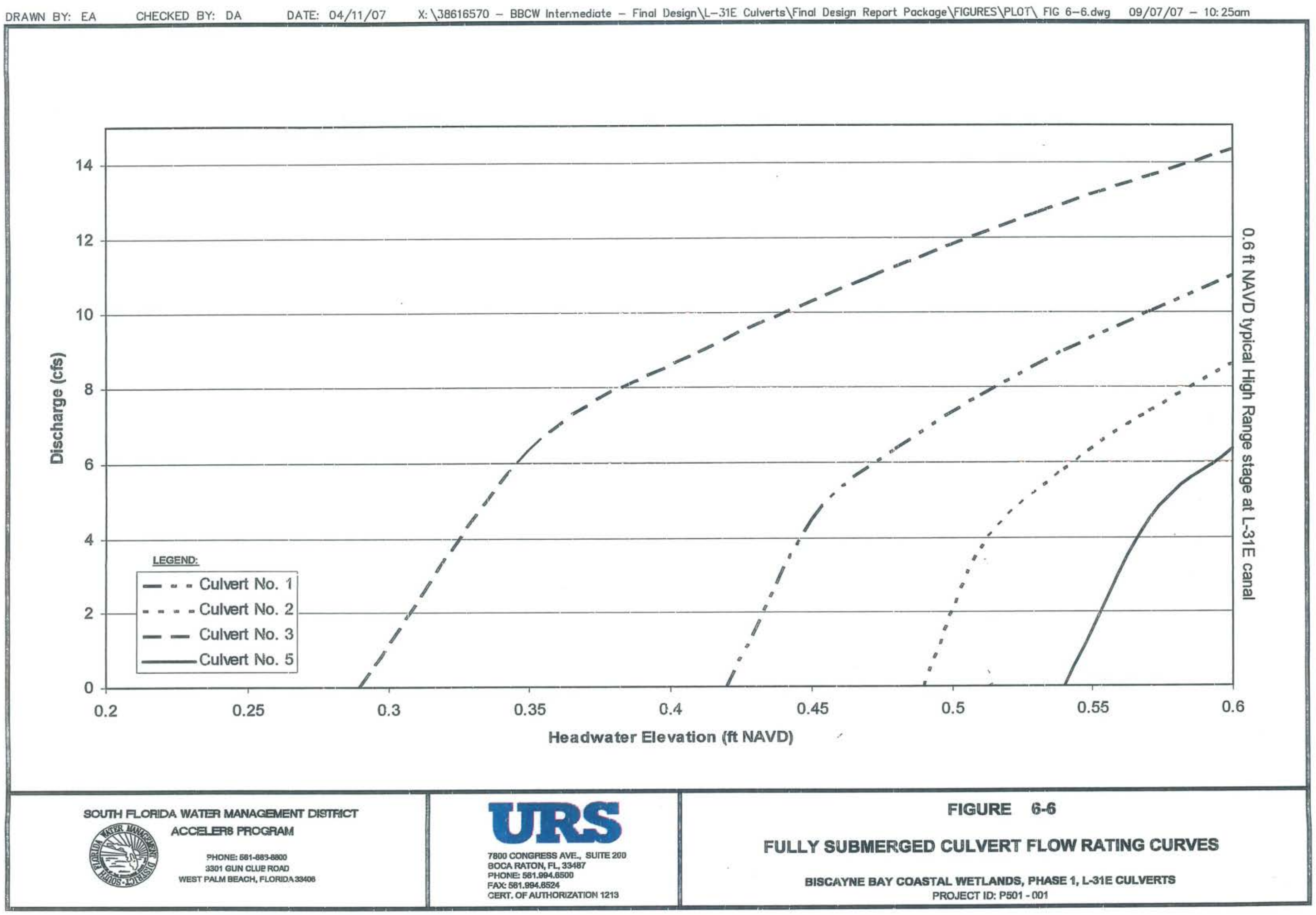


**Figure D-1.** Fully submerged culvert flow rating curves for BBCW Project L31E culverts. Headwater elevation from structures S-21A, S-20G and S-20F were utilized to calculate discharges for Culverts S-23A, S-23B, S-23C and S-23D. (Source: URS 2007).

# LITERATURE CITED

URS. 2007. Final Design Report, L-31E Culverts. URS Corporation, Boca Raton, FL, submitted under Work Order CN040936, WO#37, Job No. 38616570 to South Florida Water Management District, West Palm Beach, FL. September 7, 2007.

# Attachment E: Biscayne Bay Coastal Wetlands Deering Estate Flow-way Annual Mitigation Monitoring Report

# SOUTH FLORIDA WATER MANAGEMENT DISTRICT

**Ref. No. 08212013-02**

August 21, 2013

Mr. Robert Kirby
Enforcement Section
U.S. Army Corps of Engineers
9900 SW 107th Ave, Suite 203
Miami, FL 33176

Dear Mr. Kirby:

**Subject: Biscayne Bay Coastal Wetland Project-Deering Estate Flow-Way**
**Permit No. SAJ-2007-139 (IP-AAZ) - 1st Annual Mitigation Monitoring Report**

The U.S. Army Corps of Engineers issued the above referenced permit to the South Florida Water Management District on December 17, 2009, for the Deering Estate Flow-Way Project, a component of the Biscayne Bay Coastal Wetlands. In accordance with Special Condition 13(b), please find enclosed the 1st Annual Mitigation Monitoring Report for Biscayne Bay Coastal Wetlands, Deering Estates Flow-Way.

If you have questions or need additional information, please contact Leslye Waugh at (561) 682-6483 or via email at lwaugh@sfwmd.gov.

Sincerely,

Nimmy Jeyakumar
Section Administrator
Permit Acquisition & Compliance Section
Office of Everglades Policy & Coordination

NJ/am
Enclosure

c: Bahram Charkhian, SFWMD
Jorge Jaramillo, SFWMD
Leslye Waugh, SFWMD

# First Annual Mitigation Monitoring Report for Biscayne Bay Coastal Wetlands Project Deering Estate Flow-Way

USACE Permit Number: SAJ-2007-139 (IP-AAZ)

Prepared for

U. S. Army Corps of Engineers
Enforcement Section
P.O. Box 4970
Jacksonville, FL 33401

July 22, 2013

Prepared by

Bahram Charkhian

South Florida Water Management District
3301 Gun Club Road
West Palm Beach, Florida 33406

**Table 1.** Key permit-related information.

| | |
|---|---|
| **Project Name** | **Biscayne Bay Coastal Wetlands Project Deering Estate Flow-way** |
| **Permit Number** | **SAJ-2007-139 (IP-AAZ)** |
| **Issue Date** | December 17, 2009 |
| **Expiration Date for Construction** | December 16, 2014 |
| **Project Phase** | Operations |
| **Relevant Permit Conditions** | Special Conditions 11 and 12 |
| **Relevant Period of Record** | First Annual Monitoring Report |
| **Report Generator** | **Bahram Charkhian**<br>561-682-2284<br>bcharkh@sfwmd.gov |
| **Permit Coordinator** | **Leslye Waugh**<br>561-682-6483<br>lwaugh@sfwmd.gov |
| **Permittee's Consultants** | Miami-Dade County Permitting, Environmental and Regulatory Affairs<br>**Stephen Blair and Josh Mahoney**<br>Miami-Dade County Park & Natural Areas Management and Open Spaces<br>**Dallas Hazelton** |
| **Directions to Project Site** | Deering Estate at Cutler, 16701 SW $72^{nd}$ Avenue, Miami, Florida 33157. Take the Exit onto FL-826S toward Kendall, turn left on to SW 128st, turn right on to SW $82^{nd}$ Avenue, turn left on SW 168 Street / Richmond, turn right on to SW $72^{nd}$ Ave |

## TABLE OF CONTENTS



## LIST OF ATTACHMENTS

# PROJECT OVERVIEW

The Biscayne Bay Coastal Wetlands (BBCW) Project is part of the Comprehensive Everglades Restoration Plan (CERP) and is authorized at the federal level by the Water Resources Development Act. The Deering Estate Flow-way component is located in southeastern Miami-Dade County on the Deering Estate at Cutler, 1580 Old Cutler Road, Palmetto Bay, Florida (Latitude: 25.622903 North and Longitude: -80.311708).

The Deering Estate Flow-way is a site-specific reconciliation ecology effort to help restore seasonal water flow into an historic slough (a freshwater wetland habitat) that once existed within the Deering Estate boundaries, improving freshwater and estuarine habitat and salinity distribution within Biscayne Bay, reestablishing productive nursery habitat along the shoreline, and improving distribution of fresh water to the bay. The Deering Flow-way redistributes water up to 100 cubic feet per second (cfs) from South Florida Water Management District (SFWMD) flood protection canals via a spur canal and pump station. The slow moving water is then naturally filtered as it travels through the estate's habitats and out to Biscayne Bay via sheet flow.

The U.S. Army Corps of Engineers (USACE) issued Permit No. SAJ-2007-139 (IP-AAZ) on December 17, 2009 to SFWMD. The permit authorizes SFWMD to construct a 500-foot extension of the C-100A canal, a 100-cfs pump station (S-700) to withdraw water from the C-100 A spur canal, installation of 538 linear feet of 60-inch pipe downstream of pump station S-700, and construction of a structure for discharges to the wetlands located within Deering Estate (**Figure 1**).

According to Special Conditions 11 and 12, wetland impacts due to construction of project features were to be offset by project benefits, which include enhancement to salinity concentrations, and water stages within the wetland area affected by water deliveries. This "mitigation enhancement area" or "rehydration area" is estimated to be about 37.12 acres. Monitoring is being undertaken to evaluate the performance of the project benefit area.


**Figure 1.** Pump station S-700 constructed for the BBCW Deering Estate Flow-way.

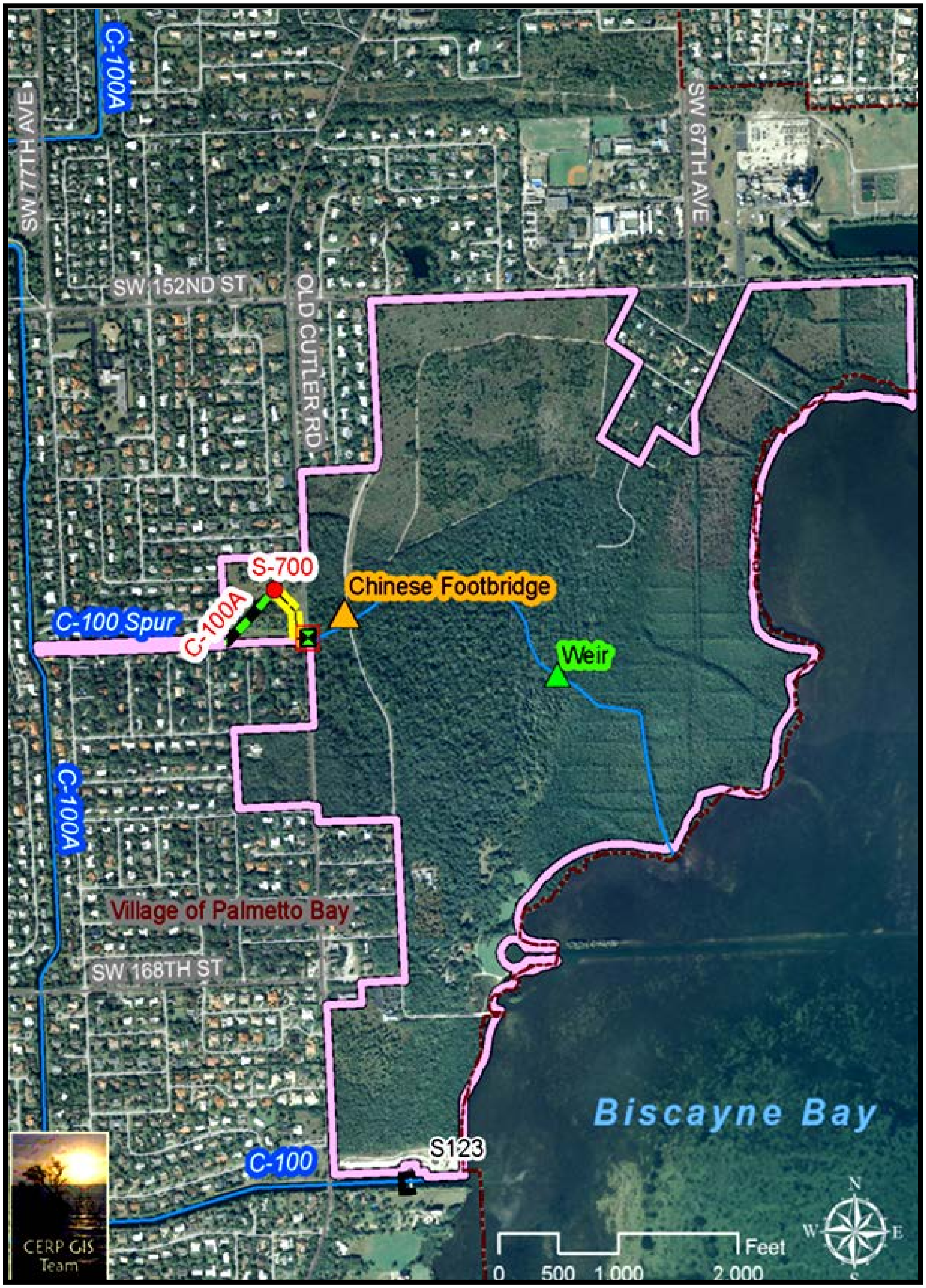


**Figure 2.** BBCW Project Deering Estate Flow-way component features.

Construction for the Deering Estate Project began on March 1, 2010, and was completed on April 30, 2012. Ecological monitoring commenced at the sites listed within **Table 2** within 60 days in accordance with Special Conditions 11 and 12 and the approved Ecological Monitoring Plan for Deering Estate Flow-way dated February 07, 2010. The baseline monitoring event was completed in 2011 and the report was submitted to USACE in March 2012. The monitoring events are conducted by SFWMD and Miami-Dade County Permitting, Environmental and Regulatory Affairs staff.

**Table 2.** Locations of ecological monitoring stations for the Deering Estate Flow-way.

| Station Name | Area Description | New/ Existing | Latitude Approximate X Coordinates | Longitude Approximate. Y Coordinates | Function and/or Description | Deering Estate Flow-way Monitoring Well Information | |
|---|---|---|---|---|---|---|---|
| | | | | | | Top of Casing Elevation (feet NGVD) [a] | Rim (feet) |
| Station 1 | Within the rehydration area | Existing Miami-Dade County monitoring stations | 885124.742 | 469012.886 | Staff gauge | Not applicable (NA) | NA |
| Station 3 | | | 885363.133 | 468759.938 | | NA | NA |
| Station 5 | | | 885729.49 | 468718.07 | Groundwater monitoring well | 8.53 | 8.78 |
| Station 2 | | | 883587.85 | 469241.68 | | 10.3 | 10.61 |

a. NGVD – National Geodetic Vertical Datum

Water level and stage at two existing wetlands staff gauges (1 and 3) and two existing groundwater monitoring stations (2 and 5) within the rehydration area are monitored (**Figure 3**). Data collected between May 2012 through June 2013 are summarized in this report.

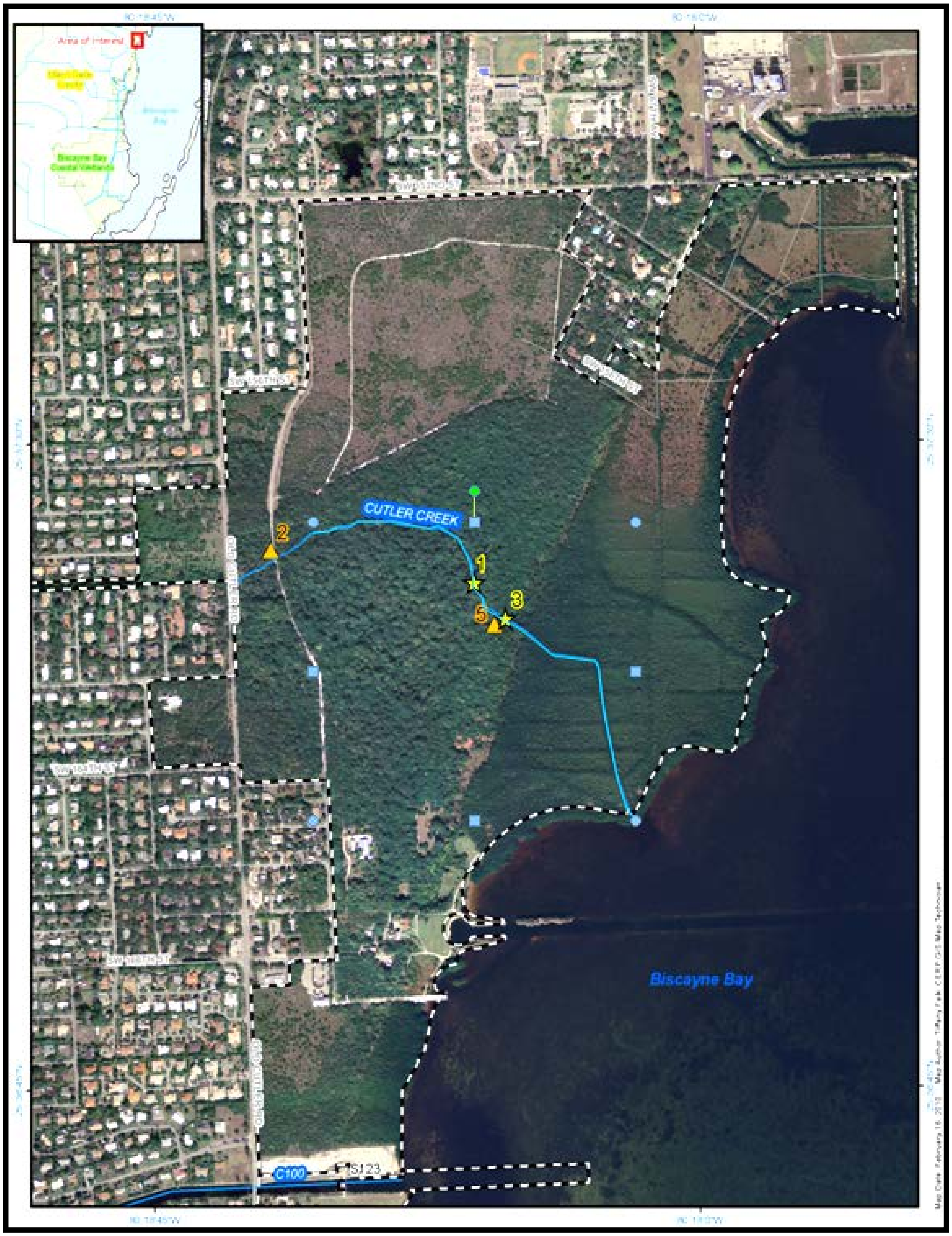


**Figure 3.** Location of ecological monitoring stations for the Deering Estate Flow-way.

# REQUIREMENTS

Existing SFWMD and Miami-Dade County monitoring stations will be utilized to satisfy requirements of the USACE 404 mitigation. This monitoring will evaluate the performance of the Deering Estate Project. The project is anticipated to result in higher water levels in Cutler Creek within the Deering Estate.

In accordance with Special Conditions 11and 12 of USACE Permit Number SAJ-2007-139 (IP-AAZ) and the Ecological Monitoring Plan for Deering Estate Flow-way dated February 07, 2010; SFWMD completed the baseline monitoring event on October 24, 2011. This permit acknowledges that implementation of the Deering Estate Flow-way will result in higher water levels in Cutler Creek and wetlands within the Deering Estate. The increased water levels are the result of operation of constructed features of the project. Monitoring will be conducted for at least three years after completion of construction of the pump station, and annual reports will be submitted to USACE.

## Hydrologic Performance

In accordance with Special Conditions 11 and 12 of USACE Permit Number SAJ-2007-139 (IP-AAZ), evaluation of the performance of the Deering Estate Flow-way component was conducted by doing the following:

- At wetland staff gauges 1 and 3, surface water grab samples were collected monthly and analyzed for specific conductance, dissolved oxygen, pH, temperature, and [calculated] salinity.
- At groundwater monitoring stations 2 and 5, groundwater was monitored in situ for specific conductance, temperature, salinity, and groundwater level using YSI data sondes every 15 minutes.

# RESULTS AND FINDINGS

All data presented and discussed in this section met quality assurance and quality control requirements.

## Pump Station Operations

By diverting approximately 10,259 acre-feet of fresh water from the C-100 Canal through pump station S-700 to historic remnant wetlands within Cutler Creek east of Old Cutler Road, salinity concentrations should be reduced, hypersaline zones should be reduced, and estuarine habitat improved. **Figure 4** compares stage and flow for pump station S-700. See **Table B-1** in **Attachment B** for the data.

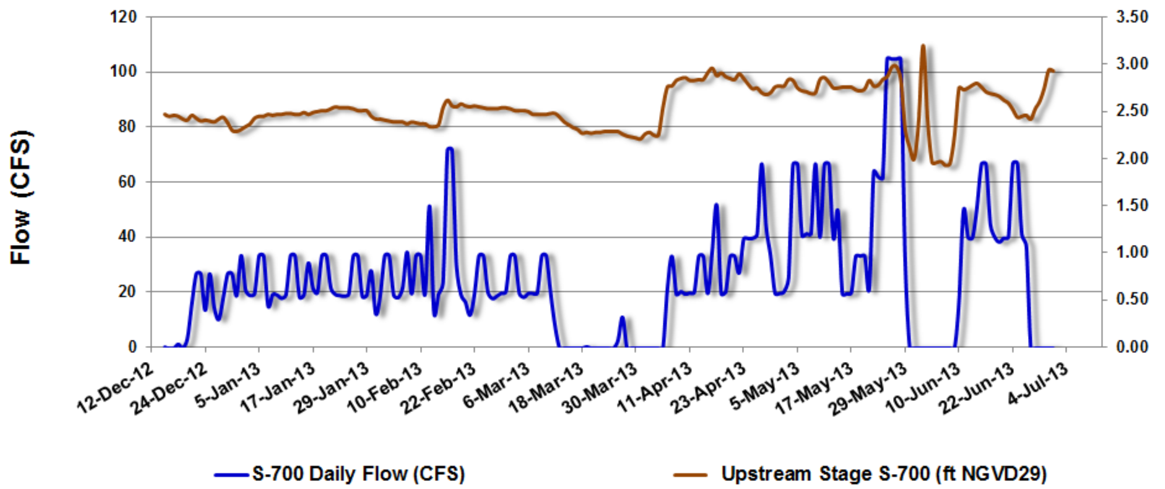


**Figure 4.** Comparison of flow and stage for pump station S-700.

## Rainfall

Rainfall monitoring station S-123 within the vicinity of Deering Estate Flow-way recorded 20.45 inches from December 2012 through June 2013 (**Table 3** and **Figure 5**).

**Table 3.** Summary rainfall (inches) at rainfall station S-123 near Deering Estate Flow-way.

| Date | S-123 Monthly Rainfall (Inches) |
|---|---|
| December 2012 | 0.46 |
| January 2013 | 0.57 |
| February 2013 | 1.83 |
| April 2013 | 3.29 |
| May 2013 | 10.61 |
| June 2013 | 3.69 |
| **Total** | **20.45** |

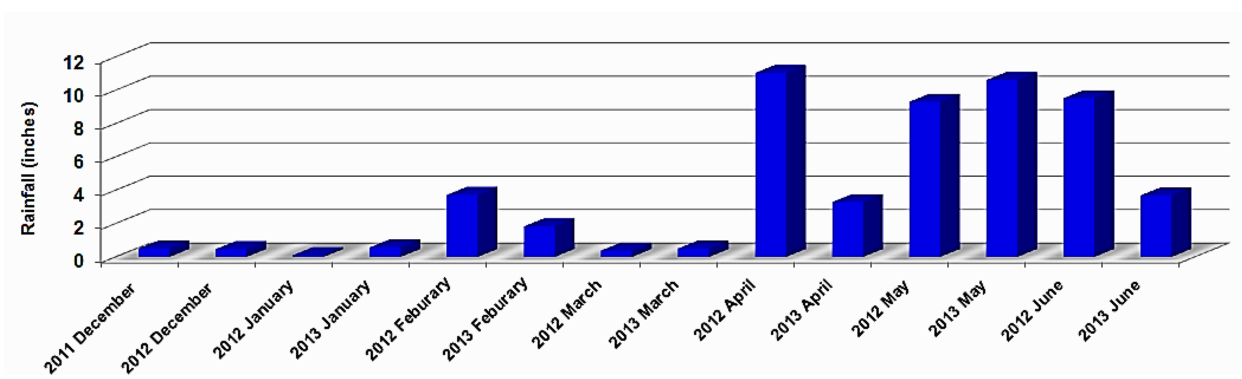


**Figure 5.** Summary of rainfall at station S-123 near Deering Estate Flow-way.

## Surface Water Levels

Once pumping began, surface water levels within the wetlands increased at staff gauges 1 and 3 after a few days lag, and decreased after pumping ceased (**Table 4** and **Figure 6**). The greatest increase in water level, a maximum average rise of about 1.25 feet, occurred at staff gauge 1.

**Table 4.** Monthly salinity concentrations and water levels at Deering Estate wetland staff gauges within the vicinity of historic remnant wetlands on Deering Estate.

| Date | Salinity Concentration | | Water Level (feet NGVD) | |
|---|---|---|---|---|
| | Wetland Staff Gauge 1 | Wetland Staff Gauge 3 | Wetland Staff Gauge 1 | Wetland Staff Gauge 3 |
| 08/24/11 | 0.49 | 5.57 | 2.36 | 1.68 |
| 09/21/11 | 0.45 | 12.35 | 2.27 | 1.70 |
| 10/26/11 | 0.41 | 5.18 | 2.25 | 2.00 |
| 11/23/11 | 0.41 | 8.47 | 2.16 | 1.60 |
| 12/22/11 | 0.36 | 6.68 | 1.90 | 1.60 |
| 01/26/12 | 0.6 | 4.33 | 1.60 | 1.30 |
| 02/27/12 | 0.43 | 1.89 | 1.82 | 1.48 |
| 03/27/12 | 1.13 | 1.94 | 1.46 | 1.28 |
| 04/25/12 | 1.17 | 3.29 | 1.62 | 1.34 |
| 05/25/12 | 0.49 | 6.35 | 2.19 | 1.67 |
| 06/28/12 | 0.57 | 2.65 | 1.94 | 1.62 |
| 07/26/12 | 0.28 | 2.16 | 2.85 | 1.60 |
| 08/30/12 | 0.42 | 2.5 | 2.14 | 2.00 |
| 09/12/12 | 0.53 | 1.9 | 1.98 | 1.65 |
| 10/24/12 | 3.82 | 17.79 | 1.95 | 1.70 |
| 11/27/12 | 19.25 | 22.2 | 2.11 | 1.91 |
| 12/20/12 | 7.65 | 12.08 | 1.96 | 1.48 |
| 01/24/13 | 0.3 | 0.31 | 3.20 | 2.04 |
| 2/26/2013 | 0.29 | 0.28 | 3.05 | 2.10 |
| 3/26/2013 | 0.36 | 2.75 | 1.70 | 1.50 |

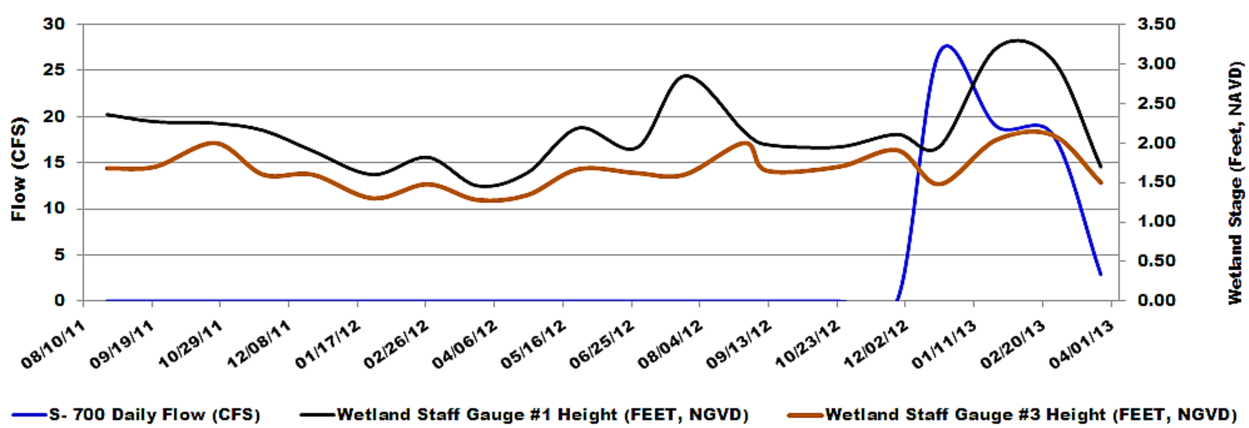


**Figure 6.** Comparison of water levels at Deering Estate staff gauges 1 and 3 versus pump station S-700 daily flow.

## Groundwater Levels

Groundwater also noticeably rose at groundwater monitoring station 2 during the initial test period, and water levels varied according to pump operations (**Table 5** and **Figure 7**). Monitoring station 2 is located about 360 feet downstream of pump station S-700 discharge. The response of groundwater levels downstream at groundwater monitoring station 5 was muted by comparison, but appeared to rise slightly in response to pumped discharges and became less variable (**Figure 7**). For the data, see **Table B-2** in **Attachment B**.

**Table 5.** Monthly average water levels in Deering Estate Flow-way groundwater monitoring stations.

| Date | Monthly Average Depth (feet NGVD) | |
|---|---|---|
| | Station 2 | Station 5 |
| Aug-11 | 9.20 | 5.65 |
| Sep-11 | 9.22 | 5.62 |
| Oct-11 | 8.95 | 6.28 |
| Nov-11 | 9.24 | 8.30 |
| Dec-11 | 7.13 | 4.63 |
| Jan-12 | 3.72 | 3.70 |
| Feb-12 | 9.12 | 8.90 |
| Mar-12 | 8.15 | 5.40 |
| Apr-12 | 8.37 | 5.82 |
| May-12 | 8.93 | 5.76 |
| Jun-12 | 12.22 | 6.24 |
| Jul-12 | 11.49 | 7.12 |
| Aug-12 | 8.99 | 6.34 |
| Sep-12 | 9.08 | 6.34 |
| Oct-12 | 9.04 | 6.15 |
| Nov-12 | 8.95 | 5.87 |
| Dec-12 | 9.03 | 5.75 |
| Jan-13 | 10.06 | 6.09 |
| Feb-13 | 10.41 | 6.34 |
| Mar-13 | 9.04 | 5.77 |

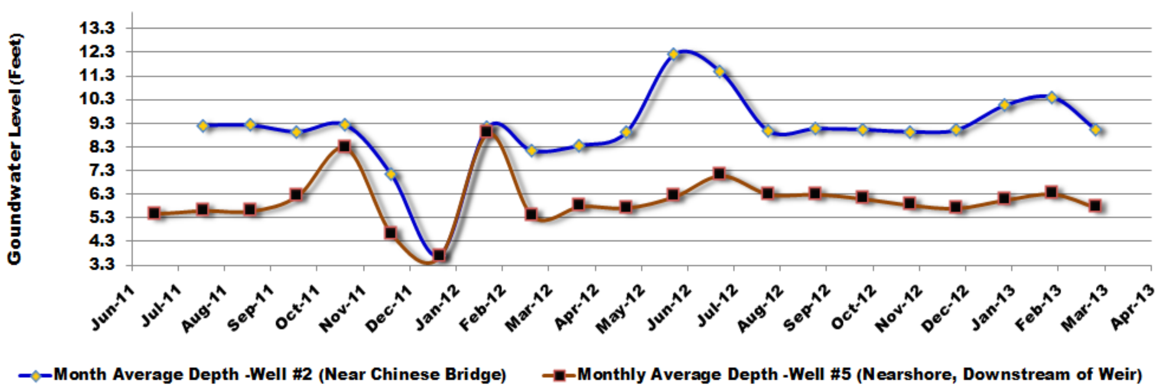


**Figure 7.** Comparison of groundwater levels within the vicinity of historic remnant wetlands of Deering Estate.

## Wetland Inundation

During this reporting period, the project team determined how much of the freshwater wetlands within the slough were inundated during different flow rates (**Table 6** and **Figures 8** and **9**). By interpolation, a flow rate of 24 cfs during the initial test period would have inundated almost 19 acres of wetlands or about 55 percent of the historical total. Typically, these wetlands are dry during this time of year, because they have been recharged only by rainfall since the C-100 canal was built. The 30 cfs flow rate after April 6, 2013 would have likely inundated about 62 percent of the historical wetlands.

**Table 6.** Estimated acreage of impounded surface water under different pumping/flow rates within Deering Estate.

| Date | Pumping Rate (cfs) | Duration of Pumping (hours) | Estimated Acres of Impounded Surface Water |
|---|---|---|---|
| January 16, 2013 | 25 | 5 | 19 |
| February 7, 2013 | 50 | 5 | 25 |
| January 30, 2013 | 75 | 5 | 27 |
| February 30, 2013 | 100 | 5 | 31 |


**Figure 8.** Freshwater diverted from pump station S-700 to the historic remnant wetlands within the vicinity of Cutler Creek in Deering Estate

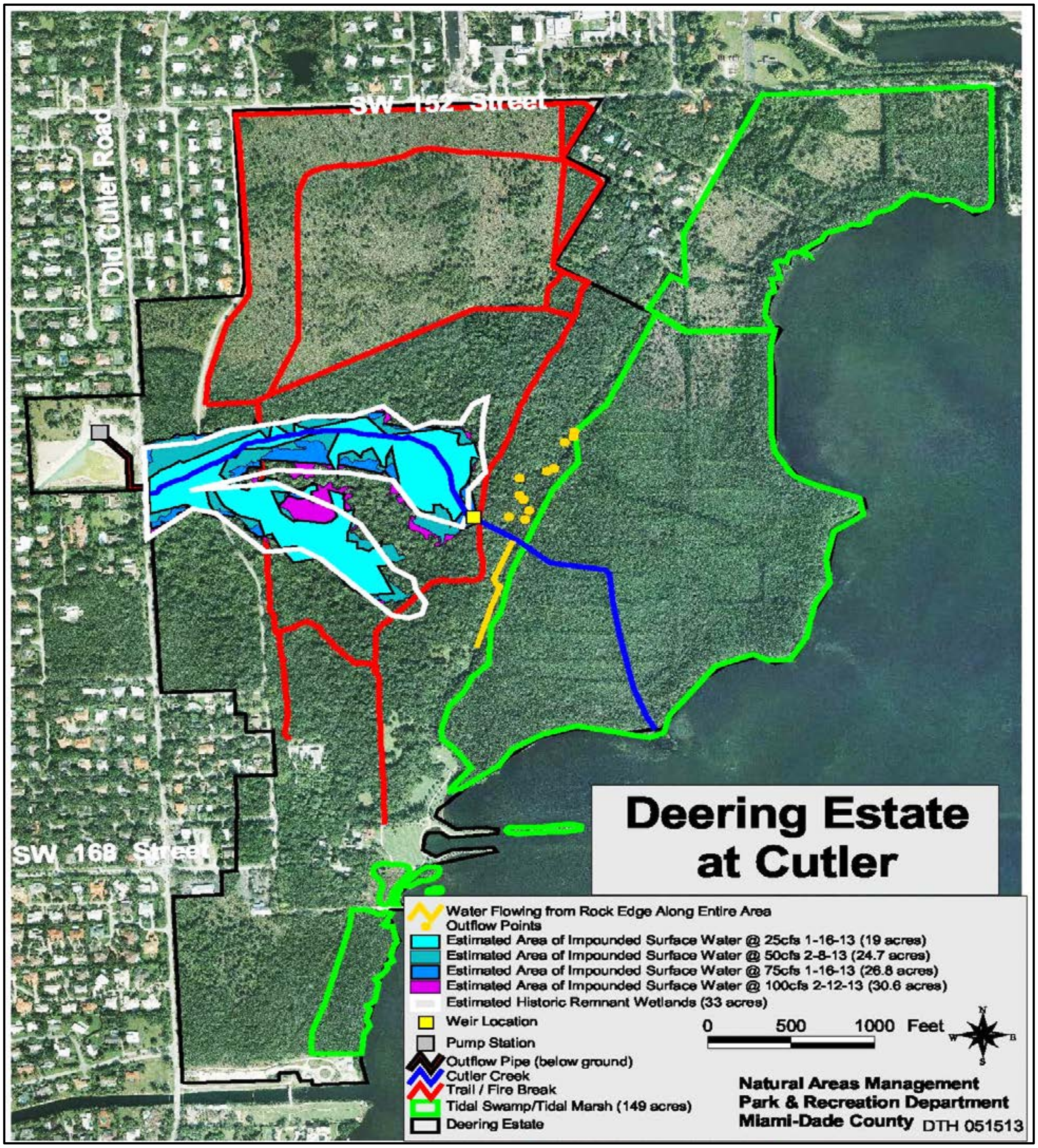


Figure **9**. Delineation of the historical freshwater wetland slough in the Deering Estate and areas of inundation at different pump rates.

## Salinity

Surface water salinity responded to the pumped inputs of fresh water from pump station S-700 into the historic remnant wetlands within the vicinity of Cutler Creek (**Table 4** and **Figure 10**). Salinity at both wetland staff gauges 1 and 3 decreased to less than 1.

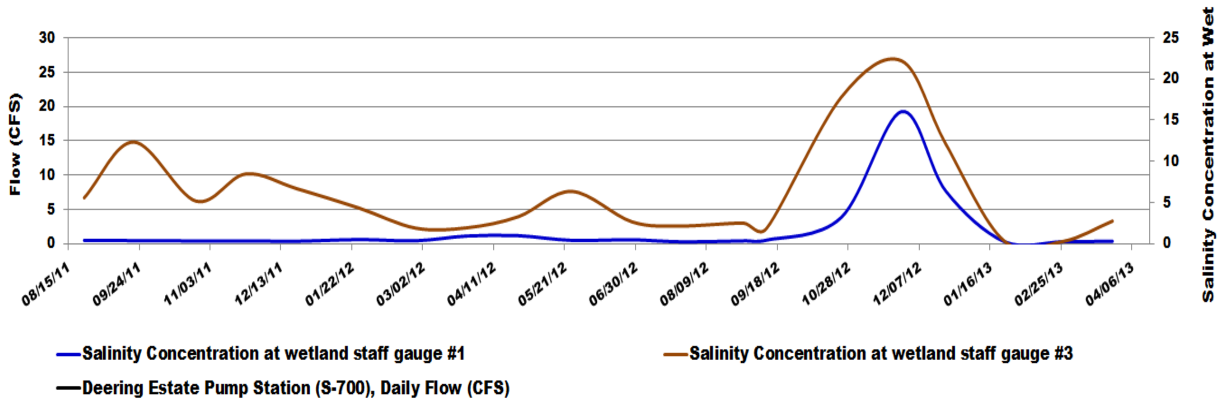


**Figure 10.** Comparison of surface water salinity concentrations at wetland staff gauges 1 and 3 within the vicinity of historic remnant wetlands of Deering Estate.

Groundwater salinity also responded to the inputs of fresh water from pump station S-700 into the historic remnant wetlands (**Figure 11**). Salinity rose rapidly at the beginning of the dry season in groundwater monitoring station 5 near the mangrove wetlands, peaking at well over 20. After pumping began at S-700, salinity decreased to less than 10. Salinity concentration in groundwater monitoring station 2 was less than 1 during this reporting period. See **Table B-2** in **Attachment B** for the data.

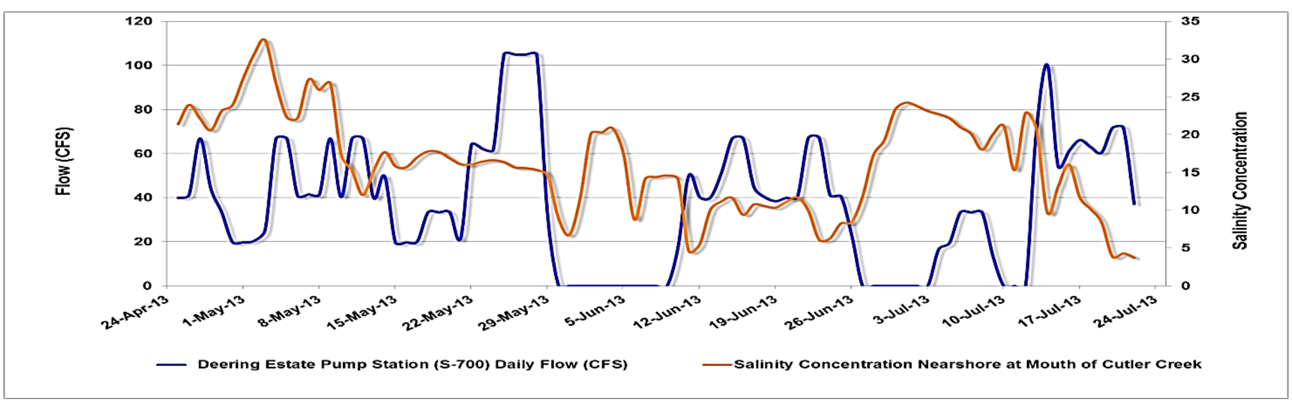


**Figure 11.** Comparison of salinity concentration in groundwater within the vicinity of historic remnant wetlands of Deering Estate versus pump station S-700 daily flow.

Salinity of the surface water nearshore at the mouth of Cutler Creek (**Figure 12**) also responded to the pumped inputs of fresh water from pump station S-700 (**Figure 13**). After pumping began, salinity decreased to less than 10. For more information see **Table B-3** in **Attachment B**.

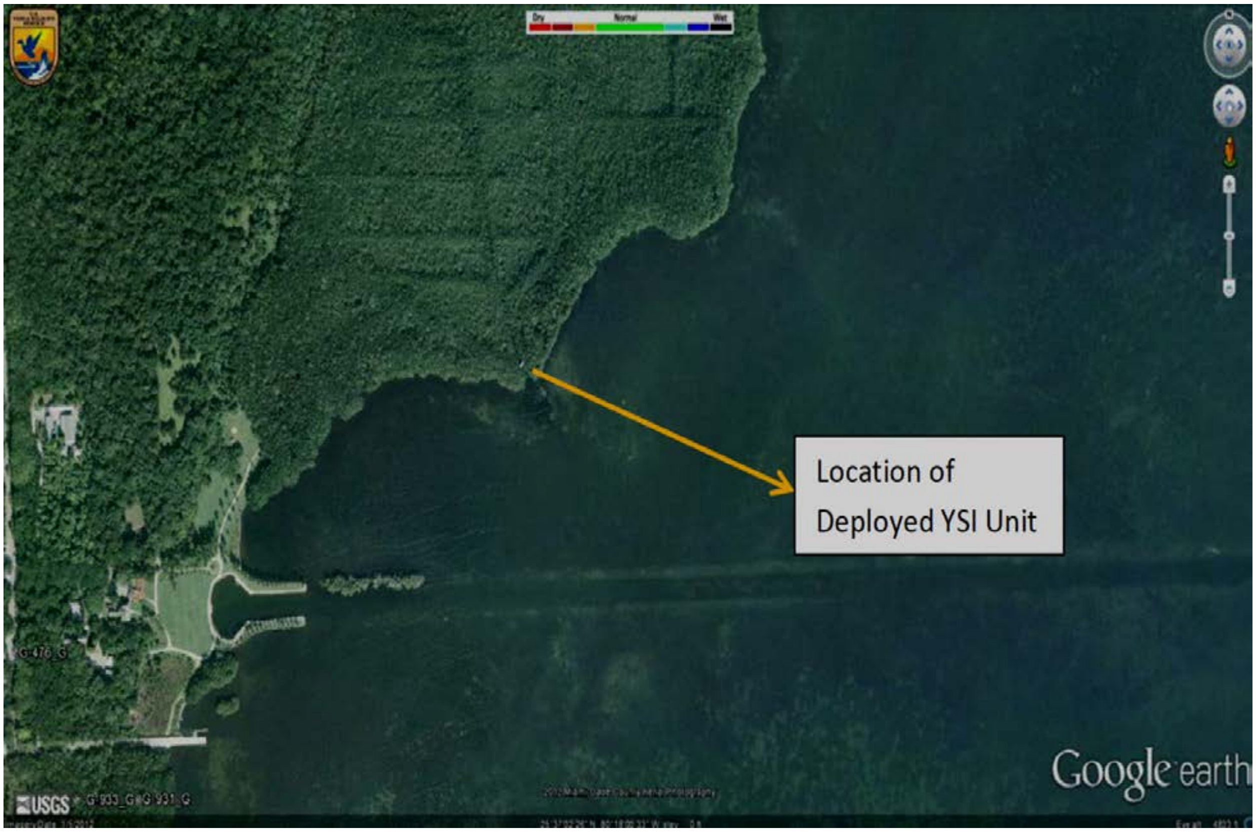


**Figure 12.** Location of deployed YSI unit in the mouth of Cutler Creek.

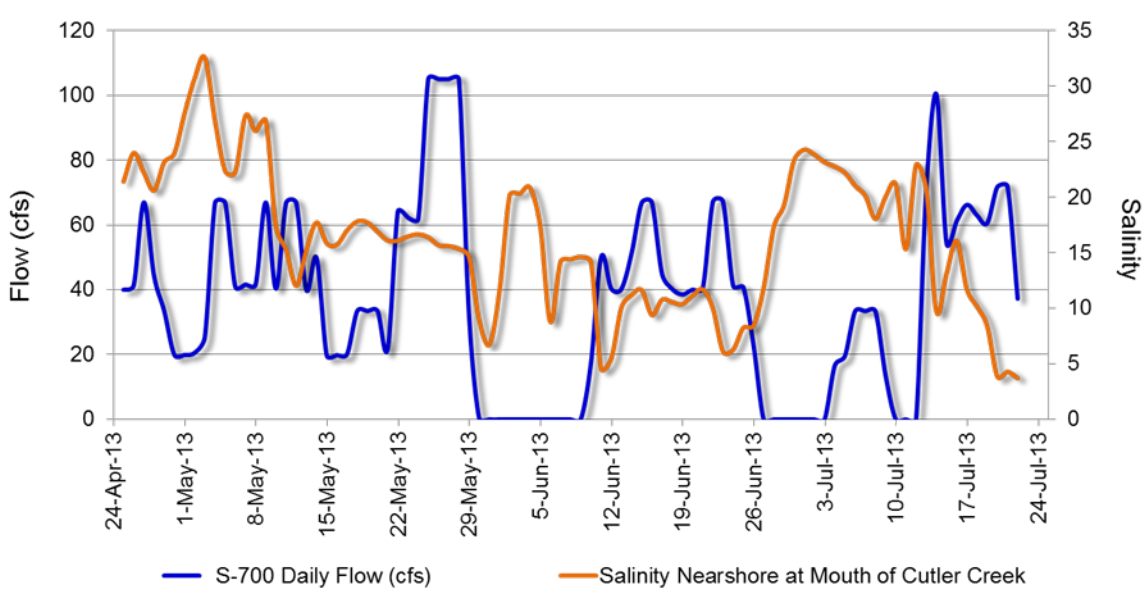


**Figure 13**. Comparison of surface water salinity concentrations nearshore at the mouth of Cutler Creek (YSI unit deployed on April 23, 2013) versus pump station S-700 daily flow.

## VEGETATION CHANGES

Changes have started occurring in the vegetation communities with the dying of upland trees that had grown into the historic wetlands within the vicinity of Cutler Creek in Deering Estate **(Figure 14)**. Now that the rehydration project is bringing increased water levels back to the historic wetlands, a lot of these trees will continue to die. As they die out, wetland species will take their place**.**

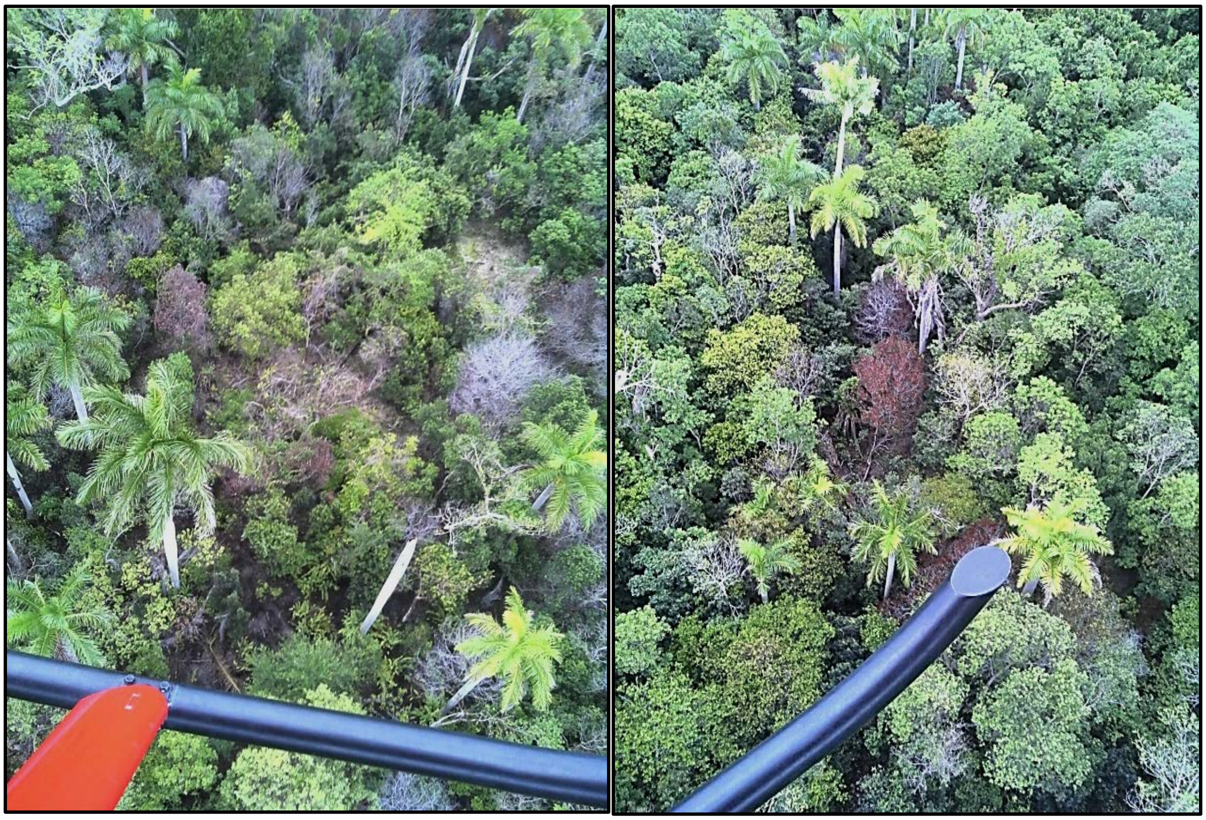

Figure 14. Changes in the vegetation communities and the beginnings of the die-back of upland trees that have grown into the historic wetlands within the vicinity of Cutler Creek in Deering Estates (June 2013).

# CONCLUSIONS

Based on a review of the monitoring data collected during the first year of ecological monitoring and a comparison of this data to baseline data, the project is trending towards success by diverting approximately 10,259 acre-feet of fresh water from the C-100 canal through pump station S-700 to historic remnant wetlands near Cutler Creek east of Old Cutler Road. Surface water level within the wetlands increased at the two wetland staff gauges. The greatest increase in water level occurred at staff gauge 1, a maximum average rise of about 1.25 feet. Groundwater also noticeably rose at monitoring station 2 during the initial test period, and water levels varied according to pump operations. Monitoring station 2 is located about 360 feet downstream of pump station S-700 discharge. The response of groundwater level downstream at monitoring station 5 was muted by comparison, but appeared to rise slightly in response to pumped discharges.

# Attachment A: Photographs

**Figure A-1**. Wetland staff gauge 3 east of the Deering Estate weir.

**Figure A-2.** Pump station S-700 and educational wetlands.


**Figure A-3**. Freshwater diverted from pump station S-700 to Deering Estate east of Old Cutler Road wetlands.

**Figure A-4**. Pump station S-700.

**Figure A-5**. Existing wetland staff gauge 3 within Cutler Creek upstream of the weir.

**Figure A-6**. Close-up of the upstream side of the weir in Cutler Creek.

**Figure A-7**. Photo of existing monitoring station (well) 5 within the rehydration area.

# Attachment B:
# Data

**Table B-1.** Summary of daily flow and upstream stage data for pump station S-700.

| Date | Daily Flow (cfs) | S-700 Upstream Stage (feet NGVD) |
|---|---|---|
| 20-Dec-12 | 2.41 | 3.27 |
| 21-Dec-12 | 2.46 | 15.96 |
| 22-Dec-12 | 2.43 | 27.05 |
| 23-Dec-12 | 2.40 | 27.04 |
| 24-Dec-12 | 2.41 | 13.82 |
| 25-Dec-12 | 2.40 | 27.04 |
| 26-Dec-12 | 2.39 | 14.84 |
| 27-Dec-12 | 2.42 | 10.43 |
| 28-Dec-12 | 2.44 | 18.26 |
| 29-Dec-12 | 2.38 | 27.03 |
| 30-Dec-12 | 2.30 | 26.99 |
| 31-Dec-12 | 2.29 | 19.13 |
| 1-Jan-13 | 2.31 | 33.70 |
| 2-Jan-13 | 2.34 | 21.13 |
| 3-Jan-13 | 2.37 | 19.17 |
| 4-Jan-13 | 2.43 | 19.88 |
| 5-Jan-13 | 2.45 | 33.63 |
| 6-Jan-13 | 2.45 | 33.63 |
| 7-Jan-13 | 2.47 | 15.43 |
| 8-Jan-13 | 2.46 | 19.43 |
| 9-Jan-13 | 2.47 | 19.35 |
| 10-Jan-13 | 2.47 | 18.18 |
| 11-Jan-13 | 2.48 | 19.42 |
| 12-Jan-13 | 2.48 | 33.61 |
| 13-Jan-13 | 2.47 | 33.62 |
| 14-Jan-13 | 2.47 | 18.58 |
| 15-Jan-13 | 2.49 | 19.46 |
| 16-Jan-13 | 2.47 | 30.98 |
| 17-Jan-13 | 2.49 | 21.87 |
| 18-Jan-13 | 2.50 | 20.30 |
| 19-Jan-13 | 2.51 | 33.60 |
| 20-Jan-13 | 2.51 | 33.59 |
| 21-Jan-13 | 2.53 | 21.79 |
| 22-Jan-13 | 2.55 | 19.59 |
| 23-Jan-13 | 2.54 | 19.17 |
| 24-Jan-13 | 2.54 | 18.96 |

**Table B-1.** Continued.

| Date | Daily Flow (cfs) | S-700 Upstream Stage (feet NGVD) |
|---|---|---|
| 25-Jan-13 | 2.54 | 19.75 |
| 26-Jan-13 | 2.53 | 33.59 |
| 27-Jan-13 | 2.51 | 33.59 |
| 28-Jan-13 | 2.51 | 18.81 |
| 29-Jan-13 | 2.51 | 19.34 |
| 30-Jan-13 | 2.45 | 28.08 |
| 31-Jan-13 | 2.42 | 12.49 |
| 1-Feb-13 | 2.42 | 19.32 |
| 2-Feb-13 | 2.41 | 33.65 |
| 3-Feb-13 | 2.40 | 33.65 |
| 4-Feb-13 | 2.39 | 19.35 |
| 5-Feb-13 | 2.39 | 18.37 |
| 6-Feb-13 | 2.39 | 21.98 |
| 7-Feb-13 | 2.37 | 34.92 |
| 8-Feb-13 | 2.39 | 19.82 |
| 9-Feb-13 | 2.38 | 33.66 |
| 10-Feb-13 | 2.37 | 33.67 |
| 11-Feb-13 | 2.37 | 19.69 |
| 12-Feb-13 | 2.34 | 51.67 |
| 13-Feb-13 | 2.34 | 12.65 |
| 14-Feb-13 | 2.36 | 19.69 |
| 15-Feb-13 | 2.54 | 23.73 |
| 16-Feb-13 | 2.62 | 72.13 |
| 17-Feb-13 | 2.56 | 72.20 |
| 18-Feb-13 | 2.55 | 29.79 |
| 19-Feb-13 | 2.58 | 19.49 |
| 20-Feb-13 | 2.56 | 16.80 |
| 21-Feb-13 | 2.55 | 12.04 |
| 22-Feb-13 | 2.56 | 19.65 |
| 23-Feb-13 | 2.55 | 33.57 |
| 24-Feb-13 | 2.54 | 33.58 |
| 25-Feb-13 | 2.53 | 20.36 |
| 26-Feb-13 | 2.53 | 18.05 |
| 27-Feb-13 | 2.53 | 18.96 |
| 28-Feb-13 | 2.54 | 20.02 |
| 1-Mar-13 | 2.54 | 20.50 |
| 2-Mar-13 | 2.53 | 33.59 |
| 3-Mar-13 | 2.51 | 33.59 |
| 4-Mar-13 | 2.51 | 19.95 |
| 5-Mar-13 | 2.51 | 18.53 |
| 6-Mar-13 | 2.50 | 19.90 |
| 7-Mar-13 | 2.47 | 19.89 |

**Table B-1.** Continued.

| Date | Daily Flow (cfs) | S-700 Upstream Stage (feet NGVD) |
|---|---|---|
| 8-Mar-13 | 2.47 | 20.03 |
| 9-Mar-13 | 2.47 | 33.62 |
| 10-Mar-13 | 2.47 | 33.62 |
| 11-Mar-13 | 2.48 | 19.77 |
| 12-Mar-13 | 2.48 | 7.67 |
| 13-Mar-13 | 2.44 | 0.00 |
| 14-Mar-13 | 2.39 | 0.00 |
| 15-Mar-13 | 2.36 | 0.00 |
| 16-Mar-13 | 2.33 | 0.00 |
| 17-Mar-13 | 2.31 | 0.00 |
| 18-Mar-13 | 2.27 | 0.00 |
| 19-Mar-13 | 2.28 | 0.52 |
| 20-Mar-13 | 2.27 | 0.00 |
| 21-Mar-13 | 2.28 | 0.00 |
| 22-Mar-13 | 2.28 | 0.00 |
| 23-Mar-13 | 2.29 | 0.00 |
| 24-Mar-13 | 2.29 | 0.00 |
| 25-Mar-13 | 2.29 | 0.00 |
| 26-Mar-13 | 2.29 | 2.87 |
| 27-Mar-13 | 2.26 | 11.25 |
| 28-Mar-13 | 2.24 | 0.00 |
| 29-Mar-13 | 2.23 | 0.00 |
| 30-Mar-13 | 2.22 | 0.00 |
| 31-Mar-13 | 2.21 | 0.00 |
| 28-Mar-13 | 2.24 | 0.00 |
| 29-Mar-13 | 2.23 | 0.00 |
| 30-Mar-13 | 2.22 | 0.00 |
| 31-Mar-13 | 2.21 | 0.00 |
| 1-Apr-13 | 2.26 | 0.00 |
| 2-Apr-13 | 2.28 | 0.00 |
| 3-Apr-13 | 2.25 | 0.00 |
| 4-Apr-13 | 2.25 | 0.00 |
| 5-Apr-13 | 2.54 | 0.00 |
| 6-Apr-13 | 2.76 | 21.51 |
| 7-Apr-13 | 2.77 | 33.46 |
| 8-Apr-13 | 2.83 | 19.69 |
| 9-Apr-13 | 2.85 | 20.59 |
| 10-Apr-13 | 2.86 | 19.68 |
| 11-Apr-13 | 2.83 | 20.08 |
| 12-Apr-13 | 2.83 | 20.32 |
| 13-Apr-13 | 2.84 | 33.43 |
| 14-Apr-13 | 2.84 | 33.45 |

**Table B-1.** Continued.

| Date | Daily Flow (cfs) | S-700 Upstream Stage (feet NGVD) |
|---|---|---|
| 15-Apr-13 | 2.91 | 19.93 |
| 16-Apr-13 | 2.96 | 35.50 |
| 17-Apr-13 | 2.88 | 51.91 |
| 18-Apr-13 | 2.91 | 19.81 |
| 19-Apr-13 | 2.87 | 20.44 |
| 20-Apr-13 | 2.85 | 33.42 |
| 21-Apr-13 | 2.84 | 33.43 |
| 22-Apr-13 | 2.90 | 27.41 |
| 23-Apr-13 | 2.85 | 39.74 |
| 24-Apr-13 | 2.79 | 39.92 |
| 25-Apr-13 | 2.74 | 39.99 |
| 26-Apr-13 | 2.75 | 41.36 |
| 27-Apr-13 | 2.70 | 66.99 |
| 28-Apr-13 | 2.68 | 44.34 |
| 29-Apr-13 | 2.70 | 33.51 |
| 30-Apr-13 | 2.76 | 19.93 |
| 1-May-13 | 2.77 | 19.91 |
| 2-May-13 | 2.77 | 20.57 |
| 3-May-13 | 2.84 | 25.41 |
| 4-May-13 | 2.83 | 66.87 |
| 5-May-13 | 2.75 | 66.95 |
| 6-May-13 | 2.72 | 40.91 |
| 7-Jun-13 | 1.93 | 0.00 |
| 8-Jun-13 | 1.95 | 0.00 |
| 9-Jun-13 | 2.25 | 0.00 |
| 10-Jun-13 | 2.75 | 17.30 |
| 11-Jun-13 | 2.73 | 50.07 |
| 12-Jun-13 | 2.75 | 40.38 |
| 13-Jun-13 | 2.78 | 40.23 |
| 14-Jun-13 | 2.80 | 51.31 |
| 15-Jun-13 | 2.76 | 66.93 |
| 16-Jun-13 | 2.71 | 66.99 |
| 17-Jun-13 | 2.69 | 44.89 |
| 18-Jun-13 | 2.68 | 40.28 |
| 19-Jun-13 | 2.66 | 38.58 |
| 20-Jun-13 | 2.62 | 40.06 |
| 21-Jun-13 | 2.59 | 40.41 |
| 22-Jun-13 | 2.52 | 67.18 |
| 23-Jun-13 | 2.44 | 67.26 |
| 24-Jun-13 | 2.45 | 41.27 |
| 25-Jun-13 | 2.46 | 40.82 |
| 26-Jun-13 | 2.42 | 23.03 |

**Table B-1.** Continued.

| Date | Daily Flow (cfs) | S-700 Upstream Stage (feet NGVD) |
|---|---|---|
| 27-Jun-13 | 2.53 | 0.00 |
| 28-Jun-13 | 2.61 | 0.00 |
| 29-Jun-13 | 2.75 | 0.00 |
| 30-Jun-13 | 2.94 | 0.00 |
| 1-Jul-13 | 2.93 | 0.00 |
| 2-Jul-13 | 2.93 | 0.00 |
| 3-Jul-13 | 2.92 | 0.00 |
| 4-Jul-13 | 2.90 | 16.60 |
| 5-Jul-13 | 2.87 | 19.58 |
| 6-Jul-13 | 2.86 | 33.42 |
| 7-Jul-13 | 2.83 | 33.43 |
| 8-Jul-13 | 2.80 | 33.44 |

**Table B-2.** Summary of daily salinity concentrations at groundwater monitoring station 5 within the vicinity of the historic remnant wetlands of Cutler Creek within Deering Estate.

| Date | Daily Salinity | Daily Flow (cfs) |
|---|---|---|
| 11/30/2012 | 20.85 | 0 |
| 12/1/2012 | 20.89 | 0 |
| 12/2/2012 | 20.90 | 0 |
| 12/3/2012 | 20.89 | 0 |
| 12/4/2012 | 20.85 | 0 |
| 12/5/2012 | 20.79 | 0 |
| 12/6/2012 | 20.71 | 0 |
| 12/7/2012 | 20.60 | 0 |
| 12/8/2012 | 20.46 | 0 |
| 12/9/2012 | 20.29 | 0 |
| 12/10/2012 | 20.11 | 0 |
| 12/11/2012 | 19.90 | 0 |
| 12/12/2012 | 19.68 | 0 |
| 12/13/2012 | 19.46 | 0 |
| 12/14/2012 | 19.23 | 0 |
| 12/15/2012 | 18.98 | 0 |
| 12/16/2012 | 19.00 | 0 |
| 12/17/2012 | 19.09 | 0 |
| 12/18/2012 | 19.13 | 0 |
| 12/19/2012 | 19.12 | 0 |
| 12/20/2012 | 18.18 | 3.27 |
| 12/21/2012 | 17.58 | 15.96 |
| 12/22/2012 | 16.94 | 27.05 |
| 12/23/2012 | 16.32 | 27.04 |
| 12/24/2012 | 16.16 | 13.82 |
| 12/25/2012 | 16.09 | 27.04 |
| 12/26/2012 | 15.93 | 14.84 |
| 12/27/2012 | 15.85 | 10.43 |
| 12/28/2012 | 15.42 | 18.26 |
| 12/29/2012 | 14.98 | 27.03 |
| 12/30/2012 | 14.59 | 26.99 |
| 12/31/2012 | 14.33 | 19.13 |
| 1/1/2013 | 14.22 | 33.7 |
| 1/2/2013 | 13.89 | 21.13 |
| 1/3/2013 | 13.69 | 19.17 |
| 1/4/2013 | 13.19 | 19.88 |
| 1/5/2013 | 12.50 | 33.63 |
| 1/6/2013 | 11.91 | 33.63 |
| 1/7/2013 | 11.96 | 15.43 |
| 1/8/2013 | 12.30 | 19.43 |
| 1/9/2013 | 11.92 | 19.35 |
| 1/10/2013 | 11.80 | 18.18 |

**Table B-2.** Continued.

| Date | Daily Salinity | Daily Flow (cfs) |
|---|---|---|
| 1/11/2013 | 11.85 | 19.42 |
| 1/12/2013 | 11.85 | 33.61 |
| 1/13/2013 | 11.90 | 33.62 |
| 1/14/2013 | 12.17 | 18.58 |
| 1/15/2013 | 12.38 | 19.46 |
| 1/16/2013 | 12.38 | 30.98 |
| 1/17/2013 | 12.37 | 21.87 |
| 1/18/2013 | 12.32 | 20.3 |
| 1/19/2013 | 12.14 | 33.6 |
| 1/20/2013 | 11.95 | 33.59 |
| 1/21/2013 | 12.00 | 21.79 |
| 1/22/2013 | 12.12 | 19.59 |
| 1/23/2013 | 12.06 | 19.17 |
| 1/24/2013 | 11.05 | 18.96 |
| 1/25/2013 | 10.28 | 19.75 |
| 1/26/2013 | 10.30 | 33.59 |
| 1/27/2013 | 10.34 | 33.59 |
| 1/28/2013 | 10.57 | 18.81 |
| 1/29/2013 | 10.91 | 19.34 |
| 1/30/2013 | 10.93 | 28.08 |
| 1/31/2013 | 10.99 | 12.49 |
| 2/1/2013 | 11.05 | 19.32 |
| 2/2/2013 | 11.06 | 33.65 |
| 2/3/2013 | 11.05 | 33.65 |
| 2/4/2013 | 11.02 | 19.35 |
| 2/5/2013 | 11.01 | 18.37 |
| 2/6/2013 | 11.01 | 21.98 |
| 2/7/2013 | 11.01 | 34.92 |
| 2/8/2013 | 11.01 | 19.82 |
| 2/9/2013 | 11.01 | 33.66 |
| 2/10/2013 | 11.01 | 33.67 |
| 2/11/2013 | 11.01 | 19.69 |
| 2/12/2013 | 11.01 | 51.67 |
| 2/13/2013 | 11.01 | 12.65 |
| 2/14/2013 | 11.01 | 19.69 |
| 2/15/2013 | 11.01 | 23.73 |
| 2/16/2013 | 11.01 | 72.13 |
| 2/17/2013 | 10.94 | 72.2 |
| 2/18/2013 | 10.79 | 29.79 |
| 2/19/2013 | 10.67 | 19.49 |
| 2/20/2013 | 10.63 | 16.8 |
| 2/21/2013 | 10.60 | 12.04 |

**Table B-2.** Continued.

| Date | Daily Salinity | Daily Flow (cfs) |
|---|---|---|
| 2/22/2013 | 10.57 | 19.65 |
| 2/23/2013 | 10.51 | 33.57 |
| 2/24/2013 | 10.39 | 33.58 |
| 2/25/2013 | 10.20 | 20.36 |
| 2/26/2013 | 9.50 | 18.05 |
| 2/27/2013 | 9.15 | 18.96 |
| 2/28/2013 | 9.19 | 20.02 |
| 3/1/2013 | 9.22 | 20.5 |
| 3/2/2013 | 9.23 | 33.59 |
| 3/3/2013 | 9.21 | 33.59 |
| 3/4/2013 | 9.18 | 19.95 |
| 3/5/2013 | 9.20 | 18.53 |
| 3/6/2013 | 9.20 | 19.9 |
| 3/7/2013 | 9.16 | 19.89 |
| 3/8/2013 | 9.11 | 20.03 |
| 3/9/2013 | 9.04 | 33.62 |
| 3/10/2013 | 8.99 | 33.62 |
| 3/11/2013 | 9.04 | 19.77 |
| 3/12/2013 | 9.22 | 7.67 |
| 3/13/2013 | 9.38 | 0 |
| 3/14/2013 | 9.40 | 0 |
| 3/15/2013 | 9.37 | 0 |
| 3/16/2013 | 9.31 | 0 |
| 3/17/2013 | 9.25 | 0 |
| 3/18/2013 | 9.17 | 0 |
| 3/19/2013 | 9.07 | 0.52 |
| 3/20/2013 | 8.98 | 0 |
| 3/21/2013 | 8.93 | 0 |
| 3/22/2013 | 8.89 | 0 |
| 3/23/2013 | 8.82 | 0 |
| 3/24/2013 | 8.73 | 0 |
| 3/25/2013 | 8.64 | 0 |
| 3/26/2013 | 8.13 | 2.87 |
| 3/27/2013 | 7.97 | 11.25 |
| 3/28/2013 | 7.99 | 0 |
| 3/29/2013 | 7.99 | 0 |
| 3/30/2013 | 7.99 | 0 |
| 3/31/2013 | 7.98 | 0 |
| 4/1/2013 | 7.97 | 0 |
| 4/2/2013 | 7.95 | 0 |
| 4/3/2013 | 7.94 | 0 |
| 4/4/2013 | 7.92 | 0 |

**Table B-2.** Continued.

| Date | Daily Salinity | Daily Flow (cfs) |
|---|---|---|
| 4/5/2013 | 7.92 | 0 |
| 4/6/2013 | 7.92 | 21.51 |
| 4/7/2013 | 7.94 | 33.46 |
| 4/8/2013 | 7.96 | 19.69 |
| 4/9/2013 | 8.20 | 20.59 |
| 4/10/2013 | 8.29 | 19.68 |
| 4/11/2013 | 8.35 | 20.08 |
| 4/12/2013 | 8.38 | 20.32 |
| 4/13/2013 | 8.37 | 33.43 |
| 4/14/2013 | 8.35 | 33.45 |
| 4/15/2013 | 8.32 | 19.93 |
| 4/16/2013 | 8.30 | 35.5 |
| 4/17/2013 | 8.25 | 51.91 |
| 4/18/2013 | 8.17 | 19.81 |
| 4/19/2013 | 8.18 | 20.44 |
| 4/20/2013 | 8.18 | 33.42 |
| 4/21/2013 | 8.16 | 33.43 |
| 4/22/2013 | 8.13 | 27.41 |
| 4/23/2013 | 8.16 | 39.74 |
| 4/24/2013 | 8.19 | 39.92 |
| 4/25/2013 | 8.21 | 39.99 |
| 4/26/2013 | 8.21 | 41.36 |
| 4/27/2013 | 8.22 | 66.99 |
| 4/28/2013 | 8.19 | 44.34 |
| 4/29/2013 | 8.15 | 33.51 |
| 4/30/2013 | 7.78 | 19.93 |
| 5/1/2013 | 7.76 | 19.91 |
| 5/2/2013 | 7.82 | 20.57 |
| 5/3/2013 | 7.86 | 25.41 |
| 5/4/2013 | 7.84 | 66.87 |
| 5/5/2013 | 7.70 | 66.95 |
| 5/6/2013 | 7.59 | 40.91 |
| 5/7/2013 | 7.68 | 41.64 |
| 5/8/2013 | 7.71 | 41.58 |
| 5/9/2013 | 7.72 | 67 |
| 5/10/2013 | 7.68 | 40.39 |
| 5/11/2013 | 7.65 | 66.84 |
| 5/12/2013 | 7.46 | 66.84 |
| 5/13/2013 | 7.30 | 39.94 |
| 5/14/2013 | 7.42 | 49.84 |
| 5/15/2013 | 7.54 | 19.69 |
| 5/16/2013 | 7.60 | 19.85 |

**Table B-2.** Continued.

| Date | Daily Salinity | Daily Flow (cfs) |
|---|---|---|
| 5/17/2013 | 7.63 | 20.15 |
| 5/18/2013 | 7.63 | 33.48 |
| 5/19/2013 | 7.61 | 33.49 |
| 5/20/2013 | 7.63 | 33.49 |
| 5/21/2013 | 7.72 | 21.83 |
| 5/22/2013 | 7.34 | 64.22 |
| 5/23/2013 | 7.23 | 62.3 |
| 5/24/2013 | 7.13 | 61.81 |
| 5/25/2013 | 6.76 | 105.25 |
| 5/26/2013 | 2.60 | 105.09 |
| 5/27/2013 | 1.39 | 105.07 |
| 5/28/2013 | 1.39 | 105.17 |

**Table B-3.** Summary data for daily salinity concentrations of the monitoring station located nearshore at the mouth of Cutler Creek.

| Date | Pump Station S-700 Daily Flow (cfs) | Daily Salinity Concentration Nearshore at Mouth of Cutler Creek |
|---|---|---|
| 25-Apr-13 | 39.99 | 21.39 |
| 26-Apr-13 | 41.36 | 24.00 |
| 27-Apr-13 | 66.99 | 22.21 |
| 28-Apr-13 | 44.34 | 20.62 |
| 29-Apr-13 | 33.51 | 23.17 |
| 30-Apr-13 | 19.93 | 23.96 |
| 1-May-13 | 19.91 | 27.54 |
| 2-May-13 | 20.57 | 30.71 |
| 3-May-13 | 25.41 | 32.55 |
| 4-May-13 | 66.87 | 26.85 |
| 5-May-13 | 66.95 | 22.37 |
| 6-May-13 | 40.91 | 22.27 |
| 7-May-13 | 41.64 | 27.34 |
| 8-May-13 | 41.58 | 25.96 |
| 9-May-13 | 67 | 26.89 |
| 10-May-13 | 40.39 | 17.44 |
| 11-May-13 | 66.84 | 15.29 |
| 12-May-13 | 66.84 | 12.05 |
| 13-May-13 | 39.94 | 15.31 |
| 14-May-13 | 49.84 | 17.75 |
| 15-May-13 | 19.69 | 15.87 |
| 16-May-13 | 19.85 | 15.76 |
| 17-May-13 | 20.15 | 17.04 |
| 18-May-13 | 33.48 | 17.85 |
| 19-May-13 | 33.49 | 17.75 |
| 20-May-13 | 33.49 | 16.91 |
| 21-May-13 | 21.83 | 16.12 |
| 22-May-13 | 64.22 | 16.12 |
| 23-May-13 | 62.3 | 16.50 |
| 24-May-13 | 61.81 | 16.68 |
| 25-May-13 | 105.25 | 16.41 |
| 26-May-13 | 105.09 | 15.70 |
| 27-May-13 | 105.07 | 15.63 |
| 28-May-13 | 105.17 | 15.38 |
| 29-May-13 | 32.31 | 14.65 |
| 30-May-13 | 0.37 | 9.03 |
| 31-May-13 | 0 | 6.77 |
| 1-Jun-13 | 0 | 11.62 |
| 2-Jun-13 | 0 | 20.20 |
| 3-Jun-13 | 0 | 20.34 |

**Table B-3.** Continued.

| Date | Pump Station S-700 Daily Flow (cfs) | Daily Salinity Concentration Nearshore at Mouth of Cutler Creek |
|---|---|---|
| 4-Jun-13 | 0 | 20.88 |
| 5-Jun-13 | 0 | 17.47 |
| 6-Jun-13 | 0 | 8.82 |
| 7-Jun-13 | 0 | 14.21 |
| 8-Jun-13 | 0 | 14.44 |
| 9-Jun-13 | 0 | 14.65 |
| 10-Jun-13 | 17.3 | 14.20 |
| 11-Jun-13 | 50.07 | 4.64 |
| 12-Jun-13 | 40.38 | 5.51 |
| 13-Jun-13 | 40.23 | 10.11 |
| 14-Jun-13 | 51.31 | 11.22 |
| 15-Jun-13 | 66.93 | 11.68 |
| 16-Jun-13 | 66.99 | 9.43 |
| 17-Jun-13 | 44.89 | 10.82 |
| 18-Jun-13 | 40.28 | 10.59 |
| 19-Jun-13 | 38.58 | 10.41 |
| 20-Jun-13 | 40.06 | 11.18 |
| 21-Jun-13 | 40.41 | 11.74 |
| 22-Jun-13 | 67.18 | 10.02 |
| 23-Jun-13 | 67.26 | 6.14 |
| 24-Jun-13 | 41.27 | 6.31 |
| 25-Jun-13 | 40.82 | 8.29 |
| 26-Jun-13 | 23.03 | 8.48 |
| 27-Jun-13 | 0 | 11.86 |
| 28-Jun-13 | 0 | 17.33 |
| 29-Jun-13 | 0 | 19.30 |
| 30-Jun-13 | 0 | 23.35 |
| 1-Jul-13 | 0 | 24.29 |
| 2-Jul-13 | 0 | 23.83 |
| 3-Jul-13 | 0 | 23.17 |
| 4-Jul-13 | 16.6 | 22.77 |
| 5-Jul-13 | 19.58 | 22.21 |
| 6-Jul-13 | 33.42 | 21.04 |
| 7-Jul-13 | 33.43 | 20.15 |
| 8-Jul-13 | 33.44 | 18.07 |