State of Louisiana
Coastal Protection and Restoration Authority

2024 Operations, Maintenance, and Monitoring Report

for

Naomi Outfall Management (BA-0003c) and Barataria Bay Waterway East Side Shoreline Protection (BA-0026)

State Project Numbers BA-0003c and BA-0026
Priority Project Lists 5 and 6

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Operations, Maintenance, and Monitoring Report for Naomi Outfall Management (BA-0003c) and Barataria Bay Waterway East Side Shoreline Protection (BA-0026) Projects

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Preface

The Naomi Outfall Management (BA-0003c) and Barataria Bay Waterway East Side Shoreline Protection (BA-0026) projects were funded through the Coastal Wetlands Planning, Protection, and Restoration Act (CWPPRA) on the 5th and 6th Priority Project Lists, respectively. The U.S. Department of Agriculture, Natural Resources Conservation Service (NRCS) is the federal sponsor for the projects, and the Coastal Protection and Restoration Authority (CPRA) is the state sponsor. This 2024 report, the fifth and final Operations, Maintenance and Monitoring (OM&M) report for the BA-0003c and BA-0026 projects, includes an analysis of monitoring data collected between November 1991 and December 2022 and a summary of the 2021 maintenance inspections. For additional information on the BA-0003c and BA-0026 projects, including past OM&M and inspection reports, visit http://www.lacoast.gov/new/projects/info.aspx?num=BA-03c and http://www.lacoast.gov/new/projects/info.aspx?num=BA-26, respectively.

I. Introduction

The State of Louisiana and Plaquemines Parish Government (PPG) jointly funded construction of the Naomi Siphon Diversion project (BA-0003), a series of eight siphons built on the west bank of the Mississippi River to re-introduce freshwater from the river into the adjacent Barataria Basin marshes (Figure 1). The re-introduction was intended to restore some of the ecological functions supported by periodic over-bank flooding of the river that occurred prior to the construction of its flood-control levees. Construction of the siphons was completed in 1992, and operations began on February 1, 1993. In 2002, as part of the Naomi Outfall Management project (BA-0003c), a fixed-crest weir with a boat bay was installed in both the Goose Bayou and Bayou Dupont canals (Figure 2 and Appendix A, Photos 1 and 2). These canals connect the open-water failed agricultural impoundment known as “the Pen” to the Barataria Bay Waterway (BBW). The weirs were intended to enhance the retention of the introduced river water within the project area and discourage saltwater intrusion from the BBW. The approximately 23,466-acre BA-0003c project area is located in the Barataria Basin in Jefferson and Plaquemines parishes and is bordered by the west shore of the Pen on the west, the Mississippi River back protection levee on the east and Bayou de Fleur to the north. The project area extends to the south shore of the Pen and the southern shoreline of Bayou Dupont, with the far southern border aligning along old oil and gas canals and extending through highly-degraded marsh and open water habitat (Figure 2).

In 2001, the Barataria Bay Waterway East Side Shoreline Protection project (BA-0026) was constructed along the eastern shore of the BBW to reestablish the shoreline and protect the area’s intermediate and brackish marshes from shoreline erosion that is exacerbated by wakes from vessel traffic. The approximately 3,504-acre BA-0026 project area includes just over three miles of foreshore rock dike bank line protection and an earthen hydrologic barrier created from material dredged from the BBW and placed to the east along the rock dike within the project area (Figure 2, Appendix A, Photos 3 and 4). The rock structure was constructed with an expanded clay core that was encapsulated in geotextile bags and placed along the centerline of the dike. The project area is in the Barataria Basin in Jefferson Parish, approximately 1.5 miles southeast of Lafitte and is bounded by the BBW to the west, the Bayou Barataria ridge to the south, unnamed canals to the east and Bayou Dupont to the north (Figure 2).

In 1999, a combined monitoring plan was written for the BA-0003c (outfall management/weirs) and BA-0026 (shoreline protection) projects. The decision was made to unify their monitoring plans because their project areas are adjacent and the projects complement and influence each other (LDNR 2003). For data analyses, all references to "project area" refer to the unified area of BA-0003c and BA-0026, unless otherwise specified. The smaller BA-0003 Naomi siphon project area is included within the BA-0003c project area and all the monitoring stations previously included in the BA-0003 monitoring plan were integrated into the BA-0003c/BA-0026 monitoring plan. Although the BA-0003c and BA-0026 projects were combined for monitoring purposes, their inspection reports and maintenance budgets remained separate. The BA-0003 Naomi siphons are fully state-funded and not a CWPPRA project; however, information about their operations is included in this report as a necessary component of these projects.

Since construction of the BA-0003c and BA-0026 projects, multiple restoration projects have been completed within their project boundaries. These projects include additional shoreline protection, as well as marsh, ridge, and terrace creation projects (Figure 2). These projects are primarily supported through CWPPRA, but some projects are supported through different funding sources, including the Coastal Impact Assistance Program and the American Recovery and Reinvestment Act. The Long-Distance Sediment Pipeline (LDSP) was utilized for construction of the neighboring marsh creation projects, and was most recently used in 2022–2023 to construct the Large-Scale Marsh Creation Project–Upper Barataria Component (BA-0207), which created approximately 1183 areas of marsh (Figure 2).

Figure 1. Naomi Siphon Diversion (BA-0003). Visible in the photograph is the location of the eight siphon intakes in the Mississippi River and the section of the siphons that was constructed over the top of the levee. The siphons discharge into an outfall pond just outside of the frame of the photograph.

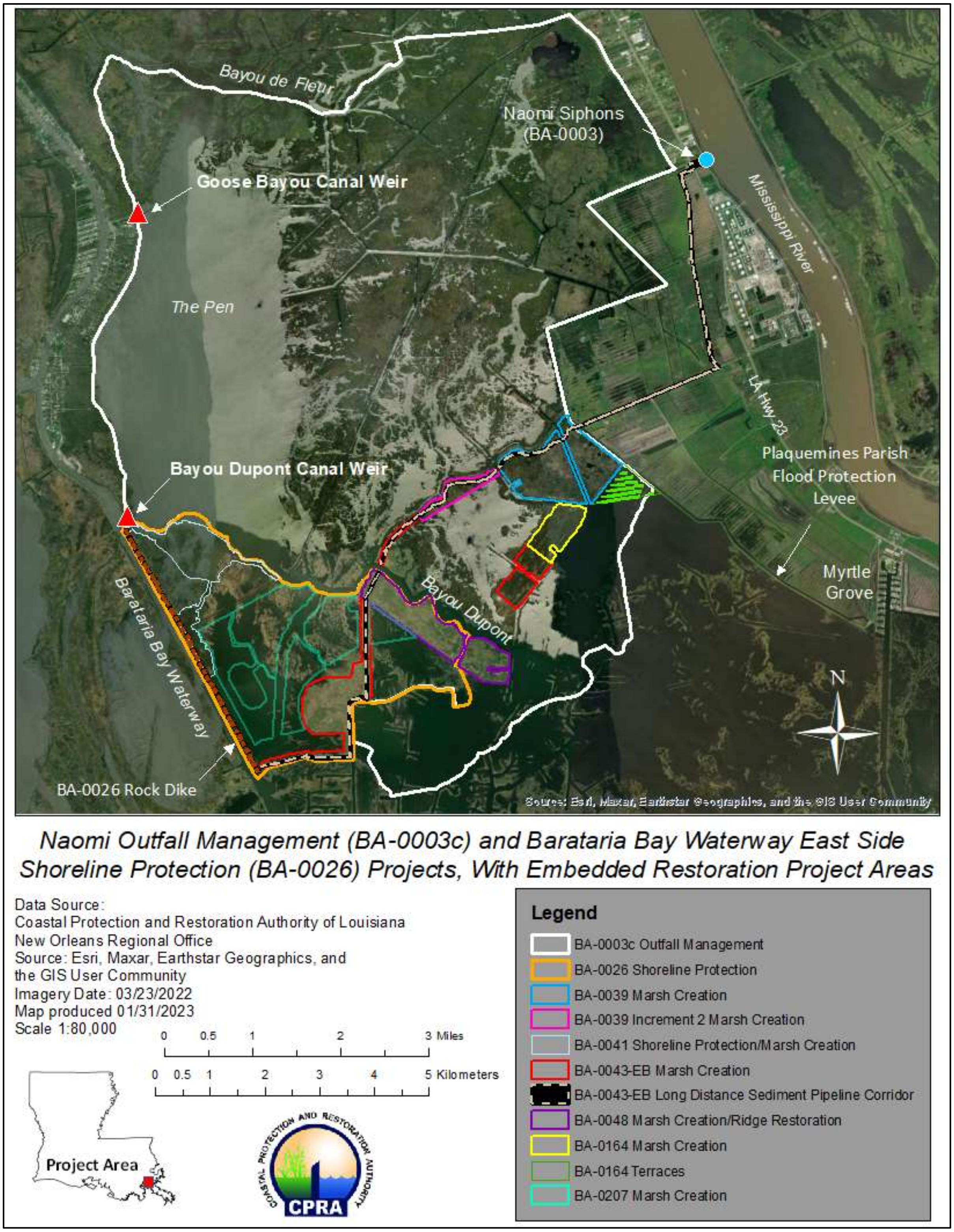


Figure 2. Naomi Outfall Management (BA-0003c) and Barataria Bay Waterway East Side Shoreline Protection (BA-0026) project boundaries and locations of the Naomi siphons, BA-0003c weirs and BA-0026 rock dike. Restoration projects constructed within their project boundaries are included on the map and identified by state number and type of restoration strategy.

II. Maintenance Activity: Naomi Outfall Management (BA-0003c)

a. Project Features

The principal project features include the following:

1. One stone weir at Goose Bayou Canal
   a. Total length of weir = 458 ft
   b. Bottom width of boat bay = 30 ft
   c. Boat bay bottom elevation= -5 ft (NAVD88)
   d. Weir crest = +1 ft (NAVD88)
   e. Rock placed directly on geotextile
   f. Rock rip rap = 3,967 tons
   g. Geotextile = 2,851 yards
   h. Rock conforms to Rock Type 1 of Material Specification 523 with the following gradations:

Percent Lighter Than	Rock Unit Weight
100	700 lbs
50–100	300 lbs
15–50	150 lbs
0–15	45 lbs

   i. Four 4-piling clusters with day board navigation signs and navigation aid lights
   j. Six single pilings with warning signs
   k. Thirty-two buoys and associated stainless steel cable

2. One stone weir at Bayou Dupont Canal
   a. Total length of weir = 302 ft
   b. Bottom width of boat bay = 30 ft
   c. Boat bay bottom elevation = -5 ft (NAVD88)
   d. Weir crest +1 ft (NAVD88)
   e. Rock placed directly on geotextile
   f. Rock rip rap = 8,505 tons
   g. Geotextile = 3,374 yards
   h. Rock conforms to Rock Type 1 of Material Specification 523 with the following gradations:

Percent Lighter Than	Rock Unit Weight
100	700 lbs
50–100	300 lbs
15–50	150 lbs
0–15	45 lbs

   i. Four 4-pile clusters with day board navigation signs and three of the piling clusters have navigation aid lights
   j. Three single pilings with warning signs (reduced from five in 2006 repair project)

k. Twenty-two warning buoys with stainless steel cable
l. Two marker buoys with warning markings and internal radar reflectors (added during 2006 repair project in place of two single pilings with warning signs)

Project construction began on June 1, 2002, and was completed on July 15, 2002. The project had a 20-year maintenance and monitoring schedule that ended in 2022.

On June 20, 2006, a contract was awarded to Double Aught Construction to place two warning buoys where warning signs were damaged and to replace five navigation lights. This project was completed on October 4, 2006.

In 2010, Regency Construction, Inc. began construction of the CWPPRA South Shore of the Pen Shoreline Protection and Marsh Creation Project (BA-0041) under contract to NRCS. As part of this construction, the rock weir at Bayou Dupont was partially deconstructed for construction access. After project construction was completed for BA-0041, another CWPPRA project, Bayou Dupont Marsh and Ridge Restoration (BA-0048), required construction access through this structure. The rock weir was replaced to as-built lines and grades in 2017, after BA-0048 construction was completed.

In 2020, the U.S. Coast Guard notified CPRA that the orange buoy strings installed at both weirs were not permitted and instructed CPRA to remove them. The CPRA contracted with the Couvillion Group to remove them in December 2020.

In 2022, the weir at Bayou Dupont was deconstructed again for access by the contractor constructing the Large-Scale Marsh Creation Project–Upper Barataria (BA-0207) project under contract to the National Oceanic and Atmospheric Administration (NOAA). During construction, it was determined that construction of the Mid-Barataria Sediment Diversion (BA-0153) would require the weir to remain deconstructed for an additional 4–5 years. The NRCS and CPRA decided to close out the BA-0003c project and request that the BA-0153 project replace the structure to as-built conditions upon demobilization. Once BA-0003c is closed out, navigational aid maintenance will be transferred to the CWPPRA Navigation Aid Program.

b. Project Feature Inspection Procedures

The purpose of an annual inspection is to evaluate the constructed project features to identify any deficiencies and prepare a report detailing their condition and recommended corrective actions. If corrective actions are needed, CPRA shall provide a detailed cost estimate for engineering, design, supervision, inspection, and construction contingencies, and an assessment of the urgency of such repairs. The annual inspection report also contains a summary of maintenance events and an estimated projected budget for the upcoming three years for operation, maintenance and rehabilitation. A three-year budget projection is not included in this report because the BA-0003c project will be closed out in 2024.

The final inspection of the BA-0003c project was a post-storm inspection (Hurricane Ida) conducted on September 23, 2021, by Barry Richard and Mark Accardo of the CPRA. Photographs of the inspection are included in Appendix A.

c. Inspection Results

<u>Bayou Dupont Canal Weir</u>

Rock Riprap
The structure was altered to facilitate construction of the BA-0207 project (completed). Rock was temporarily removed from the weir and stored within the footprint of the structure. The structure will be left altered through construction of the BA-0153 project and will be replaced as designed once construction is completed.

Pile Clusters
At the time of the inspection, there was no noticeable damage to the one remaining pile cluster. The pile cluster has since been removed to facilitate construction activities for the BA-0207 (completed) and BA-0153 projects.

Warning Signs and Day Board Navigation Signs
All remaining signs are in good condition.

Navigation Aid Lights
One of the navigation aids was removed to facilitate construction of the BA-0207 (completed) and BA-0153 projects. All navigation aids will be replaced at a later date.

Regulatory Marker Buoys
Both buoys are missing.

<u>Goose Bayou Canal Weir</u>

Rock Riprap
Based on a survey conducted in December 2010 by Pyburn and Odom, Inc., the structure settled an average of 2 feet since construction, resulting in most of the rock being submerged below the water surface. At this time, no rock maintenance is anticipated.

Pilings
Timber pilings were present and in good condition. Reflective tape was replaced as part of the 2015 maintenance event.

Warning Signs and Day Board Navigation Signs
Navigation markers were replaced in 2015. Warning signs were in good condition.

Navigation Aid Lights
No defects were observed with the navigation aid lights.

d. Maintenance Recommendations

Immediate Repairs
None recommended at this time.

Programmed Maintenance
Since this project is being closed out it is recommended that the navigation aids be submitted to the CWPPRA Navigation Aids and Signage Program for all future programmed maintenance.

III. Maintenance Activity: BBW East Side Shoreline Protection (BA-0026)

a. Project Features

The BA-0026 project includes approximately 17,100 linear feet (3.2 miles) of foreshore rock dike bank line protection and an earthen hydrologic barrier created from dredged material from the BBW placed to the east along the rock dike within the project area. The rock structure was constructed with a synthetic clay core to reduce its overall weight. The clay material was encapsulated in geotextile bags and placed along the centerline of the dike. The dike is intended to re-establish the eastern bank of the BBW and to protect the adjacent marsh from unnatural water exchange and subsequent erosion which is exacerbated by wakes from vessel traffic on the waterway.

Project construction began on February 19, 2001, and was completed on May 21, 2001. The project had a 20-year maintenance and monitoring schedule that ended in 2021.

In December 2005, a contract to raise these structures was awarded and resulted in the placement of 17,417 tons of rock riprap on the settled sections of the structure. The work was completed on January 24, 2006.

b. Project Feature Inspection Procedures

Refer to Section II. Maintenance Activity: BA-0003c, b. Project Feature Inspection Procedures (p. 5) for a description of inspection procedures.

The final inspection of the BA-0026 project was a post-storm inspection (Hurricane Ida) conducted on September 23, 2021, by Barry Richard and Mark Accardo of the CPRA. Photographs of the inspection are included in Appendix A.

c. Inspection Results

Rock Riprap

Most of the rock structure has settled, which was expected, and documented by the 2018 NRCS survey of the project that showed several areas approximately 1 to 2 feet below as-built elevations. During low water levels in the area, some sections of rock are just barely above the surface. Accretion and vegetation were observed behind the rock structure at the northern end of the project.

d. Maintenance Recommendations

Immediate Repairs

None recommended at this time.

Programmed Maintenance

None recommended at this time.

The Barataria Bay Waterway East Side Protection project (BA-0026) is performing as intended. The rock dike is protecting the existing marsh as designed. Some settlement has been observed; however, the structure still performs adequately as intended. The project has reached its 20-year end of life and it has been determined by CPRA and NRCS to close out the project without any further maintenance.

IV. Operation Activity

a. Operation Plan and Data Collection

Plaquemines Parish Government (PPG) is responsible for operation of the Naomi siphons (BA-0003). An operation plan for managing siphon flow was originally developed by Brown and Root, Incorporated (Brown and Root, Inc. 1992). A revised plan was adopted during a diversion operations meeting attended by PPG and the Department of Natural Resources, Coastal Restoration Division (currently CPRA) on December 6, 1993, that called for eight pipes to be operated in January and February and May−December, and two pipes to be operating in March and April (12/06/1993 meeting minutes).

Estimated daily siphon discharge from February 1993–October 2006 was calculated using the head differential between the river and the immediate Naomi Diversion outfall area, and the number of siphons in operation. Water elevation data were obtained from the USACE Mississippi River gauge at Alliance, LA, (01390) and the immediate outfall area staff gauge (BA03c-14). Siphon discharge during this time period was subject to significant interpolation, since marsh water elevations at BA03c-14 were collected periodically and the siphons may have lost prime days prior to detection. Since November 3, 2006, siphon discharge has been measured using a flow gauge (#07380238) installed and maintained by the United State Geological Survey (USGS) in the Naomi outfall canal http://waterdata.usgs.gov/la/nwis/. The USGS has conducted additional quality control of their data that was previously included in the 2011 BA-0003c/BA-0026 OM&M report (Richardi and Richard 2011). This quality control resulted in slight changes to mean daily discharge rates, as well as a deletion of some data that upon further USGS review did not meet quality control standards. Approximately three weeks of siphon flow data were deleted from 2009 and 2011, and 22 weeks of data were deleted from 2012.

b. Operations

Naomi siphon operations will be summarized from their start of operations on February 3, 1993, through December 31, 2022, which is the end of data assessment for the BA-0003c and BA-0026 projects.

Siphon Discharge Summary

Since the start of siphon operations in 1993, the siphons were known to be running at least 33.5% of the time based on the available discharge data, but their actual time operating is slightly higher. Discharge data were not available for 8.6% of the record, but operation logs indicate the siphons were flowing during a significant portion of that time (Figure 3). Data were typically unavailable due to malfunctioning monitoring equipment or an inability to verify data using required USGS quality control procedures.

The maximum possible siphon discharge is 2,144 cubic feet per second (cfs) if all eight siphons are running and the river is at a high river stage. It is estimated that the siphons ran at a mean daily discharge of > 2000 cfs (near their maximum capacity), approximately 1.5% of the time (Figure 3). The siphons most commonly operated at less than 1000 cfs, with mean daily discharge closely divided between 0 to 500 cfs (9.6%) and 500 to 1000 cfs (10.5%).

Between 1993 and 2022, the siphons were closed or had lost prime 57.9% of the time (Figure 3). The primary reason for limited siphon operation was low river stage; however, the following additional obstacles resulted in the siphons not operating for periods of time ranging from days to over a year: hurricanes and tropical storms, levee construction and repairs, oil spills, maintenance issues (including difficulty in re-priming the siphons), management for fisheries, staffing limitations within PPG, and lawsuits. The siphons were inoperable from August 30, 2005, through December 30, 2006, as a result of damage due to Hurricane Katrina. The siphons were also closed for an extended time between 2014 and 2016 due to construction of the New Orleans to Venice Non-Federal Levee Section 05a.1. LaReussite to Myrtle Grove. The siphons remained closed for safety reasons from Hurricane Ida (08/29/2021) through the end of the reporting time period (12/31/2022) due to dredging of the river near the siphon intake for construction of the BA-0207 project.

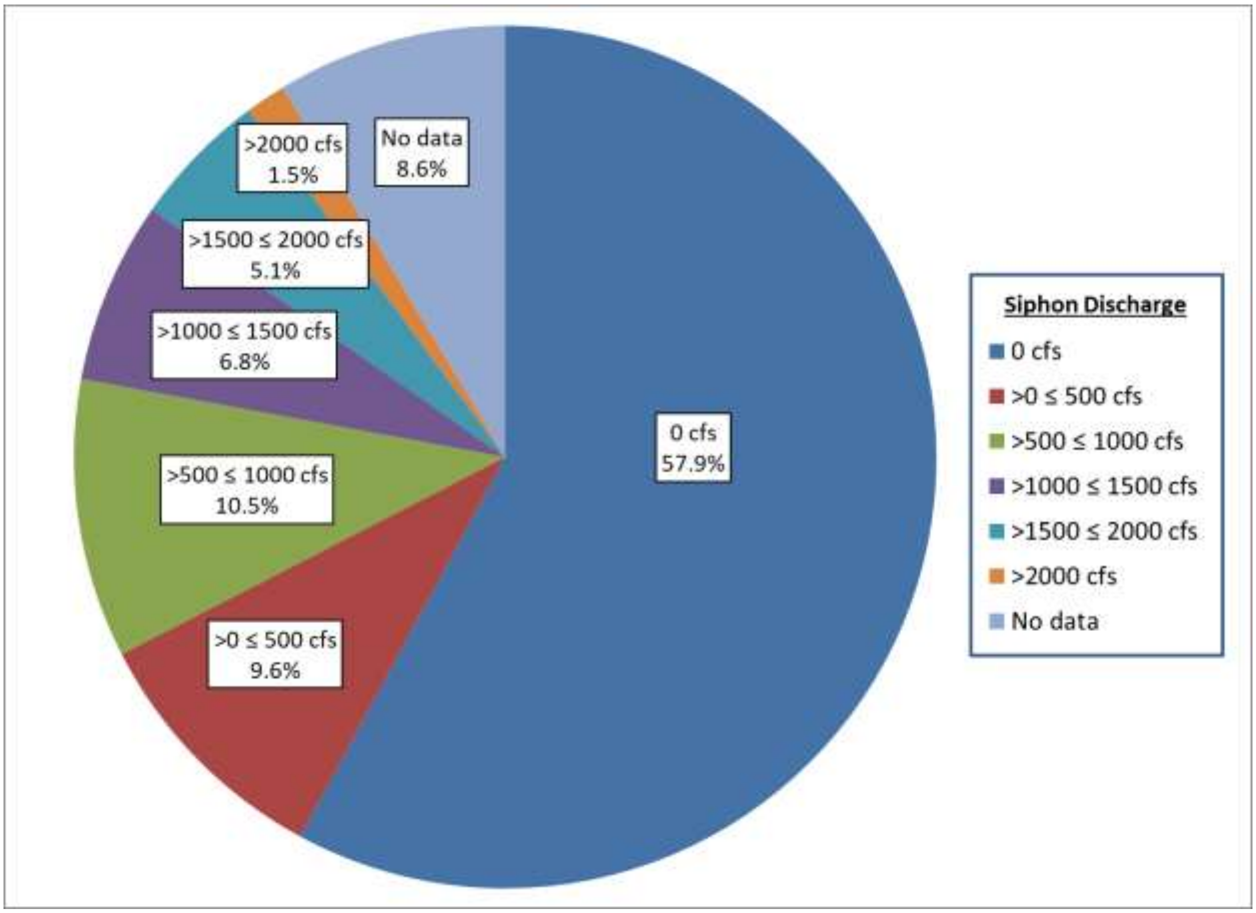


Figure 3. Siphon discharge (cfs) at the Naomi siphons between February 3, 1993, and December 31, 2022, divided into mean daily discharge categories. The percent values represent the estimated percent of time the siphons were operating within the stated range.

Annual Siphon Discharge

Annual siphon operations were compared between 1993 and 2022 using the daily mean siphon discharge to calculate the yearly mean (± standard error, SE). The highest annual mean discharge was 1102 cfs in 1993 (Figure 4); this year also had the highest percent of days the siphons were operating (94%, Table 1). Since this first year of operations, the annual siphon discharge has trended downwards due to a combination of reasons, as previously noted. The siphons were not operated in 2013, 2015, 2016 and 2022.

The graph of mean annual discharge can be misleading because of data gaps that exist in the operations record due to equipment malfunction or quality control issues. For example, despite 0 cfs indicated in Figure 4 for 2005, 2012 and 2014, the siphons were known to be running for part of each year. The number of days without discharge data are plotted by year in Figure 4 to indicate the uncertainty with mean discharge data for each year. Table 1 further outlines siphon operations by dividing the data into the number of days the siphons were operated with major, minor, or no discharge and the number of days when data are absent. The maximum discharge of the siphons is 2,144 cfs; therefore, major discharge was categorized as greater than or equal to half the maximum rate (≥ 1072 cfs), with minor discharge being categorized as less than half the maximum rate.

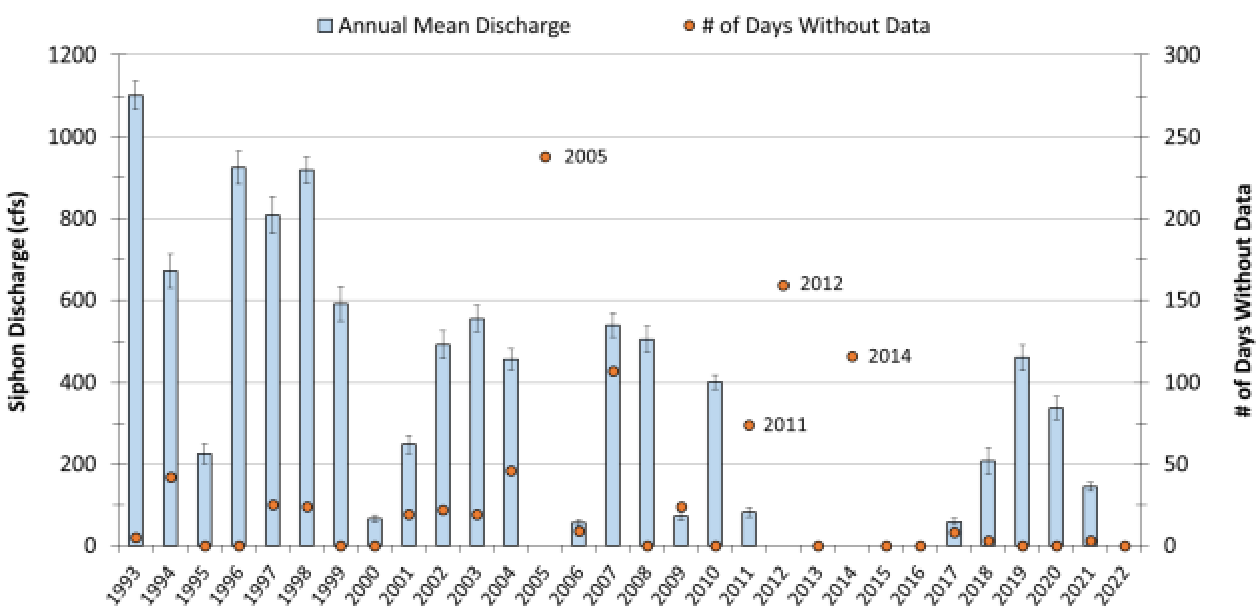


Figure 4. Yearly mean siphon discharge (± SE) for the Naomi siphons from February 1993−December 2022. The number of days without discharge data are also shown for each year.

Table 1. Annual discharge at the Naomi siphons from February 3, 1993−December 31, 2022. Discharge is divided into the number and percent of days with major discharge (≥ 1072 cfs), minor discharge (< 1072 cfs), no discharge, and no data. The siphons are assumed to have operated with minor discharge during most of the days recorded as having no data in 2011, 2012 and 2014. In 2011 and 2012, two siphons were logged as open during this time, and in 2014 three siphons were logged as open. The data are unavailable due to equipment malfunction or quality control issues.

Year	# Days ≥ 1072 cfs (Major)	%	# Days < 1072 cfs (Minor)	%	# Days 0 cfs	%	# Days No Data	%
1993	186	56	125	38	16	4.8	5	1.5
1994	97	27	109	30	117	32	42	12
1995	32	8.8	46	13	287	79	0	0
1996	152	42	101	28	113	31	0	0
1997	151	41	49	13	140	38	25	6.9
1998	116	32	211	58	14	3.8	24	6.6
1999	110	30	49	13	206	56	0	0
2000	3	0.8	107	29	256	70	0	0
2001	14	3.8	138	38	194	53	19	5.2
2002	59	16	111	30	173	47	22	6
2003	63	17	193	53	90	25	19	5.2
2004	27	7.4	181	49	112	31	46	13
2005	0	0	0	0	127	35	238	65
2006	0	0	50	14	306	84	9	2.5
2007	25	6.9	143	39	90	25	107	29
2008	60	16	123	34	183	50	0	0
2009	0	0	47	13	294	81	24	6.6
2010	0	0	233	64	132	36	0	0
2011	0	0	52	14	239	65	74	20
2012	0	0	0	0	207	57	159	43
2013	0	0	0	0	365	100	0	0
2014	0	0	0	0	249	68	116	32
2015	0	0	0	0	365	100	0	0
2016	0	0	0	0	366	100	0	0
2017	0	0	55	15	302	83	8	2.2
2018	39	11	0	0	323	88	3	0.8
2019	130	36	14	3.8	221	61	0	0
2020	95	26	5	1.4	266	73	0	0
2021	0	0	156	43	206	56	3	0.8
2022	0	0	0	0	365	100	0	0

V. Monitoring Activity

a. Monitoring Goals

The combined goals of the Naomi Outfall Management (BA-0003c) and Barataria Bay Waterway East (BA-0026) projects are to manage the freshwater introduced into the project area from the Naomi siphons via the installation of two water control structures designed to reduce freshwater loss and saltwater intrusion, and to rebuild the east bank of the BBW to protect the adjacent marsh from erosion that is exacerbated by boat wakes.

The following objectives were developed to evaluate the above goals:

1. Reduce mean salinity in the project area.
2. Improve the growing conditions and increase the relative abundance of fresh-to-intermediate marsh species.
3. Reduce the rate of conversion of marsh to open water in the project area.

b. Monitoring Elements

Salinity

Salinity was measured hourly using sondes deployed at hydrographic stations BA03c-16 and BA03c-60 from June 1999−September 2011 and at station BA03c-61 from June 1999–March 2021. Two Coastwide Reference Monitoring System (CRMS) sites, CRMS0287 and CRMS4103, are within the project area and hourly salinity data have been recorded at their hydrographic stations since February 2008, following procedures outlined in Folse et al 2020 (Figure 5). Salinity was measured monthly using a handheld meter at 16 discrete stations from November 1992−May 1999 and at 24 discrete stations from June 1999−September 2011 (Figure 5). Data collection at stations BA03c-16 and BA03c-60 and at the discrete stations was ended early based on the results of the 2011 OM&M report (Richardi et al. 2011) and a determination that data collection from the CRMS sites and from station BA03c-61 was sufficient for the continued evaluation of the project. A detailed analysis of the effects of the siphons and weirs on salinity in the project area is included in the 2011 OM&M report. This 2024 OM&M report summarizes salinity in the project area during the project's life using hourly salinity data (not discrete) for analysis.

Water elevation

Water elevation (NAVD88) was measured hourly using sondes deployed at hydrographic stations BA03c-16 and BA03c-60 from June 1999−August 2011 and at station BA03c-61 from June 1999–March 2021. Two CRMS sites, CRMS0287 and CRMS4103, are within the project area and hourly water elevation has been measured at their hydrographic stations since February 2008, following procedures outlined in Folse et al 2020 (Figure 5). Water elevation was also measured monthly at seven staff gauges from January 1993−March 2000 and at nine staff gauges from April 2000−September 2011 (Figure 5). Water elevation is not discussed in this report; however, an analysis of the effects on the siphons and weirs on water elevation prior to 2011 is included in Richardi et al. 2011. A summary of these earlier findings indicated that the only significant difference in water elevation when the siphons were running was in the immediate outfall area at discrete hydrologic station BA03c-14, and at the next closest discrete station BA03c-03, which was approximately 1.3 miles from the outfall (Figure 5).

Additionally, installation of the BA-0003c weirs had no discernable impact on water elevation within the project area.

Vegetation

Species composition and cover of emergent vegetation were quantified using modified Braun-Blanquet methods described in Steyer et al. (1995). Vegetation survey methodology has since been refined in multiple revisions of the CRMS Standard Operating Procedures manual (Folse et al. 2020). Using analyses of species and cover, the floristic quality index (FQI) and marsh classification were calculated over years. Twenty-one vegetation stations were surveyed in 1992 (pre-siphon construction) and in 1995 (post-siphon construction). Forty stations (4 m^2) were surveyed in 1997, 2000, 2003 and 2006. In 2009, only 39 stations were surveyed due to station BA03c-48 being located within the Mississippi River Sediment Delivery System-Bayou Dupont (BA-0039) marsh creation project. A final vegetation survey was conducted in 2018 at 30 stations, with a reduction of nine additional stations from the 2009 survey due to expired land rights agreements and construction of the Bayou Dupont Sediment Delivery Marsh Creation #3 (BA-0164) and Long-Distance Sediment Pipeline Marsh Creation (BA-0043-EB) projects. The stations that were not surveyed in 2018 included BA03c-21, BA03c-26, BA03c-27, BA03c-28, BA03c-36, BA03c-37, BA03c-38, BA03c-48, BA03c-51, and BA03c-56 (Figure 6). Two CRMS sites are within the project area and assessments of their marsh communities are included in this report. Annual vegetation surveys have been conducted at CRMS0287 since 2007, and at CRMS4103 since 2008, following the same survey protocols as conducted at the project-specific stations. However, at each CRMS site, ten 4 m^2 stations are aligned along a 283 m diagonal transect within a 200 m^2 data collection area.

Land-Water Analysis

Analysis of color-infrared aerial photography was used to evaluate land to water ratios within the BA-0003, BA-0003c, and BA-0026 project areas over the life of the projects. Land-water analysis was conducted by the USGS Wetland and Aquatic Research Center (WARC) using standard operating procedures documented in Steyer et al. 1995 (revised 2000), in which all areas characterized by emergent vegetation, wetland forest, scrub-shrub, or upland are classified as land, while open water, aquatic beds, and non-vegetated mudflats are classified as water. Aerial photography was acquired in 1991 of the BA-0003 project area (pre-siphon construction), in 2000 of the BA-0003, BA-0003c, and BA-0026 project areas (pre-weir and shoreline protection), in 2009 of the BA-0003c project area, in 2011 of the BA-0026 project area, and in 2018 of the BA-0003, BA-0003c, and BA-0026 project areas. The 2018 analysis used CRMS aerial photography, while the earlier imagery acquisitions were project-specific.

Multiple restoration projects, including marsh, ridge, and terrace creation projects, have been constructed within the BA-0003, BA-0003c and BA-0026 boundaries since 2009 (Figure 2). The impacts of these land-building projects was significant for the 2018 land-water analysis. In order to provide an assessment of land and water changes in the BA-0003, BA-0003c and BA-0026 project areas without the direct impacts of the land-creation projects, the USGS conducted a second analysis of the land and water acres in each of the three project boundaries over years, with the contained restoration project acres removed from the total acres. This analysis also used a consistent project boundary for each of the three projects, remedying a few earlier instances where project boundaries varied slightly between years. These data will be presented, along with the original land-water analysis results.

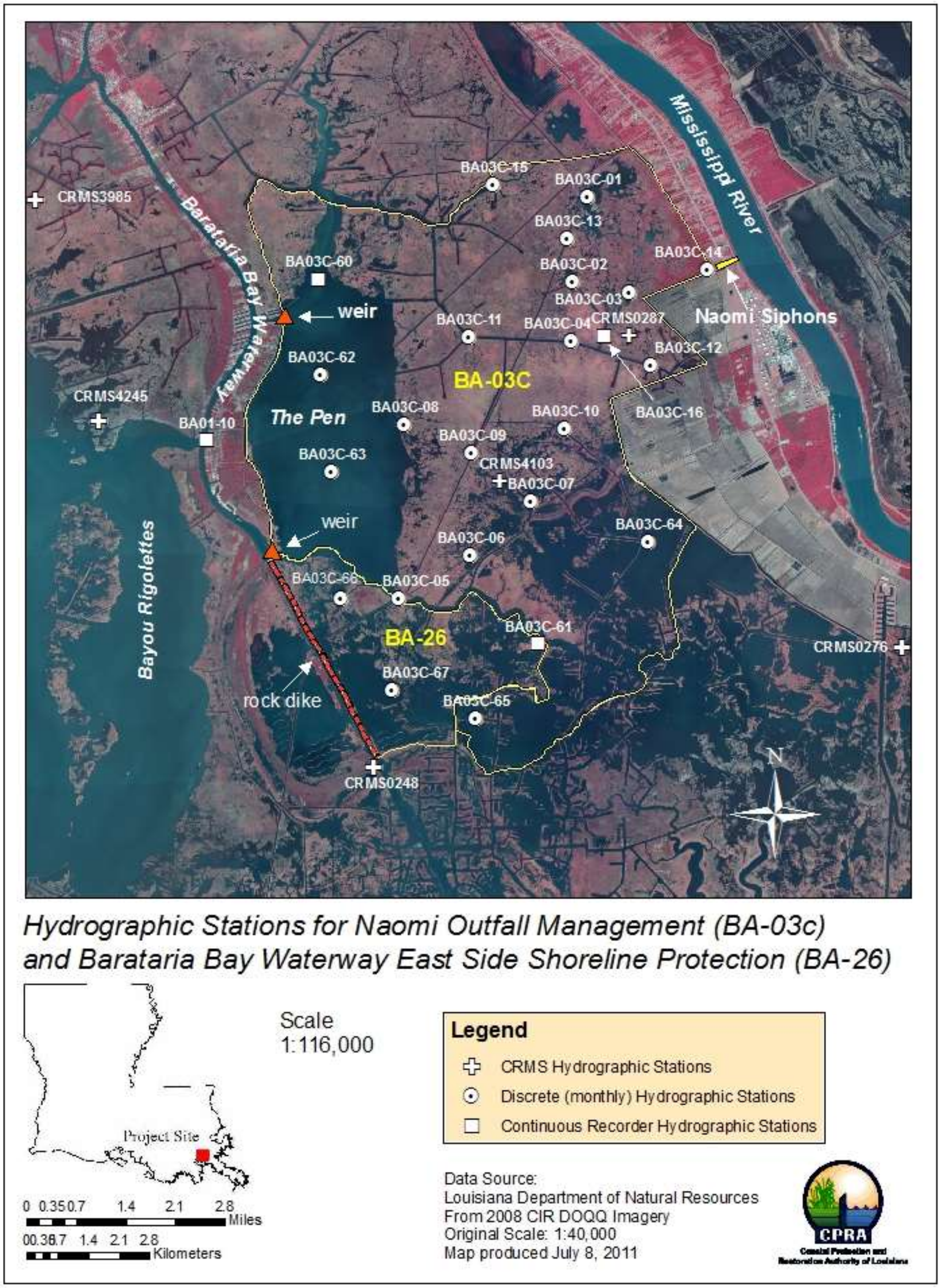


Figure 5. Naomi Outfall Management (BA-0003c) and Barataria Bay Waterway East Side Shoreline Protection (BA-0026) hydrographic stations. Staff gauges were located at stations BA03c-01, 03, 06, 10, 11, 14, 16, 60, and 61. This figure shows current and historic monitoring stations. Only continuous recorders (sondes) BA03c-16, BA03c-60, BA03c-61, CRMS0287 and CRMS4103 were used for salinity analysis in this report.

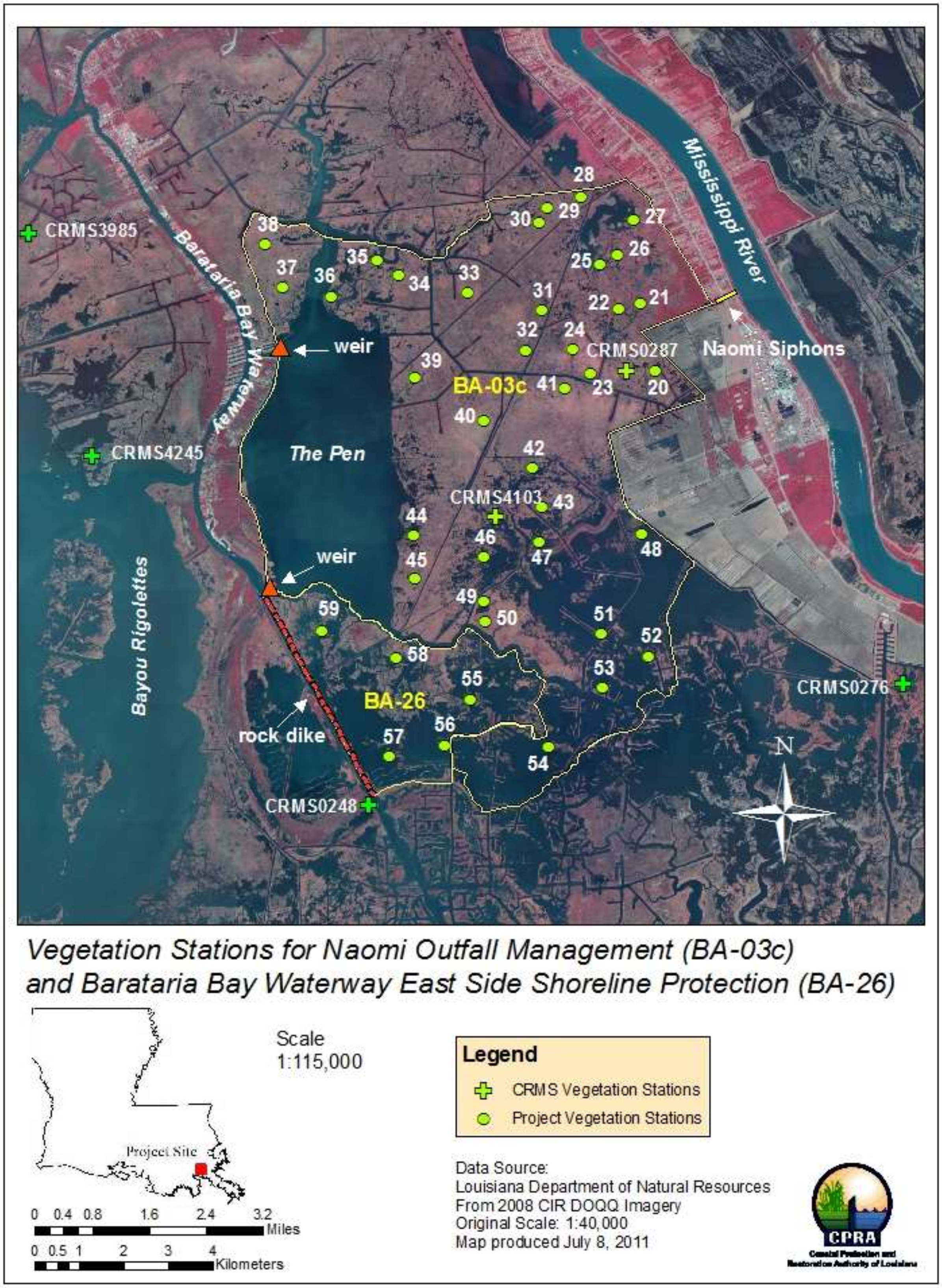


Figure 6. Naomi Outfall Management (BA-0003c) and Barataria Bay Waterway East Side Shoreline Protection (BA-0026) vegetation stations.

c. Monitoring Results and Discussion

New salinity, vegetation, and land-water analysis monitoring data are included in this final BA-0003c/BA-0026 OM&M report. These three monitoring elements were included in the monitoring plan (Boshart 2003) to address the combined projects' three monitoring objectives: 1) reduce mean salinity in the project area, 2) improve the growing conditions and increase the relative abundance of fresh to intermediate marsh species, and 3) reduce the rate of conversion of marsh to open water in the project area. This section addresses whether these objectives were met. All means are presented with standard deviation (SD).

i. Salinity

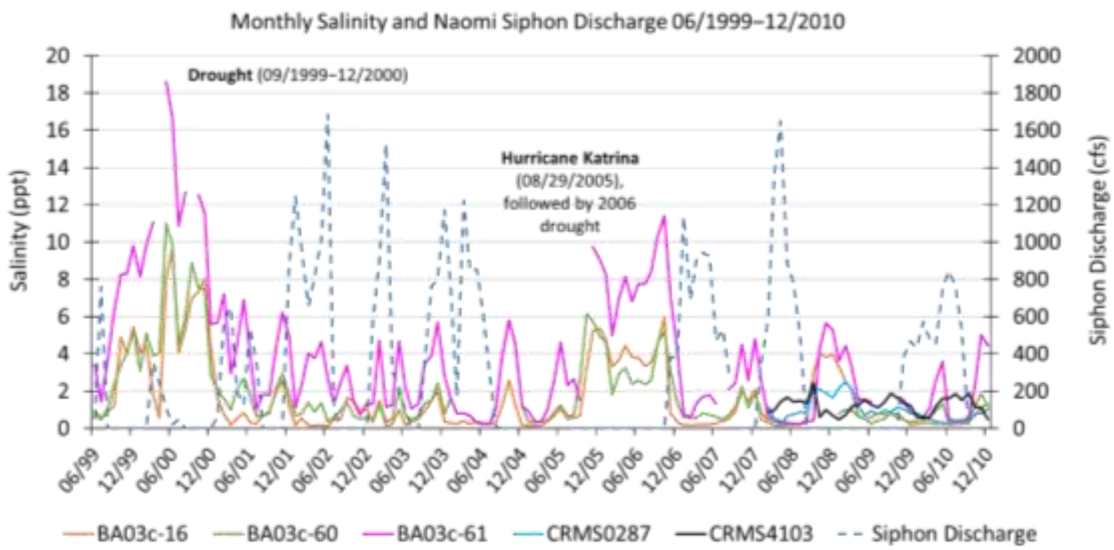
The 2011 OM&M report assessed the impacts of the weirs and siphon operations on salinity in the project area. In summary, no impacts on salinity were detected as a result of the weirs, but the siphons were effective at lowering salinity in the northeastern and central project area when they were able to be run consistently and at an adequate flow (Richardi et al 2011). The impact of the siphons on lowering salinity in the project area was also documented in earlier OM&M reports (Boshart and Richard, 2008, 2005, and others). Farther from the siphon outfall, natural environmental factors including river discharge, precipitation, wind, tides, and potentially operations of the Davis Pond Diversion (BA-0001), complicated the ability to isolate the freshening influence of the siphons.

Considering the results of the previous salinity analyses, the settlement and re-occurring partial deconstruction of the weirs, and the limited siphon operations since 2011, this final OM&M report does not repeat the detailed salinity assessments in relation to construction of the weirs or siphon operations. Rather, this report provides a general assessment of salinity in the project area, noting significant events and trends and whether salinity remained within a range to support the fresh to intermediate marsh community targeted in the projects' objectives.

<u>Significant Salinity Events</u>

Since the start of salinity monitoring in June 1999, there were three periods when salinity increased considerably and remained elevated for an extended time. The highest salinity in the project area was recorded prior to construction of the BA-0003c/BA-0026 projects during the drought that started expanding throughout the state in May 1999. Drought was categorized as severe or greater March 2000−December 2000 in Jefferson and Plaquemines parishes (https://www.drought.gov/states/Louisiana/county/). Salinity in the project area reached a monthly high of 18.6 parts per thousand (ppt) in May 2000 at station BA03c-61 (Figure 7); however, the river stage was too low during the drought to consistently operate the siphons. The siphons were started in March 2000 and ran briefly until they lost prime. Even this minimal discharge of water appeared to temporarily lower salinity at station BA03c-16, which is closest to the siphon outfall (Figure 7).

Salinity increases in the project area also resulted from storms in the Gulf of Mexico pushing high salinity water into the basin. Salinity peaked and remained elevated for over a year after Hurricane Katrina (August 29, 2005), which was followed by drought conditions through spring and most of summer 2006. However, salinity declined rapidly at hydrographic stations in November 2006, when the siphons resumed operations after the storm and helped to freshen the project area (Figure 7). Similarly, salinity increased after Hurricane Ida (August 29, 2021) and remained elevated at least through December 2022, the end of monitoring for this report (Figure 7). As after Hurricane Katrina, the area experienced drought conditions during the following year, with drought recorded during the spring and much of fall of 2022. The siphons remained closed during this time due to safety concerns related to nearby sediment dredging in the river for construction of the BA-0207 marsh creation project (Figure 2).



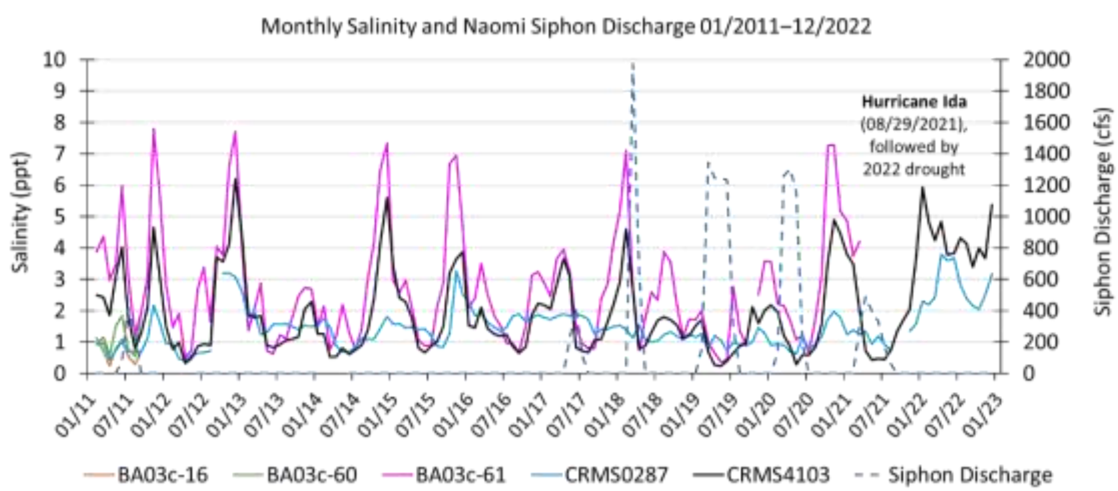


Figure 7. Mean monthly salinity and Naomi siphon discharge in the BA-0003c/BA-0026 project area from 06/1999−12/2010 (top) and 01/2011–12/2022 (bottom).

BA-0003c/BA-0026 Mean Salinity

Salinity was assessed pre- and post-construction of the weirs and shoreline protection features using mean daily salinity data from five sondes in the project area (3 project-specific, 2 CRMS). Pre-construction salinity data were available from only the three project-specific stations between 1999 and 2002, but salinity was sharply elevated during much of this time due to drought and was not representative of typical values. Therefore, data during the drought (09/1999–12/2000) were removed from the data set prior to analysis. Pre-construction salinity data, both including and excluding data during the drought, are presented in Table 2. The BA-0003/BA-0026 wetland value assessment (WVA) project fact and information sheets used available pre-construction salinity data within a longer, 20-year period. The WVA reported salinity ranged from 1 ppt to 5 ppt in the project area, with salinity lowest in the northeast and highest in the southwest (NRCS and LDNR 1995).

Pre-construction mean salinity (drought excluded) was lowest at station BA03c-16 (0.7 ± 0.8 ppt) in the northeastern project area closest to the siphon outfall, and highest at BA03c-61 (3.6 ± 2.4 ppt) in the southern project area (Table 2). Mean pre-construction project area salinities were within the range reported in the WVA. The mean salinity measured at hydrographic stations in the project area after project construction ranged from a low of 1.2 ± 1.5 ppt at BA03c-16, to a high of 2.8 ± 2.4 ppt at BA03c-61 (Table 2). Mean daily salinity was higher at BA03c-16 after project construction ($p < 0.0001$, $F = 63.97$), lower at BA03c-61 after construction ($p < 0.0001$, $F = 70.16$) and similar pre- and post-construction at BA03c-60. Salinity was lowest closest to the diversion outfall and in the northern project area, and increased along a northern to southern trajectory. Different temporal records at stations, diversion operation frequencies/discharges, river discharges, storm impacts, weir structural conditions, and additional influences, possibly including the construction of other restoration projects in the project area, make it difficult to determine any broad-scale project-induced change in salinity pre- and post-construction.

Table 2. Mean salinity (± SD) at each hydrographic station in the BA-0003c/BA-0026 project area pre- and post-project construction. n = number of days of data used for analysis within each data record.

Pre-Construction							
Stations	Data Record	Mean Salinity (ppt)	Max Salinity (ppt)	Min Salinity (ppt)	n	Mean Salinity (ppt) Drought Excluded	n
BA03c-16	05/1999-07/2002	2.6 ± 3.0	15.1	0.04	1088	0.7 ± 0.8	627
BA03c-60	06/1999-07/2002	3.2 ± 3.1	16.0	0.2	1124	1.3 ± 1.1	648
BA03c-61	06/1999-07/2002	6.1 ± 4.4	20.0	0.4	1044	3.6 ± 2.4	648

Post-Construction					
Stations	Data Record	Mean Salinity (ppt)	Max Salinity (ppt)	Min Salinity (ppt)	n
BA03c-16	08/2002–09/2011	1.2 ± 1.5	10.0	0.1	3188
BA03c-60	08/2002–09/2011	1.3 ± 1.5	13.2	0.2	3150
BA03c-61	08/2002–03/2021	2.8 ± 2.4	20.0	0.2	6190
CRMS0287	02/2008–12/2022	1.4 ± 0.7	4.7	0.1	5202
CRMS4103	02/2008–12/2022	1.9 ± 1.5	7.9	0.1	5270

<u>Monthly Salinity</u>

To identify seasonal salinity trends in the project area, mean monthly salinity was calculated over years at each station for the post-construction monitoring period noted in Table 2. Mean monthly salinity was highest in the fall, with the highest mean salinity at each station occurring between October and December (Figure 8). The highest monthly salinity of 4.5 ± 2.5 ppt was measured for November at BA03c-61, the most southern station. Salinity was typically lowest in the spring and summer, with the lowest monthly salinity of 0.5 ± 0.2 ppt measured at BA03c-60 for July.

Generally, salinity was highest in the project area during months when siphon discharge was lower and the siphons were operated less frequently, and lowest during months of greater operations (Figure 8). Siphon operation is dependent on the river stage, with the siphons losing prime when the river stage is too low in relation to the water elevation in the receiving basin. Consequently, siphon discharge was greatest during months when the river stage was highest, with discharge and river stage following a similar trend (Figures 8 and 9). Between August 2002 and December 2022, the post-construction period of analysis for the BA-0003c/BA-0026 projects, the mean monthly river stage at the USACE Mississippi River at New Orleans, Carrollton gage (01300) was lowest (< 5.0 ft NAVD88) between August and November and highest (> 10.0 ft NAVD88) between March and May (Figure 9).

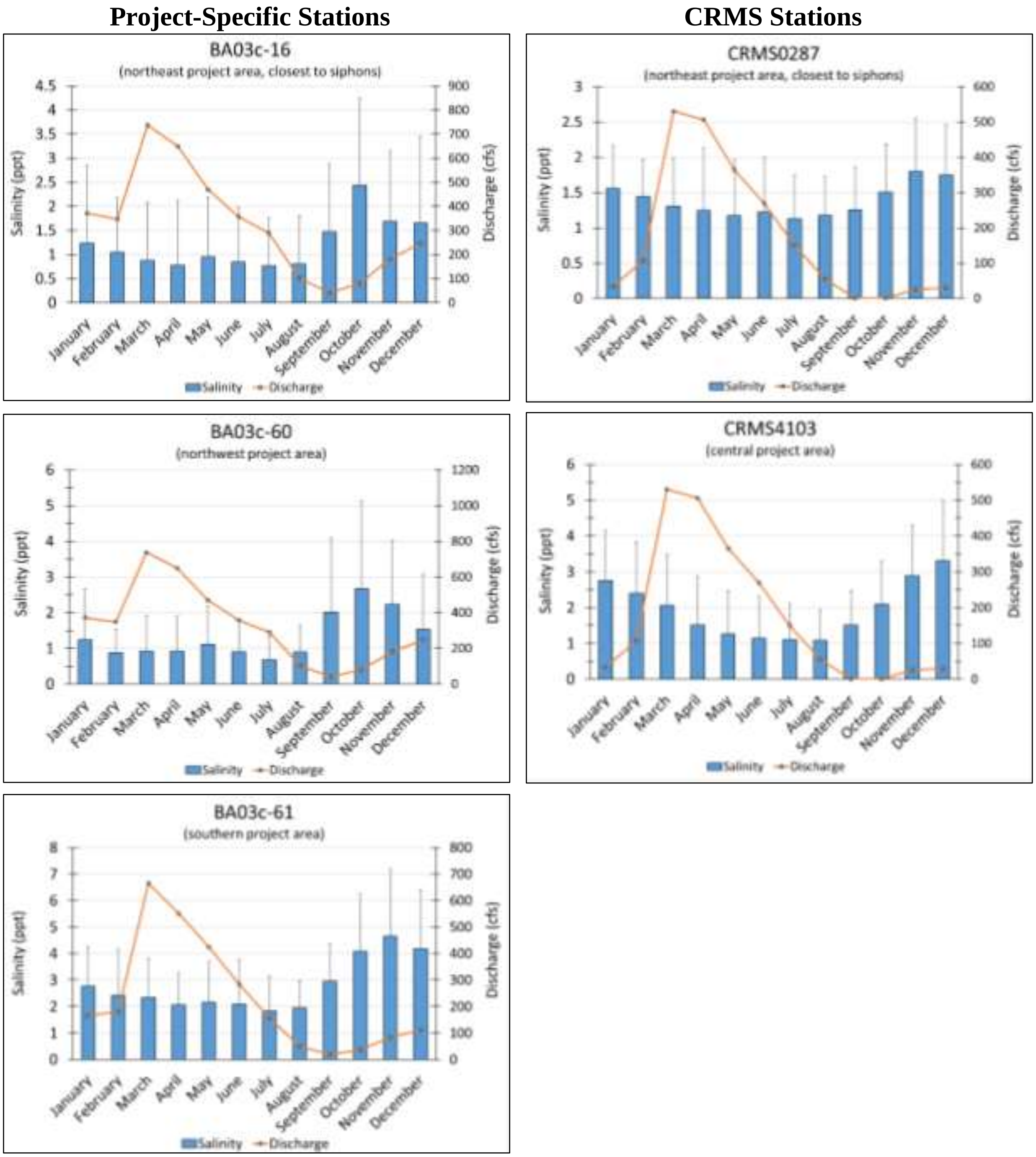


Figure 8. Post-construction mean monthly salinity (+ SD) for hydrographic stations in the BA-0003c/BA-0026 project area, with the mean monthly siphon discharge during each station's time frame (Table 2).

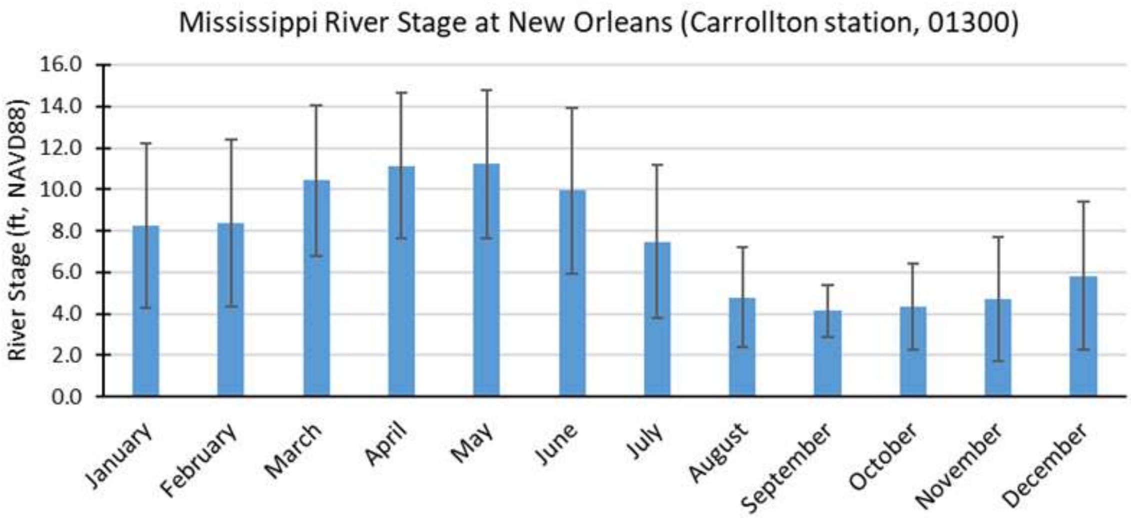


Figure 9. Mean monthly Mississippi River stage (± SD) between August 2002 and December 2022 at USACE gage 01300.

<u>Annual Salinity</u>

Mean annual salinity was calculated for the available data set for each project-specific and CRMS station to provide a general assessment of whether salinity was within the range to support fresh to intermediate marsh species. The range of salinity tolerance varies by species, but salinity between 0.0 – 0.5 ppt is considered fresh marsh, and salinity between 0.5 – 5.0 ppt is considered intermediate marsh. Based on this classification, salinity in the northern and central project area largely remained within a threshold to support fresh to primarily intermediate marsh species (Figure 10). Mean annual salinity was highest at BA03c-61, the most southern station, with an annual salinity range to support intermediate to brackish marsh species. The highest mean annual salinity occurred in 2000 (drought), prior to project construction, with mean salinity climbing above 5.0 ppt at all three project-specific stations. Responses from the vegetation community in the project area to increases in salinity is described in the next section.

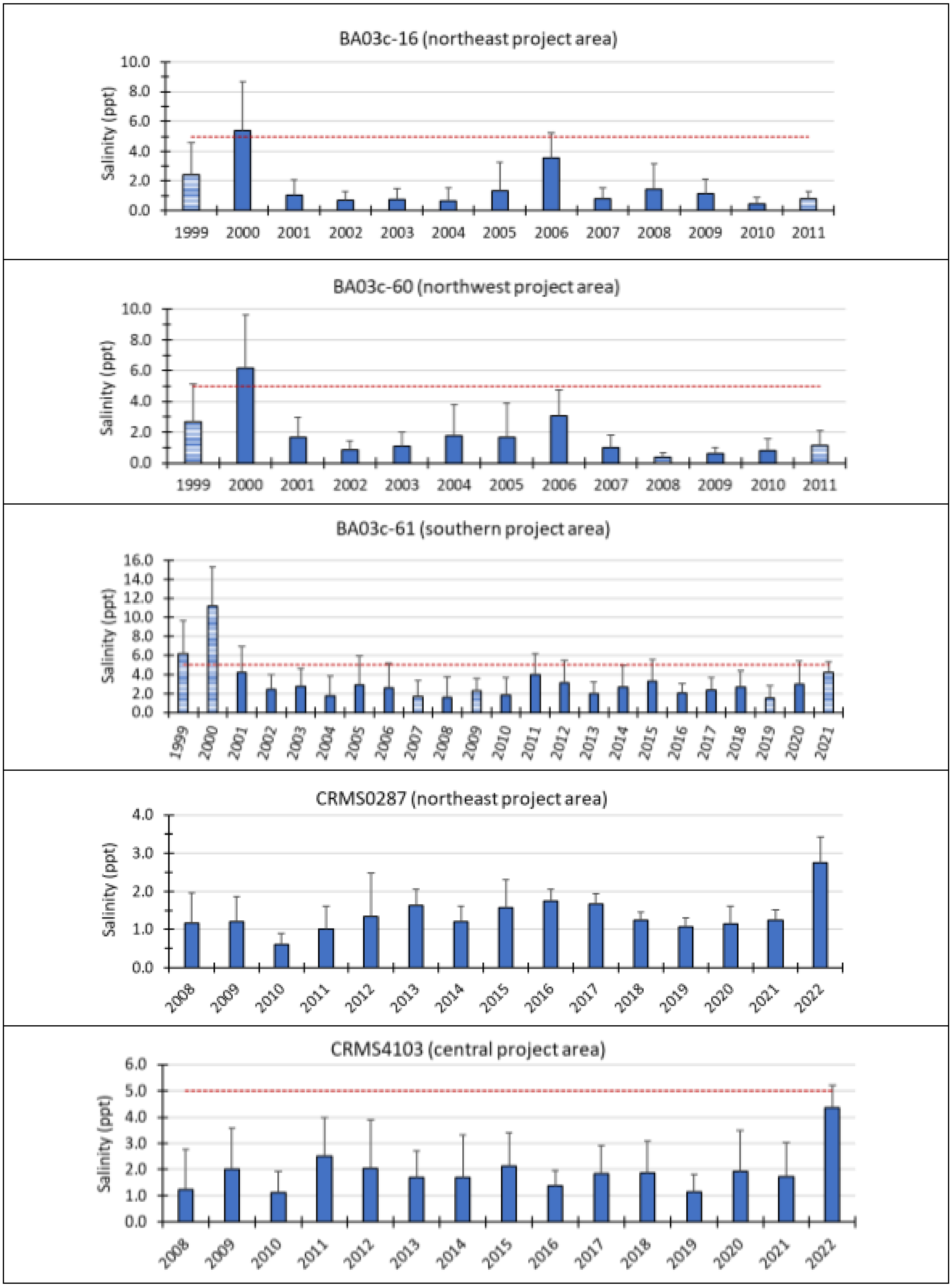


Figure 10. Mean annual salinity (+ SD) at project-specific hydrographic stations in the BA-0003c/BA-0026 project area, showing the 5 ppt salinity line as the upper salinity range for intermediate marsh. Years with greater than 25% data missing from the record are hashed.

ii. Vegetation

Pre-construction vegetation surveys at BA-0003c/BA-0026 project-specific stations were conducted in 1992, 1995, 1997 and 2000, and post-construction surveys were conducted in 2003, 2006, 2009, and 2018. Data from the 1992 and 1995 surveys are not included in this report because surveys followed different methodologies and were conducted at different monitoring stations than the later surveys. However, data from these early surveys indicated that the northeastern project area was comprised of fresh to intermediate marsh with *Sagittaria lancifolia* (bulltongue) as the dominant species. The southern region of the project area was comprised of brackish marsh with *Spartina patens* (marshay cordgrass) as the dominant species. As included in this report, forty vegetation stations were surveyed in 1997, 2000, 2003 and 2006, 39 stations were surveyed in 2009, and 30 stations were surveyed in 2018 (Figure 6). The reduction of stations was due to the construction of marsh creation projects that significantly impacted the stations (2009 and 2018) and/or expired landrights agreements in the far northwestern and northeastern corners of the project area (2018). Project assessment has benefitted from having both CRMS0287 and CRMS4103 located within the project boundary (Figure 6), with annual vegetation surveys conducted at both sites since 2007 and 2008, respectively.

<u>Total Percent Cover</u>

Total percent cover is an assessment of the total live vegetative cover at a station, with the maximum cover being 100%. A total percent cover of 100% means that if a station was viewed from above, no ground would be viewable beneath the live vegetation. Total percent cover was assessed at the BA-0003/BA-0026 project-specific stations during all surveys between 1997 and 2018, but it was measured differently in 1997 and is not included in this report. Between 2000 and 2018, the mean total vegetative cover at the project-specific stations was 78 ± 7%, with cover ranging from a low of 67 ± 30% in 2000 (pre-construction) to a high of 87 ± 13% in 2003 (Figure 11). During just the post-construction monitoring period, mean total cover was 81% ± 19%. Total cover was different between years ($p = 0.002$, F = 4.31), with cover in 2000 being significantly lower than in 2003. The low vegetative cover in 2000 likely resulted from the drought that year. Three stations, BA03c-45, 54 and 57, had transitioned to open water for the 2018 survey, the first year any project-specific stations had been noted as open water; yet, the overall 2018 mean cover remained high due to an increase in cover at other stations. BA03c-45 is located in the central project area, just east of The Pen, and BA03c-54 and 57 are located in the far southern project area (Figure 6).

At CRMS0287 (northeastern project area), the mean total cover was 87 ± 7% and ranged from a low of 70 ± 13% in 2010 to a high of 95 ± 0% in 2014 (Figure 12). As with the project-specific stations, total cover was different over years ($p = < 0.0001$, F = 6.77), but it remained high throughout the period of monitoring and showed no significant trend. At CRMS4103 (central project area), mean total cover was 72 ± 7% and ranged from a low of 59 ± 24% in 2016, to a high of 90 ± 5% in 2008 (Figure 12). There was no significant difference in percent total cover over years, but the variation between stations within each survey year was higher than at CRMS0287.

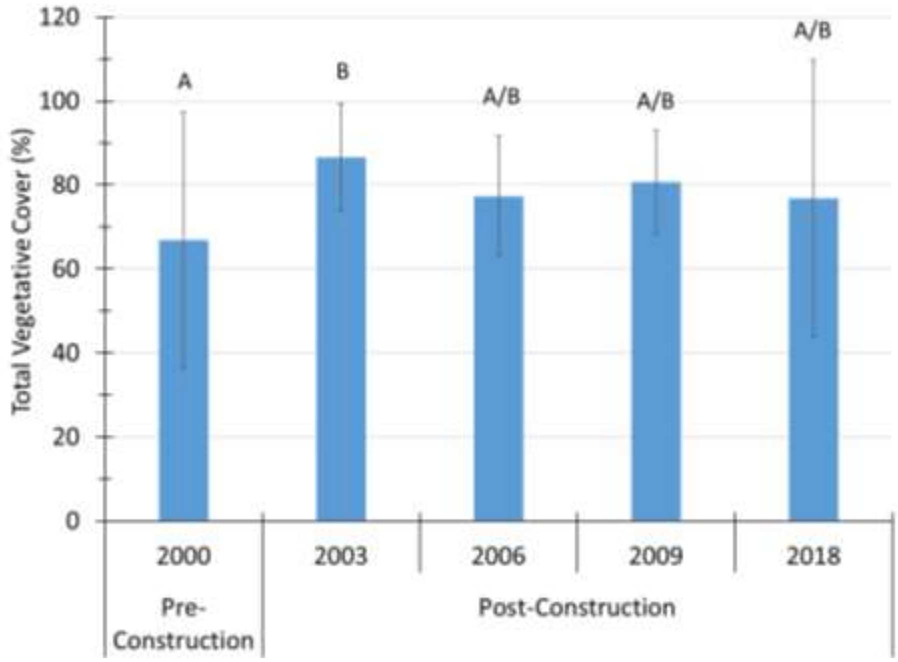


Figure 11. Mean total percent vegetative cover (± SD) at BA-0003c/BA-0026 project-specific stations. Forty stations were surveyed in 2000, 2003, and 2006, 39 stations were surveyed in 2009, and 30 stations were surveyed in 2018.

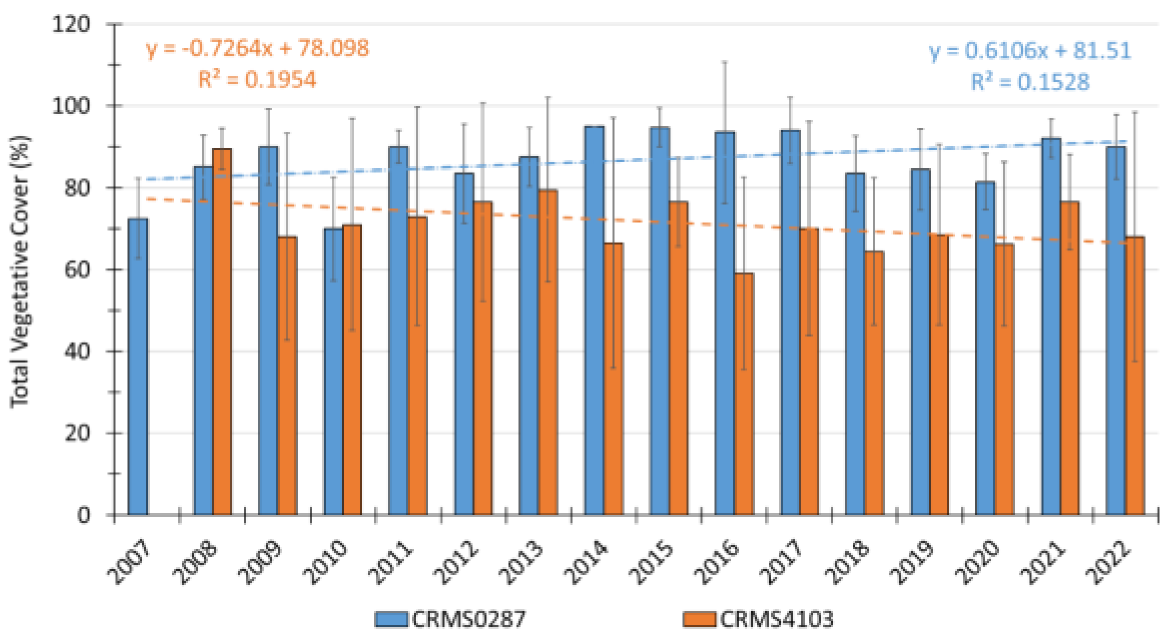


Figure 12. Mean total percent vegetative cover (± SD) at CRMS0287 and CRMS4103. Ten stations were surveyed at each CRMS site each year.

Individual Species Cover

Project-Specific Stations: Since 1997, *Spartina patens* (marshhay cordgrass), a species associated with intermediate-brackish marsh, had the highest mean cover in the project area, at 33 ± 8% over years (Figure 13). This species was also the most widely distributed, occurring at an average of 71 ± 7% of stations. The cover of *S. patens* has trended downwards since 1997, with the lowest cover of 20% recorded in 2018. *Sagittaria lancifolia* (bulltongue), a fresh-intermediate marsh species, had the second highest cover over years at 11 ± 5% and also had the second highest distribution, occurring at 51 ± 7% of stations. As noted for the 1992 and 1995 surveys, this species has been concentrated in the northern project area, with *S. patens* typically dominant in the southern extent where salinities are higher. *Eleocharis cellulosa* (Gulf Coast spikerush), a sedge associated with intermediate marsh, had the third highest mean cover over years at 7 ± 4%, and like *S. patens*, has trended downwards since 1997. All of the vegetation stations located north of BA03c-43 were categorized as floating marsh in 2018, while those south of BA03c-43, with the exception of one station, were categorized as attached (Figure 6). The designation of floating or attached was not noted during previous surveys. A list of all species identified at the project-specific stations and their mean covers and distributions is included in Appendix B.

CRMS Stations: CRMS0287 is located in the northeastern project area and is categorized as floating marsh. The species with the highest cover at CRMS0287 over years has been *S. lancifolia* (36 ± 16%), followed by *Schoenoplectus americanus* (olney bulrush, 17 ± 11%) and *Eleocharis macrostachya* (pale spikerush, 14 ± 11%) (Figure 14). *Sagittaria lancifolia* was the most widely-distributed species, being recorded at nearly all stations (96 ± 5%), with *Polygonum punctatum* (dotted smartweed), having the second highest distribution (83 ± 17%) and *S. americanus* being the third most-distributed species (68 ± 29%). *Eleocharis macrostachya* started appearing consistently at CRMS0287 in 2013, and was first identified at the BA-0003c/BA-0026 project-specific stations in 2018, when it tied with *S. patens* as having the highest cover for that year. It is possible this species was present before, but was identified only to genus.

A significant change occurred in the cover of *S. lancifolia* in 2022, with cover dropping from 47% in 2021 to only 3% in 2022 (Figure 14). This decline is a result of Hurricane Ida, a Category 4 hurricane that came ashore at Port Fourchon, Louisiana, on August 29, 2021. The marsh in the Barataria Basin was significantly impacted from this hurricane, with major marsh fragmentation and erosion. The floating marsh at CRMS0287 was pushed northward and the vegetation stations needed to be reestablished at their original locations for the 2022 survey. The shift in community at this site was partially due to a physical shift in the marsh, but was also likely influenced by an extended period of high salinity in the project area after Hurricane Ida that stressed fresher species and favored those with a higher salinity tolerance.

At CRMS4103, located in the central project area, *S. patens* had the highest percent cover over years (19 ± 17%), followed by *S. lancifolia* (17 ± 12%) and the vine *Ipomoea sagittata* (saltmarsh morning glory, 14 ± 7%) (Figure 15). The cover of *S. patens* has remained low in more recent years, with the highest covers recorded in 2008 and 2011, while the cover of *S. lancifolia* has shown a largely consistent increase over years. *Ipomoea sagittata* was present at the greatest percentage of stations (87 ± 12%), followed by *S. patens* (83 ± 12%). *Polygonum punctatum* (75 ± 28%) and the vine *Vigna luteola* (hairypod cowpea, 75 ± 26%) were tied for the third greatest distribution among stations. Unlike CRMS0287, the marsh is still largely categorized as attached, with only one station in 2015, 2016, and 2019 being noted as floating.

Floristic Quality Index

The Floristic Quality Index (FQI) goes beyond providing information on species cover and distribution by characterizing the quality and stability of the marsh. The calculation of the FQI was developed by Swink and Wilhelm (1979), but has been modified by Cretini et al. (2011) to better describe the coastal community in Louisiana. The FQI score is calculated using the percent cover for each species and a value that is assigned to each species based on how indicative it is of a stable marsh community. This value is called the coefficient of conservatism (CC) and ranges from 0 to 10, with 0 being a species of lowest value (e.g., invasive species) and 10 being a species that is characteristic of a vigorous Louisiana coastal wetland (e.g., *S. alterniflora*). A station with a high FQI score represents a community that has a low percentage of invasive and disturbance species and is dominated by species that are found in a stable marsh community. Based on a maximum score of 100, an FQI score > 71 is considered good, < 39 is considered poor, and between these ranges is considered fair (CPRA 2022).

The mean FQI score for the BA-0003c/BA-0026 project area between 1997 and 2018 was 56 ± 2 and ranged from a high of 61 ± 18 in 2006, to a low of 50 ± 5 in 2018 (Figure 13). There was no significant difference in the mean FQI score among years and the FQI score during the project life remained in the fair category. The mean FQI score for CRMS0287 over years was 59 ± 1 and the score ranged from a high of 65 ± 5 in 2022, to a low of 49 ± 8 in 2007 (Figure 14). The mean FQI score remained in the fair category for all years, but was significantly different among years ($p < 0.0001$, F = 4.98), with a slight upwards trend. For CRMS4103, the mean FQI score was 51 ± 2 and the score ranged from a high of 67 ± 1 in 2008 to a low of 44 ± 6 in 2014 (Figure 15). As with CRMS0287, the site remained in the fair category over years. There was no significant difference in the mean FQI score for CRMS4103 during the monitoring period and there was no trend.

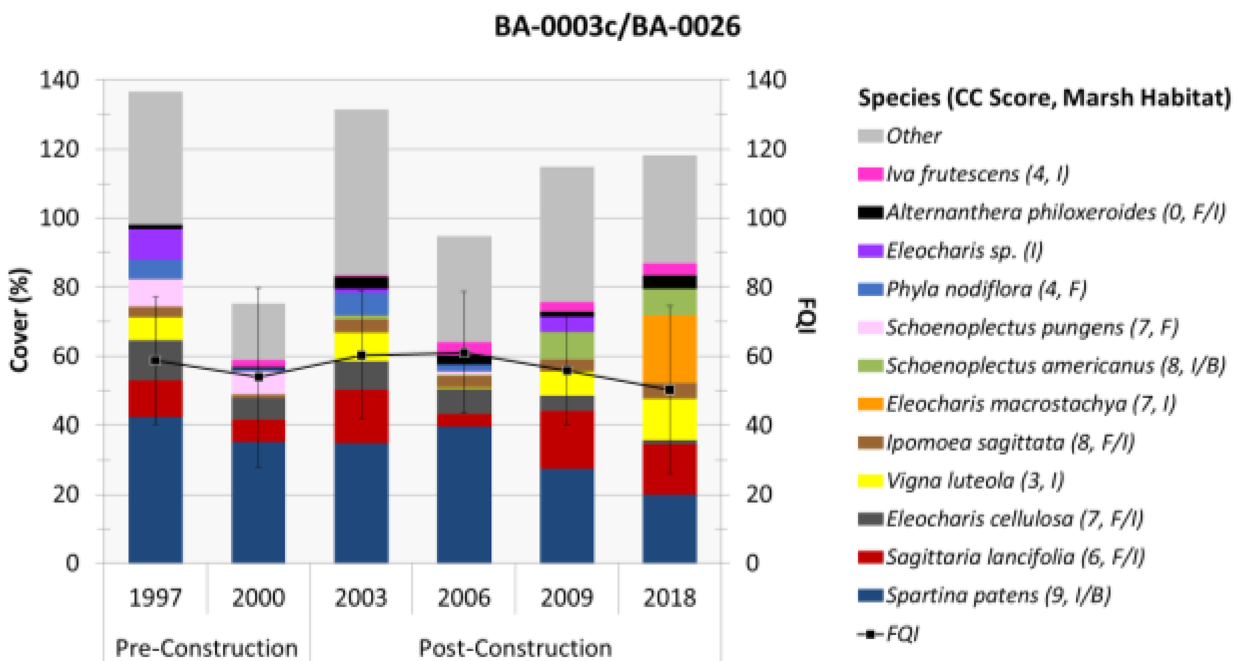


Figure 13. Vegetation species mean percent cover and FQI score (± SD) at BA-0003c/BA-0026 project-specific stations. The CC score and the marsh habitat where the species is typically found are included in the legend for this and subsequent FQI charts.

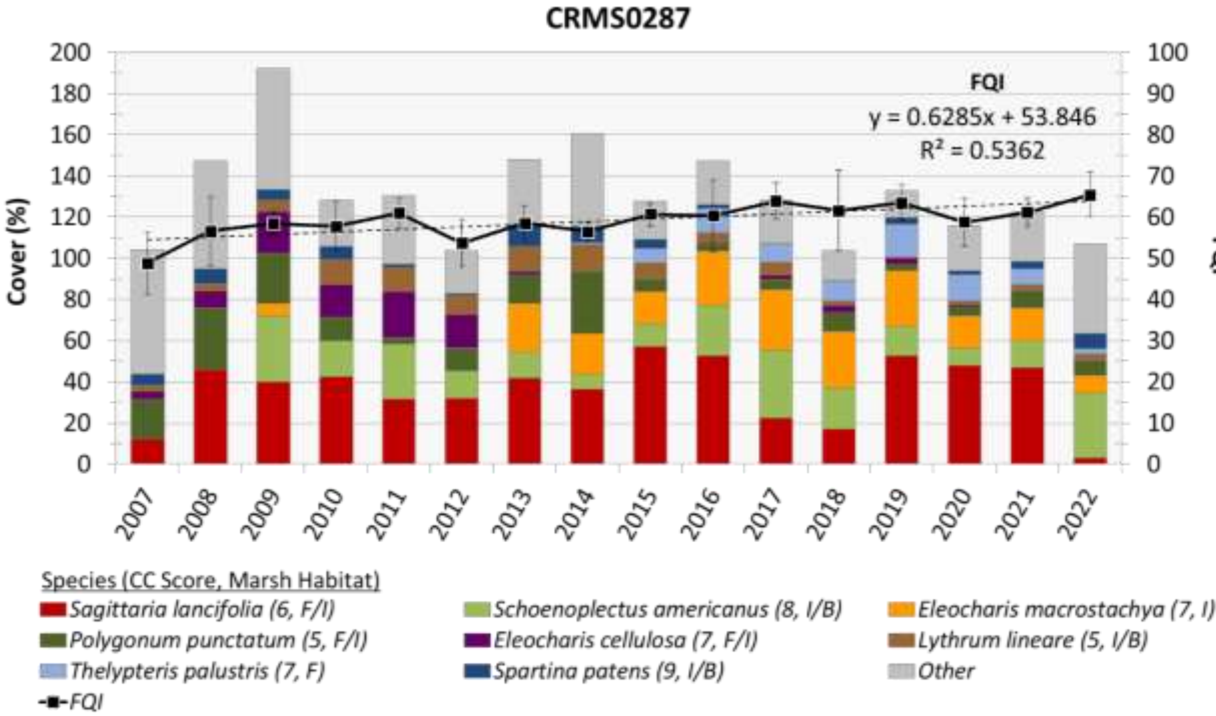


Figure 14. Vegetation species mean percent cover and FQI score (± SD) for CRMS0287.

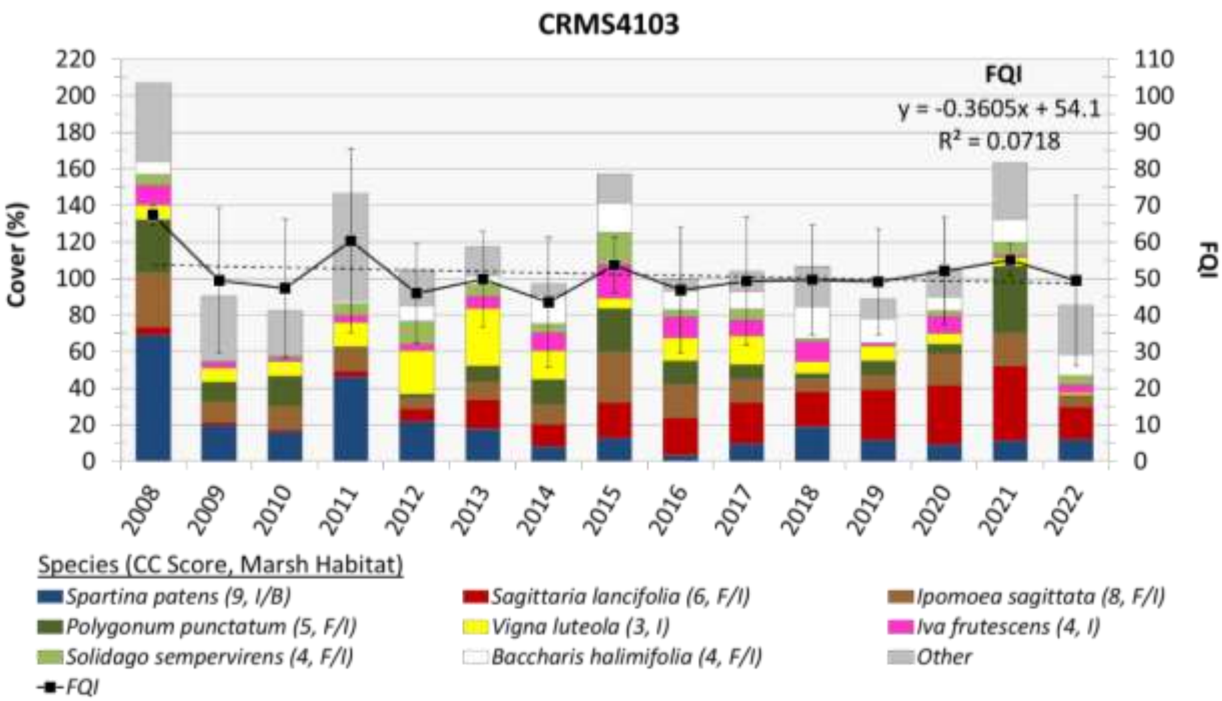


Figure 15. Vegetation species mean percent cover and FQI score (± SD) for CRMS4103.

Marsh Communities

One of the project objectives is to increase the relative abundance of fresh-to-intermediate marsh species in the project area. This objective assumed that construction of the weirs would improve the retention of fresh river water in the project area and reduce salt water intrusion via the Barataria Bay Waterway. Changes in the abundance of fresh-to-intermediate marsh species were assessed by using a marsh classification algorithm that categorizes each vegetation station as fresh, intermediate, brackish, or salt marsh (Visser et al 2002). The algorithm assigns this marsh classification using the species composition at a station, each species' cover, and the marsh habitat where each species is typically found.

The BA-0003c/BA-0026 project-specific stations were classified primarily as intermediate marsh over years (Figure 16). The percent of intermediate marsh stations ranged from a low of 48% in 2000 (drought), to a high of 89% in 2018, and increased consistently for surveys between these years. If the number of intermediate and fresh marsh stations are combined, the percent of stations ranges from 75% in 2000 to 100% in 2018. The number of fresh marsh stations has continually declined since 1997, with fresh marsh mainly transitioning to intermediate marsh. The number of brackish marsh stations has declined since 2000, with none recorded during the 2018 survey. Salt marsh has remained the least-represented marsh habitat in the project area, with a high of two stations recorded in 2000 (drought) and none recorded in 1997, 2006 and 2018. Of the 10 stations that were not surveyed in 2018, six had been classified consistently as intermediate or fresh marsh, and four had been classified as intermediate marsh for the previous two surveys (2006 and 2009). Conditions in the project area are supporting primarily intermediate marsh habitat and appear to be promoting its expansion.

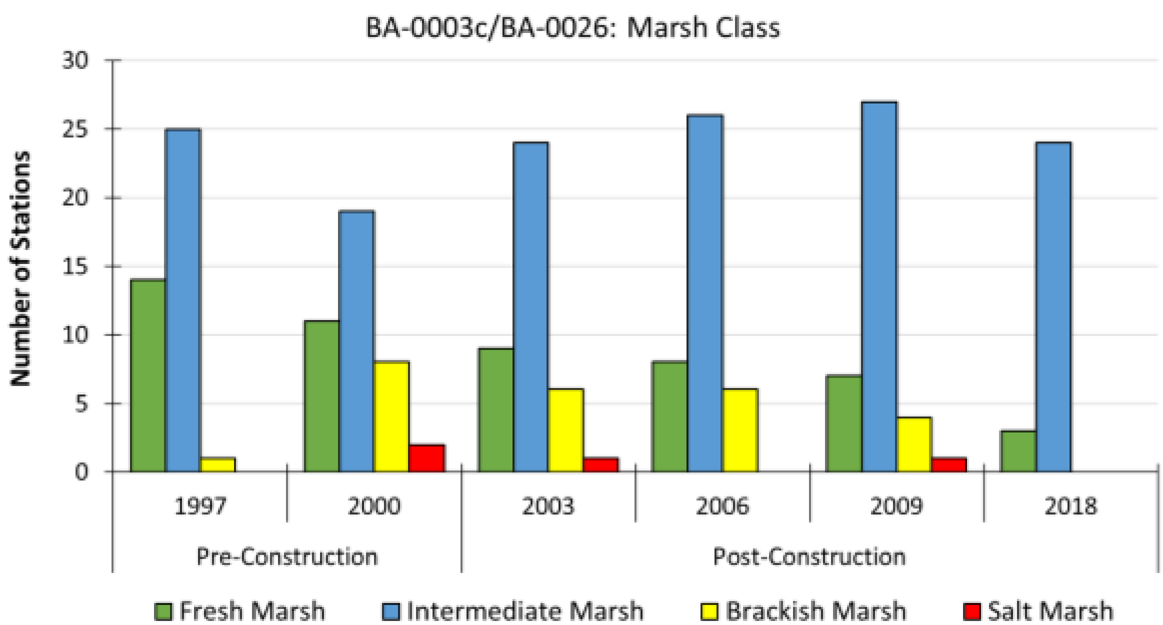


Figure 16. Number of BA-0003c/BA-0026 project-specific vegetation stations by marsh class by year.

All of the 10 vegetation stations at CRMS0287 have been classified as fresh or intermediate marsh since the surveys began in 2007, with most of the stations alternating between these two marsh classes over years (Figure 17). CRMS4103 stations have also consistently been classified as either fresh or intermediate marsh; however, between 2008 and 2012, all stations were classified as intermediate marsh (Figure 18). An increase in *S. lancifolia* cover since 2012 has resulted in some stations being reclassified as fresh marsh, but intermediate marsh has remained the dominant classification. The marsh classification algorithm assigns stations as fresh marsh once the cover of *S. lancifolia* reaches ≥ 50%.

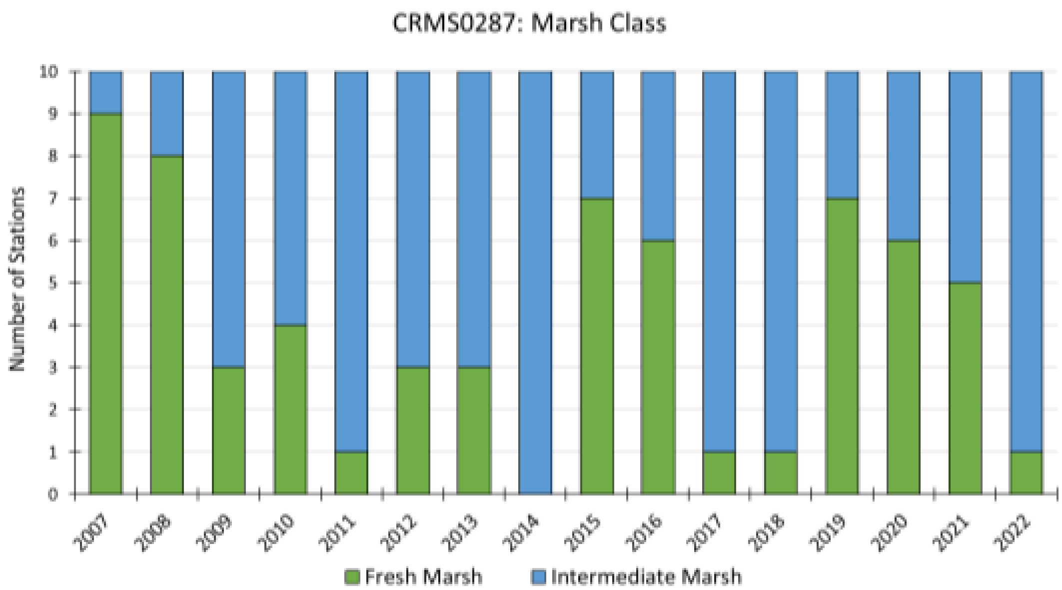


Figure 17. Marsh classification of the 10 vegetation stations at CRMS0287 between 2007 and 2022.

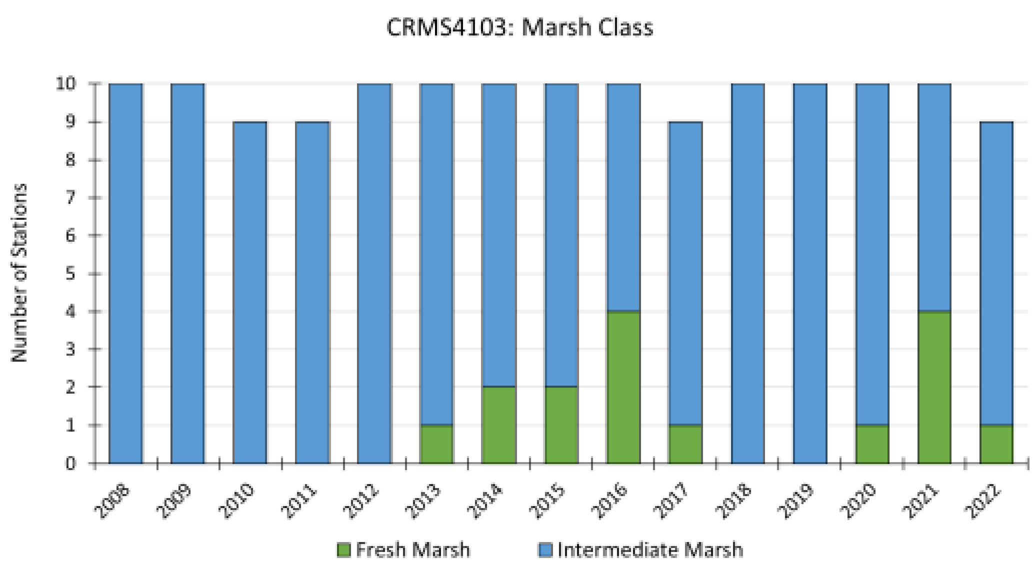


Figure 18. Marsh classification of the vegetation stations at CRMS4103 between 2008 and 2022. Nine stations are shown in 2010, 2011, 2017, and 2022 because one station each year had 0% cover

iii. Land-Water Analysis

A land-water analysis of the BA-0003 (Naomi Siphon Diversion) project area was conducted on aerial imagery acquired November 05, 1991 (Figure 19), prior to the start of siphon operations in 1992. The subsequent analysis was conducted on imagery acquired November 23, 2000 (Figure 20), and includes an assessment of the BA-0003 project area, as well as the expanded BA-0003c (Naomi Outfall Management) project area and the BA-0026 project area. At the time of this analysis, the siphons had been operating for seven years and the BA-0003c weirs and BA-0026 shoreline protection feature had not been constructed. The 2000 imagery was acquired at a resolution of 1:24,000, rather than at 1:12,000, which was utilized for other land-water analyses. The reduced resolution of the 2000 imagery may have impacted the results of the analysis in comparison to other years. The first land-water analysis of the BA-0003c project area after weir installation was conducted on aerial imagery acquired December 19, 2009 (Figure 21). The project area for BA-0003 was extracted from this imagery and also analyzed to allow for a comparison to the 1991 BA-0003 land-water analysis results (Figure 22). The first post-construction land-water analysis of the BA-0026 project area was conducted on imagery acquired November 11, 2011 (Figure 23), approximately 10.5 years after initial construction of the shoreline protection feature. A final analysis of all three project areas was conducted on imagery acquired November 16, 2018 (Figure 24).

Multiple coastal restoration projects (primarily marsh creation) have been constructed within the three project areas, starting in 2009 with the Mississippi River Sediment Delivery System-Bayou Dupont (BA-0039) marsh creation project. By the final 2018 land-water analysis, a significant area within the project boundaries had become impacted by these land-building restoration projects. Therefore, an additional analysis was conducted that removed the acres of embedded restoration projects for each year of analysis (1991 imagery for BA-0003 was not reanalyzed). These project areas are differentiated in the 2018 land-water analysis (Figure 24) and are referred to as Excluded Restoration Projects in the legend. Each project is identified by state project number and restoration type in Figure 2.

The analyzed project boundary changed slightly for the BA-0003c, BA-0026 and BA-0003c projects throughout the years. These inconsistencies were rectified for the additional land-water analyses that removed the embedded restoration project acres, with a consistent boundary being used for each analysis. Additional maps were not created for the revised analyses.

<u>Naomi Outfall Management (BA-0003c)</u>
If the acres of land created by other restoration projects are excluded from the land-water analyses, land in the BA-0003c project area declined from 11,211 acres in 2000 (pre-weir construction), to 10,206 acres in 2009, for a loss of 1005 acres (Table 3). The pronounced loss of land during this time is largely due to Hurricane Katrina (08/29/2005). By the final 2018 analysis, the acres of land had increased to 10,451 acres, but there was still an overall loss of land between 2000 and 2018 of 760 acres. If the analysis is conducted with the inclusion of the land-creating restoration projects, the acres of land between 2000 and 2018 increased from 11,385 acres to 11,497 acres, for an increase of 112 acres (Table 3). There was an initial decline in land between the 2000 and 2009 analyses (1043 acres); however, the increase of 1155 acres due to marsh creation projects between the 2009 and 2018 analyses overcame the initial loss.

BBW East Side Shoreline Protection (BA-0026)

If the acres of land created by other restoration projects are excluded from the land-water analyses, land in the BA-0026 project area declined from 932 acres in 2000 (pre-construction) to 739 acres in 2011, for a loss of 193 acres (Table 3). In the seven years between the 2011 and 2018 land-water analyses, the acres of land have remained stable, with a decline of only 3 acres between 2011 and 2018 to 736 acres. Between 2000 and 2018, a total of 196 acres of land were lost in the project area. If the analysis is conducted with the inclusion of other restoration project acres, the project area gained 333 acres between 2000 and 2018 (Table 3). The initial loss of land between the 2000 and 2011 analyses was counteracted by the significant increase in land that occurred between 2011 and 2018 (528 acres) due to marsh creation projects. Construction was completed in 2023 for the Large-Scale Marsh Creation–Upper Barataria Component (BA-0207) project (Figure 2), which built approximately 1183 acres of land within the BA-0026 project area using sediment dredged from the Mississippi River and delivered through the Long-Distance Sediment Pipeline (BA-0043-EB). This project should convert > 40% of the BA-0026 open water acres to land (based on the 2018 land-water analysis).

Naomi Siphon Diversion (BA-0003)

If the acres of land created by other restoration projects are excluded from the land-water analyses, the acres of land in the BA-0003 project area declined from 8,946 acres in 2000 to 8,210 acres in 2009, for a loss of 736 acres (Table 3). Between the 2009 and 2018 land-water analyses, there was an increase of 246 acres of land, but there was still an overall loss of land between 2000 and 2018 of 490 acres. If the analysis is conducted with the inclusion of restoration projects, the acres of land between 1991 (pre-siphon operations) and 2018 increased from 8,175 acres to 9,147 acres, for an increase of 972 acres (Table 3). The acres of land fluctuated between years, initially increasing between the 1991 and 2000 analyses by 882 acres. The acres of land then declined by 768 acres for the 2009 analysis, before rebounding by 858 acres for the 2018 analysis. The increase in land after the 2009 analysis can be credited to the expansive marsh creation that occurred within the project boundary.

Combined BA-0003c, BA-0026 and BA-0003

If the acres of land created by other restoration projects are excluded from the land-water analyses, the total acres of land in the combined project areas declined from 21,089 acres in 2000 to 19,643 acres in 2018, for a loss of 1,446 acres (Table 3). Hurricane Katrina (August, 29, 2005) occurred during this time and caused significant impacts to marsh in the Barataria basin. Additionally, between the 2009 (BA-0003c and BA-0003) and 2011 (BA-0026) analyses, and the final 2018 analysis, the percent of land in each project area either remained stable or increased.

If the analysis is conducted with the inclusion of restoration project acres, the acres of land increased from 21,519 acres in 2000, to 22,054 acres in 2018, for an increase of 535 acres (Table 3). The 2000 land-water analysis was conducted at a lower resolution than the other analyses (1:24,000 instead of 1:12,000) and this could have impacted the assessment of land and water acres for that year. Additionally, the land-water analyses without the embedded restoration projects is meant to give an approximation of acres. It does not consider land gain/loss outside of the project boundaries that resulted during project construction, or as a result of changing hydrology and localized sediment distribution due to the projects after construction. Land-change rates were not calculated due to the scarcity of data points and different resolution for the 2000 imagery analysis.

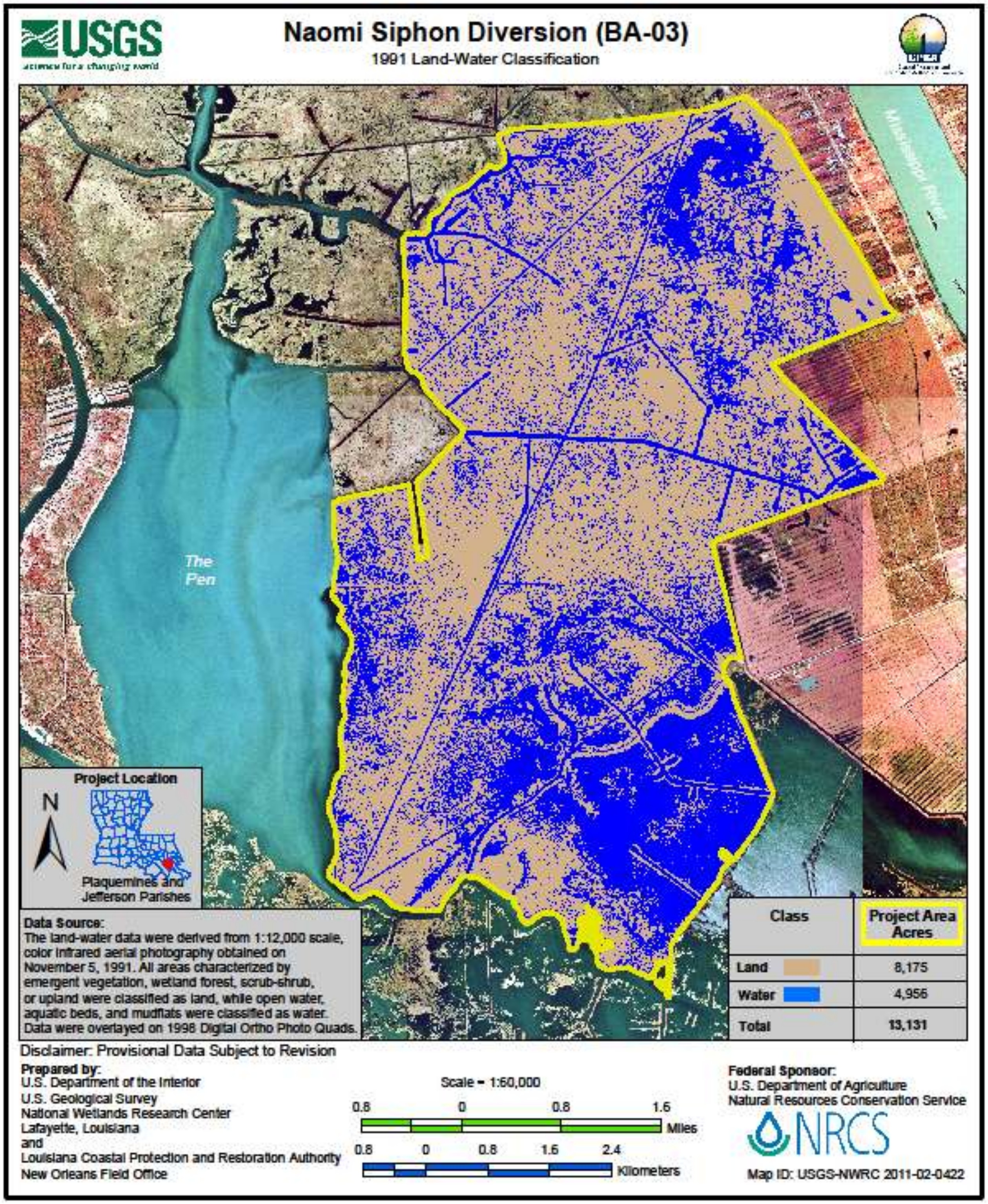


Figure 19. Land-water analysis of the BA-0003 project area (pre-construction) conducted on November 5, 1991 aerial imagery.

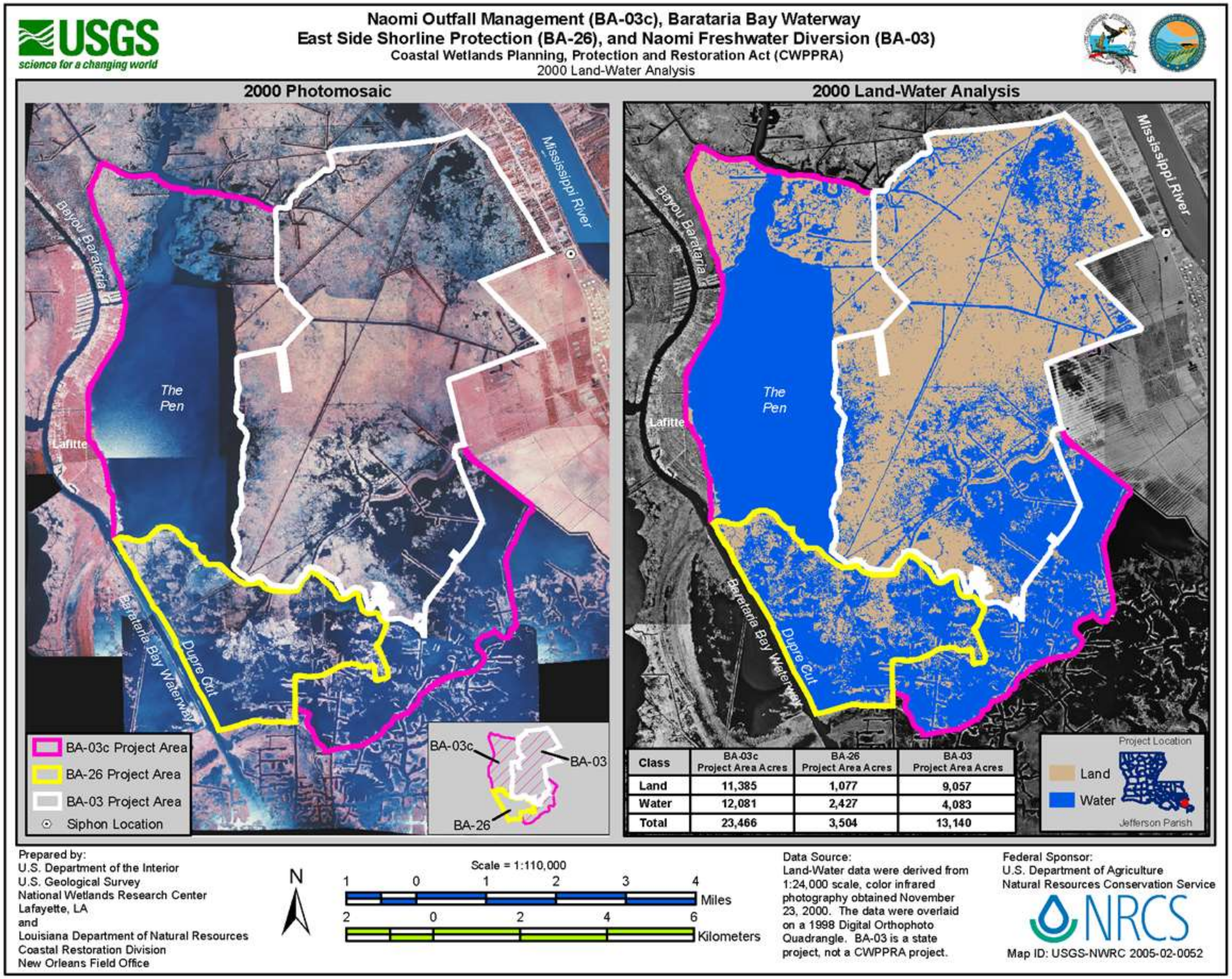


Figure 20. Land-water analysis of the BA-0003c, BA-0026 and BA-0003 project areas conducted on November 23, 2000 aerial imagery.

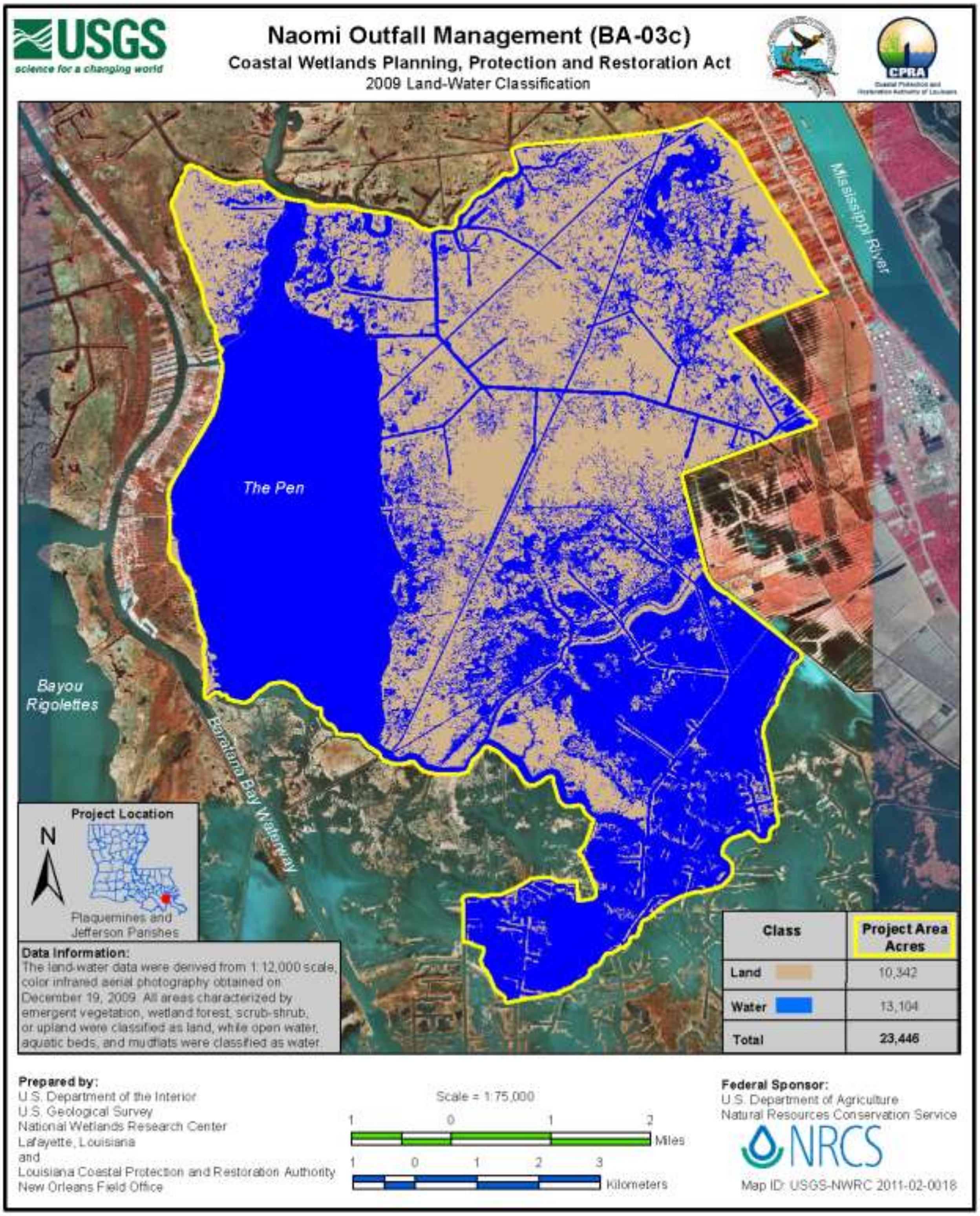


Figure 21. Land-water analysis of the BA-0003c project area conducted on December 19, 2009 aerial imagery.

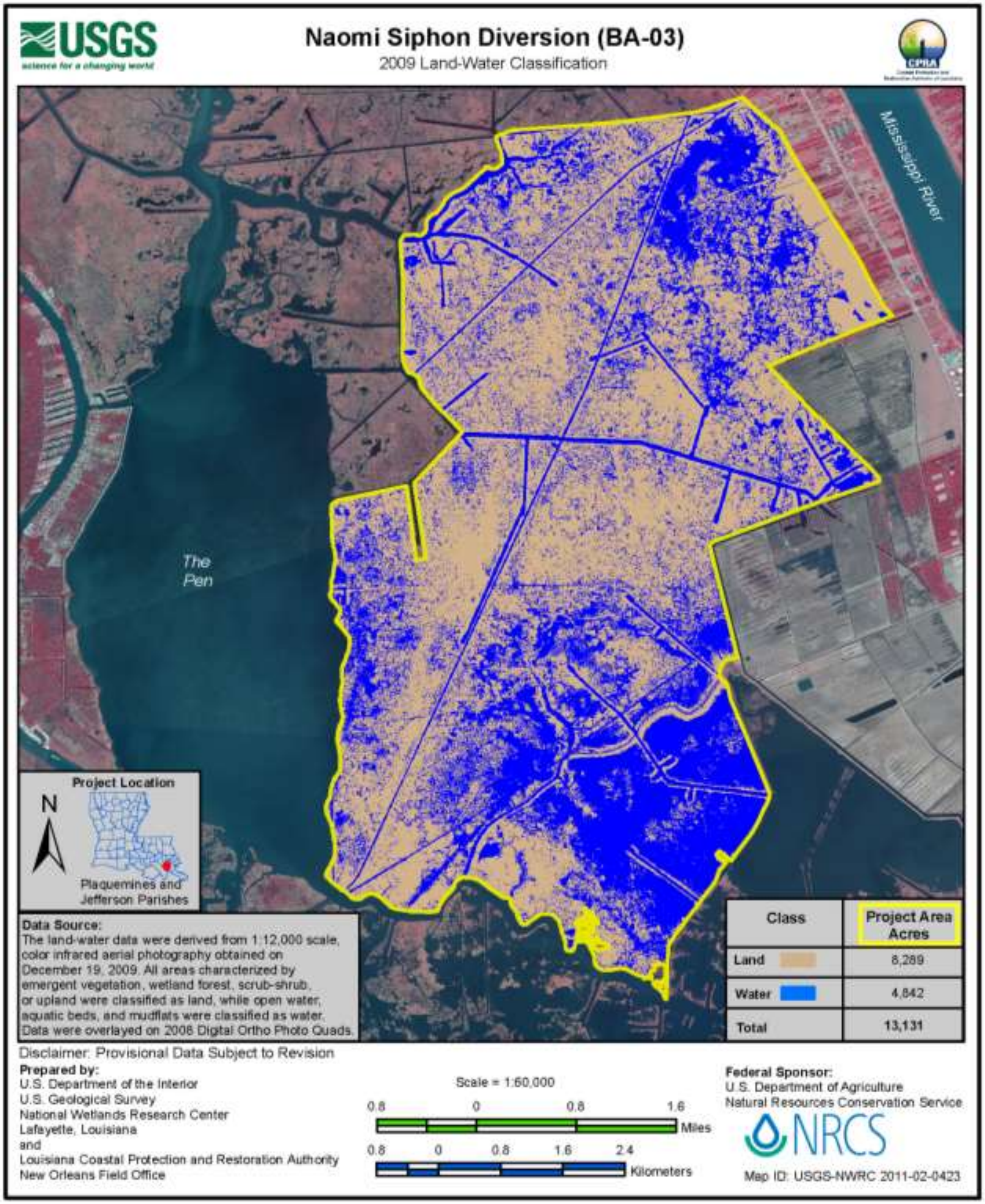


Figure 22. Land-water analysis of the BA-0003 project area conducted on December 19, 2009 aerial imagery.

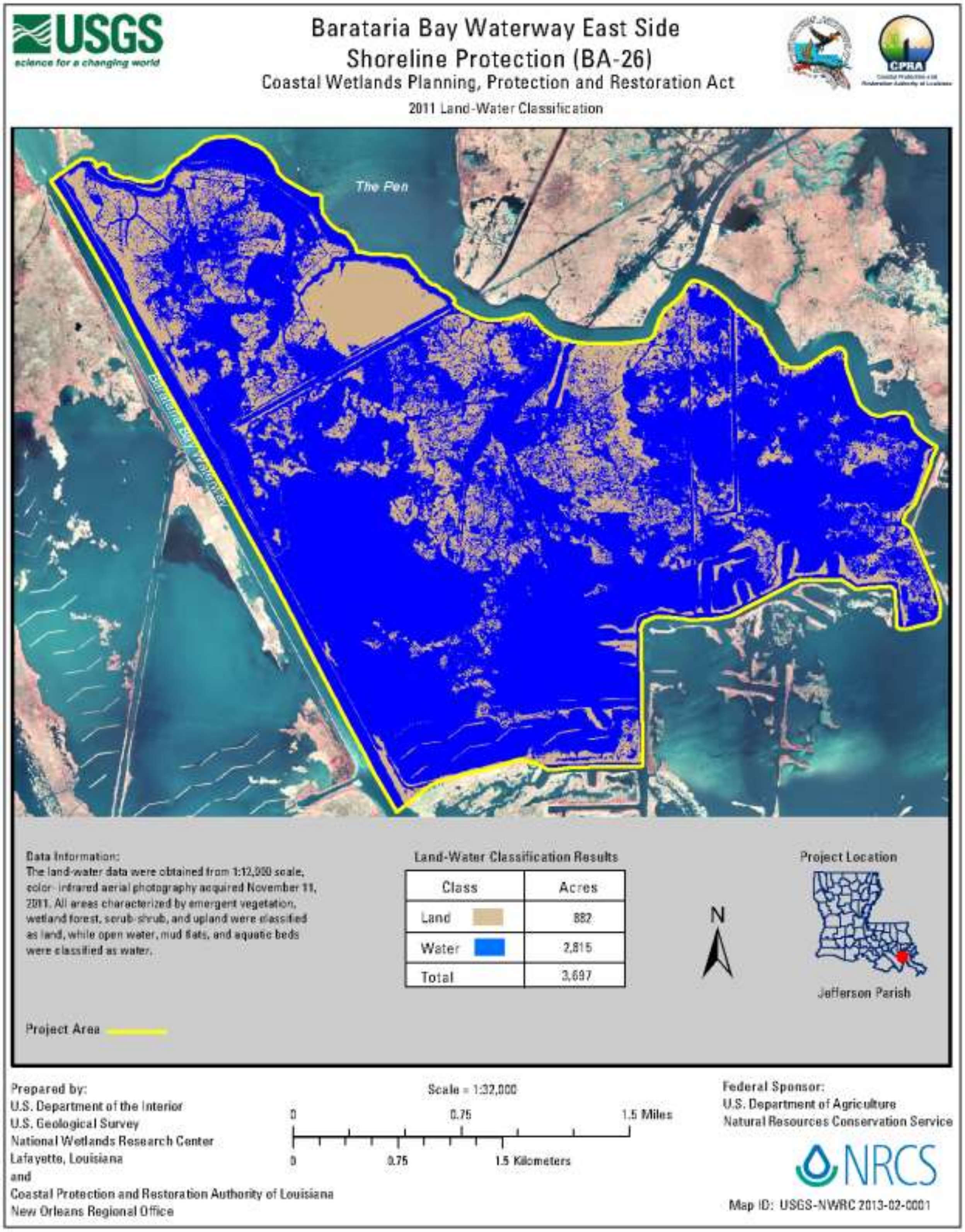
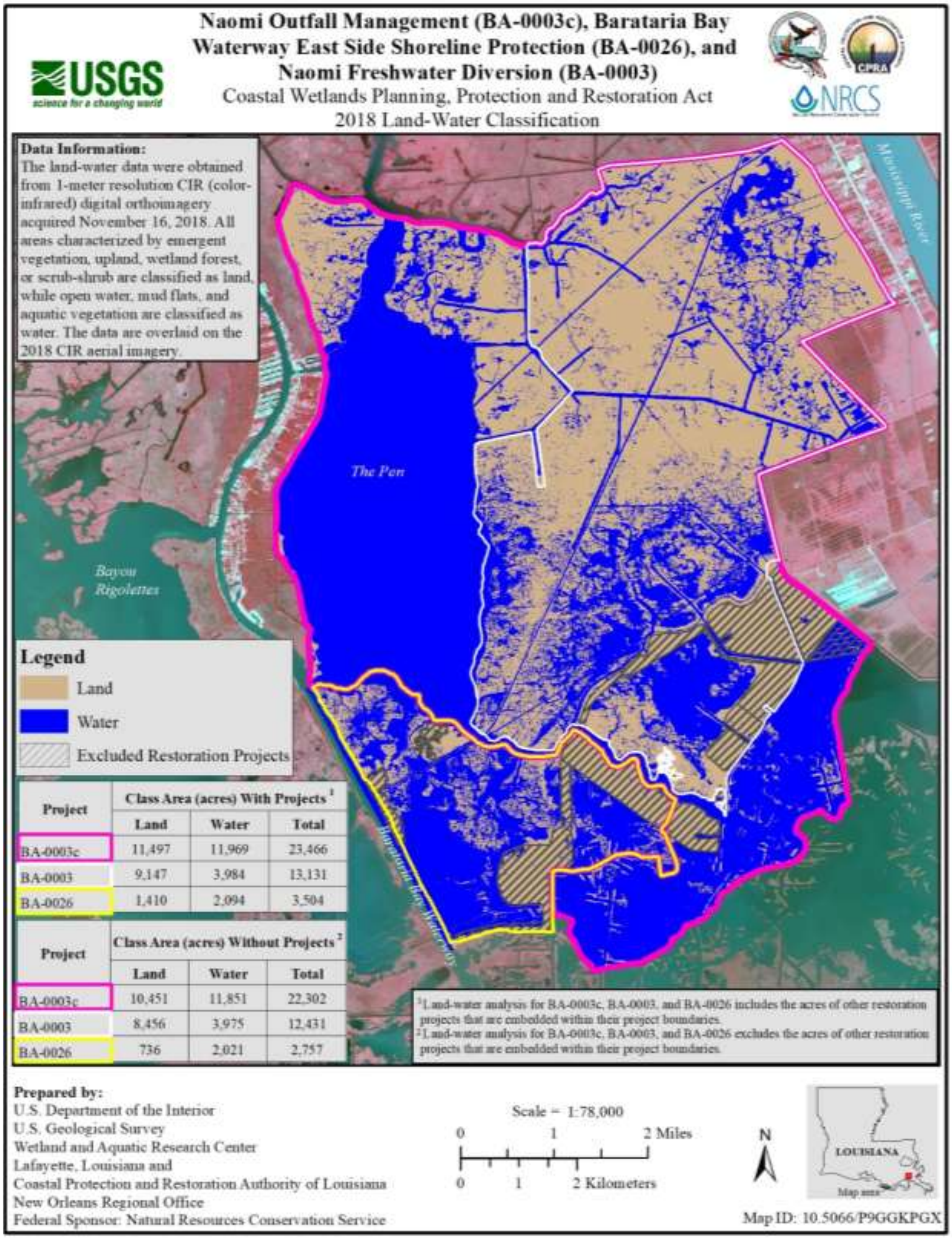


Figure 23. Land-water analysis of the BA-0026 project area conducted on November 11, 2011 aerial imagery.



Project	Class Area (acres) With Projects [1]		
	Land	Water	Total
BA-0003c	11,497	11,969	23,466
BA-0003	9,147	3,984	13,131
BA-0026	1,410	2,094	3,504

Project	Class Area (acres) Without Projects [2]		
	Land	Water	Total
BA-0003c	10,451	11,851	22,302
BA-0003	8,456	3,975	12,431
BA-0026	736	2,021	2,757

Figure 24. Land-water analysis of the BA-0003c, BA-0026, and BA-0003 project areas conducted on November 16, 2018 aerial imagery.

Table 3. Land-water analysis results for the BA-0003c, BA-0026 and BA-0003 project areas. Values are presented for the analyses with all acres included and for the additional analyses that were conducted with the acres of embedded restoration projects removed.

Land-Water Analysis of BA-0003c, BA-0026 and BA-0003: Acres for Contained Restoration Projects INCLUDED. Data correspond to Figures 19–24.					
BA-0003c					
Year	**Land (ac)**	**Land (%)**	**Water (ac)**	**Water (%)**	**Total (ac)**
2000	11,385	49	12,081	51	23,466
2009	10,342	44	13,104	56	23,446
2018	11,497	49	11,969	51	23,466
2000–2018: +112 acres of land					
BA-0026					
Year	**Land (ac)**	**Land (%)**	**Water (ac)**	**Water (%)**	**Total (ac)**
2000	1,077	31	2,427	69	3,504
2011	882	24	2,815	76	3,697
2018	1,410	40	2,094	60	3,504
2000–2018: +333 acres of land					
BA-0003					
Year	**Land (ac)**	**Land (%)**	**Water (ac)**	**Water (%)**	**Total (ac)**
1991	8,175	62	4,956	38	13,131
2000	9,057	69	4,083	31	13,140
2009	8,289	63	4,842	37	13,131
2018	9,147	70	3,984	30	13,131
1991–2018: +972 acres of land					
Combined BA-0003c/BA-0026/BA-0003					
Year	**Land (ac)**	**Land (%)**	**Water (ac)**	**Water (%)**	**Total (ac)**
2000	21,519	54	18,591	46	40,110
2018	22,054	55	18,047	45	40,101
2000–2018: +535 acres of land					

Land-Water Analysis of BA-0003c, BA-0026 and BA-0003: Acres for Contained Restoration Projects EXCLUDED. With the exception of the 2018 analysis (Figure 24), these re-analyzed data are NOT included in the land-water analysis figures.					
BA-0003c					
Year	**Land (ac)**	**Land (%)**	**Water (ac)**	**Water (%)**	**Total (ac)**
2000	11,211	50	11,091	50	22,302
2009	10,206	46	12,096	54	22,302
2018	10,451	47	11,851	53	22,302
2000–2018: -760 acres of land					
BA-0026					
Year	**Land (ac)**	**Land (%)**	**Water (ac)**	**Water (%)**	**Total (ac)**
2000	932	34	1,825	66	2,757
2011	739	27	2,018	73	2,757
2018	736	27	2,021	73	2,757
2000–2018: -196 acres of land					
BA-0003					
Year	**Land (ac)**	**Land (%)**	**Water (ac)**	**Water (%)**	**Total (ac)**
2000	8,946	72	3,485	28	12,431
2009	8,210	66	4,221	34	12,431
2018	8,456	68	3,975	32	12,431
2000–2018: -490 acres of land; 1991 data were not re-analyed					
Combined BA-0003c/BA-0026/BA-0003					
Year	**Land (ac)**	**Land (%)**	**Water (ac)**	**Water (%)**	**Total (ac)**
2000	21,089	56	16,401	44	37,490
2018	19,643	52	17,847	48	37,490
2000–2018: -1446 acres of land					

VI. Conclusions

The most recent documentation of a Naomi Siphon Diversion (BA-0003) operations plan is from December 1993, when representatives from Plaquemines Parish Government (PPG) and the Department of Natural Resources, Coastal Restoration Division (currently CPRA) agreed that eight pipes would be operated in January and February and May−December, and two pipes would be operated in March and April (12/06/1993 meeting minutes). Since 1993, the siphons have been operated slightly upwards of 33.5% of the time. The siphons most commonly operated at less than 1000 cfs, with mean daily discharge closely divided between 0 to 500 cfs (9.6%) and 500 to 1000 cfs (10.5%). Mean annual discharge trended down over years, with the highest discharge of 1102 cfs recorded in 1993, the first year of operations. A reduction in operations resulted from multiple challenges, including the siphons losing prime when the Mississippi River was at a low river stage, oil spills, hurricanes, maintenance issues, fishery interests, and lawsuits. Additionally, the siphons were closed for extended periods due to the construction of neighboring coastal protection and restoration projects.

The 2011 OM&M report noted the difficulty in determining any effects from the Goose Bayou and Bayou Dupont weirs on project monitoring goals. The evaluation of weir effectiveness was complicated not only by infrequent diversion operations, but also by settlement of the weirs and by the partial deconstruction of the Bayou Dupont weir to facilitate access for construction of other restoration projects. The Bayou Dupont weir is anticipated to remain partially deconstructed at least through 2024 to provide construction access for the Mid-Barataria Sediment Diversion project (BA-0153). This sediment diversion will have the potential to discharge up to 75,000 cfs of Mississippi River water just south of the project area, with the maximum discharge possible when the river flow is 1,000,000 cfs at Belle Chase, Louisiana. When the river flow decreases below 450,000 cfs, the operations plan calls for a baseline flow of up to 5000 cfs (USACE 2022). If the diversion is operated according to plan, it will increase freshwater input to the basin at a volume that will likely render operation of the maximum 2,144 cfs Naomi siphons inconsequential, except for in the immediate outfall area.

Due to the limited amount of new data collected since the 2011 OM&M report and the previous conclusions presented in that report, this final report provided analyses of a condensed number of monitoring elements, focusing on salinity, vegetation, and land-water changes in the BA-0003c/BA-0026 project area throughout the 20-year, post-construction monitoring life span.

a. Project Effectiveness

<u>Salinity</u>

The first objective of the Naomi Outfall Management and Barataria Bay Waterway East Side Shoreline Protection projects is to reduce the mean salinity in the project area. A general comparison was made of mean daily salinity in the project area prior to and after construction of the project features. Mean daily salinity was higher at hydrologic station BA03c-16 after project construction, lower at BA03c-61 after construction, and similar pre- and post-construction at BA03c-60. Mean post-construction salinity ranged from 1.2 ± 1.5 ppt at BA03c-16, located in the northeast project area and closest to the siphon outfall, to 2.8 ± 2.4 ppt at BA03c-61 located in the southwest region of the project area. Regardless of whether the weirs had an impact on reducing salinity in the project area, mean salinity after construction largely remained within a range to support the fresh to intermediate marsh species targeted in the project objectives. Only in the far southern reaches of the project area were salinities high enough to support brackish marsh habitat. Event-driven increases in salinity (severe drought, storm surge) temporarily increased salinity above the fresh-intermediate salinity range; however, vegetation analyses have shown no long-term impacts to the community. Salinity was highest at stations in the fall, when the Mississippi River was typically at the lowest river stage and the diversion was consequently run at the lowest frequency and discharge. Salinity was lowest in the spring and early summer when river stage and discharge were highest and the siphons could be run at a greater frequency and capacity.

Vegetation

The second objective of this project is to improve the growing conditions and increase the relative abundance of fresh-to-intermediate marsh species in the project area. An improvement to the growing conditions due to the project is difficult to assess; however, as previously stated, salinity did remain within a range to support the targeted marsh community throughout most of the project area. Mean total cover remained high at project-specific stations throughout the post-construction project life (81 ± 19%). Total cover also remained high at CRMS0287 and CRMS4103, with an average of 87 ± 7% and 72 ± 7%, respectively. The floristic quality index (FQI), which gauges the quality and stability of the marsh, remained in the fair category for the project-specific and CRMS sites over years.

Changes in the abundance of fresh-to-intermediate marsh species were assessed by using a marsh classification algorithm. Most of the BA-0003c/BA-0026 project-specific stations were classified as intermediate marsh, with conditions appearing to support its expansion. The percent of intermediate marsh stations ranged from 48% in 2000 (drought), to 89% in 2018. If the number of intermediate and fresh marsh stations are combined, the percent of stations ranged from 75% in 2000 to 100% in 2018. The number of fresh and brackish marsh stations has been in decline since the 1997 and 2000 surveys, respectively. The vegetation stations at CRMS0287 have been classified as fresh or intermediate marsh since the vegetation surveys began in 2007, with many of the stations alternating between these two marsh classes over years. All stations at CRMS4103 were classified as intermediate marsh 2008 through 2012. Since 2013, an increase in the cover of *Sagittaria lancifolia* (bulltongue) has resulted in some stations being reclassified as fresh marsh, but intermediate marsh has still been the dominant classification at stations each year.

Land-Water Analysis

The third objective of the BA-0003/BA-0026 project is to reduce the rate of conversion of marsh to open water in the project area. Due to the extensive amount of coastal restoration that has occurred in the project area during the project's life, two land-water analyses were conducted—one that included the restoration acres, and one that excluded the restoration acres. The analysis that excluded the restoration projects is not exact, since dredged sediments extended outside of project boundaries in some cases. If restoration project acres are excluded from the land-water analyses, there was a loss of approximately 1,446 acres of land between 2000 and 2018. This period of analysis includes the devastating impacts to the marsh from Hurricane Katrina. However, between the later surveys (2009/2011) and 2018, the percent of land either remained stable (BA-0026) or increased (BA-0003/BA-0003c). If the land-water analysis is conducted with the inclusion of restoration project acres, there was an increase of approximately 535 acres between 2000 and 2018. Since the 2018 analysis, approximately 1183 acres of additional marsh have been built within the BA-0026 project boundary as part of the Large-Scale Marsh Creation-Upper Barataria Component (BA-0207) project.

b. Recommended Improvements

1. The Bayou Dupont weir is currently partially deconstructed to aid in construction of the Mid-Barataria Sediment Diversion (BA-0153) project. Despite no quantifiable influence on the project objectives from the BA-0003c/BA-0026 monitoring activities, it is recommended that the weir be constructed back to its as-design specifications once passage of construction equipment through Bayou Dupont is no longer required. Restoration of the weir is currently included as part of the BA-0153 project responsibilities.

2. The Naomi siphons should be operated by Plaquemines Parish to maintain salinity in the project area within a range that supports the current marsh community, with fresh to intermediate marsh in the northern and central project area and brackish marsh limited to the southern project area.

3. Future operations of the Naomi siphons will need to be reassessed by CPRA and Plaquemines Parish in relation to construction of the BA-0153 sediment diversion project.

c. Lessons Learned

Since this is the final OM&M report for the BA-0003c/BA-0026 projects, the list of lessons learned includes new observations, as well as important lessons learned that were included in earlier reports. This list also includes lessons learned regarding the BA-0003 siphons.

1. The development of a revised siphon operations plan may have improved operations. Operations fell far short of the intended frequency and discharge due to a long list of issues, including but not limited to the siphons losing prime, fisheries conflicts, and storm impacts. There may have also been a lack of clarity regarding the intended operations regime. Revising the operations plan with stakeholder input and engaging stakeholders periodically to review operations and the operations plan may have increased siphon operations and project benefits.

2. A hydrologic tracer study within the project area would have been useful to better understand water movement, both during and outside of siphon operations. Results of this study could have better-informed the placement and type of water control features and could have helped to refine project boundaries to reflect expected areas of impact.

3. A redesign of the siphons and automated priming would likely have improved operations. Loss of prime was one of the top reasons for the siphons not operating, and re-priming the siphons is labor intensive. However, the cost associated with these upgrades would have been high, as was seen with a proposed project (never constructed) to automate priming of the West Pointe a la Hache siphons (BA-0004).

4. The project objectives should have been developed with greater detail for assessing project success. For example, a target salinity range with isohalines and a description of what growing conditions are desired should have been developed, rather than using vague objectives such as “reduce mean salinity in the project area” and “improve growing conditions.”

5. Reference stations/project areas should have been included in the initial monitoring plan.

6. A flow gauge to measure siphon discharge should have been installed before the start of diversion operations. Prior to USGS gauge installation in November 2006, discharge was calculated using several variables that were not monitored frequently enough to reliably calculate discharge.

7. The greatest project benefits from the freshwater diversion could be realized during drought and after storm surge events, when salinity is typically elevated in the basin. Unfortunately, the siphons were often not operational during these times due to low river stage (and other issues), a diversion operations problem that is not unique to this project.

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Appendix A

Inspection Photographs for Naomi Outfall Management (BA-0003c) and Barataria Bay Waterway East Side Shoreline Protection (BA-0026)

Naomi Outfall Management (BA-0003c)

Photo 1. Bayou Dupont Canal weir, looking out from the Pen.

Photo 2. Goose Bayou Canal weir, looking east. The weir has settled below the waterline.

Barataria Bay Waterway East Side Shoreline Protection (BA-0026)

Photo 3. Barataria Bay Waterway East Side Shoreline Protection (BA-0026).

Photo 4. Evidence of accretion behind the rock wall for the BA-0026 project.

Appendix B

BA-0003c/BA-0026 Project-Specific Vegetation Table

Table 1. Mean percent cover (% C) and percent of stations (% S) where species occurred at BA-0003c/BA-0026 project-specific vegetation stations (n = 40 for 1997−2006, n = 39 for 2009, and n = 30 for 2018). Abbreviations for marsh habitat where species typically occur: F: freshwater, F/I: freshwater-intermediate, I: intermediate, I/B: intermediate-brackish, B: brackish, B/S: brackish-salt, S: salt.

		Vegetation Survey Year												
Scientific Name	Common Name	1997		2000		2003		2006		2009		2018		Habitat
		% C	% S	% C	% S	% C	% S	% C	% S	% C	% S	% C	% S	
Alternanthera philoxeroides	alligatorweed	1.1	10.0	0.4	15.0	3.5	10.0	2.6	12.5	1.5	10.3	3.9	26.7	F/I
Amaranthus australis	southern amaranth	0.3	2.5			0.6	15.0	< 0.1	2.5					I/B
Amaranthus cannabinus	tidalmarsh amaranth									1.2	15.4			I/B
Amaranthus sp.	pigweed							0.3	7.5					*
Ammannia coccinea	valley redstem			0.0	2.5									F/I
Ammannia latifolia	pink redstem					0.4	10.0	0.2	5.0	1.0	23.1	0.2	6.7	F/I
Ammannia sp.	redstem	< 0.1	2.5											F/I
Andropogon glomeratus	bushy bluestem	0.2	17.5	0.1	7.5					0.6	5.1	0.3	6.7	F
Baccharis halimifolia	eastern baccharis	2.4	17.5	2.0	10.0	1.5	5.0	0.3	5.0			6.2	16.7	F/I
Bacopa monnieri	Coastal Waterhyssop	1.1	10.0	2.7	17.5	3.4	22.5	1.7	22.5	1.6	12.8	0.1	3.3	F/I
Bolboschoenus robustus	sturdy bulrush					9.3	37.5	3.4	12.5					B
Cuscuta indecora	bigseed alfalfa dodder					0.1	2.5							I
Cuscuta sp.	dodder							0.4	5.0	0.4	7.7			F/I
Cynanchum angustifolium	gulf coast swallow-wort									0.4	12.8	0.4	16.7	B/S
Cyperus compressus	poorland flatsedge					1.1	15.0							F
Cyperus filicinus	fern flatsedge											0.2	6.7	F/I
Cyperus haspan	haspan flatsedge									0.1	5.1			F
Cyperus odoratus	fragrant flatsedge	0.9	12.5	0.1	10.0	2.7	20.0	0.3	7.5	1.3	17.9	0.7	10.0	I
Cyperus strigosus	Strawcolored Nutgrass									0.6	28.2			F
Cyperus sp.	flatsedge	0.4	12.5	0.2	15.0			0.2	10.0					F/I
Distichlis spicata	Seashore Saltgrass	< 0.1	2.5	4.2	25.0	1.1	10.0	0.9	5.0	4.0	15.4	0.4	10.0	B/S
Echinochloa crus-galli	barnyardgrass	< 0.1	2.5											F/I
Echinochloa walteri	Coast Cockspur			0.0	2.5	1.2	10.0	0.5	10.0	1.3	17.9			I
Eleocharis cellulosa	Gulf Coast spikerush	11.8	40.0	6.4	27.5	8.4	45.0	7.3	42.5	4.4	28.2	1.1	20.0	F/I
Eleocharis macrostachya	pale spikerush											19.7	46.7	I
Eleocharis parvula	Dwarf Spikesedge	< 0.1	2.5	0.6	2.5	3.2	20.0	0.7	5.0	0.5	5.1			I/B
Eleocharis rostellata	beaked spikerush											2.7	10.0	I
Eleocharis sp.	spikerush	8.9	27.5			1.3	5.0			4.4	28.2			I
Eupatorium capillifolium	dogfennel											0.2	3.3	F
Fuirena squarrosa	hairy umbrella-sedge					0.1	2.5							F
Galium tinctorium	stiff marsh bedstraw					< 0.1	7.5			< 0.1	2.6			F
Hibiscus moscheutos	crimsoneyed rosemallow	< 0.1	5.0											F/I
Hibiscus sp.	rosemallow	< 0.1	12.5											F/I
Hydrocotyle umbellata	manyflower marshpennywort									1.3	28.2	0.3	10.0	F
Hydrocotyle sp.	hydrocotyle	1.4	35.0	0.2	10.0	3.1	32.5	0.1	7.5			0.1	6.7	F
Ipomoea sagittata	Saltmarsh Morningglory	3.1	30.0	1.2	37.5	4.0	42.5	3.4	40.0	3.4	35.9	4.6	46.7	F/I
Iva frutescens	Bigleaf Sumpweed	0.1	2.5	2.1	10.0	0.4	5.0	3.9	15.0	2.8	10.3	3.6	20.0	I
Juncus effusus	common rush	2.3	5.0										3.3	F
Juncus roemerianus	needlegrass rush	1.3	2.5	1.4	2.5	1.5	2.5	1.3	2.5	1.3	2.6			B/S
Kosteletzkya virginica	Virginia saltmarsh mallow			0.3	2.5	0.1	2.5	2.0	20.0	0.7	10.3	2.0	26.7	F/I
Ludwigia alternifolia	seedbox									0.4	17.9			*
Ludwigia microcarpa	smallfruit primrose-willow	< 0.1	2.5											F
Ludwigia sp.	primrose-willow	0.2	17.5									0.2	3.3	F
Lythrum lineare	wand lythrum					1.6	37.5	0.7	25.0	2.2	20.5	0.6	10.0	I/B
Mikania scandens	climbing hempvine	2.3	7.5					0.5	10.0					F

Table 1 con't. Mean percent cover (% C) and percent of stations (% S) where species occurred at BA-0003c/BA-0026 project-specific vegetation stations (n = 40 for 1997−2006, n = 39 for 2009, and n = 30 for 2018). Abbreviations for marsh habitat where species typically occur: F: freshwater, F/I: freshwater-intermediate, I: intermediate, I/B: intermediate-brackish, B: brackish, B/S: brackish-salt, S: salt.

		Vegetation Survey Year												
Scientific Name	Common Name	1997		2000		2003		2006		2009		2018		Habitat
		% C	% S	% C	% S	% C	% S	% C	% S	% C	% S	% C	% S	
Panicum dichotomiflorum	Fall Panic							0.1	2.5					F/I
Panicum hemitomon	maidencane							1.0	12.5			0.2	3.3	F
Panicum repens	Torpedograss			< 0.1	2.5	0.7	7.5			0.9	12.8	0.2	6.7	I
Paspalum distichum	knotgrass					< 0.1	2.5							F
Phragmites australis	common reed											3.0	3.3	I
Phyla lanceolata	Lanceleaf Frog Fruit									0.2	12.8			F
Phyla nodiflora	turkey tangle fogfruit	5.5	45.0	0.7	25.0	6.6	40.0	2.0	20.0			0.3	6.7	F
Pluchea camphorata	camphor pluchea	1.4	17.5	0.2	5.0	3.2	20.0	1.1	15.0			0.2	3.3	I/B
Pluchea foetida	stinking camphorweed	< 0.1	2.5											F
Pluchea odorata	sweetscent									3.4	30.8			I/B
Polygonum hydropiperoides	swamp smartweed							0.1	2.5	9.7	61.5			F
Polygonum pensylvanicum	Pennsylvania smartweed	6.7	37.5											F
Polygonum punctatum	dotted smartweed	0.5	2.5	< 0.1	5.0	8.7	60.0	0.1	2.5			0.8	16.7	F/I
Polygonum sp.	knotweed	1.7	20.0											F
Rhynchospora colorata	starrush whitetop									< 0.1	2.6	0.1	3.3	F
Sabatia stellaris	rose of Plymouth											0.0	3.3	B/S
Sacciolepis striata	American cupscale	0.1	5.0	0.7	17.5					< 0.1	2.6	1.1	20.0	F
Sagittaria lancifolia	Bulltongue	10.7	45.0	6.2	47.5	15.4	50.0	3.7	45.0	16.6	56.4	14.8	56.7	F/I
Sagittaria platyphylla	delta arrowhead	1.3	5.0											F
Schoenoplectus americanus	Olney Bulrush					1.0	5.0	0.4	5.0	8.0	41.0	7.7	53.3	I/B
Schoenoplectus pungens	common threesquare	8.1	35.0	6.7	25.0			0.9	2.5					F
Schoenoplectus sp.	bulrush							1.5	7.5					*
Setaria magna	giant bristlegrass	0.3	2.5			0.1	2.5	0.8	5.0					I
Setaria parviflora	Knotroot Bristlegrass	0.1	5.0	0.1	2.5	< 0.1	5.0					0.1	3.3	F
Setaria pumila	yellow foxtail							< 0.1	2.5	0.2	7.7			I/B
Setaria sp.	bristlegrass	1.3	17.5											*
Solidago sempervirens	seaside goldenrod	2.5	17.5	0.2	15.0	0.1	5.0	0.5	10.0	1.2	7.7	0.6	16.7	F/I
Spartina alterniflora	smooth cordgrass	< 0.1	2.5	0.8	10.0	2.0	7.5	0.3	5.0					S
Spartina cynosuroides	big cordgrass									0.2	7.7			B
Spartina patens	Marshhay Cordgrass	42.2	65.0	35.2	75.0	34.7	70.0	39.5	75.0	27.4	61.5	19.9	73.3	I/B
Sphenoclea zeylanica	chickenspike	0.8	2.5											F
Sporobolus sp.	dropseed	1.1	7.5											B/S
Symphyotrichum subulatum	eastern annual saltmarsh aster	2.8	27.5			1.4	20.0	5.4	15.0	1.7	25.6			I
Symphyotrichum tenuifolium	perennial saltmarsh aster	3.2	35.0	2.4	40.0			3.6	17.5					I/B
Symphyotrichum sp.	aster											0.2	10.0	*
Thelypteris noveboracensis	New York fern					0.7				1.5	10.3			*
Thelypteris palustris	eastern marsh fern	1.7	10.0	0.1	2.5	0.3	7.5	1.2	10.0			3.4	16.7	F
Typha latifolia	broadleaf cattail			0.1	2.5					1.5	7.7	6.5	16.7	F
Typha sp.	cattail						2.5	0.6	5.0			0.1	3.3	F/I
Vigna luteola	hairypod cowpea	6.5	45.0			8.2	40.0	0.3	12.5	7.1	35.9	11.7	43.3	I
Zizaniopsis miliacea	giant cutgrass					0.1	2.5							F

* Habitat not defined