Documentation in Support of Category 4e

Waterbody/Watershed Identification

Organization	Florida Paper and Pulp Association	
Point of Contact	Tony Greco Nutter & Associates, Inc. 360 Hawthorne Ln. Athens, GA 30606 tgreco@nutterinc.com (706) 354-7925	Ron Stewart Executive Direction, FPPAEA 1168 Kilkenny Ln. Ormond Beach, FL 32174 rstewart@fppaea.org (813) 215-8856
Waterbody(s)	462A – Perdido River (South Marine) 797 – Perdido Bay (Upper Segment)	
No. Waterbody / Pollutant Combinations	2 waterbody segments verified impaired for: 462A Nutrients (Chlorophyll-a) 797 Nutrients (Chlorophyll-a) On the Group 5 Cycle 3 Verified List	

Description of Baseline Conditions

Watershed(s)	Perdido River (South Marine) WBID 462A – Perdido/Perdido River (WBID462) Perdido Bay (Upper Segment) WBID 797 – Perdido/Perdido Bay (WBID797)
Baseline Data	Run 54, 2018 (Verification Period: 1/1/2010 – 6/30/2017) **462A** - Nutrients (Chlorophyll-a) – ENRK2 Criterion: no more than 10% of samples shall exceed 11.5 µg/L • Six (6) total stations (four (4) geographically unique stations) with Chlorophyll-a data: 21FLPNS 33010006, 21FLPNS 3301462A3, 21FLPNS 3301A462A2, 21FLPNS G5NW0016, 21FLPNS G5NW0017, 21FLPNS G5NW0018, 21FLPNS G5NW0070 • Number of exceedances/Total samples = 8/31 (26% exceedance rate) **797** - Nutrients (Chlorophyll-a) – ENRK2 Criterion: no more than 10% of samples shall exceed 11.5 µg/L • Eleven (11) total stations with Chlorophyll-a data: 21AWIC 755, 21AWIC 761, 21AWIC 762, 21FLPNS 330100A1, 21FLPNS 330100A4, 21FLPNS 330100A5, 21FLPNS 330100A7, 21FLPNS 330100C6, 21FLPNS 330100D4, 21FLPNS 33010A10, 21FLPNS 33010C14 • Number of exceedances/Total samples = 15/44 (34% exceedance rate)
Map	See Figure 1

Evidence of Watershed Approach

Area of Effort	WBIDs 462A and 797 are located near the confluence of the Perdido River and Perdido Bay in Escambia County, Florida. The Florida-Alabama state boundary bisects the River and Bay such that areas generally north and east of the state boundary are considered Florida waters. The Perdido River drains an approximately 1,165 square mile watershed with approximately 30% of the total drainage area occurring in Florida. Both WBIDs are tidally influenced and classified as Class III – predominantly marine waterbodies, although salinities can fluctuate widely depending on river flow. See Figure 2.
Key Stakeholders Involved and Their Roles	International Paper and Emerald Coast Utility Authority (ECUA) – management of Combined Effluent Distribution Project, water quality monitoring, NPDES permit compliance
Watershed Plan & Other Supporting Documentation	Watershed drainage to WBIDs 462A and 797 primarily occurs from the Perdido River HUC8 watershed (HUC03140106) with other prominent drainage, including Elevenmile Creek and Bayou Marcus, originating from northern portions of the Perdido Bay HUC8 watershed (HUC03140107) (Figures 2 and 3). Both WBID 462A and 797 are impaired for Nutrients (Chlorophyll-a) based on the number of exceedances for the sample size. International Paper and ECUA implemented an effluent redistribution project between 2010 and 2012, which resulted in 100% effluent discharge removal from Elevenmile Creek and redistribution to an approximately 1,400-acre receiving wetland adjacent to WBIDs 462A and 797 by November 2012. Approximately 28.5 MGD of treated effluent from the two facilities is authorized to be discharged to the wetland tract under NPDES Permit No. FL0002526-008-IWIS/NR (Figure 3). The primary objective of the project was to reduce nutrient loading to Perdido Bay. In addition to the watershed improvement project identified above, the Northwest Florida Water Management District developed the *Perdido River and Bay Surface Water Improvement and Management Plan* (Program Development Series 17-07, October 2017) which is targeted to "provide a framework for resource management, protection and restoration using a watershed approach". Fifteen (15) watershed management projects were recommended in the plan to meet the identified objectives.
Point Sources and Indirect Source Monitoring (Sites)	Three prominent NPDES permittees discharge directly to or near the subject WBIDs: 1. International Paper (NPDES Permit No. FL0002526-008-IWIS/NR) – average annual flow = 23.5 MGD 2. ECUA Central Water Reclamation Facility (NPDES Permit No. FL0002526-008-IWIS/NR) – average annual flow = 5.0 MGD 3. ECUA Bayou Marcus Water Reclamation Facility (NPDES Permit No. FLL05G596) – average annual flow = 8.2 MGD All land areas within the State of Florida surrounding the two WBIDs are regulated by a Municipal Separate Storm Sewer System (MS4) permit – NPDES MS4 Permit No. FLS000019, Permittee = Escambia County. The most current MS4 permit was issued on July 10, 2017 and expires on July 9, 2022 (http://agenda.myescambia.com/docs/2018/REGBCC/20180201_4009/13542_13130_Escambia_FINAL_C4_Permit.pdf)

	Note: Generic Permits for stormwater discharge from large and small construction activities are considered temporary; therefore, are not included in this listing.
Nonpoint Sources	2012-2013 Land Use and Land Cover within the Perdido River and Bay Watershed (NWFWMD, 2017). FLUCCS land use data was not provided due to the large portion of the watershed occurring within Alabama. Land Use Category / Square Miles in HUC8 / Percentage of HUC8: Agriculture / 256 / 22% Developed / 128 / 11% Open Land / 12 / 1% Upland Forest / 501 / 43% Water / 12 / 1% Wetlands / 256 / 22% Based upon watershed land use characteristics and watershed observations, the two most prominent non-point sources of pollution are likely associated with agricultural lands in Florida and Alabama and associated nutrient loading as well as stormwater runoff from rapidly developing areas west of Pensacola, Florida in the Elevenmile Creek and Bayou Marcus watersheds.
Water Quality Criteria	It is expected that Class-III water quality standards for Chlorophyll-a will be attained upon implementation of the specified watershed improvement projects. Preliminary data analysis indicates that Chlorophyll-a concentrations within the WBIDs are decreasing with observed compliance with the respective WBID criteria during monitoring years 2015, 2016, and 2017.
Restoration Work	International Paper and ECUA implemented an effluent redistribution project, which resulted in 100% effluent discharge removal from Elevenmile Creek and redistribution to an approximately 1,400-acre receiving wetland adjacent to WBIDs 462A and 797 in November 2012 (Figure 3). 100% effluent discharge to the receiving wetlands has been maintained since November 2012. NPDES required water quality monitoring indicates that an approximately 86% and 88% reduction in total nitrogen and total phosphorus concentrations, respectively, are achieved between the effluent discharge to the receiving wetlands and the marine receiving waters, which includes WBID 462A and 797. As described above, NPDES required monitoring conducted between 2012 and 2017 of the two receiving WBIDs (462A and 797) demonstrate that: 1. Total nitrogen and total phosphorus NNC criteria are being met for WBID 462A and 797 2. Chlorophyll-a concentrations within the two WBIDs have decreased since 2012 with observed compliance with the applicable criteria during 2015, 2016, and 2017 Any additional watershed improvement projects implemented by the NWFWMD associated with the *Perdido River and Bay Surface Water Improvement and Management Plan* (Program Development Series 17-07, October 2017) or Escambia County associated with the existing MS4 permit (FLS000019) will further act to improve water quality conditions within the WBIDs. A more detailed description and assessment of the Group 5 Cycle 3 IWR database and additional NPDES required monitoring is provided in Appendix B.

Critical Milestones/Monitoring

Anticipated Critical Milestone(s) and Completion Dates:	Combined Effluent Distribution Project: completed November 2012
Monitoring Component	Pursuant to NPDES Permit FL0002526-008-IWIS/NR, quarterly monitoring is conducted within the two WBIDs as well as in adjacent and upstream predominantly freshwater areas. The *Surface Water Monitoring Plan* (Nutter & Associates, 2014) which describes sampling methods and sample locations is included in Appendix C. Data will be reported to FDEP once per year via WIN. As described above, an average of 86% and 88% reduction in total nitrogen and total phosphorus concentrations, respectively, have been observed between the effluent inflow and outflow from the receiving wetlands during the 2013 – 2017 monitoring period. It is expected that similar nutrient concentration reductions will be observed into the future.

Other Key Dates

Estimated Delisting Date	The WBID is in the state's Group 5 Basin in the Northwest District. The next review and assessment cycle (cycle 4) is expected in 2022; at which time sufficient data will be acquired to fully assess the WBID, and if not impaired, DEP is expected to request the WBID be delisted from the federal 303(d) list (if applicable).

Financial Commitments

Estimated Implementation Cost	The total project cost to implement the Combined Effluent Distribution Project, including land acquisition (if applicable) was approximately $68,000,000, which included wastewater treatment plant upgrades, project design and engineering, construction of the 10-mile effluent conveyance pipeline, construction of the effluent distribution site, and baseline environmental monitoring. The estimated 20-year operation and maintenance cost for the Combined Effluent Distribution Project is approximately $4,000,000, which includes long-term monitoring, land management activities, and infrastructure maintenance. Other watershed improvement projects that may be implemented as a part of the NWFWMD *Perdido River and Bay Surface Water Improvement and Management Plan* (Program Development Series 17-07, October 2017) or Escambia County MS4 permit (FLS000019) are not detailed here as no specific projects have been identified.
Land Acquisition (if applicable)	**Funding Source:** Not-Applicable / No additional land acquisition proposed Total……………………………………………………………..**$ 0**
Design and Construction (if applicable)	**Funding Source:** Not-Applicable / design and construction is complete Total……………………………………………………………...$ **0**

References:

Appendix A. Figures
Appendix B. Comments and analysis for the proposed IWR assessment category revision of Perdido Bay, Upper Segment (WBID 797), March 30, 2018.
Appendix C. Surface Water Monitoring Plan (Nutter & Associates, Inc., 2014)

APPENDIX A

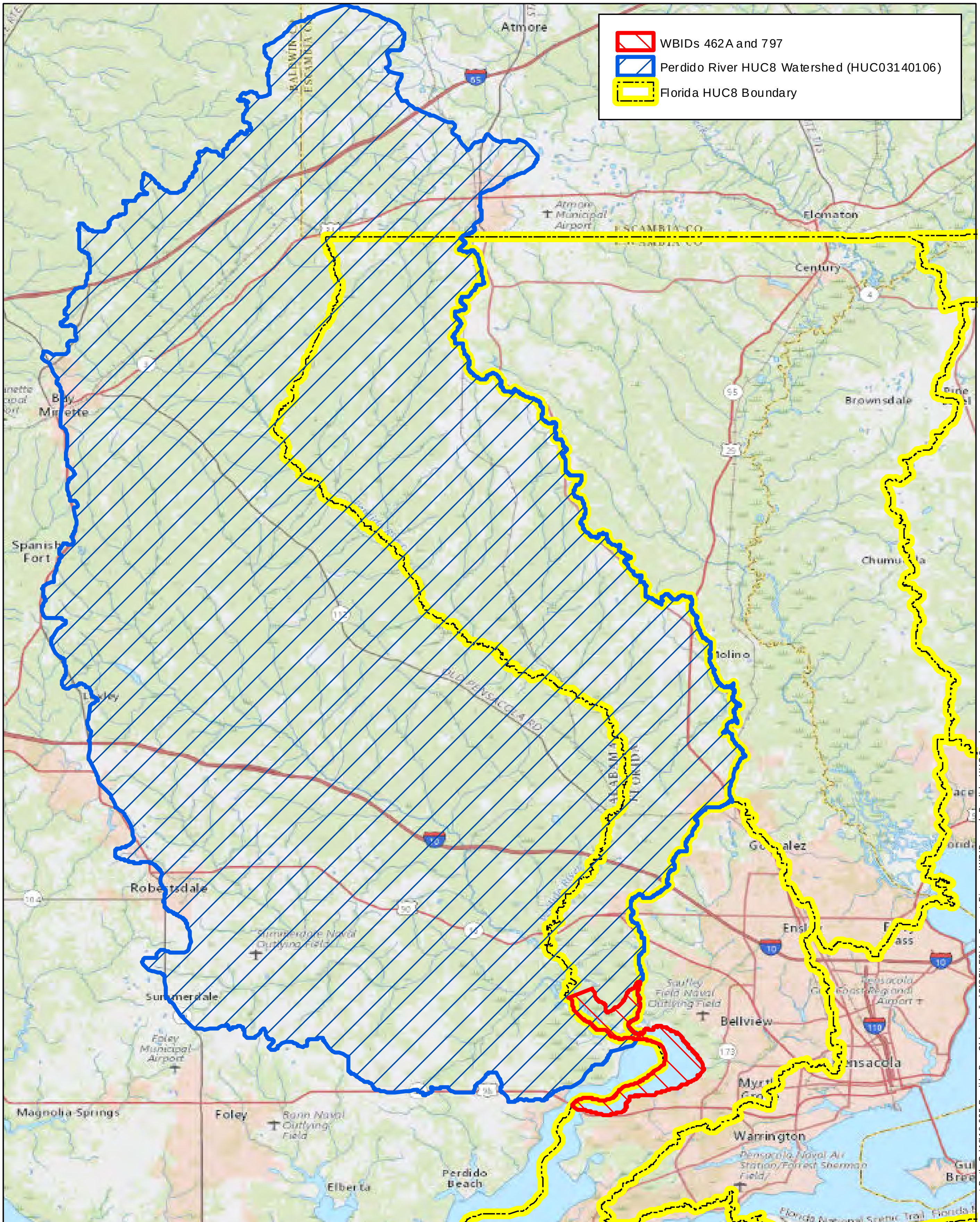
Figures

Data Source: FDEP, ESRI World Imagery

Document Path: G:\18\18-035 Perdido Bay Chlorophyll-a\GIS\FILES\4e_Report_Figures\WBIDs_and_IWR_Stations.mxd

Figure 1. WBID 462A and 797 boundaries and IWR Database stations.

Nutter & Associates
environmental consultants



Data Source: FDEP, ESRI USGS Topo, USDA Spatial Data Gateway

Document Path: G:\18\18-035 Perdido Bay Chlorophyll-a\GIS\FILES\4e_Report_Figures\WBIDs_and_Perdido_HUC8.mxd

Figure 2. WBID 462A and 797 location within the larger Perdido River HUC8 watershed.

0 3 6 12 Miles

1 in = 6 miles

N

Nutter & Associates
environmental consultants

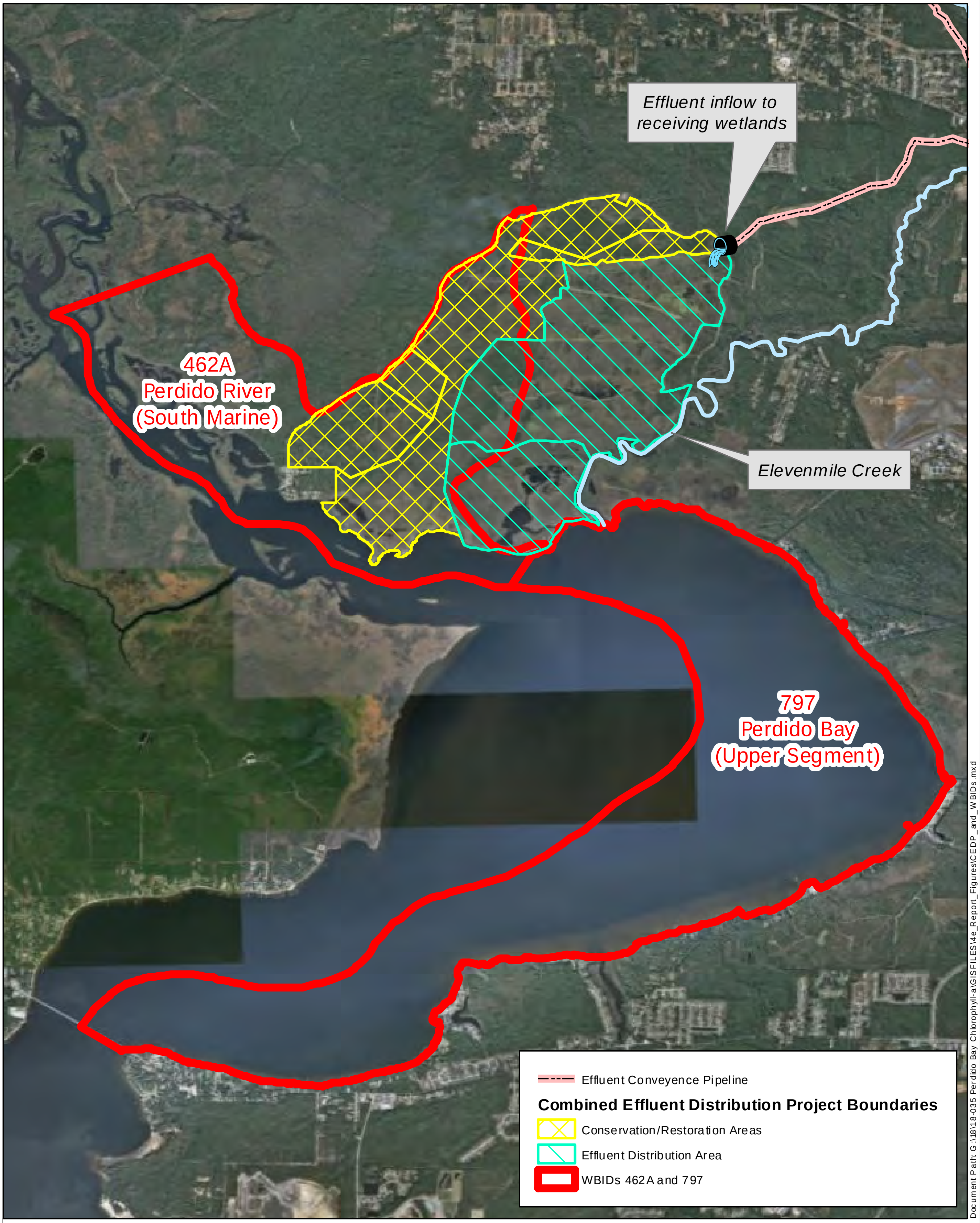


Figure 3. Combined Effluent Distribution Project location and proximity to WBID 462A and 797 boundaries.

Nutter & Associates
environmental consultants

APPENDIX B

Comments and analysis for the proposed IWR assessment category revision of Perdido Bay, Upper Segment (WBID 797), March 30, 2018.

COMMENTS AND ANALYSIS

for the proposed IWR assessment category revision of

PERDIDO BAY, UPPER SEGMENT (WBID 797)

Prepared for:

Florida Department of Environmental Protection

Watershed Assessment Section

Prepared by:

Nutter & Associates, Inc.

Athens, Georgia

March 30, 2018

INTRODUCTION

Pursuant to Florida Administrative Code (F.A.C.) 62-303, the Florida Department of Environmental Protection (FDEP) is proposing to revise the Assessment Category designation for Perdido Bay, Upper Segment (WBID 797) (herein referred to as Upper Perdido Bay) from an Assessment Category 3b designation to a 5 designation[1] as a part of the Impaired Waters assessment/303(d) listing process for Nutrients (Chlorophyll-*a*). The Upper Perdido Bay is classified as a predominantly marine Class III waterbody included in the Cycle 3, Group 5 assessment period study group with a 3M[2] waterbody classification. As established in F.A.C. 62-302.532, Numeric Nutrient Criteria (NNC) have been developed for Perdido Bay and are summarized in Table 1 below.

Table 1. Upper Perdido Bay Numeric Nutrient Criteria (F.A.C. 62-392.532)

(k) Perdido Bay	Criteria expressed as annual geometric means (AGM) are not to be exceeded more than once in a three year period. For all other bay segments, the criteria shall not be exceeded in more than 10 percent of the measurements and shall be assessed over the most recent seven year period. Nutrient and nutrient response values do not apply to tidally influenced areas that fluctuate between predominantly marine and predominantly fresh waters during typical climatic and hydrologic conditions.		
Estuary Segment	Total Phosphorus	Total Nitrogen	Chlorophyll-*a*
Big Lagoon	0.036 mg/L as AGM	0.61 mg/L as AGM	6.4 µg/L
Upper Perdido Bay	0.102 mg/L	1.27 mg/L	11.5 µg/L
Central Perdido Bay	0.103 mg/L	0.97 mg/L	7.5 µg/L
Lower Perdido Bay	0.110 mg/L	0.78 mg/L	6.9 µg/L

Based upon review of Estuary Nutrient Region (ENR) Impaired Waters Rule (IWR) Run 54 summary statistics, 15 of the 44 (34% exceedance rate) Verification Period (1/1/2010 – 6/30/2017) Chlorophyll-*a* sample results exceeded the Upper Perdido Bay 11.5 µg/L Chlorophyll-*a* NNC. Additionally, a 23% Chlorophyll-*a* exceedance rate (29 of 129 samples exceeded the NNC) was observed during the Planning Period (1/1/2005 – 12/31/2014).

The purpose of this report is to provide comment regarding the FDEP proposed revision to the Assessment Category designation for Upper Perdido Bay for Nutrients (Chlorophyll-*a*). This report provides an evaluation of existing IWR Run 54 data, supplemental data collected in Upper Perdido Bay between 2012 and 2017, and preliminary statistical analyses in support of the comments provided herein. In an attempt to maintain brevity, this analysis focuses primarily on the evaluation of

[1] EPA's Integrated Report Category:

3b – Some data and information are present but not enough to determine if any designated use is attained.

5 - Water quality standards are not attained and a TMDL is required.

[2] 3M waterbody classification – recreation, propagation, and maintenance of a health, well-balanced population of fish and wildlife in marine water.

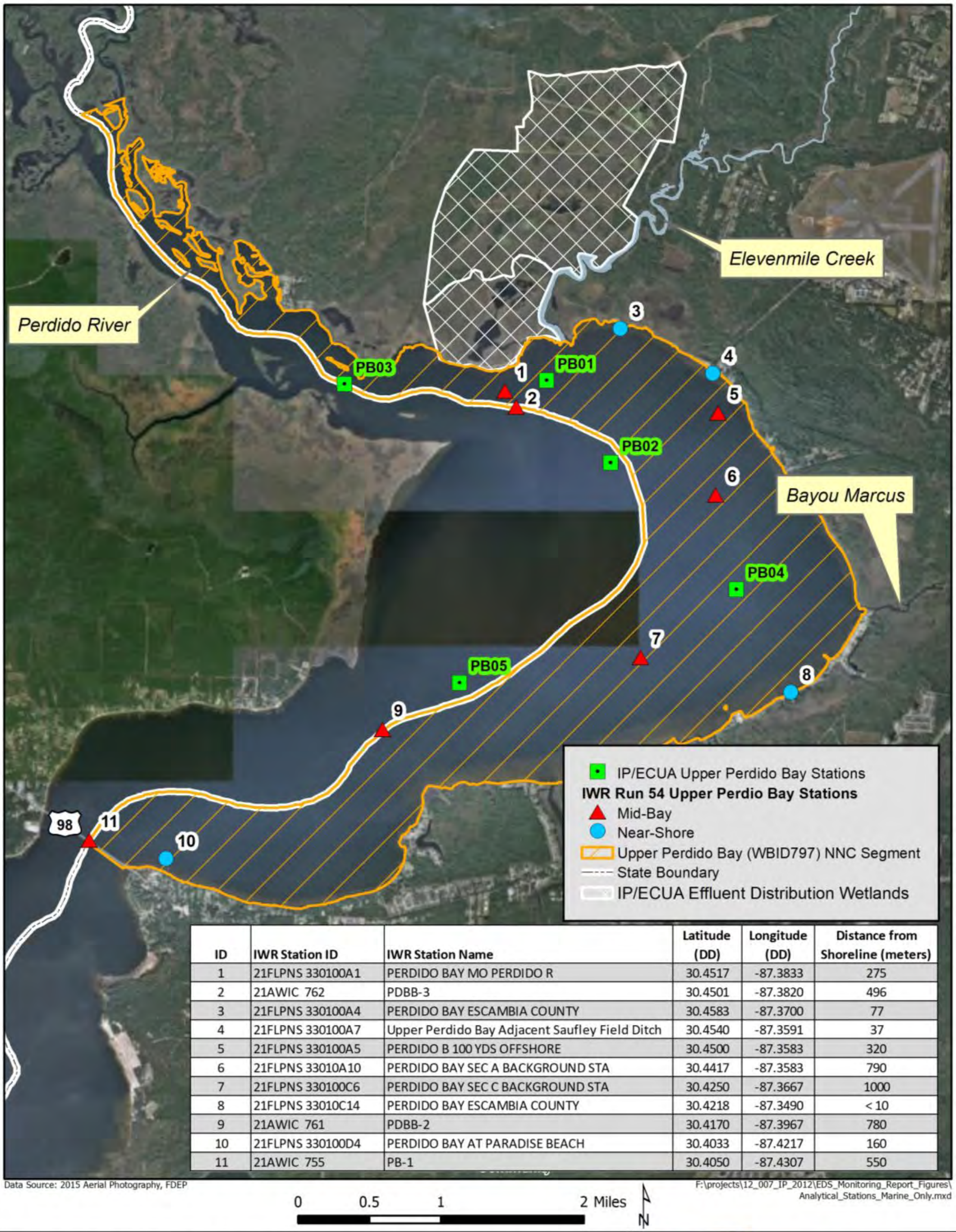
Chlorophyll-*a* and relationships with total nitrogen and total phosphorus. It is acknowledged that general water quality, including Chlorophyll-*a* dynamics within Upper Perdido Bay are likely correlated with numerous environmental variables. It is the authors' opinion that the listing of the Upper Perdido Bay (WBID 797) as a verified impaired waterbody is not supported by data included in the IWR Database or by additional Verification Period water quality data not considered by FDEP in the listing process. As is described in subsequent report sections, this opinion was based upon review of the IWR 54 Database water quality data, additional water quality data collected from within the waterbody, and technical support documentation and scientific literature specific to the waterbody and/or NNC criteria development published by FDEP.

WATERBODY DESCRIPTION

The Upper Perdido Bay waterbody area (WBID 797) is bound to the west by the Florida-Alabama state boundary and spans between the lower portions of the Perdido River and the U.S. Highway 98 crossing of the Bay (Figures 1 and 2).

Watershed Description

The 1,165 square mile Perdido River (HUC 03140106) and Bay (HUC03140107) watershed drains predominantly upland forested (43%), agricultural (22%), and wetland (22%) lands of Florida and Alabama, with approximately 30% of the total drainage area occurring in Florida (NWFWMD, 2017). Within the watershed, five NPDES publicly owned treatment works (POTW) and two NPDES industrial dischargers were identified from U.S. Environmental Protection Agency geodatabases. Many additional facilities identified as a NPDES-minor discharger and/or a NPDES stormwater permittee were identified during the records search but were not presented in Figure 2, due to the large number, and relative insignificance of these discharges on Perdido Bay. Three facilities discharge in close proximity to Upper Perdido Bay and include International Paper (annual average daily flow = 23.8 MGD), the Emerald Coast Utility Authority (ECUA) Central Water Reclamation Facility (WRF) (annual average daily flow = 5 MGD), and the ECUA Bayou Marcus WRF (annual average daily flow = 8.2 MGD) (Figure 2).



ID	IWR Station ID	IWR Station Name	Latitude (DD)	Longitude (DD)	Distance from Shoreline (meters)
1	21FLPNS 330100A1	PERDIDO BAY MO PERDIDO R	30.4517	-87.3833	275
2	21AWIC 762	PDBB-3	30.4501	-87.3820	496
3	21FLPNS 330100A4	PERDIDO BAY ESCAMBIA COUNTY	30.4583	-87.3700	77
4	21FLPNS 330100A7	Upper Perdido Bay Adjacent Saufley Field Ditch	30.4540	-87.3591	37
5	21FLPNS 330100A5	PERDIDO B 100 YDS OFFSHORE	30.4500	-87.3583	320
6	21FLPNS 33010A10	PERDIDO BAY SEC A BACKGROUND STA	30.4417	-87.3583	790
7	21FLPNS 330100C6	PERDIDO BAY SEC C BACKGROUND STA	30.4250	-87.3667	1000
8	21FLPNS 33010C14	PERDIDO BAY ESCAMBIA COUNTY	30.4218	-87.3490	< 10
9	21AWIC 761	PDBB-2	30.4170	-87.3967	780
10	21FLPNS 330100D4	PERDIDO BAY AT PARADISE BEACH	30.4033	-87.4217	160
11	21AWIC 755	PB-1	30.4050	-87.4307	550

Figure 1. Location of IWR Run 54 and International Paper water quality monitoring stations within the Upper Perdido Bay NNC segment (WBID797).

Nutter & Associates
environmental consultants

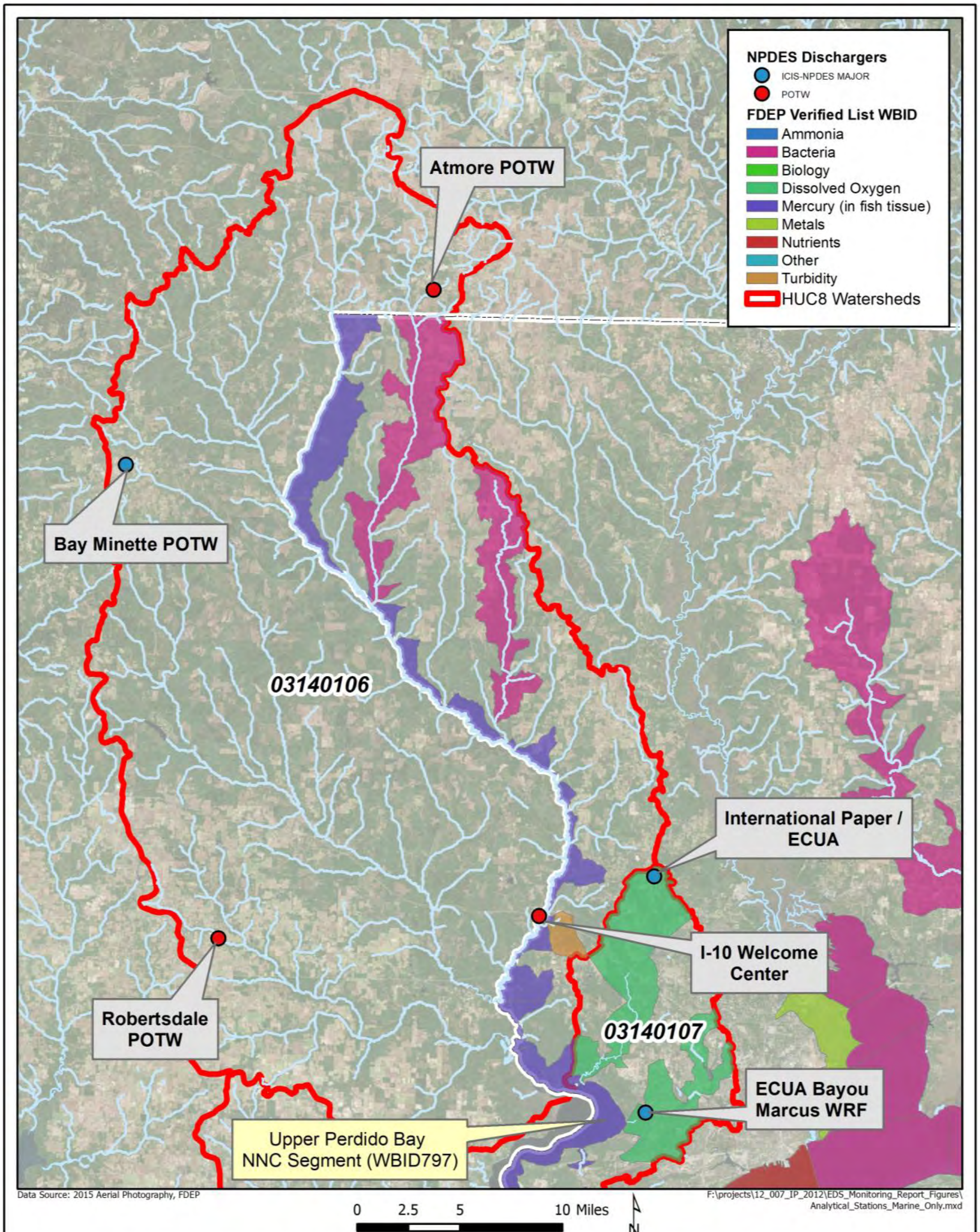


Figure 2. Upper Perdido Bay watershed overview, FDEP Verified List impaired waters, and prominant point-source discharges.

Nutter & Associates environmental consultants

Hydrologic and Water Quality Dynamics in Upper Perdido Bay

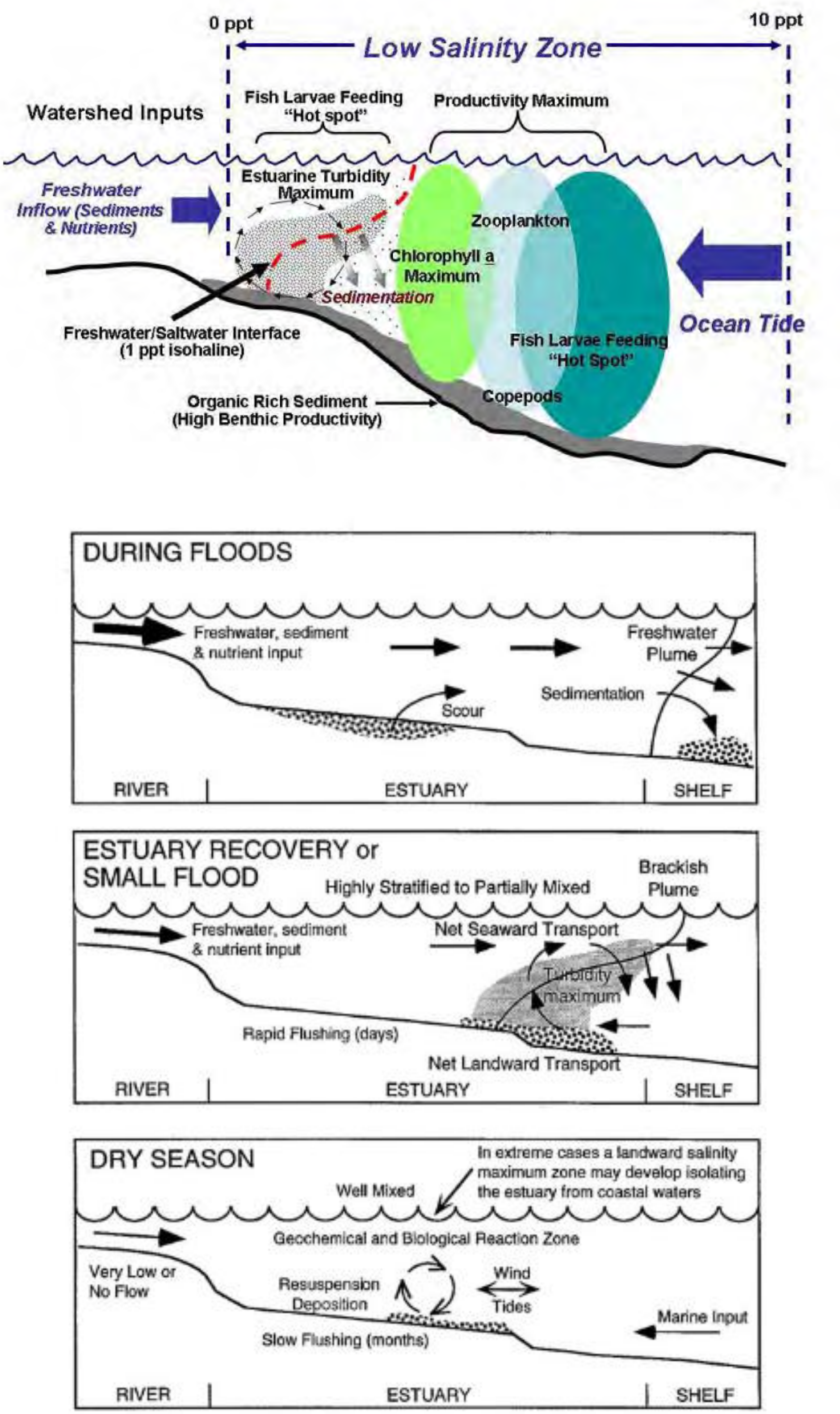
The spatial orientation of Perdido Bay, which is long and narrow, results in a dynamic hydrologic regime that can oscillate between riverine and marine dominated hydrology, depending on climatic conditions. This is especially true for the upper portions of Perdido Bay, which are the furthest from the Gulf of Mexico and have substantial riverine inputs, including the Perdido River and Elevenmile Creek. The magnitude of freshwater inflows influences Upper Perdido Bay water quality conditions, with the most notable being a negative correlation between freshwater discharge and salinity and specific conductivity. Given the landscape setting, water column stratification is almost always prevalent in Upper Perdido Bay with freshwater inflows typically having a larger influence in the upper portion of the water column throughout the Perdido Bay (Orlando et al., 1993).

Seasonal scale oscillations in water elevations are common within the Upper Perdido Bay and are primarily influenced by the magnitude of fresh water inflows, along with wind direction and magnitude. Astronomical tides are not a dominant factor in Gulf of Mexico Bays, and seasonal water elevation oscillations are largely driven by meteorological forcing, specifically seasonal differences in wind direction (Orlando, et al., 1993). The variation in seasonal water elevations in the Gulf of Mexico has been described as bimodal, with higher elevations in spring and fall, and low elevations in winter and summer, with the winter minimum and fall maximum predominating (Chew, 1964). The larger declines in water elevations in the winter are driven by north winds that are created by continental high pressure systems and the passage of cold fronts in October through March, whereas fall highs are the result of the peak of warm gulf waters and subsequent increases in south winds (Orlando et al., 1993). Ultimately, and depending on freshwater inflows from the Perdido River, the tidal oscillations not only impact water levels, but can also impact water quality and specifically, salinities of the Upper Perdido Bay. Sustained northern winds and forcing of marine waters south can sharply reduce Gulf estuary salinities and water elevations while southerly winds can result in increases in salinities and water elevations (Orlando et al., 1993). Therefore, during a year with average rainfall, it would be expected that lower salinities because of elevated freshwater influences during the winter low elevations would predominate in the Upper Bay with higher salinities expected during the late summer and early fall.

While seasonal trends are evident in the data record, the Upper Perdido Bay can exhibit episodic hydrologic variability that results in deviations from "typical" seasonal trends. Sources of this variability include tropical low-pressure systems that typically form annually between June and November, high intensity, short duration warm season convective storm systems, drought, and tidal oscillations.

The high degree of seasonal and episodic variability and location within a large freshwater/marine water mixing zone influences water quality and biological characteristics. As depicted in Figure 3, a variety of biogeochemical transformations occur within estuarine mixing zones which may be expected to exhibit higher nutrient and Chlorophyll-*a* levels in comparison to higher salinity open water areas (Eyre, 1998; FDEP, 2012). These conditions also result in the support of important ecological functions, including providing nursery areas for aquatic species, an abundance of food sources, and protection from marine predators (FDEP, 2012).

Figure 3. Freshwater and marine water mixing zone schematic and relationships between biogeochemical processes and aquatic communities (FDEP, 2012; Eyre, 1998).



IWR Verification Period Conditions

In addition to the naturally high variability in hydrologic and water quality drivers that influence the Upper Perdido Bay, another significant anthropogenic modification occurred during the Verification Period. In 2012, International Paper (IP) and ECUA, as authorized under NPDES Permit FL0002526-008-IWIS/NR, began redistributing an annual average daily effluent flow of 28.8 MGD (23.8 MGD from IP and 5.0 MGD from ECUA) from Elevenmile Creek, a tributary to Upper Perdido Bay, to an approximately 1,400-acre receiving wetland tract adjacent to Upper Perdido Bay and Elevenmile Creek in efforts to reduce nutrient loading and associated harmful *Heterosigma akashiwo* algal blooms in the Bay (Livingston, 2007; FDEP, 2012) (Figures 1 and 2). Over the course of 2012, effluent flow was incrementally redistributed to the receiving wetlands at a rate of approximately 25% of the effluent flow per quarter with 100% of the effluent discharge to the receiving wetlands occurring by October 2012. Since October 2012, 100% of the total effluent flow has been maintained to the receiving wetlands.

While the overall hydrologic loading to Upper Perdido Bay was mostly unchanged, the hydrologic timing and nutrient loading associated with the effluent discharge has been altered based upon water quality data collection conducted in conjunction with the IP/ECUA effluent redistribution project. The overarching goal of the project was to reduce nutrient loading to Upper Perdido Bay, which was demonstrated to be correlated with harmful algal blooms (FDEP, 2012). Based upon results of long-term monitoring of the receiving wetland, total nitrogen and total phosphorus concentrations were shown to decrease by 86% and 88%, respectively, in 2017 between the effluent inflow to the receiving wetlands and the tidal receiving waters (NAI, 2018). Similar reductions in nutrient concentrations were also observed during the 2013 through 2016 monitoring periods (NAI, 2018).

As a result of the project, the IWR Verification Period was characterized by three distinct anthropogenically-influenced hydrologic and water quality loading conditions: 1) 100% IP effluent flow to Elevenmile Creek (1/1/2010 through 12/31/2011), 2) IP effluent redistribution transitional period (1/1/2012 through 10/31/2012), and 100% IP/ECUA effluent flow to the receiving wetlands (11/1/2012 through 6/30/2017). As a part of the IP/ECUA effluent redistribution project, a comprehensive monitoring program was implemented in 2012 that included quarterly water quality monitoring within Upper Perdido Bay (Figure 1).

WATER QUALITY DATA EVALUATION

IWR Water Quality Dataset

Based upon review of output statistics from the IWR Run 54 database, a total of 796 unique sample events collected from eleven stations were available within the Upper Perdido BAY WBID area beginning in 2005 (Figure 1). During the Planning (1/1/2005 – 12/31/2014) and Verification (1/1/2010 – 6/30/2017) Periods, 472 and 324 samples events were conducted, respectively. Of the samples collected during the Planning and Verification Periods, 135 and 44 sample events, respectively, contained Chlorophyll-*a* data results with a total of 163 Chlorophyll-*a* data results available (Table 2).

Table 2. Number of FDEP IWR Run 54 Chlorophyll-*a* results by station location and sampling period.

Station Location	**All Years (2005-2017)**	**Planning Period (1/1/2005 – 12/31/2014)**	**Verification Period (1/1/2010 – 6/30/2017)**
All Locations	163	135	44
Near-Shore Stations	134	118	32
Mid-Bay Stations	29	17	12

It should be noted that seven of the sample results included in the IWR Run 54 dataset appear to contain QA/QC verification errors. During these events which occurred during 2005 and 2006 monitoring, reported temperatures ranged between 40.14 ^{o}C and 58.6 ^{o}C and dissolved oxygen percent saturations ranged between 185.6 % and 225.7%. Correspondingly, five of these sample results contained Chlorophyll-*a* concentrations that exceeded the 11.5 µg/L NNC threshold for Upper Perdido Bay, and two samples had Chlorophyll-*a* concentrations of 10 µg/L. While these samples were collected outside of the Verification Period, the apparent QA/QC issues suggest that these data results should be removed from the IWR Run 54 database unless further documentation can be provided to support the quality of the data results.

IWR Station and Data Result Suitability Assessment

Upon review of IWR station location attributes, it was determined that seven of the eleven stations sampled during the Planning and Verification Periods were located within the main Upper Perdido Bay body (i.e. at a distance greater than 160 meters from the shoreline; herein referred to as "Mid-Bay" stations), while the remaining four stations were located in close proximity to the shoreline (herein referred to as "Near-Shore" stations) (Table 3; Figures 1 and 4).

Table 3. Location of stations used in the IWR Run 54 NNC assessment of Upper Perdido Bay (WBID 797).

Station ID	Latitude (DD)	Longitude (DD)	Distance from Shoreline (meters)	Station Description
21AWIC 755	30.4050	-87.4307	550	Main Bay body approx. 6,600 meters from mouth of Perdido River; southern (downstream) extent of WBID
21AWIC 761	30.4170	-87.3967	780	Main Bay body approx. 3,800 meters from mouth of Perdido River
21AWIC 762	30.4501	-87.3820	496	Main Bay body near mouth of Perdido River; approx. 215 meters southeast of Station 21FLPNS 330100A1
21FLPNS 330100A1	30.4517	-87.3833	275	Main Bay body near mouth of Perdido River; approx. 215 meters northwest of Station 21AWIC 762
21FLPNS 330100A4	30.4583	-87.3700	77	Near shoreline approx. 585 meters east of mouth of Elevenmile Creek
21FLPNS 330100A5	30.4500	-87.3583	320	Main Bay body approx. 450 meters south of Station 21FLPNS 330100A7
21FLPNS 330100A7	30.4540	-87.3591	37	Near shoreline at mouth of “Saufley Field ditch”
21FLPNS 330100C6	30.4250	-87.3667	1,000	Main Bay body approx. 3,400 meters from mouth of Perdido River
21FLPNS 330100D4	30.4033	-87.4217	160	Near shoreline near southern (downstream) extent of WBID
21FLPNS 33010A10	30.4417	-87.3583	790	Main Bay body approx. 2,800 meters from mouth of Perdido River
21FLPNS 33010C14	30.4218	-87.3490	< 10	Near shoreline adjacent to S.R. 298 (Lillian Highway)

As described in FDEP’s *Overview of Approaches for Numeric Nutrient Criteria Development in Marine Waters – Draft* (2010), several considerations are provided regarding the suitability of any given sample station for NNC compliance assessments based upon spatial location, including avoidance of stations that do not represent the overall segment, stations that would be expected to have higher nutrient concentrations due to organic inputs (i.e. tidal marshes, tidal creeks, etc.), and stations located within the zone of freshwater-estuarine water mixing (i.e. river and stream mouths). A schematic extracted from the FDEP NNC development document is provided in Figure 3 to illustrate the spatial considerations described above.

Figure 3. FDEP schematic depicting theoretical estuarine sample station spatial locations and suitability considerations for NNC compliance evaluations (FDEP, 2010).

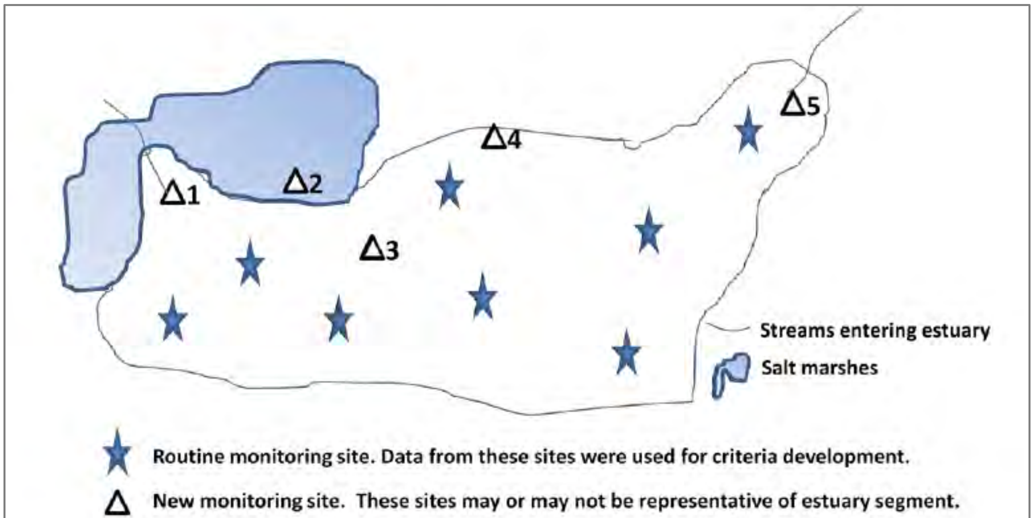


Figure 23. Schematic of a hypothetical estuary containing routine monitoring sites and proposed new monitoring sites

Based upon this evaluation and FDEP-developed considerations pursuant to the evaluation of NNC for any WBID, statistical analyses were conducted to compare the four Near-Shore stations to the seven Mid-Bay stations used in the IWR Run 54 data assessment. Based upon these analyses, it is the authors' opinion that these stations bias the final IWR assessment of Upper Perdido Bay given the higher frequency of sampling at these stations in comparison to Mid-Bay stations. Specific rationale for this assessment is provided below and with supporting information provided in Tables 4 and 5.

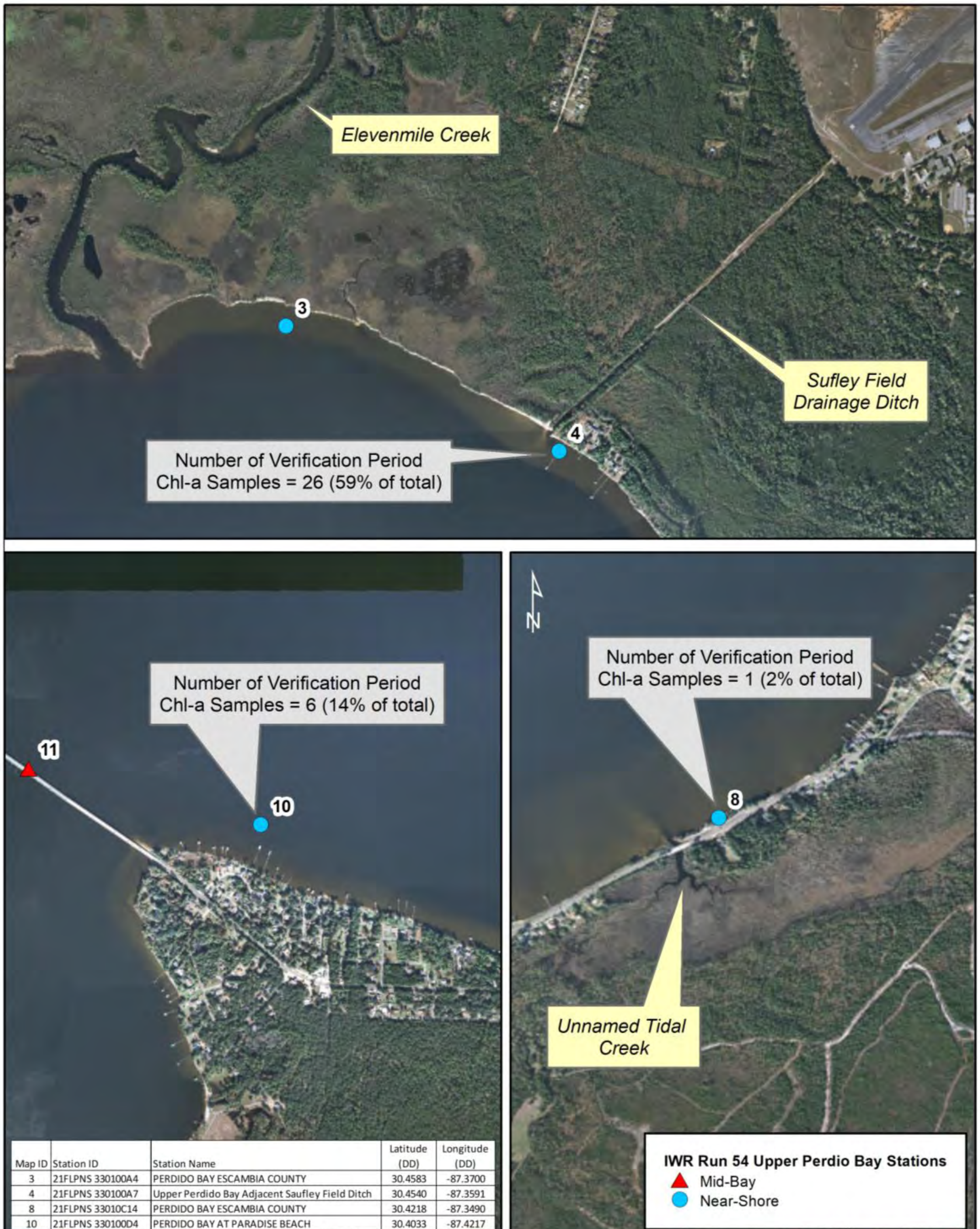
In an effort to demonstrate the potential bias imposed by inclusion of the Near-Shore sample data, a Wilcoxon-Mann Whitney test was utilized to compare the IWR Run 54 Chlorophyll-*a* concentrations reported during the combined Planning and Verification Periods between Near-Shore and Mid-Bay sample station groups (Figure 4). This non-parametric procedure tests the distributional similarity between two samples. Because the Near-Shore data do not follow any discernable distribution, parametric means tests are not appropriate. Because of the low sample size (n=12) of the IWR Mid-Bay data results and given that all Mid-Bay data were only collected during calendar year 2015, supplemental Mid-Bay data collected by IP/ECUA was incorporated into the Mid-Bay group. Based on this analysis, the distribution of the Near-Shore Chlorophyll-*a* data was skewed significantly higher than Mid-Bay data, resulting in more Near-Shore exceedances and a higher average Chlorophyll-*a* concentration (Tables 5 and 6).

Table 4. Upper Perdido Bay IWR Run 54 Near-Shore stations and potential reasons for NNC criteria assessment bias (see Figures 1 and 4 for spatial depiction of sample stations).

Station ID	Distance from Shoreline (meters)	Rationale for potential NNC assessment bias
21FLPNS 330100A4	77	Station is located close to the shoreline near extensive brackish water marsh areas and situated between the mouth of Elevenmile Creek and a small tidal creek.
21FLPNS 330100A7	37	Station is located close to the shoreline at the mouth of a man-made ditch that drains a small airfield located approximately 1,500 meters northeast of Perdido Bay.
21FLPNS 330100D4	160	Station is located close to the shoreline near a densely populated coastal residential area.
21FLPNS 33010C14	< 10	Station is located close to the shoreline adjacent to a prominent highway and near the mouth of a tidal creek that drains an extensive brackish water marsh area.

Table 5. Study and Verification Period Wilcoxon-Mann-Whitney comparison between Mid-Bay and Near-Shore IWR Run 54 data collected from the Upper Perdido Bay (WBID 797). Mid-Bay data includes IWR Run 54 and IP/ECUA supplemental data.

Wilcoxon-Mann-Whitney Statistic	Chlorophyll-*a* (2005-2017)	
	Mid-Bay	Near-Shore
Number of Valid Observations	136	135
Minimum	0.53	0.29
Maximum	66	80
Mean	7.04	11.27
Median	5.0	6.3
Std. Dev.	7.97	12.48
Std. Error of Mean	0.68	1.07
Sample 1 (Mid-Bay) Rank Sum W-Stat		15568
WMW U-Stat		6252
Standardized WMW U-Stat		-4.551
Mean (U)		9180
SD(U) - Adj ties		643.4
Lower Approximate U-Stat Critical Value (0.025)		-1.96
Upper Approximate U-Stat Critical Value (0.975)		1.96
P-Value (Adjusted for Ties)		0.0000053



Map ID	Station ID	Station Name	Latitude (DD)	Longitude (DD)
3	21FLPNS 330100A4	PERDIDO BAY ESCAMBIA COUNTY	30.4583	-87.3700
4	21FLPNS 330100A7	Upper Perdido Bay Adjacent Saufley Field Ditch	30.4540	-87.3591
8	21FLPNS 33010C14	PERDIDO BAY ESCAMBIA COUNTY	30.4218	-87.3490
10	21FLPNS 330100D4	PERDIDO BAY AT PARADISE BEACH	30.4033	-87.4217

Data Source: 2015 Aerial Photography, FDEP

F:\projects\12_007_IP_2012\EDS_Monitoring_Report_Figures\Analytical_Stations_Marine_Only.mxd

Figure 4. Location of Near-Shore IWR Run 54 water quality monitoring stations within Upper Perdido Bay.

Nutter & Associates
environmental consultants

Additionally, and if the Near-Shore stations are removed from the IWR Run 54 analysis for Upper Perdido Bay, only 29 total data records that include Chlorophyll-*a* data results exist for the Mid-Bay stations (Tables 2 and 6). Of these 29 data records, only 12 Chlorophyll-*a* records were collected during the Verification Period (Tables 2 and 6). As specified by F.A.C. 62-303.420, a minimum of twenty qualifying samples must be present to include a water on the Verified List. Based on the rationale provided above, a sufficient number of samples from the main body of the Upper Perdido Bay WBID have not been collected within the Verification Period to move the WBID from the Planning List to the Verified List.

As described above, the IWR Run 54 dataset includes data that preferentially biases water quality data collection toward Near-Shore locations instead of the main body of Upper Perdido. In total, two Mid-Bay and four Near-Shore stations were utilized to conduct the IWR assessment for Upper Perdido Bay (Table 6; Figures 1 and 4). During the Verification Period, 12 Chlorophyll-*a* samples were collected from Mid-Bay stations while 32 Chlorophyll-*a* samples were collected from Near-Shore sample stations (Tables 2 and 6). Further, 26 of the 44 total Chlorophyll-*a* samples collected during the Verification Period (59%) were collected from a single Near-Shore location at the mouth of a man-made ditch (21FLPNS 330100A7) (Table 6; Figures 1 and 4). Based upon data analysis conducted (see Tables 5 and 7), the sampling design has likely biased the long-term Verification Period Chlorophyll-*a* conditions higher, which has the potential to result in Type I error (incorrectly concluding that a system is impaired, when it is actually healthy) (FDEP, 2012).

Table 6. Number of Chlorophyll-*a* sample results by station and station location within Upper Perdido Bay (see Figures 1 and 4 for station locations).

Station ID	Location Category	No. of total Chl-*a* Samples	No. of Planning Period Chl-*a* Samples	No. of Verification Period Chl-*a* Samples	No. of Verification Period Chl-*a* NNC Exceedances
21AWIC 755	Mid-Bay	2	2	0	--
21AWIC 761	Mid-Bay	2	2	0	--
21AWIC 762	Mid-Bay	2	2	0	--
21FLPNS 330100A1	Mid-Bay	9	3	6	1
21FLPNS 330100A5	Mid-Bay	2	2	0	--
21FLPNS 330100C6	Mid-Bay	9	3	6	3
21FLPNS 33010A10	Mid-Bay	3	3	0	--
Total Mid-Bay		**29**	**17**	**12**	**4 (33%)**
21FLPNS 330100A4	Near-Shore	1	0	1	1
21FLPNS 330100A7	Near-Shore	26	16	26	13
21FLPNS 330100D4	Near-Shore	107	102	5	2
21FLPNS 33010C14	Near-Shore	0	0	0	0
Total Near-Shore		**134**	**118**	**32**	**16 (50%)**

IWR Water Quality Data Summary

To evaluate the comparability and potential water quality differences between the Near-Shore and Mid-Bay data results, summary statistics were calculated for the two groups for all water quality sample events that included Chlorophyll-*a* results during the Verification Period (Table 7). Based upon review of the summary statistics, the Near-Shore and Mid-Bay results differ in many notable ways that verify the validity of FDEP sample location considerations described above. Specifically, Chlorophyll-*a* geometric mean concentrations were 3.1 µg/L lower at the Mid-Bay stations (Geomean = 7.1 µg/L) in comparison to the Near-Shore (Geomean = 10.2 µg/L) sample locations with potential correlations with lower Near-Shore salinities and higher Near-Shore total suspended solids concentrations (Table 7). The exceedance rate of the Chlorophyll-*a* NNC of 11.5 µg/L also differed between Near-Shore and Mid-Bay stations with respective NNC exceedance rates of 50% and 33%, with 30% of the total IWR exceedances occurring at a single Near-Shore Station (21FLPNS 330100A7) (Table 6). No significant differences were evident between the groups with respect to total nitrogen or phosphorous concentrations (Table 7). Given that Chlorophyll-*a* shows significant dependence on location (Near-Shore vs. Mid-Bay), and nutrient concentrations do not significantly differ between these groups, it cannot be concluded that nutrient concentrations are driving Chlorophyll-*a* trends within the Upper Perdido Bay.

Table 7. Planning and Verification Period Summary statistics comparison between Near-Shore and Mid-Bay IWR Run 54 data for the Upper Perdido Bay (WBID 797).

Statistic	**Temp.**	**DO**	**Salinity**	**Sp. Cond.**	**Turbidity**	**Chl-*a***	**Total-N**	**Total-P**	**TSS**
	°C	% Sat.	ppt	µS/cm	NTU	µg/L	mg/L	mg/L	mg/L
Near-Shore IWR Run 54 Data – 1/1/2010 to 6/30/2017									
No. of Valid Samples	32	28	31	31	31	32	32	32	30
Minimum	11.7	51.1	0.1	120	1.7	0.58	0.36	0.00	2.0
Maximum	31.9	136.9	18.4	29,710	13	80	1.36	0.10	20
Mean	24.0	93.1	9.2	15,391	5.6	15.8	0.63	0.03	7.9
Standard deviation (n)	6.3	21.4	5.8	9,261	3.0	16.9	0.22	0.02	4.6
Geometric mean	23.1	90.4	5.9	10,103	4.8	10.2	0.60	0.02	6.7
Main Bay Body IWR Run 54 Data – 1/1/2010 to 6/30/2017									
No. of Valid Samples	12	12	12	12	12	12	12	12	12
Minimum	15.7	65.4	3.3	6,087	1.5	2.9	0.33	0.01	2.0
Maximum	29.8	108.5	17.5	28,442	7.1	20	0.69	0.03	8.0
Mean	24.7	96.0	8.0	13,610	3.3	8.8	0.57	0.02	4.3
Standard deviation (n)	4.8	13.5	4.6	7,282	1.5	5.6	0.09	0.01	2.0
Geometric mean	24.1	94.9	6.9	12,043	3.0	7.1	0.56	0.02	3.9

Supplemental Perdido Bay Water Quality Data Results

Pursuant to International Paper's NPDES Permit (FL0002526-008-IWIS/NR), quarterly water quality sampling has been conducted at three stations in 2012 and five stations between 2013 and 2018 within the main body of Upper Perdido Bay (Figure 1). A detailed summary of water quality methods and data results over the course of the monitoring period is provided annually to FDEP as required by the International Paper NPDES permit. A brief summary of the sampling methodologies and results are provided below to facilitate and justify the inclusion of the results in these comments. In order to provide a comparison to the IWR Run 54 dataset, only data collected during the Verification Period (1/1/2010 – 6/30/2017) was utilized in the assessment provided below.

All surface water quality monitoring was conducted in accordance with the most current DEP-SOP-001/01, FS 1000 General Sampling Procedures (SOP), FT 1000 General Field Testing and Measurement, FS 2000 General Aqueous Sampling, FS 2100 Surface Water Sampling, and specific SOPs related to pH (FT 1100), specific conductivity (FT1200), salinity (FT 1300), dissolved oxygen (FT 1500), and turbidity (FT 1600). Phytoplankton samples were collected in accordance with FDEP SOP FS7100. Quality control procedures followed guidelines outlined in DEP-SOP-001/01 FQ 1000 Field Quality Control Requirements. Additional QA/QC information can be provided at the request of FDEP.

Annual Chlorophyll-*a* geometric mean results ranged between 2.7 µg/L in 2016 and 7.2 µg/L in 2012 with a general observed decline in annual geometric means during the monitoring period (Table 8). An annual geometric mean was not calculated for 2017 because only a single sample event was conducted, but the geometric mean for this event was 1.7 µg/L (Table 8). During the five and a half year monitoring period (2012 – June 2017), 11 of the 91 Chlorophyll-*a* samples exceeded the NNC criteria, a 12% exceedance rate. While the entire data record indicates that Chlorophyll-*a* concentrations exceed the NNC, the observed exceedance rates of 10% in 2015 and 5% in 2016 suggest a long-term decreasing trend in Upper Perdido Bay Chlorophyll-*a* concentrations (Table 8). Additional trend analysis is provided in subsequent sections.

Table 8. International Paper Upper Perdido Bay station Chlorophyll-*a* concentrations and NNC compliance assessment during the Verification Period.

Year	Chlorophyll-a (µg/L)						
	Station	**PB01**	**PB02**	**PB03**	**PB04**	**PB05**	**Seasonal Geomean**
	NNC Criterion	11.5 µg/L (Upper Perdido Bay Segment 62-302.532)					
2012	Winter 2012	--	--	--	--	--	--
	Spring 2012	66.0	15.0	7.5	--	--	**19.5**
	Summer 2012	6.9	10.0	12.0	--	--	**9.4**
	Fall 2012	1.3	4.1	1.6	--	--	**2.0**
	Station Geo Mean	**8.4**	**8.5**	**5.2**	**--**	**--**	**--**
	Overall Chlorophyll-a Geomean 2012						**7.2**
	Number of Chlorophyll-a NNC Exceedances						**3**
	% of Sample Exceeding Chlorophyll-a NNC						**33%**
2013	Winter 2013	5.3	5.8	1.3	3.7	5.9	**3.9**
	Spring 2013	5.9	1.6	1.6	--	--	**2.5**
	Summer 2013	13.0	6.9	1.1	27.0	8.0	**7.3**
	Fall 2013	6.9	8.5	2.1	9.1	3.7	**5.3**
	Station Geo Mean	**7.3**	**4.8**	**1.5**	**9.7**	**5.6**	**--**
	Overall Chlorophyll-a Geomean 2013						**4.7**
	Number of Chlorophyll-a NNC Exceedances						**2**
	% of Sample Exceeding Chlorophyll-a NNC						**11%**
2014	Winter 2014	4.3	4.8	1.6	4.3	3.2	**3.4**
	Spring 2014	30.0	23.0	6.4	7.5	21.0	**14.7**
	Summer 2014	9.0	9.7	7.5	--	8.0	**8.5**
	Fall 2014	2.9	2.1	0.8	2.1	2.8	**2.0**
	Station Geo Mean	**7.6**	**6.9**	**2.8**	**4.1**	**6.2**	**--**
	Overall Chlorophyll-a Geomean 2014						**5.2**
	Number of Chlorophyll-a NNC Exceedances						**3**
	% of Sample Exceeding Chlorophyll-a NNC						**16%**
2015	Winter 2015	2.7	0.5	0.5	1.1	2.7	**1.2**
	Spring 2015	5.3	4.3	2.1	6.0	6.7	**4.5**
	Summer 2015	5.6	10.0	4.8	15.0	13.0	**8.8**
	Fall 2015	5.1	8.5	1.9	5.1	5.6	**4.7**
	Station Geo Mean	**4.5**	**3.7**	**1.8**	**4.7**	**6.0**	**--**
	Overall Chlorophyll-a Geomean 2015						**3.9**
	Number of Chlorophyll-a NNC Exceedances						**2**
	% of Sample Exceeding Chlorophyll-a NNC						**10%**
2016	Winter 2016	3.1	3.7	1.1	3.6	2.5	**2.6**
	Spring 2016	2.8	7.7	12.0	5.5	4.6	**5.8**
	Summer 2016	1.8	2.1	3.6	5.0	6.4	**3.4**
	Fall 2016	0.8	1.6	0.8	1.6	0.8	**1.1**
	Station Geo Mean	**1.9**	**3.1**	**2.5**	**3.5**	**2.8**	**--**
	Overall Chlorophyll-a Geomean 2016						**2.7**
	Number of Chlorophyll-a NNC Exceedances						**1**
	% of Sample Exceeding Chlorophyll-a NNC						**5%**
2017	Winter 2017	1.6	2.1	0.5	2.4	3.5	**1.7**
	Spring 2017[1]	No Data	No Data	No Data	No Data	No Data	--
	Station Geo Mean	**--**	**--**	**--**	**--**	**--**	**--**
	Overall Chlorophyll-a Geomean 2017						**--**
	Number of Chlorophyll-a NNC Exceedances						**0**
	% of Sample Exceeding Chlorophyll-a NNC						**0%**
2012-2017	**Total Number of Chlorophyll-a Samples**						**91**
	Number of Chlorophyll-a NNC Exceedances						**11**
	% of Samples Exceeding Chlorophyll-a NNC						**12%**

[1] Chlorophyll-*a* water quality data was not collected during Spring 2017 due to a tropical storm system that prevented boat-based sampling.

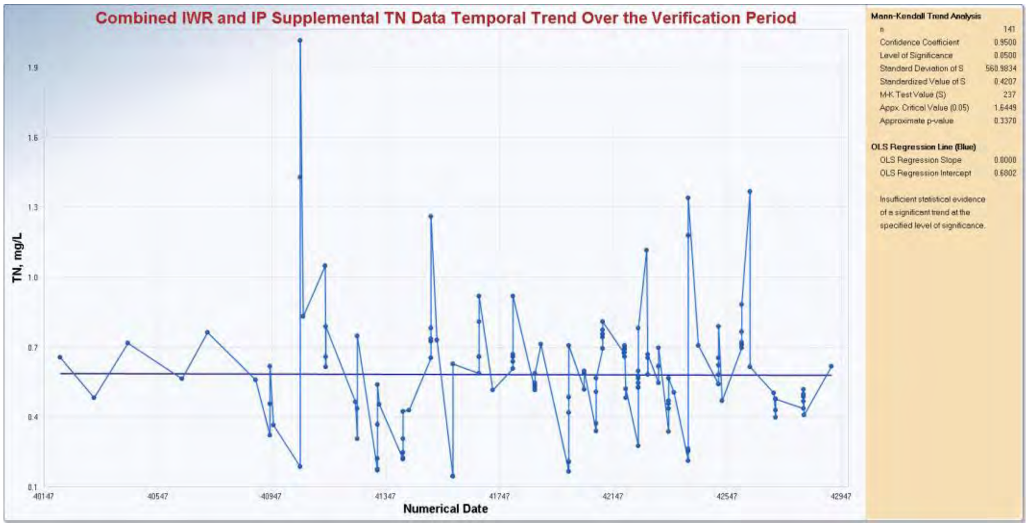
Upper Perdido Bay Statistical Evaluations of Chlorophyll-*a* and Nutrient Parameters

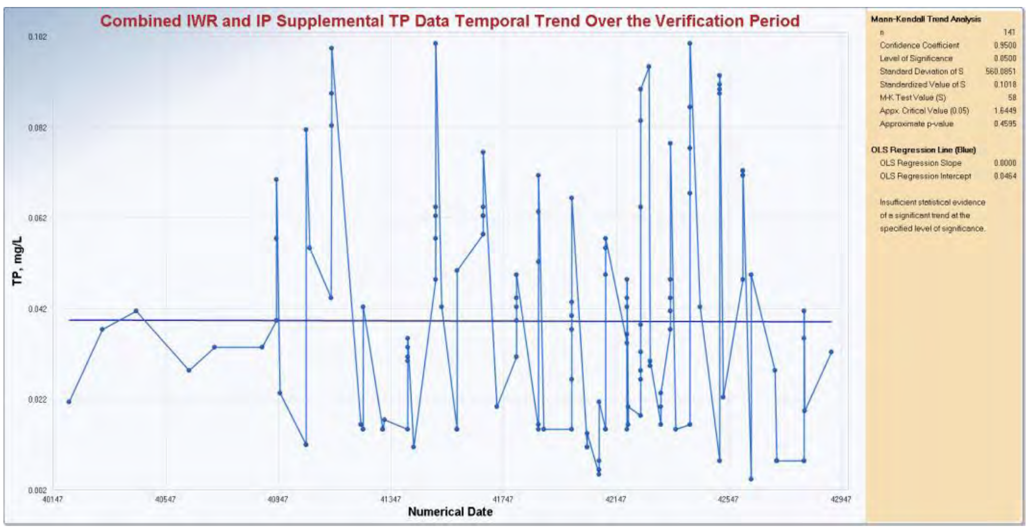
Kendall correlations and Mann-Kendall Trends analyses were performed on all Verification Period data including IWR Run 54 and IP supplemental data (N = 136) as these statistical methods were specifically cited in F.A.C. 62-303 to evaluate long-term water quality trends. Significant correlations and evidence of Mann-Kendall trends were determined at a calculated probability (p) < 0.05. Verification Period Chlorophyll-*a* concentrations had significant positive correlations with several factors including temperature, salinity, turbidity, total kjeldahl nitrogen (TKN), total nitrogen (TN), total phosphorus (TP), and total suspended solids (TSS), whereas there are significant negative correlations for date, depth, and nitrate+nitrite nitrogen (NO_3+NO_2) (Table 9). However, Chlorophyll-*a* does not exhibit a strong linear relationship with any of the significant correlating variables as determined by R^2 values, indicating a lack of evidence for a direct relationship with any one water quality variable (Table 9). While it is true that nutrients are often correlated with increased Chlorophyll-*a* concentrations, simple correlations do not explain temporal trends in Chlorophyll-*a*. Temporal increases in nutrients for the Upper Perdido Bay during the Verification Period are not supported by the data (Figure 5), and any notion that Chlorophyll-*a* has increased over the Verification Period is contradicted by the data (Figure 5). The results of the trend analyses suggest there is statistically significant evidence for a decreasing trend in Chlorophyll-*a* concentrations during the Verification Period for the combined IWR Run 54 and IP supplemental data, whereas there is insufficient statistical evidence for an increasing or decreasing temporal trend in TN or TP during the verification period (Figure 5).

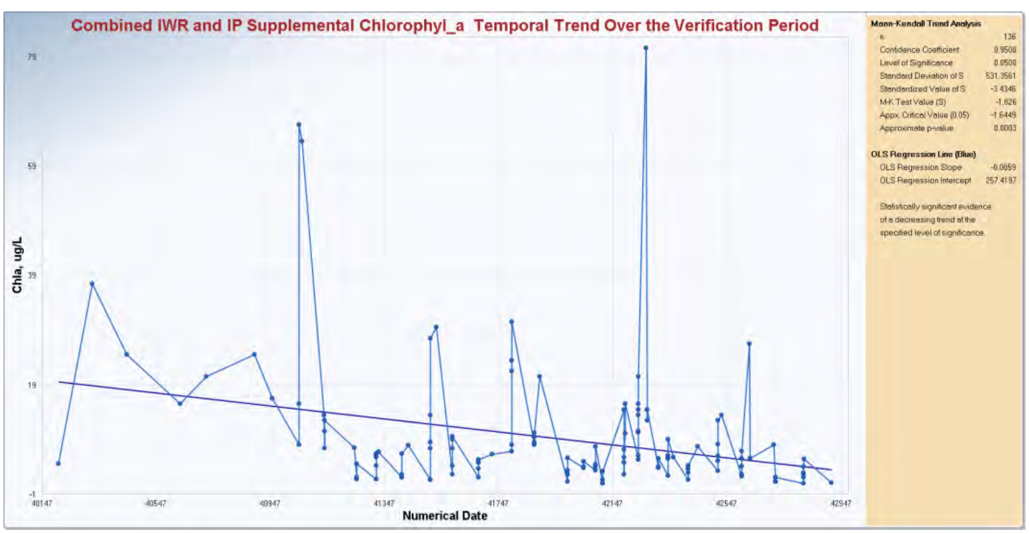
Table 9. Kendall Chlorophyll-*a* concentration correlation statistics for combined IWR and IP supplemental data collected over the Verification Period. Bolded values indicate significant correlations at p < 0.05.

Statistic	**Date**	**Temp.**	**DO**	**Sal.**	**Turb.**	**TKN**	**NO3+ NO2**	**TN**	**TP**	**TSS**	**NH$_4$**
		°C	% Sat.	ppt	NTU	mg/L					
Correlation Matrix	**-0.22**	**0.39**	0.10	**0.16**	**0.27**	**0.27**	**-0.34**	**0.15**	**0.16**	**0.15**	-0.05
P value	**<0.001**	**< 0.001**	0.096	**0.008**	**< 0.001**	**< 0.001**	**< 0.001**	**0.011**	**0.008**	**0.014**	0.434
R^2	0.050	0.151	0.010	0.027	0.073	0.071	0.117	0.022	0.024	0.023	0.002

Figure 5. Total nitrogen (TN), total phosphorus (TP), and Chlorophyll-a Mann-Kendall trend analysis for the combined IWR and IP datasets during the Verification Period. No significant trend was observed for TN or TP, while Chlorophyll-*a* concentrations showed a significant (p=0.0003) decreasing trend in concentration.







The combined IWR Run 54 and IP supplemental data that were above the exceedance threshold of 11.5 µg/L (N = 31), showed no significant positive correlations ($p < 0.05$) with any nutrient constituent collected at the time Chlorophyll-*a* exceedance samples were collected (Table 10). As expected, there was a significant positive correlation with temperature, and a somewhat positive correlation with TSS, although not statistically significant ($p = 0.07$). Exceedances of the Chlorophyll-*a* standard show a significant decreasing temporal trend over the Verification Period, indicating that the level of Chlorophyll-*a* exceedances has been decreasing in the Upper Perdido Bay since 2010 (Figure 5). The temporal trend in TSS for corresponding Chlorophyll-*a* exceedance data shows a significant decreasing trend, suggesting that TSS might be more predictive of Chlorophyll-*a* exceedances than total nitrogen or total phosphorus. TSS and Chlorophyll-*a* exceedance data were moderately correlated although not statistically significant ($p=0.066$) (Table 10).

Table 10. Kendall Chlorophyll-*a* correlation statistics for only Chlorophyll-*a* data results greater than 11.5 µg/L for the combined IWR and IP supplemental data collected over the Verification Period. Bolded values indicate significant correlations at $p < 0.05$.

Statistic	**Date**	**Temp.**	**DO**	**Sal.**	**Turb.**	**TKN**	**NO3+ NO2**	**TN**	**TP**	**TSS**	**NH_4**
		°C	% Sat.	ppt	NTU	mg/L					
Correlation Matrix	-0.29	0.05	-0.12	0.12	0.22	0.02	-0.05	0.11	0.07	0.25	-0.07
P value	**0.026**	0.707	0.386	0.403	0.125	0.891	0.719	0.400	0.608	0.066	0.605
R^2	0.086	0.003	0.014	0.014	0.050	0.000	0.002	0.012	0.005	0.060	0.005

The IP supplemental data could be considered more comprehensive and more indicative of the Bay body, as Chlorophyll-*a* and nutrient data have been collected quarterly since 2012 at five stations and at a significant distance away from the shoreline. In contrast, IWR Mid-Bay data was collected only during 2015 and from only two stations. Additional concerns with the IWR Run 54 data including the location of sampling stations near the shoreline have been discussed previously. Additionally, the IP supplemental data is somewhat better controlled for temperature and hydrological effects as data have been collected consistently between stations and seasons. The IP supplemental data indicates that Upper Perdido Bay Chlorophyll-*a* concentrations have been declining since 2012 as evidenced by a significant decreasing trend in all data points and in the annual geometric mean concentrations (Figure 6). The IP supplemental data annual exceedance percentages have dropped from 33% in 2012 to 5% in 2016, with an overall exceedance percentage of 12% during the Verification Period (Table 8). Accordingly, there is insufficient evidence of a significant decreasing or increasing trend in TN or TP concentrations over the Verification Period for the IP supplemental data. Further, TN and TP concentrations are consistently below Upper Perdido Bay NNC thresholds of 1.27 mg/L and 0.102 mg/L, respectively (Tables 11 and 12). During the Verification Period, a total of 107 total nitrogen and total phosphorus samples were collected as a part of the IP long-term monitoring program with a 3.7% and 0.0% observed NNC exceedance rate, respectively, demonstrating compliance with Upper Perdido Bay TN and TP NNC (Tables 11 and 12).

Figure 6. Chlorophyll-*a* annual geometric means from the five IP Upper Perdido Bay monitoring stations between 2012 and 2017. A significant (p=0.0301) decreasing trend in concentration was observed.

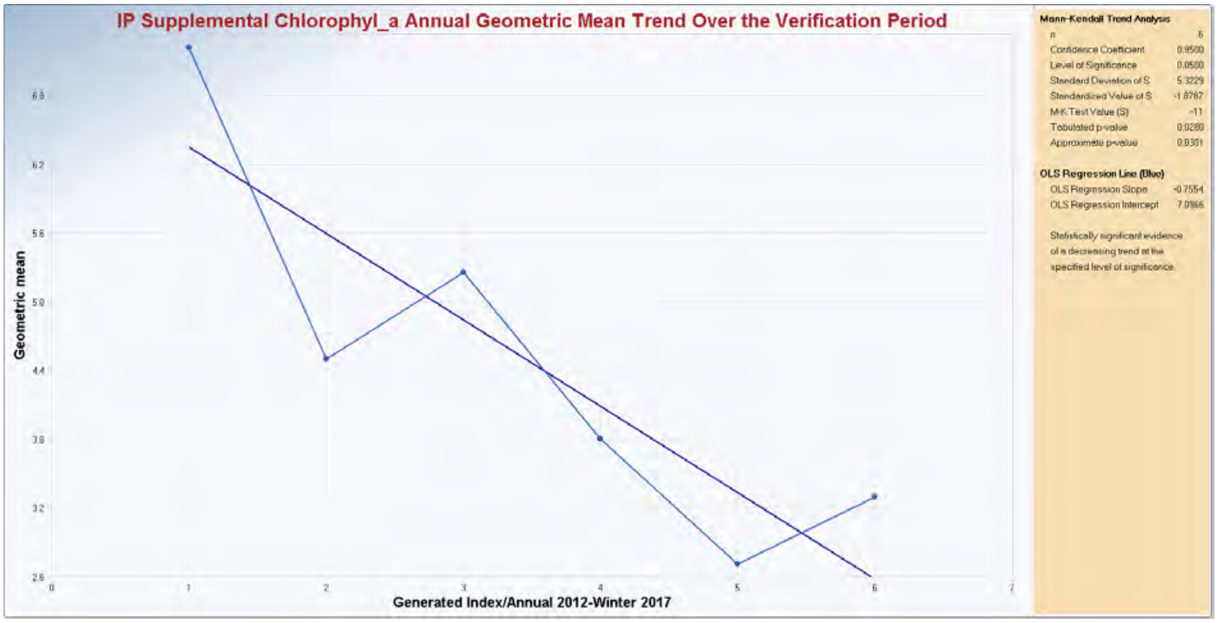


Table 11. International Paper Upper Perdido Bay station total nitrogen concentrations and NNC compliance assessment during the Verification Period (TN NNC = 1.27 mg/L).

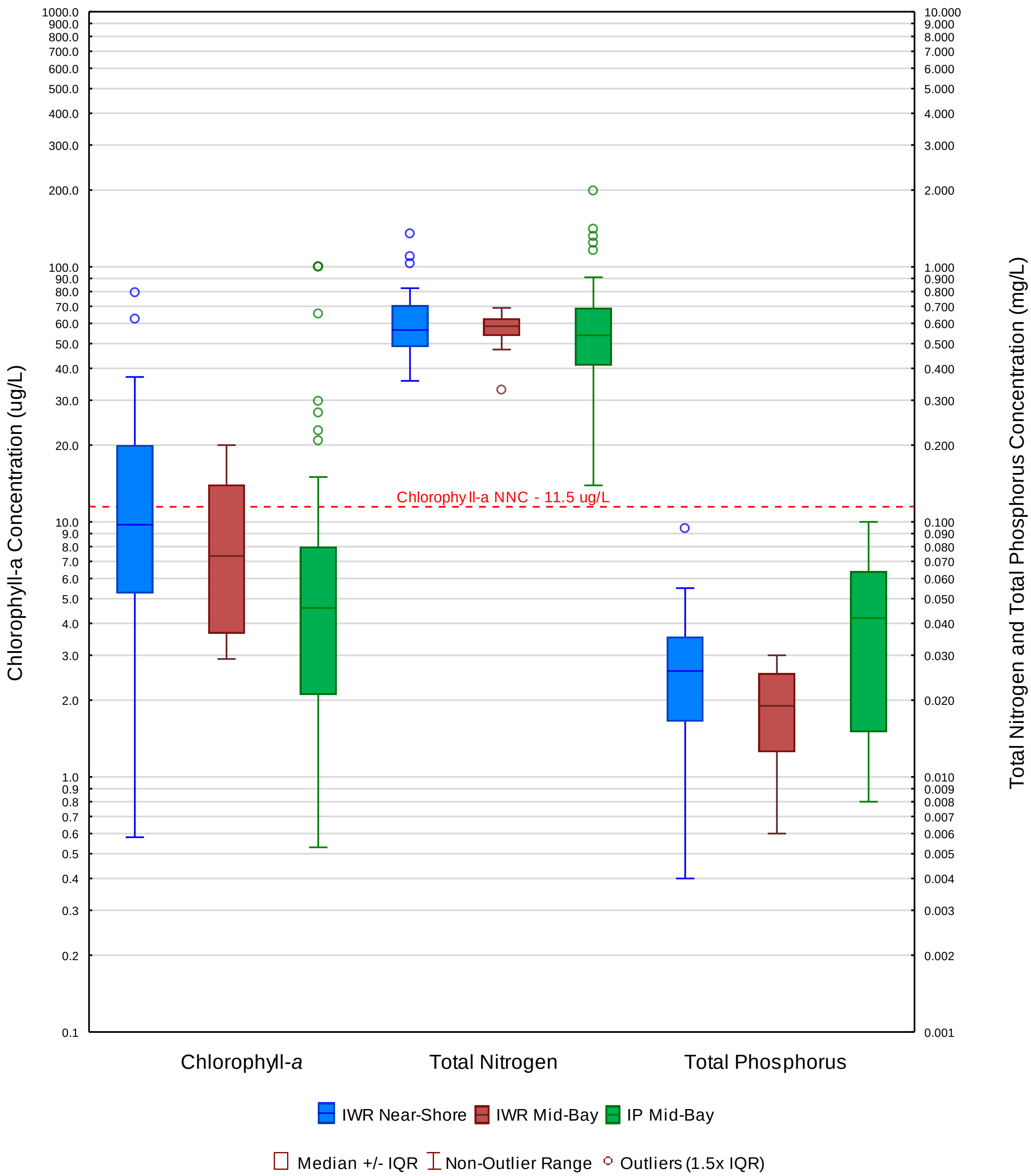
Year	Station	PB01	PB02	PB03	PB04	PB05	Seasonal Geomean
2012	Winter 2012	0.45	0.32	0.61	--	--	0.44
	Spring 2012	0.18	2.01	1.42	--	--	0.80
	Summer 2012	0.78	0.61	0.65	--	--	0.67
	Fall 2012	0.74	0.30	0.43	--	--	0.46
	Station Geo Mean	0.46	0.58	0.70	--	--	--
	Overall TN Geomean 2012						0.57
	Number of TN NNC Exceedances						2
	% of Sample Exceeding TN NNC						17%
2013	Winter 2013	0.16	0.17	0.21	0.53	0.36	0.26
	Spring 2013	0.21	0.22	0.30	0.24	0.42	0.27
	Summer 2013	0.73	1.25	0.65	0.72	0.77	0.80
	Fall 2013	0.14	0.14	0.62	0.14	0.14	0.19
	Station Geo Mean	0.24	0.28	0.40	0.34	0.36	--
	Overall TN Geomean 2013						0.32
	Number of TN NNC Exceedances						0
	% of Sample Exceeding TN NNC						0%
2014	Winter 2014	0.65	0.65	0.91	0.80	0.58	0.71
	Spring 2014	0.91	0.60	0.65	0.66	0.63	0.68
	Summer 2014	0.54	0.53	0.52	0.58	0.51	0.53
	Fall 2014	0.48	0.20	0.41	0.16	0.20	0.26
	Station Geo Mean	0.62	0.45	0.60	0.47	0.44	--
	Overall TN Geomean 2014						0.51
	Number of TN NNC Exceedances						0
	% of Sample Exceeding TN NNC						0%
2015	Winter 2015	0.80	0.46	0.72	0.75	0.77	0.69
	Spring 2015	0.69	0.68	0.70	0.65	0.67	0.68
	Summer 2015	0.52	0.27	0.57	0.52	0.54	0.47
	Fall 2015	0.56	0.46	0.33	0.43	0.45	0.44
	Station Geo Mean	0.63	0.44	0.55	0.57	0.59	--
	Overall TN Geomean 2015						0.56
	Number of TN NNC Exceedances						0
	% of Sample Exceeding TN NNC						0%
2016	Winter 2016	0.32	0.31	0.27	2.13	1.97	0.65
	Spring 2016	0.78	0.62	0.65	0.58	0.54	0.63
	Summer 2016	0.76	0.71	0.88	0.70	0.69	0.74
	Fall 2016	0.42	0.47	0.47	0.47	0.39	0.44
	Station Geo Mean	0.53	0.50	0.52	0.80	0.73	--
	Overall TN Geomean 2016						0.60
	Number of TN NNC Exceedances						2
	% of Sample Exceeding TN NNC						10%
2017	Winter 2017	0.48	0.46	0.56	0.49	0.51	0.50
	Spring 2017	No Data	No Data	No Data	NoData	No Data	No data
	Overall TN Geomean 2017						--
	Number of TN NNC Exceedances						0
	% of Sample Exceeding TN NNC						0%
2012-2017	Total Number of TN Samples						107
	Number of TN NNC Exceedances						4
	% of Samples Exceeding TN NNC						3.7%

Table 12. International Paper Upper Perdido Bay station total phosphorus concentrations and NNC compliance assessment during the Verification Period (TP NNC = 0.102 mg/L).

Year	Station	PB01	PB02	PB03	PB04	PB05	Seasonal Geomean
2012	Winter 2012	0.070	0.039	0.057	--	--	0.054
	Spring 2012	0.081	0.012	0.012	--	--	0.022
	Summer 2012	0.099	0.082	0.089	--	--	0.090
	Fall 2012	0.042	0.015	0.015	--	--	0.021
	Station Geo Mean	0.070	0.027	0.031	--	--	--
	Overall TP Geomean 2012						0.039
	Number of TP NNC Exceedances						0
	% of Sample Exceeding TP NNC						0%
2013	Winter 2013	0.015	0.015	0.015	0.015	0.015	0.015
	Spring 2013	0.030	0.035	0.015	0.033	0.031	0.028
	Summer 2013	0.064	0.100	0.048	0.062	0.057	0.064
	Fall 2013	0.015	0.015	0.050	0.015	0.015	0.019
	Station Geo Mean	0.026	0.030	0.027	0.026	0.025	--
	Overall TP Geomean 2013						0.027
	Number of TP NNC Exceedances						0
	% of Sample Exceeding TP NNC						0%
2014	Winter 2014	0.062	0.062	0.058	0.076	0.064	0.064
	Spring 2014	0.042	0.049	0.031	0.039	0.044	0.041
	Summer 2014	0.071	0.063	0.015	0.052	0.016	0.035
	Fall 2014	0.043	0.066	0.015	0.037	0.040	0.036
	Station Geo Mean	0.053	0.060	0.025	0.049	0.037	--
	Overall TP Geomean 2014						0.043
	Number of TP NNC Exceedances						0
	% of Sample Exceeding TP NNC						0%
2015	Winter 2015	0.057	0.015	0.015	0.055	0.049	0.032
	Spring 2015	0.044	0.036	0.015	0.042	0.048	0.034
	Summer 2015	0.064	0.038	0.032	0.083	0.045	0.049
	Fall 2015	0.078	0.048	0.041	0.037	0.044	0.048
	Station Geo Mean	0.059	0.032	0.023	0.052	0.046	--
	Overall TP Geomean 2015						0.040
	Number of TP NNC Exceedances						0
	% of Sample Exceeding TP NNC						0%
2016	Winter 2016	0.067	0.077	0.032	0.10	0.086	0.068
	Spring 2016	0.016	0.089	0.093	0.091	0.090	0.064
	Summer 2016	0.072	0.071	0.072	0.071	0.048	0.066
	Fall 2016	0.016	0.016	0.016	0.016	0.016	0.016
	Station Geo Mean	0.033	0.053	0.043	0.057	0.049	--
	Overall TP Geomean 2016						0.046
	Number of TP NNC Exceedances						0
	% of Sample Exceeding TP NNC						0%
2017	Winter 2017	0.016	0.016	0.035	0.016	0.041	0.023
	Spring 2017	No Data	No Data	No Data	No Data	No Data	No Data
	Overall TP Geomean 2017						--
	Number of TP NNC Exceedances						0
	% of Sample Exceeding TP NNC						0%
2012-2017	Total Number of TP Samples						107
	Number of TP NNC Exceedances						0
	Percent of Samples Exceeding TP NNC						0%

Similarly, comparisons among all sample sites (IWR Run 54 and IP supplemental data) with respect to bay location (Mid-Bay vs. Near-Shore) failed to indicate a relationship between nutrient and Chlorophyll-*a* distributions. Regardless of data set examined, it is clear that Chlorophyll-*a* values are higher Near-Shore than Mid-Bay (Figure 7), and this difference is statistically significant for the combined dataset (W=2481, p<0.0001). However, there is no difference in central tendency in total nitrogen between the groups, and the IP supplemental data shows higher Total Phosphorous in Mid-Bay locations, where Chlorophyll-*a* is lower. As seen with the temporal trends, this lack of accordance between spatial patterns among nutrients and Chlorophyll-*a* contradicts the idea that nutrient loading is causing elevated Chlorophyll-*a* values in Upper Perdido Bay.

Figure 7. Verification period Chlorophyll-a, total nitrogen, and total phosphorus concentrations between the IWR Near-Shore, IWR Mid-Bay, and IP Mid-Bay station groups.



In an effort to identify alternative drivers of Chlorophyll-*a* variability, exploratory analyses were conducted to evaluate the relationships between hydrological dynamics and Chlorophyll-*a* concentrations. Hydrologic variables were calculated from the meteorological station at Pensacola International Airport, along with three USGS flow gaging stations: USGS 02377570 (Styx River near Elsanor, AL), USGS 02366115 (Elevenmile Creek near Pensacola, FL), and USGS 02376500 (Perdido River at Barrineau Park, Florida). Three precipitation metrics were calculated: total precipitation over the 3 days, 7 days, and 30 days prior to each sampling event. Ten streamflow metrics were calculated for each of the three gaging stations, summarizing the mean, maximum, and minimum daily flows over periods of 3, 7, and 30 days prior to each sampling event. Mean daily flow on each sampling date was also included. None of the hydrological variables showed more than a weak bivariate correlation with Chlorophyll-*a*, with the strongest shown with flow on the Styx River (Spearman's rho = -0.284, p = 0.001).

A stepwise multiple regression analysis was then conducted to determine the strongest predictors of Chlorophyll-*a* variability across all sampling locations. Initially, 7 water quality variables, 33 hydrological parameters, and the categorical location variable describing whether sites are Near-Shore or Mid-Bay (hereafter: "location") were considered for inclusion in the analysis. This large set of explanatory variables was reduced where possible, in circumstances of significant cross-correlations and conceptual redundancy among the variables. In such cases, the explanatory variable showing the strongest pairwise correlation with Chlorophyll-*a* was retained for the analysis. The dependent variable, Chlorophyll-*a*, was $\log_{10}$-transformed to achieve a normal distribution. A parametric, forward stepwise regression analysis was performed including the following explanatory variables: water temperature (°C), specific conductance (µS/cm), total nitrogen (mg/L), total phosphorous (mg/L), total suspended solids (mg/L), location category (Near-Shore vs. Mid-Bay), and maximum flow of the Styx River over the previous three days (cfs). The resultant best model is summarized in Table 13. The final model excluded total nitrogen and maximum three-day river flow. Water temperature and location were the strongest predictors of Chlorophyll-*a*, and together these variables explain 42.6% of the variability.

The results of this stepwise regression confirm that there is insufficient evidence to conclude that nutrient concentrations are driving Chlorophyll-*a* concentrations in Upper Perdido Bay. Total nitrogen was not retained in the model, and the variability in Chlorophyll-*a* concentrations explained by total phosphorous is only 3.7%. These regression results also confirm the possibility of bias in the Chlorophyll-*a* values across Upper Perdido Bay from elevated values at Near-Shore sampling locations, as location category explains 13.9% of the total variability in Chlorophyll-*a* across the Bay.

Table 13. Stepwise regression Chlorophyll-*a* correlation output statistics. Normality (Shapiro-Wilk P=0.741) and constant variance (Spearman P=0.897) statistical model assumptions were met. Total Nitrogen and hydrologic statistics did not show a significant correlation within the stepwise regression model and thus are not included in the table below.

Variable	Delta R^2	P
Temperature	0.288	<0.001
Location (Near-Shore or Mid-Bay)	0.139	<0.001
Total Suspended Solids	0.060	0.037
Total Phosphorus	0.037	<0.001
Specific Conductivity	0.026	0.012

Phytoplankton

As described above, the Upper Perdido Bay has historically experienced Harmful Algal Blooms (HAB), primarily consisting of *Heterosigma akashiwo* blooms, that were demonstrated to be correlated with nitrogen and phosphorus loading from freshwater inflows and point-source dischargers (Livingston, 2007; FDEP 2012). In the development of Upper Perdido Bay NNC, FDEP utilized a "historical conditions approach" based upon water quality data collected between 1988 and 1991 when "a relatively natural, well-balanced plankton community was observed in Perdido Bay" (FDEP, 2012). As described in the Upper Perdido Bay NNC development document (FDEP, 2012), phytoplankton blooms (nuisance or toxic) were identified as a primary indicator[3] of nutrient enrichment effects on aquatic life use in establishment of the NNC.

In conjunction with the IP/ECUA water quality monitoring program for Upper Perdido Bay, phytoplankton samples were collected at multiple stations twice annually during summer (August) and autumn (November/December) monitoring events between 2012 and 2016 (three stations in 2012 and five stations between 2013 and 2016). During the Verification Period, 46 unique samples were collected for phytoplankton community characterization. Species present within the samples were grouped in two primary ways in regard to their potential to cause "nuisance" or "toxic" blooms (Table 14). Taxa were assigned to these groups using the methodologies and citations below which includes only those taxa found in 2012 – 2016 Upper Perdido Bay samples:

[3] Primary indicators are those that respond directly to nutrient enrichment (*e.g.*, excess algal growth) that result in measurable adverse ecological effects (*e.g.*, reduction in nursery function related to SAV loss or undesirable changes in trophic relationships in fish/invertebrate communities (FDEP, 2012).

Table 14. List of Harmful Algal Bloom and nuisance bloom forming phytoplankton taxa identified during historic and contemporary Upper Perdido Bay monitoring studies.

Data Source: Florida Fish and Wildlife Conservation Commission, 2009 (FWRI Technical Report TR-14, Appendix D)		
	HAB species present in 2012-2016 Upper Perdido Bay samples	
		Coelospaerium kuetzingianum
		Prorocentrum minimum
Data Source: Livingston, 2007 (results of 1989-2005 Perdido Bay monitoring program)		
	HAB species identified in Upper Perdido Bay 1989-2005	
		Heterosigma akashiwo
	"Bloom-forming" species identified in Upper Perdido Bay 1989-2005	
		Merismopedia tenuissima
		Prorocentrum cordatum (syn. P. minimum)
		Cyclotella choctawhatcheeana
		Gymnodium spp. (syn. Karenia spp.)
		Chaetoceros subtilis (syn. C. subtilis var. abnormis F simplex)
		Synedropsis sp. (syn. Synedra sp.)

FFWCC (2009) HAB Species

Two phytoplankton taxa, *Coelospaerium kuetzingianum* and *Prorocentrum minimum*, were identified from Upper Perdido Bay samples collected during the 2012 to 2016 monitoring period that are listed in the FFWCC (2009) Appendix D – Known or Potentially Toxic or Harmful Algal Species in Florida (Table 14). During the monitoring period, these two taxa never exceeded 3% of the total phytoplankton community at any station during any sample event (Figure 7). Further, these two taxa were absent from 31 of the 46 samples (67%) with an overall study dominance of 0.3% (Figure 8).

Livingston (2007) HAB and "Bloom" Species

As described by Livingston (2007), several phytoplankton HAB and bloom taxa were correlated with nutrient loading during the 17-year study of Perdido Bay. Of the species identified by Livingston as being problematic and/or associated with elevated nutrient loading, six taxa were identified from samples collected during the 2012 to 2016 monitoring period (see Table 14). During the Livingston studies, *Heterosigma akashiwo* was determined to be the most problematic species as a correlation between increased *H. akashiwo* density and decreased biological integrity was established. While *H. akashiwo* blooms were observed beginning in 1993 with periodic occurrences up through the end of the Livingston (2007) study (2005), *H. akashiwo* was never observed in any of the 2012 to 2016 samples. For the six taxa identified between 2012 and 2016, the IP Upper Perdido Bay station annual average bloom-species percent dominance decreased over the five-year study period from 19.5% of the phytoplankton community in 2012 to 2.1% in 2016 (Figure 8). The 2014, 2015, and 2016 dominances of these bloom-species, 4.0%, 4.8%, and 2.1%, respectively, were similar to "historic condition" background assessment period dominances with annual dominances of 1.2%, 7.1%, and 1.8% reported by Livingston (2007) in 1989, 1990, and 1991, respectively (Figure 8).

Figure 8. FFWCC (2009) Harmful Algal Bloom (HAB) species dominance at the five IP Upper Perdido Bay monitoring stations between 2012 and 2016. The taxa that were found in the samples were *Coelospaerium kuetzingianum* and *Prorocentrum minimum*.

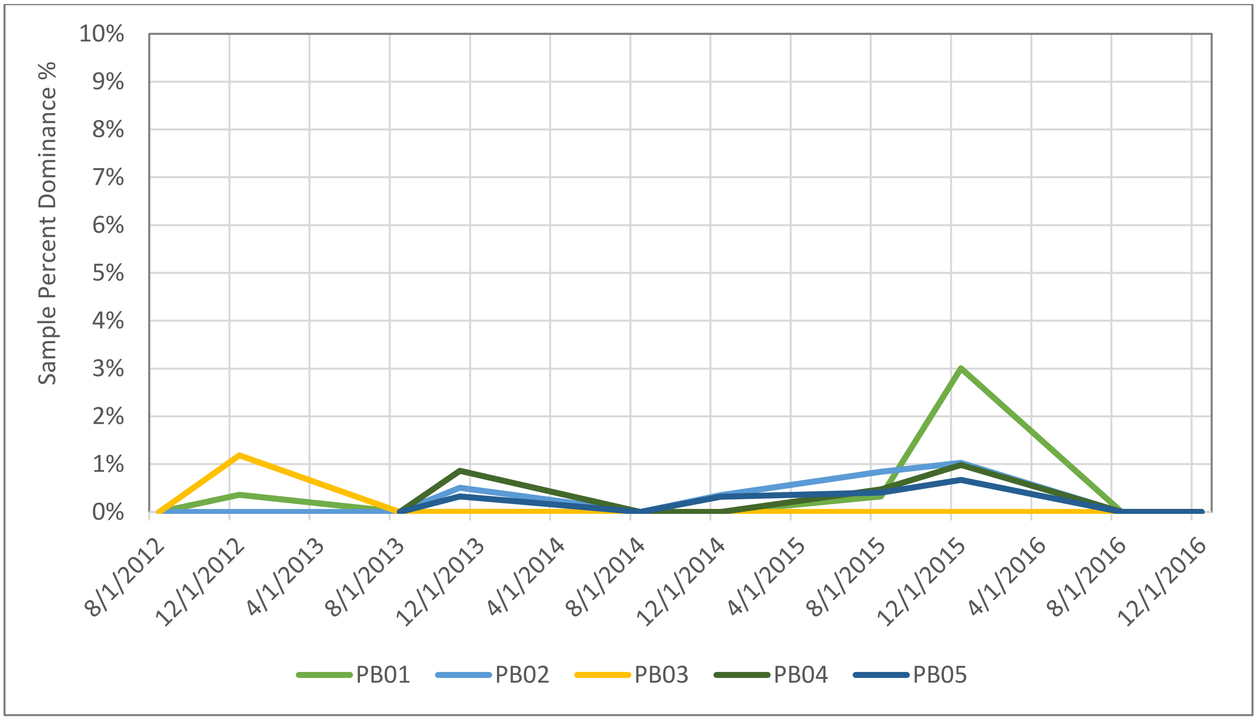
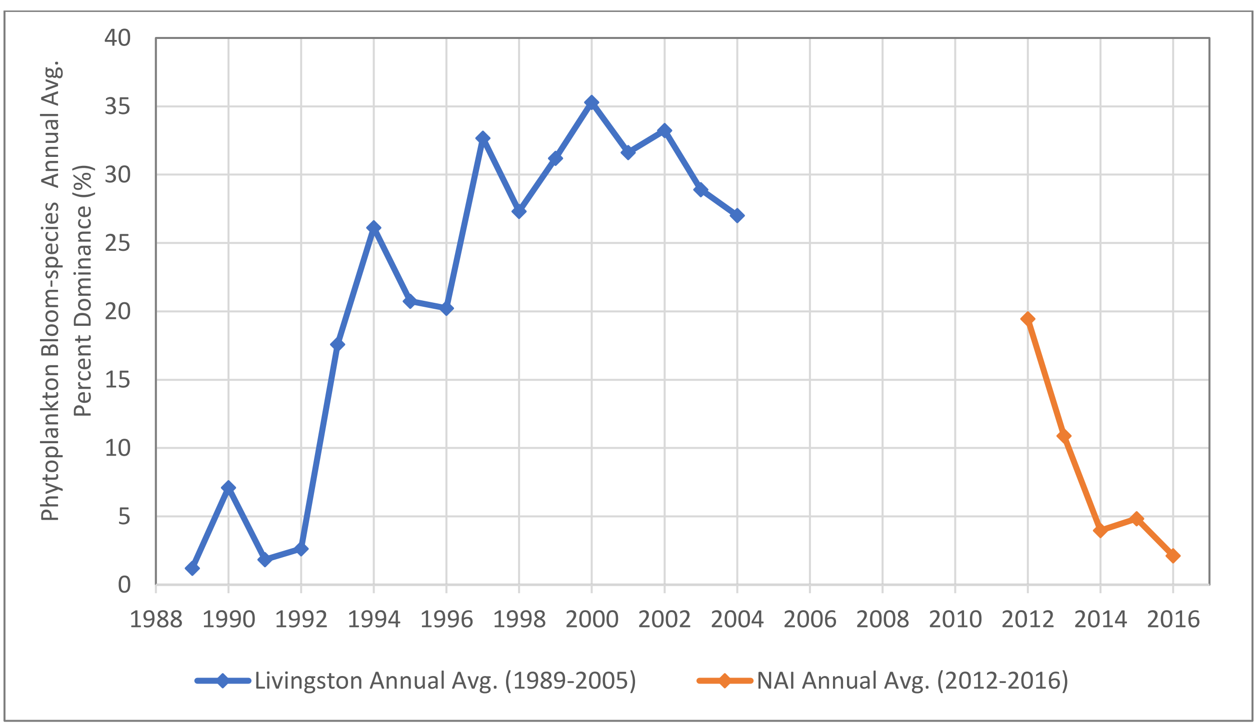


Figure 9. Average annual Harmful Algal Bloom (HAB) and nuisance bloom species dominance, as identified by Livingston (2007), trends between during the 1989 – 2005 Livingston study and 2012 and 2016 International Paper study.



Verification Period Upper Perdido Bay Phytoplankton Trends

During the IWR Verification Period, no *Heterosigma akashiwo* blooms were documented, and in fact, no *H. akashiwo* individuals were identified from any of the 46 samples collected between 2012 and 2016. Other potentially toxin producing HAB taxa were identified during the 5-year study period but were absent during a majority of sampling events, and when present comprised no more than 3% of the individuals of any given sample (Figure 8). Potential nuisance species, as identified by Livingston (2007), dominance decreased during the 2012 to 2016 monitoring period to dominances levels similar to those measured during the 1989-1991 period (Figure 9) which was determined to be a period that supported a "relatively natural, well-balanced plankton community" (FDEP, 2012).

Phytoplankton community diversity statistics were also compared to the 1989-1991 Livingston (2007) results to support the opinion that the Upper Perdido Bay is supporting a "relatively natural, well-balanced plankton community". While taxa richness was slightly lower during the 2012-2016 data collection period, Shannon-diversity and evenness diversity statistics indicate that the phytoplankton community during the 2012-2016 monitoring period exhibited similar phytoplankton community structure and composition trends as those observed during the NNC baseline assessment period.

Table 15. Comparison of 1989-1991 (Livingston, 2007) and 2012-2016 (IP) phytoplankton community diversity statistics.

Data Source	**Phytoplankton Diversity Statistic - average**		
	Taxa Richness	Shannon Diversity (Log base 10)	Evenness
Livingston (2007)			
1989 – 1991 all months	26.7	1.74	0.54
1989 – 1991 only August, November, and December	24.0	1.71	0.49
International Paper Supplemental Data			
2012	19.3	2.56	0.60
2013	17.4	2.70	0.66
2014	13.5	1.54	0.49
2015	20.1	1.85	0.76
2016	21.9	1.30	0.66
2012 – 2016 Study Period Average	18.4	1.94	0.64

Interestingly, the decline in the Livingston (2007) nuisance taxa dominance follows similar trends as those observed for Upper Perdido Bay Chlorophyll-*a* concentrations which showed decreasing concentrations and compliance with NNC during the latter part of the 2012-2017 study period.

CONCLUSIONS

The purpose of this document was to provide additional analysis of the IWR Run 54 dataset as well as to present additional water quality data pursuant to the proposed Assessment Category revision for Upper Perdido Bay as a result of a preliminary determination of elevated Chlorophyll-*a* concentrations above the NNC threshold. A summary of the main conclusions of this assessment are provided below.

- Upper Perdido Bay is located within a dynamic freshwater/marine water mixing zone which exhibits high productivity due to natural biogeochemical processes. These mixing zones are ecologically important to estuarine ecosystems.

- During the Verification Period (1/1/2010 to 6/30/2017), nutrient loading to Upper Perdido Bay was changed due to International Paper's redistribution of 23.8 MGD of effluent from Elevenmile Creek to a receiving wetland distribution system adjacent to Upper Perdido Bay. Based upon long-term monitoring associated with the effluent redistribution project, nutrient loading to Upper Perdido Bay has been significantly reduced. As a result, this project effectively created three different nutrient loading scenarios during the Verification Period.

- IWR Station spatial locations, data collection frequency, and temporal distribution during the Verification Period potentially bias an accurate assessment of Chlorophyll-*a* dynamics and long-term conditions within Upper Perdido Bay. Specifically, it was demonstrated that Near-Shore sampling locations, which were collected at a higher frequency than Mid-Bay samples, exhibited significantly higher Chlorophyll-*a* concentrations. Additionally, the Near-Shore sampling stations were established at locations that were uncharacteristic of the larger Upper Bay WBID segment based upon existing FDEP NNC guidance documentation. Given these considerations, an insufficient number of Mid-Bay sample data were collected during the Verification Period to satisfy F.A.C. 62-303.420 sample size requirements.

- Both IWR Run 54 and IP datasets indicate a statistically significant declining trend in Chlorophyll-*a* concentrations within Upper Perdido Bay during the Verification Period. In fact, IP Upper Perdido Bay Chlorophyll-*a* data results indicate that NNC were met during the 2015 and 2016 monitoring period.

- Although weak correlations can be made between Chlorophyll-*a* concentrations and several other variables, including nutrients, a temporal trend of increasing nutrients and Chlorophyll-*a* concentrations is contradicted by the data. Based on step-wise regression analysis, Upper Perdido Bay Chlorophyll-*a* concentrations were not statistically correlated with total nitrogen or total phosphorus concentrations, which were determined to be in compliance with Upper Perdido Bay NNC. Spatial and temporal patterns in Chlorophyll-*a* differed significantly from nutrient parameters, underscoring the lack of a clear relationship. A variety of potential environmental variable correlations were investigated, suggesting that Chlorophyll-*a* concentrations are driven by multiple interacting variables including freshwater inflows, climate, temperature, and sediment, and cannot be mitigated by controlling nutrient loading alone.

- NNC criteria were established based upon a "historical conditions" approach during years in which Harmful Algal Bloom species (HAB) and nuisance phytoplankton blooms were absent (1989-1991). Based upon phytoplankton community analysis during the IP 2012 to 2016 monitoring period, HAB species were observed to comprise a very small percentage of the Upper Perdido Bay phytoplankton community. Importantly, the HAB species *Heterosigma akashiwo* was absent from the 46 phytoplankton samples collected between 2012 and 2016. Further, the dominance of nuisance phytoplankton taxa as identified by Livingston was shown to decrease to near-background levels in 2014, 2015, and 2016.

Based upon the analyses conducted, a definitive or highly correlated driver was not identified for the observed decrease in overall Chlorophyll-*a* concentrations and decreases in exceedances during the Verification Period. With this said, the water quality data does suggest that Chlorophyll-*a* concentrations within Upper Perdido Bay are trending toward NNC compliance. Based upon the results of the IWR database analysis and additional long-term data collection, three recommendations have been developed:

1) Revise the Assessment Category of the Upper Perdido Bay WBID from a 3b category to a 4b category based upon point-source watershed modifications, namely the IP/ECUA effluent redistribution project;
2) Maintain the 3b category and revise the 7.5-year assessment period to 1/1/2013 to 6/30/2020 given the nutrient load reductions associated with the IP/ECUA effluent redistribution project, or;
3) Maintain the 3b category and continue to collect data given the insufficient number of Mid-Bay sample results. Additional data collection should be collected systematically to ensure that potential bias is not imposed by the location and frequency of sampling.

REFERENCES

Eyre, B. 1998. Transport, Retention and Transformation of Material in Australian Estuaries. Estuaries Vol. 21, No. 4A, p. 540-551, December 1998.

Florida Department of Environmental Protection (FDEP). 2010. Overview of Approaches for Numeric Nutrient Criteria Development in Marine Waters – Draft. Florida Department of Environmental Protection, November 2010 draft.

Florida Department of Environmental Protection (FDEP). 2012. Site-Specific Information in Support of Establishing Numeric Nutrient Criteria for Perdido Bay. Florida Department of Environmental Protection, December 2012.

Florida Fish and Wildlife Conservation Commission (FFWCC). 2009. Resource Guide for Public Health Response to Harmful Algal Blooms in Florida. Fish and Wildlife Research Institute Technical Report TR-14, 2009.

Livingston, R.J. Perdido Project: Final Report, River, Bay and Marsh Analyses. Environmental Planning & Analysis, Inc., December 2007.

Northwest Florida Water Management District (NWFWMD). 2017. Perdido River and Bay Surface Water Improvement and Management Plan. Program Development Series 17-07, October 2017.

Nutter & Associates, Inc. (NAI). 2018. 2017 Annual Monitoring Report: Combined Effluent Distribution System. Prepared for International Paper, Pensacola, Florida pursuant to NPDES Permit FL0002526-008-IWIS/NR and submitted to FDEP, February 2018.

Orlando, S.P.J., L.P. Rozas, G.H. Ward, and C.J. Klein. 1993. Salinity Characteristics of Gulf of Mexico Estuaries. National Oceanic and Atmospheric Administration, July 1993.

APPENDIX C

Surface Water Monitoring Plan
(Nutter & Associates, Inc., 2014)

SURFACE WATER MONITORING PLAN

ECUA / IP Combined Effluent Distribution Project

Pensacola, FL

August 2014

PREPARED BY

NUTTER & ASSOCIATES, INC.

360 Hawthorne Lane

Athens, GA 30606-2152

Phone: 706.354.7925

Fax: 706.354.7928

NutterInc.com

Nutter & Associates

environmental consultants

SURFACE WATER MONITORING PLAN

ECUA/IP Combined Effluent Distribution Project

AUGUST 2014

Prepared by

Nutter & Associates, Inc.
360 Hawthorne Lane
Athens, Ga 30606
www.NutterInc.com

.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1.0 BACKGROUND

A framework for monitoring the Effluent Distribution Project (EDP) was prepared in April 2004 by Robert J. Livingston, Environmental Planning & Analysis, Inc. (EP&A), Wade L. Nutter, Nutter & Associates, Inc. (NAI), and Alan Niedoroda, URS Corporation (Tallahassee Office) and was updated in June 2008. The aforementioned documents outlined the framework for establishing a program for baseline, construction, and post-project implementation monitoring. The framework was divided into four stages:

Stage 1. Field set-up and planning
Stage 2. Baseline monitoring (2003 - 2008)
Stage 3. Ramp-up discharge monitoring (2012)
Stage 4. Routine monitoring (2013-2014)

Stages 1 and 2 have been completed and a report describing the results was submitted to the Florida DEP in March 2008. The title of the report is *Integrated Monitoring - July 2005 through April 2007, ECUA/IP Combined Effluent Distribution Project* (March 2008) and was prepared by Nutter & Associates, Inc. This report also includes as an appendix, a report entitled, *Perdido Project: Final Report River, Bay, & Marsh Analyses*, by Robert J. Livingston Ph.D. This report represents completion of Stages 1 & 2 of the 2004 Framework Plan.

Stage 3 Initial discharge monitoring of the freshwater receiving wetlands, Perdido Bay, Elevenmile Creek, the Perdido River, and the Tee/Wicker Lake Complex during the one year ramp-up period was completed between January and December 2012. To date, Stage 4 Routine monitoring has been conducted quarterly beginning in February 2013. The results of Stage 3 and 4 monitoring are detailed in the NPDES permit required annual monitoring reports submitted to Florida Department of Environmental Protection Division (FDEP) on February 1st of 2012 and 2013. Stage 4 monitoring will be completed in December 2014 and the 2014 annual monitoring report will be presented to the FDEP in February 2015

Current surface water monitoring is being conducted in accordance with several FDEP NPDES and Consent Order (OGC File No. 08-0358) requirements. Specific monitoring objectives and their associated monitoring support documents are detailed below:

Monitoring Location / Objective	Monitoring Program Documents and Methods
Freshwater receiving wetlands and mitigation areas	1. *Assessment of the ECUA/IP Combined Effluent Distribution Project Wetlands, Monitoring and Land Management* (February 2008) 2. Technical Memorandum No. 00-020.17a: *S2 Habitats Conservation and Management* (February 8, 2008)
Marine receiving waters (Perdido Bay, lower Elevenmile Creek, and Tee / Wicker Lake Complex)	*Final Discharge Monitoring Plan, ECUA/IP Combined Effluent Distribution Project* (November 2012)
Elevenmile Creek	Condition I.E.4.b (NPDES Permit No. FL0002526-008-IW1S/NR)

In order to consolidate and simplify long-term monitoring requirements, this document presents a comprehensive monitoring program for all aspects of the surface and ground water monitoring program associated with discharge of treated effluent to the Effluent Distribution System (EDS) receiving waters. As a result, this monitoring plan establishes all NPDES required monitoring activities to be conducted during the 2015 – 2020 NPDES permit period and supersedes all other monitoring described in the previously approved monitoring plans.

2.0 INTRODUCTION

The Effluent Distribution Project (EDP) included wastewater treatment plant improvements (IWWTP) at the International Paper mill and discharge of the highly treated effluent to a 1,406-acre wetland system. The principal components of the project were an upgrade to the treatment plant resulting in an improvement of the effluent quality and relocation of the discharge from Elevenmile Creek to a wetland tract adjacent to the northern shore of Perdido Bay. The effluent is currently delivered to the wetland by a gravity-flow pipeline approximately 10 miles in length. As a result of this project, mill effluent has been entirely removed from the freshwater portions of Elevenmile Creek during normal operations. The Emerald Coast Utilities Authority (ECUA) and IP jointly sponsor the project and will include an average daily discharge of 23.8 mgd by IP and up to 5 mgd by ECUA. In addition, IP is currently accepting up to 5 mgd from ECUA for reuse by the IP mill in the manufacturing process.

To provide ongoing assurance that the improved and relocated IP effluent discharge will maintain designated uses and support a healthy and well balanced biological community within the Upper Perdido Bay ecosystem and to show that this project will improve the environmental conditions in Elevenmile Creek and Perdido Bay, a multi-year monitoring plan conducted between January 2012 and February 2015 has been implemented in the Bay, Creek, and wetlands.

This updated document presents a comprehensive long-term monitoring plan that combines all aspects of the project including, the freshwater receiving wetlands and conservation areas, marine receiving waters, and Elevenmile Creek.

The principal components of the long term monitoring program are:

- Monitoring of the freshwater receiving wetlands and conservation area wetlands,
- Monitoring of the marine receiving waters, including the tidally influenced Tee and Wicker Lakes complex, Perdido Bay, and lower Elevenmile Creek, and
- Monitoring of the freshwater portions of Elevenmile Creek.

Long-term monitoring will be initiated following re-issuance of IP's NPDES permit in March 2015 and will culminate at the end of the permit cycle in March 2020. The objectives of the long term monitoring plan are to record the ongoing performance of the EDS and to provide data required by the FDEP. Long-term monitoring is designed to assess the recovery of Elevenmile Creek and Perdido Bay due to the removal of direct mill effluents from Elevenmile Creek.

3.0 METHODS

Within the freshwater wetlands, marine receiving waters, and Elevenmile Creek, different monitoring programs will be employed. General water quality sampling methods are included below, while detailed monitoring methodologies are included in subsequent sections.

3.1. General Water Quality Monitoring

All surface water monitoring will be conducted in accordance with the most current DEP-SOP-001/01, FS 1000 General Sampling Procedures (SOP), FT 1000 General Field Testing and Measurement, FS 2000 General Aqueous Sampling, FS 2100 Surface Water Sampling, and specific SOP related to pH (FT 1100), specific conductivity (FT1200), salinity (FT 1300), dissolved oxygen (FT 1500), and turbidity (FT 1600). Quality control procedures will adhere to DEP-SOP-001/01 FQ1000 Field Quality Control Requirements.

3.2. Freshwater EDS and Conservation Area Wetlands

Water quality samples will be collected quarterly along with in-situ water quality at four (4) EDS stations and two (2) reference wetland stations (Figure 2).

Freshwater Wetland Monitoring Stations	Area	Water Quality	Biological	Latitude	Longitude
		Sample Type (Frequency)		(DD)	
DWT-01	EDS	Instantaneous Grab Samples (quarterly)	Benthic Macroinvertebrates (annual) Vegetation (semi-annual)	30.469539	-87.379153
DWT-02				30.478440	-87.372271
FWT-03				30.473943	-87.379100
SWT-03				30.470139	-87.382885
FWC-01	Conservation Areas			30.475704	-87.394617
SWR-01				30.473405	-87.411342

3.2.1 Water Quality

Water quality samples will be collected for laboratory analysis of color, 5-day biochemical oxygen demand, total suspended solids, total phosphorus, orthophosphate, total kjedahl nitrogen, ammonia, nitrate-nitrite, total organic carbon, sulfate, and chlorophyll-a. Field sampling for orthophosphate will be completed using an inline 0.45 µm capsule filter attached to a peristaltic pump or equivalent filter mechanism.

Surface water quality samples will be conducted as direct grabs from the field by hand within the upper 0.3 meters of the water or at mid-depth if the total depth is less than 0.5 meters. All water quality samples will be delivered within applicable holding times to a NECLAC Certified Lab and analyzed in accordance with approved FDEP and USEPA methods.

Table 2 presents a summary of the laboratory measured parameters method detection limits (MDL), practical quantitation limits (PQL), analytical method and holding time.

In-situ field measurements of pH, specific conductivity, salinity, DO concentration, DO saturation, and temperature will be collected utilizing a multiparameter water quality instrument (Hydrolab™ Model DS5X or equivalent). The water quality instrument will be submersed in the water at each target depth. In-situ values will be recorded on a field datasheet once individual in-situ parameters have equilibrated in the water. In-situ turbidity will be measured in the field using a nephelometer (Lamotte™ Model 2020 or equivalent) and recorded on the field datasheet. Transparency will be measured by lowering a secchi disc into the water to a depth where it can no longer be seen, and recording the depth on the field data sheet. Pre- and post-calibration records for all in-situ water quality instruments and nephelometers along with grab sample data sheets will be utilized and stored for record keeping.

3.2.2 Biological Communities

3.2.2.1 Benthic Macroinvertebrates

Macroinvertebrate sampling events will be conducted annually between January and February at four (4) EDS and two (2) Conservation Area stations (Figure 3). Macroinvertebrates will be semi-quantitatively sampled using multi-habitat sampling methods outlined in the Florida Wetland Condition Index (WCI) SOP (FS7470). During sampling 20 discrete 0.25m x 0.5m sweeps distributed proportionally to the major habitat types will be conducted using a D-frame dip net with no. 30 mesh. Sampling will be targeted for habitats that have been inundated for a minimum of 28 days and after at least 3 months of inundation if the area to be sampled has gone dry. Macroinvertebrate habitat will be catalogued by documenting the availability of varied substrate types, including coarse woody debris, overhanging and/or submerged vegetation, stable substrate, etc. Wetland characteristics, including percent canopy cover, dominant vegetation, water depth, water chemistry, and substrate type will be measured and recorded on a field data sheet (similar to form FD 9000-3) prior to macroinvertebrate sampling. Samples will be preserved in the field using a 10% formalin solution and sent to a laboratory for sorting and taxonomic enumeration.

Laboratory sorting follows methods described in FDEP SOP LT7010. Laboratory quality control utilizing SOP LQ7410 will be conducted on all WCI samples and will include a calculation of sorting efficiency. The target control limit for cumulative sorting efficiency is 95%. Following sub-sorting, macroinvertebrates will be identified to the lowest possible taxonomic level. One replicate sub-sample of 150 (±10%) species each will be identified for each station.

The macroinvertebrate community will be evaluated using The Florida Wetland Condition Index (WCI) for both isolated forested wetlands and isolated herbaceous wetlands depending on the particular wetland type of each station as depicted in the table below.

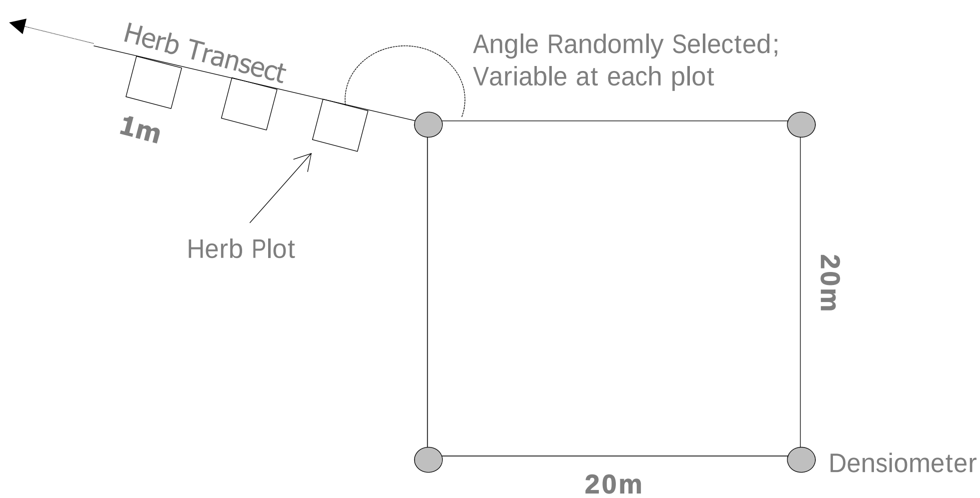
Station	Location	WCI
DWT01	EDS	Herbaceous WCI
DWT02		
FWT03		
FWC01	Reference	
SWT03	EDS	Forested WCI
SWR01	Reference	

3.2.2.2 Vegetation

Vegetation community monitoring will be conducted annually at 67 stations for the following parameters: herbaceous community composition and canopy speciation and coverage during the autumn season (Figure 3). Of these stations, 37 monitoring stations are located within the EDS, whereas 30 stations are located within the Conservation Areas. Community-scale vegetation sampling will be based on permanent fixed-area plots at each monitoring station. At each sampling station, a point marking the northwest corner of a single 20m x 20m (0.1 acre) plot was established remotely using ArcGIS and field located using a GPS unit capable of sub-meter accuracy in 2008. Tree speciation and diameter at breast height (dbh) will be recorded for all trees (>3-inch dbh) within this 400m^2 plot only during the autumn monitoring period. Densiometer readings will also collected from each corner (4) of the 400m^2 plot, and averaged to represent the total percent canopy coverage of the plot itself.

For herbaceous vegetation monitoring, a random bearing and distance from the northwest corner of the plot was used to mark the first 1m^2 herbaceous quadrat in 2008, and subsequent quadrats were established along the same bearing spaced at fixed 1m intervals along the herbaceous transect. Percent coverage of all herbaceous species and woody perennial species <1m height will be visually estimated from these 1m^2 quadrats. Additional quadrats will be sited and sampled until the species-area curve reaches a plateau. A generalized vegetation monitoring plot schematic is presented below.

Typical Vegetation Plot



3.3 Marine Receiving Waters

Water quality samples will be collected quarterly along with in-situ water quality at five (5) Perdido Bay stations, two (2) Tee / Wicker Lake complex stations, one (1) reference tidal marsh station, two (2) lower Elevenmile Creek stations, and one (1) tidal creek station (Figure 2).

Tee / Wicker Lake Complex, Perdido Bay, and Perdido River Monitoring Stations	Sample ID	Water Quality	Biological	Latitude	Longitude
		Sample Type (Frequency)		(DD)	
Tee Lake	TWT-01	Instantaneous Surface and Bottom (quarterly)	Vegetation (annual) / Phytoplankton (semi-annual)	30.462763	-87.384626
Wicker Lake	TWT-02		Phytoplankton (semi-annual)	30.457546	-87.386349
Reference Tidal Wetland	TWR-01			30.457001	-87.403175
Tee / Wicker Lake Marsh	Marsh-1		Vegetation (annual)	30.465563	-87.38396
Tee / Wicker Lake Marsh	Marsh-2			30.458634	-87.38243
Perdido Bay, Mouth of Tee / Wicker Lake and Elevenmile Creek	PB-01		Phytoplankton (semi-annual)	30.452875	-87.378521
Perdido Bay	PB-02			30.451983	-87.402175
Perdido River, 1-mile upstream from mouth	PB-03			30.444677	-87.37074
Perdido Bay	PB-04			30.432101	-87.355629
Perdido Bay	PB-05			30.421967	-87.387844
Elevenmile Creek, 1-mile upstream from mouth	SWD-3			30.46468	-87.373621
Elevenmile Creek, Mouth	SWD-4			30.456984	-87.376586
Tidal Creek	GS-05		None	30.464231	-87.379148

3.3.1 Water Quality

Water quality samples will be collected for laboratory analysis of color, 5-day biochemical oxygen demand, total suspended solids, total phosphorus, orthophosphate, total kjedahl nitrogen, ammonia, nitrate-nitrite, total organic carbon, sulfate, and chlorophyll-a. Field sampling for orthophosphate will be completed using an inline 0.45 µm capsule filter attached to a peristaltic pump or equivalent filter mechanism.

Water quality sampling will be comprised of surface and bottom samples at each station. Surface water samples will be conducted as direct grabs from the field by hand within the upper 0.3m of the water column. Bottom samples will be conducted with a Van Dorn sampler at 0.3m above the bottom of the water body. The Van Dorn sampler will be decontaminated according to FDEP SOP FQ1000 and rinsed with site water prior to collecting the samples. All water quality samples will be delivered within applicable holding times to a NECLAC Certified Lab and analyzed in accordance with approved FDEP and USEPA methods. Table 2 presents a summary of the laboratory measured parameters method detection limits (MDL), practical quantitation limits (PQL), analytical method and holding time.

In-situ field measurements of pH, specific conductivity, salinity, DO concentration, DO saturation, and temperature will be collected utilizing a multiparameter water quality instrument (Hydrolab™ Model DS5X or equivalent). The water quality instrument will be submersed in the water at each target depth. In-situ values will be recorded on a field datasheet once individual in-situ parameters have equilibrated in the water. In-situ turbidity will be measured in the field using a nephelometer (Lamotte™ Model 2020 or equivalent) and recorded on the field datasheet. Transparency will be measured by lowering a secchi disc into the water to a depth where it can no longer be seen, and recording the depth on the field data sheet. Pre- and post-calibration records for all in-situ water quality instruments and nephelometers along with grab sample data sheets will be utilized and stored for record keeping.

3.3.2 Biological Communities

3.3.2.1 Phytoplankton

Phytoplankton sampling will be conducted in accordance with the most current DEP-SOP-001/01 FS2100 Surface Water Sampling and FS7100 Phytoplankton Sampling Standard Operating Procedures. Phytoplankton sampling will be conducted semiannually as grab samples from the top 0.3m of the surface water during the summer and autumn monitoring periods at five (5) Perdido Bay and at two (2) Tee / Wicker Lake Complex monitoring stations (Figure 3). Two 100-mL samples will be collected and individually preserved with a 4% formalin solution and 3 mL of Lugols solution, respectively. Analyses of the phytoplankton samples will be conducted by a capable laboratory and will follow the standard procedure for inverted microscope analyses.

3.3.2.2 Vegetation

Vegetative sampling will be conducted at three (3) stations in the marsh system adjacent to the Tee / Wicker Lake Complex and will be based on 20m x 20m (0.1 acre) permanent fixed-area plots at each monitoring station (see section 3.2.3.2 for specific methods) (Figure 3). Herbaceous community composition and canopy speciation and coverage will be measured at each station during the autumn monitoring period.

3.4 Freshwater Portions of Elevenmile Creek

Annual water quality and biological monitoring will be conducted at three designated monitoring stations between the months of June and August. Two stations are located on Elevenmile Creek while one background station, located on Coffee Branch, will also be monitored.

Elevenmile Creek Monitoring Stations	Sample ID	Latitude (DD)	Longitude (DD)
State Road 186 (above outfall)	SWU-1	30.576521	-87.317720
State Route 297A	SWD-1	30.547674	-87.329509
Coffee Branch (control site and reference background site)	SWB-1	30.515562	-87.347288

3.4.1 Water Quality

Water quality samples will be collected for laboratory analysis of color, 5-day biochemical oxygen demand, total suspended solids, total phosphorus, orthophosphate, total kjedahl nitrogen, ammonia, nitrate-nitrite, total organic carbon, and sulfate. Field sampling for orthophosphate will be completed using an inline 0.45 µm capsule filter attached to a peristaltic pump or equivalent filter mechanism.

Surface water quality samples will be conducted as direct grabs from the field by hand within the upper 0.3 meters of the water or at mid-depth if the total depth is less than 0.5 meters. All water quality samples will be delivered within applicable holding times to a NECLAC Certified Lab and analyzed in accordance with approved FDEP and USEPA methods. Table 2 presents a summary of the laboratory measured parameters method detection limits (MDL), practical quantitation limits (PQL), analytical method and holding time.

In-situ field measurements of pH, specific conductivity, salinity, DO concentration, DO saturation, and temperature will be collected utilizing a multiparameter water quality instrument (Hydrolab™ Model DS5X or equivalent). The water quality instrument will be submersed in the water at each target depth. In-situ values will be recorded on a field datasheet once individual in-situ parameters have equilibrated in the water. In-situ turbidity will be measured in the field using a nephelometer (Lamotte™ Model 2020 or equivalent) and recorded on the field datasheet. Transparency will be measured by lowering a secchi disc into the water to a depth where it can no longer be seen, and recording the depth on the field data sheet. Pre- and post-calibration records for all in-situ water quality instruments and nephelometers along with grab sample data sheets will be utilized and stored for record keeping.

3.4.2 Biological Communities

Biological community monitoring will be conducted annually between the months of June and August at stations SWD-1 and SWB-1 and will consist of benthic macroinvertebrate monitoring. Benthic macroinvertebrate sampling will follow protocols detailed in the most recent DEP-SOP-001/01 FS7420 Stream Condition Index Sampling. An aquatic habitat characterization (FT3000) will be conducted in conjunction with the biologic

Benthic macroinvertebrate samples will be returned to the laboratory and sub-sorted according to DEP-SOP-002/01 LT7200 Stream Condition Index Determination Standard Operating Procedures. Following sub-sorting, the two (2) 140-160 individual samples will be transmitted to a laboratory for taxonomic identification.

4.0 REPORTING

Monitoring reports detailing the data collected from implementation of the plan will be submitted annually to the FDEP Northwest District Office, the FDEP Wastewater Compliance Evaluation Section, U.S. EPA Region 4, and the Alabama Department of Environmental Management (ADEM) no later than February 1 in accordance with part VI.3. of the NPDES permit.

Agency	Address
Florida Department of Environmental Protection Northwest District Office Industrial Wastewater Section	160 Governmental Center Pensacola, FL 32502-5794
Florida Department of Environmental Protection Wastewater Compliance and Evaluation Section, MS#3551	Bob Martinez Center 2600 Blair Stone Road Tallahassee, FL 32399-2400
Alabama Department of Environmental Management Deputy Chief, Water Division	P.O. Box 301463 Montgomery, AL 36130
U.S. Environmental Protection Agency, Region 4 Director, Water Management Division	Atlanta Federal Center 61 Forsyth Street Atlanta, GA 30303-8960

5.0 REFERENCES CITED

Livingston R.L., W.L. Nutter, and A. Niedoruda. 2004. A Framework for Monitoring Perdido Bay, Elevenmile Creek, and the Effluent Distribution Wetlands. Prepared for International Paper, April 30, 2004.

Livingston, R.L. 2007. Perdido Project: Final Report. River, Bay, and Marsh Analyses. December, 2007.

Nutter & Associates, Inc. 2007. Assessment of the ECUA/IP Combined Effluent Distribution Project Wetlands, Monitoring and Land Management. August, 2007.

Nutter & Associates, Inc. 2008. Integrated Monitoring, July 2005 through April 2007, ECUA/IP Combined Effluent Distribution Project. March, 2008.

Nutter & Associates, Inc. 2008. Baseline water quality, ECUA/IP Combined Effluent Distribution Project. June, 2008.

Nutter & Associates, Inc. 2008. A Framework for Monitoring Perdido Bay, Elevenmile Creek, and the Effluent Distribution Wetlands: Phase II. Prepared for International Paper, June, 2008.

Table 1. Monitoring goals, associated monitoring activities and goal achievement determination.

Monitoring Goal	Monitoring Activity	Goal Achievement Determination[1]
Document the environmental conditions following 100% effluent discharge to the wetland ecosystem	* Water quality * Biological communities benthic macroinvertebrates, vegetation, phytoplankton * Groundwater	Compare pre- and post-project environmental conditions in the freshwater and marine wetland ecosystems after stabilization is reached due to effluent application
Document the environmental conditions in the freshwater portion of Elevenmile Creek.	* Water quality * Biological communities: benthic macroinvertebrates, vegetation, phytoplankton	Compare pre- and post-effluent removal environmental conditions after the Creek stabilizes to effluent removal. Compare post-effluent removal data with control stream (Coffee Branch).
Document the effect of the project on the dissolved oxygen regimes and water transparency of the tidal portion of Elevenmile Creek, the tidal ponds (Tee and Wicker Lakes), and the adjacent areas of Upper Perdido Bay to meet water quality standards.	* Water Quality	Compare pre- and post-project water quality once the environmental conditions in the freshwater and marine wetland ecosystems stabilize due to effluent application.
Document the improvement in overall response of the Upper Perdido Bay ecosystem to reduced nutrient inputs.	* Water quality * Biological communities: phytoplankton	Long-term compliance with WQBEL and Permit nutrient limits

[1] Monitoring activities within the freshwater portion of the EDS site will also be utilized to assess the achievement of the stated goals.

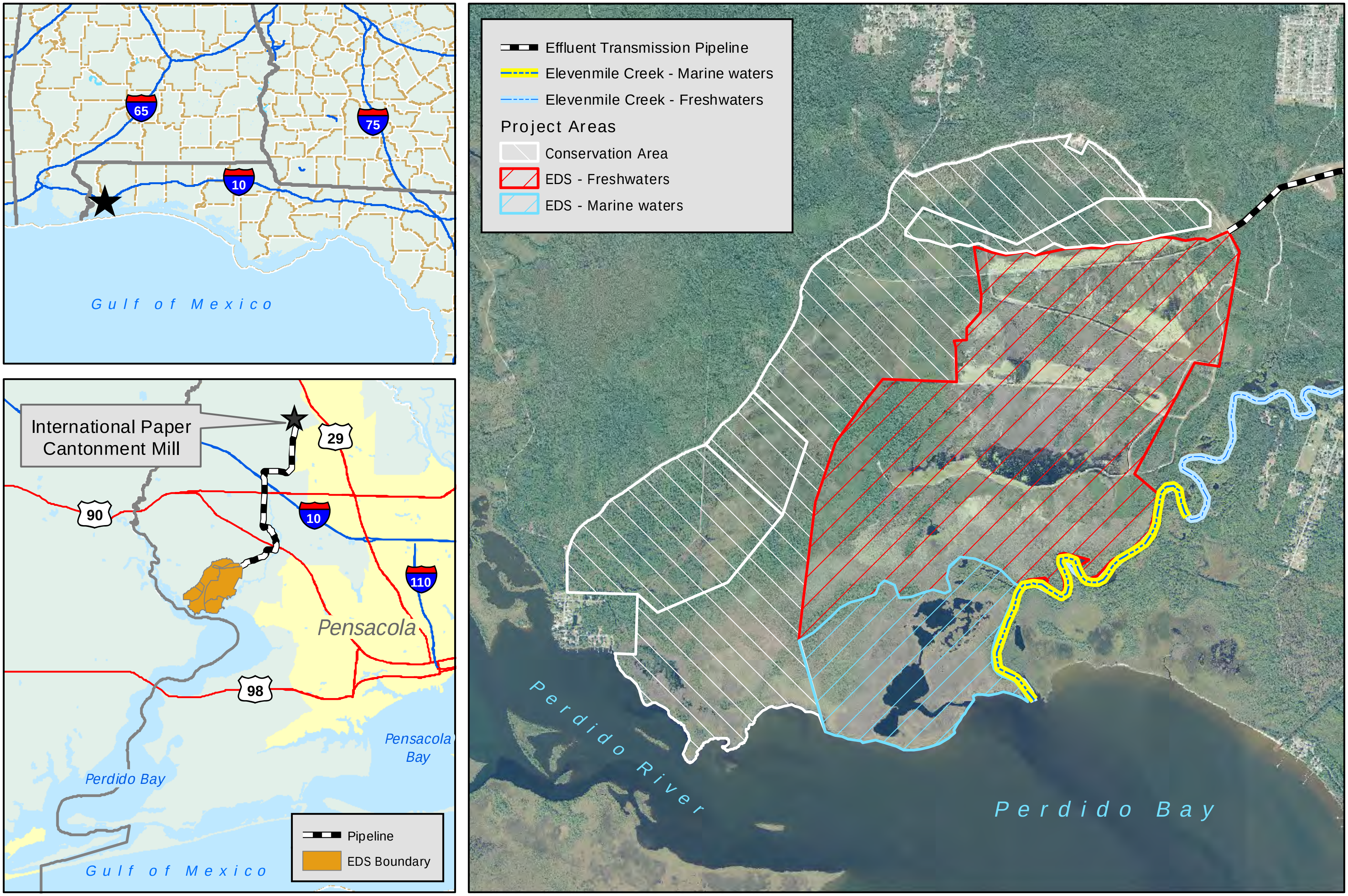
Table 2. Monitoring parameters, methods, and quantification limits.

Parameter	Units	Method	PQL	MDL
Temperature	°C	In-situ water quality meter	-5 to 50	
Specific Conductance	µmhos/cm		0 to 100,000	
Salinity	ppt		0 to 70	
Dissolved Oxygen	mg/L		0 to 30	
pH	S.U.		0 to 14	
Redox Potential	mV		-999 to 999	
Turbidity	NTU		0.00 to 1,100	
Transparency	ft	Secchi Disk	N/A	
BOD-5 day	mg/L	SM 5210B	2.0	2.0
Total Suspended Solids		SM 2540D	5.0	5.0
Ammonia, Total		4500 NH3 H	0.050	0.016
Unionized Ammonia		Calculated		
Nitrogen, Total Kjeldahl		351.2	0.50	0.26
Nitrite + Nitrate		SM 4500	0.050	0.018
Phosphorus, Total		365.4	0.10	0.030
Phosphorus, Ortho		365.1	0.050	0.015
Organic Carbon, Total		SM 5310B	1.0	0.50
Color, True	Pt-Co Units	SM2120B	10	3.0
Sulfate	mg/L	SM 4500 SO4 E	25	7.0
Chlorophyll a	mg/m3	SM 10200H-2001	0.50	0.50
Biological Integrity	N/A	FDEP SOP FS7470: WCI	N/A	
Nuisance Species		FDEP SOP FS7200: SCI		
Aquatic Flora and Fauna		FDEP SOP FS2100: Phytoplankton		

Table 3. Monitoring parameters and sample frequencies by water body type.

Parameter	Units	Sample Type by Location		
		EDS and Conservation Area[1]	Marine – Upper Perdido Bay[2]	Freshwater Elevenmile Creek[3]
Temperature	°C	Instantaneous (Quarterly)	Instantaneous – Stratified Sampling (Quarterly)	Instantaneous (Annual)
Specific Conductance	µS/cm			
Salinity	ppt			
Dissolved Oxygen	mg/L			
pH	S.U.			
Redox Potential	mV			
Turbidity	NTU			
Transparency	ft			
BOD-5 day	mg/L	Grab Samples – mid-depth (Quarterly)	Grab Samples – Surface and Bottom (Quarterly)	Grab Samples – mid-depth (Annual)
Total Suspended Solids				
Ammonia, Total				
Unionized Ammonia				
Nitrogen, Total Kjeldahl				
Nitrite + Nitrate				
Phosphorus, Total				
Phosphorus, Ortho				
Organic Carbon, Total				
Color, True	Pt-Co Units			
Sulfate	mg/L			
Chlorophyll a	mg/m3	None		None
Benthic Macroinvertebrates	N/A	WCI – Annually (Winter)	None	SCI – Annually (Summer)
Phytoplankton		None	Bi-annually (Summer and Autumn)	None
Vegetation		Annually (Autumn)	None	None

1 EDS and Conservation Area sampling will be conducted at monitoring locations defined in Section 3.2
2 Marine sampling will include monitoring stations located in Perdido Bay, lower Elevenmile Creek, and the Tee / Wicker Lake Complex as defined in Section 3.3
3 Elevenmile Creek stations include two freshwater stations located on Elevenmile Creek and one station located on Coffee Branch; specific locations are defined in Section 3.4



Data Source: USDA 2013 aerial photography, StreetMap NA

Path: F:\projects\12_007_IP_2012\SSAC_Figures\EDS_Vicinity_Overview.mxd

Figure 1. Project vicinity and overview.

0 1,500 3,000 6,000 Feet

N

Nutter & Associates
environmental consultants

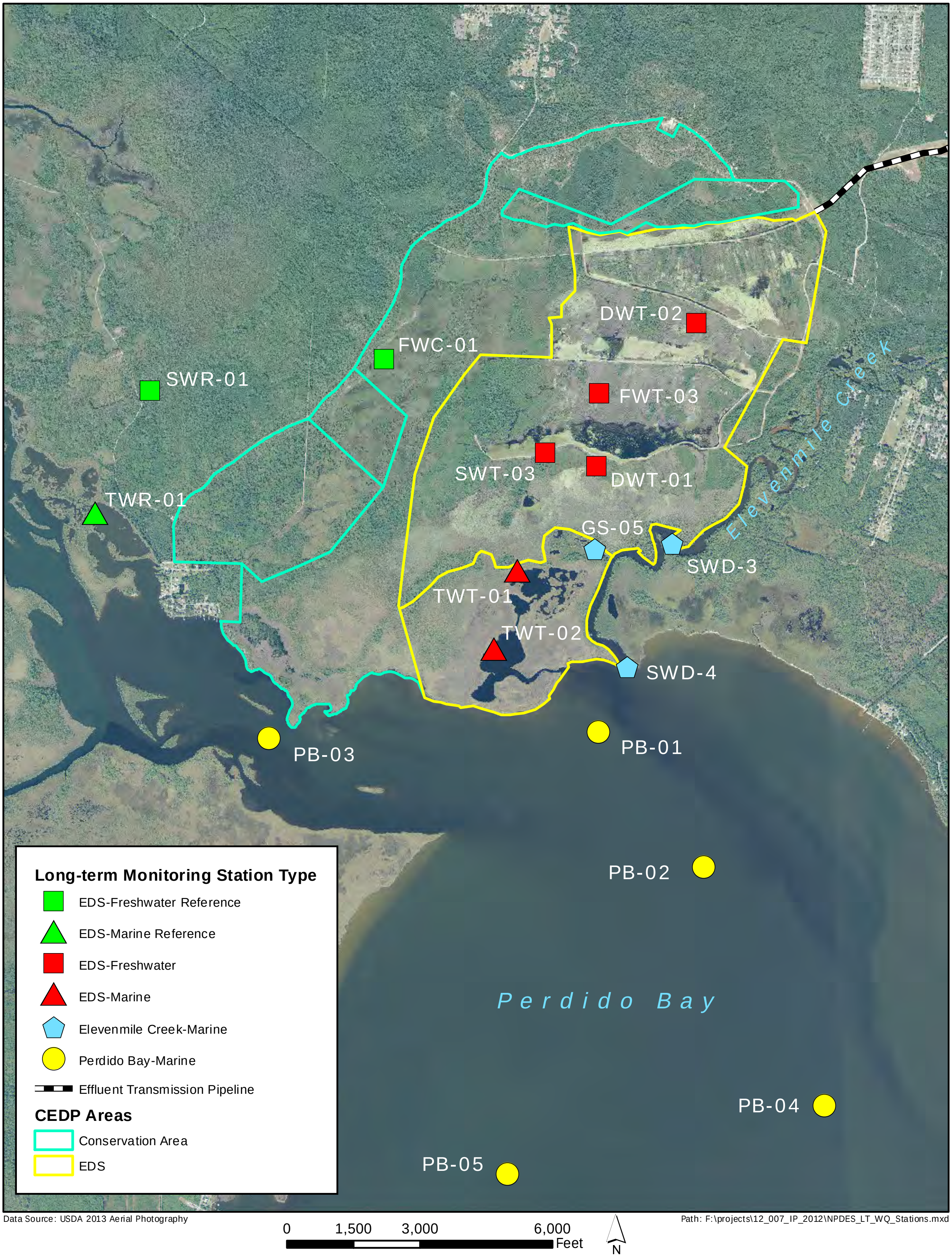


Figure 2. Water quality monitoring stations.

Nutter & Associates
environmental consultants

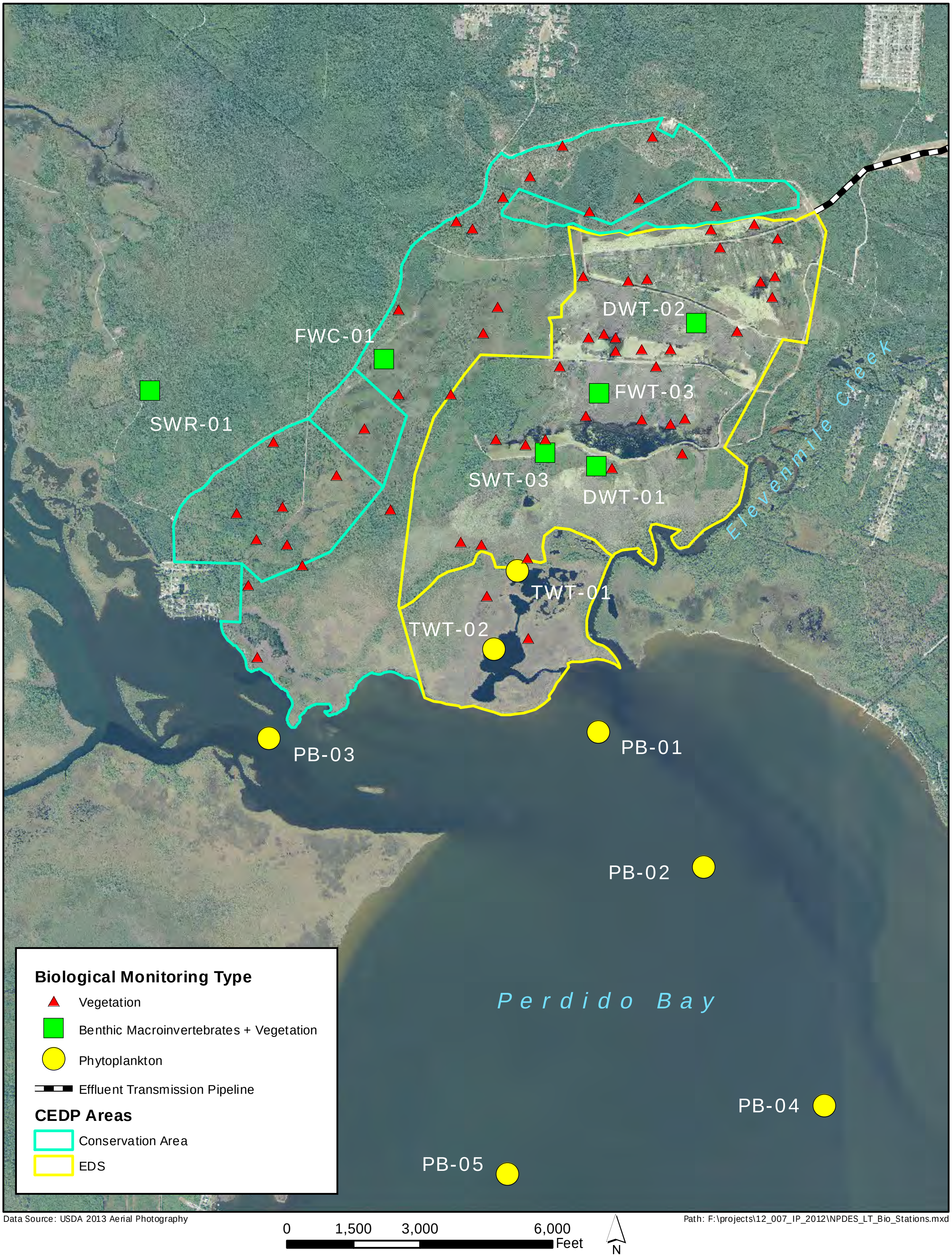
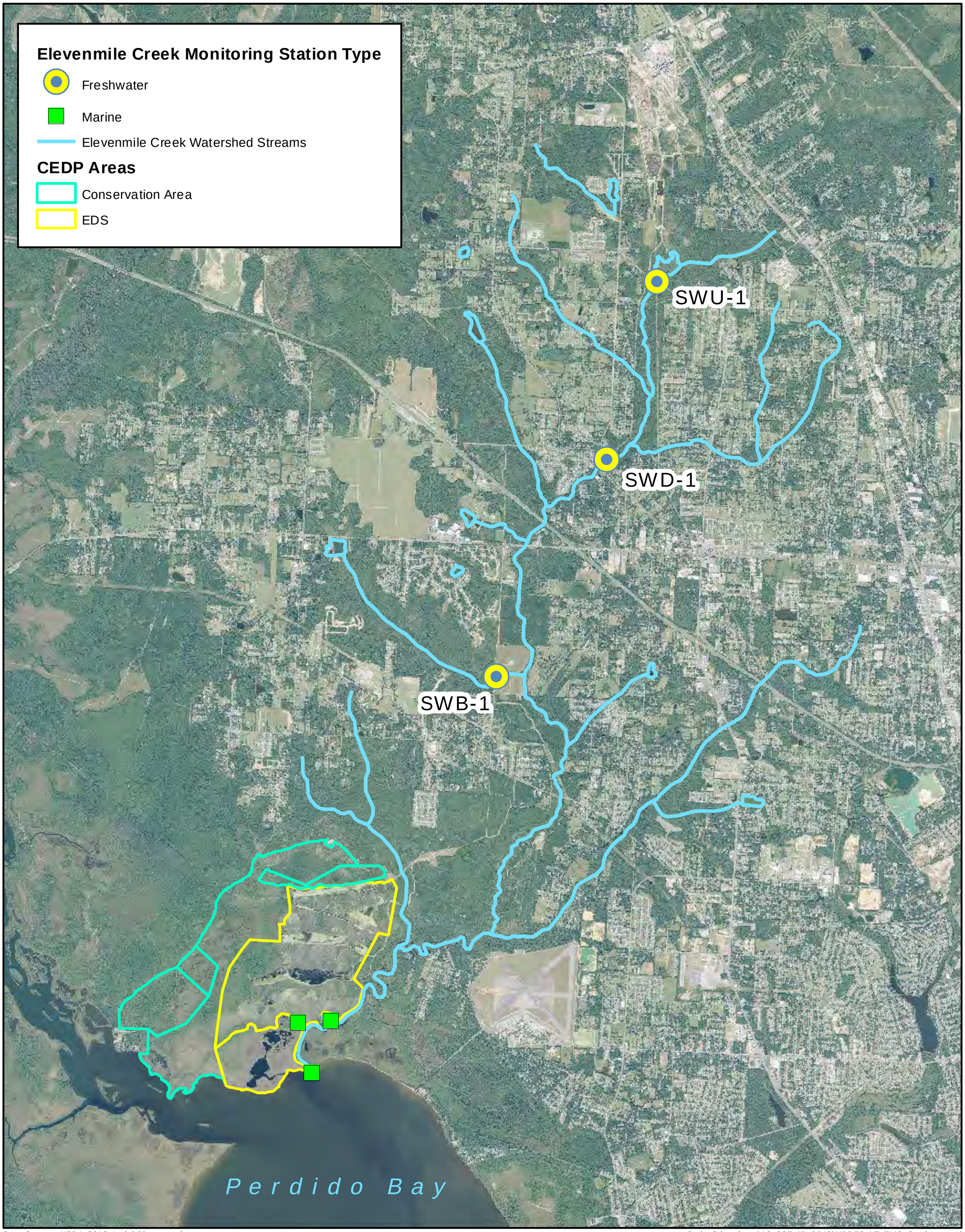


Figure 3. Biological monitoring stations.

Nutter & Associates
environmental consultants



Data Source: USDA 2013 Aerial Photography

Path: F:\projects\12_007_IP_2012\NPDES_LT_EMC_Stations.mxd

0 0.5 1 2 Miles

N

Figure 4. Elevenmile Creek monitoring stations.

Nutter & Associates
environmental consultants