2017 ANNUAL MONITORING REPORT

COMBINED EFFLUENT DISTRIBUTION SYSTEM

INTERNATIONAL PAPER

Pensacola, FL

February 2018

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

INTERNATIONAL PAPER

375 Muscogee Road
PO Box 87
Cantonment, Florida 32533-0087

PENSACOLA WASTEWATER PROJECT

February 1, 2018

Florida Department of Environmental Protection
Northwest District
Industrial Wastewater Section
160 Governmental Center
Pensacola, Fl 32502-5794

Florida Department of Environmental Protection
Wastewater Compliance Evaluation Section, MS#3551
Bob Martinez Center
2600 Blair Stone Road
Tallahassee, Florida 32399-2400

Alabama Department of Environmental Management
Deputy Chief, Water Division
Post Office Box 301463
Montgomery, Alabama 36130

U.S. Environmental Protection Agency, Region 4
Director, Water Protection Division
Atlanta Federal Center
61 Forsyth Street
Atlanta, Georgia 30303-8960

Re: Annual Monitoring Report Summary, 2017 Discharge Monitoring for the Combined Effluent Distribution System, Pensacola, Florida – NPDES Permit No. FL0002526; Consent Order OGC File No. 08-0358.

Pursuant to consent order -- Part 1, 13(d)(i-iii) and NPDES permit – Part I.E.4.a.2. requirements, International Paper and Nutter & Associates are pleased to submit the included *Annual Monitoring Report Summary* that documents monitoring results during the 2017 monitoring period at the Combined Effluent Distribution System site located in Pensacola, Florida.

During the 2017 monitoring period, International Paper continued to discharge all of their treated process wastewater to the Effluent Distribution Site. In conjunction with the wastewater re-distribution project, management of the conservation and mitigation areas continued.

The attached report details the results of 2017 quarterly surface water and groundwater monitoring, wetland vegetation and benthic macroinvertebrate assessments, soil chemistry and hydrologic evaluations, and Elevenmile Creek monitoring. The report details the findings of the fifth full year of 100% effluent monitoring period for the freshwater and tidally influenced portions of the project site, which include lower Elevenmile Creek, upper Perdido Bay, and the brackish marsh adjacent to these two water bodies.

Please contact me at 850-968-4287 should you have any questions or comments.

Sincerely,

Laurie McLain
Manager – Environment, Health, Safety

cc: Shawn Hamilton - FDEP
David Morres - FDEP
Bill Armstrong -FDEP
Phil Coram - Tallahassee FDEP
Eric Hickman - Tallahassee FDEP
Ken Weaver- Tallahassee FDEP
Nijole Wellendorf- Tallahassee FDEP
Elizabeth Orr - FDEP
Doug Beason - Tallahassee FDEP
Ed Sarfert – USACE
Glenda Dean- ADEM Montgomery
Tony Greco – Nutter & Associates, Inc.

TABLE OF CONTENTS

1.0 INTRODUCTION 1-1
1.1 Monitoring Framework 1-1
1.1.1 Monitoring History 1-2
1.2 Construction and Planting 1-3
1.3 Effluent Flows 1-4
1.4 Report Approach 1-4

2.0 CEDP SITE AND STATION CHARACTERIZATION 2-1
2.1 General Site Characterization 2-1
2.1.1 Climate 2-1
2.1.2 Topography 2-1
2.1.3 CEDP Land Use History 2-2
2.1.4 CEDP Habitat Enhancements 2-2
2.1.5 Current EDS Layout 2-3
2.2 Station Descriptions and General Methodologies 2-3
2.2.1 CEDP Multivariate Stations 2-3
2.2.1.1 Multivariate Sampling Stations Wetland Settings 2-4
2.2.2 CEDP Grab Sample Stations 2-6
2.2.3 Perdido Bay Stations 2-6
2.2.4 Elevenmile Creek Stations 2-6
2.2.5 CEDP Vegetation and Soil Sampling Stations 2-6
2.2.5.1 Wetted Effluent Vegetation Stations: 2-7
2.2.5.2 Conservation Area Vegetation Stations: 2-8
2.3 Monitoring Report Organization 2-8

3.0 HYDROLOGY 3-1
3.1 Methods 3-1
3.1.1 Well Installation Methods 3-1
3.1.2 Field Data Collection, Data Processing, Quality Control, and Analysis 3-2
3.2 Results and Discussion 3-3
3.2.1 Precipitation 3-3
3.2.2 Depression and Flat Wetland Stations 3-3
3.2.3 Slough Wetland Stations 3-4
3.2.4 Tidal Wetland Stations 3-4
3.3 Conclusions 3-5

4.0 GROUNDWATER 4-1
4.1 General Procedures 4-1
4.2 Results 4-2
4.2.1 Background Wells (MWB1 and MWB2) 4-3
4.2.2 Interior Wells (MWI3, MWI4, MWI5) 4-4
4.2.3 Compliance Wells (MWC6 and MWC7) 4-5
4.3 Conclusions 4-5
4.4 Literature Cited 4-6

5.0 DIEL IN-SITU MONITORING 5-1
5.1 48-Hour Diel In-Situ Methods 5-1
5.1.1 Field Methods 5-1
5.1.2 Field QA/QC and Post Processing 5-1
5.1.3 Data Analysis Methods 5-2
5.2 48-Hour Diel Water Quality Results 5-2
5.2.1 Freshwater Temperature Results 5-2
5.2.2 Freshwater Specific Conductivity and Salinity Results 5-3
5.2.3 Freshwater pH Results 5-3
5.2.4 Freshwater Dissolved Oxygen Results 5-4
5.2.5 Tidal Temperature Results 5-4
5.2.6 Tidal Specific Conductivity and Salinity Results 5-4
5.2.7 Tidal pH Results 5-5
5.2.8 Tidal DO Results 5-5
5.3 Conclusions 5-5

6.0 FRESHWATER ANALYTICAL WATER QUALITY MONITORING 6-1
6.1 Analytical Water Quality Methods 6-1
6.1.1 Field and Laboratory Methods 6-1
6.1.2 Analysis Methods 6-2
6.2 Nutrient Results 6-2
6.2.1 Total Phosphorus (TP) 6-3
6.2.1.1 Phosphorus in the Freshwater EDS 6-3
6.2.1.2 EDS Zonal Analysis of Total Phosphorus 6-3
6.2.2 Total Nitrogen (TN) 6-3
6.2.2.1 Total Nitrogen in the Freshwater EDS 6-3
6.2.2.2 EDS Zonal Analysis of Total Nitrogen 6-4
6.2.2.3 Ammonia Concentrations 6-4
6.2.3 Sulfate (SO_4) 6-4
6.2.3.1 Sulfate in the Freshwater EDS 6-4
6.3 Other Water Quality Parameters 6-5
6.3.1 Biochemical Oxygen Demand 6-5
6.3.2 Transparency, Solids and Organic Carbon 6-5
6.4 Conclusions 6-6

7.0 SOILS 7-1
7.1 Sampling Methodology and Analyses 7-1
7.2 Results and Discussion 7-2
7.2.1 Soil pH and Nutrient Availability 7-3
7.2.2 Cation Exchange Capacity and Base Saturation 7-3
7.2.3 Total Nitrogen, Organic Matter and Carbon: Nitrogen Ratio 7-3
7.2.4 Soluble Salts 7-4
7.2.5 Sodium Adsorption Ratio 7-4
7.2.6 Phosphorus Sorption Capacity 7-4
7.3 Conclusions 7-5
7.4 Literature Cited 7-5

8.0 WETLAND MACROINVERTEBRATES 8-1
8.1 Macroinvertebrate Station Locations 8-1
8.2 Collection and Identification Methods 8-2
8.3 Data Analysis Methods 8-2
8.3.1 Diversity Metrics Analysis Methods 8-2
8.3.2 Wetland Condition Index 8-2
8.3.3 Multivariate Analysis Overview 8-3
8.3.3.1 Hierarchical Cluster Analysis 8-3
8.3.3.2 Multi-Response Permutation Procedure (MRPP) and Indicator Species Analysis (ISA) 8-3
8.3.3.3 Nonmetric Multidimensional Scaling (NMS) 8-4
8.4 Macroinvertebrate Results 8-4
8.4.1 Diversity Analysis Results 8-4
8.4.2 Wetland Condition Index Results 8-5
8.4.3 Multivariate Analysis Results 8-5
8.4.3.1 A Priori Grouped by Year 8-6
8.4.3.2 Ad Hoc Parsimonious Groupings 8-7
8.5 Conclusions 8-8
8.6 Literature Cited 8-8

9.0 VEGETATION 9-1
9.1 Vegetation Community Monitoring 9-1
9.2 Vegetation Data Analysis 9-2
9.2.1 Canopy Layer Characterization 9-3
9.2.2 Herbaceous Vegetation Characterization 9-3
9.3 Vegetation Results 9-4
9.3.1 Canopy Layer 9-4
9.3.2 Herbaceous Layer Vegetation 9-5
9.3.2.1 Diversity Statistics 9-5
9.3.2.1.1 Freshwater EDS 9-5
9.3.2.1.2 Freshwater Conservation Area 9-6
9.3.2.1.3 Tidally Influenced Wetlands 9-7
9.3.2.2 Conservation Area Management 9-7
9.4 Conclusions 9-8
9.5 Literature Cited 9-8

10.0 TIDAL EDS AND PERDIDO BAY 10-1
10.1 Hydrologic Dynamics in Upper Perdido Bay 10-1
10.2 Analytical Water Quality Methods 10-2
10.3 In-situ Water Quality Monitoring Results 10-3
10.4 Nutrient and Chlorophyll-a Results 10-4
10.4.1 Total Phosphorus 10-5
10.4.2 Total Nitrogen 10-5
10.4.3 Chlorophyll-a 10-6
10.5 Other Water Quality Parameters 10-6
10.6 Phytoplankton 10-7
10.7 Conclusions 10-8

11.0 ELEVENMILE CREEK 11-1
11.1 Methods 11-1
11.1.1 Sample Locations 11-1
11.1.2 Water Quality Methods 11-2
11.1.3 Biological Methods 11-2
11.2 Results 11-3
11.2.1 Water Quality 11-3
11.2.2 Biology 11-3
11.2.2.1 Stream Condition Index Results 11-4
11.3 Conclusions 11-4

APPENDIX 5-A : 2017 Diel plots

APPENDIX 8-A: 2008 through 2017 wetland macroinvertebrate collection results

APPENDIX 9-A: Results of Autumn 2017 Vegetation Monitoring

LIST OF TABLES

Table 2-1. Historic and CY2017 monthly climate data compiled from the Pensacola Regional Airport weather station.

Table 2-2. Monitoring stations, station type, monitoring parameters, and frequency for the CY 2017 monitoring of the CEDP, Elevenmile Creek, and the Perdido Bay.

Table 2-3. Multivariate stations, salinity regime, and treatment designations for the 2017 CEDP monitoring period.

Table 3-1. Monthly climate data compiled from the Pensacola Regional Airport weather station for CY 2017.

Table 3-2. Comparison of selected hydrologic change indicators for each monitoring station.

Table 4-1. ECUA/IP Combined Effluent Distribution System monitoring well locations, elevations, and construction details.

Table 4-2. Permit requirements for groundwater constituents. Permit Number FL0002526-008-IWIS.

Table 4-3. Summary results of background monitoring well MWB1 for baseline monitoring years 2003-2005 combined, 100% EDS operational flow years 2012 through 2016 combined, and individual quarterly monitoring results for 2017.

Table 4-4. Summary results of background monitoring well MWB2 for baseline monitoring years 2003-2005 combined, 100% EDS operational flow years 2012 through 2016 combined, and individual quarterly monitoring results for 2017.

Table 4-5. Summary results of interior monitoring well MWI3 for baseline monitoring years 2003-2005 combined, 100% EDS operational flow years 2012 through 2016 combined, and individual quarterly monitoring results for 2017.

Table 4-6. Summary results of interior monitoring well MWI4 for baseline monitoring years 2003-2005 combined, 100% EDS operational flow years 2012 through 2016 combined, and individual quarterly monitoring results for 2017.

Table 4-7. Summary results of interior monitoring well MWI5 for baseline monitoring years 2003-2005 combined, 100% EDS operational flow years 2012 through 2016 combined, and individual quarterly monitoring results for 2017.

Table 4-8. Summary results of compliance monitoring well MWC6 for baseline monitoring years 2003-2005 combined, 100% EDS operational flow years 2012 through 2016 combined, and individual quarterly monitoring results for 2017.

Table 4-9. Summary results of compliance monitoring well MWC7 for baseline monitoring years 2003-2005 combined, 100% EDS operational flow years 2012 through 2016 combined, and individual quarterly monitoring results for 2017.

Table 4-10. Historic groundwater parameter results from monitoring wells in the Northwest Reporting Unit D-Sand & Gravel Aquifer. Background Network Summary Statistics 1994-1997.

Table 5-1. Data quality summary table for the 2017 *in-situ* diel water quality monitoring year.

Table 5-2. 48-hour *in-situ* diel summary statistics for the 2017 monitoring year EDS stations.

Table 5-3. 48-hour *in-situ* diel summary statistics for the 2017 monitoring year freshwater reference stations.

Table 5-4. 48-hour in-situ diel summary statistics for the 2017 monitoring year tidal EDS stations TWT01 and TWT02.

Table 6-1. Location Identifiers for the analytical water quality stations.

Table 6-2. Water quality parameter, test methods, and reporting limits.

Table 6-3. Zonal identifiers for the stations used in the 2017 water quality zonal analyses.

Table 6-4. Pre-effluent (2003-2008) sampling matrix. The letter "X" denotes that grab samples were collected during that sampling event.

Table 6-5. Annual surface water quality results collected during pre-effluent and 2012 through 2017 monitoring years for the combined effluent distribution project.

Table 6-6. Zonal Analysis of nutrient concentrations in the EDS during pre-effluent, 2013-2016 combined, and 2017 monitoring years.

Table 7-1. Summary of soil pH by zone and sampling event.

Table 7-2. Summary of soil phosphorus by zone and sampling event.

Table 7-3. Summary of soil potassium by zone and sampling event.

Table 7-4. Summary of soil calcium by zone and sampling event.

Table 7-5. Summary of soil magnesium by zone and sampling event.

Table 7-6. Summary of soil sulfur by zone and sampling event.

Table 7-7. Summary of soil sodium by zone and sampling event.

Table 7-8. Summary of soil zinc by zone and sampling event.

Table 7-9. Summary of soil manganese by zone and sampling event.

Table 7-10. Summary of soil iron by zone and sampling event.

Table 7-11. Summary of soil copper by zone and sampling event.

Table 7-12. Summary of soil boron by zone and sampling event.

Table 7-13. Summary of soil aluminum by zone and sampling event.

Table 7-14. Summary of soil cation exchange capacity by zone and sampling event.

Table 7-15. Summary of soil base saturation by zone and sampling event.

Table 7-16. Summary of soil total nitrogen by zone and sampling event.

Table 7-17. Summary of soil organic matter by zone and sampling event.

Table 7-18. Summary of soil carbon:nitrogen ratio by zone and sampling event.

Table 7-19. Summary of soil soluble salts by zone and sampling event.

Table 7-20. Summary of soil sodium adsorption ratio by zone and sampling event.

Table 7-21. Summary of soil phosphorus sorption capacity by zone and sampling event.

Table 8-1. Results of March 23, 2017 macroinvertebrate monitoring at the four EDS stations (SWT03, DWT01, DWT02, and FWT03) and two reference stations (SWR01 and FWC01).

Table 8-2. Summary of the individual EDS and reference station calculated diversity metrics and the combined average EDS and reference station macroinvertebrate diversity metrics.

Table 8-3. Tukey pairwise comparison of within year EDS station (N=4) mean Shannon-Weiner diversity index scores.

Table 8-4. Tukey pairwise comparison of within year EDS station (N=4) mean taxa richness.

Table 8-5. Summary analysis of variance results comparing pooled pre-effluent EDS, post-effluent EDS, and freshwater reference wetland macroinvertebrate Shannon-Weiner Diversity.

Table 8-6. Summary analysis of variance results comparing pooled pre-effluent EDS, post-effluent EDS, and freshwater reference wetland macroinvertebrate species richness.

Table 8-7. Herbaceous WCI macroinvertebrate metric scores at each monitoring station during baseline (2008 and 2011), ramp-up (2012), and 100% effluent flow (2013-2017) periods.

Table 8-8. Forested WCI macroinvertebrate metric scores at each monitoring station during baseline (2008 and 2011), ramp-up (2012), and 100% effluent flow (2013-2017) periods.

Table 8-9. Summary analysis of variance results comparing pooled pre-effluent EDS, post-effluent EDS, and freshwater reference wetland macroinvertebrate WCI scores.

Table 8-10. Multi Response Permutation Procedure (MRPP) pairwise comparison test of significant differences ($p < 0.05$) of benthic samples collected each year at EDS stations.

Table 8-11. Multi Response Permutation Procedure (MRPP) pairwise comparison test of significant differences ($p < 0.05$) of benthic samples parsed using cluster analysis.

Table 9-1. Average canopy tree density within the EDS by management zone, 2008 (baseline) and 2012 through 2017 (post-effluent).

Table 9-2. EDS station canopy metrics, 2008 (baseline) and 2012 through 2017 (post-effluent).

Table 9-3. Average canopy tree density within the Conservation Area by management type, 2008 (baseline) and 2012 through 2017 (post-management).

Table 9-4. Conservation Area station canopy metrics, 2008 (baseline) and 2012 through 2017 (post-effluent).

Table 9-5. Species richness by sampling event and area, 2008 and 2012 through 2017.

Table 9-6. EDS herbaceous layer vegetative species metrics for all species with an importance value > 0.075 by year, 2008 and 2012 through 2017.

Table 9-7. Conservation Area herbaceous layer vegetative species metrics for all species with an importance value > 0.07 by year, 2008 and 2012 through 2017.

Table 9-8. Average herbaceous layer vegetation diversity statistics, 2008 (baseline) and 2012 through 2017 (post-effluent), EDS and Conservation Area freshwater areas.

Table 9-9. Average herbaceous layer vegetation diversity statistics, 2008 (baseline) and 2012 through 2017 (post-effluent), EDS marine areas.

Table 9-10. EDS marine area herbaceous layer vegetative species metrics for all species with an importance value > 0.075 by year, 2008 and 2012 through 2017.

Table 9-11. Conservation area diversity metric summary statistics at non-managed vegetative monitoring plots, 2008 (pre-management) and 2012 through 2017 (post- and/or on-going-management).

Table 9-12. Conservation area diversity metric summary statistics at managed vegetative monitoring plots, 2008 (pre-management) and 2012 through 2017 (post- and/or on-going-management).

Table 10-1. Historic and yearly freshwater inflow statistics to Upper Perdido Bay.

Table 10-2. Summary statistics for *in situ* monitoring at tidal creek station GS05.

Table 10-3. Summary statistics for *in situ* monitoring at lower Elevenmile Creek stations SWD3 and SWD4.

Table 10-4. 2017 summary statistics for *in situ* monitoring at Perdido Bay stations PB01, PB02, PB03, PB04, and PB05.

Table 10-5. Annual nutrient and chlorophyll-a concentrations measured during pre-effluent (when available) and the 2012-2017 monitoring years in the tidal receiving waters surrounding the International Paper combined effluent distribution project.

Table 10-6. Upper Perdido Bay station nutrient and chlorophyll-a concentrations in 2012–2017 monitoring years for the combined effluent distribution project.

Table 10-7. Annual BOD, TOC, color, TSS, and turbidity measurements from pre-effluent (when available) and the 2012-2017 monitoring years in the tidal receiving waters surrounding the International Paper combined effluent distribution project.

Table 10-8. Secchi depths collected at tidal receiving waters and Upper Perdido Bay stations in 2012 through 2016.

Table 10-9. Results of August and December 2017 phytoplankton sampling at the Upper Perdido Bay monitoring stations.

Table 10-10. Upper Perdido Bay station phytoplankton diversity statistics for 2010-2017 monitoring events.

Table 11-1. Results of Elevenmile Creek water quality monitoring, August 2017.

Table 11-2. Water quality data from all sampling events at freshwater stations SWU-1, SWB-1, SWD-1, and SWD-2 between 2010 and 2017.

Table 11-3. Results of water quality analyses at SWD-1 and SWB-1 collected during August 2017 monitoring.

Table 11-4. Stream Condition Index Habitat Assessment Scores for SWB-1 and SWD-1 between 2010 and 2017.

Table 11-5. Results of Stream Condition Index sampling at SWB-1 (November 7, 2017) and SWD-1 (August 29, 2017).

Table 11-6. Total individuals, taxa richness and SCI scores at SWB-1 and SWD-1 between 2010 and 2017.

Table 11-7. Raw metric SCI indices used to calculate final SCI scores for SWB-1 and SWD-1 during 2010 to 2017 monitoring events.

LIST OF FIGURES

Figure 1-1. Combined Effluent Distribution Project (CEDP) overview and vicinity map.

Figure 1-2. Combined Effluent Distribution Project (CEDP) overview.

Figure 2-1. Combined Effluent Distribution Project (CEDP) overview.

Figure 2-2. Combined Effluent Distribution System elevation gradient extending between the xeric sand hill (A) and upper Perdido Bay (A').

Figure 2-3. Location of EDS zones.

Figure 2-4. Location of CEDP monitoring stations.

Figure 3-1. Location of hydrologic monitoring stations.

Figure 3-2. Water levels for depression and flat wetland monitoring locations, 2008-2017 (precipitation shown for reference).

Figure 3-3. Water levels for wetland slough monitoring locations, 2008-2017 (precipitation shown for reference).

Figure 3-4. Water levels for tidal monitoring locations, 2008-2017 (precipitation shown for reference).

Figure 4-1. Location of groundwater monitoring wells.

Figure 4-2. Comparison of baseline (2003-2005), 2012 through 2016, and 2017 groundwater temperature at the background, interior, and compliance wells.

Figure 4-3. Comparison of baseline (2003-2005), 2012 through 2016, and 2017 groundwater specific conductivity at the background, interior, and compliance wells.

Figure 4-4. Comparison of baseline (2003-2005), 2012 through 2016, and 2017 groundwater pH at the background, interior, and compliance wells.

Figure 4-5. Comparison of baseline (2003-2005), 2012 through 2016, and 2017 groundwater turbidity at the background, interior, and compliance wells.

Figure 4-6. Comparison of baseline (2003-2005), 2012 through 2016, and 2017 groundwater sodium at the background, interior, and compliance wells.

Figure 4-7. Comparison of baseline (2003-2005), 2012 through 2016, and 2017 groundwater total kjeldahl nitrogen (TKN) at the background, interior, and compliance wells.

Figure 4-8. Comparison of baseline (2003-2005), 2012 through 2016, and 2017 groundwater ammonia at the background, interior, and compliance wells.

Figure 4-9. Comparison of baseline (2003-2005), 2012 through 2016, and 2017 groundwater nitrate at the background, interior, and compliance wells.

Figure 4-10. Comparison of baseline (2003-2005), 2012 through 2016, and 2017 groundwater total dissolved solids (TDS) at the background, interior, and compliance wells.

Figure 4-11. Comparison of baseline (2003-2005), 2012 through 2016, and 2017 groundwater sulfate at the background, interior, and compliance wells.

Figure 4-12. Comparison of baseline (2003-2005), 2012 through 2016, and 2017 groundwater chloride at the background, interior, and compliance wells.

Figure 4-13. Comparison of baseline (2003-2005), 2012 through 2016, and 2017 groundwater color at background, interior, and compliance wells.

Figure 4-14. Comparison of baseline (2003-2005), 2012 through 2016, and 2017 groundwater odor at the background, interior, and compliance wells.

Figure 4-15. Comparison of baseline (2003-2005) and 2012 through 2016, and 2017 groundwater total organic carbon (TOC) at the background, interior, and compliance wells.

Figure 4-16. Comparison of baseline (2003-2005), 2012 through 2016, and 2017 groundwater antimony at the background, interior, and compliance wells.

Figure 4-17. Comparison of baseline (2003-2005), 2012 through 2016, and 2017 groundwater arsenic at the background, interior, and compliance wells.

Figure 4-18. Comparison of baseline (2003-2005), 2012 through 2016, and 2017 groundwater chromium at the background, interior, and compliance wells.

Figure 4-19. Comparison of baseline (2003-2005), 2012 through 2016, and 2017 groundwater iron at the background, interior, and compliance wells.

Figure 4-20. Comparison of baseline (2003-2005), 2012 through 2016, and 2017 groundwater manganese at the background, interior, and compliance wells.

Figure 4-21. Comparison of baseline (2003-2005), 2012 through 2016, and 2017 groundwater nickel at the background, interior, and compliance wells.

Figure 4-22. Comparison of baseline (2003-2005), 2012 through 2016, and 2017 groundwater zinc at the background, interior, and compliance wells.

Figure 4-23. Comparison of baseline (2003-2005), 2012 through 2016, and 2017 groundwater chloroform at the background, interior, and compliance wells.

Figure 4-24. Comparison of baseline (2003-2005), 2012 through 2016, and 2017 groundwater ethylbenzene at the background, interior, and compliance wells.

Figure 5-1. Location diel in-situ water quality stations at the International Paper combined effluent distribution system.

Figure 5-2. Annual summary 48-hour diel water temperature (°C) data for the EDS and freshwater reference stations during combined pre-effluent and individual post-effluent monitoring years 2012 through 2017.

Figure 5-3. Annual summary 48-hour diel specific conductivity (µS/cm) data for the EDS and freshwater reference stations during combined pre-effluent and individual post-effluent monitoring years 2012 through 2017.

Figure 5-4. Annual summary 48-hour diel pH (S.U.) data for the EDS and freshwater reference stations during combined pre-effluent and individual post-effluent monitoring years 2012 through 2017.

Figure 5-5. Annual summary 48-hour diel dissolved oxygen (DO) percent saturation data for the EDS and freshwater reference stations during combined pre-effluent and individual post-effluent monitoring years 2012 through 2017.

Figure 5-6. Annual summary 48-hour diel dissolved oxygen (DO) concentration (mg/L) data for the EDS and freshwater reference stations during combined pre-effluent and individual post-effluent monitoring years 2012 through 2017.

Figure 5-7. Annual summary 48-hour diel water temperature (°C) data for the receiving water (TWT01 and TWT02) and reference (TWR01) tidal stations during combined pre-effluent and individual post-effluent monitoring years 2012 through 2017.

Figure 5-8. Annual summary 48-hour diel specific conductivity (µS/cm) data for the receiving water (TWT01 and TWT02) and reference (TWR01) tidal stations during combined pre-effluent and individual post-effluent monitoring years 2012 through 2017.

Figure 5-9. Annual summary 48-hour diel salinity (ppt) data for the receiving water (TWT01 and TWT02) and reference (TWR01) tidal stations during combined pre-effluent and individual post-effluent monitoring years 2012 through 2017.

Figure 5-10. Annual summary 48-hour diel pH (S.U.) data for the receiving water (TWT01 and TWT02) and reference (TWR01) tidal stations during combined pre-effluent and individual post-effluent monitoring years 2012 through 2017.

Figure 5-11. Annual summary 48-hour diel dissolved oxygen (DO) percent saturation data for the receiving water (TWT01 and TWT02) and reference (TWR01) tidal stations during combined pre-effluent and individual post-effluent monitoring years 2012 through 2017.

Figure 5-12. Annual summary 48-hour diel dissolved oxygen (DO) concentration (mg/L) data for the receiving water (TWT01 and TWT02) and reference (TWR01) tidal stations during combined pre-effluent and individual post-effluent monitoring years 2012 through 2017.

Figure 6-1. Location of analytical water quality grab stations.

Figure 6-2. Delineation of EDS zones used for analysis of water quality variables.

Figure 6-3. Annual summary total phosphorus concentrations for freshwater portions of the EDS and freshwater reference wetlands from pre-effluent and post-effluent 2012 through 2017 monitoring years.

Figure 6-4. Annual summary orthophosphate concentrations for freshwater portions of the EDS and freshwater reference wetlands from pre-effluent and post-effluent 2012 through 2017 monitoring years.

Figure 6-5. Total phosphorus concentrations moving from the outfall through Zones 1 and 2 of freshwater portions of the EDS and into the Zone 3 tidal creek (GS05) and tidal lake (TWT) portions of the EDS.

Figure 6-6. Annual summary total nitrogen concentrations for freshwater portions of the EDS and freshwater reference wetlands from pre-effluent and post-effluent 2012 through 2017 monitoring years.

Figure 6-7. Annual summary total kjeldahl nitrogen (TKN) concentrations for freshwater portions of the EDS and freshwater reference wetlands from pre-effluent and post-effluent 2012 through 2017 monitoring years.

Figure 6-8. Annual summary nitrite+nitrate concentrations for freshwater portions of the EDS and freshwater reference wetlands from pre-effluent and post-effluent 2012 through 2017 monitoring years.

Figure 6-9. Total nitrogen concentrations moving from the outfall through Zones 1 and 2 of freshwater portions of the EDS and into the Zone 3 tidal creek (GS05) and tidal lake (TWT) portions of the EDS.

Figure 6-10. Annual summary ammonia concentrations for freshwater portions of the EDS and freshwater reference wetlands from pre-effluent and post-effluent 2012 through 2017 monitoring years.

Figure 6-11. Annual summary sulfate concentrations for freshwater portions of the EDS and freshwater reference wetlands from pre-effluent and post-effluent 2012 through 2017 monitoring years.

Figure 6-12. Annual summary 5-day biochemical oxygen demand concentrations for freshwater portions of the EDS and freshwater reference wetlands from pre-effluent and post-effluent 2012 through 2017 monitoring years.

Figure 6-13. 5-day biochemical oxygen demand concentrations moving from the outfall through Zones 1 and 2 of freshwater portions of the EDS and into the Zone 3 tidal creek (GS05) and tidal lake (TWT) portions of the EDS.

Figure 6-14. Annual summary color values for freshwater portions of the EDS and freshwater reference wetlands from pre-effluent and post-effluent 2012 through 2017 monitoring years.

Figure 6-15. Annual summary turbidity values for freshwater portions of the EDS and freshwater reference wetlands from pre-effluent and post-effluent 2012 through 2017 monitoring years.

Figure 6-16. Annual summary total suspended solids concentrations for freshwater portions of the EDS and freshwater reference wetlands from pre-effluent and post-effluent 2012 through 2017 monitoring years.

Figure 6-17. Annual summary total organic carbon concentrations for freshwater portions of the EDS and freshwater reference wetlands from pre-effluent, and post-effluent 2012 through 2017 monitoring years.

Figure 7-1. Soil chemistry sample locations and corresponding zones used for grouping analysis.

Figure 7-2. Summary of soil pH by zone and sampling event.

Figure 7-3. Summary of soil cation exchange capacity (CEC) by zone and sampling event.

Figure 7-4. Summary of soil base saturation (BS) by zone and sampling event.

Figure 7-5. Summary of soil carbon to nitrogen (C:N) ratio by zone and sampling event.

Figure 8-1. Location of wetland macroinvertebrate monitoring stations.

Figure 8-2. Summary macroinvertebrate Shannon-Weiner diversity scores from combined pre-effluent and post-effluent EDS stations, and the freshwater reference stations between 2008 and 2017.

Figure 8-3. Summary macroinvertebrate taxa richness results from combined pre-effluent and post-effluent EDS stations and freshwater reference stations between 2008 and 2017.

Figure 8-4. Summary of total herbaceous Wetland Condition Index (WCI) scores from the freshwater EDS and reference stations, 2008 to 2017.

Figure 8-5. Summary of total forested Wetland Condition Index (WCI) scores from the freshwater EDS and reference stations, 2008 to 2017.

Figure 8-6. Summary macroinvertebrate Wetland Condition Index (WCI) results from combined pre-effluent and post-effluent EDS stations and freshwater reference stations between 2008 and 2017.

Figure 8-7. Two dimensional NMS bi-plot solution of macroinvertebrate data collected between years at the EDS stations.

Figure 8-8. Ad hoc group cluster analysis of macroinvertebrate data collected from EDS stations in all years and color coded by year, indicating the within group fidelity of most years.

Figure 8-9. Parsimonious group cluster analysis of macroinvertebrate data collected from EDS stations during all monitoring years.

Figure 9-1. Location of vegetation monitoring stations.

Figure 9-2. Location of vegetation monitoring stations and vegetation zones.

Figure 9-3. Conservation management areas and vegetation monitoring plots.

Figure 9-4. EDS average canopy species densities between 2008 and 2017: A) Harvested stations within Zone 1 (n=8); B) Non-harvested stations within Zones 2 and 3 (n=29).

Figure 9-5. Conservation Area canopy species characterization, 2008 through 2017.

Figure 9-6. EDS and Conservation Area freshwater station species richness by year. Box plots present the median ± 20^{th} and 80^{th} percentiles (box) and non-outlier range (whisker).

Figure 9-7. EDS and Conservation Area freshwater station effective species richness by year. Box plots present the median ± 20^{th} and 80^{th} percentiles (box) and non-outlier range (whisker).

Figure 9-8. EDS and Conservation Area freshwater station Shannon-Wiener diversity by year. Box plots present the median ± 20^{th} and 80^{th} percentiles (box) and non-outlier range (whisker).

Figure 9-9. EDS and Conservation Area freshwater station evenness by year. Box plots present the median ± 20th and 80th percentiles (box) and non-outlier range (whisker).

Figure 9-10. Autumn relative percent dominance for species with importance values > 0.075 within the EDS.

Figure 9-11. Autumn average plot occurrence frequency for species with importance values > 0.075 within the EDS.

Figure 9-12. Autumn relative percent dominance for species with importance values > 0.075 within the Conservation Area.

Figure 9-13. Autumn average plot occurrence frequency for species with importance values > 0.075 within the Conservation Area.

Figure 9-14. Conservation area species richness trends by land management type between 2008 and 2017. Letter groups denote statistical similarity or difference at $p<0.05$ based upon Kruskal-Wallis median test.

Figure 9-15. Conservation area Shannon-Wiener diversity trends by land management type between 2008 and 2017. Letter groups denote statistical similarity or difference at $p<0.05$ based upon Kruskal-Wallis median test.

Figure 10-1. Location of marine analytical water quality grab stations.

Figure 10-2. Daily discharge by major freshwater inflow to Upper Perdido Bay, 2010–2017.

Figure 10-3. Summary total phosphorus concentrations in samples collected from EDS tidal receiving waters during 2012–2017 monitoring events. The red line indicates the numeric nutrient criteria threshold which no more than 10% of samples collected in the most recent seven years can exceed.

Figure 10-4. Summary ortho-phosphate concentrations in samples collected from EDS tidal receiving waters during 2012–2017 monitoring events.

Figure 10-5. Summary total nitrogen concentrations in samples collected from EDS tidal receiving waters during 2012–2017 monitoring events. The red line indicates the numeric nutrient criteria threshold which no more than 10% of samples collected in the most recent seven years can exceed.

Figure 10-6. Summary total Kjeldahl nitrogen concentrations in samples collected from EDS tidal receiving waters during 2012–2017 monitoring events.

Figure 10-7. Summary total ammonia nitrogen concentrations in samples collected from EDS tidal receiving waters during 2012–2017 monitoring events.

Figure 10-8. Summary total nitrite-nitrate concentrations in samples collected from EDS tidal receiving waters during 2012–2017 monitoring events.

Figure 10-9. Summary chlorophyll-a concentrations in samples collected from EDS tidal receiving waters during 2012–2017 monitoring events. The red line indicates the numeric nutrient criteria threshold which no more than 10% of samples collected in the most recent seven years can exceed.

Figure 10-10. Summary sulfate concentrations in samples collected from EDS tidal receiving waters during 2012–2017 monitoring events.

Figure 10-11. Summary total organic carbon concentrations in samples collected from EDS tidal receiving waters during 2012–2017 monitoring events.

Figure 10-12. Summary color unit values in samples collected from EDS tidal receiving waters during 2012–2017 monitoring events.

Figure 10-13. Summary turbidity values in samples collected from EDS tidal receiving waters during 2012–2017 monitoring events.

Figure 10-14. Summary total suspended solids concentrations in samples collected from EDS tidal receiving waters during 2012–2017 monitoring events.

Figure 10-15. Summary BOD concentrations in samples collected from EDS tidal receiving waters during 2012–2017 monitoring events.

Figure 11-1. Location of Elevenmile Creek water quality and biological monitoring stations.

Figure 11-2. Trends in Stream Condition Index macroinvertebrate relative percent dominance for all taxa that represented greater than a 10% relative dominance during a single monitoring event at SWB-1 and SWD-1 between 2010 and 2017.

LIST OF PLATES

Plate 2-1. Effluent outfall location at the eastern extent of Berm 1, view east, December 2012.

Plate 2-2. Berm 1 view west depicting flow control structures and planted hummocks, August 2012.

Plate 2-3. Overland flow area within Zone 1 view west, October 2016.

Plate 2-4. Slash pine swamp forest located in Zone 2 view north, October 2015.

Plate 2-5. Hummock area within the Berm 4 inundation area, October 2015.

Plate 2-6. Forested wetland located in Zone 2 view south, August 2012.

Plate 2-7. Swamp forest located within the freshwater to brackish water transitional area view east, October 2014.

Plate 2-8. Brackish water marsh located in Zone 3 view west, May 2012.

Plate 2-9. Tee and Wicker Lake complex view east, May 2016.

Plate 2-10. Lower Elevenmile Creek view upstream approximately 1-mile upstream from the mouth, May 2016.

Plate 2-11. Xeric sandhill habitat located in the northern section of the conservation area, October 2016.

Plate 2-12. Seepage slope wetland located within the conservation area near the footslope of the xeric sandhill view west, October 2015.

Plate 2-13. Wet prairie habitat located in the central portion of the conservation area view east, October 2016.

Plate 2-14. Hydric pine savannah located in the central portion of conservation area view east, October 2014.

Plate 2-15. Representative titi (Cliftonia monophylla) dominated wetland located within the conservation area view north, October 2016.

Plate 2-16. Representative hydric pine flatwoods located in the conservation area view east, October 2016.

Plate 11-1. Elevenmile Creek upstream of Hwy 297a (SWD-1), (A) August 2011, (B) August 2012, (C) December 2012, (D) August 2014, and (E) August 2016.

Plate 11-2. Coffee Branch near Jamesville Lane (SWB-1): (A) August 2011, (B) August 2012, (C) December 2012, (D) August 2014, (E) August 2016, and (F) November 2017.

Executive Summary

International Paper (IP) has prepared, in conjunction with Nutter & Associates, Inc., the 2017 Annual Discharge Monitoring Report for the Combined Effluent Distribution Project (CEDP) pursuant to NPDES permit FL0002526 and State of Florida Consent Order 08-0358 requirements. Contributors from Nutter & Associates included Alan Moore, a stream and wetland ecologist, Tony Greco, an aquatic and wetland ecologist, Lane Rivenbark, a professional soil scientist, Shelley Dodd, an aquatic ecologist, and Drew Miller, a groundwater specialist. Dr. Wade Nutter, a Professional Hydrologist, provided technical review and oversight. Additional information regarding land management activities was provided by Mark Free, Wetland Solutions. This report was compiled primarily based upon data collected by Nutter & Associates' scientists from the CEDP site. Additional information regarding effluent discharge records was provided by Laurie McLain, Environment, Health, and Safety Manager, International Paper.

In 2012, IP initiated the removal of effluent flow to Elevenmile Creek and application, via a 10 mile gravity-flow pipeline, to the 1,406 acre effluent distribution system (EDS). Beginning in January 2012, flow was ramped-up incrementally to the EDS and reached 100% flow to the EDS by the end of October 2012. During the 12-month ramp-up period, the average effluent flow was 12.52 million gallons per day (MGD) and averaged 22.55 MGD following 100% effluent discharge to the EDS. Pursuant to State of Florida Consent Order requirements, several land management practices have been implemented in a 1,258 acre conservation area adjacent to the EDS as well as within the EDS. Land management has included prescribed burning and mechanical shrub reduction within the conservation area, and the planting of 160,698 canopy and 15,000 sub-canopy species within the EDS. In combination, the EDS and conservation areas comprise the larger CEDP site.

The CEDP site is comprised of several upland and wetland ecosystems that generally grade from a xeric sandhill in the northern portion of the site through a mosaic of freshwater wetland depressions, sloughs, and flats, and eventually into a tidally influenced brackish water marsh system adjacent to Perdido Bay in the south. The EDS was designed with four primary effluent distribution berms to increase effluent residence time on the site and to collect and evenly redistribute effluent across the EDS, thus preventing mass channelization and "short circuiting". As a part of the monitoring program, the EDS site was divided into zones based on the analysis of interest, in order to characterize water quality and ecological conditions. EDS zones differed depending on the specified analysis, and specific zone boundaries are identified in each chapter.

The purpose of the report is to present and evaluate data collected within the Upper Perdido Bay, the Perdido River, Elevenmile Creek, and the freshwater and tidally influenced wetlands associated with the CEDP project as outlined in the NPDES and WRP permits. Field monitoring during 2017 was conducted between February and December. Specific monitoring studies included quarterly surface water *in-situ* and analytical quality, quarterly groundwater quality, autumn soil chemistry, autumn herbaceous vegetation surveys, winter benthic macroinvertebrate sampling, continuous hydrological monitoring, and annual Elevenmile Creek water quality and ecology assessments. Baseline data collection began in 2003 and culminated in a series of reports documenting water quality and biological community conditions within the vicinity of the project through 2011.

Hydrology

Water levels were tracked across four different wetland types during the 2017 monitoring period and compared to data collected during the 2008 to 2011 baseline period and previous years of EDS operation in 2012 through 2016. With the exception of the tidal sites, water levels at all EDS locations, irrespective of wetland type, were elevated during the 2017 monitoring period relative to baseline conditions. Further, natural water level fluctuations were generally reduced–attributable to a combination of sustained higher water volumes introduced to the site and the management of water levels via the control structures installed on each berm. Due to increased water volumes in the EDS, the most substantial difference in freshwater EDS wetlands and freshwater reference wetlands is the muted response to normal precipitation events in the EDS compared to the more dramatic response to precipitation events in the freshwater reference wetlands. The above average rainfall in Pensacola resulting from several tropical storm systems in the Gulf of Mexico, resulted in slightly higher median water levels in the EDS and tidal lakes in 2017, when compared with previous post-effluent monitoring years. The tidal receiving waters and Upper Perdido Bay are hydrologically influenced by freshwater inputs from the Perdido River, Elevenmile Creek, and the EDS, as well as daily and seasonal tidal dynamics. Freshwater inputs largely influence water quality of tidal receiving waters, whereas marine tidal dynamics have a stronger influence on daily and seasonal water elevations, and to some extent, depending on seasonal meteorological effects, also influence water quality.

Groundwater

FDEP states that groundwater chemical and physical parameters must be in compliance with the state's drinking water standards, except if natural background conditions exceed those standards. Exceedances of the specific permit limits were observed at compliance well MWC6 for water quality parameters pH, iron, and odor and at compliance well MWC7 for water quality parameters pH, and iron. In all but two cases of permit exceedances for pH, the compliance well water quality parameter values were within the range of baseline values collected between 2003 and 2005, during 2012 through 2016 post-effluent monitoring, and historical groundwater data collected from regional wells between 1994 and 1997. The pH value at MWC7 fell slightly below baseline and historic pH values during the first quarter spring sampling event but was above the minimum value collected between 2012 and 2016. It is unlikely that low groundwater pH values at MWC7 are due to EDS operations as the effluent discharge to the EDS has resulted in a substantial increase in EDS surface water pH to neutral values (~7.0 S.U.) With the exception of one lower than background pH reading at MWC7, and one higher than background odor result at MWC6, the 2017 groundwater quality at the CEDP wells fell within background conditions and met NPDES permit limits as stated by the FDEP.

In-situ Water Quality

Following effluent application, increased specific conductivity and pH readings were observed when compared to pre-effluent conditions. Within the EDS, specific conductivities in the range of 1,100 µS/cm and 1,600 µS/cm and neutral pH readings (6.5 – 7.5 S.U.) predominate. Specific conductivity and salinity were considerably lower in 2017 in comparison to previous post-effluent monitoring years, likely the result of the proximity of dates when samples were collected during or after heavy precipitation events which resulted

in depressed values due to surface and shallow groundwater runoff and dilution. Effluent specific conductivity, salinity, and pH have little effect on the water quality within the Tee and Wicker Lake Complex largely due to tidal and freshwater inputs from adjacent rivers and streams. Seasonal meteorological cycles and the degree of freshwater inflows to the Upper Perdido Bay appeared to influence diel water quality (especially specific conductivity and salinity) more so than effluent application. Dissolved oxygen saturation was similar to or above pre-effluent conditions within the EDS. A petition to implement Type II Site Specific Alternative Criteria (SSAC) for specific conductivity, pH, and dissolved oxygen is in progress for the freshwater portions of the EDS. A petition to implement Type II dissolved oxygen SSAC for the marine waters is also in progress.

Freshwater EDS Analytical Water Quality

Based on analytical water quality monitoring of 100% operational flows to the EDS in 2013 through 2017, it appears that the removal of effluent discharge from the headwaters of Elevenmile Creek and subsequent application to the EDS wetlands has resulted in beneficial improvements to water quality within the tidal receiving waters. Values for nutrients and other water quality variables have remained similar to other post-effluent monitoring years. Total phosphorus concentrations decline substantially as water moves south through the EDS. Zonal analyses also indicated declines in total nitrogen (TN) and biochemical oxygen demand concentrations as water moves through the EDS. The reductions in nutrient loading to Upper Perdido Bay and the adjacent marshes will promote the continued presence of a healthy and well-balanced biological community. In 2017, there were declines in, sulfate, TOC, TSS, BOD and color over previous post-effluent monitoring years. Other than turbidity, there were no substantial increases in water quality variables in 2017 compared with previous post-effluent monitoring years within the EDS. Based on the 2017 monitoring record, it appears that the EDS is functioning as designed and water quality is improving to the tidal receiving waters and Upper Perdido Bay as a result of diverting effluent from the headwaters of Elevenmile Creek and into the EDS wetlands.

Soils

Differences in soil chemical properties beyond normal variation were attributed primarily to changes between sampling events (pre-and-post EDS construction conditions, ramp-up and full operations, etc.). There appear to be minimal differences related to zonal designation. Notable differences include an overall increase in soil pH, BS, and nutrient availability, and a decrease in available sodium in year five. Some differences (e.g., pH, SAR) do appear to be related to zonal designation. The CEC on the site has remained low during the ramp-up period and during the first five years of operation. Base saturation has increased significantly from pre-effluent conditions to the ramp-up period and during the first five years of operation. The base saturation and soil pH are interrelated, and in general base saturation increases with increasing soil pH. There has been an overall increase in soil pH, which has contributed to an increase in availability of the majority of the analyzed plant available and/or exchangeable macro- and micro-nutrient content during the ramp up period and first five years of operation. The median P sorption capacity on the EDS site ranged from 220 to 401 lbs/acre/ft of soil across all zones and depths in year five, respectively, suggesting significant P sorption capacity remains on the EDS. In general the C:N ratio has

been at, or greater than 30:1 throughout the ramp up period and first five years of operation, so it is assumed that much of the soil N has been immobilized through uptake.

Wetland Benthic Macroinvertebrates

Metrics for evaluating the freshwater EDS macroinvertebrate community included established wetland community indices and diversity metrics used commonly in community ecology evaluations of ecological integrity, as well as multivariate analyses assessing community structural differences. The EDS has had year over upward or downward changes in macroinvertebrate diversity. The 2017 diversity metrics were lower than all other post-effluent years except the summer of 2014, although differences between years other than summer 2014 were not statistically significant. Wetland Condition Index metrics have remained similar to pre-effluent and reference conditions during the course of 100% operational flows since late 2012. It may prove significant that there has been little separation in ordination space and cluster analysis for those data collected in winter and summer of 2014 through 2017. There were dramatic changes in benthic macroinvertebrate community structure that occurred year over year between 2011 and 2014 due to the multiple changes in environmental variables associated with the application of effluent flows. Those variables included changes in the wetland hydroperiod to a perennial hydroperiod with greater depths, changes in vegetative community and habitat availability resulting from large scale vegetation mortality and introductions of new vegetative species, as well as changes in water quality constituents. Dramatic community structural changes did not occur between samples collected between winter 2014 and 2017 suggesting that the macroinvertebrate community within the EDS may be stabilizing compared with the early phases of effluent distribution between 2012 and 2014. Further changes in community structure are expected as the vegetative community transforms to a more mature forested system, however, those changes would likely occur slowly over time.

Vegetation

Based upon the results of vegetation community sampling, several vegetative community trends were observed on the overall project site. Increased hydroperiods since 2012 coupled with the historic presence of silvicultural established canopy species (i.e. slash and loblolly pine) within the EDS has resulted in a large decline in canopy species density and abundance between 2008 and 2017 due to mass tree mortality. It is anticipated that canopy species native to the area and tolerant of long periods of inundation (i.e. bald and pond cypress, swamp tupelo, sweetbay, etc) will become reestablished within the EDS. Additionally, initial construction of the EDS in 2011 also contributed to canopy species declines observed since 2012. Differences in soil chemistry, surface water quality, and hydrology were correlated with vegetation community differences and similarities between stations and between pre- and post-effluent conditions, although surface water quality may be coincidental to the increase of water depth and prolonged inundation across the EDS site. Preliminary results indicate that land management activities within the Conservation Area are resulting in increased vegetative community diversity when compared to unmanaged areas. It is anticipated that continued management to maintain an open canopy will continue to stimulate a diverse herbaceous and graminoid community. Future post-project monitoring events will be compared to pre-project results in order to document further ongoing changes in vegetation communities within the EDS and Conservation Areas.

Marine EDS and Perdido Bay

Effects of typical hydrologic dynamics as well as regional climate conditions were evident in 2017 monitoring data collected in the tidal receiving waters of the EDS, including lower Elevenmile Creek, Tee and Wicker Lakes, and upper Perdido Bay. Several tropical storms in the Gulf of Mexico brought above average precipitation to the Pensacola region in 2017. Total 2017 annual precipitation at PNS was 92 inches, which was 28 inches higher than the long-term annual average precipitation recorded at the PNS from 1981 through 2010. The excess rainfall contributed to chlorophyll-a concentration in the Bay stations during the summer sampling event. Despite the heavy rainfall events, total phosphorus and total nitrogen concentrations were lower in 2017 than previous years in tidal receiving waters directly adjacent to the EDS including lower Elevenmile Creek and Tee and Wicker Lakes. The numeric nutrient criteria for the upper Perdio Bay has continued to be met for total phosphorus and total nitrogen but was exceeded for chlorophyll-a in 15% of samples collected since 2012. Based on color, turbidity, and transparency data collected in 2017, the EDS tidal receiving waters are not impaired due to high concentrations of sediments or other particulate matter in the water column. Transparency was highest during the fall monitoring event, probably due to low rainfall totals in November. Phytoplankton cell densities and biovolumes have varied over the 2012 – 2017 monitoring years. Although increased algal biomass in the warm summer months would be expected, high rainfall totals in August 2017 likely contributed to the observed increase in biomass due to excess runoff from the Bay's watershed. Based on the 2017 monitoring record, the EDS is functioning as designed and water quality is improving in the tidal receiving waters and Upper Perdido Bay due to the diversion of effluent flows from the Elevenmile Creek headwaters to the EDS wetlands.

Elevenmile Creek

Based upon the results of both water quality and biological monitoring, effluent discharge to Elevenmile Creek through October 2012 resulted in a deviation in various water quality parameters and aquatic biological community characteristics when compared to reference conditions. Since removal of the effluent, water quality parameters measured in Elevenmile Creek are more similar to those measured in Coffee Branch. In monitoring years 2013 – 2017, water quality in Elevenmile Creek has been relatively stable, and year-to-year variations are attributable to climatic conditions at the time of sampling.

Despite the changes in water quality in Elevenmile Creek since 2013, abundance metrics from macroinvertebrate data from both stations continue to indicate lower biological diversity at SWD-1 compared to SWB-1. Although physical habitat assessment scores for Elevenmile Creek have remained similar across all monitoring years, SCI scores and taxa richness in SCI samples from Elevenmile Creek were significantly higher during 2015 through 2017 compared to all previous monitoring events. SCI index calculations indicate that a higher diversity of more sensitive macroinvertebrate taxa are now present at SWD-1 than in previous years. The observed shift in macroinvertebrate community structure is likely associated with the reduction in nutrients, increase in dissolved oxygen, and overall water quality improvement that has occurred since effluent discharge was removed from Elevenmile Creek. A significant drop in baseflow of Elevenmile Creek occurred after 100% of effluent flow was redirected to the EDS, which resulted in a change to stream morphology and macroinvertebrate habitat availability. As the stream continues to transition to a more

stable morphological condition, macroinvertebrate habitat is expected to be variable between years. Based on observed changes in water quality and macroinvertebrate community in Elevenmile Creek in years since effluent removal, it is anticipated that macroinvertebrate communities will continue to shift towards a higher diversity of organisms and a lower abundance of pollution-tolerant filter feeders as water quality continues to improve.

1.0 INTRODUCTION

Pursuant to NPDES Permit No. FL0002526 issued on March 15, 2010 for the International Paper (IP) Cantonment Mill, removal of effluent from Elevenmile Creek and the reapplication to a large wetland tract adjacent to the Perdido Bay was initiated in February of 2012. The principal components of the project were to upgrade the treatment plant resulting in an improvement of effluent quality and relocation of the discharge from Elevenmile Creek to the aforementioned wetland tract. The Emerald Coast Utilities Authority (ECUA) and International Paper jointly sponsor the Combined Effluent Distribution Project (CEDP) and flows to the CEDP will include an average daily discharge of 23.8 mgd by IP and up to 5.0 mgd by ECUA. Also, IP is currently accepting reuse quality wastewater from ECUA in their manufacturing process. The effluent is delivered to the wetland by a gravity-flow pipeline approximately 10 miles in length (Figure 1-1). As of October 2012, mill effluent has been entirely removed from the freshwater portions of Elevenmile Creek during normal operations. As part of the CEDP, comprehensive water quality and ecological studies were implemented prior to initiation of effluent flows to the CEDP. These studies are ongoing and include assessments of Elevenmile Creek, the freshwater and tidally influenced portions of the effluent distribution wetland area, herein referred to as the Effluent Distribution System (EDS), and a large conservation and mitigation area adjacent to the EDS, and Upper Perdido Bay. As specified in the NPDES permit, annual reporting and analysis of data collected as a part of these studies are required. This report presents data collection and analysis pursuant to Calendar Year (CY) 2017 monitoring.

In addition to the EDS, the CEDP project includes an adjacent approximately 1,258 acre conservation easement mitigation area (Figure 1-2). The conservation area is actively managed to restore, enhance, and/or maintain habitat types considered by the Florida Natural Areas Inventory to be imperiled. Due to ongoing maintenance, many of these areas now support numerous documented occurrences and/or populations of State listed threatened or endangered plant species, primarily including pitcher plants (*Sarracenia leucophylla, S. psitticina, S. rosea*) and the spoonleaf sundew (*Drosera intermedia*).

1.1 Monitoring Framework

A framework for monitoring the CEDP was prepared in April, 2004 and updated in June, 2008 by Robert J. Livingston, Environmental Planning & Analysis, Inc. (EP&A), Wade L. Nutter, Nutter & Associates, Inc., and Alan Niedoroda, URS Corporation (Tallahassee Office). 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 and 2010–2011)

Stage 3. Ramp-up discharge monitoring (2012)

Stage 4. Routine monitoring (2013–2017)

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 based on the framework for monitoring of the CEDP has been implemented in the Upper Perdido Bay, tidal ponds adjacent to the bay, Elevenmile Creek, Perdido River, EDS freshwater wetlands, and all conservation/mitigation areas.

A series of monitoring goals were established in the 2004 Framework document. The goals, which are detailed below, provide the rationale for implementation of the Initial and Long-term Monitoring Plans required as a part of the NPDES permit (FL0002526). The *Initial Discharge Monitoring Plan* (September 2011) and the *Final Discharge Monitoring Plan* (November 2012) were developed to initiate post-effluent wetland monitoring and assess landscape-scale parameters (i.e. vegetative communities, flow patterns, and general water quality trends). Monitoring results over the course of CY 2012 through CY 2017 have been utilized to manage and evaluate effluent flow and distribution across the EDS site, document the environmental conditions following effluent discharge to the wetland ecosystem, and document ecosystem effects as a result of land management activities conducted within the conservation area. This demonstration will provide data to verify that no change in designated use occurs. The goals of the monitoring are to:

- Document the environmental conditions in the freshwater portion of Elevenmile Creek;

- Document the effect of the project on the water quality conditions of the tidal portion of Elevenmile Creek, the tidal ponds (Tee and Wicker Lakes), and the adjacent areas of Upper Perdido Bay; and

- Document the improvement in overall response of the Upper Perdido Bay ecosystem to reduced nutrient inputs.

1.1.1 Monitoring History

Prior to the distribution of effluent to the EDS in 2012, an extensive water quality and biological evaluation was conducted to establish baseline conditions on the project site. Pre-effluent baseline data collection was implemented in 2003 and continued through January 2011. The results of pre-effluent baseline monitoring conducted between 2003 and 2008 are presented in two previously submitted reports: 1) *Integrated Monitoring - July 2005 through April 2007, ECUA/IP Combined Effluent Distribution Project* (March 2008) and 2) *Baseline Surface Water Quality Monitoring - June 2003 through April 2007, ECUA/IP Combined Effluent Distribution Project* (May 2008). The aforementioned reports were prepared by Nutter & Associates, Inc. except the Integrated Monitoring report which included the results of the 3-year pre-effluent monitoring conducted by Dr. Livingston of EP&A, along with Dr. Livingston's 19-year study of the Perdido Bay system.

Both the *Integrated Monitoring* and *Baseline Surface Water Quality Monitoring* reports focused on water quality conditions within the freshwater and tidally influenced portions of the CEDP site. Additional pre-effluent baseline monitoring results conducted between 2008 and 2011 were submitted to the FDEP in a report entitled *Supplemental Baseline Monitoring Report 2008-2011* (September 2011). As part of the Supplemental Baseline Monitoring Report 2008-2011, the following studies were conducted across different wetland classes, including freshwater and marine water ecosystems, on the CEDP site:

- Monitor and assess shallow groundwater dynamics in relationship to temporal and climatic conditions;
- Conduct soil chemistry analyses;
- Assess benthic macroinvertebrate community composition; and
- Document and characterize vegetative communities.

Pre-effluent baseline monitoring through 2011 represents the completion of Stages 1 and 2 of the initial CEDP monitoring framework. Monitoring during the Stage 3 Ramp-up Discharge Monitoring period was completed over the course of 2012 and is detailed in the 2012 Annual Monitoring Report (January 2013). Monitoring during Stage 4 Routine Monitoring occurred over the course of 2013 through 2017 and results are detailed in the 2013 through 2017 Annual Monitoring Reports submitted to the FDEP.

As a part of the 2015 NPDES permit renewal, a new monitoring program for the CEDP was established in efforts to consolidate monitoring methodologies and to reduce the scale of the monitoring. The new monitoring program, as detailed in the *Surface Water Monitoring Plan* (August 2014), was initiated during CY 2015 and will continue through the end of the current NPDES permitting period. This report presents the findings of CY 2017 monitoring.

1.2 Construction and Planting

Construction of the effluent pipeline, effluent redistribution berms, and tree planting hummocks was initiated in September 2010 and completed by September 2011. Within the EDS, almost six miles of earthen berms, 50 flow-control structures, and an effluent distribution structure that releases water to the wetlands with passive aeration were constructed between 2010 and 2011. Hummocks were constructed in all areas of inundation greater than 6 inches in depth in order to facilitate the establishment of canopy and mid-canopy vegetation. Hummocks were constructed at various sizes depending on inundation depth.

Planting within the effluent pipeline corridor and the hummock areas was conducted between January and March 2011 for canopy species and between October and November 2011 for all sub-canopy species. In total, 160,698 canopy and 15,000 sub-canopy species comprising 17 taxa were planted on the EDS site. All planting was conducted in accordance with Wetlands Resource Permit (WRP) No. 17-0207101-002-DF.

1.3 Effluent Flows

Beginning on February 1, 2012, effluent was introduced to the EDS site and was gradually ramped-up between February and October 2012. Between February and March 2012, flow to the wetlands ranged between 17% (3.6 MGD) and 25% (5 to 6 MGD) of the total mill flow. Between April and June, flow to the wetlands ranged between 32% (6.7 MGD) and 46% (10.2 MGD) of total mill flow. By September 2012, flow to the wetlands reached 75%. By October 1, 2012, 100% of the total mill flow was allocated to the wetlands which equated to an average daily flow of 21.23 MGD. Between 2013 and 2017, 100% of the total mill flow continued to be allocated to the EDS site.

1.4 Report Approach

This report documents the completion of CY 2017 monitoring as outlined in the *Surface Water Monitoring Plan* (August 2014). Where appropriate, comparisons of CY 2017 monitoring data are evaluated against pre-effluent baseline monitoring data, ramp-up monitoring data, and post-effluent CY 2013 through CY 2016 annual monitoring data.

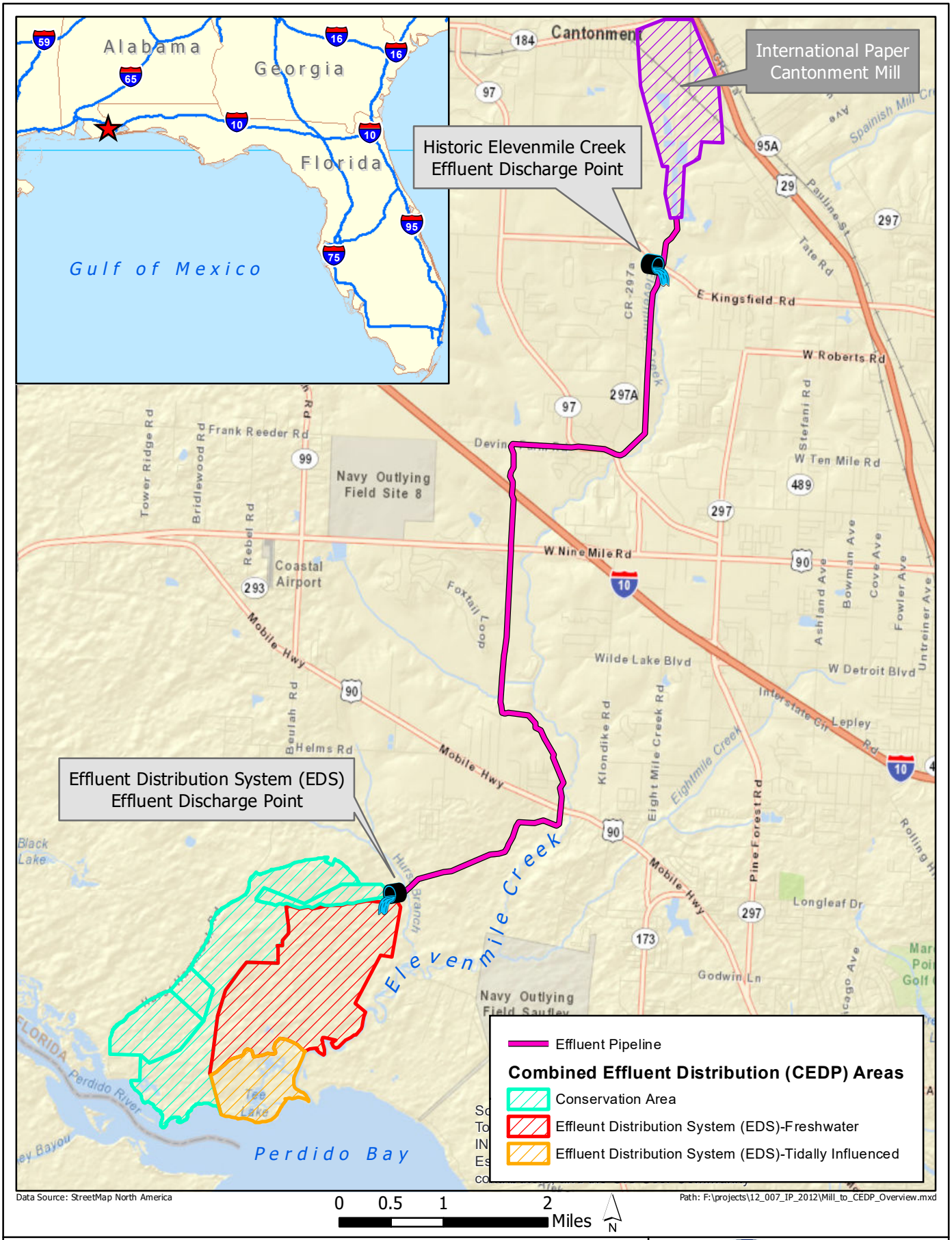


Figure 1-1. Combined Effluent Distribution Project (CEDP) overview and vicinity map.

Nutter & Associates
environmental consultants

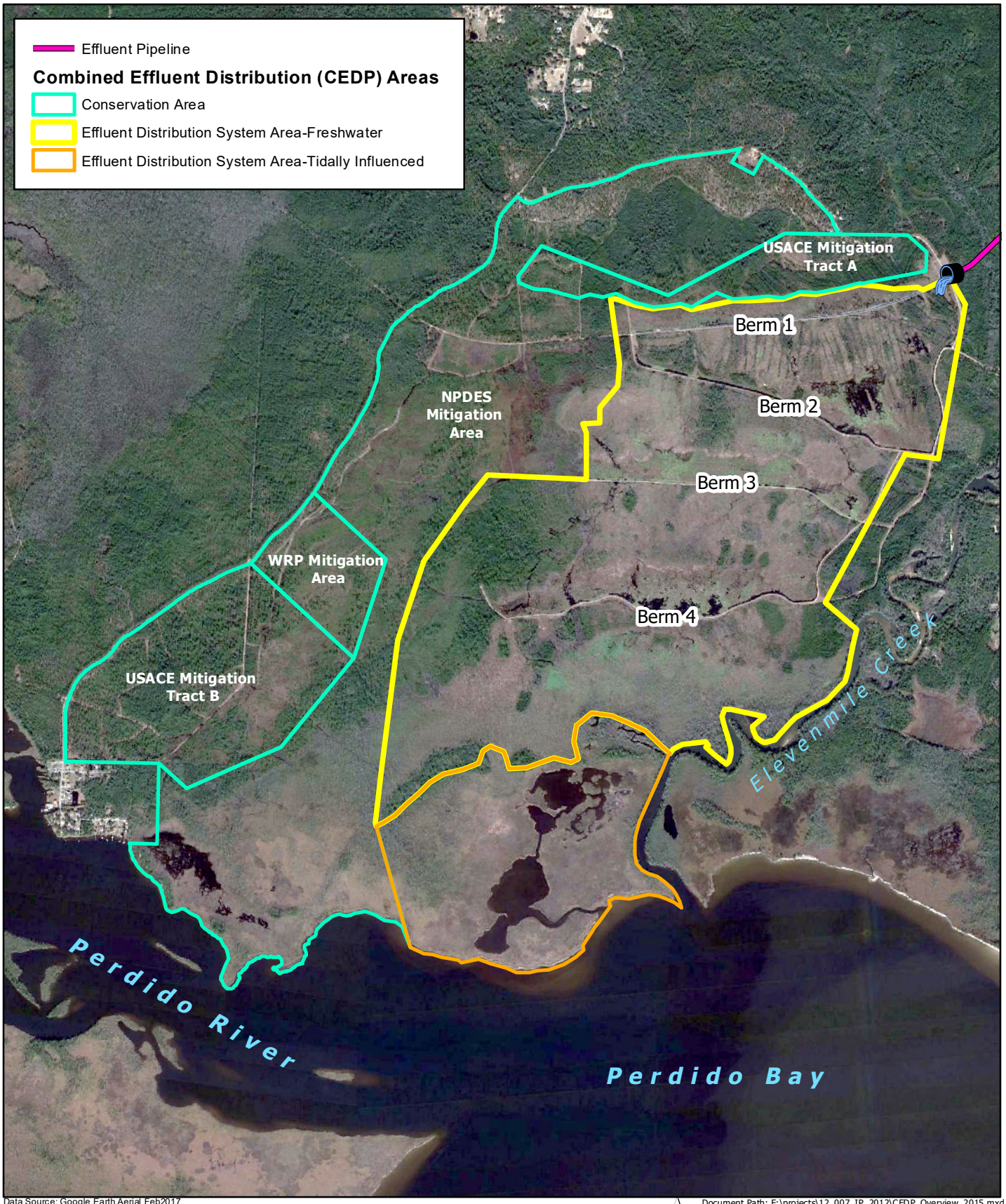


Figure 1-2. Combined Effluent Distribution Project (CEDP) overview.

Nutter & Associates
environmental consultants

2.0 CEDP SITE AND STATION CHARACTERIZATION

2.1 General Site Characterization

The combined effluent distribution project (CEDP) is located near Hurst Hammock, Florida, adjacent and north of the Upper Perdido Bay, and approximately 10 miles west of downtown Pensacola, Florida. The effluent distribution system (EDS) lies between Elevenmile Creek to the east, the Upper Perdido Bay to the south, and an 1,258 acre mitigation/conservation area to the north and west (Figure 2-1). The conservation area extends from the EDS to the community of Hurst Hammock south and east of Hurst Hammock Road. A ten mile pipeline distributes effluent from the International Paper pulp processing mill in Cantonment, Florida south to the EDS.

2.1.1 Climate

Historical climate data were compiled for the Pensacola Regional Airport weather station using the Southeast Regional Climate Center website. The average annual temperature for the Pensacola region between 1981 and 2010 was 68 °F. The average annual precipitation between 1981 and 2010 was 63.69 inches. Monthly average precipitation and temperature at the Pensacola Regional Airport during the 2017 monitoring period are provided in Table 2-1. During CY 2017, a total of 91.31 inches of rainfall were recorded which is approximately 27.62 inches above historic average precipitation conditions. Well above average precipitation conditions were observed during June, August, and October 2017 due to tropical storms. Well below average precipitation conditions were observed from February to March, and July, September, and November 2017 (Table 2-1).

2.1.2 Topography

Historically within the freshwater portion of the EDS, there were areas of wetland sloughs, flats, and depressions as based upon the hydrogeomorphic wetland classification system developed by Brinson (1993). The depression and flat wetlands occurred in areas with slopes less than 0.5 percent. The sloughs were present in areas with slightly higher slopes where natural drainage features created positive flow and non-continuous anastomose channel features within the EDS wetlands. Due to the introduction of effluent flows, wetland features have changed in many locations due to the persistent presence of hydrology throughout the EDS. The EDS system terminates into a series of tidal creeks, estuary wetlands, and tidal ponds adjacent to the Upper Perdido Bay.

The conservation areas adjacent to the EDS consist of a combination of flats, sloughs, depressional, and slope wetlands as well as xeric pine flats and gentle pine slopes of 2-5%. In the northern portion of the property there is a relatively large upland pine terrace with slopes of up to 5%. The lower slope portion of the terrace contains seepage wetlands and pine flat wetlands that extend to the boundary of the Berm 1 inundation area. An elevational depiction of the project site is included in Figure 2-2 and illustrates the topographic gradient based upon National Elevation Data 1/3 ArcSecond Digital Elevation Models extending from the xeric pine terrace to upper Perdido Bay.

2.1.3 CEDP Land Use History

Anthropogenic disturbances on the CEDP tracts began in the late 19th and early 20th centuries when conventional railroad logging techniques were used to harvest timber from the site. Subsequent to this initial harvest, the site was managed for continued timber production, naval stores, and open range grazing. During this time, which lasted into the mid-1900's, fire was an important management tool that was used to control undesired woody vegetation, increase grazing opportunities, and maintain access for the naval stores operations. With the decline of the naval stores industry and open range grazing interests, fire became excluded from the site, and the site was planted with slash and loblolly pine to convert the area to fiber production. Since that time, the site was actively managed for fiber/forest products. Various forest roads and ditches were in place throughout the site and several roads in the conservation area still exist today. Additional site disturbances include a 2001 wildfire which burned large portions of the conservation and EDS areas and historic tropical storms. Prior to construction of the EDS and protection of the surrounding conservation area, black titi (*Cliftonia monophyla*), swamp titi (*Cyrilla racemiflora*), loblolly pine (*Pinus taeda*), and slash pine (*Pinus elliottii*) were the dominate species with pond cypress (*Taxodium ascendens*), sweetbay (*Magnolia virginiana*), swamp tupelo (*Nyssa sylvatica var. biflora*), and Atlantic white cedar (*Chamaecyparis thyoides*) present in some low-lying areas.

Prior to the allocation of 100% effluent flow to the EDS, Elevenmile Creek transmitted effluent from the mill to the Upper Perdido Bay. As a result of the proximity of the EDS site to Elevenmile Creek, the tidal influence of the Bay, and based upon historic observations and studies, effluent periodically was present within the tidally influenced portions of the EDS site, including the Tee and Wicker Lake complex. Thus, pre-effluent baseline EDS water quality characterizations within the tidally influenced portions of the site do not represent true no-effluent conditions

2.1.4 CEDP Habitat Enhancements

A series of elevated hummocks upgradient of each effluent redistribution Berm were constructed within the EDS freshwater wetland area to increase habitat for wetland flora and fauna and to establish a canopy and mid-canopy layer within the inundated areas. Bottomland wetland tree species were planted to restore the natural vegetative community in the EDS flats. The conservation/mitigation areas surrounding the EDS are being managed with a combination of mechanical shrub removal and prescribed burns. Management of the conservation areas is being targeted to reestablish characteristic vegetative communities which are typically dominated by a relatively open canopy and a diverse and fire dependent herbaceous community. Specific habitat types being targeted include hydric pine savannah, wet prairie, and hydric pine flatwood communities. The upland pine flats and terraces in the conservation areas are being replaced by longleaf pine (*Pinus palustris*) plantings and managed with prescribed burns to restore the natural longleaf pine savannah forest systems that occupied this region prior to anthropogenic disturbance and management.

2.1.5 Current EDS Layout

The 1,406-acre EDS lies within a freshwater wetland system north of the Upper Perdido Bay and terminates into a series of tidal estuary ponds adjacent to the Bay and Elevenmile Creek in the southern portion of the site (Figure 2-1). The freshwater portions of the EDS are separated by four artificial Berms designed to control the flow of effluent through the EDS through riser board outfall structures situated along the length of each Berm. These Berms are identified as Berms 1 through 4 and are oriented east to west moving from north to south across the site (Figure 2-1). The EDS was divided into three zones to summarize water quality data collected (Figure 2-3). Zone 1 includes the EDS area north of Berm 4; Zone 2 includes freshwater areas south of Berm 4; and Zone 3 includes all tidal wetland and tidal pond areas adjacent to the Upper Perdido Bay (Figure 2-3). Representative photographs of the EDS and conservation areas are included in Plates 2-1 through 2-16.

2.2 Station Descriptions and General Methodologies

Water quality, multivariate, and vegetation monitoring stations were established throughout the 2,664 acre CEDP, including within the 1,406 acre EDS, the tidal ponds (Tee and Wicker Lake complex), and reference areas in the 1,258 acre conservation area. A sample station matrix of sampling parameters for all stations is provided in Table 2-2. Multivariate stations included those stations where some combination of hydrological, water quality grab sampling, *in-situ* water quality sampling, and biological sampling occurred (Table 2-2). All other stations included surface water or groundwater grab sampling or are stations associated with the Elevenmile Creek and Perdido Bay stations that include surface water and biological sampling.

2.2.1. CEDP Multivariate Stations

Some combination of hydrological, biological, and water quality monitoring (both *in-situ* physiochemical and analytical) was conducted at the multivariate monitoring stations, which were segregated prior to the construction of the EDS into four primary landscape settings based on the hydrogeomorphic classification of wetlands: tidal, sloughs, flats, and depressions. The major portion of the site under tidal influence is the Tee and Wicker Lakes and marsh complex (Zone 3, Figures 2-3 and 2-4), whereas the sloughs, flats, and depressions occur in the freshwater wetlands upgradient from the Lakes complex (Zones 1 and 2 and Conservation Areas) (Figure 2-4).

Multivariate station identification codes were assigned based on hydrogeomorphic classification: (Flats (F), Slough (S), Depression (D), Tidal (T)), and proposed treatment zones (Effluent Treatment Stations (T), Non-effluent Control Stations (C), and Reference Stations (R). Station identification codes assume the following form:

HWT##

Where H = Hydrogeomorphic Class = Flats (F), Slough (S), Depression (D), Tidal (T)
W = "Wetland"

T = Treatment = Effluent Treatment Stations (T), Non-effluent Control Stations (C), and Reference Stations (R).

For example, station SWT03 stands for slough wetland (SW), Effluent Treatment (T), station 03. Table 2-2 identifies the sample stations and indicates the sampling parameters for each station.

Station identifications were established in earlier monitoring documents and have not been changed in this monitoring report. In practice, the term "control" indicates areas in which historic disturbance regimes, similar to those conducted within the EDS, were conducted. The term "reference" indicates areas in which disturbance activities were not evident based upon field reconnaissance. For all other sampling parameters including hydrological, water quality, and benthic macroinvertebrates, control stations are referred to as reference stations, since these stations do not receive a hydrological change equal to increases in hydrology due to effluent discharge into the EDS. Table 2-3 lists the multivariate stations, their salinity regime, and whether those stations are control, reference, or treatment (EDS) stations according to which parameter is being evaluated.

2.2.1.1 Multivariate Sampling Stations Wetland Settings

Multivariate stations were segregated into four wetland settings: tidal, sloughs, flats, and depressions based on the conditions prior to construction and operation of the EDS. Due to the hydrologic changes that have occurred since 100% operational flows were initiated, some stations may not exhibit the hydrogeomorphic wetland features identified prior to implementation of the EDS. Physiochemical and analytical water quality data were collected from each station. Benthic macroinvertebrates were collected at freshwater stations only. All multivariate stations served as vegetation stations in addition to the vegetation-only stations. During previous studies, some stations were relocated, others were removed entirely, and new stations were sited. The data presented in this report compares data from each station sampled in CY 2017 with 2012 ramp-up discharge monitoring data, 2013 through 2016 annual 100% effluent discharge monitoring data, and pre-effluent baseline monitoring data, to compare water quality conditions on and adjacent to the CEDP site.

Tidal Wetland Stations

The reference tidal station (TWR01) is located approximately 0.64 linear miles northwest of Hurst Landing in an embayment on the left bank of the Perdido River (Figure 2-4). Primary access to this station is by boat from the Perdido River, and the station itself is exposed to low fetch from the southeast. The area is generally protected by marsh islands with various densities of woody perennial trees and shrubs.

The EDS tidal station (TWT01) is located on the western shore of Wicker Lake in Zone 3 of the EDS (Figure 2-4). This is also the location of an automated stage recorder installed in February 2003 to monitor fluctuations in the water level of Wicker Lake. TWT01 is exposed to greater fetch than the reference tidal station at TWR01, primarily from the southeast. There is more open water at TWT01 compared with TWR01, and TWT01 is surrounded on three sides by estuarine/freshwater marsh with only widely scattered woody vegetation. The EDS tidal station TWT02 is located on the western shore of Tee lake south of TWT01 in

Zone 3 of the EDS (Figure 2-4). This station is surrounded by brackish black needle rush (*Juncus roemerianus*) marsh and exposed to fetch from the southeast.

Slough Wetland Stations

The reference slough station (SWR01) is located approximately 0.7 miles west of Hurst Hammock Road on River Road (Figure 2-4). The station is sited approximately 70 feet north of River Road in a relatively undisturbed slough characterized by numerous multithreaded channels, hummocks, and perennially saturated or inundated conditions. Swamp tupelo (*Nyssa sylvatica* var. *biflora*), pond cypress (*Taxodium ascendens*), and sweetbay (*Magnolia virginiana*) dominate the upper canopy. The understory is somewhat sparse due to heavy shade provided by canopy trees and the perennially saturated conditions. Virginia chain fern (*Woodwardia virginiana*) and cat briar (*Smilax laurifolia*) are two of the more prominent herbaceous components growing on natural hummocks at SWR01.

One (1) treatment slough, SWT03, is currently being monitored (Figure 2-4). SWT03 is characterized by a defined, multi-threaded channel with a narrow riparian zone. Slash pine, black titi (*Cliftonia monophylla*), swamp tupelo, and sweetbay dominate the riparian corridor. SWT03 lies within Zone 2 just south of Berm 4. Due to its landscape position and location downgradient of Berm 4, continuous flow has been observed at this station following the application of effluent to the EDS.

Wetland Flats

The treatment flat FWT03 was added during the January 2007 monitoring event. FWT03 lies between Berms 3 and 4 in Zone 1 just east of a large fire break remnant of the 2001 wildfire (Figure 2-4). FWT03 is located within a broad, sloping flat that exhibited low flow conditions during a majority of post-effluent monitoring events.

In April 2007, a control flat, FWC01, was located to the west of the proposed wetted effluent area and to the east of Hurst Hammock Road (Figure 2-4). FWC01 is located within a large depressional wetland area that exhibited near perennial inundation except during extremely dry time periods. Due to its depressional nature, flowing water conditions do not occur at this station. FWC01 was sited in the area which burned during the May 2001 wildfire and is subject to on-going land management activities.

Wetland Depressions

There are two treatment depressions (DWT01 and DWT02) located within the EDS (Figure 2-4). DWT01 is a treatment depression located south of Berm 4 (Zone 2) in the south-central portion of the project area, which was historically harvested for fuel wood (Figure 2-4). Due to its location downgradient of Berm 4, flowing water conditions were routinely observed at this station following effluent application to the EDS.

Station DWT02 was sited as a treatment depression located south of Berm 2 (Zone 1). DWT02 is characteristic of a true depressional wetland with very low to no flow conditions during post-effluent monitoring (Figure 2-4). DWT02 is characterized by a mixture of open water and vegetated hummocks.

2.2.2 CEDP Grab Sample Stations

GS05 is located in a tidal creek and water quality including quarterly grab samples and *in-situ* monitoring is conducted at this station. This station was established to assess water quality conditions in one of the primary outlets from the EDS flowing into lower Elevenmile Creek.

2.2.3 Perdido Bay Stations

Five (5) stations located in Upper Perdido Bay are included in the current monitoring program and include quarterly analytical and *in-situ* water quality analysis and semi-annual phytoplankton sampling (Figure 2-4). Stations PB01 and PB02 are in the northern portions of the Bay, and situated away from freshwater and shoreline areas. However, in the context of the entire Upper Perdido Bay, PB01 and PB02 are still relatively close to the freshwater sources and may not be representative of high salinity Upper Perdido conditions. Station PB03 is located at the mouth of the Perdido River (Figure 2-4). Stations PB04 and PB05 were both sited further south in the upper Perdido Bay to assess water quality in the Bay further away from the influence of Elevenmile Creek, Bayou Marcus, and the Perdido River.

2.2.4 Elevenmile Creek Stations

In accordance with Part I.E.4.b. of the NPDES permit, annual water quality and biological monitoring was conducted at six designated monitoring stations in the Elevenmile Creek watershed annually between 2010 and 2017. Monitoring is conducted yearly between June and August to monitor changes in Elevenmile Creek after the cessation of direct discharge to the creek. Five stations are located on Elevenmile Creek (SWU-1, SWD-1, SWD-2, SWD-3, and SWD-4) while one background station, located on Coffee Branch, is also monitored (SWB-1) (Figure 2-4 and Figure 11-1). These stations were monitored annually for water quality, while biological sampling was conducted only at stations SWD-1 and SWB-1.

Stations SWD-3 and SWD-4 were monitored quarterly for water quality synoptically with other quarterly grab sample monitoring. Benthic macroinvertebrates were monitored annually at SWD-1 and SWB-1 using FDEP Stream Condition Index sampling protocols.

2.2.5 CEDP Vegetation and Soil Sampling Stations

An additional layer of monitoring stations focusing on vegetative communities and soil characteristics were sited to provide additional sample coverage in areas anticipated to change most rapidly and/or to the greatest extent relative to pre-project conditions (Figure 2-4). Specifically, four target conditions were used to formulate the design and placement of additional sampling stations:

- Areas within the permanent EDS inundation zones or areas adjacent to the permanent EDS inundation zones where soil saturation is likely to become permanent;

- Areas within 100 meters downstream of the outfall structures where extant vegetative communities may be exposed and eventually adapt to physical conditions more typical of flowing water systems (i.e. lotic);

- Areas not in one of the above referenced areas, but otherwise within the EDS wetted effluent area (e.g. overland flow zones); and

- Areas located in the conservation areas, which will be subject to restoration activities (e.g. prescribed burning and mechanical shrub reduction).

Extant vegetative cover community types have been mapped throughout the EDS and conservation areas using the *Florida Land Use, Cover and Forms Classification System (FLUCCS)*, 3rd Edition (FDOT, 1999) (*S2 Habitats Conservation and Management*, Nutter & Associates, Inc. 2007). The proportion of each FLUCCS class occupying each of the above referenced three target conditions was used to apportion the number of additional vegetative sampling stations located within the wetted effluent and conservation areas.

Station identification codes were based on: 1) the broad-level site characterization zones (1 through 5 or N or W) introduced in the *Demonstration of No Significant Adverse Impact* (Nutter & Associates, Inc., August 2007); the assigned FLUCCS class of the community in which the station was located; and 3) an alphabetical character that designates the number of sample stations per FLUCCS category. Station identification codes for these added vegetation sampling stations assumed the following form:

2.2.5.1 Wetted Effluent Vegetation Stations:

vB-123a

where: v = vegetation sampling station
B = Berm area 1 - 5
123 = three-digit FLUCCS code classifying the existing vegetative community
a = alphabetical letter indicating the number of stations per FLUCCS class

For example, station v2-625c is a vegetative sampling station (v) located in Berm area 2 (i.e. between Berm 1 and Berm 2), it is located in a hydric pine flatwood community type (FLUCCS 625), and it is the third sampling station sited in this community type (c). A total of 33 vegetative monitoring stations were originally established within the wetted effluent area (Table 2-2; Figure 2-4). Vegetative monitoring was also conducted at four additional multivariate stations within the EDS as described above. In 2017, the number of vegetative stations sampled in the EDS was reduced from the originally established 37 stations to 20 stations as a result of data analysis that demonstrated a slowing in vegetative community change, redundancy in vegetative community monitoring results, and field health and safety concerns.

2.2.5.2 Conservation Area Vegetation Stations:

vC-123a

where: v = vegetation sampling station
C = Conservation area N (North) or W (West)
123 = three-digit FLUCCS code classifying the existing vegetative community
a = alphabetical letter indicating the number of stations per FLUCCS class

For example, station vW-643b is a vegetative sampling station (v) located in conservation area W (i.e. conservation area west of the EDS). It is located in a wet prairie community type (FLUCCS 643), and it is the second sampling station sited in this community type (b).

A total of 25 vegetative monitoring stations were established within the conservation area (Table 2-2; Figure 2-4). Vegetative monitoring was also conducted at two additional multivariate stations within the conservation area as described above.

2.3 Monitoring Report Organization

This report is organized into chapters for each monitoring parameter, with an additional chapter detailing the results of Elevenmile Creek monitoring in accordance with Part I.E.4.b. of the NPDES permit. Each chapter details the specific field and analytical methodologies, results, and discussions for each monitoring parameter. Report tables and figures as well as any associated appendices follow each chapter. Where possible, comparisons are made to baseline data collected prior to initial effluent discharge to the EDS and to data collected during Stage 3 and 4 monitoring. Chapters do not represent stand-alone reports as a given chapter, table, or figure reference, may refer to other chapter tables and figures. The following chapters document the completion of CY 2017 monitoring as outlined in the *Surface Water Monitoring Plan* (August 2014) submitted as a part of 2015 NPDES permit renewal. All laboratory reports and calibration records are included on a DVD attached to the report.

Table 2-1. Historic and CY2017 monthly climate data compiled from the Pensacola Regional Airport weather station.

Month	2017 Precipitation	Historic Average Precipitation (1981-2010)	2017 Average Daily Temperature	Historic Average Temperature (1981-2010)
	Inches		°F	
Jan	11.79	4.43	61	52
Feb	3.62	5.03	64	55
Mar	2.36	5.75	66	61
Apr	3.71	4.82	72	68
May	7.08	4.12	76	75
Jun	20.73	6.45	81	81
Jul	5.18	7.65	85	82
Aug	19.78	6.63	84	82
Sep	3.01	6.40	81	79
Oct	10.30	4.20	74	70
Nov	0.09	3.82	65	60
Dec	3.66	4.39	56	54
Total	**91.31**	**63.69**		

Table 2-2. Monitoring stations, station type, monitoring parameters, and frequency for the CY 2017 monitoring of the CEDP, Elevenmile Creek, and the Perdido Bay.

<table>
<tr><th>Station Name</th><th>Station Type</th><th>48 Hr Diel Water Quality</th><th>Water Quality Grab Stations</th><th>Hydrological</th><th>Soils</th><th>Benthic Macroinvertebrates</th><th>Vegetation</th><th>Phytoplankton</th></tr>
<tr><td>DWT01</td><td rowspan="8">CEDP Multivariate</td><td rowspan="6">Quarterly</td><td rowspan="19">Quarterly</td><td rowspan="5">Continuous</td><td rowspan="19">None</td><td rowspan="5">Annually (winter)</td><td rowspan="5">Annually (autumn)</td><td rowspan="5">None</td></tr>
<tr><td>DWT02</td></tr>
<tr><td>FWC01</td></tr>
<tr><td>FWT03</td></tr>
<tr><td>SWT03</td></tr>
<tr><td>SWR01</td></tr>
<tr><td>TWT01</td><td rowspan="12">None</td><td rowspan="12">None</td><td rowspan="2">Semi-annually (summer and autumn)</td></tr>
<tr><td>TWT02</td><td rowspan="11">None</td></tr>
<tr><td>TWR01</td><td rowspan="3">CEDP Surface Grab</td><td rowspan="2">None</td></tr>
<tr><td>Outfall</td><td>None</td></tr>
<tr><td>GS05</td><td rowspan="6">None</td></tr>
<tr><td>PB01</td><td rowspan="5">Perdido Bay Surface Grab</td><td rowspan="5">Semi-annually (summer and autumn)</td></tr>
<tr><td>PB02</td></tr>
<tr><td>PB03</td></tr>
<tr><td>PB04</td></tr>
<tr><td>PB05</td></tr>
<tr><td>MWB-1</td><td rowspan="6">CEDP Groundwater</td><td rowspan="6">Instantaneous - Quarterly</td><td rowspan="13">None</td></tr>
<tr><td>MWB-2</td></tr>
<tr><td>MWI-3</td></tr>
<tr><td>MWI-4</td></tr>
<tr><td>MWI-5</td></tr>
<tr><td>MWC-6</td></tr>
<tr><td>MWC-7</td><td rowspan="5">Elevenmile Creek Grab Station</td><td rowspan="3">Annually</td><td rowspan="2">Continuous</td></tr>
<tr><td>SWU-1</td></tr>
<tr><td>SWD-1</td><td>None</td><td>Annually (summer)</td></tr>
<tr><td>SWD-2</td><td>Continuous - USGS Gage</td><td rowspan="2">None</td></tr>
<tr><td>SWD-3</td><td rowspan="2">Quarterly</td><td rowspan="2">None</td></tr>
<tr><td>SWD-4</td></tr>
</table>

Table 2-2. Monitoring stations, station type, monitoring parameters, and frequency for the CY 2017 monitoring of the CEDP, Elevenmile Creek, and the Perdido Bay (continued).

Station Name	Station Type	48 Hr Diel Water Quality	Water Quality Grab Stations	Hydrological	Soils	Benthic Macroinvertebrates	Vegetation	Phytoplankton
Marsh1	CEDP Vegetation Sampling Station	None	None	None	None	None	Annually (autumn)	None
Marsh2								
TWC01								
V1-643a					Annually (autumn)			
V2-625a								
V2-625c								
V2-626c								
V3-625e								
V3-625f								
V3-625g								
V3-627a								
V3-627c								
V4-611c								
V4-625i								
V4-625k								
V4-643c								
V4-643d								
V5-625m								
V5-613a					None			
V5-613b								

Table 2-2. Monitoring stations, station type, monitoring parameters, and frequency for the CY 2017 monitoring of the CEDP, Elevenmile Creek, and the Perdido Bay (continued).

Station Name	Station Type	48 Hr Diel Water Quality	Water Quality Grab Stations	Hydrological	Soils	Benthic Macroinvertebrates	Vegetation	Phytoplankton
VN-411a	CEDP Vegetation Sampling Station	None	None	None	None	None	Annually (autumn)	None
VN-412a								
VN-412b								
VN-611a								
VN-614a								
VN-625a								
VN-625b								
VN-626a								
VN-627a								
VW-411a								
VW-611a								
VW-614a								
VW-625a								
VW-625b								
VW-625c								
VW-625d								
VW-625e								
VW-626a								
VW-626b								
VW-626c								
VW-626d								
VW-626e								
VW-627a								
VW-627b								

Table 2-3. Multivariate stations, salinity regime, and treatment designations for the 2017 CEDP monitoring period.

Station Name	Salinity Regime	Parameter	
		Vegetation	All Others
DWT01	Freshwater	EDS	EDS
DWT02			
FWC01		Control	Reference
FWT03		EDS	EDS
SWT03			
SWR01		Reference	Reference
TWR01	Tidal Brackish		
TWT01		EDS	EDS
TWT02			
GS05			

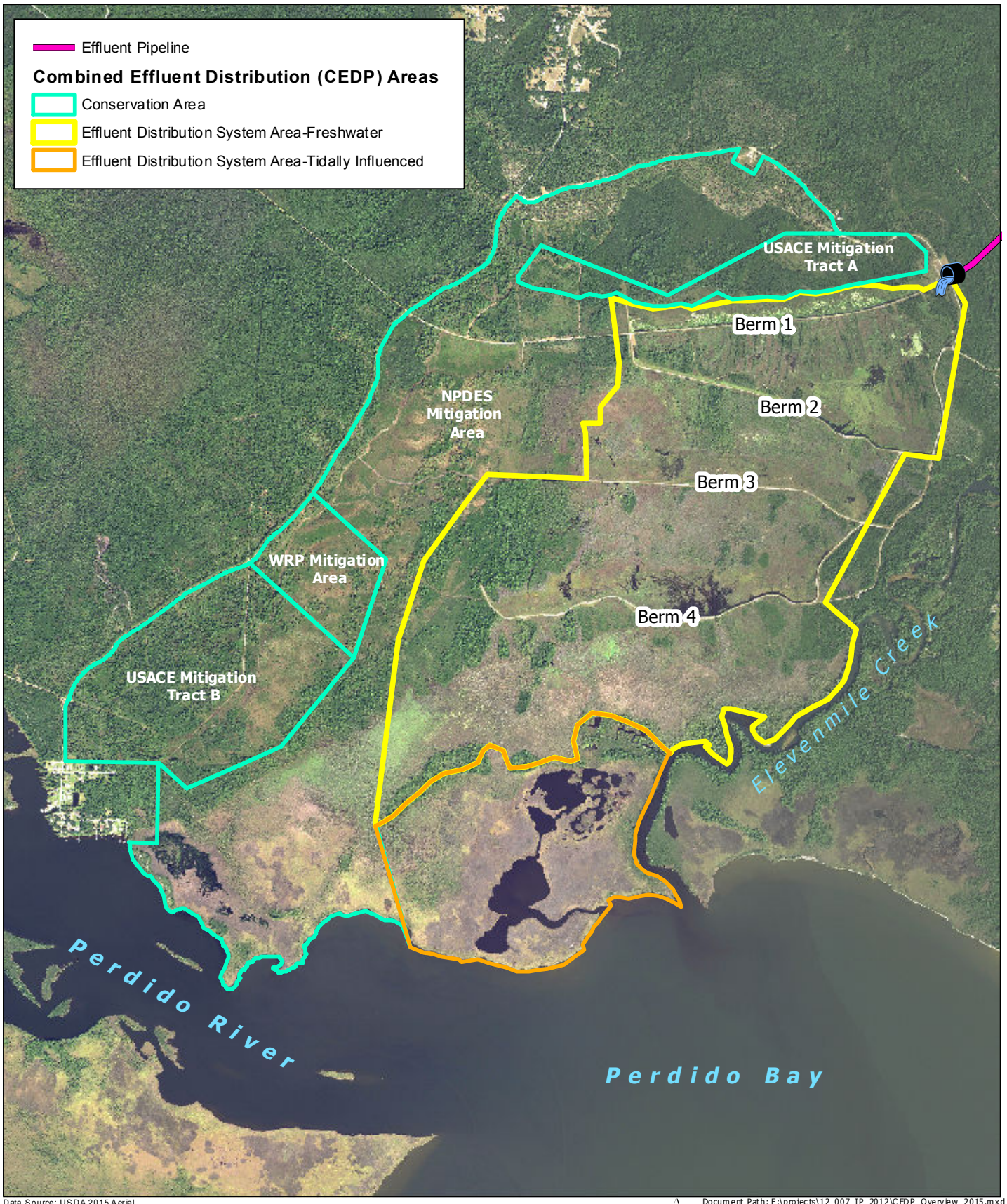


Figure 2-1. Combined Effluent Distribution Project (CEDP) overview.

Nutter & Associates
environmental consultants

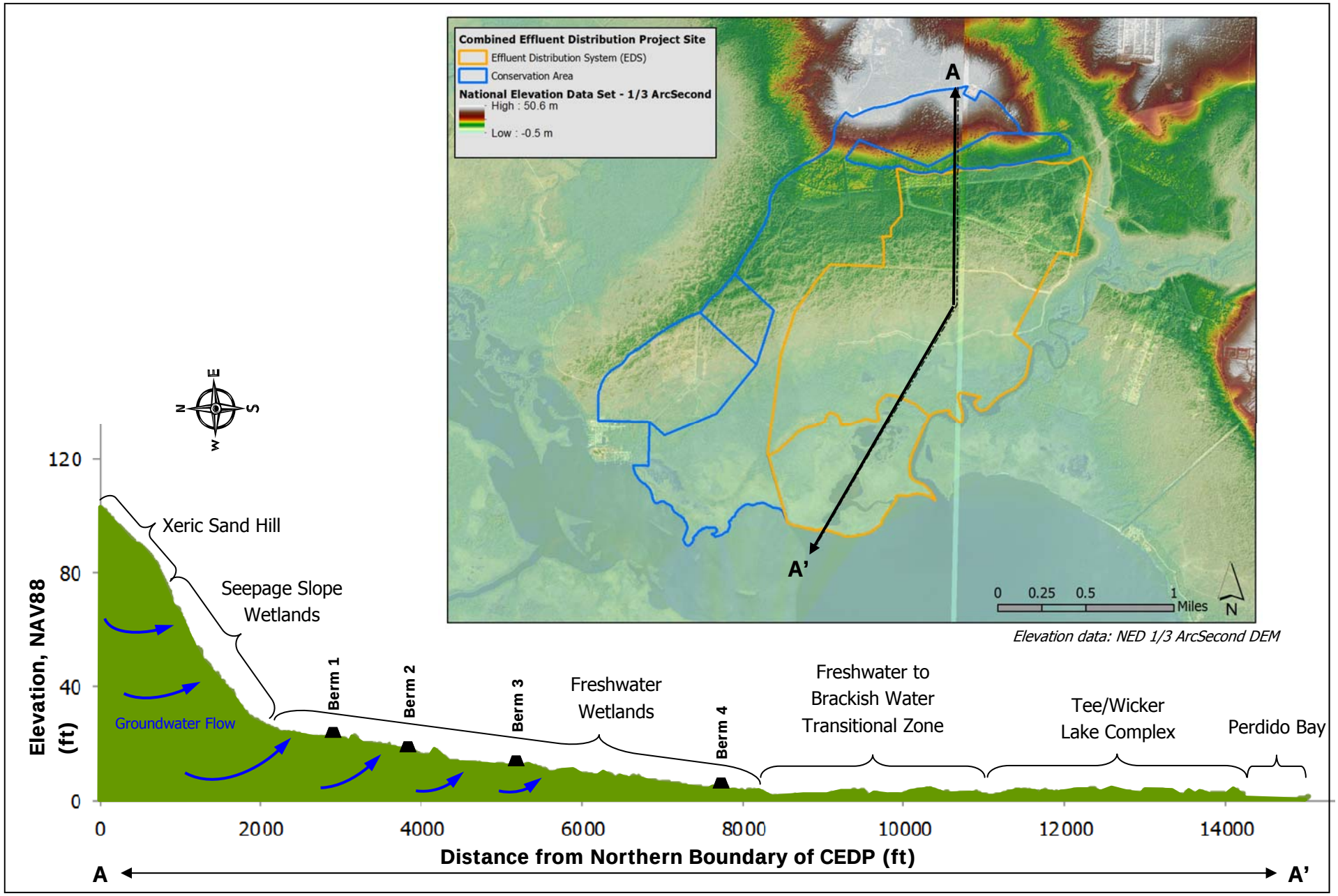
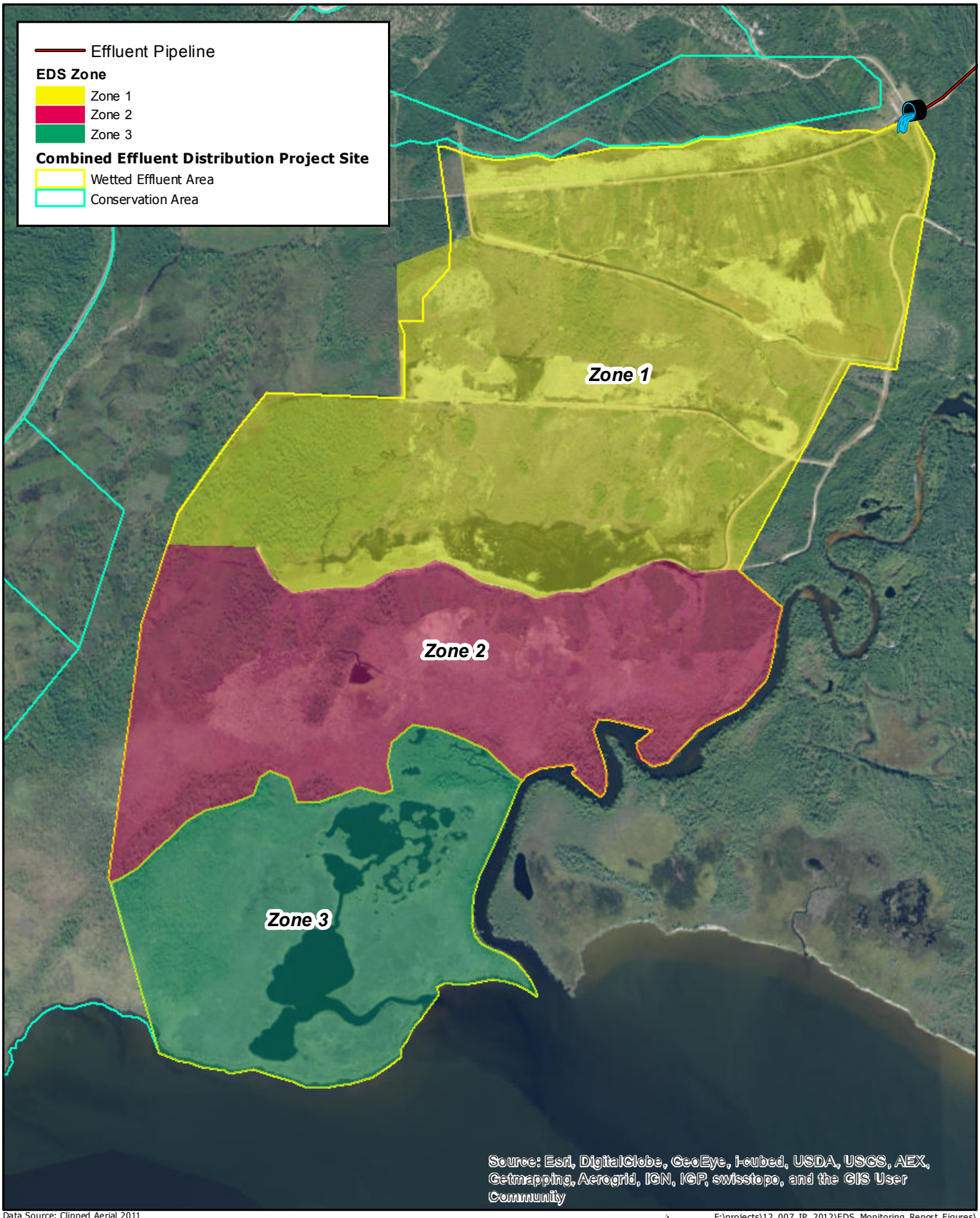


Figure 2-2. Combined Effluent Distribution System elevation gradient extending between the xeric sand hill (A) and upper Perdido Bay (A').



Data Source: Clipped Aerial 2011

0 1,000 2,000 4,000 Feet

N

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

Figure 2-3. Location of EDS zones.

Nutter & Associates
environmental consultants

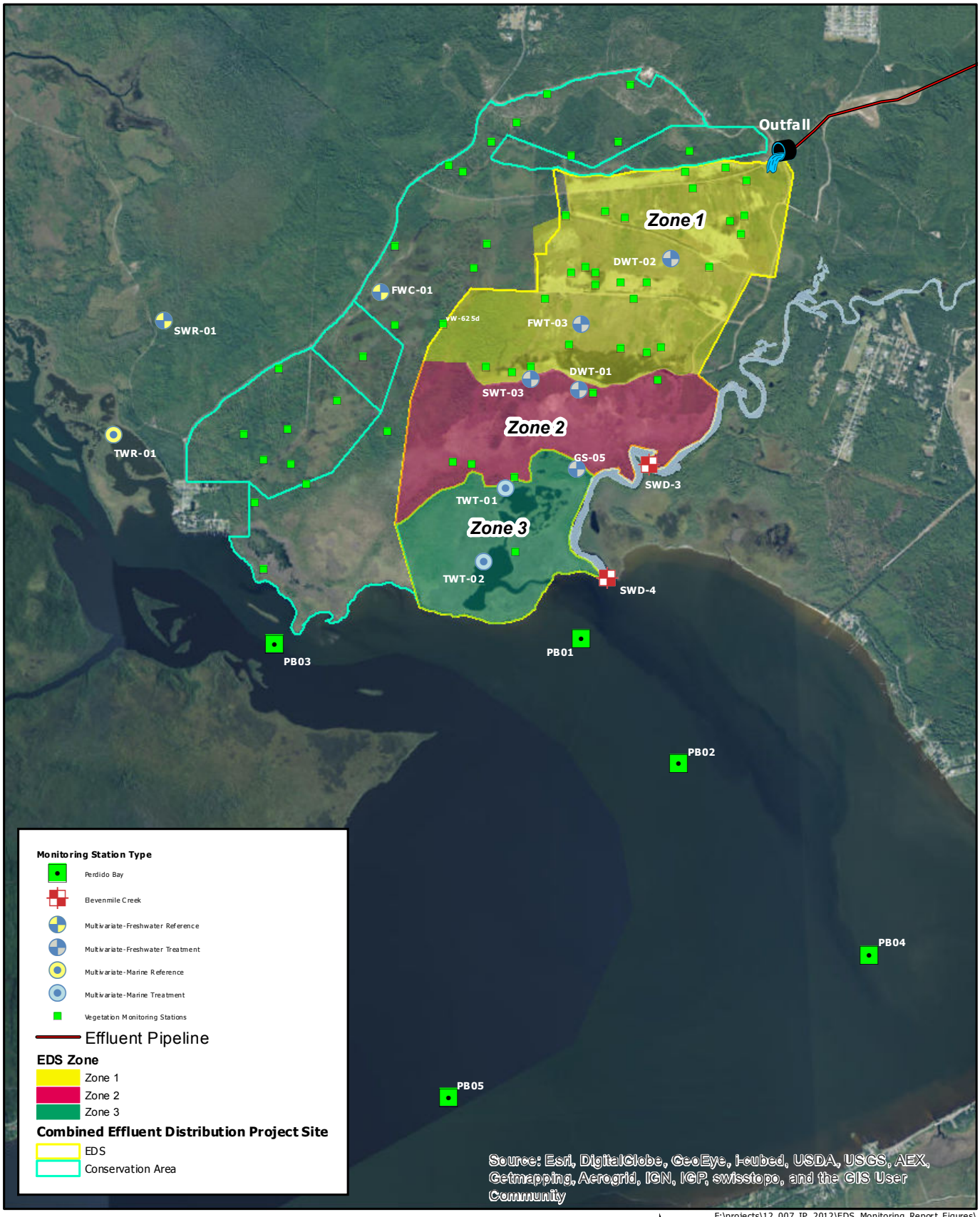


Figure 2-4. Location of CEDP monitoring stations.

Nutter & Associates
environmental consultants

Plate 2-1. Effluent outfall location at the eastern extent of Berm 1, view east, December 2012.

Plate 2-2. Berm 1 view west depicting flow control structures and planted hummocks, August 2012.

Plate 2-3. Overland flow area within Zone 1 view west, October 2016.

Plate 2-4. Slash pine swamp forest located in Zone 2 view north, October 2015.

Plate 2-5. Hummock area within the Berm 4 inundation area, October 2015.

Plate 2-6. Forested wetland located in Zone 2 view south, August 2012.

Plate 2-7. Swamp forest located within the freshwater to brackish water transitional area view east, October 2014.

Plate 2-8. Brackish water marsh located in Zone 3 view west, May 2012.

Plate 2-9. Tee and Wicker Lake complex view east, May 2016.

Plate 2-10. Lower Elevenmile Creek view upstream approximately 1-mile upstream from the mouth, May 2016.

Plate 2-11. Xeric sandhill habitat located in the northern section of the conservation area, October 2016.

Plate 2-12. Seepage slope wetland located within the conservation area near the foot-slope of the xeric sandhill view west, October 2015.

Plate 2-13. Wet prairie habitat located in the central portion of the conservation area view east, October 2016.

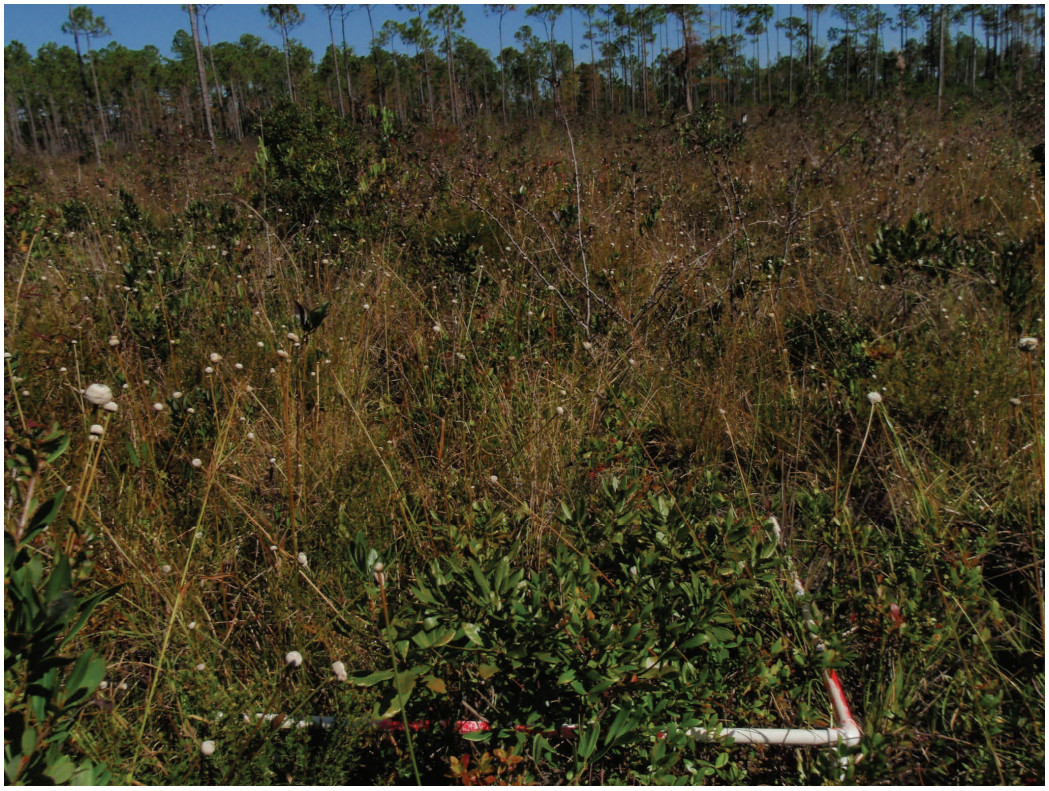


Plate 2-14. Hydric pine savannah located in the central portion of conservation area view east, October 2014.

Plate 2-15. Representative titi (*Cliftonia monophylla*) dominated wetland located within the conservation area view north, October 2016.

Plate 2-16. Representative hydric pine flatwoods located in the conservation area view east, October 2016.

3.0 HYDROLOGY

Pursuant to the International Paper Combined Effluent Distribution Project (CEDP) monitoring goals, hydrometric monitoring was conducted at select stations throughout the CEDP. The primary goals of the hydrometric monitoring effort are to:

- Document and evaluate changes in water levels across the four main wetland types (depression, flat, slough, and tidal; described in detail in Chapter 2) as a result of implementing the CEDP;
- Provide the data necessary to interpret any shifts in biological communities within the Effluent Distribution System (EDS) or the conservation tract; and,
- Produce data critical to supporting ongoing management decisions for the EDS.

This chapter describes the hydrometric monitoring data collected during the 2017 monitoring period, and the results relative to baseline conditions, the ramp-up period in 2012, and the 100% effluent flow 2013 through 2016 monitoring periods. The hydrometric monitoring wells were installed to assess shallow groundwater and surface water dynamics. These wells were solely dedicated to water level monitoring and were sampled independently of the groundwater monitoring wells which were installed and screened deeper in the soil profile (see Chapter 4 for details).

3.1 Methods

Local water level data was monitored throughout calendar year (CY) 2017 at select stations established in January 2008 within the freshwater portion of the effluent distribution system (EDS), in the tidal portion of the EDS at Wicker Lake (TWT01), in a tidal creek partially draining the southeastern portion of the EDS (GS05), and at reference freshwater wetland stations. A weather station at the Pensacola Regional Airport (PNS) (11 miles to the east), provided data used to characterize the climate of the CEDP site during the 2017 monitoring year. The PNS weather station was relied upon for CEDP precipitation records as this weather station was determined to be the most reliable precipitation record in the area.

3.1.1 Well Installation Methods

Shallow sub-surface wells or stilling wells were installed at four multivariate freshwater EDS stations (DWT01, DWT02, FWT03, and SWT03), two freshwater reference wetland stations (SWR01 and FWC01), tidal station TWT01 in the Tee and Wicker Lakes complex, and in the tidal creek at station GS05 that partially drains the EDS area (Figure 3-1). See Chapter 2 for a detailed description of the monitoring locations and station naming conventions. Shallow subsurface wells were installed at the flat wetland (FW series) and depression wetland (DW series) station types. Stilling wells were installed at the slough wetland stations (SW series) and in Wicker Lake at TWT01 and the tidal creek at GS05. All wells and stilling wells were constructed of 2-inch PVC pipe with a slotted screen section placed so that surficial and, in the case of depression and flat wetlands sites, shallow subsurface water levels could be monitored. The slotted section was covered with a filter sock to minimize silt accumulation. For wells

installed below the ground surface, a hand auger was used to create a borehole for the well pipe. The annulus was backfilled with sand and sealed with bentonite at the surface to prevent surface runoff from draining into the well. Each well was securely fixed to a fence post or a tree to prevent vertical or horizontal movement. Wells were fitted with a PVC cap and a weep hole was drilled to prevent pressurization of the well.

Each well was outfitted with an Onset HOBO® U20 Water Level Logger suspended in the well using non-stretching steel cable. The water level loggers were programmed to collect data every four hours with a measurement accuracy of 0.015 ft. The non-vented pressure transducers utilized in these sensors require compensation for atmospheric pressure fluctuations in order to convert the raw data to an actual water depth reading. Barometric pressure measurements for this compensation procedure were collected using the same model water level logger mounted on-site in a location that ensured that the sensor was never submersed in water.

3.1.2 Field Data Collection, Data Processing, Quality Control, and Analysis

Precipitation data was obtained from a National Atmospheric and Oceanic Administration (NOAA) rain gauge at PNS. Historical precipitation records for PNS from 1981–2010 were used to compare recent observations with long-term averages (Table 3-1).

Water level data files were post-processed within the Onset HOBOware® software using the onsite barometric pressure record to generate a water depth field within the data file. During each visit, manual water level measurements were made and water level records were then checked against manual measurements to ensure data integrity and quality control. Well maintenance, including removal of debris, securing the mount, and sediment flushing was conducted on an as needed basis at the time of each site visit. Questionable or bad data were removed from the record. Water surface elevations relative to the ground surface elevation were generated from the raw water level data using offsets determined from the installation specification of each well and water level logger.

Data from the instrumentation in the hydrometric network was downloaded during site visits in March and December 2017. Sensors installed at stations FWC01 and DWT02 malfunctioned during the download event in December 2017. Therefore, data from those stations is only available through March 2017, and the data analysis did not include data collected after that date from either of those monitoring stations.

Time-series water level data was divided into three periods for analysis and comparison of hydrologic changes in the EDS (treatment stations) and at reference and control stations:

- Baseline Monitoring: January 2008 – December 2011
- 2013 – 2016 100% Discharge Monitoring: January 2013 – November 2016
- 2017 100% Discharge Monitoring: December 2016 – November 2017

Median water level, percent of time inundated, and water level standard deviation were calculated from each station's water level record and used as hydrologic change indicators. Differences in the change indicators were compared between the monitoring stations. For the

purposes of this chapter, the term "reference" refers to stations designated as either "control" (for example, FWC01) or "reference" (SWR01) since there is no distinction from a hydrological perspective.

3.2 Results and Discussion

Effluent ramp-up began on January 22, 2012 with nearly 3 million gallons per day (mgd) and continued to increase throughout 2012. 100% discharge was reached in late October 2012, totaling 23 mgd of IP effluent and 5 mgd from ECUA, and has continued with some minor interruption at 100% flow through 2017. Precipitation affects the depth of water within freshwater and tidal portions of the EDS, but the largest impact on EDS water depth is due to the discharge of effluent to this system. The following sections detail comparative analyses of hydrologic data collected in 2017 with data collected at CEDP stations annually since 2008.

Due to the variability of hydrologic conditions that existed during the "ramp-up" period from January 22, 2012 until December 1, 2012, that period was removed from the comparative analysis. However, complete hydrographs of all stations presented in Figures 3-2, 3-3, and 3-4 include all available data from each station beginning in January 2008.

An explosion at the Cantonment Mill on January 22, 2017 caused a temporary reduction in effluent discharge to the EDS, resulting in a change in the depth of water over the EDS. Approximately 50% of the usual volume of effluent was discharged to the EDS until mill repairs were completed. The mill was operating at full capacity by April 2017.

3.2.1 Precipitation

Total 2017 annual precipitation at PNS was 91.81 inches, which was 28 inches higher than the long-term annual average precipitation recorded at the PNS from 1981 through 2010 (Table 3-1). Total monthly precipitation for the Pensacola area was either drastically above or well below average during almost every month of 2017. Over 20 inches of rain fell in June 2017, with almost eight inches falling in two days due to Tropical Storm Cindy, which made landfall in southwestern Louisiana on June 22. Over 20 inches of rain fell again in August 2017, including almost eight inches associated with Hurricane Harvey which fell in three days between August 29 and 31. In addition to these high precipitation tropical storm events, January, May, and October also had above average rainfall. Although seven out of twelve months had below average rainfall, the extremely wet months of January, June, August, and October resulted in the 28.12 inch surplus of precipitation for the Pensacola area for 2017.

3.2.2 Depression and Flat Wetland Stations

Continued hydrologic monitoring took place at reference station FWC01 and treatment stations DWT01, DWT02, and FWT03 during 2017 (See Figure 3-2 for individual well hydrographs). Data for April – November 2017 for stations FWC01 and DWT02 were not included in the analysis due to sensor malfunction (Table 3-2). However, the median water level for December 2016 – March 2017 was higher than previous years for both FWC01 and DWT02. Beaver activity in the vicinity of the DWT02 stage recorder was first observed in 2016 and the area continues to be affected by beaver dams resulting in deeper water than compared to previous years. Wells at stations DWT01 and DWT02 have remained inundated since before the beginning of the 2013

monitoring period. The median water level at DWT01 was 1.18 feet during 2017 which is slightly higher than the overall 2013–2016 monitoring period median of 1.05 feet (Table 3-2). During 2017 monitoring, FWT03 remained inundated with a median water level of 0.40 feet, which was only 0.04 feet higher than the previous post-effluent monitoring years median water level. (Table 3-2, Figure 3-2). Higher median water levels at all stations in 2017 compared with the overall median from 2013-2016 were likely a result of above average precipitation.

As observed during previous post-effluent monitoring periods, water level response to precipitation at the treatment depression and flat wetlands has continued to be muted relative to baseline conditions (Figure 3-2). The variability in water level (standard deviation) was 0.09 feet, 0.12 feet, and 0.07 feet, at FWT03, DWT01, and DWT02, respectively in 2017 (Table 3-2). The standard deviation in water level for reference station FWC01 was 0.46 feet in 2017, illustrating the substantial response to precipitation events that occurs at this reference station due to a lack of effluent flows to this wetland (Table 3-2; Figure 3-2).

3.2.3 Slough Wetland Stations

Hydrologic monitoring of freshwater slough wetlands in 2017 continued at reference station SWR01 and treatment station SWT03. Similar to the previous post-effluent monitoring years, large responses were observed during moderate to large precipitation events at SWR01. The median water level at SWR01 was 0.24 feet higher than the median level for years 2013–2016, illustrating the effect of the above average rainfall in 2017 on reference wetland water levels (Figure 3-3, Table 3.2). Water levels at the treatment slough SWT03 have decreased since 2013, and the median level for 2017 was only 0.26 feet despite the surplus precipitation in Pensacola during 2017. Station SWT03 is located approximately 25 feet downgradient of Berm 4 and a substantial distance from the outfall. Water levels at SWT03 have reduced over time due to erosional processes and diverting of water away from the SWT03 well into other channels and wetland depression areas.

3.2.4 Tidal Wetland Stations

Stations TWT01 and GS05 are both located in tidally-influenced areas downgradient of the EDS site and receive inflow from the EDS at multiple entry points (Figure 3-1). There are data gaps due to logger malfunctions from May 16, 2012 through August 14, 2012 at both stations, and from November 17, 2013 through June 3, 2014 at GS05 (Figure 3-4). Median water levels in 2017 at TWT01 (2.13 feet) were higher than baseline monitoring level of 1.40 feet, and only slightly higher than water levels in 2013 – 2016 (2.08 feet; Table 3-2). Median water levels at GS05 have also been consistently higher than the baseline period of 2.15 feet with a median water level for 2013–2016 of 2.41 feet and 2.71 feet in 2017 (Table 3-2). Tidal changes influence daily water level fluctuations similarly at TWT01 and GS05 as measured by standard deviations of 0.54 and 0.58 in 2017, respectively, which were similar to previous monitoring years including the baseline period (Table 3-2). Hydrology at the tidal stations was largely influenced by the magnitude of freshwater inflows to Upper Perdido Bay, tidal amplitude, and other climatic variables including precipitation, wind speed, and wind direction (see Chapter 10 for further data and discussion of Perdido Bay dynamics).

3.3 Conclusions

As expected, 2017 hydrology data are consistent with data collected in previous monitoring years, and show that water levels in the EDS have increased substantially since application of effluent began in 2012. The slough treatment station SWT03 is the exception; this station has had reduced water levels over the years due to erosional processes and the diversion of water away from the well. All monitoring stations were affected by above-average precipitation in 2017. A total of 92 inches of rain fell in the Pensacola area in 2017 which is 28 inches above the average annual rainfall. In general, slightly higher median water levels were recorded at all multivariate stations and the tidal receiving waters. Although beaver activity continues to affect water levels at some locations, higher levels in 2017 are likely the result of excess rainfall during the 2017 monitoring year. Manipulation of riser boards at the berms may also contribute to oscillations in water levels. Continued monitoring of CEDP hydrology is scheduled through calendar year 2018.

Table 3-1. Monthly climate data compiled from the Pensacola Regional Airport weather station for CY 2017.

Month	Precipitation						Temperature	
	2013	2014	2015	2016	2017	Average (1981 - 2010)[1]	2017	Average (1981 - 2010)[1]
Jan	2.29	3.45	6.47	3.94	11.73	4.63	60.8	52.0
Feb	8.64	7.88	3.94	4.71	3.62	5.06	63.8	54.9
Mar	1.12	9.79	2.38	7.65	2.36	5.81	66.1	60.6
Apr	3.76	29.53	9.98	6.00	3.71	4.32	71.7	67.5
May	1.79	5.84	5.13	1.96	7.08	4.18	76.1	75.0
Jun	7.79	3.26	4.11	7.65	20.73	6.60	80.7	80.7
Jul	17.60	7.65	7.00	6.83	5.18	7.41	85.0	82.3
Aug	7.07	1.37	6.71	12.04	20.44	6.76	84.1	82.0
Sep	8.47	5.28	6.37	3.36	3.00	5.98	80.8	78.7
Oct	1.84	4.44	8.07	0.00	10.32	5.24	74.4	69.8
Nov	3.80	1.20	7.22	0.86	0.09	4.73	64.6	60.1
Dec	2.46	3.50	8.33	9.63	3.55	4.55	56.6	54.0
Total	**66.63**	**83.19**	**75.72**	**64.63**	**91.81**	**63.69**		

[1] Average temperature and precipitation measured at the Pensacola Regional Airport between 1981 and 2010.

Table 3-2. Comparison of selected hydrologic change indicators for each monitoring station.

Station[1]	Median Water Level (ft)			Percent of time Inundated			Standard Deviation (ft)		
	Baseline	2013 - 2016	2017	Baseline	2013-2016	2017	Baseline	2013-2016	2017
DWT01	0.35	1.05	1.18	76.9	100.0	100.0	0.80	0.18	0.12
DWT02	-0.80	0.84	1.08	18.2	100.0	100.0	0.76	0.23	0.07
FWC01[2]	0.04	0.13	0.29	56.8	62.0	96.7	0.78	0.70	0.46
FWT03[2,3]	0.11	0.36	0.40	67.7	100.0	100.0	0.46	0.08	0.09
SWR01	0.27	0.60	0.84	90.1	100.0	100.0	0.26	0.30	0.23
SWT03[2]	0.69	0.70	0.26	96.1	98.6	98.2	0.45	0.43	0.28
TWT01	1.40	2.08	2.13	99.8	100.0	100.0	0.56	0.58	0.54
GS05[2]	2.15	2.41	2.71	100.0	100.0	100.0	0.59	0.54	0.58

[1] All stations have incomplete records during the baseline monitoring period (Jan 2008 - Jan 2012).
[2] Incomplete record during 2013 - 2016 monitoring period (Dec 2012 – Nov 2016).
[3] Incomplete record during 2017 monitoring period (Dec 2016 – Nov 2017).

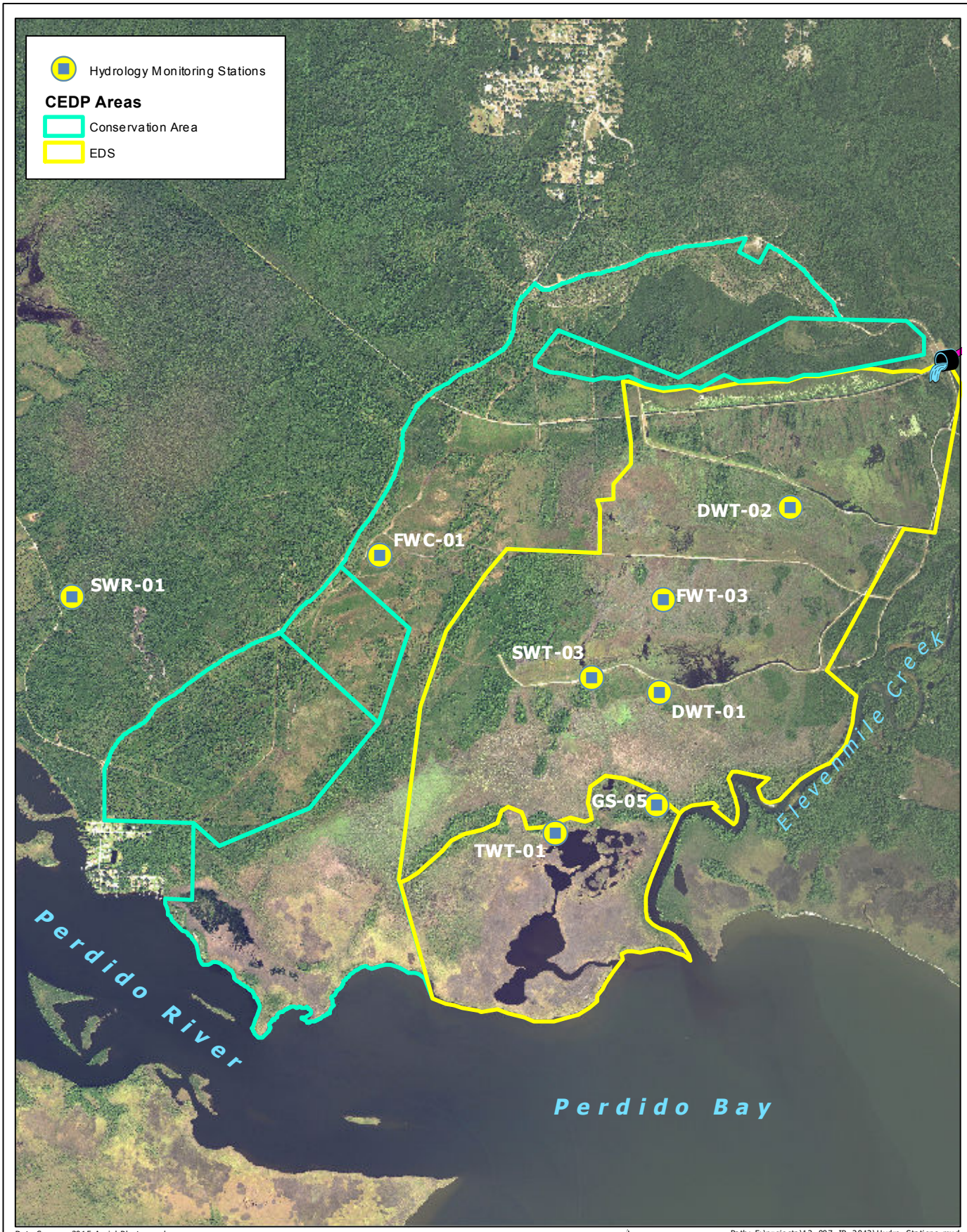


Figure 3-1. Location of hydrologic monitoring stations.

Nutter & Associates
environmental consultants

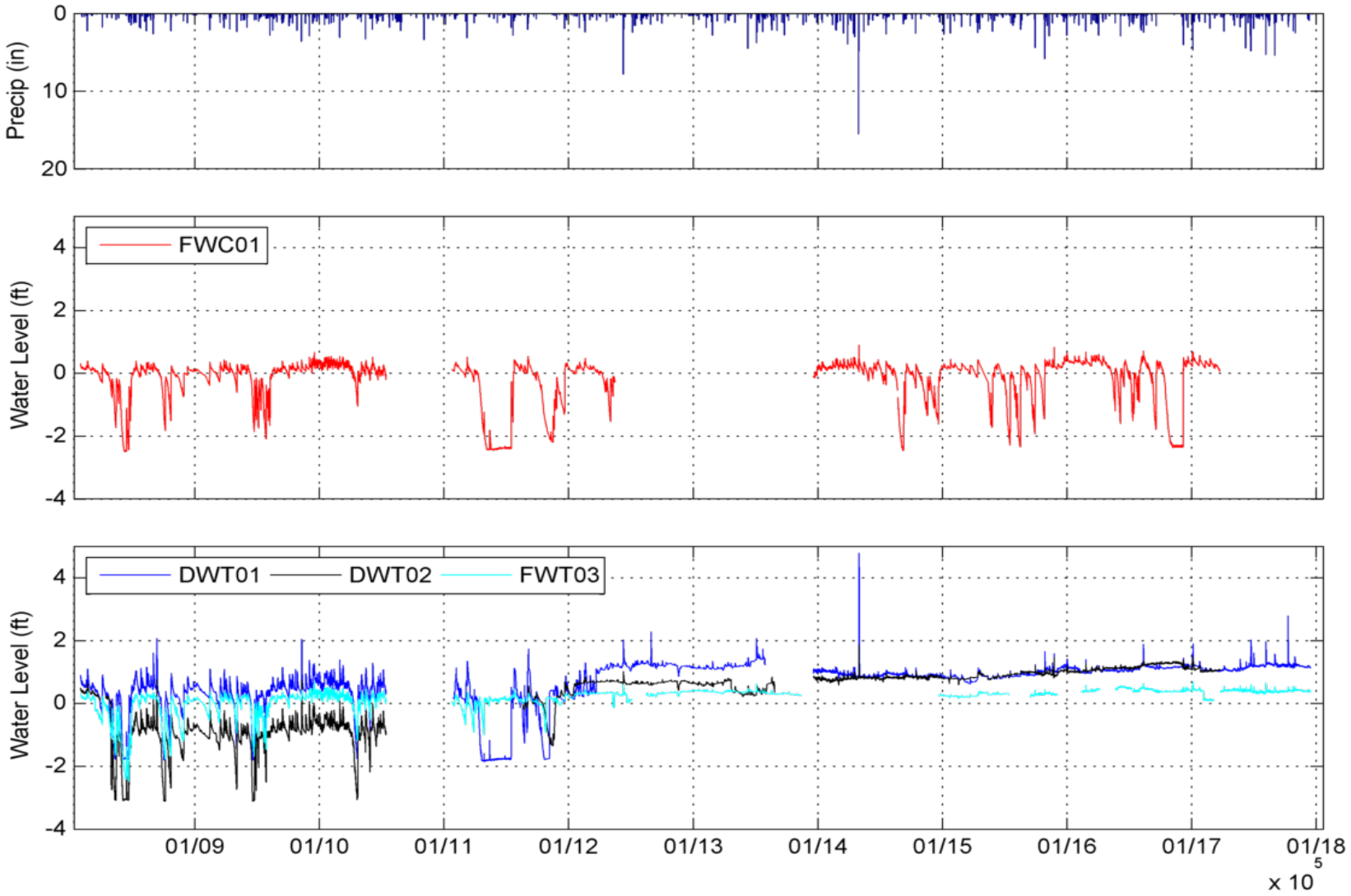


Figure 3-2. Water levels for depression and flat wetland monitoring locations, 2008-2017 (precipitation shown for reference).

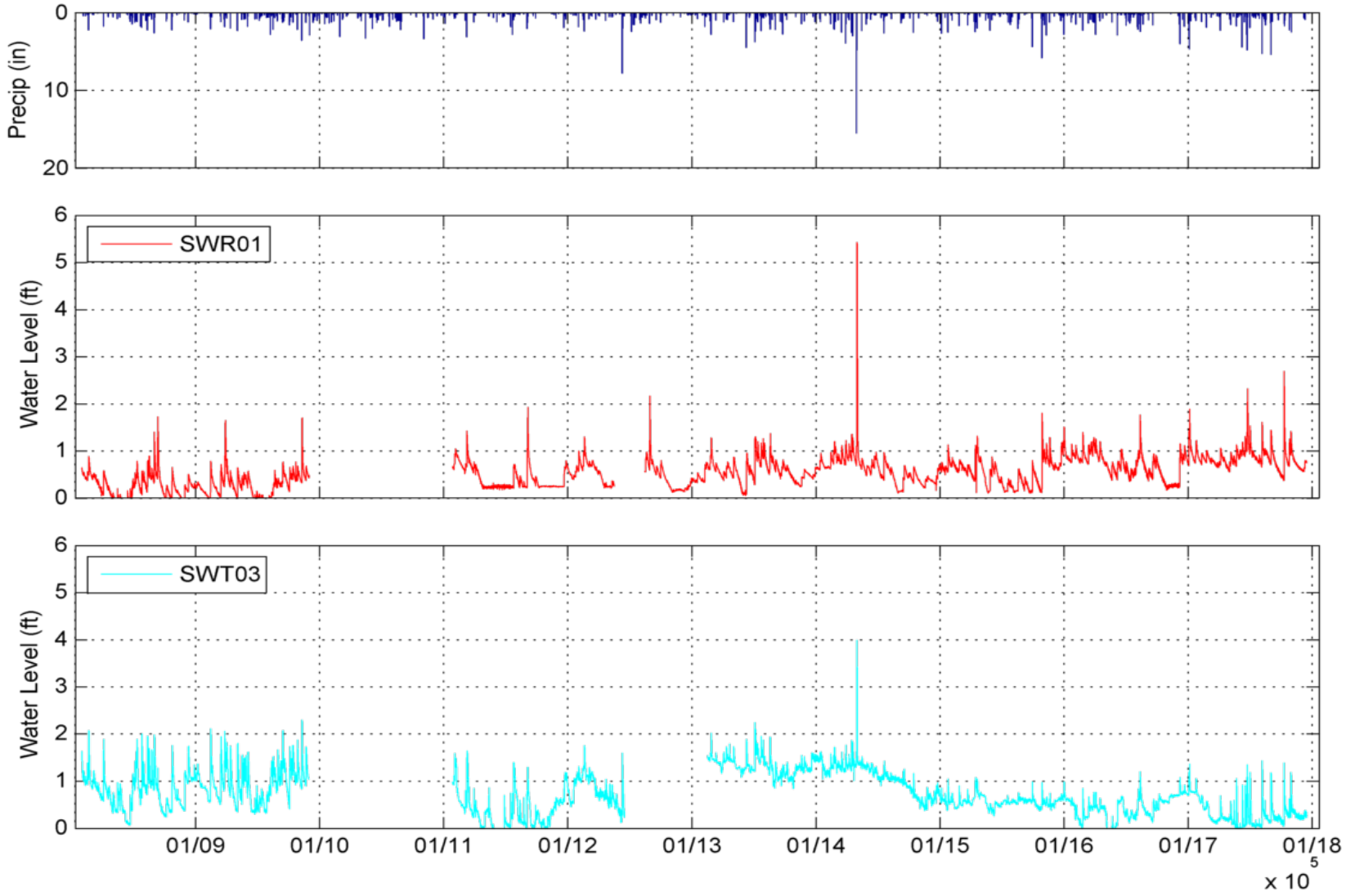


Figure 3-3. Water levels for wetland slough monitoring locations, 2008-2017 (precipitation shown for reference).

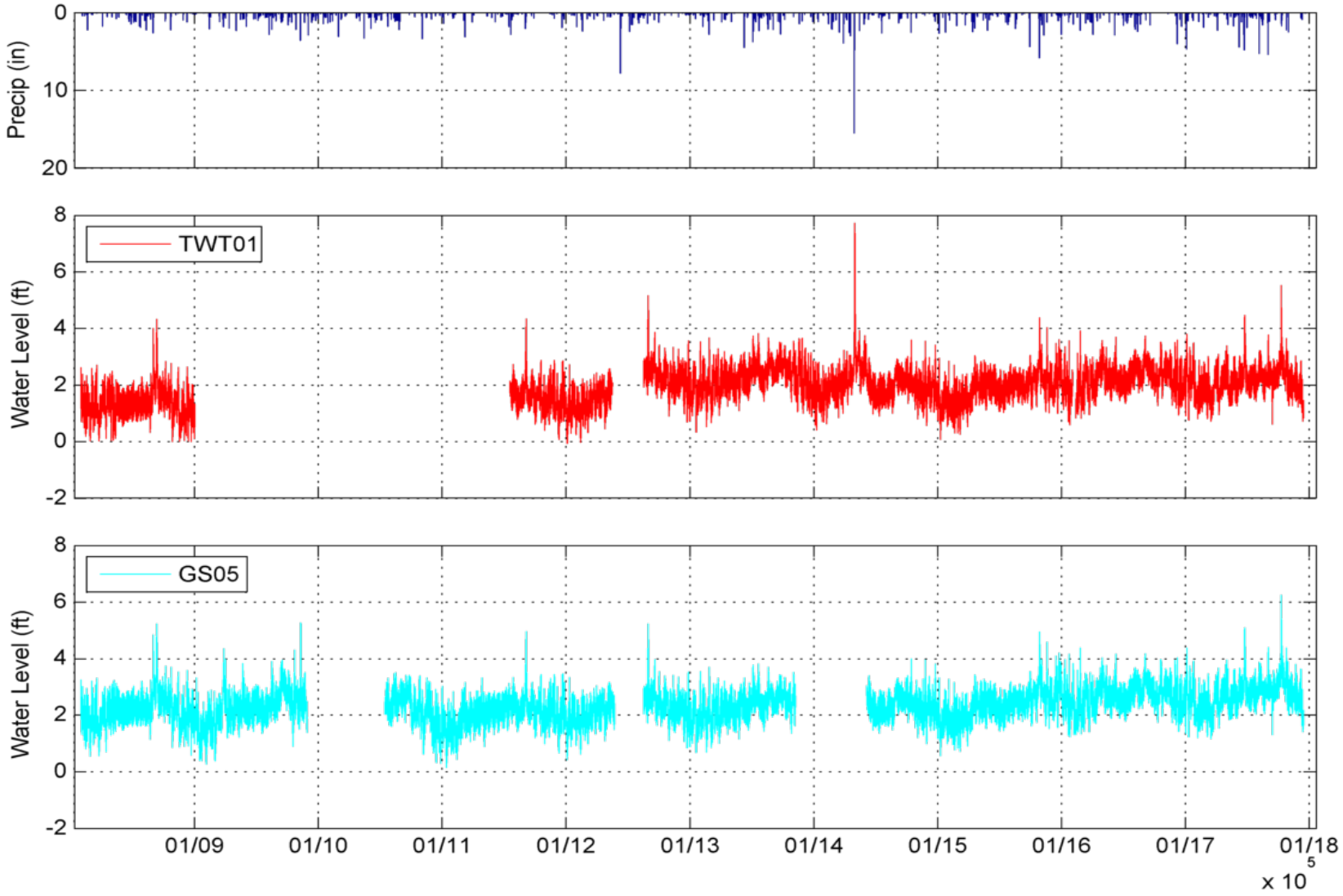


Figure 3-4. Water levels for tidal monitoring locations, 2008-2017 (precipitation shown for reference).

4.0 GROUNDWATER

As part of the initial International Paper (IP) combined effluent distribution project (CEDP) planning phase, a network of seven groundwater monitoring wells were installed at select locations upgradient, within, and downgradient of the proposed effluent distribution system (EDS) (Figure 4-1). The locations of each well were specified by the Florida Department of Environmental Protection (FDEP) to develop long-term background information and, upon application of effluent, document potential changes to groundwater quality over the course of the effluent discharge monitoring period.

Initial baseline monitoring of groundwater wells at the CEDP was conducted during July 2003, November 2003, February 2004, May 2004, August 2004, and July 2005. Pursuant to monitoring goals detailed in the Framework for Monitoring the IP CEDP, quarterly groundwater monitoring was reinitiated in February 2012 so that groundwater quality could be tracked as the project began the ramp-up phase of discharging to the EDS. In 2017, quarterly sampling was conducted during March, June, August, and December. The following sections detail the methodologies and results of groundwater monitoring during the 2017 monitoring year.

4.1 General Procedures

The seven established groundwater monitoring wells include two background wells located up-gradient from the EDS (MWB1 and MWB2), three wells interior to the EDS (MWI3, MWI4, and MWI5), and two compliance wells (MWC6 and MWC7) located down-gradient and outside of the EDS (Table 4-1; Figure 4-1).

For *in-situ* groundwater sampling, all water quality instruments were calibrated prior to use each day and post-calibration checks were conducted after use each day per FDEP sampling procedures (DEP-SOP-001/01, FT1000, FT1100, FT1200, FT1300, FT1500, FT1600, FT1900, FS 2000, FS2200) and USEPA (*Ecological Assessment Standard Operating Procedures and Quality Assurance Manual* (USEPA, 2002). Field quality control measures were implemented pursuant to FL DEP SOP-001/01, FQ 1000.

Well water was purged using a variable speed peristaltic pump, high density polyethylene (HDPE) down-well tubing, and silicon pump head tubing. A multi-parameter sonde with a flow through cell and outfitted with temperature, pH, dissolved oxygen, specific conductivity and turbidity probes, was used for taking *in-situ* water quality measurements while purging. Decontamination of all materials (well tubing, tubing weights, and water level indicator) was performed pursuant to FDEP SOP FC 1000.

Depth to the water table was measured using a water level indicator prior to, and during purging. Samples were collected in laboratory-provided containers that were sealed, labeled, and placed in an iced cooler. Samples and chain-of-custody forms were hand-delivered to Test America Laboratories in Pensacola, FL within designated hold times. Laboratory analytical and *in-situ* parameters along with NPDES compliance well permit limits for each parameter are listed in Table 4-2.

Prior to collecting groundwater samples, each well was purged utilizing the minimal-purge technique specified in the groundwater sampling chapter of the FDEP's Standard Operating Procedure manual (FL DEP SOP-001/01, FS 2200) (FDEP, 2004). The minimal purge method involves pumping water from the well at a slow rate such that water is drawn from the surrounding geologic media without inadvertently sampling stagnant water present within the well casing.

The well water level was continually monitored throughout the procedure to ensure that the drawdown rate equaled the recharge rate to the best extent practicable, thus minimizing the mixing of stagnant and formation water. Temperature, pH, specific conductivity, dissolved oxygen, and turbidity were recorded throughout the purging process at each well. *In-situ* water quality parameters were measured at intervals no less than four minutes apart (based on pumping rate and pump volume) to document stabilization of groundwater *in-situ* parameters before samples were collected.

The following five *in-situ* parameters had to stabilize within the stated range for three consecutive measurements before a sample was collected:

Temperature	± 0.2˚C
pH	± 0.2 Standard Units
Specific Conductance	± 5.0% of reading.
Dissolved Oxygen	≤ 20% Saturation
Turbidity	≤ 20 NTU

When dissolved oxygen and/or turbidity were not within the above specified limits, the following parameters had to stabilize within the stated range for three consecutive measurements before a sample was collected:

Temperature	± 0.2˚C
pH	± 0.2 Standard Units
Specific Conductance	± 5.0% of reading
Dissolved Oxygen	± 0.2 mg/L or 10%, whichever is greater
Turbidity	± 5 NTUs or 10%, whichever is greater.

If stabilization of the specified parameters was unattainable, a minimum of one full well volume was pumped at a rate that did not result in significant drawdown or turbidity prior to initiating sample collection.

4.2 Results

The FDEP states that groundwater chemical and physical parameters must be in compliance with the State's drinking water standards unless natural background conditions exceed those standards. This standard is assessed at the two compliance wells (MWC6 and MWC7) shown in Figure 4-1 as documented in the National Pollutant Discharge Elimination System (NPDES) permit FL0002526-008-IWIS. The permit also requires that the data for each background (MWB1 and MWB2) and internal (MWI3, MWI4, and MWI5) well be reported quarterly. The groundwater quality parameter results that exceeded baseline ranges and/or permit limits are discussed in relation to the baseline ranges of each specific well, the ranges measured at the background wells (baseline and current), historical regional values, and the permitted limits for the compliance wells. Over the course of the fourteen-year

monitoring period (2003–2017), laboratory reporting and minimum detection limits changed due to advances in water quality analysis technology and methodologies. As a result, values reported as "below detection limit" vary between the sample events. The results of baseline, 2012 through 2016 combined, and 2017 groundwater monitoring at the CEDP are presented in Tables 4-3 through 4-9 and Figures 4-2 through 4-24. Historical regional groundwater data values are presented in Table 4-10.

4.2.1 Background Wells (MWB1 and MWB2)

Background wells MWB1 and MWB2 are not compliance wells but permitting limits for compliance wells were used in addition to historic regional background value ranges, and baseline well water quality conditions (2003-2005), as standards to discuss groundwater data for these wells. Background wells located up gradient of the effluent distribution site represent real time reference or background water quality conditions for the project's interior and compliance wells (Figure 4-1).

During the baseline monitoring period prior to 2012, pH values were below the compliance well permit limit range (6.5 - 8.5 S.U.) for MWB1 and within the permit limit range at MWB2 (Tables 4-3 and 4-4; Figure 4-4). Both background wells were below the compliance well pH value permit limit during each quarterly sampling event in monitoring years 2012 through 2017 (Tables 4-3 and 4-4; Figure 4-4). However, the pH values at MWB1 measured in 2017 are within the baseline range for all four monitoring events (Table 4-3; Figure 4-4). At MWB2, pH values were below the compliance well permit limit and baseline minimums in 2017, but still within the range of historical regional groundwater values (Tables 4-4 and 4-10; Figure 4-4). Regional groundwater results from 50 monitoring wells indicate that pH values range from a minimum of 4.85 S.U. to a maximum of 6.48 S.U. (median = 5.25 S.U.) (Table 4-10; source: FDEP, 2012). This historical data illustrates that groundwater pH values in the region are below the limits set by the permit for compliance wells. According to Wolfe, 1988, the natural background pH of the groundwater contained within the Sand and Gravel Aquifer is acidic. Based on these findings, low pH values measured onsite are indicative of water contained in the regional sand and gravel aquifer.

Specific conductivity at MWB1 was within or below the range of baseline values in 2017 (Table 4-3; Figure 4-3). The range of specific conductivity values at MWB2 during 2017 (39-44 µS/cm) were significantly lower than the baseline range (169-380 µS/cm) but similar to the range of values observed during 2012 through 2016 (26-69 µS/cm) (Table 4-4; Figure 4-3). Specific conductivity values at MWB1 and MWB2 in 2017 were also well within the range of regional background values (15-122 µS/cm) for the Sand and Gravel Aquifer region (Tables 4-4 and 4-10).

Iron concentrations at MWB1 were all below baseline conditions, but above the compliance well permit limit of 0.3 mg/L during all quarterly sampling events in 2017 (Table 4-3; Figure 4-19). An examination of 58 different wells in the Sand and Gravel Aquifer in the region revealed that total iron concentrations ranged from a minimum of 0.013 mg/L to a maximum of 10.015 mg/L (median = 0.570 mg/L) (Table 4-10; source: FDEP, 2012). The historical regional groundwater results show that concentrations of iron observed at MWB1 were within the natural background range for all of the 2017 monitoring events (Tables 4-3 and 4-10). In contrast, iron concentrations at MWB2 were consistently below baseline values and the compliance well permit limit during 2017, with the exception of the third quarter 2017 monitoring event when the iron concentration rose to 0.97 mg/L (Table 4-4).

Color values, as measured by color units (C.U.), were above the permit limit (15 C.U.) at MWB1 during all quarterly sampling events in 2017 (Table 4-3). However, color values were equal to or below the range of baseline monitoring results at MWB1 and below the 2012 through 2016 average during all quarterly events in 2017 (Table 4-3; Figure 4-15). Values for color were not reported for regional historical groundwater data (FDEP, 2012). At station MWB2, color values were within the compliance well permit limit (15 C.U.) during all of the quarterly sampling events in 2017 (Table 4-4; Figure 4-15).

The odor values at MWB1 and MWB2 during 2017 sampling events were below the compliance well permit limit of 3 TON. (Table 4-3 and 4-4; Figure 4-14).

4.2.2 Interior Wells (MWI3, MWI4, MWI5)

Interior wells MWI3, MWI4, and MWI5 are not compliance wells but permitting limits for compliance wells were used in addition to historic regional background value ranges, and baseline well water quality conditions (2003-2005), as standards to discuss groundwater data for these wells. Interior wells MWI3, MWI4, and MWI5 had pH values below the compliance well permit range of 6.5 - 8.5 S.U. during each monitoring event of the 2017 monitoring year (Tables 4-5 through 4-7; Figure 4-4). However, these pH values are consistent with background wells MWB1 and MWB2, as well as interior well baseline data (Tables 4-5 through 4-7; Figure 4-4).

MWI3 had elevated specific conductivity concentrations (255 – 409 µS/cm) during all 2017 quarterly monitoring events relative to baseline values (54 – 60 µS/cm) and historical regional values (15 – 122 µS/cm) (Tables 4-5 and 4-10; Figure 4-3). These higher specific conductivity readings at MWI3 are likely due to a compromised well and subsequently, effluent water reaching and mixing with groundwater. In 2017, specific conductivities at MWI4 were generally lower than pre-effluent and 2012 through 2016 monitoring results (Table 4-6). MWI5 has exhibited specific conductivities levels that are higher than baseline data. However, 2017 specific conductivity values at MWI5 fell within historical regional values and within 2012 to 2016 ranges (Table 4-7 and 4-10; Figure 4-3).

Color exceeded the compliance well permit limit (15 C.U.) at MWI3 during all quarterly sampling events of 2017 and was above baseline maximums for each of the four quarterly monitoring events (Table 4-5). Color values also exceeded the permit limit at MWI5 for all 2017 monitoring events but were within or below baseline ranges (Table 4-7). Color values were below compliance well permit limits at MWI4 during all quarterly monitoring events (Tables 4-6).

Odor exceeded the permit limit (3 TON) at MWI3 during all quarterly sampling events in 2017 with the exception of the fourth quarter 2017 monitoring event (Table 4-5). Odor values at MWI3 only exceeded the baseline maximum during the first and second quarter sampling events. (Table 4-5; Figure 4-14). Odor values did not exceed compliance well permit limits at wells MWI4, or MWI5 during any of the 2017 quarterly monitoring events (Tables 4-6 and 4-7). Historical regional values for odor are not reported by the FDEP (FDEP, 2012).

Iron concentrations at MWI3 (range of 2.2 -2.5 mg/L) and MWI4 (range of 0.37 – 0.58 mg/L) exceeded the compliance well permit limit (0.3 mg/L) during all 2017 quarterly sampling events. However, MWI3 and MWI4 iron concentrations were comparable to baseline results and were within historical regional ranges (0.013 – 10.0 mg/L) (Tables 4-5,

4-6 and 4-10; Figure 4-19). The compliance well permit limit for iron was exceeded during the fourth quarter sampling event at MWI5 (0.57 mg/L) but was within baseline ranges (Table 4-7). All results for MWI3, MWI4, and MWI5 were within the range of historical regional and background well iron concentrations (0.013 – 10.015 mg/L) (Table 4-5 through 4-7 and Table 4-10; Figure 4-19).

4.2.3 Compliance Wells (MWC6 and MWC7)

At the two compliance wells, pH values were below the permit range of 6.5 - 8.5 S.U. during all events in 2017 (Tables 4-8 and 4-9; Figure 4-4). However, the pH values were within the range of baseline conditions observed for each compliance well (Tables 4-8 and 4-9; Figure 4-4). Compliance well pH values were also comparable to historical regional values (4.85 – 6.48 S.U.), with the minor exception of MWC6 (4.48 S.U.) during the fourth quarter 2017 sampling event and MWC7 (4.46 S.U.) during the first quarter sampling event of 2017 (Tables 4-8 through 4-10).

Color was below the permit limit (15 PCU) at MWC6 and MWC7 for all 2017 quarterly sampling events (Tables 4-8 and 4-9; Figure 4-13). Historical regional values for color are not reported by the FDEP (FDEP, 2012).

Odor was slightly above the permit limit (3 TON) at MWC6 and for the first quarter sampling event in 2017 but was below the permit limit for all other quarterly sampling events (Table 4-8; Figure 4-14). Odor was below the permit at MWC7 for all of 2017 quarterly sampling events (Table 4-9; Figure 4-14). Historical regional values for odor are not reported by the FDEP (FDEP, 2012).

Iron exceeded the permit limit (0.3 mg/L) at MWC6 and MWC7 during all 2017 quarterly sampling events, but the concentrations were lower than the baseline values measured at each station (Tables 4-8 and 4-9; Figure 4-19). All iron concentrations were within the range of historical regional and background well values (0.013 – 10.015 mg/L) (Tables 4-8, 4-9, and 4-10; Figure 4-19).

4.3 Conclusions

FDEP states that groundwater chemical and physical parameters must be in compliance with the state's drinking water standards, except if natural background conditions exceed those standards. Permitted limits for the compliance wells are the same as the standards for drinking water. Exceedances of the specific permit limits were observed at compliance well MWC6 for water quality parameters pH, iron, and odor and at compliance well MWC7 for water quality parameters pH and iron.

In all but two cases of permit exceedances for pH, the compliance well water quality parameter values were within the range of baseline values collected between 2003 and 2005, during 2012 through 2016 post-effluent monitoring, and historical groundwater data collected from regional wells between 1994 and 1997 (Tables 4-8 through 4-10; Figure 4-4). The pH value at MWC7 fell slightly below baseline and historic pH values during the first quarter spring sampling event but was above the minimum value collected between 2012 and 2016. It is unlikely that low groundwater pH values at MWC7 are due to EDS operations as the effluent discharge to the EDS has resulted in a substantial increase in EDS surface water pH to near neutral values (~7.0 S.U.) (See Chapter 5). With the exception of one

lower than background pH reading at MWC7 and one higher than background odor result at MWC6, the 2017 groundwater quality at the CEDP wells fell within background conditions and met NPDES permit limits as stated by the FDEP.

4.4 Literature Cited

Florida Department of Environmental Protection (FDEP). 2004. Department of Environmental Protection Standard Operating Procedures for Field Activities. 2004., Bureau of Laboratories, Environmental Assessment Section. Florida Department of Environmental Protection Tallahassee, FL.

Florida Department of Environmental Protection (FDEP). 2012. Web accessed. Northwest Reporting Unit D Sand & Gravel Aquifer Background Network Summary Statistics 1994-1997. Florida Department of Environmental Protection. http://waterwebprod.dep.state.fl.us/ambient/triennial/nwf_d.htm

U.S. Environmental Protection Agency (USEPA). 2002. Region 4. Ecological Assessment Standard Operating Procedures and Quality Assurance Manual. United States Environmental Protection Agency SESD-EAB.

Wolfe, S.H., J.A. Reidenauer, D.B. Means. 1988. An ecological characterization of the Florida Panhandle. U.S. Fish and Wildlife Service. Biological Report 88(12); Minerals Management Service. OCS Study\MMS 88-0063.

Table 4-1. ECUA/IP Combined Effluent Distribution System monitoring well locations, elevations, and construction details.

Well	Location		Elevation			Riser Height[1]	Screen Length	Total Depth
			Ground	Pad	Top of Riser			
	Latitude	Longitude	ft					
MWB1	30.4866	-87.3847	52.66	53.16	54.83	1.67	10	18.5
MWB2	30.4867	-87.3691	46.98	47.62	50.86	3.24	10	22.2
MWI3	30.4753	-87.3738	11.60	11.09	13.69	2.60	10	19.5
MWI4	30.4697	-87.3841	5.14	5.74	6.93	1.19	10	17.3
MWI5	30.4702	-87.3710	6.59	7.09	8.85	1.76	10	18.3
MWC6	30.4628	-87.4039	4.09	4.47	7.51	3.04	10	15.0
MWC7	30.4714	-87.3672	3.32	3.80	5.75	1.95	10	17.5

[1] Riser height measured by tape from pad surface to top of PVC riser, except MWI-5 riser height surveyed and pad elevation measured by tape down from top of riser.

Table 4-2. Permit requirements for groundwater constituents. Permit Number FL0002526-008-IWIS.

Parameter	Permit Limits	Units
Specific Conductivity	Report	µS/cm
pH	6.5 - 8.5	S.U.
Color	15	PCU
Odor	3	TON
TDS	500	mg/L
T.O.C.	Report	mg/L
Total Sulfate	250	mg/L
Chromium, Total	0.1	mg/L
Manganese, Total	0.05	mg/L
Arsenic, Total	0.010	mg/L
Chloride, as Cl	250	mg/L
Sodium, Total	160	mg/L
Antimony, Total	0.006	mg/L
Nickel	0.1	mg/L
Chloroform	Report	mg/L
Ethylbenzene	30	µg/L
Nitrogen, Kjeldahl, Total (as N)	Report	mg/L
Nitrogen, Ammonia, Total (as N)	Report	mg/L
Nitrogen, Nitrate, Total (as N)	10	mg/L
Iron, Total Recoverable	0.3	mg/L
Zinc, Total Recoverable	5	mg/L

Table 4-3. Summary results of background monitoring well MWB1 for baseline monitoring years 2003-2005 combined, 100% EDS operational flow years 2012 through 2016 combined, and individual quarterly monitoring results for 2017.

MWB1												
Parameters	**Units**	**Permit Limit**	**Baseline Average**	**Baseline Minimum**	**Baseline Maximum**	**2012-2016 Average**	**2012-2016 Minimum**	**2012-2016 Maximum**	**Q_1 2017**	**Q_2 2017**	**Q_3 2017**	**Q_4 2017**
Temperature	°C	No Limit	22.4	17.9	24.8	22.8	17.5	27.7	20.0	22.2	24.4	21.95
Conductivity	µS/cm		49	44	55	46	10	64	44	39	49	43
pH	S.U.	6.5 - 8.5	5.05[1]	4.66[1]	5.31[1]	4.89	4.51	5.20	4.77	4.82	5.11	5.00
Turbidity	NTU	No Limit	25	10	34	20	2	138	12	NM	3	5
Sodium	mg/L	160	2.7	2.5	2.9	5.5	2.8	46.0	3.0	2.6	3.0	2.8
TKN		No Limit	0.99	0.82	1.20	0.93	0.58	2.30	0.72	0.76	0.53	0.52
NH_3-N			0.31	0.19	0.41	0.23	0.02	0.35	0.34	0.28	0.31	0.27
NO_3-N/NO_2-N			0.093	0.019	0.160	0.019	0.012	0.040	< 0.018	< 0.018	< 0.018	< 0.018
NO_2-N			< 0.080	< 0.018	< 0.100	< 0.018	< 0.018	< 0.018	NM	NM	NM	NM
NO_3-N		10	0.080	0.019	0.100	0.019	0.012	0.040	< 0.018	< 0.018	< 0.018	< 0.018
TDS		500	68	54	78	47	20	110	30	6	84	42
SO_4		250	4.6	1.1	6.7	1.4	1.4	1.9	< 1.4	< 1.4	< 1.4	< 1.4
Chloride		250	6	4	7	8	6	10	7	6	6	6
Color	PCU	15	357[1]	190[1]	520[1]	293	15	2700	140	160	190	120
Odor	TON	3	1.0	1.0	1.0	1.6	< 1.0	4.0	< 1.0	< 1.0	< 1.0	< 1.0
TOC	mg/L	No Limit	18	17	19	26	4	210	15	19	18	15
Antimony		0.006	< 0.0352	0.0057	0.0500	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Arsenic		0.010	< 0.0047	< 0.0040	< 0.0050	< 0.0040	< 0.0040	< 0.0040	< 0.0040	< 0.0040	< 0.0040	< 0.0040
Chromium		0.1	0.0058	0.0050	0.0070	0.0070	0.0020	0.0660	0.0025	0.0022	0.0027	< 0.002
Iron		0.3	10.4[1]	8.2[1]	13.0[1]	6.9	4.2	12.0	6.1	5.2	7.2	6.4
Manganese		0.05	0.058	0.040	0.081	0.023	0.011	0.048	0.02	0.02	0.022	0.021
Nickel		0.1	< 0.0040	< 0.0020	< 0.0050	< 0.0030	< 0.0030	< 0.0030	< 0.0030	< 0.0030	< 0.0030	< 0.0030
Zinc		5	0.0417	< 0.0080	0.0970	0.0086	< 0.0080	0.0190	< 0.0080	< 0.0080	< 0.0080	< 0.0080
Chloroform	µg/L	No Limit	< 3.40	< 0.20	< 5.00	0.91	0.60	6.70	< 0.60	< 0.60	< 0.60	< 0.60
Ethlybenzene		30	< 3.40	< 0.50	< 5.00	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50
Water Table Depth below ground surface*	feet	No Limit	-3.76	-4.65	-2.81	-3.47	-7.37	-2.17	-2.83	-8.43	NM	-3.13

[1] Exceeds permit limits for groundwater parameters.

* Negative values = depth to groundwater/water table below ground surface. Positive values = depth of groundwater/water table expressed above ground surface

< = indicates the compound was less than the minimum detection limit

Table 4-4. Summary results of background monitoring well MWB2 for baseline monitoring years 2003-2005 combined, 100% EDS operational flow years 2012 through 2016 combined, and individual quarterly monitoring results for 2017.

MWB2												
Parameters	**Units**	**Permit Limit**	**Baseline Average**	**Baseline Minimum**	**Baseline Maximum**	**2012-2016 Average**	**2012-2016 Minimum**	**2012-2016 Maximum**	**Q_1 2017**	**Q_2 2017**	**Q_3 2017**	**Q_4 2017**
Temperature	°C	No Limit	22.4	17.6	25.3	22.2	17.4	28.7	19.8	22.5	23.0	19.4
Conductivity	µS/cm		259	169	380	51	26	69	39	42	44	38
pH	S.U.	6.5 - 8.5	6.72	6.54	7.01	5.34	4.78	5.59	5.32	5.13	5.19	5.40
Turbidity	NTU	No Limit	978	425	1509	13	0.3	61	30	2.5	NM	1.2
Sodium	mg/L	160	52.8	36.0	77.0	4.8	3.4	7.5	3.7	3.2	3.3	3.3
TKN		No Limit	1.17	0.50	3.30	0.33	0.23	1.00	< 0.26	< 0.26	< 0.26	< 0.26
NH_3-N			0.05	0.05	0.06	0.022	< 0.016	0.110	0.17	< 0.11	< 0.11	< 0.11
NO_3-N/NO_2-N			0.100	0.019	0.180	0.017	0.012	0.025	< 0.018	< 0.018	< 0.018	< 0.018
NO_2-N			0.12	0.02	0.27	< 0.018	< 0.018	< 0.018		NM		NM
NO_3-N		10	0.117	0.019	0.220	0.018	0.012	0.025	< 0.018	< 0.018	< 0.018	< 0.018
TDS		500	550[1]	300	1200[1]	31	10	66	14	18	42	30
SO_4		250	121	25.0	320[1]	5.9	3.5	13.0	5.7	5.5	5.8	4.2
Chloride		250	25.3	6.3	83.0	6.8	4.0	11.0	5.6	5.1	5.4	4.5
Color	PCU	15	1210[1]	230[1]	1900[1]	8.6	1.5	38.0	13	< 1.5	4.8	< 1.5
Odor	TON	3	1.0	1.0	1.0	< 1.0	< 1.0	1.0	< 1.0	< 1.0	< 1.0	< 1.0
TOC	mg/L	No Limit	3.87	1.10	7.30	0.73	0.50	2.00	0.56	< 0.50	0.58	< 0.50
Antimony		0.006	< 0.0354	< 0.0063	< 0.050	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Arsenic		0.010	0.0124[1]	0.0083	0.0180[1]	< 0.0040	< 0.0040	< 0.0040	< 0.0040	< 0.0040	< 0.0040	< 0.0040
Chromium		0.1	0.0570	0.0330	0.0870	0.0025	0.0020	0.0036	< 0.0020	< 0.0020	0.0021	< 0.0020
Iron		0.3	36.3[1]	21.0[1]	56.0[1]	0.18	< 0.050	1.30	0.13	< 0.05	0.97	0.059
Manganese		0.05	0.227[1]	0.140[1]	0.320[1]	0.043	0.027	0.077	0.033	0.046	0.051	0.032
Nickel		0.1	< 0.0210	< 0.0120	0.0320	< 0.0038	< 0.0030	< 0.0150	0.0032	< 0.0030	0.0036	< 0.0030
Zinc		5	0.2800	0.1000	0.4000	0.0148	0.0080	0.0210	0.0170	0.0150	0.0200	< 0.0160
Chloroform	µg/L	No Limit	< 3.40	< 0.20	< 5.00	< 0.60	< 0.60	< 0.60	< 0.60	< 0.60	< 0.60	< 0.60
Ethlybenzene		30	< 3.40	< 0.20	< 5.00	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50
Water Table Depth below ground surface*	feet	No Limit	-5.95	-11.17	-2.62	-4.01	-8.44	-1.52	-4.32	-6.35	NM	-5.52

[1] Exceeds permit limits for groundwater parameters.

* Negative values = depth to groundwater/water table below ground surface. Positive values = depth of groundwater/water table expressed above ground surface

< = indicates the compound was less than the minimum detection limit

Table 4-5. Summary results of interior monitoring well MWI3 for baseline monitoring years 2003-2005 combined, 100% EDS operational flow years 2012 through 2016 combined, and individual quarterly monitoring results for 2017.

MWI3												
Parameters	**Units**	**Permit Limit**	**Baseline Average**	**Baseline Minimum**	**Baseline Maximum**	**2012-2016 Average**	**2012-2016 Minimum**	**2012-2016 Maximum**	**Q_1 2017**	**Q_2 2017**	**Q_3 2017**	**Q_4 2017**
Temperature	°C	No Limit	20.5	17.5	22.5	22.5	18.5	32.6	20.8	22.1	23.4	21.1
Conductivity	µS/cm		56	54	60	221	52	376	409	320	255	303
pH	S.U.	6.5 - 8.5	4.55[1]	4.11[1]	4.91[1]	4.49	4.12	5.06	4.63	4.90	4.78	4.70
Turbidity	NTU	No Limit	72	20	237	16	0.2	59	20	41	19	19
Sodium	mg/L	160	5.3	4.4	6.4	36	4.3	70	75	61	55	54
TKN		No Limit	0.54	0.40	0.69	0.74	< 0.23	1.80	2.2	2.60	1.2	1.30
NH_3-N			0.07	0.05	0.11	0.34	< 0.02	5.00	0.36	0.11	0.050	0.07
NO_3-N/NO_2-N			0.086	0.019	0.140	0.060	< 0.018	0.860	< 0.018	< 0.018	< 0.018	< 0.018
NO_2-N			0.08	0.02	0.10	< 0.018	< 0.018	< 0.018	NM	NM	NM	NM
NO_3-N		10	0.100	0.019	0.150	0.064	0.014	0.860	< 0.018	< 0.018	< 0.018	< 0.018
TDS		500	49.7	38	74	136	32	300	330	270	270	250
SO_4		250	5.6	4.6	9.0	37	1.4	69	91	59	66	79
Chloride		250	10	9	12	34	8	62	48	46	43	39
Color	PCU	15	32[1]	28[1]	35[1]	70	5	390	450	400	550	280
Odor	TON	3	8.0[1]	8.0[1]	8.0[1]	23	2.0	130	16	16	8	3
TOC	mg/L	No Limit	7.4	7.0	7.9	21.3	0.5	66.0	52.0	53.0	44.0	38.0
Antimony		0.006	< 0.0347[1]	< 0.0040	0.050	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Arsenic		0.010	0.0047	0.0040	0.0050	< 0.0040	< 0.0040	< 0.0040	0.0060	< 0.0040	< 0.0040	< 0.0040
Chromium		0.1	< 0.0040	< 0.0020	0.0050	0.0032	< 0.0020	0.0130	< 0.0020	< 0.0020	0.0021	< 0.0020
Iron		0.3	2.0[1]	1.9[1]	2.1[1]	2.1	1.6	2.6	2.2	2.5	2.5	2.3
Manganese		0.05	0.010	0.008	0.011	0.016	0.009	0.036	0.019	0.019	0.013	0.014
Nickel		0.1	< 0.0040	< 0.0020	0.0050	< 0.0030	< 0.0030	< 0.0030	< 0.0030	0.0037	< 0.0030	< 0.0030
Zinc		5	< 0.0160	< 0.0080	0.0200	0.0088	< 0.0080	0.0180	< 0.0080	< 0.0080	< 0.0080	< 0.0080
Chloroform	µg/L	No Limit	< 3.40	< 0.20	< 5.00	< 0.60	< 0.60	< 0.60	< 0.60	< 0.60	< 0.60	< 0.60
Ethlybenzene		30	< 1.81	< 0.20	< 5.00	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50
Water Table Depth below ground surface*	feet	No Limit	-1.86	-3.23	-1.18	-0.40	-0.60	0.15	-0.6	0.10	-0.40	-0.28

[1] Exceeds permit limits for groundwater parameters.

* Negative values = depth to groundwater/water table below ground surface. Positive values = depth of groundwater/water table expressed above ground surface

< = indicates the compound was less than the minimum detection limit

Table 4-6. Summary results of interior monitoring well MWI4 for baseline monitoring years 2003-2005 combined, 100% EDS operational flow years 2012 through 2016 combined, and individual quarterly monitoring results for 2017.

MWI4												
Parameters	**Units**	**Permit Limit**	**Baseline Average**	**Baseline Minimum**	**Baseline Maximum**	**2012-2016 Average**	**2012-2016 Minimum**	**2012-2016 Maximum**	**Q_1 2017**	**Q_2 2017**	**Q_3 2017**	**Q_4 2017**
Temperature	°C	No Limit	20.1	18.0	21.9	21.9	19.5	31.5	20.4	21	21.5	19.82
Conductivity	µS/cm		52	51	54	26	17	30	26	26	27	27
pH	S.U.	6.5 - 8.5	4.88[1]	4.11[1]	5.10[1]	4.84	4.16	5.08	4.66	4.91	4.88	4.99
Turbidity	NTU	No Limit	301	20	1000	3	0.1	10	0.7	1.6	0.5	0.9
Sodium	mg/L	160	5.2	2.4	8.1	2.3	2.1	2.8	2.4	2.3	2.5	2.4
TKN		No Limit	0.60	0.40	1.0	0.31	0.23	1.0	< 0.26	< 0.26	< 0.26	< 0.26
NH3-N			0.061	0.038	0.130	0.022	0.015	0.110	0.100	< 0.020	< 0.020	< 0.020
NO3-N/NO2-N			0.080	0.019	0.120	0.017	0.012	< 0.018	< 0.018	< 0.018	< 0.018	0.048
NO2-N			< 0.08	< 0.02	0.10	< 0.018	< 0.018	< 0.018	NM	NM	NM	NM
NO3-N		10	0.090	0.019	0.130	< 0.018	< 0.018	< 0.018	< 0.018	< 0.018	< 0.018	0.048
TDS		500	52	28	100	19	3	48	10	6	22	20
SO_4		250	9.7	1.5	36.0	1.6	< 1.4	2.6	< 2.6	3.0	2.4	1.6
Chloride		250	11	9.0	13	4.1	3.0	4.8	3.9	4.1	4.0	3.8
Color	PCU	15	52[1]	13	90[1]	2.9	< 1.5	9.5	< 1.5	< 1.5	< 1.5	< 1.5
Odor	TON	3	8.0[1]	8.0[1]	8.0[1]	2.0	< 1.0	20	< 1.0	< 1.0	< 1.0	< 1.0
TOC	mg/L	No Limit	1.5	0.3	2.6	1.3	< 0.5	16.0	< 0.5	0.52	0.53	< 0.5
Antimony		0.006	0.0347[1]	0.0040	0.050[1]	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Arsenic		0.010	0.0047	0.0040	0.0050	< 0.0040	< 0.0040	< 0.0040	< 0.0040	< 0.0040	< 0.0040	< 0.0040
Chromium		0.1	0.0040	0.0020	0.0050	0.0021	< 0.0020	0.0026	< 0.0020	0.0021	< 0.0020	< 0.0020
Iron		0.3	2.2[1]	1.0[1]	3.1[1]	0.36	0.08	0.57	0.54	0.58	0.37	0.40
Manganese		0.05	0.021	0.011	0.036	0.019	0.016	0.024	0.018	0.031	0.019	0.017
Nickel		0.1	< 0.0040	< 0.0020	0.0050	< 0.0038	< 0.0030	< 0.0150	< 0.0030	< 0.0030	< 0.0030	< 0.0030
Zinc		5	0.116	0.0080	0.320	0.015	< 0.008	0.053	< 0.008	0.009	0.009	0.009
Chloroform	µg/L	No Limit	< 3.40	< 0.20	< 5.00	< 0.60	< 0.60	< 0.60	< 0.60	< 0.60	< 0.60	< 0.60
Ethlybenzene		30	< 3.40	< 0.20	< 5.00	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50
Water Table Depth below ground surface*	feet	No Limit	-1.74	-3.21	-0.95	1.79	1.79	1.79	1.79	1.79	1.79	1.79

[1] Exceeds permit limits for groundwater parameters.

* Negative values = depth to groundwater/water table below ground surface. Positive values = depth of groundwater/water table expressed above ground surface

< = indicates the compound was less than the minimum detection limit

Table 4-7. Summary results of interior monitoring well MWI5 for baseline monitoring years 2003-2005 combined, 100% EDS operational flow years 2012 through 2016 combined, and individual quarterly monitoring results for 2017.

MWI5												
Parameters	**Units**	**Permit Limit**	**Baseline Average**	**Baseline Minimum**	**Baseline Maximum**	**2012-2016 Average**	**2012-2016 Minimum**	**2012-2016 Maximum**	**Q_1 2017**	**Q_2 2017**	**Q_3 2017**	**Q_4 2017**
Temperature	C deg	No Limit	20.8	18.2	22.4	21.0	17.3	24.8	20.0	21.0	23.8	20.4
Conductivity	µS/cm		29	26	31	69	29	244	39	92	67	66
pH	SU	6.5 - 8.5	4.72[1]	3.78[1]	5.14[1]	4.65	4.12	5.29	4.91	5.01	5.28	5.27
Turbidity	NTU's	No Limit	406	98	1000	11	0.4	36	26	38	11	26
Sodium	mg/L	160	2.4	2.1	2.8	10.1	2.3	40.0	5.9	15.0	12.0	10.0
TKN		No Limit	0.71	0.40	1.70	0.30	< 0.23	1.10	< 0.26	< 0.26	< 0.26	< 0.26
NH_3-N			0.048	0.035	0.050	0.022	< 0.015	0.110	0.110	< 0.022	< 0.022	< 0.022
NO_3-N/NO_2-N			0.086	0.019	0.140	0.019	< 0.018	0.034	< 0.018	0.019	< 0.018	< 0.018
NO_2-N			0.08	0.02	0.10	< 0.018	< 0.018	< 0.018	NM	NM	NM	NM
NO_3-N		10	0.097	0.019	0.160	0.020	0.013	0.034	< 0.018	0.019	< 0.018	< 0.018
TDS		500	53	34	100	40	6	150	8	28	56	42
SO_4		250	5.1	2.7	6.3	14.6	1.4	71.0	4.9	22.0	12.0	12.0
Chloride		250	5.5	3.7	8.8	6.5	3.5	15.0	5.5	7.7	6.1	5.7
Color	PCU	15	88[1]	40[1]	170[1]	16	1.4	55	< 69	37	29	47
Odor	TON	3	1.0	< 1.0	< 1.0	< 1.00	< 1.0	1.0	< 1.0	< 1.0	< 1.0	< 1.0
TOC	mg/L	No Limit	1.9	1.0	3.1	0.55	< 0.50	0.93	0.66	0.67	0.6	< 0.50
Antimony		0.006	0.0348[1]	0.0044	0.0500	< 0.0100	< 0.0100	< 0.0100	< 0.0100	< 0.0100	< 0.0100	< 0.0100
Arsenic		0.010	0.0047	0.0040	0.0050	< 0.0040	< 0.0040	< 0.0040	< 0.0088	< 0.0040	< 0.0040	< 0.0040
Chromium		0.1	0.0068	0.0033	0.0100	0.0025	< 0.0020	0.0071	0.0026	0.0023	< 0.0020	0.0023
Iron		0.3	0.5[1]	0.3	0.8[1]	0.16	0.06	0.47	0.13	0.23	0.22	0.57
Manganese		0.05	0.008	0.004	0.010	0.004	0.001	0.010	0.001	0.001	0.001	0.002
Nickel		0.1	0.0040	< 0.0020	< 0.0050	0.0035	< 0.0030	< 0.0080	< 0.0030	< 0.0030	< 0.0030	< 0.0030
Zinc		5	0.0893	< 0.0080	0.2400	< 0.0080	< 0.0080	< 0.0080	< 0.0080	< 0.0080	< 0.0080	< 0.0080
Chloroform	ug/L	No Limit	3.40	< 0.20	< 5.00	< 0.60	< 0.60	< 0.60	< 0.60	< 0.60	< 0.60	< 0.60
Ethlybenzene		30	3.40	< 0.20	< 5.00	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50
Water Table Depth below ground surface*	ft	No Limit	-1.03	-2.02	-0.38	-0.15	-0.64	0.28	-0.24	0.86	0.26	0.07

[1] Exceeds permit limits for groundwater parameters.

* Negative values = depth to groundwater/water table below ground surface. Positive values = depth of groundwater/water table expressed above ground surface

< = indicates the compound was less than the minimum detection limit

Table 4-8. Summary results of compliance monitoring well MWC6 for baseline monitoring years 2003-2005 combined, 100% EDS operational flow years 2012 through 2016 combined, and individual quarterly monitoring results for 2017.

MWC6												
Parameters	**Units**	**Permit Limit**	**Baseline Average**	**Baseline Minimum**	**Baseline Maximum**	**2012-2016 Average**	**2012-2016 Minimum**	**2012-2016 Maximum**	**Q_1 2017**	**Q_2 2017**	**Q_3 2017**	**Q_4 2017**
Temperature	C deg	No Limit	20.9	15.9	23.8	22.3	17.2	29.0	20.5	22.4	24.4	16.7
Conductivity	µS/cm		57	55	63	55	36	64	58	60	61	69
pH	SU	6.5 - 8.5	5.10[1]	4.65[1]	5.42[1]	4.92	4.45	5.27	4.82	5.02	5.02	4.48
Turbidity	NTU's	No Limit	439	120	1000	11	2.1	85	3.9	3.0	2.7	2.0
Sodium	mg/L	160	4.6	4.3	4.9	4.7	0.0	6.0	5.4	5.3	5.5	5.6
TKN		No Limit	2.25	0.43	8.60	0.37	< 0.26	1.40	0.27	< 0.26	< 0.26	< 0.26
NH_3-N			0.069	0.050	0.110	0.023	0.015	0.110	< 0.240	0.037	< 0.02	< 0.02
NO_3-N/NO_2-N			0.160	0.100	0.230	0.030	0.012	0.280	< 0.018	< 0.018	< 0.018	< 0.018
NO_2-N			0.08	0.02	0.10	< 0.018	< 0.018	< 0.018	NM	NM	NM	NM
NO_3-N		10	0.133	0.100	0.230	0.031	0.012	0.280	< 0.018	< 0.018	< 0.018	< 0.018
TDS		500	570[1]	72	2600[1]	33	6	60	36	34	46	80
SO_4		250	100	2.6	550[1]	1.4	< 1.4	1.9	1.6	1.6	< 1.4	1.7
Chloride		250	27	9	86	12	10	14	13	13	13	15
Color	PCU	15	220[1]	150[1]	360[1]	14	< 1.5	110	7.1	< 1.5	< 1.5	< 1.5
Odor	TON	3	1.5	1.0	2.0	3.6	< 1.0	16.0	< 16.0	1.0	< 1.0	< 1.0
TOC	mg/L	No Limit	3	2	5	2	2	4	2.0	2.1	2.2	2.0
Antimony		0.006	0.0347[1]	0.0040	0.0500[1]	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Arsenic		0.010	< 0.0047	< 0.0040	0.0050	< 0.0040	< 0.0040	< 0.0040	< 0.0040	< 0.0040	< 0.0040	< 0.0040
Chromium		0.1	0.0070	0.0060	0.0090	0.003	< 0.0020	0.014	< 0.0020	< 0.0020	< 0.0020	< 0.0020
Iron		0.3	4.2[1]	4.0[1]	4.5[1]	2.5	1.7	4.1	2.4	2.7	2.7	0.64
Manganese		0.05	0.011	0.010	0.012	0.008	0.006	0.016	0.008	0.008	0.009	0.009
Nickel		0.1	< 0.0040	< 0.0020	< 0.0050	0.0052	< 0.0030	0.0410	< 0.0030	< 0.0030	< 0.0030	< 0.0030
Zinc		5	0.1060	< 0.0080	0.2900	0.0089	0.0080	0.0180	< 0.0080	< 0.0080	< 0.0080	< 0.0080
Chloroform	ug/L	No Limit	< 3.40	< 0.20	< 5.00	< 0.60	< 0.60	< 0.60	< 0.60	< 0.60	< 0.60	< 0.60
Ethlybenzene		30	< 3.40	< 0.20	< 5.00	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50
Water Table Depth below ground surface*	ft	No Limit	-1.02	-2.52	-0.33	-0.63	-2.47	0.25	-0.58	0.27	NM	-0.46

[1] Exceeds permit limits for groundwater parameters.

* Negative values = depth to groundwater/water table below ground surface. Positive values = depth of groundwater/water table expressed above ground surface

< = indicates the compound was less than the minimum detection limit

Table 4-9. Summary results of compliance monitoring well MWC7 for baseline monitoring years 2003-2005 combined, 100% EDS operational flow years 2012 through 2016 combined, and individual quarterly monitoring results for 2017.

MWC7												
Parameters	**Units**	**Permit Limit**	**Baseline Average**	**Baseline Minimum**	**Baseline Maximum**	**2012-2016 Average**	**2012-2016 Minimum**	**2012-2016 Maximum**	**Q_1 2017**	**Q_2 2017**	**Q_3 2017**	**Q_4 2017**
Temperature	C deg	No Limit	20.4	17.9	22.3	19.7	16.6	25.7	18.9	20.6	22.2	19.7
Conductivity	µS/cm		44	37	52	32	24	36	30.9	32	32	33
pH	SU	6.5 - 8.5	4.84[1]	4.57[1]	5.20[1]	4.72	4.15	5.03	4.46	4.90	4.90	4.81
Turbidity	NTU's	No Limit	88	25	206	6	0.8	18	8.5	NM	2.3	3.9
Sodium	mg/L	160	3.9	2.8	5.0	2.7	0.9	3.1	2.8	2.5	2.9	2.8
TKN		No Limit	0.52	0.40	0.67	0.30	< 0.26	1.10	< 0.26	< 0.26	< 0.26	< 0.26
NH_3-N			< 0.05	< 0.050	0.068	0.031	< 0.022	0.110	< 0.091	< 0.022	< 0.022	< 0.022
NO_3-N/NO_2-N			0.083	< 0.019	0.130	0.091	< 0.018	1.500	< 0.018	< 0.018	< 0.018	< 0.018
NO_2-N			0.080	0.018	< 0.100	< 0.018	< 0.018	< 0.018	NM	NM	NM	NM
NO_3-N		10	0.085	0.019	0.120	0.092	< 0.018	1.500	< 0.018	< 0.018	< 0.018	< 0.018
TDS		500	42	38	48	17	3	42	12	14	10	10
SO_4		250	6.4	4.8	9.8	2.5	1.4	3.5	3.7	2.9	3.2	3.0
Chloride		250	6.2	4.0	8.3	4.9	3.6	5.8	5.0	4.3	4.7	4.3
Color	PCU	15	291[1]	22[1]	780[1]	6.1	< 1.5	25	< 1.5	7.3	< 1.5	< 1.5
Odor	TON	3	5.0[1]	2.0	8.0[1]	4.4	1.0	40.0	< 1.0	2.0	2.0	1.0
TOC	mg/L	No Limit	2.2	1.6	3.2	0.9	0.7	1.9	0.9	0.7	0.8	0.6
Antimony		0.006	0.0348[1]	0.0044	0.050[1]	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Arsenic		0.010	0.0047	< 0.0040	0.0050	< 0.0040	< 0.0040	< 0.0040	< 0.0040	< 0.0040	< 0.0040	< 0.0040
Chromium		0.1	< 0.0050	< 0.0020	0.0080	0.0029	< 0.0020	0.0190	< 0.0020	0.0020	0.0020	< 0.0020
Iron		0.3	1.70[1]	1.10[1]	2.30[1]	0.46	0.20	0.90	0.54	0.40	0.36	0.44
Manganese		0.05	0.009	0.008	0.010	0.006	0.004	0.0096	0.006	0.006	0.006	0.006
Nickel		0.1	< 0.0040	< 0.0020	< 0.0050	0.0040	< 0.0030	< 0.0030	< 0.0030	< 0.0030	< 0.0030	< 0.0030
Zinc		5	0.0650	< 0.0080	0.1400	< 0.0080	< 0.0080	< 0.0080	< 0.0080	< 0.0080	< 0.0080	< 0.0080
Chloroform	ug/L	No Limit	< 3.40	< 0.20	< 5.00	< 0.60	< 0.60	< 0.60	< 0.60	< 0.60	< 0.60	< 0.60
Ethlybenzene		30	< 3.40	< 0.20	< 5.00	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50
Water Table Depth below ground surface*	ft	No Limit	-2.00	-4.02	-0.97	-1.19	-2.40	1.03	-1.77	0.86	-0.07	-1.82

[1] Exceeds permit limits for groundwater parameters.

* Negative values = depth to groundwater/water table below ground surface. Positive values = depth of groundwater/water table expressed above ground surface

< = indicates the compound was less than the minimum detection limit

Table 4-10. Historic groundwater parameter results from monitoring wells in the Northwest Reporting Unit D-Sand & Gravel Aquifer. Background Network Summary Statistics 1994-1997.

Parameter	Units	# of Wells	Minimum Value	Median Value	Maximum Value
Temperature	°C	59	19.6	20.8	26.1
Specific Conductance, Field	µS/cm	59	15	33	122
pH, Field	S.U.	59	4.85	5.25	6.48
Turbidity	NTU	57	< 0.8	4.725	1600
Sodium, Dissolved	mg/L	58	0.5	2.3	16
Ammonia+Organic Nitrogen, Dissolved		58	< 0.2	< 0.2	0.43
Ammonia, Dissolved (as N)		58	< 0.01	0.01	0.07
Nitrate+Nitrite, Dissolved (as N)		58	< 0.2	< 0.2	4.2
Sulfate, Dissolved		57	< 0.2	0.75	11
Sulfide, Total		38	< 1	< 1	< 1
Chloride, Dissolved		57	1.7	3.7	18
Organic Carbon, Total		39	< 2.0	< 2.0	2.7
Arsenic, Total		58	< 0.001	0.001	0.012
Chromium, Total		58	< 0.005	< 0.005	0.011
Iron, Total		58	0.013	0.570	10.015
Manganese, Total		58	0.0014	0.0205	0.1900
Nickel, Total		58	< 0.010	< 0.010	0.010
Cadmium, Total		58	< 0.001	< 0.001	0.001
Zinc, Total		58	< 0.004	0.011	1.300

Figure 4-1. Location of groundwater monitoring wells.

Nutter & Associates
environmental consultants

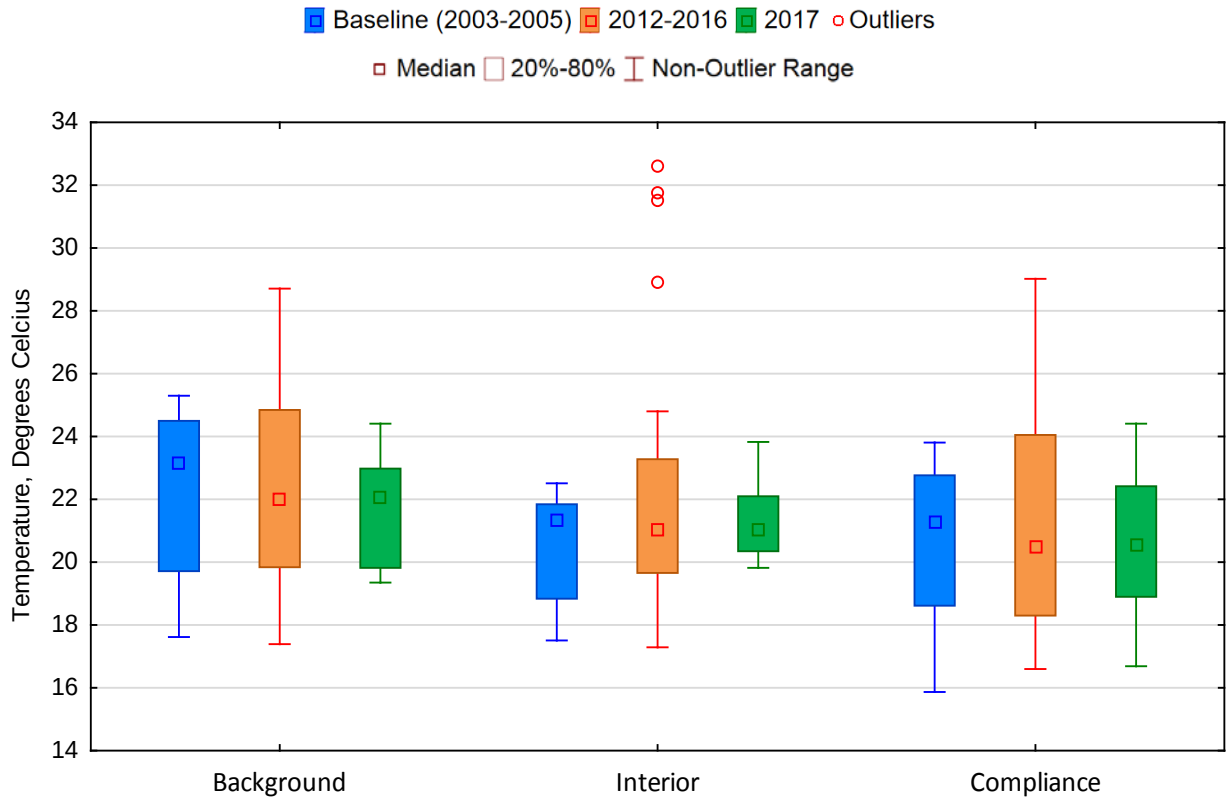


Figure 4-2. Comparison of baseline (2003-2005), 2012 through 2016, and 2017 groundwater temperature at the background, interior, and compliance wells.

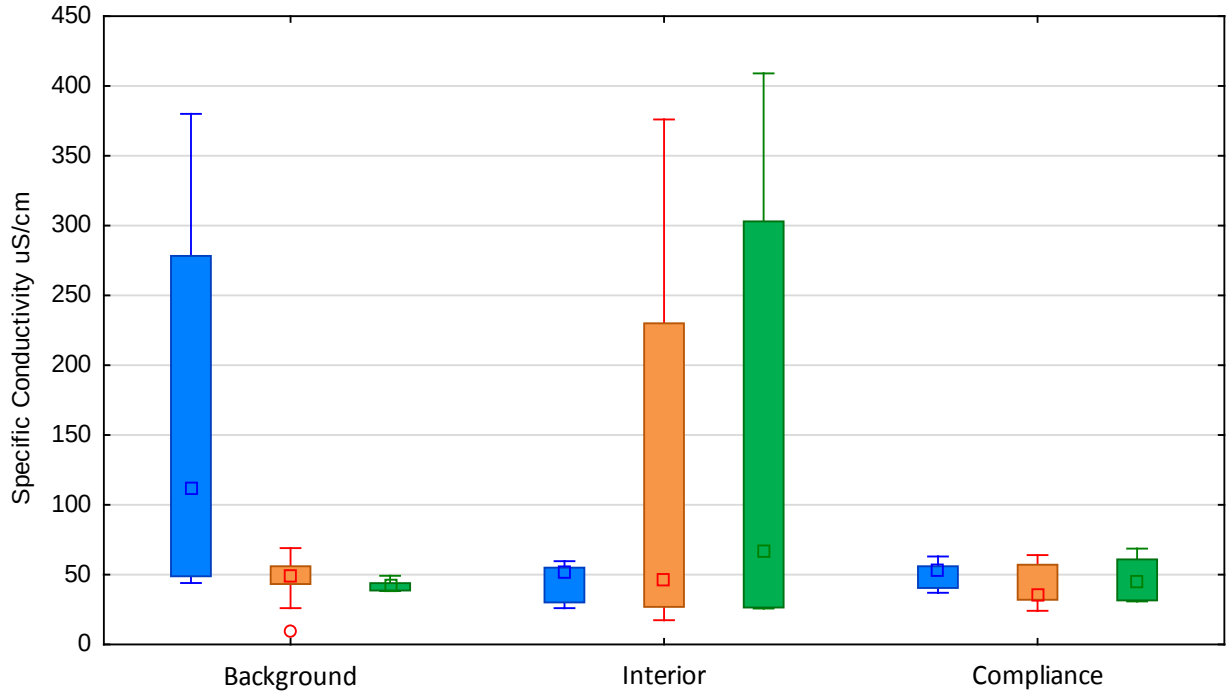


Figure 4-3. Comparison of baseline (2003-2005), 2012 through 2016, and 2017 groundwater specific conductivity at the background, interior, and compliance wells.

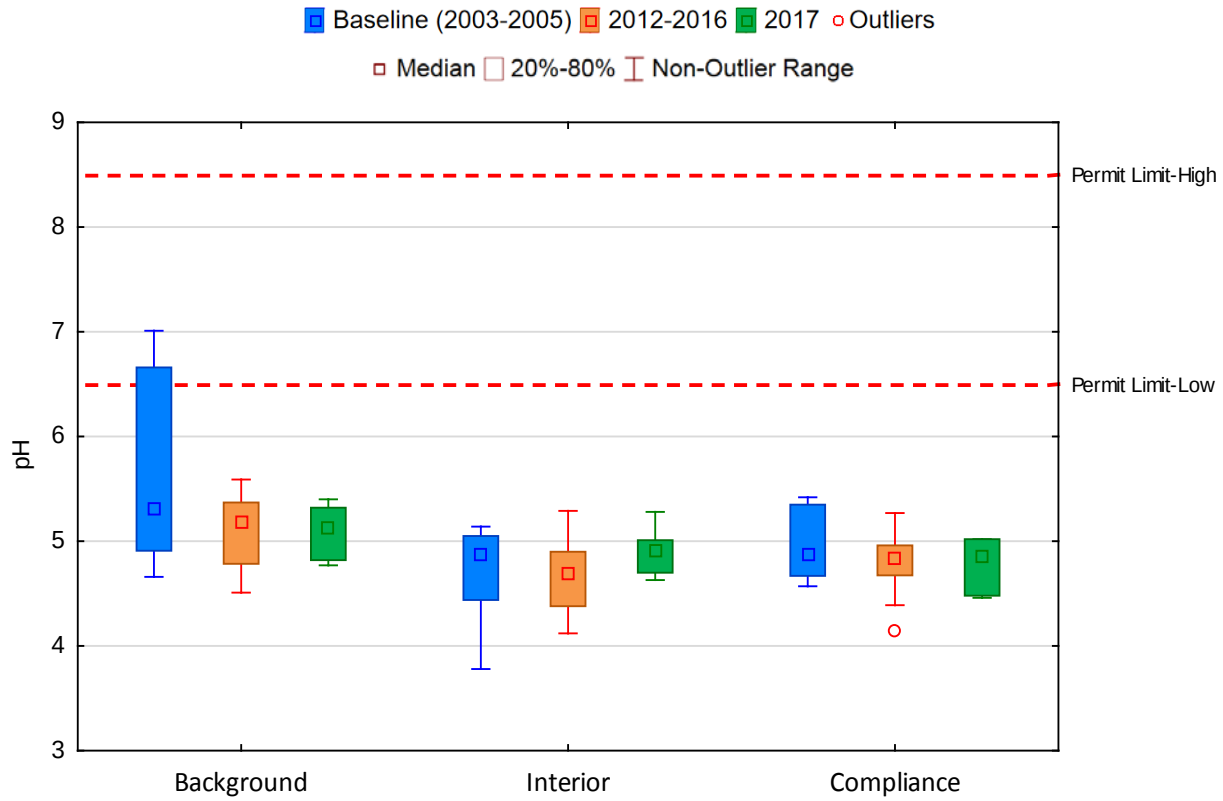


Figure 4-4. Comparison of baseline (2003-2005), 2012 through 2016, and 2017 groundwater pH at the background, interior, and compliance wells.

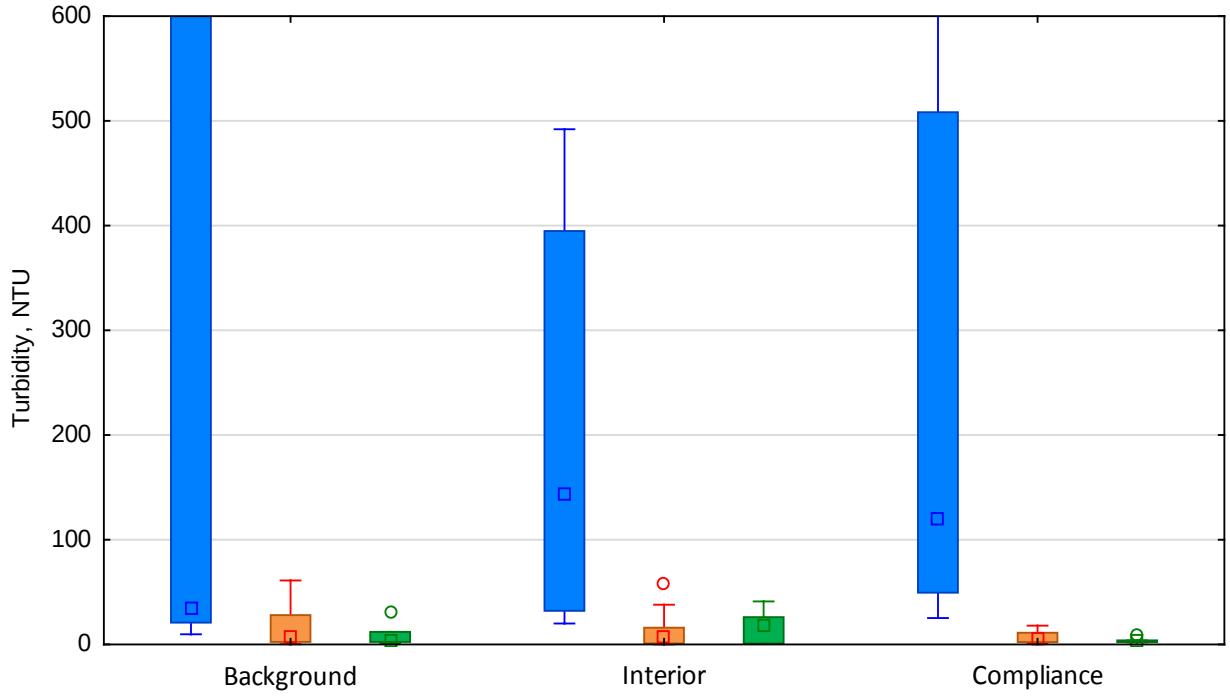


Figure 4-5. Comparison of baseline (2003-2005), 2012 through 2016, and 2017 groundwater turbidity at the background, interior, and compliance wells.

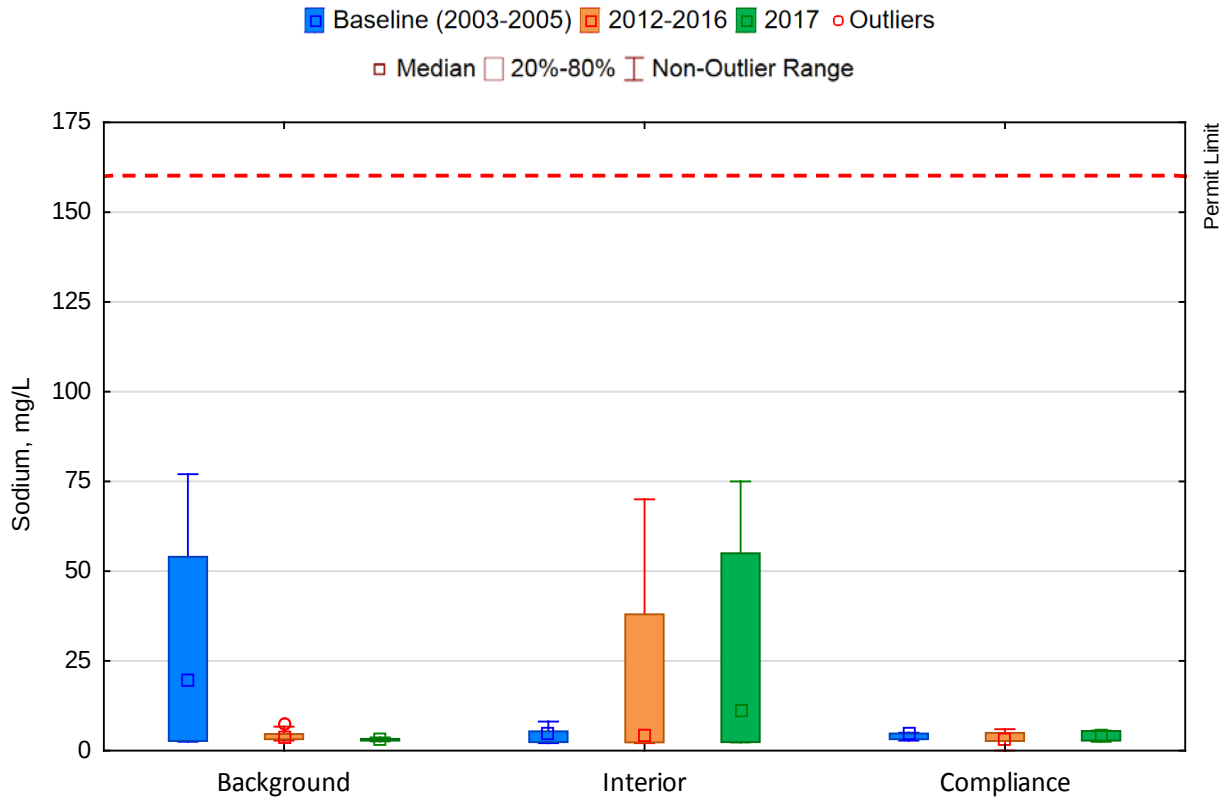


Figure 4-6. Comparison of baseline (2003-2005), 2012 through 2016, and 2017 groundwater sodium at the background, interior, and compliance wells.

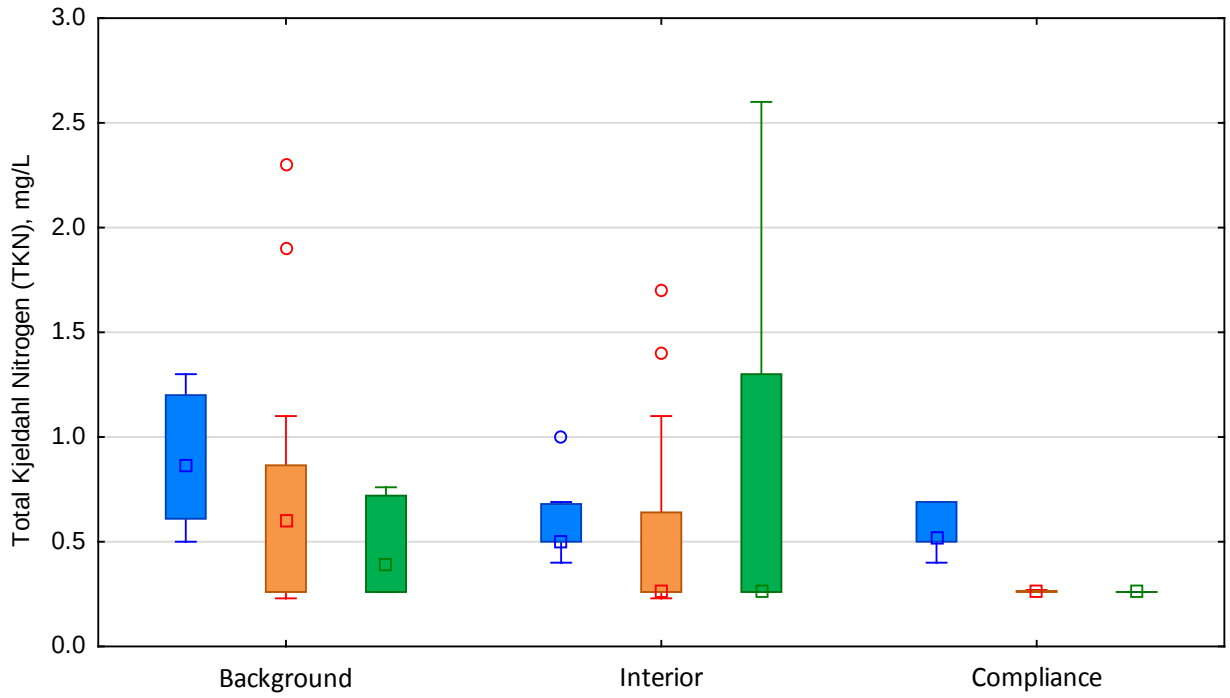


Figure 4-7. Comparison of baseline (2003-2005), 2012 through 2016, and 2017 groundwater total kjeldahl nitrogen (TKN) at the background, interior, and compliance wells.

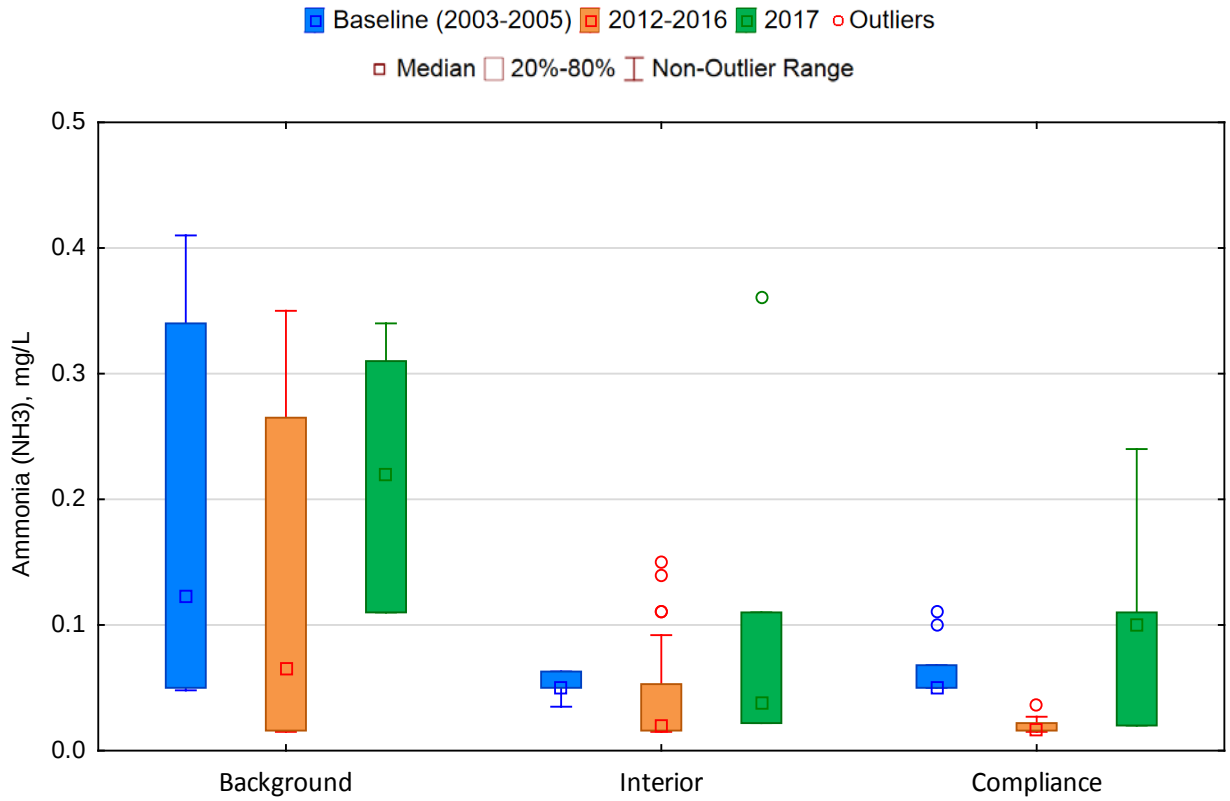


Figure 4-8. Comparison of baseline (2003-2005), 2012 through 2016, and 2017 groundwater ammonia at the background, interior, and compliance wells.

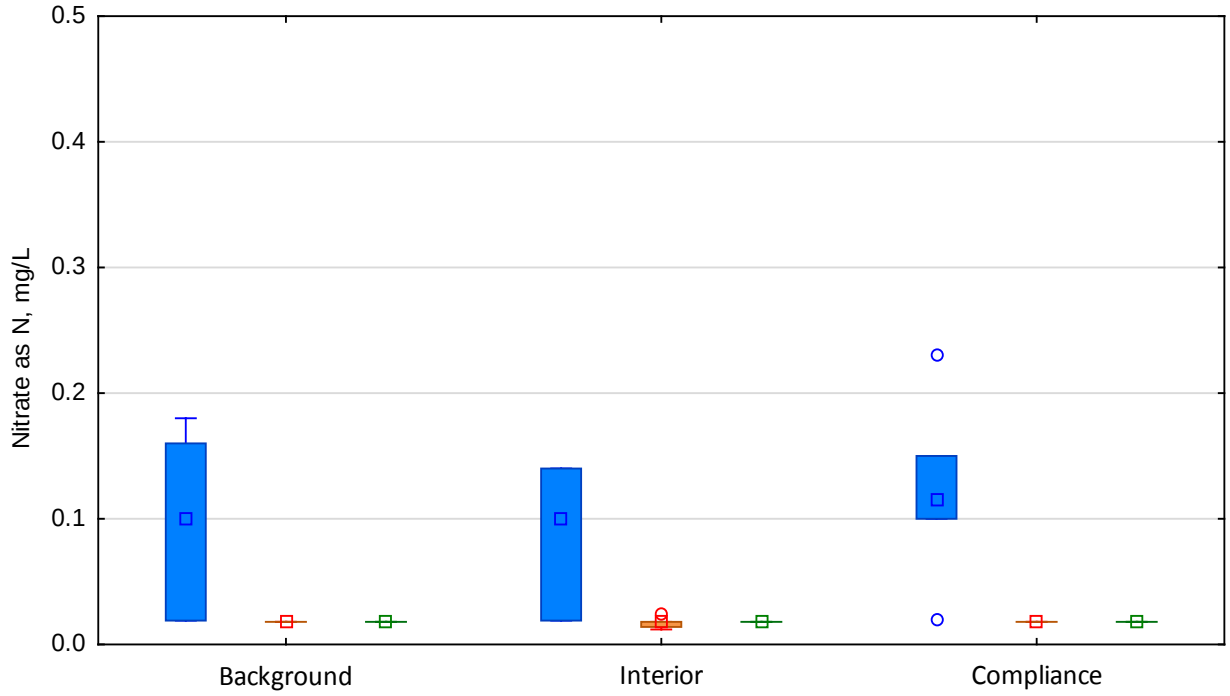


Figure 4-9. Comparison of baseline (2003-2005), 2012 through 2016, and 2017 groundwater nitrate at the background, interior, and compliance wells.

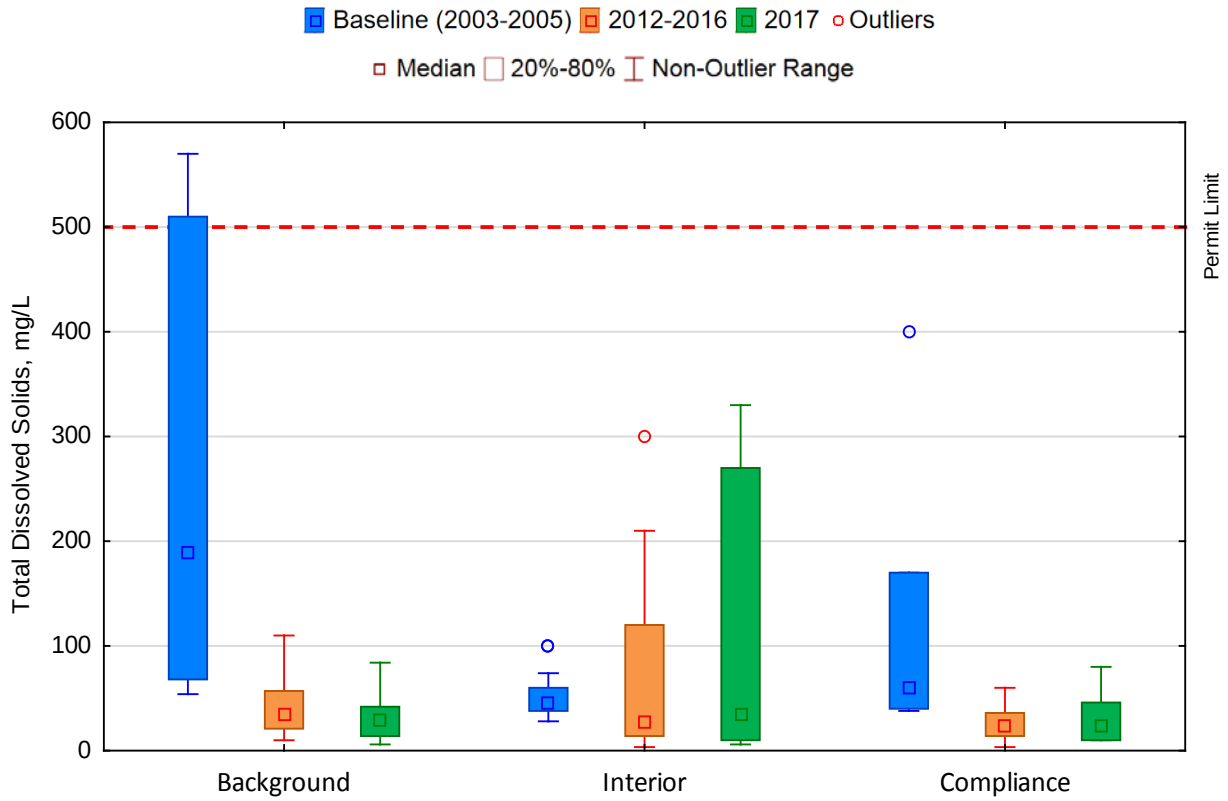


Figure 4-10. Comparison of baseline (2003-2005), 2012 through 2016, and 2017 groundwater total dissolved solids (TDS) at the background, interior, and compliance wells.

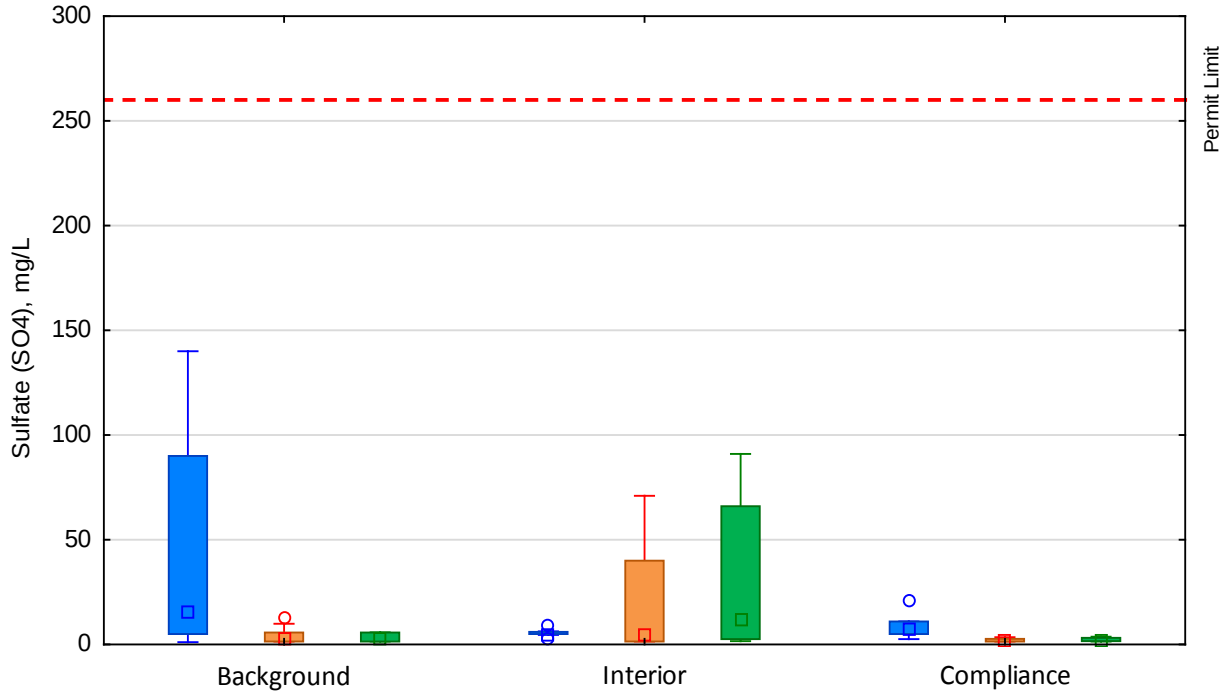


Figure 4-11. Comparison of baseline (2003-2005), 2012 through 2016, and 2017 groundwater sulfate at the background, interior, and compliance wells.

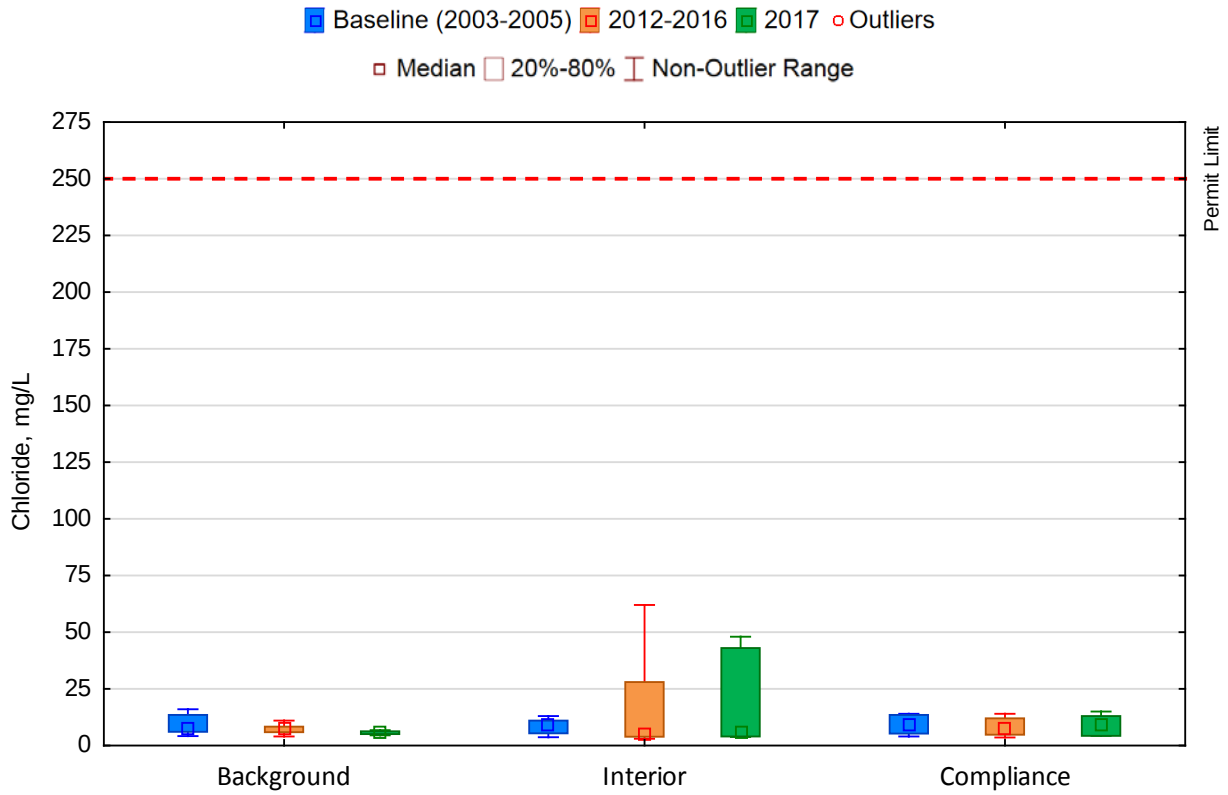


Figure 4-12. Comparison of baseline (2003-2005), 2012 through 2016, and 2017 groundwater chloride at the background, interior, and compliance wells.

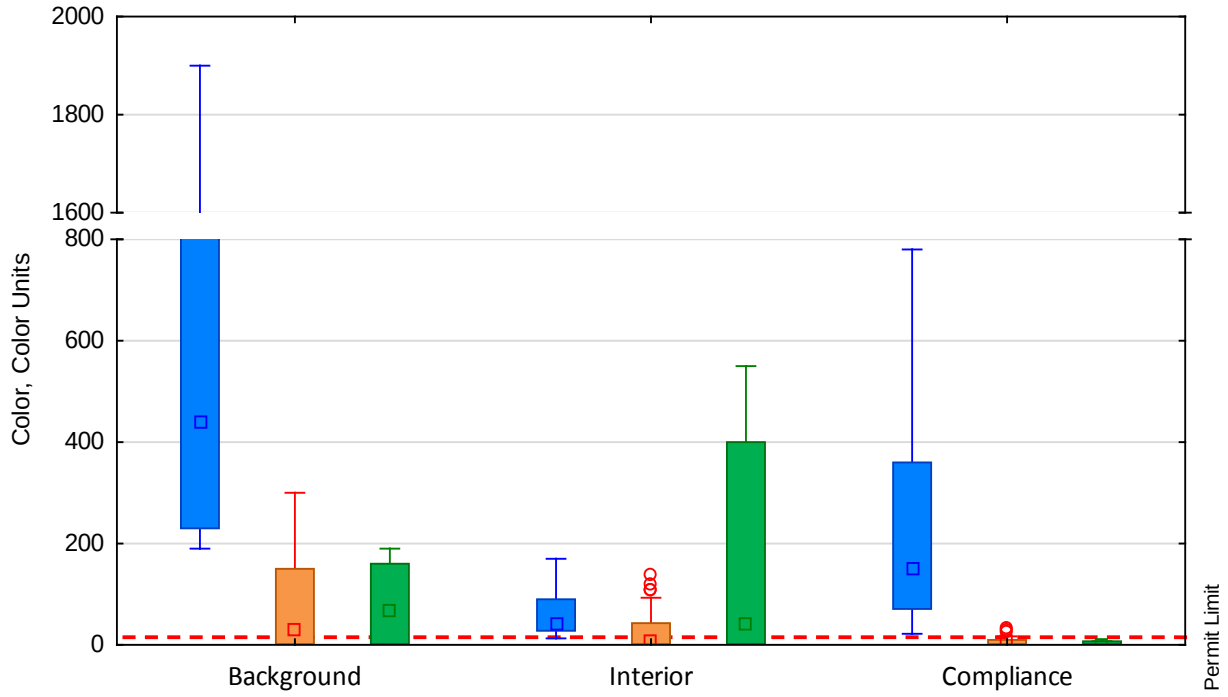


Figure 4-13. Comparison of baseline (2003-2005), 2012 through 2016, and 2017 groundwater color at background, interior, and compliance wells.

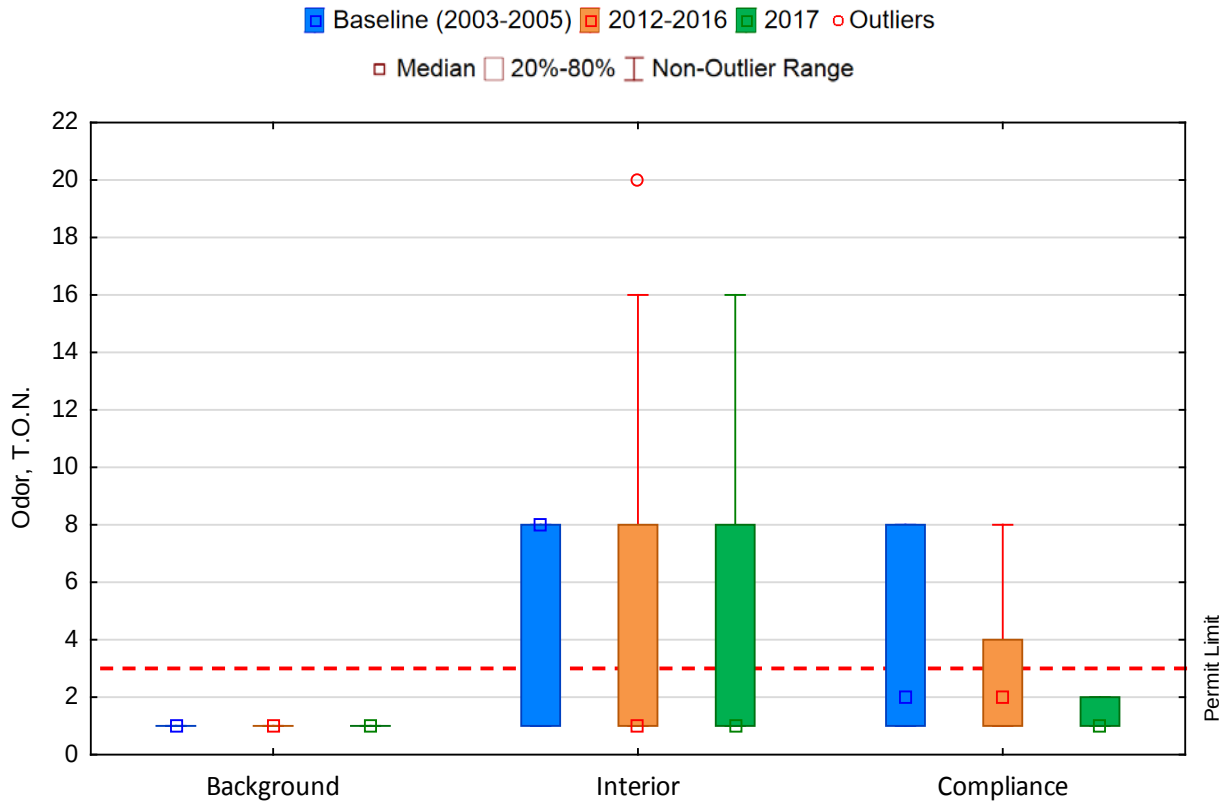


Figure 4-14. Comparison of baseline (2003-2005), 2012 through 2016, and 2017 groundwater odor at the background, interior, and compliance wells.

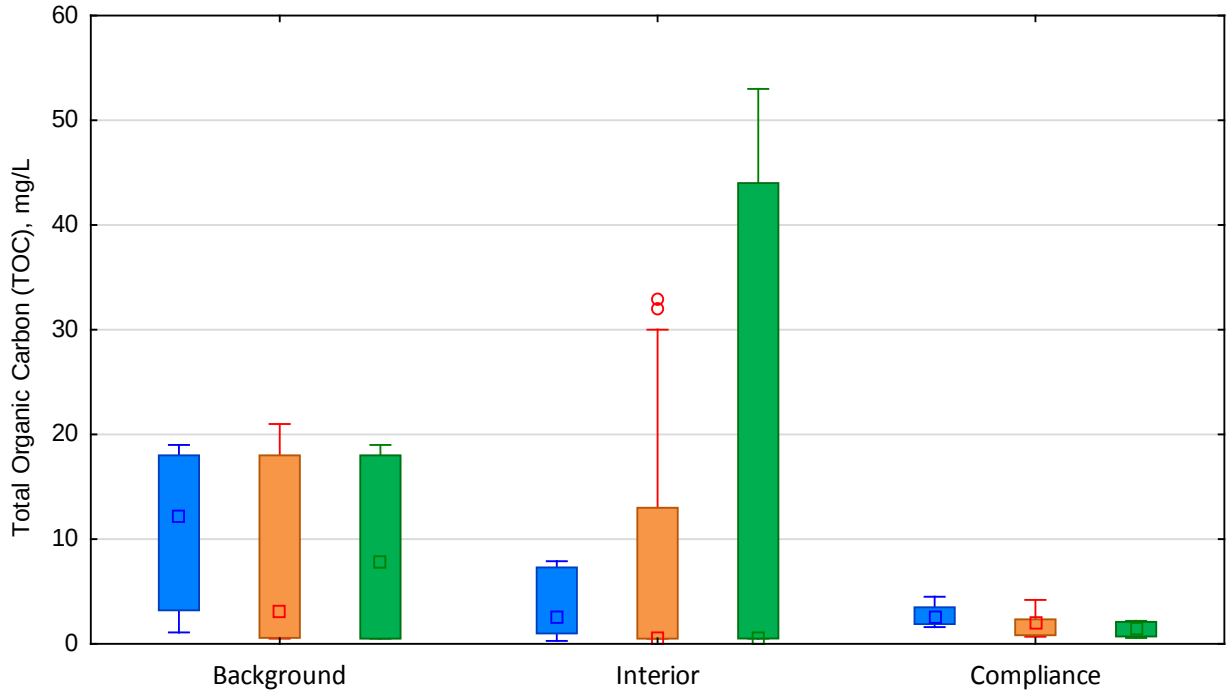


Figure 4-15. Comparison of baseline (2003-2005) and 2012 through 2016, and 2017 groundwater total organic carbon (TOC) at the background, interior, and compliance wells.

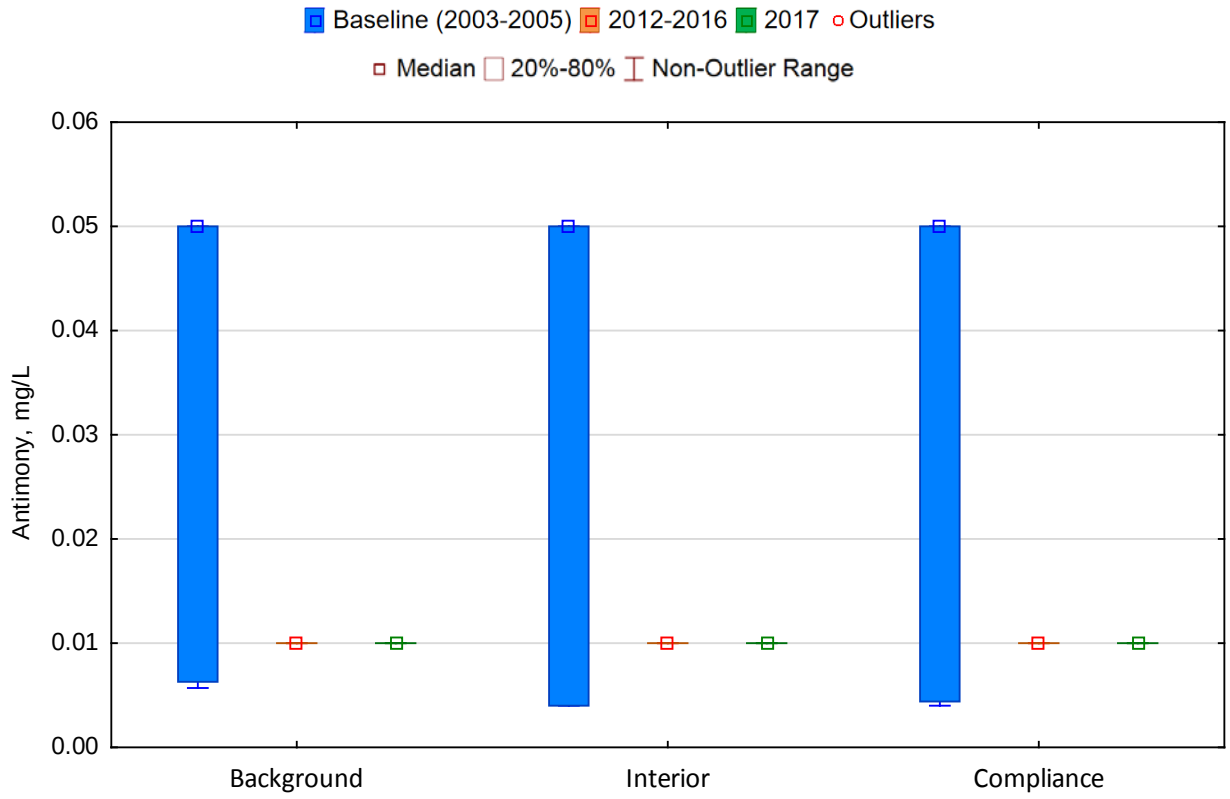


Figure 4-16. Comparison of baseline (2003-2005), 2012 through 2016, and 2017 groundwater antimony at the background, interior, and compliance wells.

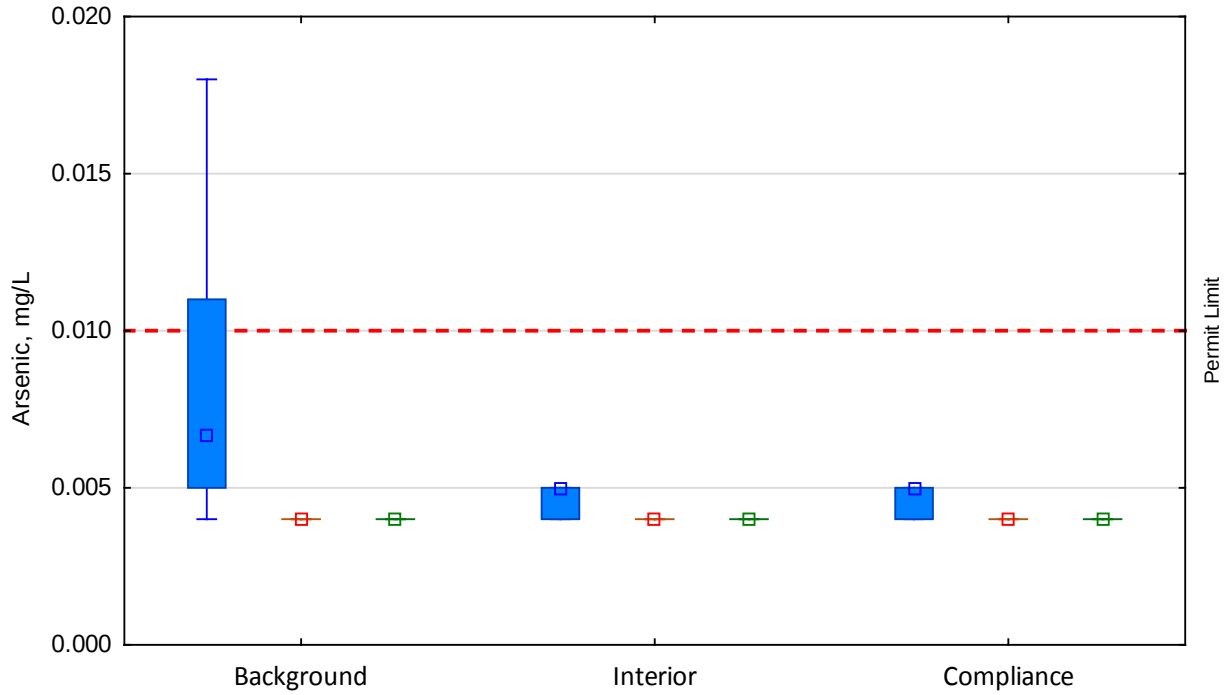


Figure 4-17. Comparison of baseline (2003-2005), 2012 through 2016, and 2017 groundwater arsenic at the background, interior, and compliance wells.

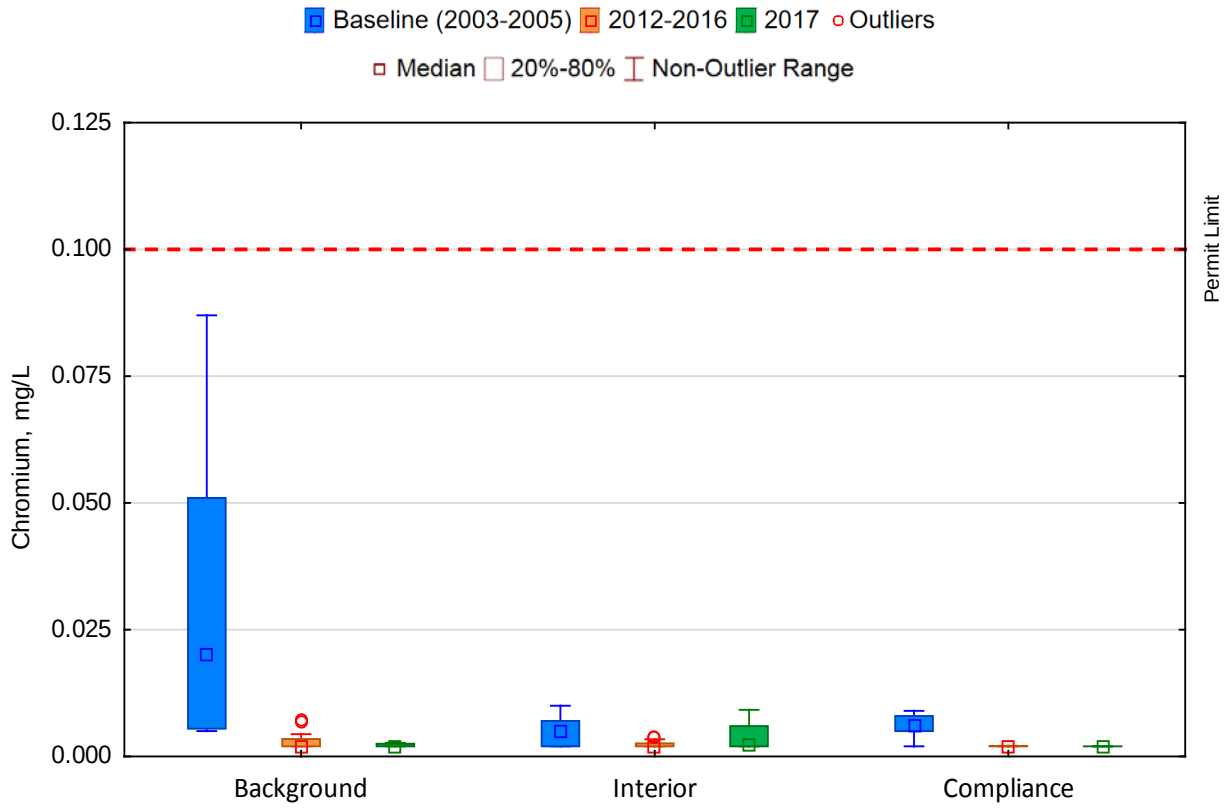


Figure 4-18. Comparison of baseline (2003-2005), 2012 through 2016, and 2017 groundwater chromium at the background, interior, and compliance wells.

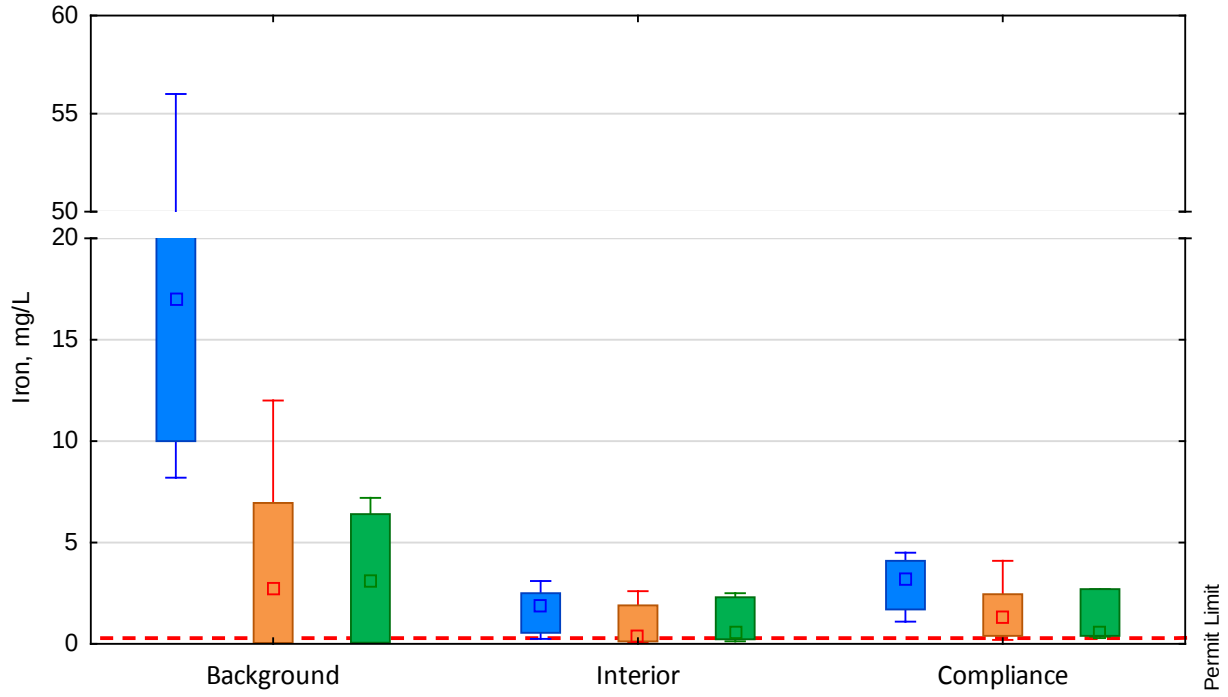


Figure 4-19. Comparison of baseline (2003-2005), 2012 through 2016, and 2017 groundwater iron at the background, interior, and compliance wells.

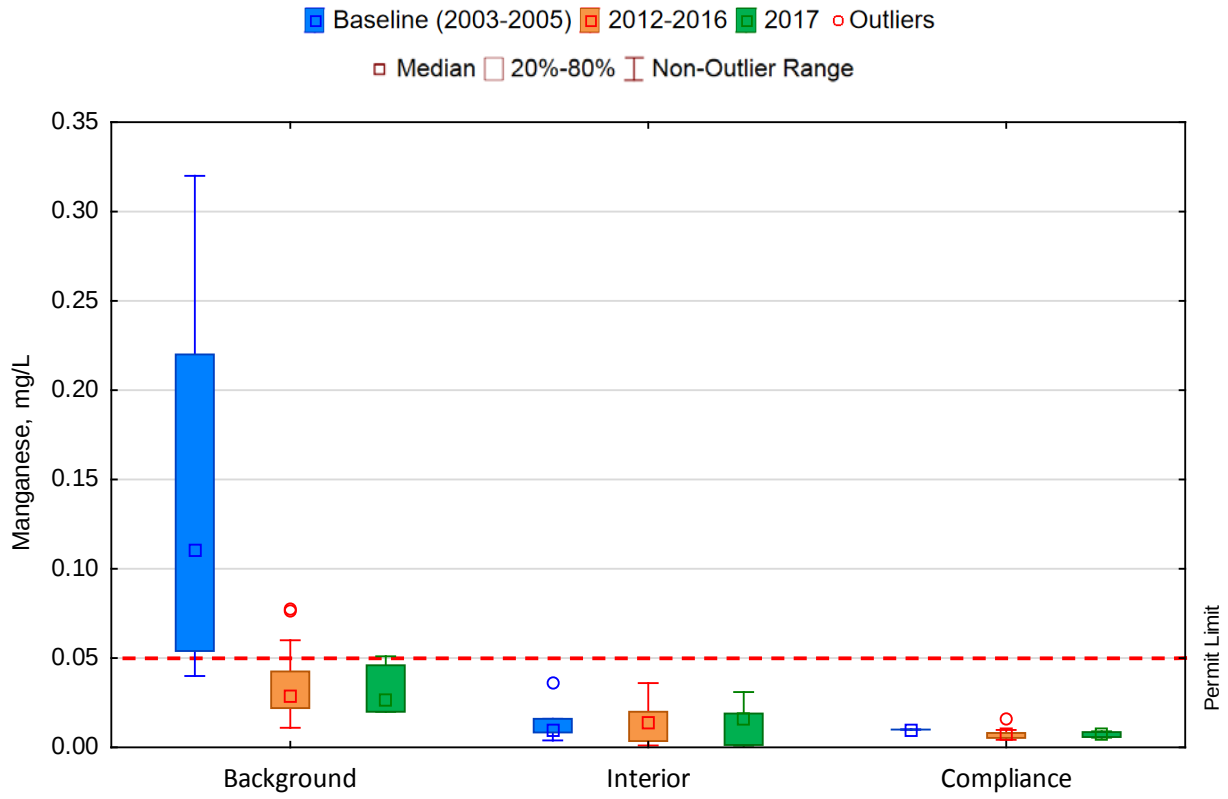


Figure 4-20. Comparison of baseline (2003-2005), 2012 through 2016, and 2017 groundwater manganese at the background, interior, and compliance wells.

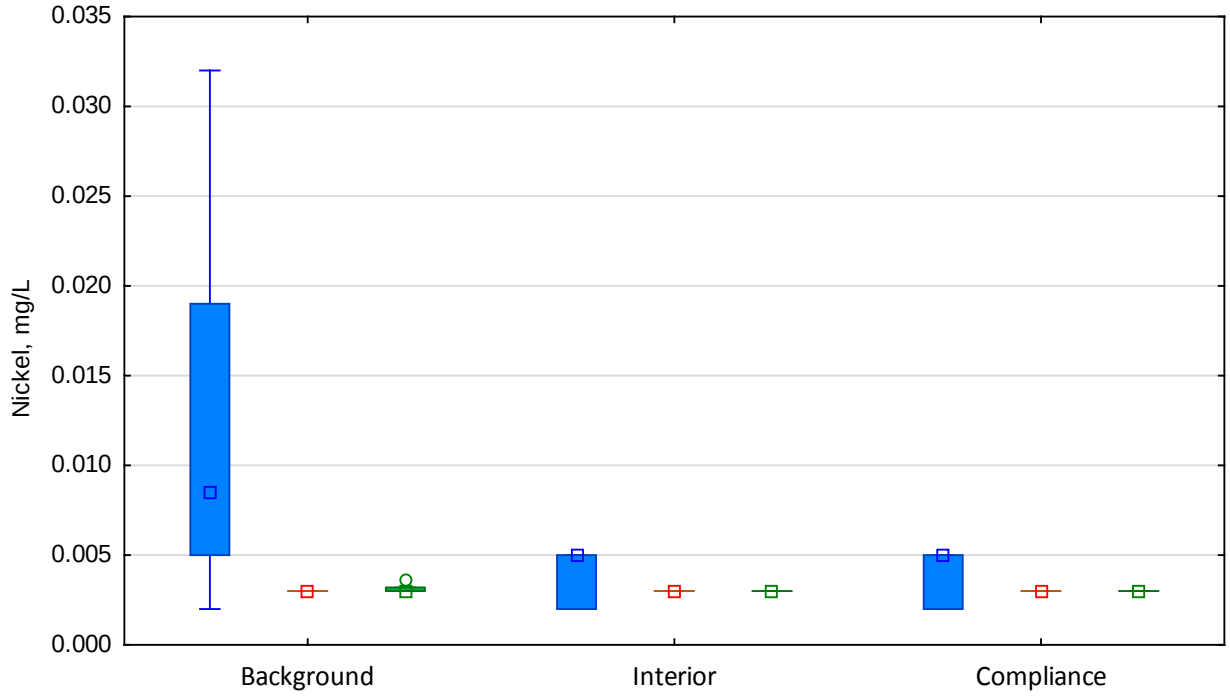


Figure 4-21. Comparison of baseline (2003-2005), 2012 through 2016, and 2017 groundwater nickel at the background, interior, and compliance wells.

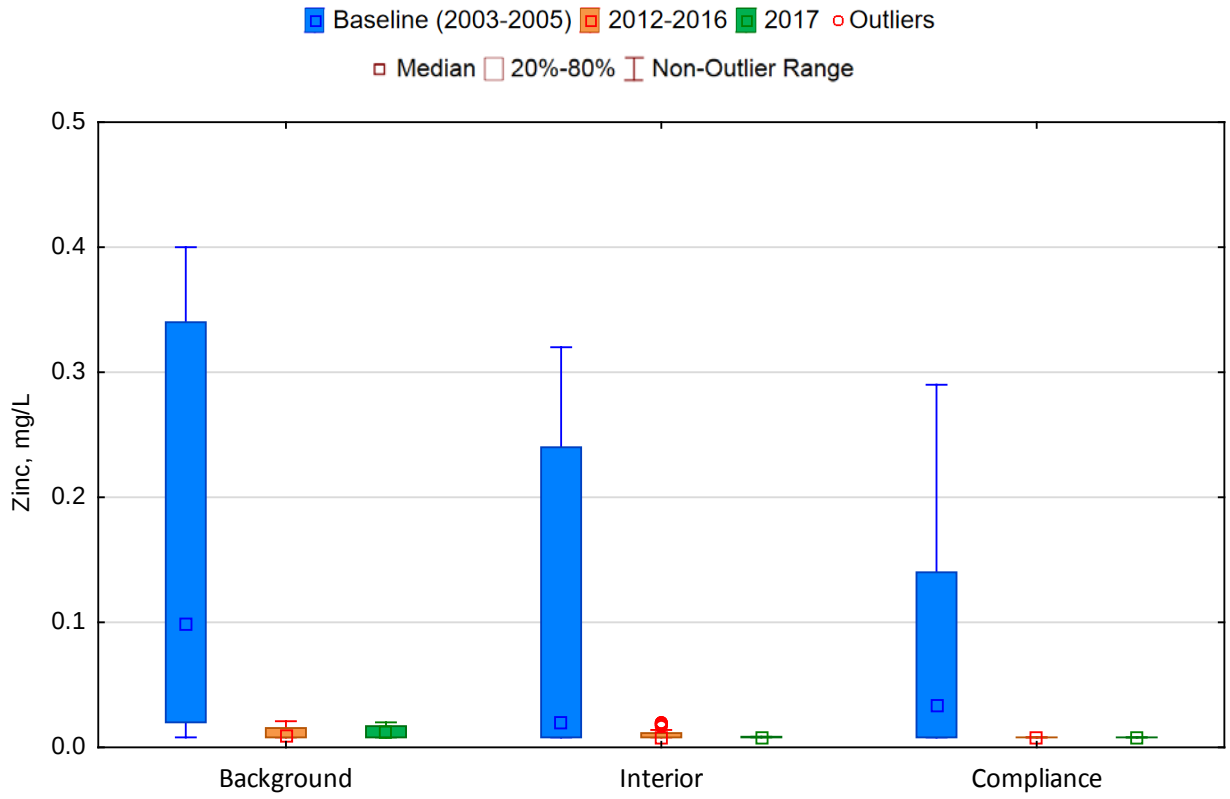


Figure 4-22. Comparison of baseline (2003-2005), 2012 through 2016, and 2017 groundwater zinc at the background, interior, and compliance wells.

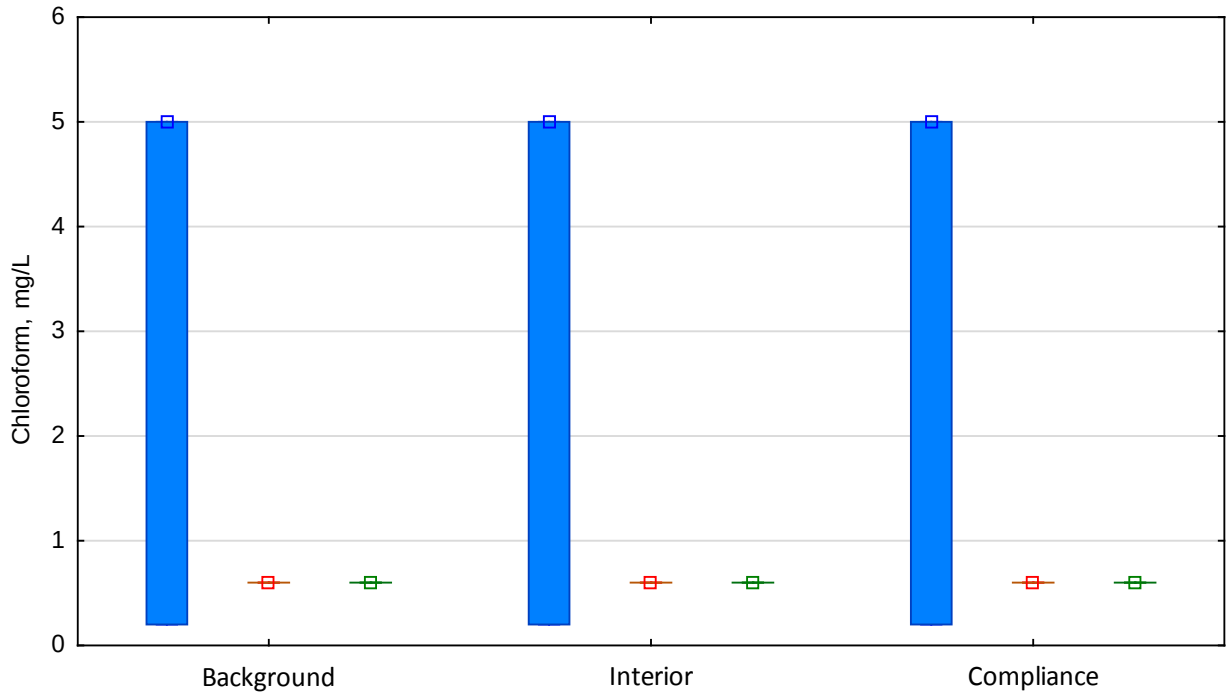


Figure 4-23. Comparison of baseline (2003-2005), 2012 through 2016, and 2017 groundwater chloroform at the background, interior, and compliance wells.

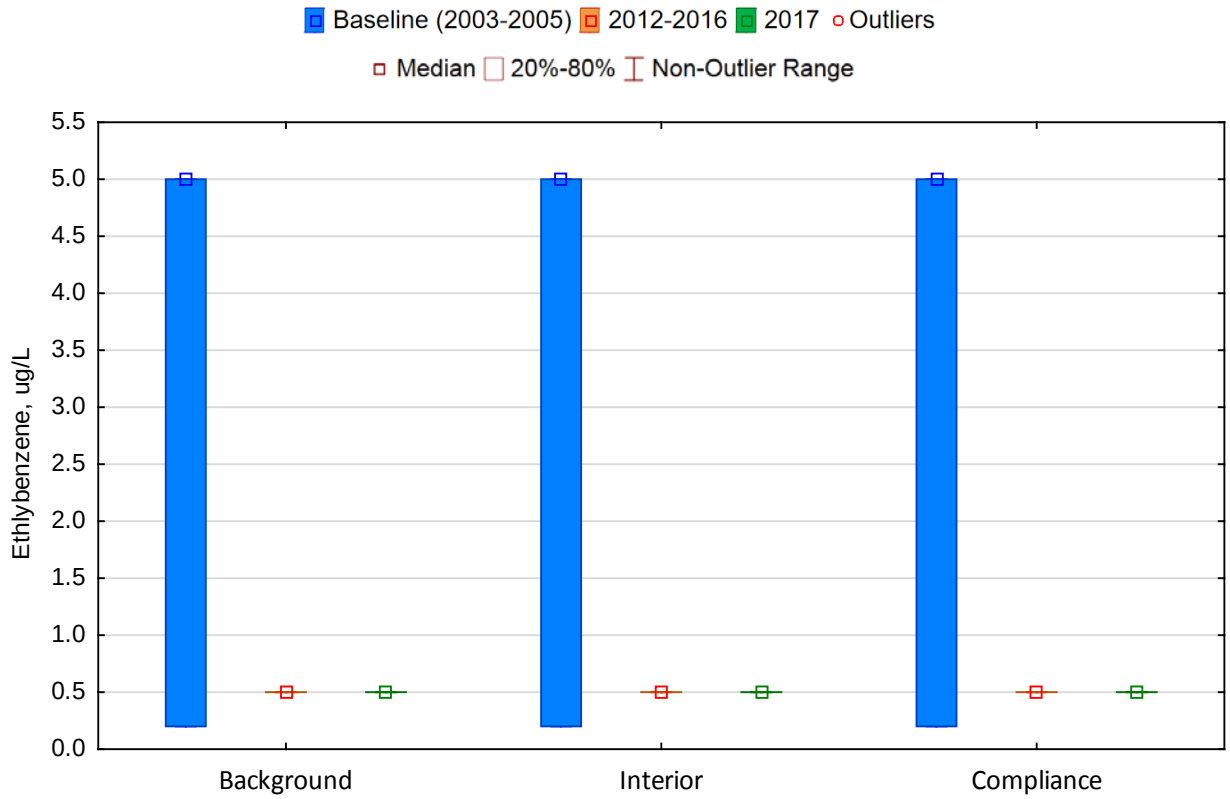


Figure 4-24. Comparison of baseline (2003-2005), 2012 through 2016, and 2017 groundwater ethylbenzene at the background, interior, and compliance wells.

Table 4-1. ECUA/IP Combined Effluent Distribution System monitoring well locations, elevations, and construction details.

Well	Location		Elevation			Riser Height[1]	Screen Length	Total Depth
			Ground	Pad	Top of Riser			
	Latitude	Longitude	ft					
MWB1	30.4866	-87.3847	52.66	53.16	54.83	1.67	10	18.5
MWB2	30.4867	-87.3691	46.98	47.62	50.86	3.24	10	22.2
MWI3	30.4753	-87.3738	11.60	11.09	13.69	2.60	10	19.5
MWI4	30.4697	-87.3841	5.14	5.74	6.93	1.19	10	17.3
MWI5	30.4702	-87.3710	6.59	7.09	8.85	1.76	10	18.3
MWC6	30.4628	-87.4039	4.09	4.47	7.51	3.04	10	15.0
MWC7	30.4714	-87.3672	3.32	3.80	5.75	1.95	10	17.5

[1] Riser height measured by tape from pad surface to top of PVC riser, except MWI-5 riser height surveyed and pad elevation measured by tape down from top of riser.

Table 4-2. Permit requirements for groundwater constituents. Permit Number FL0002526-008-IWIS.

Parameter	Permit Limits	Units
Specific Conductivity	Report	µS/cm
pH	6.5 - 8.5	S.U.
Color	15	PCU
Odor	3	TON
TDS	500	mg/L
T.O.C.	Report	mg/L
Total Sulfate	250	mg/L
Chromium, Total	0.1	mg/L
Manganese, Total	0.05	mg/L
Arsenic, Total	0.010	mg/L
Chloride, as Cl	250	mg/L
Sodium, Total	160	mg/L
Antimony, Total	0.006	mg/L
Nickel	0.1	mg/L
Chloroform	Report	mg/L
Ethylbenzene	30	µg/L
Nitrogen, Kjeldahl, Total (as N)	Report	mg/L
Nitrogen, Ammonia, Total (as N)	Report	mg/L
Nitrogen, Nitrate, Total (as N)	10	mg/L
Iron, Total Recoverable	0.3	mg/L
Zinc, Total Recoverable	5	mg/L

Table 4-3. Summary results of background monitoring well MWB1 for baseline monitoring years 2003-2005 combined, 100% EDS operational flow years 2012 through 2016 combined, and individual quarterly monitoring results for 2017.

MWB1												
Parameters	**Units**	**Permit Limit**	**Baseline Average**	**Baseline Minimum**	**Baseline Maximum**	**2012-2016 Average**	**2012-2016 Minimum**	**2012-2016 Maximum**	**Q_1 2017**	**Q_2 2017**	**Q_3 2017**	**Q_4 2017**
Temperature	°C	No Limit	22.4	17.9	24.8	22.8	17.5	27.7	20.0	22.2	24.4	21.95
Conductivity	µS/cm		49	44	55	46	10	64	44	39	49	43
pH	S.U.	6.5 - 8.5	5.05[1]	4.66[1]	5.31[1]	4.89	4.51	5.20	4.77	4.82	5.11	5.00
Turbidity	NTU	No Limit	25	10	34	20	2	138	12	NM	3	5
Sodium	mg/L	160	2.7	2.5	2.9	5.5	2.8	46.0	3.0	2.6	3.0	2.8
TKN		No Limit	0.99	0.82	1.20	0.93	0.58	2.30	0.72	0.76	0.53	0.52
NH_3-N			0.31	0.19	0.41	0.23	0.02	0.35	0.34	0.28	0.31	0.27
NO_3-N/NO_2-N			0.093	0.019	0.160	0.019	0.012	0.040	< 0.018	< 0.018	< 0.018	< 0.018
NO_2-N			< 0.080	< 0.018	< 0.100	< 0.018	< 0.018	< 0.018	NM	NM	NM	NM
NO_3-N		10	0.080	0.019	0.100	0.019	0.012	0.040	< 0.018	< 0.018	< 0.018	< 0.018
TDS		500	68	54	78	47	20	110	30	6	84	42
SO_4		250	4.6	1.1	6.7	1.4	1.4	1.9	< 1.4	< 1.4	< 1.4	< 1.4
Chloride		250	6	4	7	8	6	10	7	6	6	6
Color	PCU	15	357[1]	190[1]	520[1]	293	15	2700	140	160	190	120
Odor	TON	3	1.0	1.0	1.0	1.6	< 1.0	4.0	< 1.0	< 1.0	< 1.0	< 1.0
TOC	mg/L	No Limit	18	17	19	26	4	210	15	19	18	15
Antimony		0.006	< 0.0352	0.0057	0.0500	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Arsenic		0.010	< 0.0047	< 0.0040	< 0.0050	< 0.0040	< 0.0040	< 0.0040	< 0.0040	< 0.0040	< 0.0040	< 0.0040
Chromium		0.1	0.0058	0.0050	0.0070	0.0070	0.0020	0.0660	0.0025	0.0022	0.0027	< 0.002
Iron		0.3	10.4[1]	8.2[1]	13.0[1]	6.9	4.2	12.0	6.1	5.2	7.2	6.4
Manganese		0.05	0.058	0.040	0.081	0.023	0.011	0.048	0.02	0.02	0.022	0.021
Nickel		0.1	< 0.0040	< 0.0020	< 0.0050	< 0.0030	< 0.0030	< 0.0030	< 0.0030	< 0.0030	< 0.0030	< 0.0030
Zinc		5	0.0417	< 0.0080	0.0970	0.0086	< 0.0080	0.0190	< 0.0080	< 0.0080	< 0.0080	< 0.0080
Chloroform	µg/L	No Limit	< 3.40	< 0.20	< 5.00	0.91	0.60	6.70	< 0.60	< 0.60	< 0.60	< 0.60
Ethlybenzene		30	< 3.40	< 0.50	< 5.00	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50
Water Table Depth below ground surface*	feet	No Limit	-3.76	-4.65	-2.81	-3.47	-7.37	-2.17	-2.83	-8.43	NM	-3.13

[1] Exceeds permit limits for groundwater parameters.

* Negative values = depth to groundwater/water table below ground surface. Positive values = depth of groundwater/water table expressed above ground surface

< = indicates the compound was less than the minimum detection limit

Table 4-4. Summary results of background monitoring well MWB2 for baseline monitoring years 2003-2005 combined, 100% EDS operational flow years 2012 through 2016 combined, and individual quarterly monitoring results for 2017.

MWB2												
Parameters	**Units**	**Permit Limit**	**Baseline Average**	**Baseline Minimum**	**Baseline Maximum**	**2012-2016 Average**	**2012-2016 Minimum**	**2012-2016 Maximum**	**Q_1 2017**	**Q_2 2017**	**Q_3 2017**	**Q_4 2017**
Temperature	°C	No Limit	22.4	17.6	25.3	22.2	17.4	28.7	19.8	22.5	23.0	19.4
Conductivity	µS/cm		259	169	380	51	26	69	39	42	44	38
pH	S.U.	6.5 - 8.5	6.72	6.54	7.01	5.34	4.78	5.59	5.32	5.13	5.19	5.40
Turbidity	NTU	No Limit	978	425	1509	13	0.3	61	30	2.5	NM	1.2
Sodium	mg/L	160	52.8	36.0	77.0	4.8	3.4	7.5	3.7	3.2	3.3	3.3
TKN		No Limit	1.17	0.50	3.30	0.33	0.23	1.00	< 0.26	< 0.26	< 0.26	< 0.26
NH_3-N			0.05	0.05	0.06	0.022	< 0.016	0.110	0.17	< 0.11	< 0.11	< 0.11
NO_3-N/NO_2-N			0.100	0.019	0.180	0.017	0.012	0.025	< 0.018	< 0.018	< 0.018	< 0.018
NO_2-N			0.12	0.02	0.27	< 0.018	< 0.018	< 0.018		NM		NM
NO_3-N		10	0.117	0.019	0.220	0.018	0.012	0.025	< 0.018	< 0.018	< 0.018	< 0.018
TDS		500	550[1]	300	1200[1]	31	10	66	14	18	42	30
SO_4		250	121	25.0	320[1]	5.9	3.5	13.0	5.7	5.5	5.8	4.2
Chloride		250	25.3	6.3	83.0	6.8	4.0	11.0	5.6	5.1	5.4	4.5
Color	PCU	15	1210[1]	230[1]	1900[1]	8.6	1.5	38.0	13	< 1.5	4.8	< 1.5
Odor	TON	3	1.0	1.0	1.0	< 1.0	< 1.0	1.0	< 1.0	< 1.0	< 1.0	< 1.0
TOC	mg/L	No Limit	3.87	1.10	7.30	0.73	0.50	2.00	0.56	< 0.50	0.58	< 0.50
Antimony		0.006	< 0.0354	< 0.0063	< 0.050	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Arsenic		0.010	0.0124[1]	0.0083	0.0180[1]	< 0.0040	< 0.0040	< 0.0040	< 0.0040	< 0.0040	< 0.0040	< 0.0040
Chromium		0.1	0.0570	0.0330	0.0870	0.0025	0.0020	0.0036	< 0.0020	< 0.0020	0.0021	< 0.0020
Iron		0.3	36.3[1]	21.0[1]	56.0[1]	0.18	< 0.050	1.30	0.13	< 0.05	0.97	0.059
Manganese		0.05	0.227[1]	0.140[1]	0.320[1]	0.043	0.027	0.077	0.033	0.046	0.051	0.032
Nickel		0.1	< 0.0210	< 0.0120	0.0320	< 0.0038	< 0.0030	< 0.0150	0.0032	< 0.0030	0.0036	< 0.0030
Zinc		5	0.2800	0.1000	0.4000	0.0148	0.0080	0.0210	0.0170	0.0150	0.0200	< 0.0160
Chloroform	µg/L	No Limit	< 3.40	< 0.20	< 5.00	< 0.60	< 0.60	< 0.60	< 0.60	< 0.60	< 0.60	< 0.60
Ethlybenzene		30	< 3.40	< 0.20	< 5.00	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50
Water Table Depth below ground surface*	feet	No Limit	-5.95	-11.17	-2.62	-4.01	-8.44	-1.52	-4.32	-6.35	NM	-5.52

[1] Exceeds permit limits for groundwater parameters.

* Negative values = depth to groundwater/water table below ground surface. Positive values = depth of groundwater/water table expressed above ground surface

< = indicates the compound was less than the minimum detection limit

Table 4-5. Summary results of interior monitoring well MWI3 for baseline monitoring years 2003-2005 combined, 100% EDS operational flow years 2012 through 2016 combined, and individual quarterly monitoring results for 2017.

MWI3												
Parameters	**Units**	**Permit Limit**	**Baseline Average**	**Baseline Minimum**	**Baseline Maximum**	**2012-2016 Average**	**2012-2016 Minimum**	**2012-2016 Maximum**	**Q_1 2017**	**Q_2 2017**	**Q_3 2017**	**Q_4 2017**
Temperature	°C	No Limit	20.5	17.5	22.5	22.5	18.5	32.6	20.8	22.1	23.4	21.1
Conductivity	µS/cm		56	54	60	221	52	376	409	320	255	303
pH	S.U.	6.5 - 8.5	4.55[1]	4.11[1]	4.91[1]	4.49	4.12	5.06	4.63	4.90	4.78	4.70
Turbidity	NTU	No Limit	72	20	237	16	0.2	59	20	41	19	19
Sodium	mg/L	160	5.3	4.4	6.4	36	4.3	70	75	61	55	54
TKN		No Limit	0.54	0.40	0.69	0.74	< 0.23	1.80	2.2	2.60	1.2	1.30
NH_3-N			0.07	0.05	0.11	0.34	< 0.02	5.00	0.36	0.11	0.050	0.07
NO_3-N/NO_2-N			0.086	0.019	0.140	0.060	< 0.018	0.860	< 0.018	< 0.018	< 0.018	< 0.018
NO_2-N			0.08	0.02	0.10	< 0.018	< 0.018	< 0.018	NM	NM	NM	NM
NO_3-N		10	0.100	0.019	0.150	0.064	0.014	0.860	< 0.018	< 0.018	< 0.018	< 0.018
TDS		500	49.7	38	74	136	32	300	330	270	270	250
SO_4		250	5.6	4.6	9.0	37	1.4	69	91	59	66	79
Chloride		250	10	9	12	34	8	62	48	46	43	39
Color	PCU	15	32[1]	28[1]	35[1]	70	5	390	450	400	550	280
Odor	TON	3	8.0[1]	8.0[1]	8.0[1]	23	2.0	130	16	16	8	3
TOC	mg/L	No Limit	7.4	7.0	7.9	21.3	0.5	66.0	52.0	53.0	44.0	38.0
Antimony		0.006	< 0.0347[1]	< 0.0040	0.050	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Arsenic		0.010	0.0047	0.0040	0.0050	< 0.0040	< 0.0040	< 0.0040	0.0060	< 0.0040	< 0.0040	< 0.0040
Chromium		0.1	< 0.0040	< 0.0020	0.0050	0.0032	< 0.0020	0.0130	< 0.0020	< 0.0020	0.0021	< 0.0020
Iron		0.3	2.0[1]	1.9[1]	2.1[1]	2.1	1.6	2.6	2.2	2.5	2.5	2.3
Manganese		0.05	0.010	0.008	0.011	0.016	0.009	0.036	0.019	0.019	0.013	0.014
Nickel		0.1	< 0.0040	< 0.0020	0.0050	< 0.0030	< 0.0030	< 0.0030	< 0.0030	0.0037	< 0.0030	< 0.0030
Zinc		5	< 0.0160	< 0.0080	0.0200	0.0088	< 0.0080	0.0180	< 0.0080	< 0.0080	< 0.0080	< 0.0080
Chloroform	µg/L	No Limit	< 3.40	< 0.20	< 5.00	< 0.60	< 0.60	< 0.60	< 0.60	< 0.60	< 0.60	< 0.60
Ethlybenzene		30	< 1.81	< 0.20	< 5.00	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50
Water Table Depth below ground surface*	feet	No Limit	-1.86	-3.23	-1.18	-0.40	-0.60	0.15	-0.6	0.10	-0.40	-0.28

[1] Exceeds permit limits for groundwater parameters.

* Negative values = depth to groundwater/water table below ground surface. Positive values = depth of groundwater/water table expressed above ground surface

< = indicates the compound was less than the minimum detection limit

Table 4-6. Summary results of interior monitoring well MWI4 for baseline monitoring years 2003-2005 combined, 100% EDS operational flow years 2012 through 2016 combined, and individual quarterly monitoring results for 2017.

MWI4												
Parameters	**Units**	**Permit Limit**	**Baseline Average**	**Baseline Minimum**	**Baseline Maximum**	**2012-2016 Average**	**2012-2016 Minimum**	**2012-2016 Maximum**	**Q_1 2017**	**Q_2 2017**	**Q_3 2017**	**Q_4 2017**
Temperature	°C	No Limit	20.1	18.0	21.9	21.9	19.5	31.5	20.4	21	21.5	19.82
Conductivity	µS/cm		52	51	54	26	17	30	26	26	27	27
pH	S.U.	6.5 - 8.5	4.88[1]	4.11[1]	5.10[1]	4.84	4.16	5.08	4.66	4.91	4.88	4.99
Turbidity	NTU	No Limit	301	20	1000	3	0.1	10	0.7	1.6	0.5	0.9
Sodium	mg/L	160	5.2	2.4	8.1	2.3	2.1	2.8	2.4	2.3	2.5	2.4
TKN		No Limit	0.60	0.40	1.0	0.31	0.23	1.0	< 0.26	< 0.26	< 0.26	< 0.26
NH3-N			0.061	0.038	0.130	0.022	0.015	0.110	0.100	< 0.020	< 0.020	< 0.020
NO3-N/NO2-N			0.080	0.019	0.120	0.017	0.012	< 0.018	< 0.018	< 0.018	< 0.018	0.048
NO2-N			< 0.08	< 0.02	0.10	< 0.018	< 0.018	< 0.018	NM	NM	NM	NM
NO3-N		10	0.090	0.019	0.130	< 0.018	< 0.018	< 0.018	< 0.018	< 0.018	< 0.018	0.048
TDS		500	52	28	100	19	3	48	10	6	22	20
SO_4		250	9.7	1.5	36.0	1.6	< 1.4	2.6	< 2.6	3.0	2.4	1.6
Chloride		250	11	9.0	13	4.1	3.0	4.8	3.9	4.1	4.0	3.8
Color	PCU	15	52[1]	13	90[1]	2.9	< 1.5	9.5	< 1.5	< 1.5	< 1.5	< 1.5
Odor	TON	3	8.0[1]	8.0[1]	8.0[1]	2.0	< 1.0	20	< 1.0	< 1.0	< 1.0	< 1.0
TOC	mg/L	No Limit	1.5	0.3	2.6	1.3	< 0.5	16.0	< 0.5	0.52	0.53	< 0.5
Antimony		0.006	0.0347[1]	0.0040	0.050[1]	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Arsenic		0.010	0.0047	0.0040	0.0050	< 0.0040	< 0.0040	< 0.0040	< 0.0040	< 0.0040	< 0.0040	< 0.0040
Chromium		0.1	0.0040	0.0020	0.0050	0.0021	< 0.0020	0.0026	< 0.0020	0.0021	< 0.0020	< 0.0020
Iron		0.3	2.2[1]	1.0[1]	3.1[1]	0.36	0.08	0.57	0.54	0.58	0.37	0.40
Manganese		0.05	0.021	0.011	0.036	0.019	0.016	0.024	0.018	0.031	0.019	0.017
Nickel		0.1	< 0.0040	< 0.0020	0.0050	< 0.0038	< 0.0030	< 0.0150	< 0.0030	< 0.0030	< 0.0030	< 0.0030
Zinc		5	0.116	0.0080	0.320	0.015	< 0.008	0.053	< 0.008	0.009	0.009	0.009
Chloroform	µg/L	No Limit	< 3.40	< 0.20	< 5.00	< 0.60	< 0.60	< 0.60	< 0.60	< 0.60	< 0.60	< 0.60
Ethlybenzene		30	< 3.40	< 0.20	< 5.00	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50
Water Table Depth below ground surface*	feet	No Limit	-1.74	-3.21	-0.95	1.79	1.79	1.79	1.79	1.79	1.79	1.79

[1] Exceeds permit limits for groundwater parameters.

* Negative values = depth to groundwater/water table below ground surface. Positive values = depth of groundwater/water table expressed above ground surface

< = indicates the compound was less than the minimum detection limit

Table 4-7. Summary results of interior monitoring well MWI5 for baseline monitoring years 2003-2005 combined, 100% EDS operational flow years 2012 through 2016 combined, and individual quarterly monitoring results for 2017.

MWI5												
Parameters	**Units**	**Permit Limit**	**Baseline Average**	**Baseline Minimum**	**Baseline Maximum**	**2012-2016 Average**	**2012-2016 Minimum**	**2012-2016 Maximum**	**Q_1 2017**	**Q_2 2017**	**Q_3 2017**	**Q_4 2017**
Temperature	C deg	No Limit	20.8	18.2	22.4	21.0	17.3	24.8	20.0	21.0	23.8	20.4
Conductivity	µS/cm		29	26	31	69	29	244	39	92	67	66
pH	SU	6.5 - 8.5	4.72[1]	3.78[1]	5.14[1]	4.65	4.12	5.29	4.91	5.01	5.28	5.27
Turbidity	NTU's	No Limit	406	98	1000	11	0.4	36	26	38	11	26
Sodium	mg/L	160	2.4	2.1	2.8	10.1	2.3	40.0	5.9	15.0	12.0	10.0
TKN		No Limit	0.71	0.40	1.70	0.30	< 0.23	1.10	< 0.26	< 0.26	< 0.26	< 0.26
NH_3-N			0.048	0.035	0.050	0.022	< 0.015	0.110	0.110	< 0.022	< 0.022	< 0.022
NO_3-N/NO_2-N			0.086	0.019	0.140	0.019	< 0.018	0.034	< 0.018	0.019	< 0.018	< 0.018
NO_2-N			0.08	0.02	0.10	< 0.018	< 0.018	< 0.018	NM	NM	NM	NM
NO_3-N		10	0.097	0.019	0.160	0.020	0.013	0.034	< 0.018	0.019	< 0.018	< 0.018
TDS		500	53	34	100	40	6	150	8	28	56	42
SO_4		250	5.1	2.7	6.3	14.6	1.4	71.0	4.9	22.0	12.0	12.0
Chloride		250	5.5	3.7	8.8	6.5	3.5	15.0	5.5	7.7	6.1	5.7
Color	PCU	15	88[1]	40[1]	170[1]	16	1.4	55	< 69	37	29	47
Odor	TON	3	1.0	< 1.0	< 1.0	< 1.00	< 1.0	1.0	< 1.0	< 1.0	< 1.0	< 1.0
TOC	mg/L	No Limit	1.9	1.0	3.1	0.55	< 0.50	0.93	0.66	0.67	0.6	< 0.50
Antimony		0.006	0.0348[1]	0.0044	0.0500	< 0.0100	< 0.0100	< 0.0100	< 0.0100	< 0.0100	< 0.0100	< 0.0100
Arsenic		0.010	0.0047	0.0040	0.0050	< 0.0040	< 0.0040	< 0.0040	< 0.0088	< 0.0040	< 0.0040	< 0.0040
Chromium		0.1	0.0068	0.0033	0.0100	0.0025	< 0.0020	0.0071	0.0026	0.0023	< 0.0020	0.0023
Iron		0.3	0.5[1]	0.3	0.8[1]	0.16	0.06	0.47	0.13	0.23	0.22	0.57
Manganese		0.05	0.008	0.004	0.010	0.004	0.001	0.010	0.001	0.001	0.001	0.002
Nickel		0.1	0.0040	< 0.0020	< 0.0050	0.0035	< 0.0030	< 0.0080	< 0.0030	< 0.0030	< 0.0030	< 0.0030
Zinc		5	0.0893	< 0.0080	0.2400	< 0.0080	< 0.0080	< 0.0080	< 0.0080	< 0.0080	< 0.0080	< 0.0080
Chloroform	ug/L	No Limit	3.40	< 0.20	< 5.00	< 0.60	< 0.60	< 0.60	< 0.60	< 0.60	< 0.60	< 0.60
Ethlybenzene		30	3.40	< 0.20	< 5.00	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50
Water Table Depth below ground surface*	ft	No Limit	-1.03	-2.02	-0.38	-0.15	-0.64	0.28	-0.24	0.86	0.26	0.07

[1] Exceeds permit limits for groundwater parameters.

* Negative values = depth to groundwater/water table below ground surface. Positive values = depth of groundwater/water table expressed above ground surface

< = indicates the compound was less than the minimum detection limit

Table 4-8. Summary results of compliance monitoring well MWC6 for baseline monitoring years 2003-2005 combined, 100% EDS operational flow years 2012 through 2016 combined, and individual quarterly monitoring results for 2017.

MWC6												
Parameters	**Units**	**Permit Limit**	**Baseline Average**	**Baseline Minimum**	**Baseline Maximum**	**2012-2016 Average**	**2012-2016 Minimum**	**2012-2016 Maximum**	**Q_1 2017**	**Q_2 2017**	**Q_3 2017**	**Q_4 2017**
Temperature	C deg	No Limit	20.9	15.9	23.8	22.3	17.2	29.0	20.5	22.4	24.4	16.7
Conductivity	µS/cm		57	55	63	55	36	64	58	60	61	69
pH	SU	6.5 - 8.5	5.10[1]	4.65[1]	5.42[1]	4.92	4.45	5.27	4.82	5.02	5.02	4.48
Turbidity	NTU's	No Limit	439	120	1000	11	2.1	85	3.9	3.0	2.7	2.0
Sodium	mg/L	160	4.6	4.3	4.9	4.7	0.0	6.0	5.4	5.3	5.5	5.6
TKN		No Limit	2.25	0.43	8.60	0.37	< 0.26	1.40	0.27	< 0.26	< 0.26	< 0.26
NH_3-N			0.069	0.050	0.110	0.023	0.015	0.110	< 0.240	0.037	< 0.02	< 0.02
NO_3-N/NO_2-N			0.160	0.100	0.230	0.030	0.012	0.280	< 0.018	< 0.018	< 0.018	< 0.018
NO_2-N			0.08	0.02	0.10	< 0.018	< 0.018	< 0.018	NM	NM	NM	NM
NO_3-N		10	0.133	0.100	0.230	0.031	0.012	0.280	< 0.018	< 0.018	< 0.018	< 0.018
TDS		500	570[1]	72	2600[1]	33	6	60	36	34	46	80
SO_4		250	100	2.6	550[1]	1.4	< 1.4	1.9	1.6	1.6	< 1.4	1.7
Chloride		250	27	9	86	12	10	14	13	13	13	15
Color	PCU	15	220[1]	150[1]	360[1]	14	< 1.5	110	7.1	< 1.5	< 1.5	< 1.5
Odor	TON	3	1.5	1.0	2.0	3.6	< 1.0	16.0	< 16.0	1.0	< 1.0	< 1.0
TOC	mg/L	No Limit	3	2	5	2	2	4	2.0	2.1	2.2	2.0
Antimony		0.006	0.0347[1]	0.0040	0.0500[1]	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Arsenic		0.010	< 0.0047	< 0.0040	0.0050	< 0.0040	< 0.0040	< 0.0040	< 0.0040	< 0.0040	< 0.0040	< 0.0040
Chromium		0.1	0.0070	0.0060	0.0090	0.003	< 0.0020	0.014	< 0.0020	< 0.0020	< 0.0020	< 0.0020
Iron		0.3	4.2[1]	4.0[1]	4.5[1]	2.5	1.7	4.1	2.4	2.7	2.7	0.64
Manganese		0.05	0.011	0.010	0.012	0.008	0.006	0.016	0.008	0.008	0.009	0.009
Nickel		0.1	< 0.0040	< 0.0020	< 0.0050	0.0052	< 0.0030	0.0410	< 0.0030	< 0.0030	< 0.0030	< 0.0030
Zinc		5	0.1060	< 0.0080	0.2900	0.0089	0.0080	0.0180	< 0.0080	< 0.0080	< 0.0080	< 0.0080
Chloroform	ug/L	No Limit	< 3.40	< 0.20	< 5.00	< 0.60	< 0.60	< 0.60	< 0.60	< 0.60	< 0.60	< 0.60
Ethlybenzene		30	< 3.40	< 0.20	< 5.00	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50
Water Table Depth below ground surface*	ft	No Limit	-1.02	-2.52	-0.33	-0.63	-2.47	0.25	-0.58	0.27	NM	-0.46

[1] Exceeds permit limits for groundwater parameters.

* Negative values = depth to groundwater/water table below ground surface. Positive values = depth of groundwater/water table expressed above ground surface

< = indicates the compound was less than the minimum detection limit

Table 4-9. Summary results of compliance monitoring well MWC7 for baseline monitoring years 2003-2005 combined, 100% EDS operational flow years 2012 through 2016 combined, and individual quarterly monitoring results for 2017.

MWC7												
Parameters	**Units**	**Permit Limit**	**Baseline Average**	**Baseline Minimum**	**Baseline Maximum**	**2012-2016 Average**	**2012-2016 Minimum**	**2012-2016 Maximum**	**Q_1 2017**	**Q_2 2017**	**Q_3 2017**	**Q_4 2017**
Temperature	C deg	No Limit	20.4	17.9	22.3	19.7	16.6	25.7	18.9	20.6	22.2	19.7
Conductivity	µS/cm		44	37	52	32	24	36	30.9	32	32	33
pH	SU	6.5 - 8.5	4.84[1]	4.57[1]	5.20[1]	4.72	4.15	5.03	4.46	4.90	4.90	4.81
Turbidity	NTU's	No Limit	88	25	206	6	0.8	18	8.5	NM	2.3	3.9
Sodium	mg/L	160	3.9	2.8	5.0	2.7	0.9	3.1	2.8	2.5	2.9	2.8
TKN		No Limit	0.52	0.40	0.67	0.30	< 0.26	1.10	< 0.26	< 0.26	< 0.26	< 0.26
NH_3-N			< 0.05	< 0.050	0.068	0.031	< 0.022	0.110	< 0.091	< 0.022	< 0.022	< 0.022
NO_3-N/NO_2-N			0.083	< 0.019	0.130	0.091	< 0.018	1.500	< 0.018	< 0.018	< 0.018	< 0.018
NO_2-N			0.080	0.018	< 0.100	< 0.018	< 0.018	< 0.018	NM	NM	NM	NM
NO_3-N		10	0.085	0.019	0.120	0.092	< 0.018	1.500	< 0.018	< 0.018	< 0.018	< 0.018
TDS		500	42	38	48	17	3	42	12	14	10	10
SO_4		250	6.4	4.8	9.8	2.5	1.4	3.5	3.7	2.9	3.2	3.0
Chloride		250	6.2	4.0	8.3	4.9	3.6	5.8	5.0	4.3	4.7	4.3
Color	PCU	15	291[1]	22[1]	780[1]	6.1	< 1.5	25	< 1.5	7.3	< 1.5	< 1.5
Odor	TON	3	5.0[1]	2.0	8.0[1]	4.4	1.0	40.0	< 1.0	2.0	2.0	1.0
TOC	mg/L	No Limit	2.2	1.6	3.2	0.9	0.7	1.9	0.9	0.7	0.8	0.6
Antimony		0.006	0.0348[1]	0.0044	0.050[1]	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010	< 0.010
Arsenic		0.010	0.0047	< 0.0040	0.0050	< 0.0040	< 0.0040	< 0.0040	< 0.0040	< 0.0040	< 0.0040	< 0.0040
Chromium		0.1	< 0.0050	< 0.0020	0.0080	0.0029	< 0.0020	0.0190	< 0.0020	0.0020	0.0020	< 0.0020
Iron		0.3	1.70[1]	1.10[1]	2.30[1]	0.46	0.20	0.90	0.54	0.40	0.36	0.44
Manganese		0.05	0.009	0.008	0.010	0.006	0.004	0.0096	0.006	0.006	0.006	0.006
Nickel		0.1	< 0.0040	< 0.0020	< 0.0050	0.0040	< 0.0030	< 0.0030	< 0.0030	< 0.0030	< 0.0030	< 0.0030
Zinc		5	0.0650	< 0.0080	0.1400	< 0.0080	< 0.0080	< 0.0080	< 0.0080	< 0.0080	< 0.0080	< 0.0080
Chloroform	ug/L	No Limit	< 3.40	< 0.20	< 5.00	< 0.60	< 0.60	< 0.60	< 0.60	< 0.60	< 0.60	< 0.60
Ethlybenzene		30	< 3.40	< 0.20	< 5.00	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50	< 0.50
Water Table Depth below ground surface*	ft	No Limit	-2.00	-4.02	-0.97	-1.19	-2.40	1.03	-1.77	0.86	-0.07	-1.82

[1] Exceeds permit limits for groundwater parameters.

* Negative values = depth to groundwater/water table below ground surface. Positive values = depth of groundwater/water table expressed above ground surface

< = indicates the compound was less than the minimum detection limit

Table 4-10. Historic groundwater parameter results from monitoring wells in the Northwest Reporting Unit D-Sand & Gravel Aquifer. Background Network Summary Statistics 1994-1997.

Parameter	Units	# of Wells	Minimum Value	Median Value	Maximum Value
Temperature	°C	59	19.6	20.8	26.1
Specific Conductance, Field	µS/cm	59	15	33	122
pH, Field	S.U.	59	4.85	5.25	6.48
Turbidity	NTU	57	< 0.8	4.725	1600
Sodium, Dissolved	mg/L	58	0.5	2.3	16
Ammonia+Organic Nitrogen, Dissolved		58	< 0.2	< 0.2	0.43
Ammonia, Dissolved (as N)		58	< 0.01	0.01	0.07
Nitrate+Nitrite, Dissolved (as N)		58	< 0.2	< 0.2	4.2
Sulfate, Dissolved		57	< 0.2	0.75	11
Sulfide, Total		38	< 1	< 1	< 1
Chloride, Dissolved		57	1.7	3.7	18
Organic Carbon, Total		39	< 2.0	< 2.0	2.7
Arsenic, Total		58	< 0.001	0.001	0.012
Chromium, Total		58	< 0.005	< 0.005	0.011
Iron, Total		58	0.013	0.570	10.015
Manganese, Total		58	0.0014	0.0205	0.1900
Nickel, Total		58	< 0.010	< 0.010	0.010
Cadmium, Total		58	< 0.001	< 0.001	0.001
Zinc, Total		58	< 0.004	0.011	1.300

Figure 4-1. Location of groundwater monitoring wells.

Nutter & Associates
environmental consultants

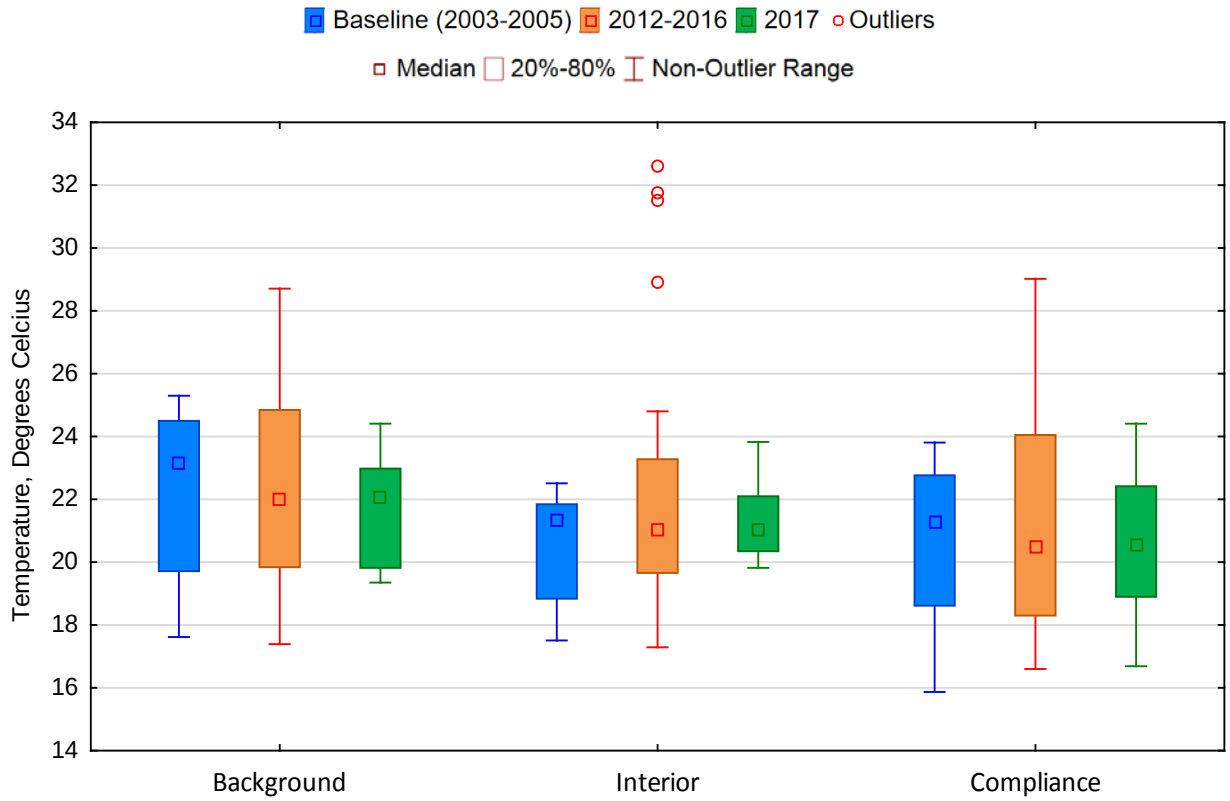


Figure 4-2. Comparison of baseline (2003-2005), 2012 through 2016, and 2017 groundwater temperature at the background, interior, and compliance wells.

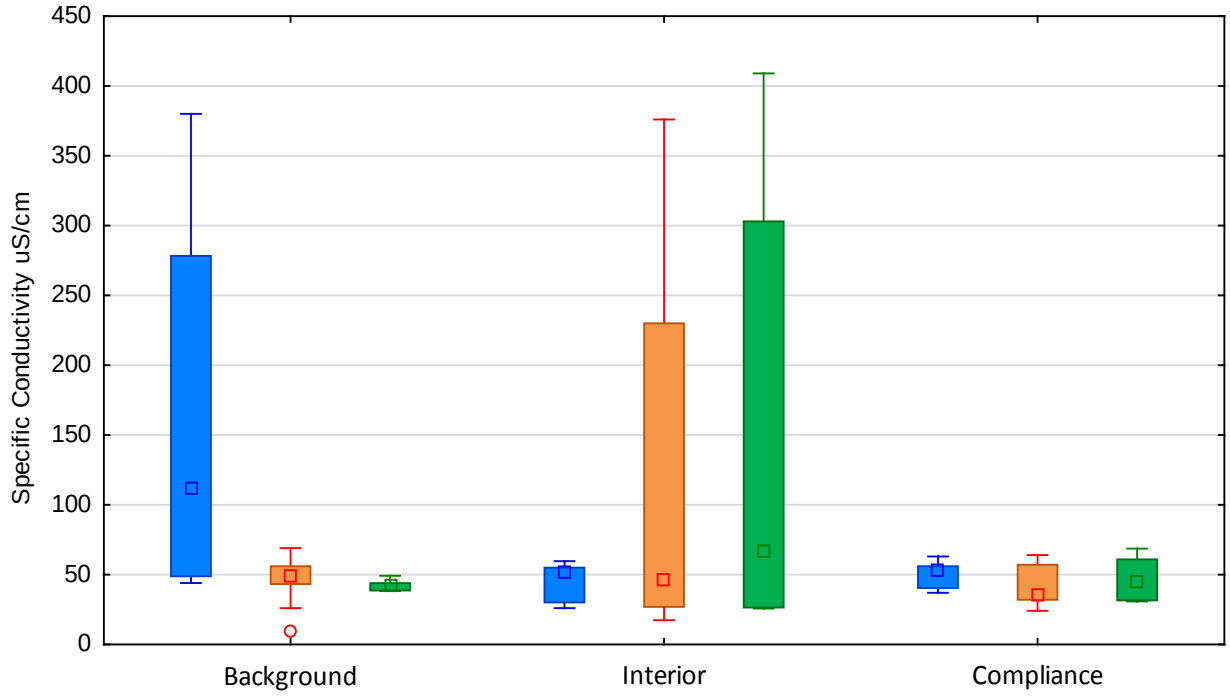


Figure 4-3. Comparison of baseline (2003-2005), 2012 through 2016, and 2017 groundwater specific conductivity at the background, interior, and compliance wells.

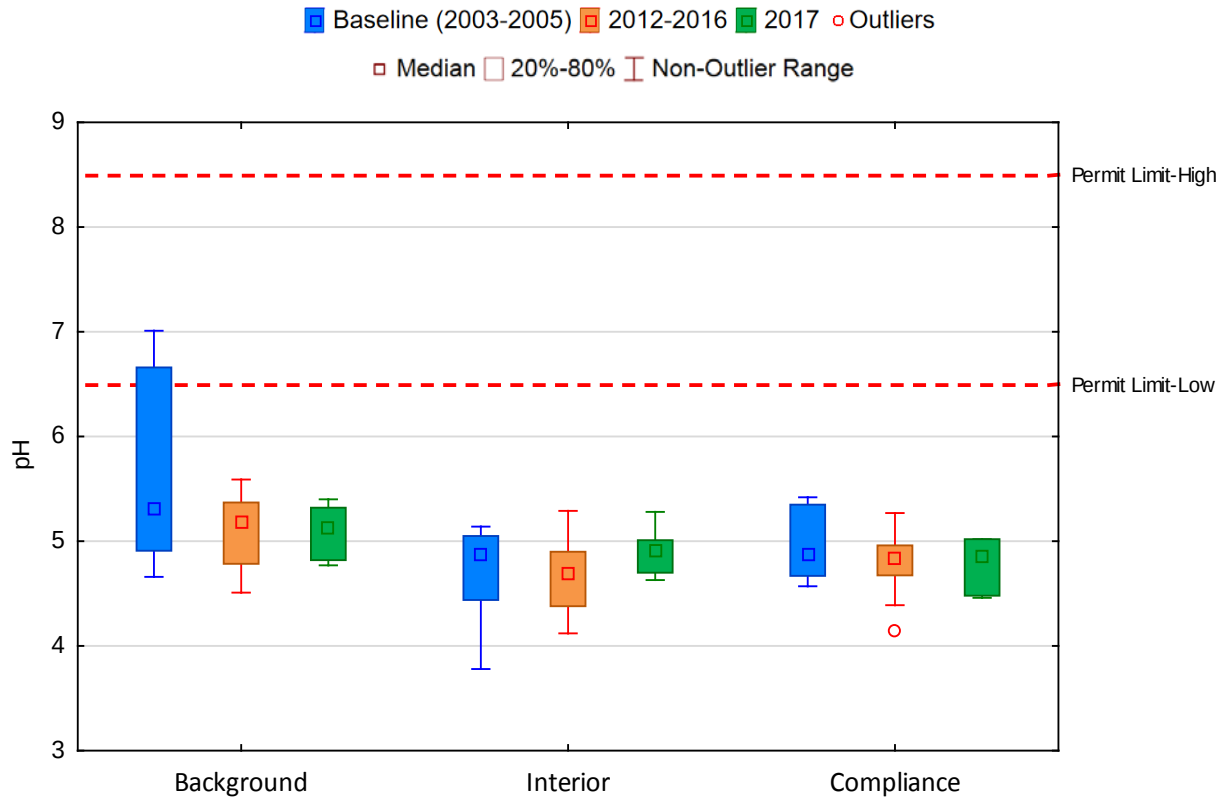


Figure 4-4. Comparison of baseline (2003-2005), 2012 through 2016, and 2017 groundwater pH at the background, interior, and compliance wells.

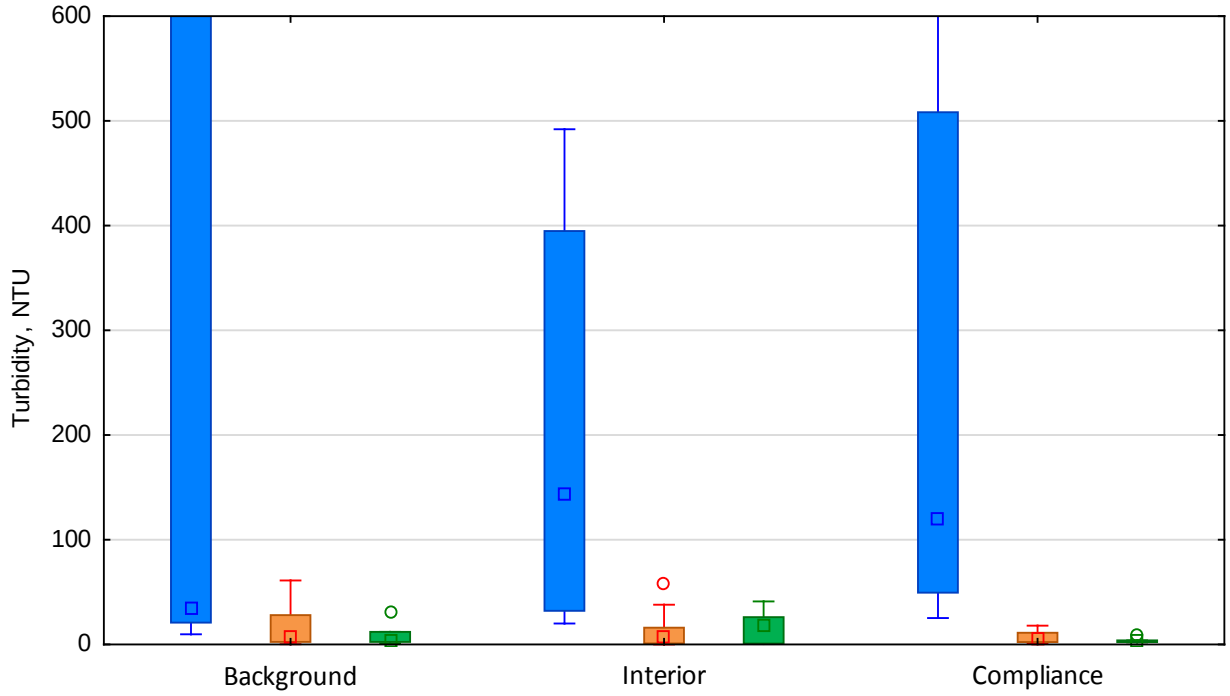


Figure 4-5. Comparison of baseline (2003-2005), 2012 through 2016, and 2017 groundwater turbidity at the background, interior, and compliance wells.

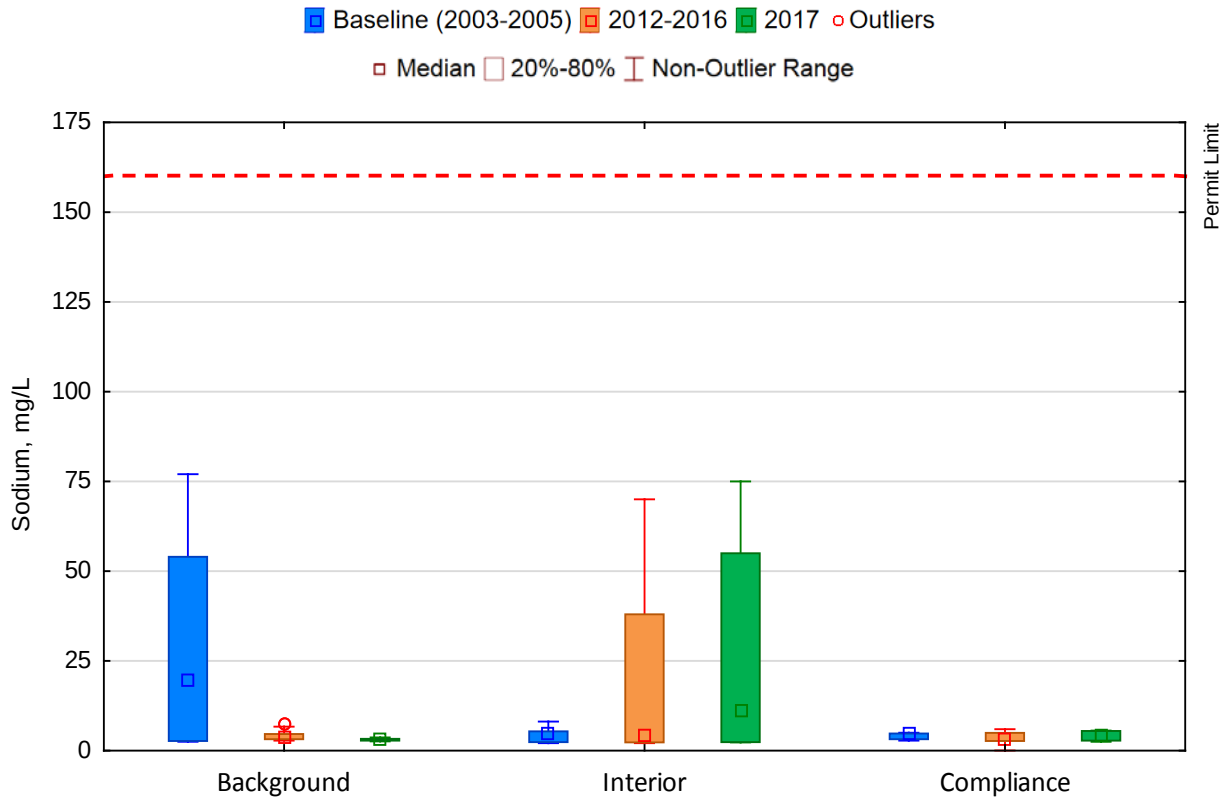


Figure 4-6. Comparison of baseline (2003-2005), 2012 through 2016, and 2017 groundwater sodium at the background, interior, and compliance wells.

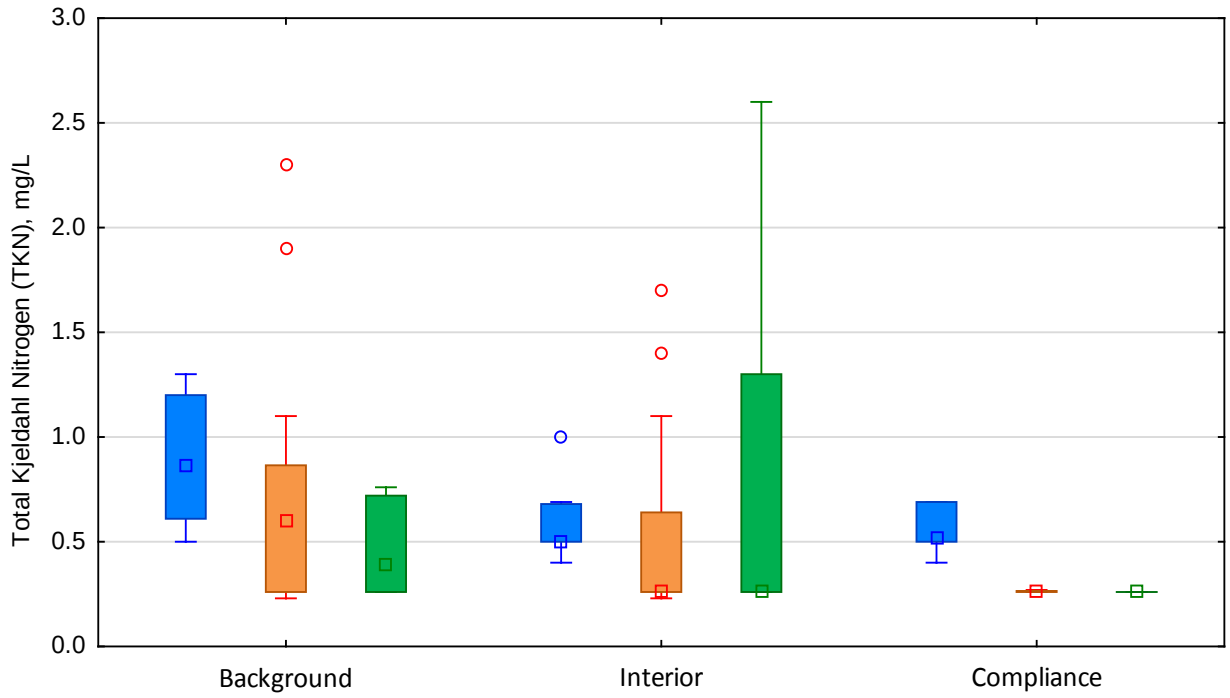


Figure 4-7. Comparison of baseline (2003-2005), 2012 through 2016, and 2017 groundwater total kjeldahl nitrogen (TKN) at the background, interior, and compliance wells.

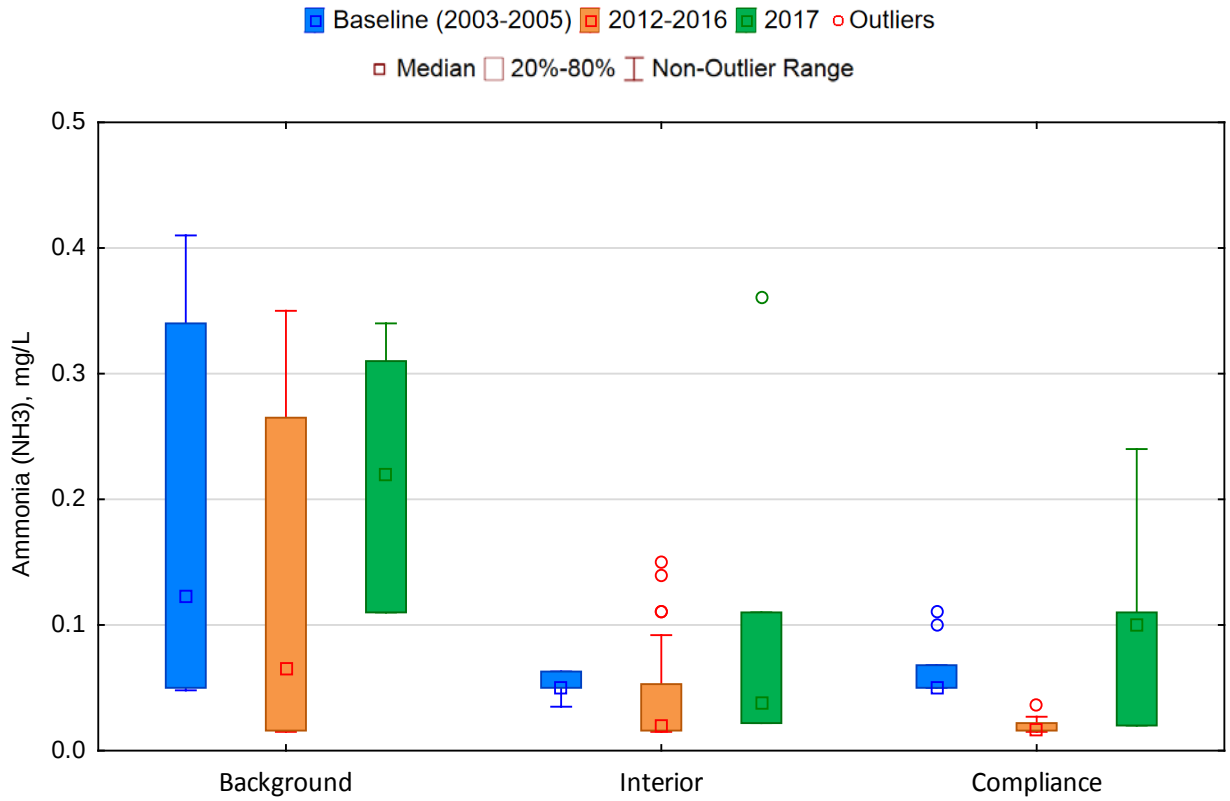


Figure 4-8. Comparison of baseline (2003-2005), 2012 through 2016, and 2017 groundwater ammonia at the background, interior, and compliance wells.

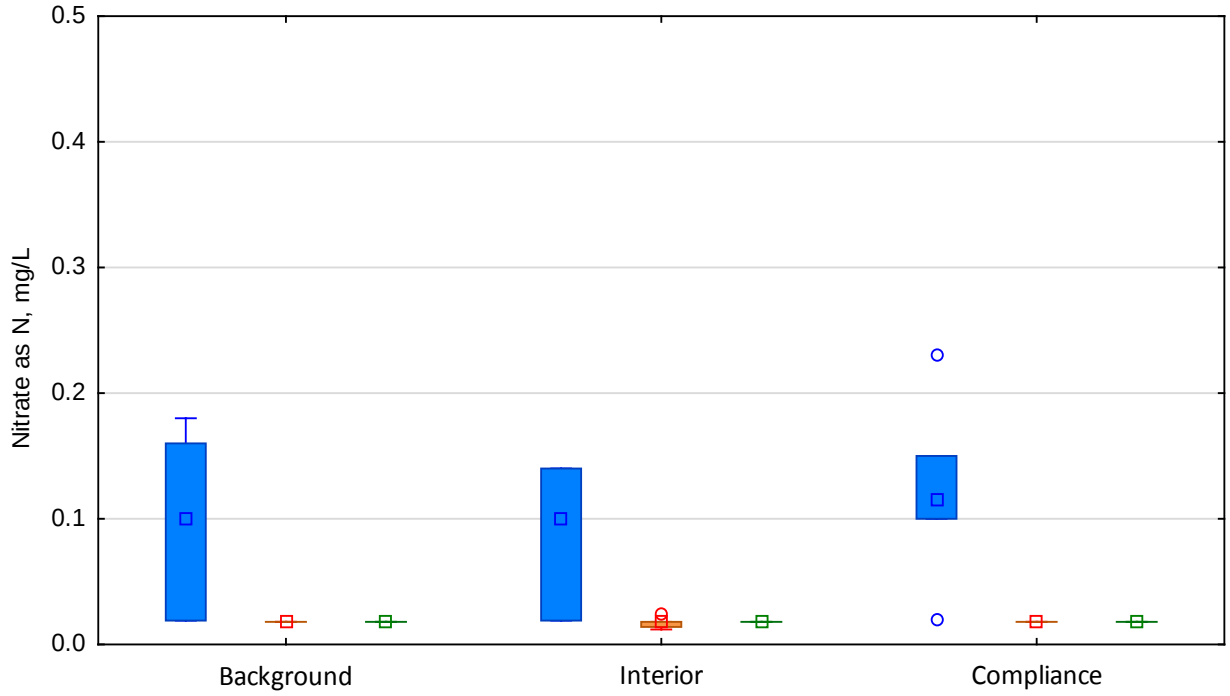


Figure 4-9. Comparison of baseline (2003-2005), 2012 through 2016, and 2017 groundwater nitrate at the background, interior, and compliance wells.

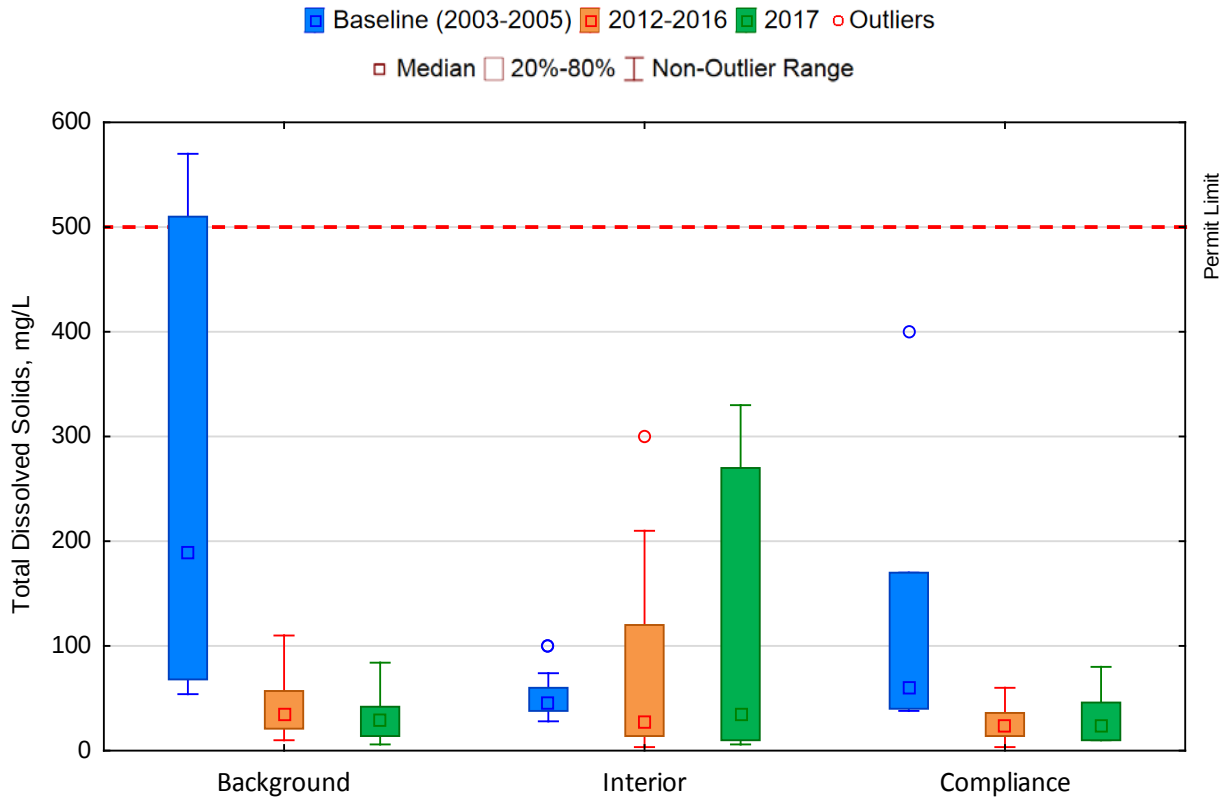


Figure 4-10. Comparison of baseline (2003-2005), 2012 through 2016, and 2017 groundwater total dissolved solids (TDS) at the background, interior, and compliance wells.

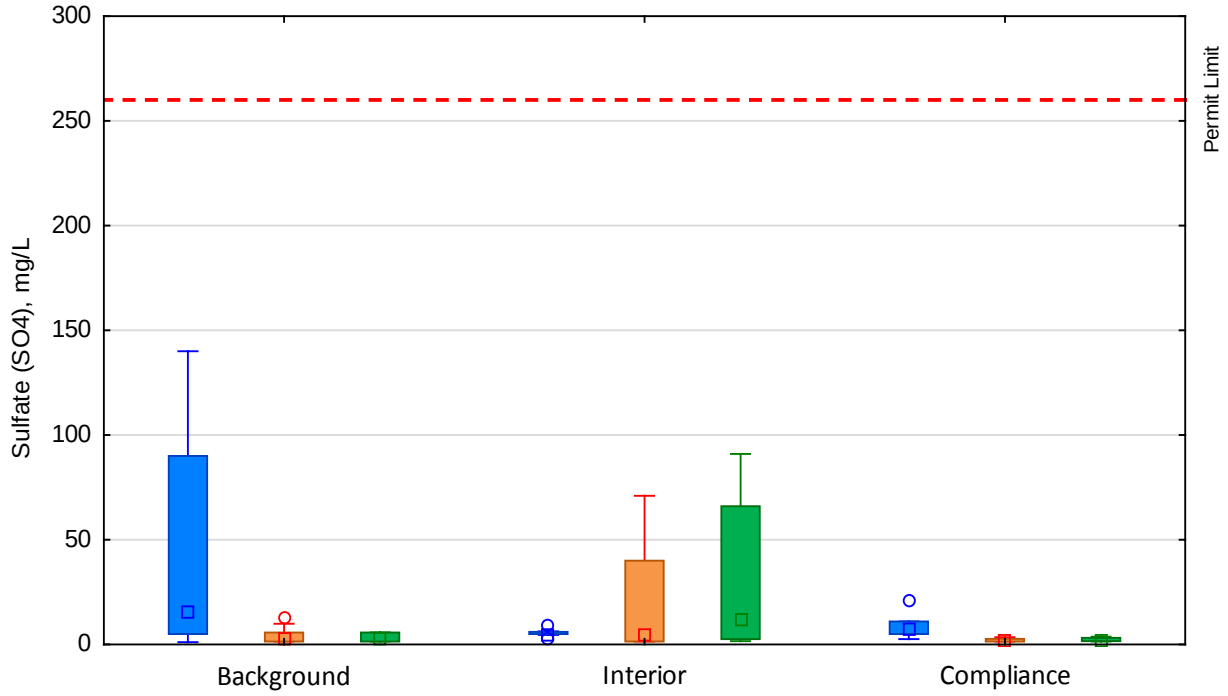


Figure 4-11. Comparison of baseline (2003-2005), 2012 through 2016, and 2017 groundwater sulfate at the background, interior, and compliance wells.

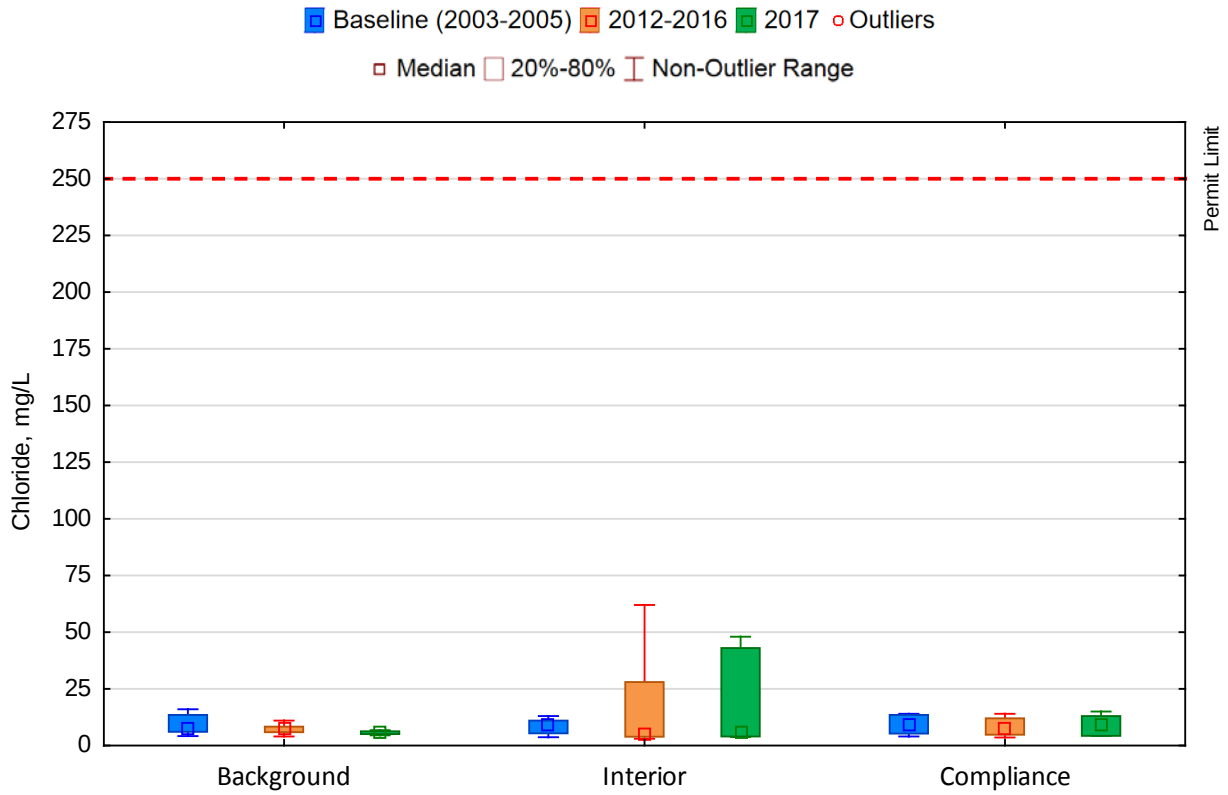


Figure 4-12. Comparison of baseline (2003-2005), 2012 through 2016, and 2017 groundwater chloride at the background, interior, and compliance wells.

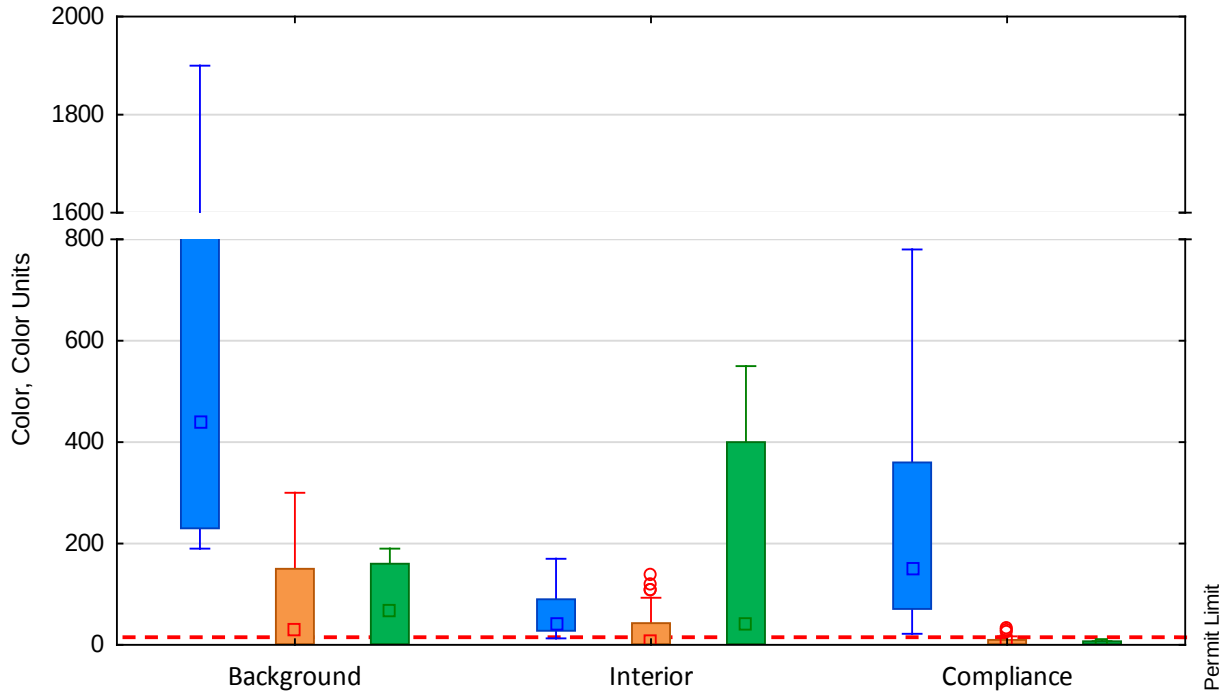


Figure 4-13. Comparison of baseline (2003-2005), 2012 through 2016, and 2017 groundwater color at background, interior, and compliance wells.

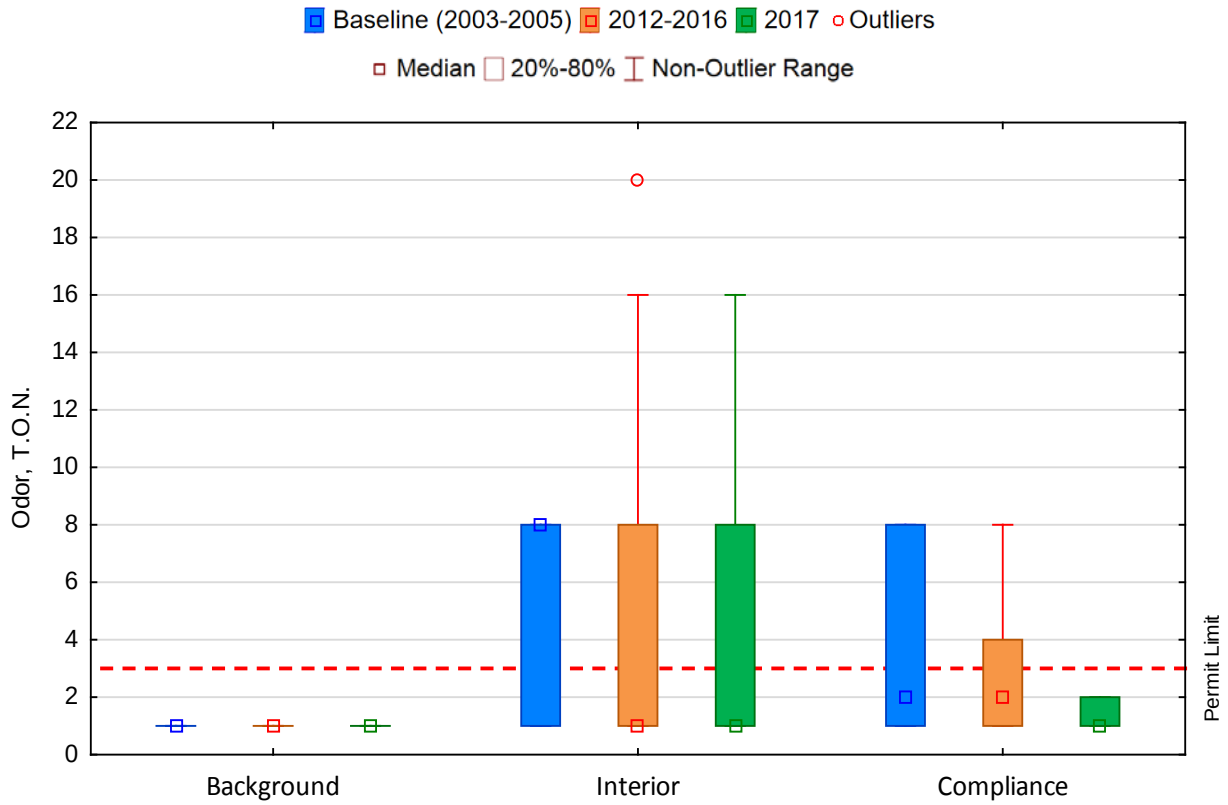


Figure 4-14. Comparison of baseline (2003-2005), 2012 through 2016, and 2017 groundwater odor at the background, interior, and compliance wells.

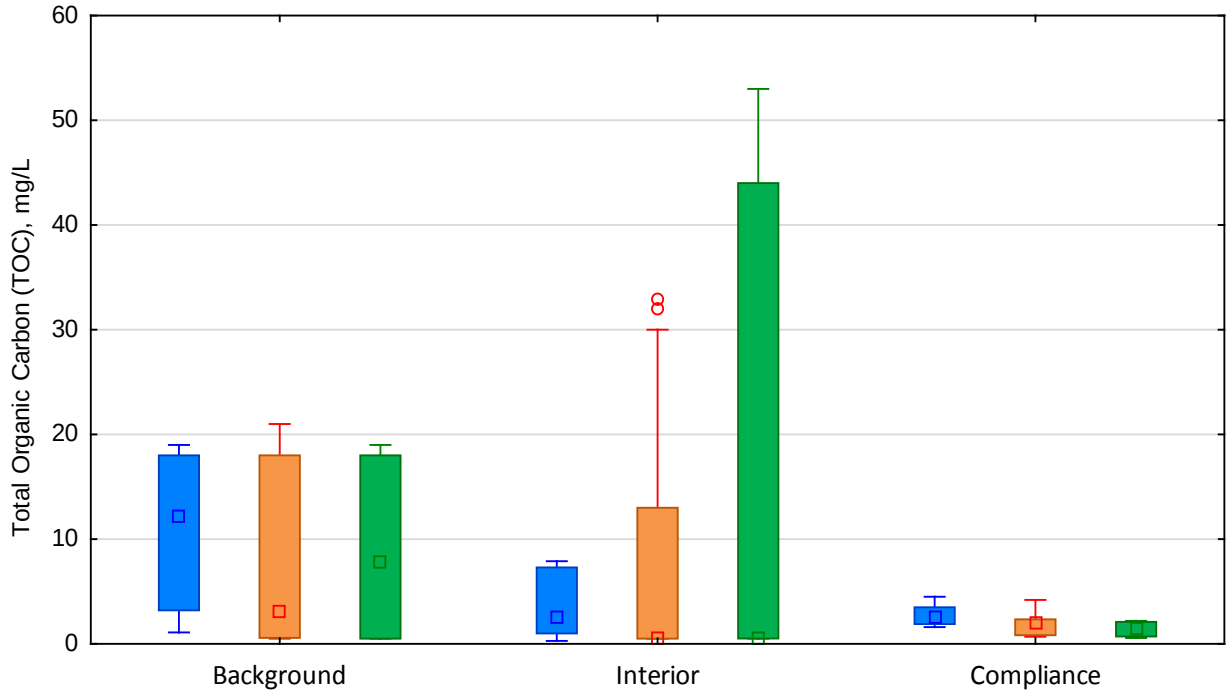


Figure 4-15. Comparison of baseline (2003-2005) and 2012 through 2016, and 2017 groundwater total organic carbon (TOC) at the background, interior, and compliance wells.

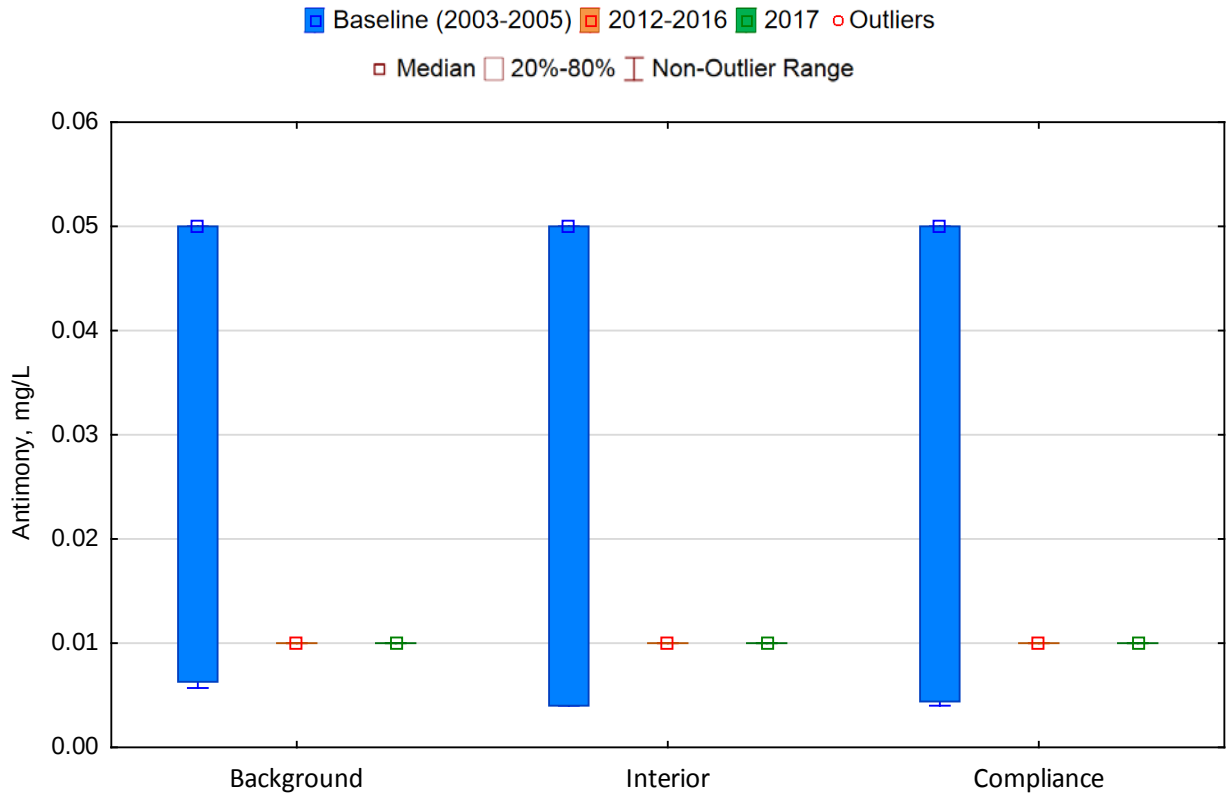


Figure 4-16. Comparison of baseline (2003-2005), 2012 through 2016, and 2017 groundwater antimony at the background, interior, and compliance wells.

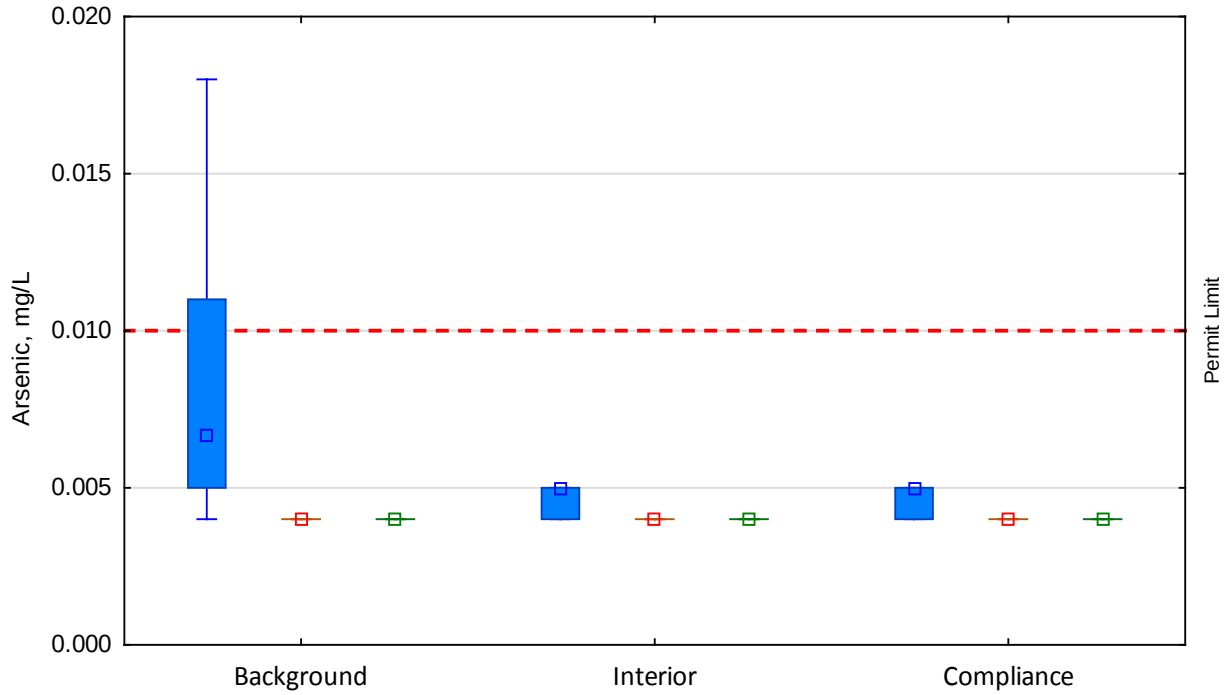


Figure 4-17. Comparison of baseline (2003-2005), 2012 through 2016, and 2017 groundwater arsenic at the background, interior, and compliance wells.

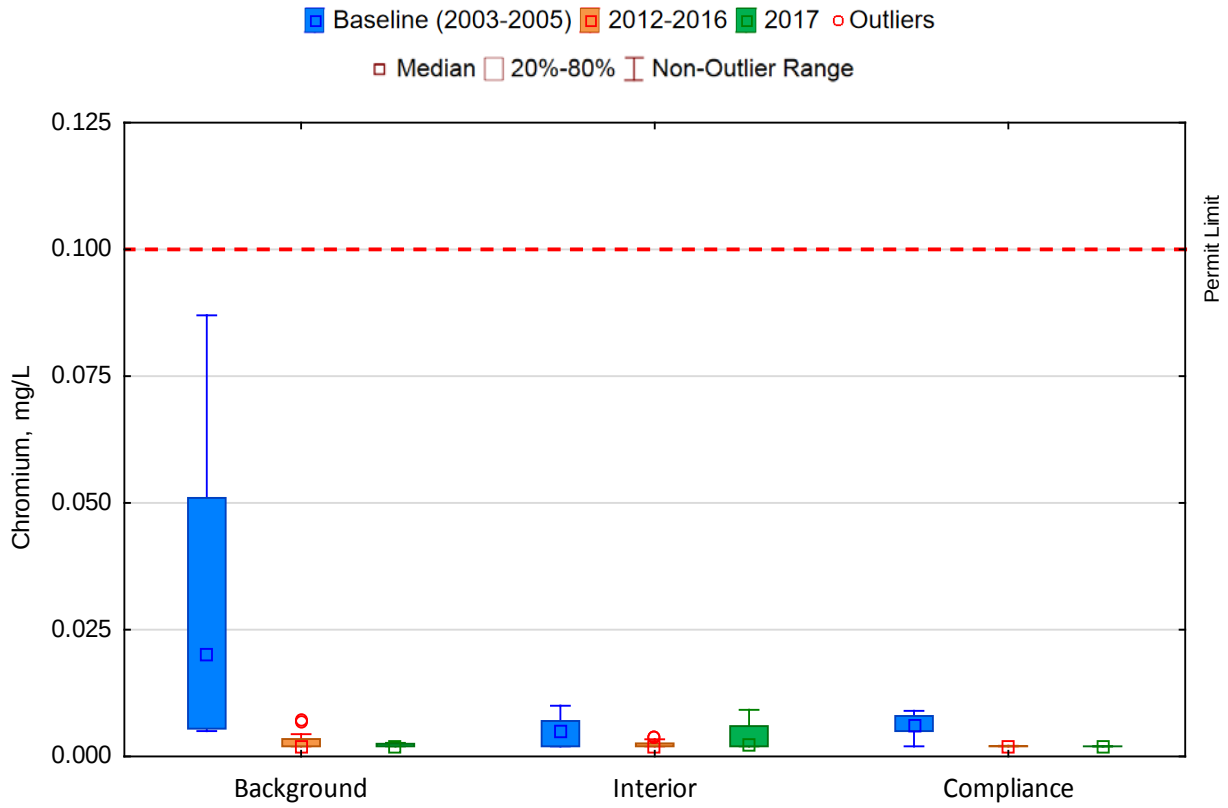


Figure 4-18. Comparison of baseline (2003-2005), 2012 through 2016, and 2017 groundwater chromium at the background, interior, and compliance wells.

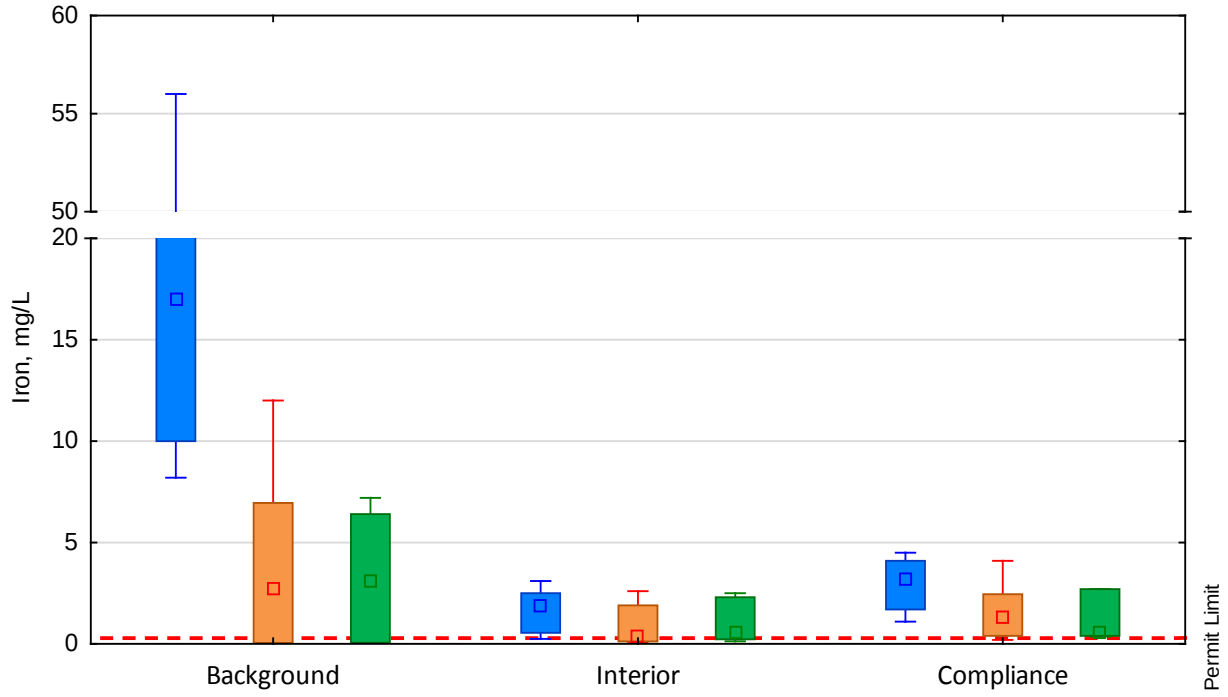


Figure 4-19. Comparison of baseline (2003-2005), 2012 through 2016, and 2017 groundwater iron at the background, interior, and compliance wells.

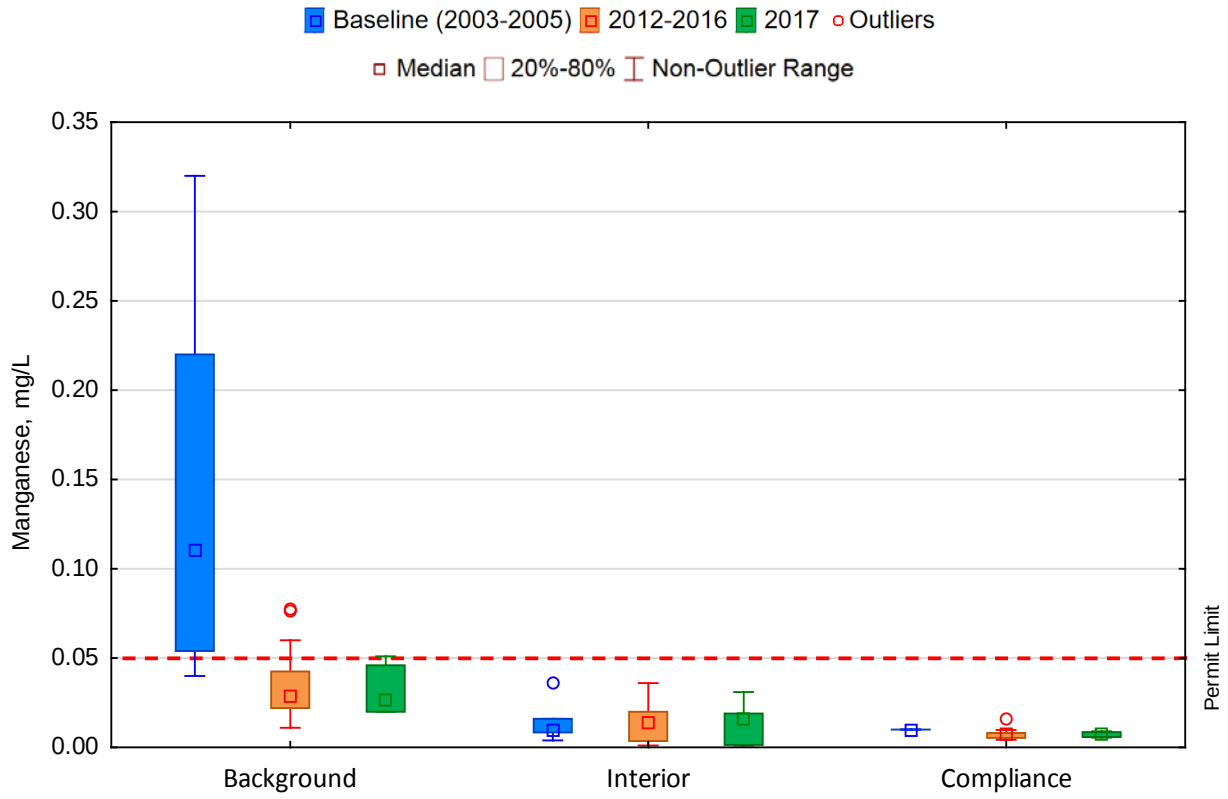


Figure 4-20. Comparison of baseline (2003-2005), 2012 through 2016, and 2017 groundwater manganese at the background, interior, and compliance wells.

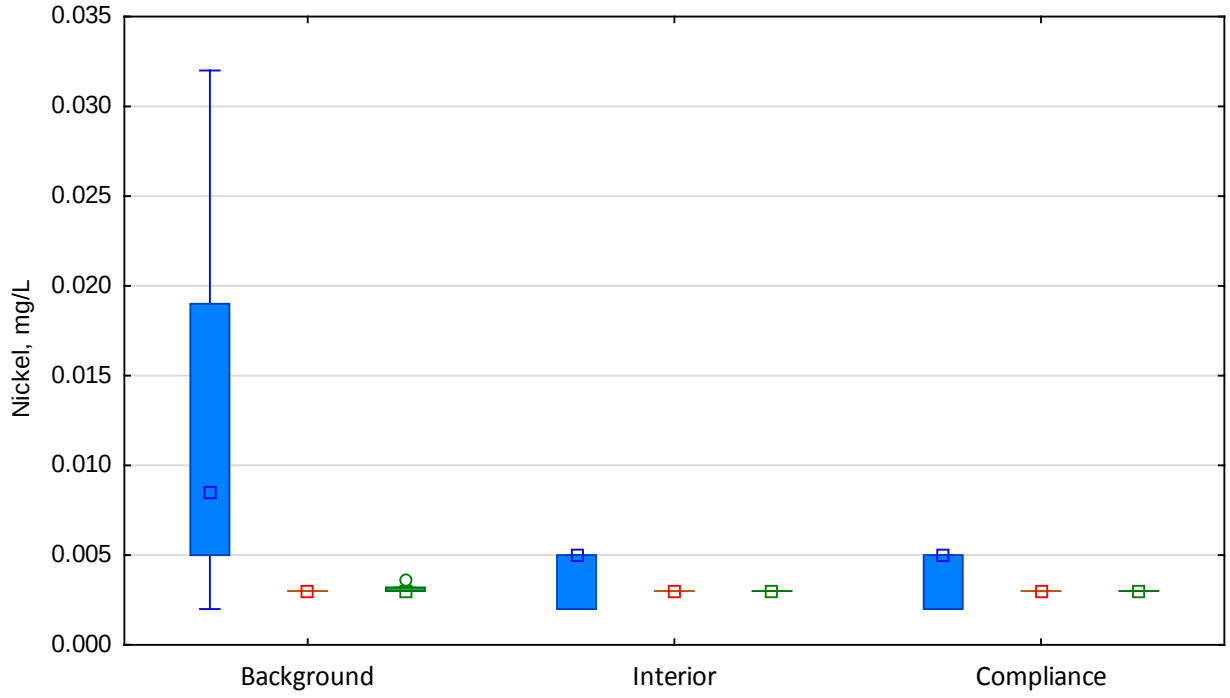


Figure 4-21. Comparison of baseline (2003-2005), 2012 through 2016, and 2017 groundwater nickel at the background, interior, and compliance wells.

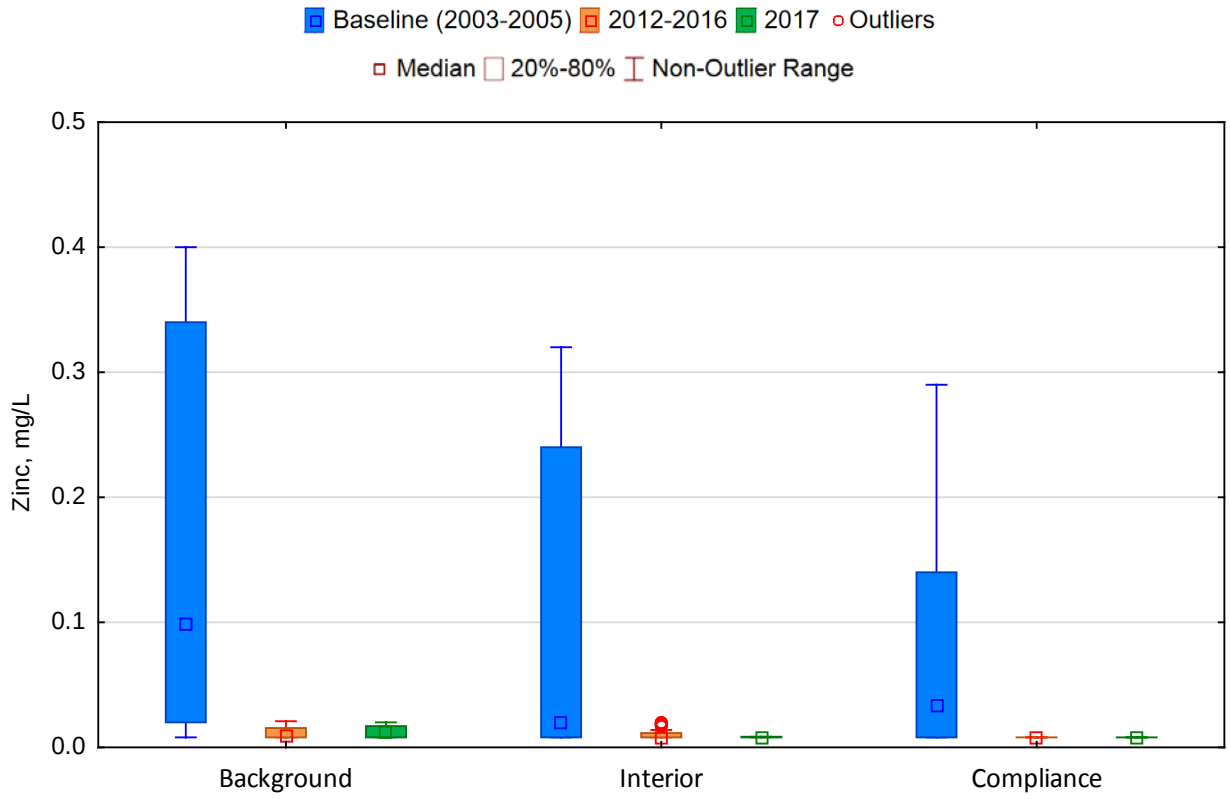


Figure 4-22. Comparison of baseline (2003-2005), 2012 through 2016, and 2017 groundwater zinc at the background, interior, and compliance wells.

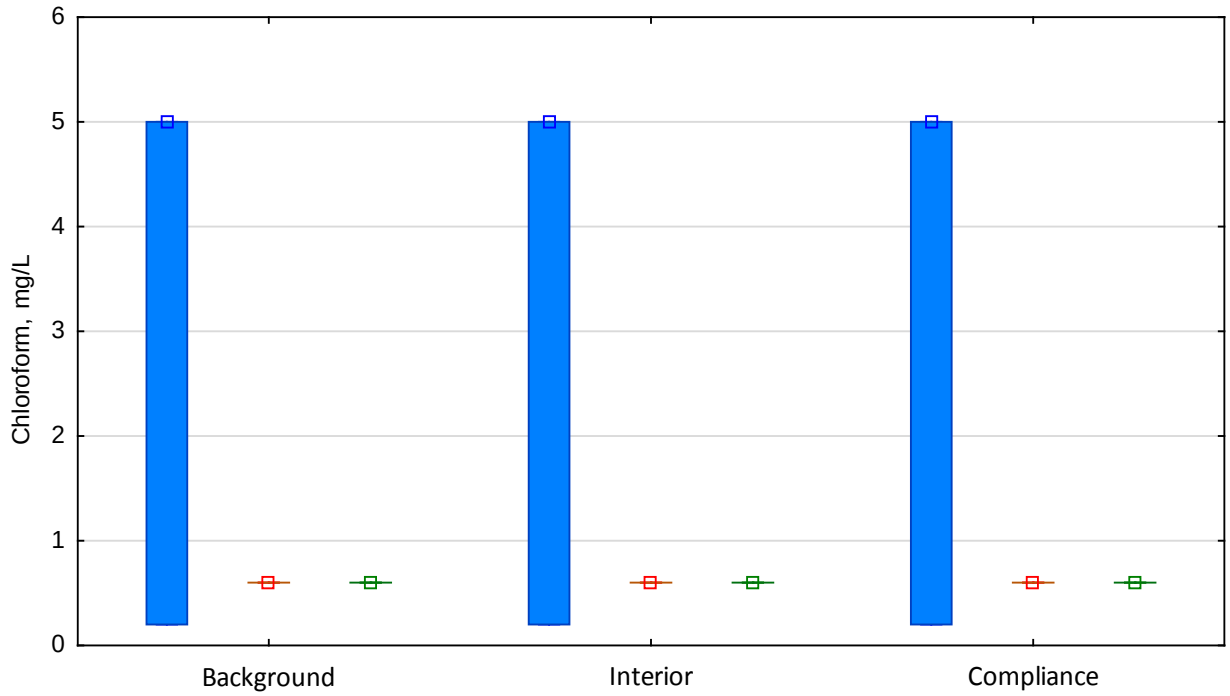


Figure 4-23. Comparison of baseline (2003-2005), 2012 through 2016, and 2017 groundwater chloroform at the background, interior, and compliance wells.

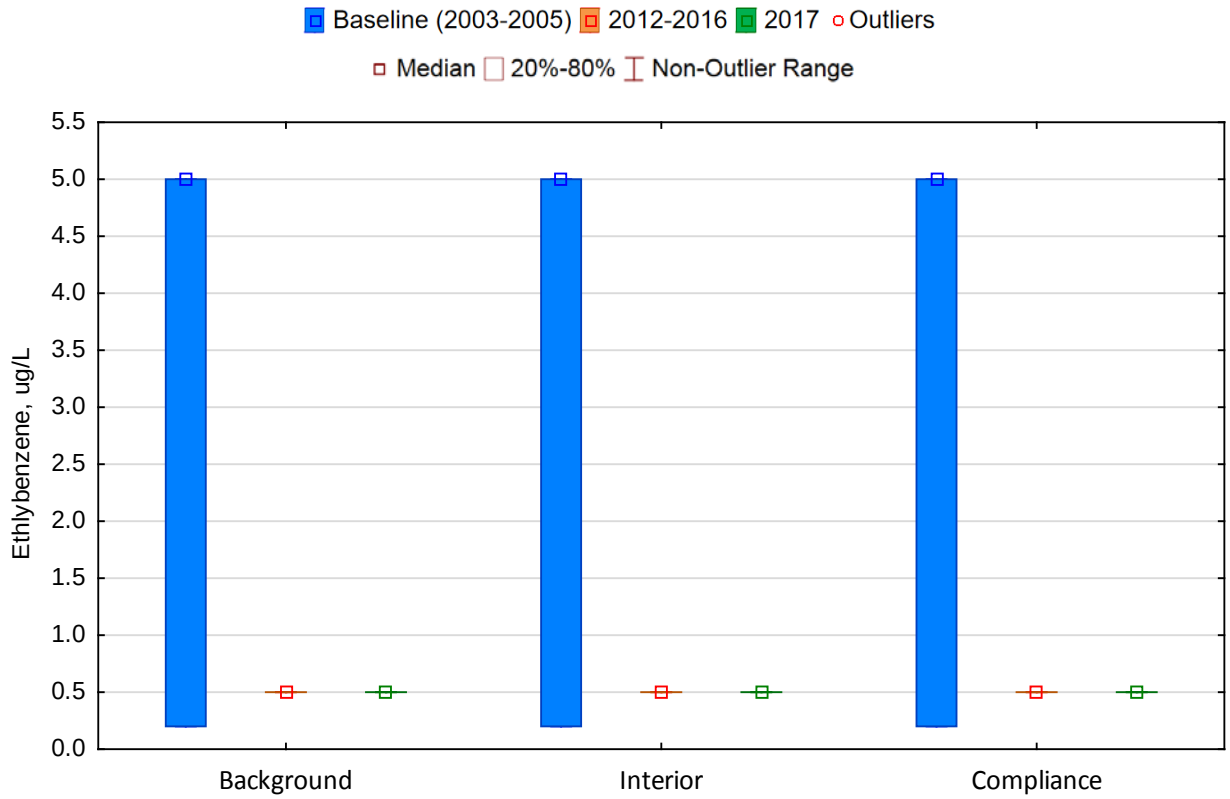


Figure 4-24. Comparison of baseline (2003-2005), 2012 through 2016, and 2017 groundwater ethylbenzene at the background, interior, and compliance wells.

5.0 DIEL IN-SITU MONITORING

In-situ diel monitoring was conducted at all four freshwater EDS stations, two freshwater reference stations, and two tidal lake stations quarterly during the 2017 monitoring year (Figure 5-1). Diel monitoring has also been conducted at the multivariate stations during various seasons and years since 2003. The following report presents the methodologies and results of quarterly 48-hour *in-situ* water quality monitoring conducted during calendar year 2017. Where appropriate, comparisons are made between reference and treatment (EDS) stations, as well as pre- and post-effluent discharge.

5.1 48-Hour Diel In-Situ Methods

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 SOP related to pH (FT 1100), specific conductivity (FT1200), salinity (FT 1300), dissolved oxygen (FT 1500), and turbidity (FT 1600). Quality control procedures followed guidelines outlined in DEP-SOP-001/01 FQ 1000 Field Quality Control requirements.

5.1.1 Field Methods

Diel *in-situ* monitoring included the collection of physiochemical water quality parameters temperature, dissolved oxygen (DO), pH, specific conductivity, and salinity. Readings were collected using unattended (automatic) In-Situ AquaTROLL® 600 multiparameter water quality instruments (sondes). Each sonde was programmed to take automatic readings every 15 minutes for a minimum of a 48-hour period during each quarterly sampling event. Each water quality parameter sensor was calibrated prior to deployment and calibration records were maintained for post-deployment verification analysis. At the end of the 48-hour diel monitoring period, each sonde was retrieved and returned to the lab for post-deployment verification analysis to assess if any mechanical or sensor fouling drift had occurred. All post-deployment verification results were recorded on the original station calibration sheets and stored for record keeping and analysis (all field data forms are included on DVD attached to report).

5.1.2 Field QA/QC and Post Processing

Calibration and post-deployment verification threshold standards are listed in the table below. Prior to deployment of diel sondes, all sensors were calibrated to within field testing acceptance criteria for dissolved oxygen, pH, and specific conductivity as outlined in DEP-SOP-001/01 FT 1000 General Field Testing and Measurement. Those sondes not meeting acceptance criteria listed in the table below were set aside for maintenance, or not used in the field. Sondes that did not meet acceptance criteria during post-deployment verifications were flagged, and downloaded data were discarded. During the course of diel sampling, there were occasions when diel data were not collected at a given station. This may have included instances when there was no surface water at a given station, the water quality sonde malfunctioned during the course of sampling, a specific parameter was not programmed into the log file, or specific

sensors on the multi-parameter sonde malfunctioned or were not provided with the sonde. Data quality records for each station and sampling event in 2017 are listed in Table 5-1.

Parameter	Calibration Thresholds (FT1000)
Dissolved Oxygen	Within ± 0.3 mg/L at Barometric Pressure
Specific Conductivity	Within ± 5% of Calibration Standard
pH	Within ± 0.2 S.U. of Calibration Standard

5.1.3 Data Analysis Methods

Seasonal and overall summary statistics were calculated for each area within the CEDP including the EDS, freshwater reference stations, and tidal EDS stations. All water quality summary statistics were calculated using STATISTICA software or an equivalent statistical program. Calculated metrics include the mean, median, 20th and 80th percentile, and minimum/maximum readings collected over each 48-hour deployment. Non-tidal (Freshwater) and tidal stations were evaluated and plotted separately due to differences in diel parameters at these stations.

Diel summary data for monitoring year 2017 are presented in Tables 5-2 through 5-4 and Figures 5-2 through 5-12. Diel summary data for 2012 through 2016 monitoring years are detailed in annual monitoring reports submitted to the FDEP and are entitled *Year (2012, 2013, 2014, 2015, 2016) Annual Monitoring Report; Combined Effluent Distribution Project* (NAI, January 2013; NAI, February 2014; and NAI, January 2015, February 2016, February 2017). Results of the 2017 diel *in-situ* monitoring are discussed below.

5.2 48-Hour Diel Water Quality Results

Diel *in-situ* water quality monitoring has been conducted at various locations at the International Paper CEDP since 2003. Diel *in-situ* water quality was sampled quarterly in 2017 during the sampling event dates listed in the table below. The following sections detail the results of the 2017 diel water quality monitoring. Diel plots for each station and event are included in Appendix 5-A.

2017 Monitoring Season	Field Water Quality Monitoring Dates
1st Quarter (Winter)	March 20-23, 2017
2nd Quarter (Spring)	June 20-22, 2017
3rd Quarter (Summer)	August 28 - 31, 2017
4th Quarter (Fall)	December 11-13, 2017

5.2.1 Freshwater Temperature Results

Summary 48-hour diel monitoring data and box-plots of *in-situ* temperature readings collected at the freshwater EDS and freshwater reference stations in 2017 are given in Tables 5-2 and 5-

3 and depicted in Figure 5-2. In 2017, the overall median water temperature (24° C) within the EDS and at the reference stations (23° C), were both slightly higher than previous years. Higher than average air temperatures recorded for 11 out of 12 months at the Pensacola Regional Airport (PNS), contributed to higher median water temperatures in the EDS and reference wetlands (See Chapter 3, Table 3-1). However, the maximum water temperature recorded during the summer monitoring event was slightly lower than previous years for the EDS (29° C) and the reference stations (30° C). The minimum water temperature recorded during the fall monitoring trip in the reference wetlands (3° C) was lower than any previously recorded year, whereas within the EDS, the minimum water temperature (8° C) was the third lowest among monitoring years. Overall, EDS and freshwater reference wetland water temperatures were consistent with previous post-effluent monitoring years.

5.2.2 Freshwater Specific Conductivity and Salinity Results

Summary 48-hour diel monitoring data and box-plots of *in-situ* specific conductivity and salinity readings collected at freshwater EDS and reference stations in 2017 are given in Tables 5-2 and 5-3, respectively, and annual specific conductivity is depicted in Figure 5-3. The reference stations average annual and seasonal specific conductivity and salinity values were similar to previous years (Table 5-3; Figure 5-3). Median specific conductivity within the EDS over the course of the 2017 monitoring year was 976 μS/cm, with minimum and maximum single specific conductivity values collected between 68 and 1,672 μS/cm, respectively (Table 5-2). The extremely low specific conductivity recorded in the EDS during the spring monitoring event was the result of two factors: 1) the paper mill was discharging at approximately 50% capacity to the EDS during the spring monitoring event because of a boiler explosion that occurred in January 2017 and 2) Tropical Storm Cindy made landfall in Louisiana on June 22, producing an abundance of rain during the spring monitoring event that depressed specific conductivity values in the EDS and reference wetlands. Over 20 inches of rain fell in June 2017, with almost eight inches falling in two days due to Tropical Storm Cindy (See Chapter 3, Table 3-1). The overall median specific conductivity was lower than all previous monitoring years due in part to the 50% reduction in effluent flows for approximately two months during the first quarter and to several tropical storm events including Cindy and Hurricane Harvey. Total precipitation in 2017 was 92 inches, which is 28 inches above the average annual rainfall for the region. Large rainfall events typically depress conductivities and salinities in the EDS due to dilution by increased surface water and shallow groundwater inputs. Based on *in-situ* data collected in post-effluent years 2013 through 2016, median specific conductivities in the EDS when at 100% operational flows is between 1,100 and 1,600 μS/cm. Year 2017 represents a below average year for specific conductivity values in the EDS. Despite this, the current specific conductivity regime within the freshwater portion of the EDS does not meet state Class III specific conductivity standards due to an increase of more than 50% above background levels and a specific conductivity site specific alternative criteria (SSAC) is currently under development for the freshwater portions of the EDS.

5.2.3 Freshwater pH Results

Summary 48-hour diel monitoring data and box-plots of annual *in-situ* pH readings collected at freshwater EDS and reference stations in 2017 are given in Tables 5-2 and 5-3 and depicted in Figure 5-4. Overall, pH values within the EDS and reference wetlands during the 2017 monitoring year were within the range of values during all previous post-effluent years. The overall EDS median pH was 7.2, and the minimum and maximum pH was 6.6 and 7.5,

respectively. The highest pH readings in the EDS occurred during the winter monitoring event, whereas the lowest pH values were recorded during the spring monitoring event. In general, median pH values between 7.0 and 7.4 S.U. represent the approximate range of median pH values to be expected at 100% operational effluent discharge. The current pH regime within the EDS does not meet state Class III pH standards due to an increase above background levels of more than one standard unit (S.U.). As a result, a pH SSAC is currently under development for the freshwater portions of the EDS.

5.2.4 Freshwater Dissolved Oxygen Results

Summary 48-hour diel monitoring data and graphs of *in-situ* DO percent saturation and concentration (mg/L) readings collected at freshwater EDS and references stations in 2017 are given in Tables 5-2 and 5-3 and depicted in Figures 5-5 through 5-6. In 2017, the median and range of DO percent saturation was similar to other post-effluent monitoring years in both the EDS and freshwater reference wetlands. The overall 2017 median DO saturation was 47% and ranged from a minimum of 8% to a maximum of 91%. The lowest saturation values were recorded during the summer monitoring event, whereas the highest values were recorded during the winter monitoring event. Saturation values in the EDS were similar to the reference stations, in large part due to low saturation values that are typical of reference station SWR01. Dissolved oxygen saturation within the EDS currently does not meet the Class III water quality standard of "no more than 10% of the daily average percent saturation values shall be below 67%". However, dissolved oxygen saturation values within the EDS are similar to reference stations and pre-effluent conditions and are typical for wetland systems in Northwest Florida. Despite the fact that DO saturation values are consistent with background and reference wetland conditions in the freshwater portions of the EDS, a DO SSAC is currently under development.

5.2.5 Tidal Temperature Results

Summary 48-hour diel monitoring data and graphs of *in-situ* water temperature readings collected at tidal EDS stations in 2017 are given in Table 5-4 and annual readings are depicted in Figure 5-7. Diel water quality monitoring was not conducted at reference station TWR01 during 2017 (Figure 5-7). Reference station TWR01 is located in a backwater of the Perdido River and is far more influenced by the Perdido River than the tidal Lakes are, reflecting water quality conditions more dominated by freshwater inputs from the river, rather than the marine tidal fluctuations that Tee and Wicker Lakes experience. Due to the presence of Tropical Storm Cindy along the gulf coast, the tidal lakes could not be safely accessed by boat during the spring monitoring event, and no *in-situ* water quality data was recorded in spring. Median temperatures at TWT01 and TWT02 (25° C) were similar to previous years but had lower ranges than previous monitoring years (Figure 5-7). The lowest temperatures were recorded during the fall monitoring event conducted in December 2017. The Winter monitoring event wasn't conducted until March resulting in higher winter water temperatures than previous years.

5.2.6 Tidal Specific Conductivity and Salinity Results

Summary 48-hour diel monitoring data and graphs of *in-situ* specific conductivity and salinity readings collected at tidal EDS stations in 2017 are given in Table 5-4 and depicted in Figures 5-8 and 5-9. Although no data were collected in the lakes during the spring monitoring event, tidal lake conductivities were fairly high compared with previous years. Higher conductivities were likely the result of meteorological forcing events resulting from several tropical storms

during the year, that increase marine water inputs into the tidal lakes. The overall median specific conductivity for the tidal lakes was 13,215 µS/cm, and ranged from a minimum of 456 µS/cm to a maximum of 21,912 µS/cm.

5.2.7 Tidal pH Results

Summary 48-hour diel monitoring data and graphs of *in-situ* pH readings collected at tidal EDS stations in 2017 are given in Table 5-4 and depicted in Figure 5-10. Median pH values in the tidal receiving stations during the 2017 monitoring year were similar to previous monitoring years and slightly more variable than 2015 and 2016 (Figure 5-10). Values of pH in the tidal lakes are typically neutral ranging from 6.5 to 7.5 S.U. throughout the year, and based on pre-effluent monitoring at TWT01, pH values in the tidal EDS lakes are typically higher than acidic backwaters near the Perdido River, including station TWR01 (Figure 5-10). Median pH values in 2017 for the tidal lakes was 6.5 and ranged from a minimum of 5.5 to a maximum of 7.5. The EDS tidal lakes currently meet the Class III marine waters standard for pH.

5.2.8 Tidal DO Results

Summary 48-hour diel monitoring data and graphs of *in-situ* DO percent saturation and concentration (mg/L) readings collected at the tidal EDS stations in 2017 are given in Table 5-4 and depicted in Figures 5-11 and 5-12. Overall, median DO saturation during the 2017 monitoring year at TWT01 and TWT02 was higher than most previous monitoring years (Figures 5-11 and 5-12). Based on pre-effluent monitoring of DO concentrations at TWT01, the 2017 DO concentrations were higher than pre-effluent conditions (Figure 5-12). During most quarterly monitoring events in all years, TWT02 had slightly higher saturation values than TWT01 (Figures 5-11). This is due to the location of TWT02, which is situated closer to the tidal exchange input channel that flows into these lakes creating more mechanical mixing at the TWT02 location. Overall 2017 median saturation values in the tidal lakes was 81% and ranged from a minimum of 14% to a maximum of 117%. Dissolved oxygen saturation within both EDS tidal lakes in 2017 met the Class III marine water quality standard of "no more than 10% of the daily average percent saturation values shall be below 42 percent saturation". Due to some failures in past years of the marine DO standard, a DO SSAC is currently under development for the EDS tidal lakes.

5.3 Conclusions

The diel water quality results from 2017 are within range of prior monitoring years except for lower conductivities recorded in freshwater portions of the EDS. Lower conductivities in the EDS are the result of both multiple tropical rainfall events and a 50% reduction in effluent flows to the EDS during two months in 2017. The results of *in-situ* monitoring for the 2017 monitoring year are consistent with monitoring that took place during the 2012 ramp-up discharge monitoring year and the 2013-2016 100% effluent discharge monitoring years. State criteria for DO, pH, and specific conductivity were not met within freshwater portions of EDS. However, a Site Specific Alternative Criteria (SSAC) for these constituents in the EDS is currently being developed. Despite the need for a DO SSAC within the EDS, saturation values are consistent with reference wetland conditions and generally, Florida Panhandle wetland conditions. State criteria for DO saturation was met within the EDS tidal Lakes. Due to some failures of state criteria in the past, a SSAC for DO in the EDS tidal lakes is also under development. *In-situ* monitoring and analysis is scheduled to continue through 2018.

Table 5-1. Data quality summary table for the 2017 *in-situ* diel water quality monitoring year.

EDS Station	**Season**	***In-Situ* Data Quality**
DWT01	Winter	Salinity Not Recorded
	Spring	All Data Collected
	Summer	
	Fall	
DWT02	Winter	Salinity Not Recorded
	Spring	All Data Collected
	Summer	
	Fall	
FWT03	Winter	Salinity Not Recorded
	Spring	All Data Collected
	Summer	
	Fall	
SWT03	Winter	Salinity Not Recorded
	Spring	pH QA/QC Post-Calibration Failure
	Summer	All Data Collected
	Fall	pH QA/QC Post-Calibration Failure
Freshwater Reference Station	**Season**	***In-Situ* Data Quality**
FWC01	Winter	Salinity Not Recorded
	Spring	All Data Collected
	Summer	
	Fall	
SWR01	Winter	Salinity Not Recorded; DO QA/QC Post Calibration Failure
	Spring	pH QA/QC Post-Calibration Failure
	Summer	pH QA/QC Post-Calibration Failure
	Fall	All Data Collected
Tidal Station	**Season**	***In-Situ* Data Quality**
TWT01	Winter	Salinity Not Recorded
	Spring	Sondes Not Deployed Due to Tropical Storm
	Summer	All Data Collected
	Fall	
TWT02	Winter	Salinity Not Recorded
	Spring	Sondes Not Deployed Due to Tropical Storm
	Summer	All Data Collected
	Fall	pH QA/QC post-calibration failure

Table 5-2. 48-hour *in-situ* diel summary statistics for the 2017 monitoring year EDS stations.

Area	Season	Descriptive Statistic	Temperature	Specific Conductivity	Salinity	pH	Dissolved Oxygen
			°C	µS/cm	ppt	S.U.	% Saturation
EDS 2017	Overall	Valid N	3668	3668	2625	3285	3668
		Min	7.66	67	0.03	6.56	8.1
		Max	28.99	1672	0.85	7.53	90.7
		20th Percentile	13.98	839	0.37	6.93	28.7
		80th Percentile	26.21	1544	0.79	7.37	59.7
		Median	24.14	976	0.69	7.16	46.6
		Average	21.51	1090	0.58	7.14	44.6
		Std. Dev.	5.95	411	0.24	0.23	17.1
	Winter	Valid N	1043	1043	-	1043	1043
		Min	18.01	844	-	6.84	9.8
		Max	26.54	1002	-	7.53	90.7
		20th Percentile	19.60	891	-	7.26	46.1
		80th Percentile	23.14	972	-	7.43	68.2
		Median	21.16	953	-	7.38	57.0
		Average	21.47	941	-	7.36	57.0
		Std. Dev.	1.98	37	-	0.08	13.4
	Spring	Valid N	774	774	774	583	774
		Min	23.03	68	0.03	6.56	22.5
		Max	26.97	1309	0.66	7.13	67.3
		20th Percentile	24.10	271	0.13	6.70	30.3
		80th Percentile	25.79	943	0.47	7.00	51.3
		Median	25.04	700	0.35	6.88	43.8
		Average	24.98	643	0.32	6.86	42.7
		Std. Dev.	0.94	351	0.18	0.15	11.5
	Summer	Valid N	1087	1087	1087	1087	1087
		Min	24.50	288	0.14	6.64	8.1
		Max	28.99	1626	0.83	7.30	71.1
		20th Percentile	25.68	852	0.42	6.89	16.1
		80th Percentile	27.32	1535	0.78	7.13	43.8
		Median	26.37	1375	0.70	7.02	28.6
		Average	26.53	1209	0.61	7.02	29.2
		Std. Dev.	0.96	370	0.19	0.15	13.3
	Fall	Valid N	764	764	764	572	764
		Min	7.66	1529	0.77	6.97	27.0
		Max	14.91	1672	0.85	7.42	72.5
		20th Percentile	9.53	1541	0.77	7.15	34.9
		80th Percentile	12.57	1604	0.81	7.36	64.3
		Median	10.72	1570	0.79	7.23	53.6
		Average	10.95	1577	0.79	7.25	51.6
		Std. Dev.	1.62	36	0.02	0.10	12.8

Table 5-3. 48-hour *in-situ* diel summary statistics for the 2017 monitoring year freshwater reference stations.

Area	Season	Descriptive Statistic	Temperature	Specific Conductivity	Salinity	pH	Dissolved Oxygen
			°C	µS/cm	ppt	S.U.	% Saturation
Freshwater Reference 2017	Overall	Valid N	1698	1698	1253	1303	1521
		Minimum	2.66	18	0.01	3.62	2.7
		Maximum	29.55	543	0.26	4.57	139.1
		20th Percentile	12.10	34	0.01	4.12	29.4
		80th Percentile	25.11	113	0.03	4.31	68.8
		Median	23.42	46	0.02	4.26	51.3
		Average	20.23	100	0.05	4.22	50.3
		Std. Dev.	6.71	141	0.08	0.12	22.7
	Winter	Valid N	445	445	-	445	268
		Min	16.85	43	-	4.05	39.0
		Max	28.77	122	-	4.57	106.8
		20th Percentile	18.90	46	-	4.09	49.2
		80th Percentile	23.62	115	-	4.29	79.4
		Median	21.47	48	-	4.26	62.7
		Average	21.57	74	-	4.21	64.9
		Std. Dev.	2.76	34	-	0.10	17.0
	Spring	Valid N	403	403	403	201	403
		Min	22.47	18	0.01	4.13	17.7
		Max	26.12	56	0.03	4.51	84.7
		20th Percentile	22.93	27	0.01	4.22	33.9
		80th Percentile	24.59	43	0.02	4.39	65.5
		Median	23.70	33	0.01	4.28	48.6
		Average	23.79	35	0.02	4.30	49.0
		Std. Dev.	0.79	10	0.00	0.09	17.1
	Summer	Valid N	465	465	465	272	465
		Min	23.98	25	0.01	4.12	13.2
		Max	29.55	54	0.02	4.37	139.1
		20th Percentile	24.66	30	0.01	4.19	32.6
		80th Percentile	26.10	44	0.02	4.30	62.5
		Median	25.40	40	0.02	4.27	48.9
		Average	25.42	39	0.02	4.25	49.1
		Std. Dev.	0.86	8	0.00	0.06	21.0
	Fall	Valid N	385	385	385	385	385
		Min	2.66	51	0.02	3.62	2.7
		Max	15.74	543	0.26	4.40	95.5
		20th Percentile	7.01	56	0.03	4.10	14.8
		80th Percentile	9.70	492	0.24	4.30	69.5
		Median	8.34	422	0.20	4.17	37.0
		Average	8.67	271	0.13	4.18	42.8
		Std. Dev.	2.56	216	0.10	0.15	28.2

Table 5-4. 48-hour in-situ diel summary statistics for the 2017 monitoring year tidal EDS stations TWT01 and TWT02.

Area	Season	Descriptive Statistic	Temperature	Specific Conductivity	Salinity	pH	Dissolved Oxygen
			°C	µS/cm	ppt	S.U.	% Saturation
TWT01 and TWT02 2017	Overall	Valid N	1311	1311	909	1118	1311
		Minimum	10.07	456	0.22	5.51	13.9
		Maximum	28.85	21,912	13.24	7.54	116.6
		20th Percentile	14.36	7,113	3.25	6.430	59.9
		80th Percentile	26.61	20,430	12.49	7.23	97.1
		Median	25.46	13,216	6.45	6.80	81.2
		Average	22.19	12,988	7.53	6.82	78.2
		Std.Dev.	5.69	6,031	4.45	0.39	21.8
	Winter	Valid N	402	402	-	402	402
		Min	22.09	12,901	-	5.51	4.2
		Max	27.82	13,753	-	7.40	9.0
		20th Percentile	23.33	13,157	-	6.71	5.6
		80th Percentile	26.26	13,637	-	7.11	7.8
		Median	24.47	13,302	-	6.93	6.8
		Average	24.73	13,368	-	6.92	6.7
		Std. Dev.	1.49	227	-	0.22	1.2
	Spring	Valid N	-	-	-	-	-
		Min	-	-	-	-	-
		Max	-	-	-	-	-
		20th Percentile	-	-	-	-	-
		80th Percentile	-	-	-	-	-
		Median	-	-	-	-	-
		Average	-	-	-	-	-
		Std. Dev.	-	-	-	-	-
	Summer	Valid N	523	523	523	523	523
		Min	25.39	456	0.22	5.80	13.9
		Max	28.85	14,354	8.44	7.21	93.7
		20th Percentile	25.98	4,482	2.42	6.274	42.6
		80th Percentile	27.05	10,393	5.96	6.77	77.2
		Median	26.45	7,109	3.96	6.52	66.4
		Average	26.52	7,005	3.94	6.53	60.7
		Std. Dev.	0.60	3,278	1.94	0.29	19.1
	Fall	Valid N	386	386	386	193	386
		Min	10.07	17,765	10.50	7.11	75.4
		Max	16.88	21,912	13.24	7.54	116.6
		20th Percentile	12.44	20,345	12.10	7.26	87.4
		80th Percentile	14.94	21,500	12.94	7.46	104.1
		Median	13.59	20,791	12.46	7.37	95.5
		Average	13.68	20,701	12.40	7.36	95.7
		Std. Dev.	1.52	850	0.57	0.09	8.9

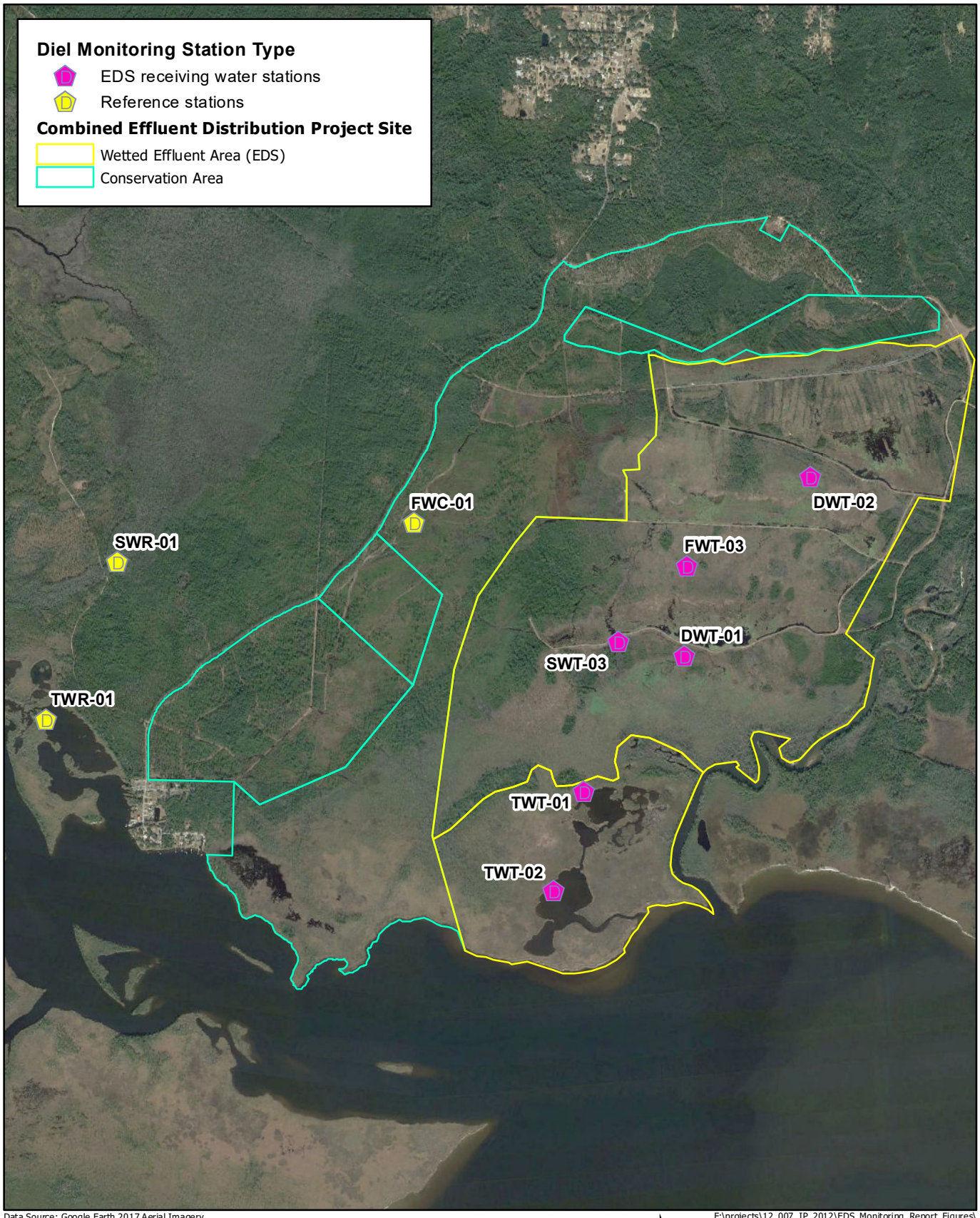


Figure 5-1. Location diel *in-situ* water quality stations at the International Paper combined effluent distribution system.

Nutter & Associates
environmental consultants

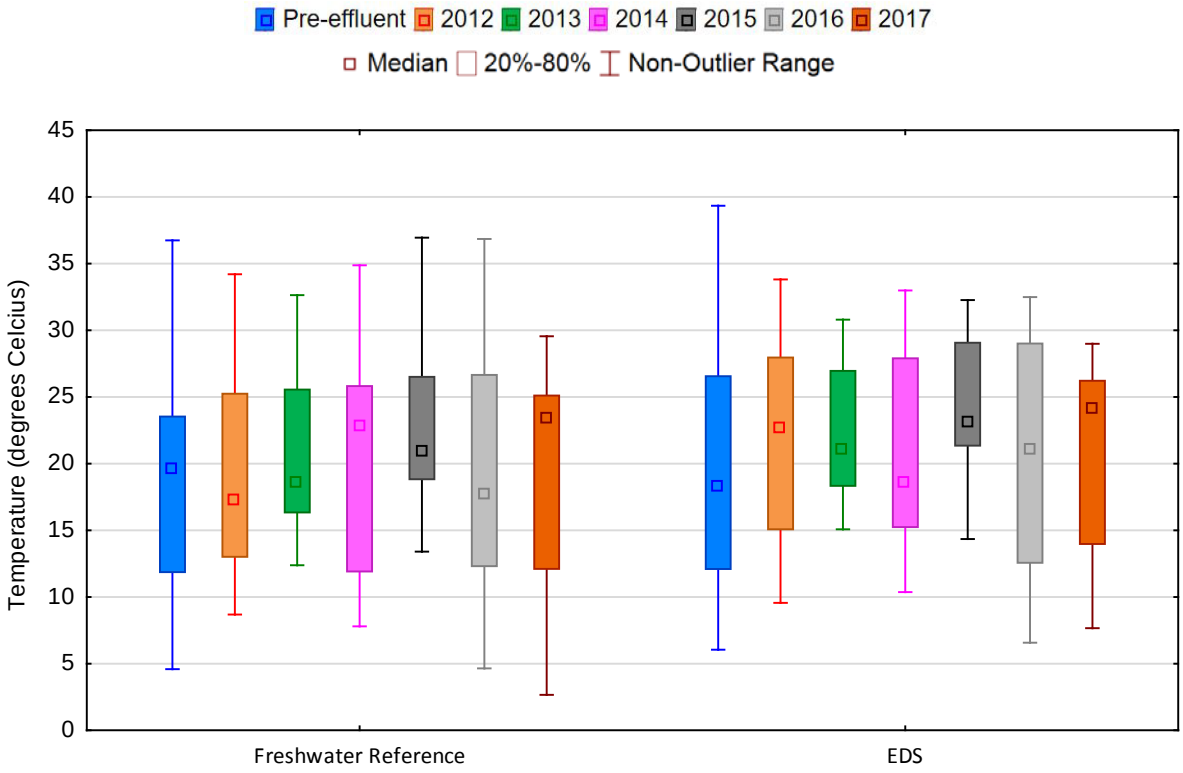


Figure 5-2. Annual summary 48-hour diel water temperature (°C) data for the EDS and freshwater reference stations during combined pre-effluent and individual post-effluent monitoring years 2012 through 2017.

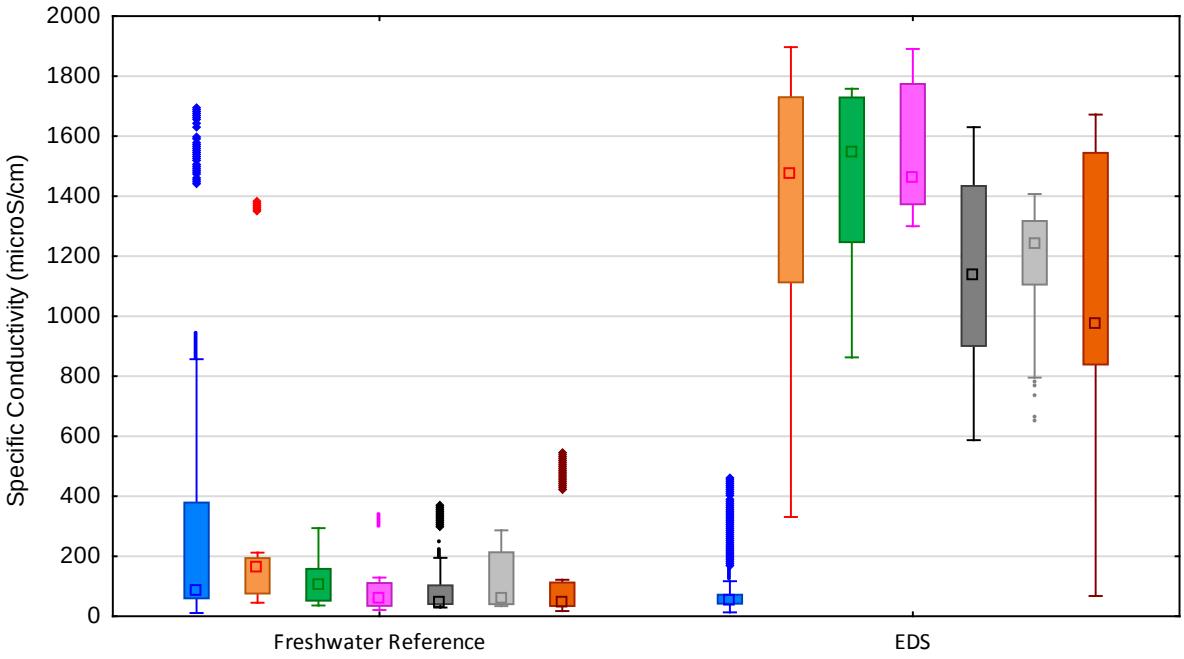


Figure 5-3. Annual summary 48-hour diel specific conductivity (µS/cm) data for the EDS and freshwater reference stations during combined pre-effluent and individual post-effluent monitoring years 2012 through 2017.

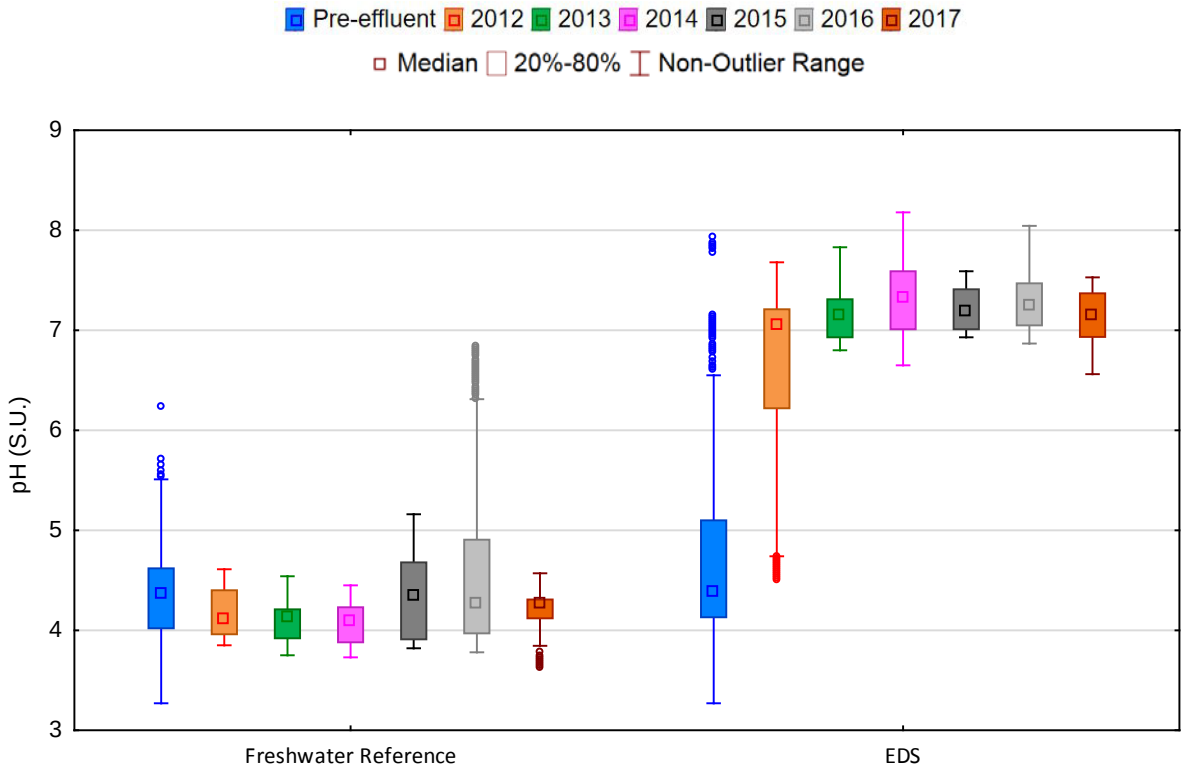


Figure 5-4. Annual summary 48-hour diel pH (S.U.) data for the EDS and freshwater reference stations during combined pre-effluent and individual post-effluent monitoring years 2012 through 2017.

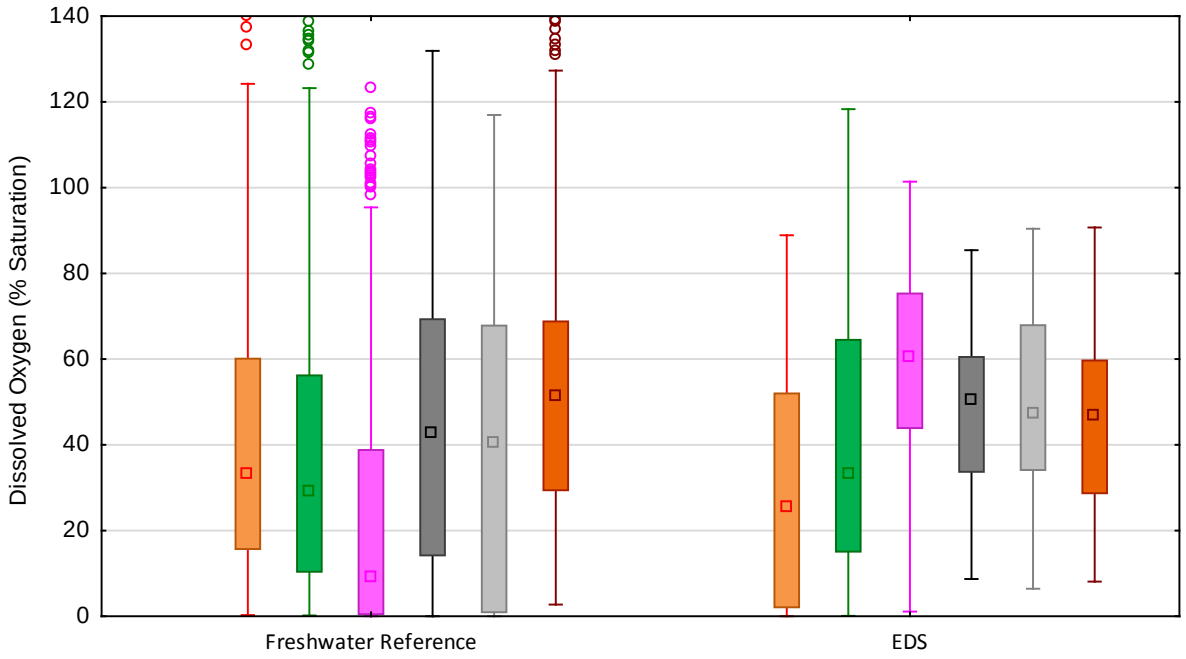


Figure 5-5. Annual summary 48-hour diel dissolved oxygen (DO) percent saturation data for the EDS and freshwater reference stations during combined pre-effluent and individual post-effluent monitoring years 2012 through 2017.

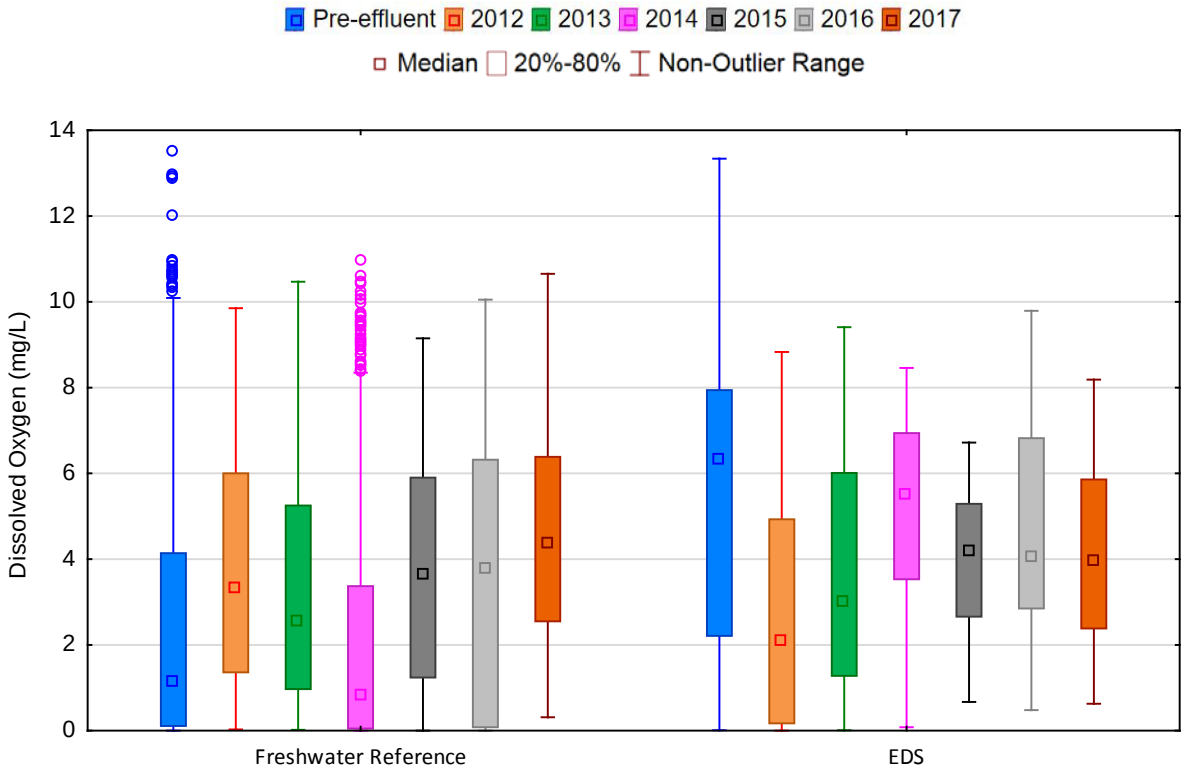


Figure 5-6. Annual summary 48-hour diel dissolved oxygen (DO) concentration (mg/L) data for the EDS and freshwater reference stations during combined pre-effluent and individual post-effluent monitoring years 2012 through 2017.

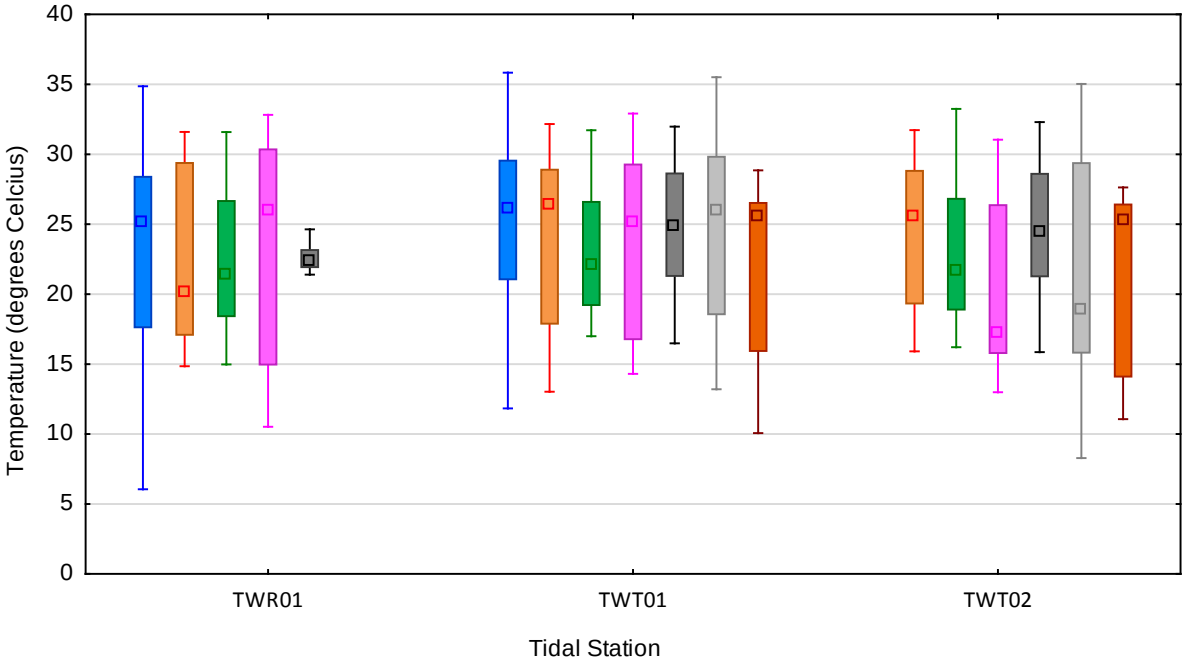


Figure 5-7. Annual summary 48-hour diel water temperature (°C) data for the receiving water (TWT01 and TWT02) and reference (TWR01) tidal stations during combined pre-effluent and individual post-effluent monitoring years 2012 through 2017.

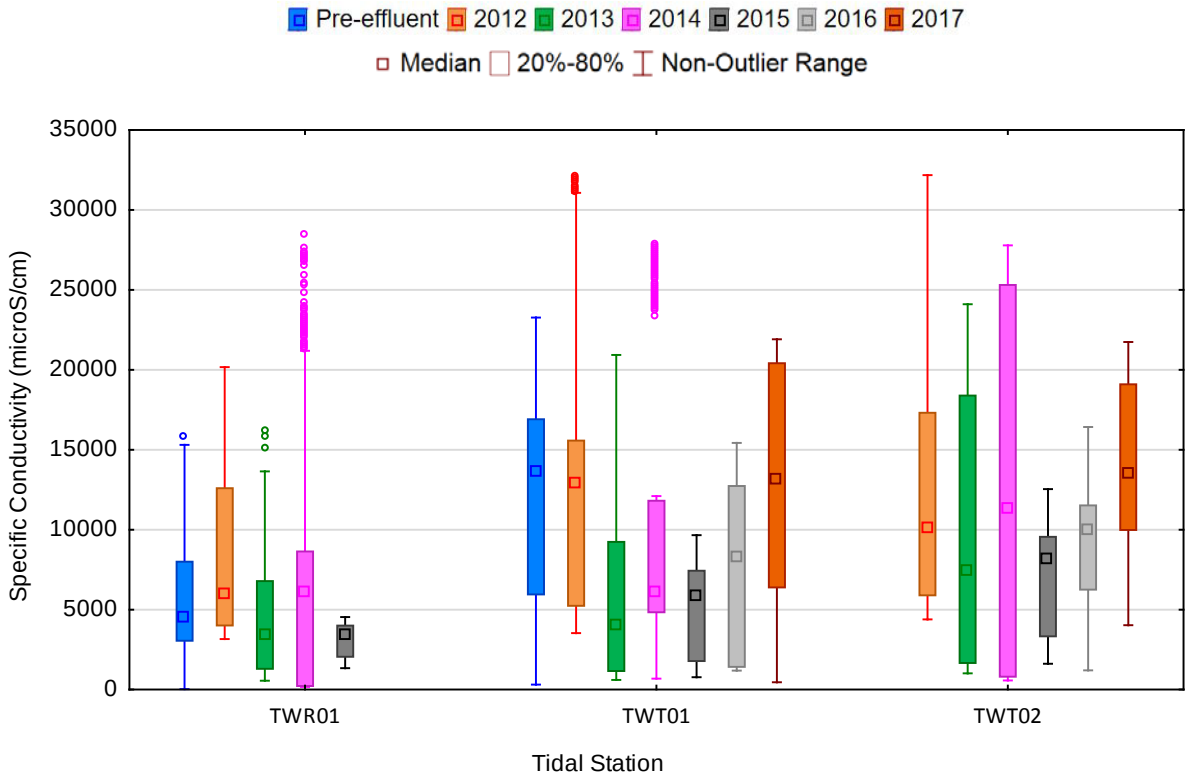


Figure 5-8. Annual summary 48-hour diel specific conductivity (µS/cm) data for the receiving water (TWT01 and TWT02) and reference (TWR01) tidal stations during combined pre-effluent and individual post-effluent monitoring years 2012 through 2017.

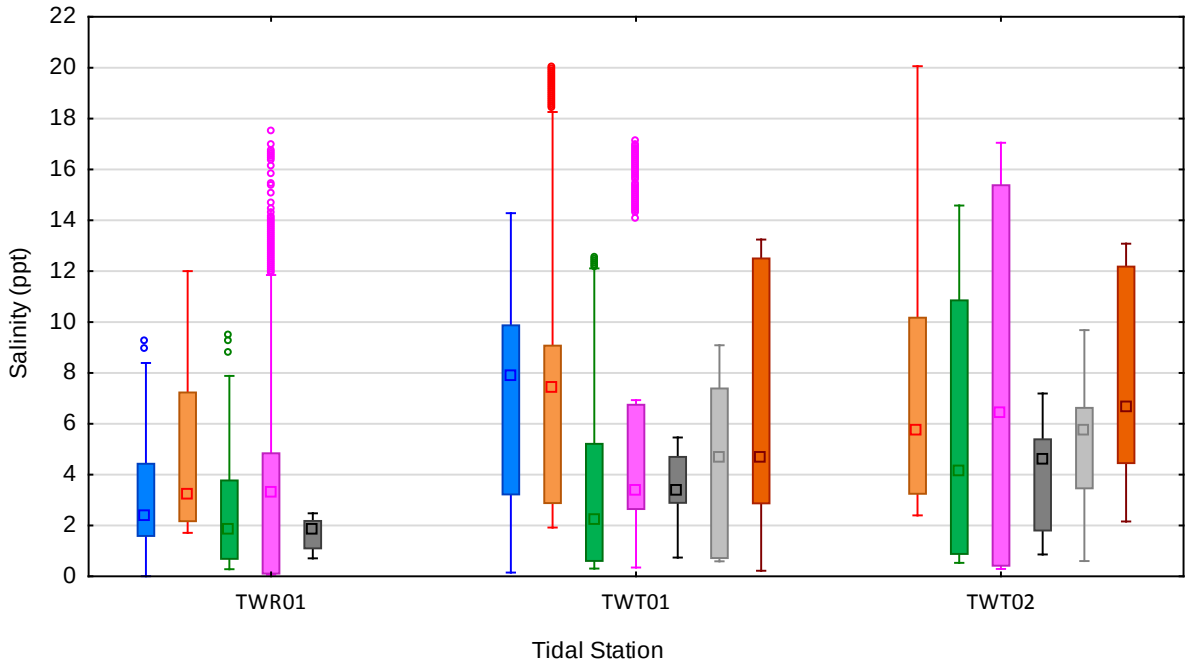


Figure 5-9. Annual summary 48-hour diel salinity (ppt) data for the receiving water (TWT01 and TWT02) and reference (TWR01) tidal stations during combined pre-effluent and individual post-effluent monitoring years 2012 through 2017.

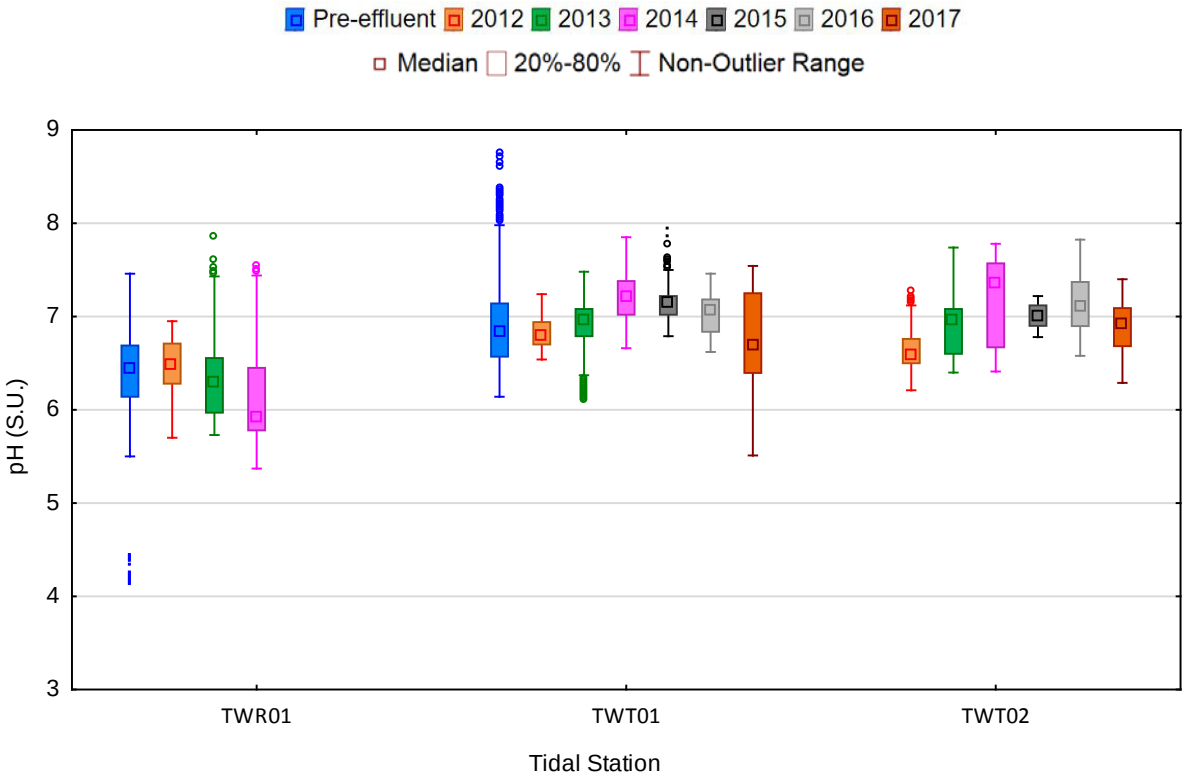


Figure 5-10. Annual summary 48-hour diel pH (S.U.) data for the receiving water (TWT01 and TWT02) and reference (TWR01) tidal stations during combined pre-effluent and individual post-effluent monitoring years 2012 through 2017.

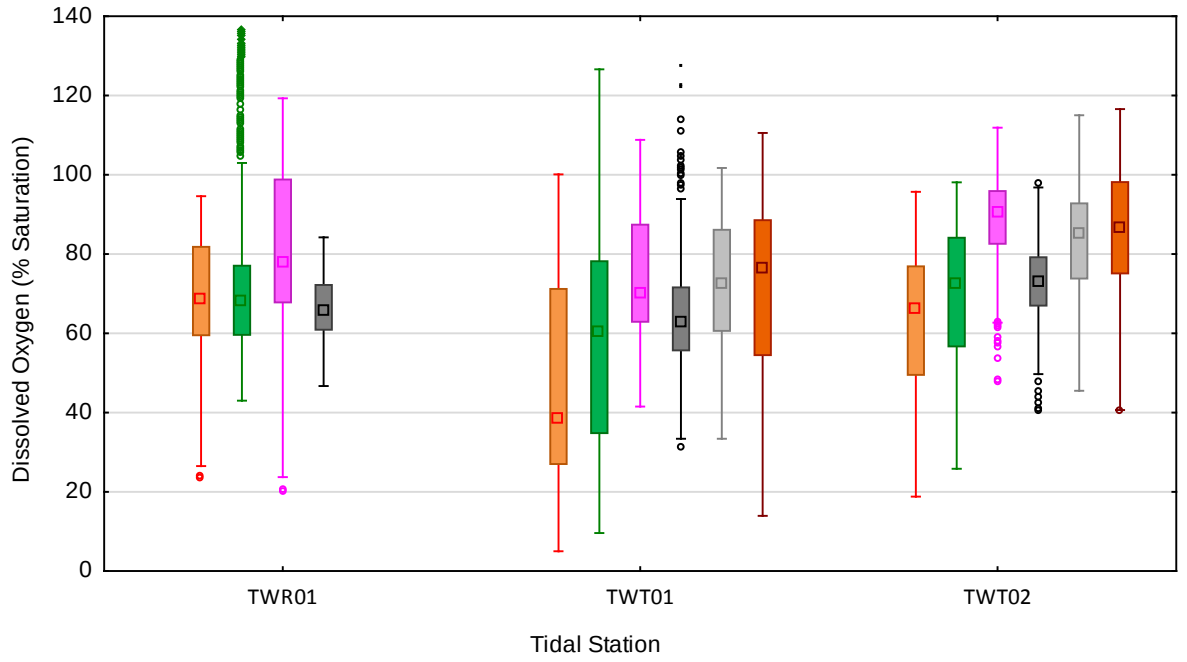


Figure 5-11. Annual summary 48-hour diel dissolved oxygen (DO) percent saturation data for the receiving water (TWT01 and TWT02) and reference (TWR01) tidal stations during combined pre-effluent and individual post-effluent monitoring years 2012 through 2017.

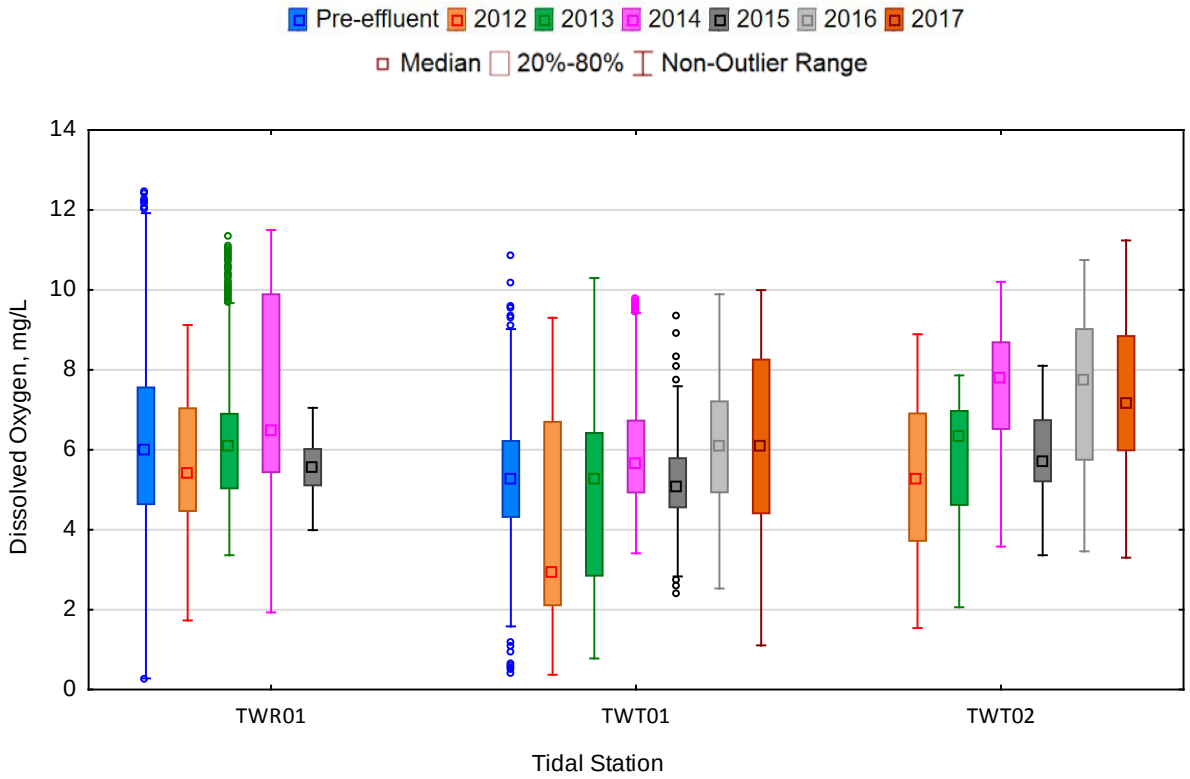
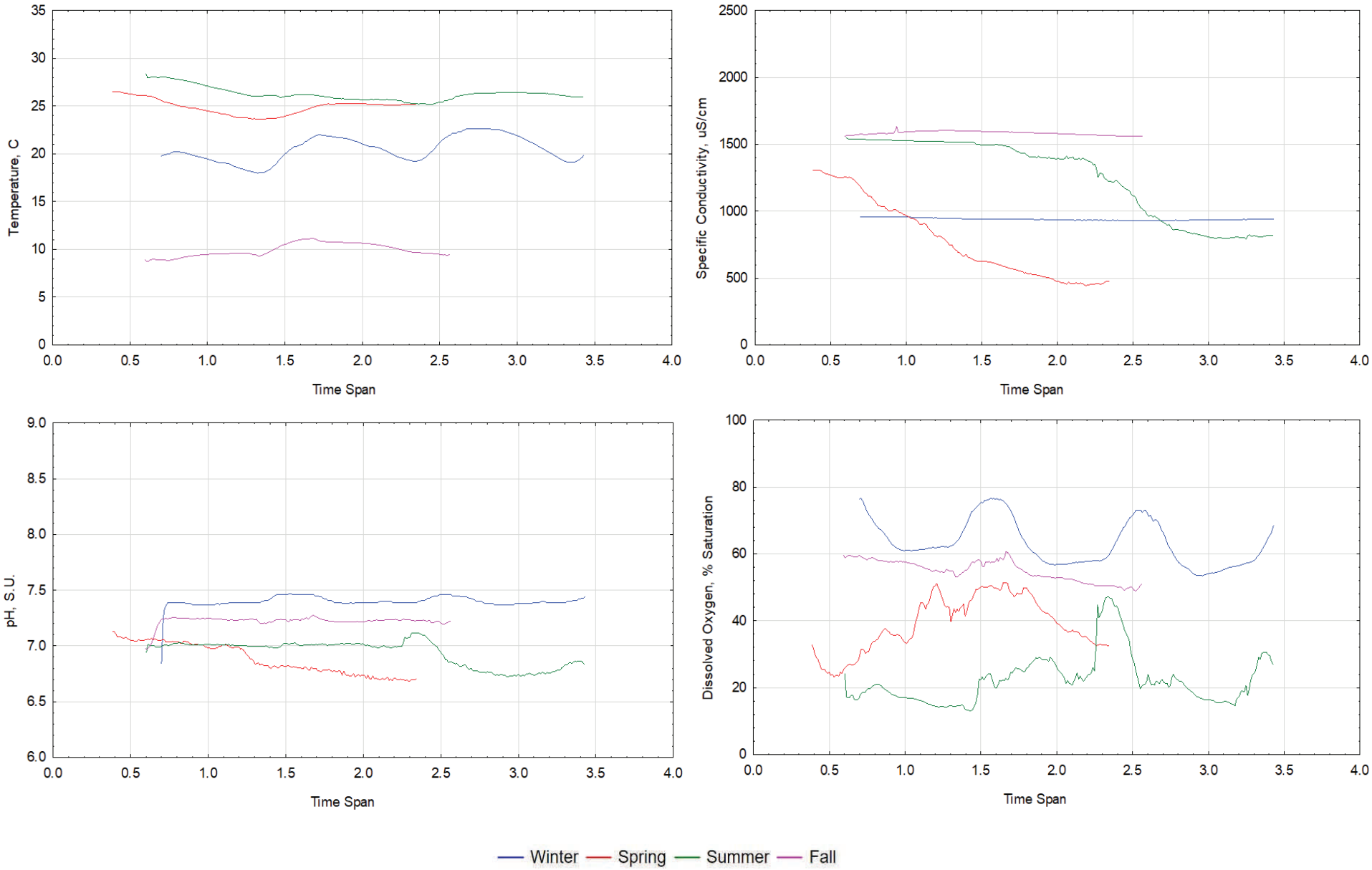


Figure 5-12. Annual summary 48-hour diel dissolved oxygen (DO) concentration (mg/L) data for the receiving water (TWT01 and TWT02) and reference (TWR01) tidal stations during combined pre-effluent and individual post-effluent monitoring years 2012 through 2017.

APPENDIX 5-A

Selected Diel Plots Pre-and Post-effluent

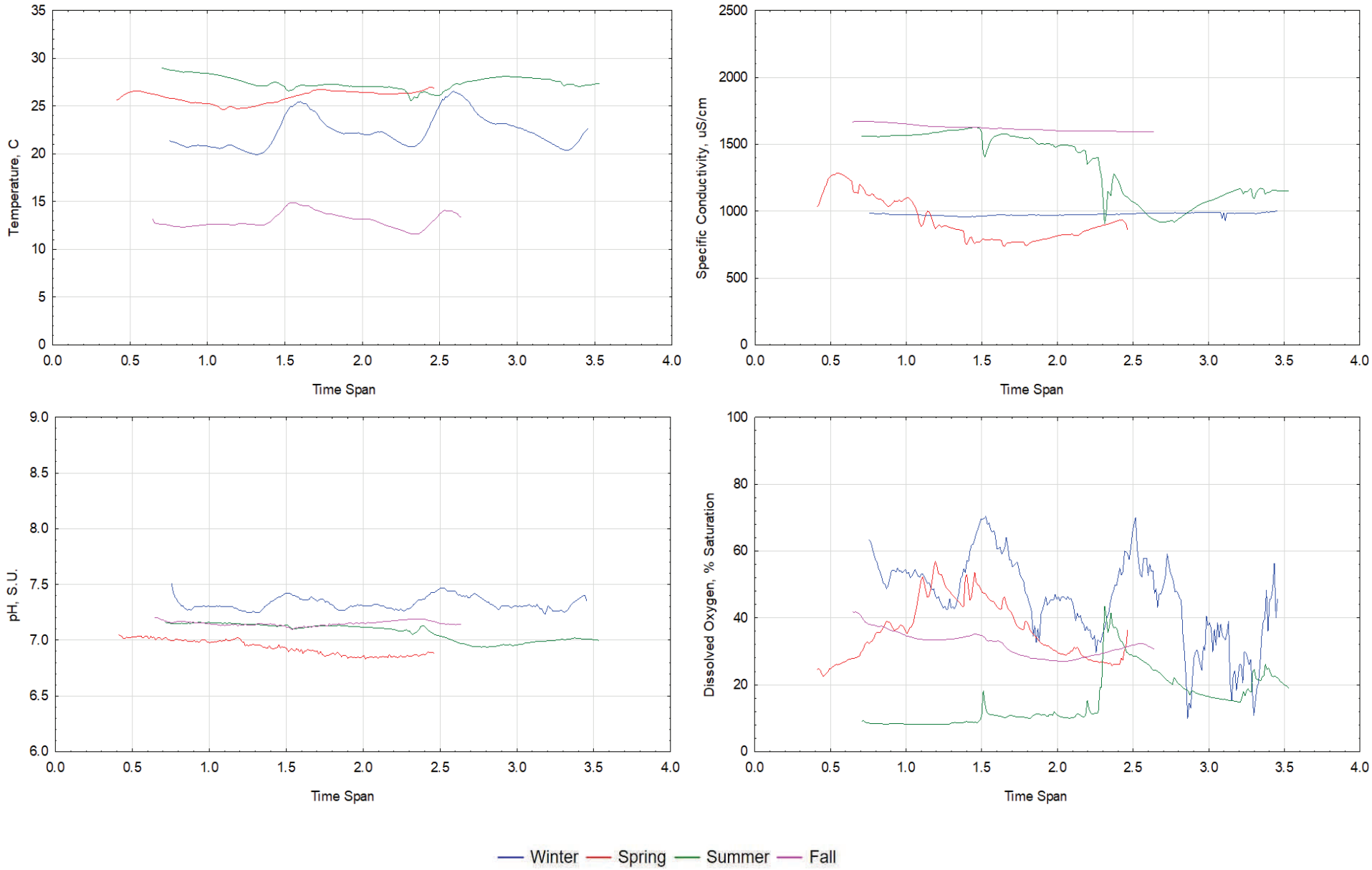


DWT01 2017 diel deployment results.

Deployment Dates: Winter = 3/20—3/23/2017, Spring = 6/20—6/22/2017, Summer = 8/28—8/31/2017, Fall = 12/11—12/13/2017.

Time Span (Days) of 0.0 was set to the midnight of the night prior to deployment.

No QA/QC failures occurred during calibrations.

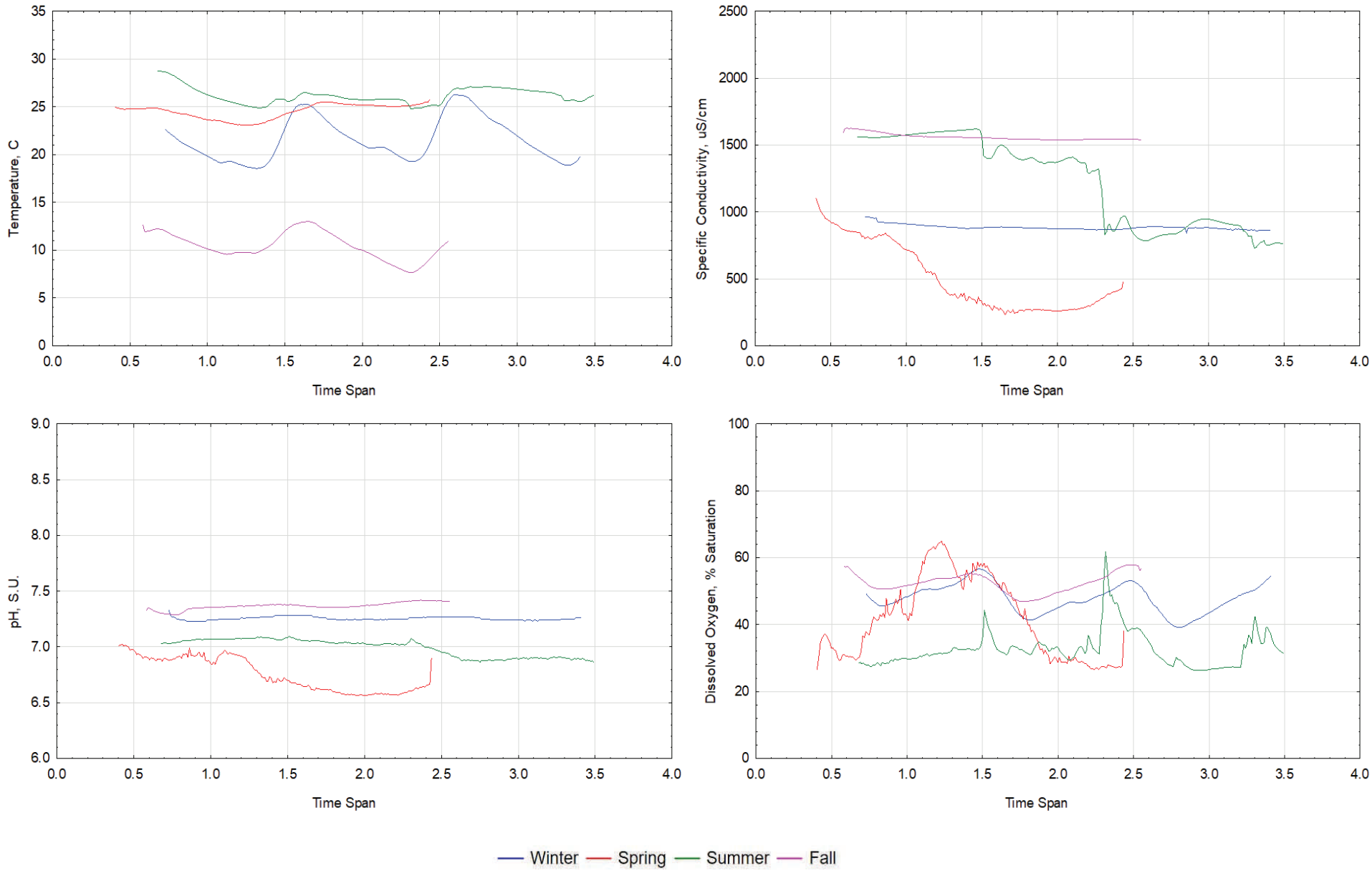


DWT02 2017 diel deployment results.

Deployment Dates: Winter = 3/20—3/23/2017, Spring = 6/20—6/22/2017, Summer = 8/28—8/31/2017, Fall = 12/11—12/13/2017.

Time Span (Days) of 0.0 was set to the midnight of the night prior to deployment.

No QA/QC failures occurred during calibrations.

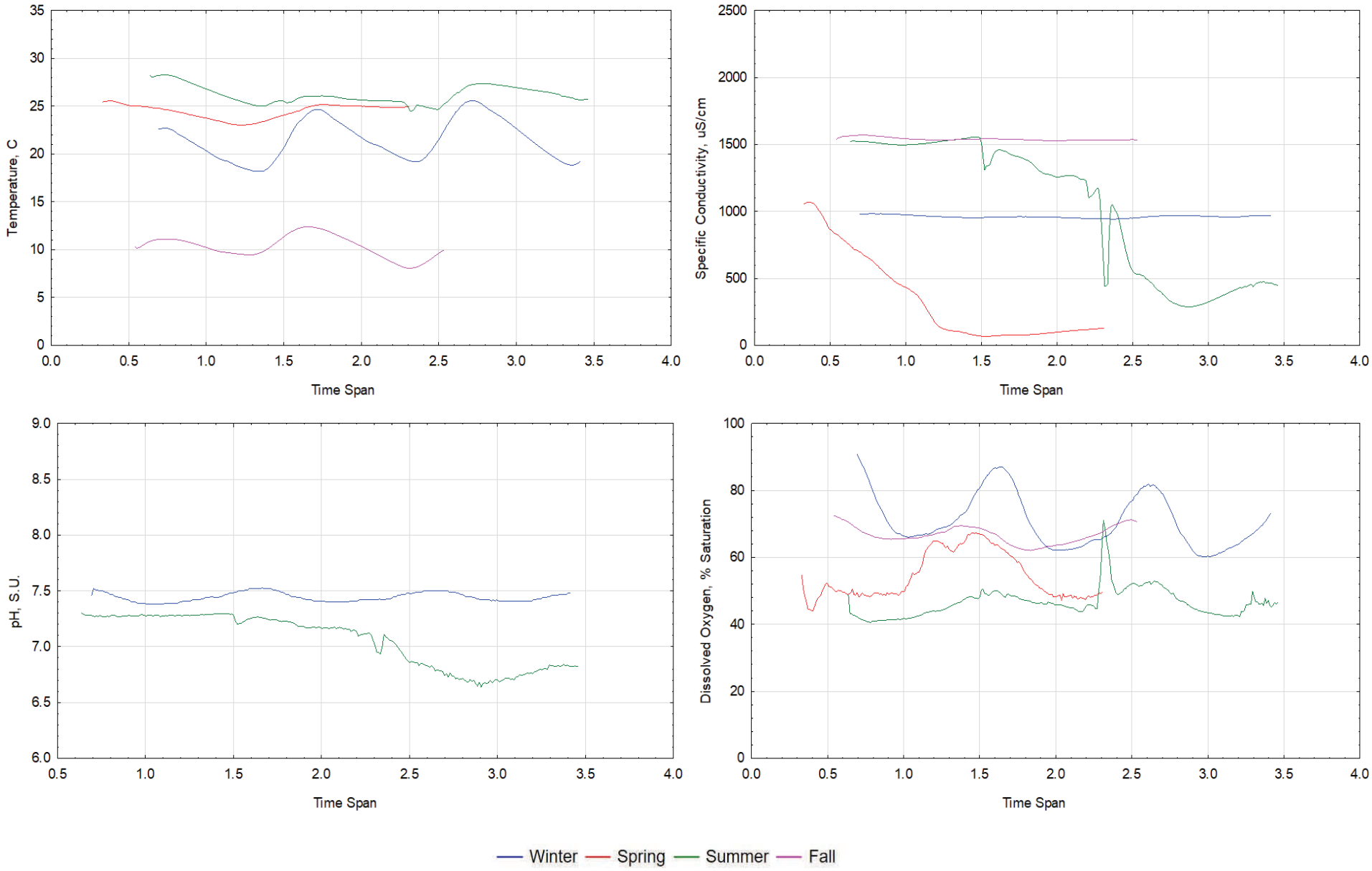


FWT03 2017 diel deployment results.

Deployment Dates: Winter = 3/20—3/23/2017, Spring = 6/20—6/22/2017, Summer = 8/28—8/31/2017, Fall = 12/11—12/13/2017.

Time Span (Days) of 0.0 was set to the midnight of the night prior to deployment.

No QA/QC failures occurred during calibrations.

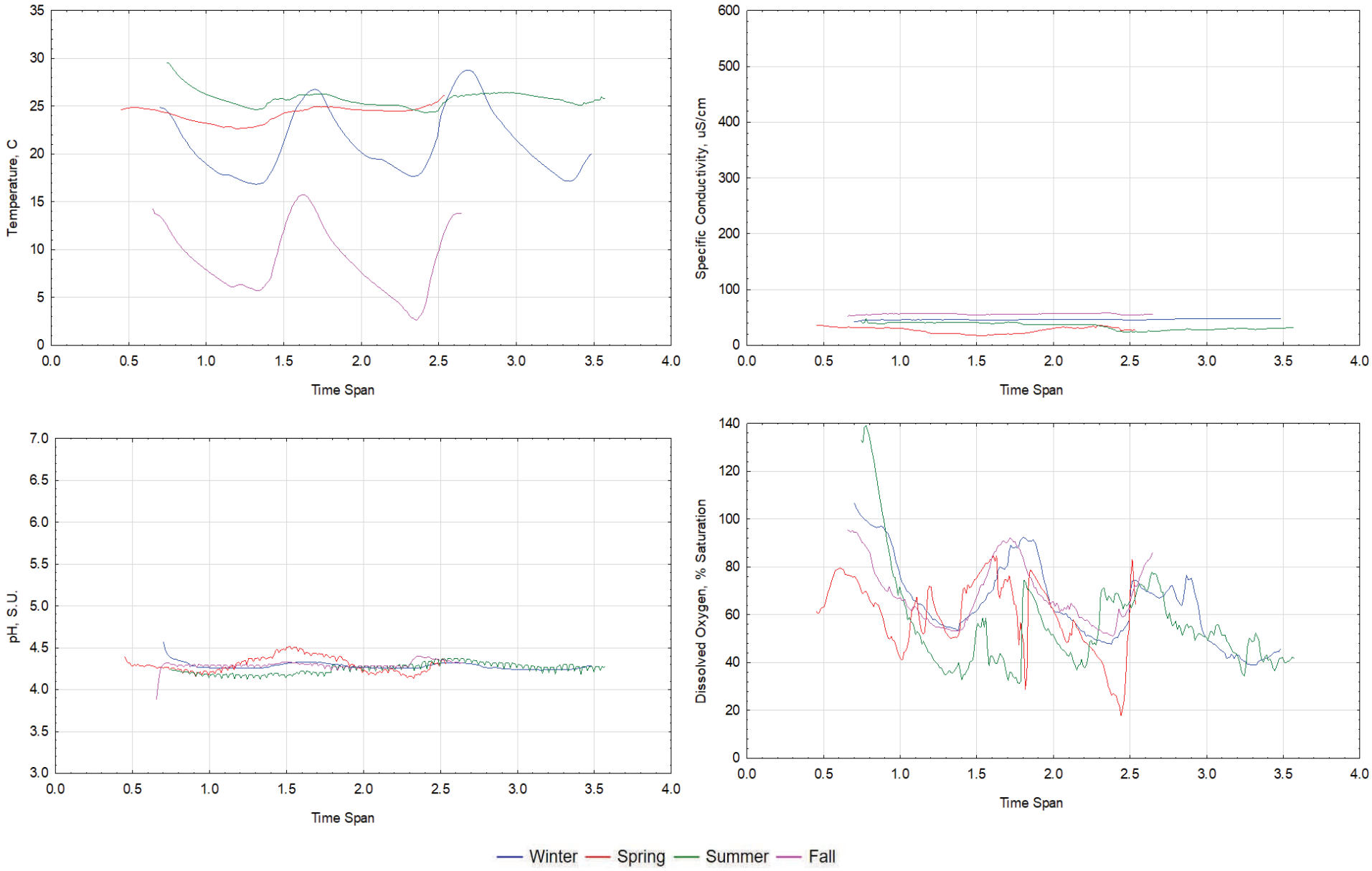


SWT03 2017 diel deployment results.

Deployment Dates: Winter = 3/20—3/23/2017, Spring = 6/20—6/22/2017, Summer = 8/28—8/31/2017, Fall = 12/11—12/13/2017.

Time Span (Days) of 0.0 was set to the midnight of the night prior to deployment.

QA/QC failures for pH occurred during spring and fall events; no other QA/QC failures occurred.

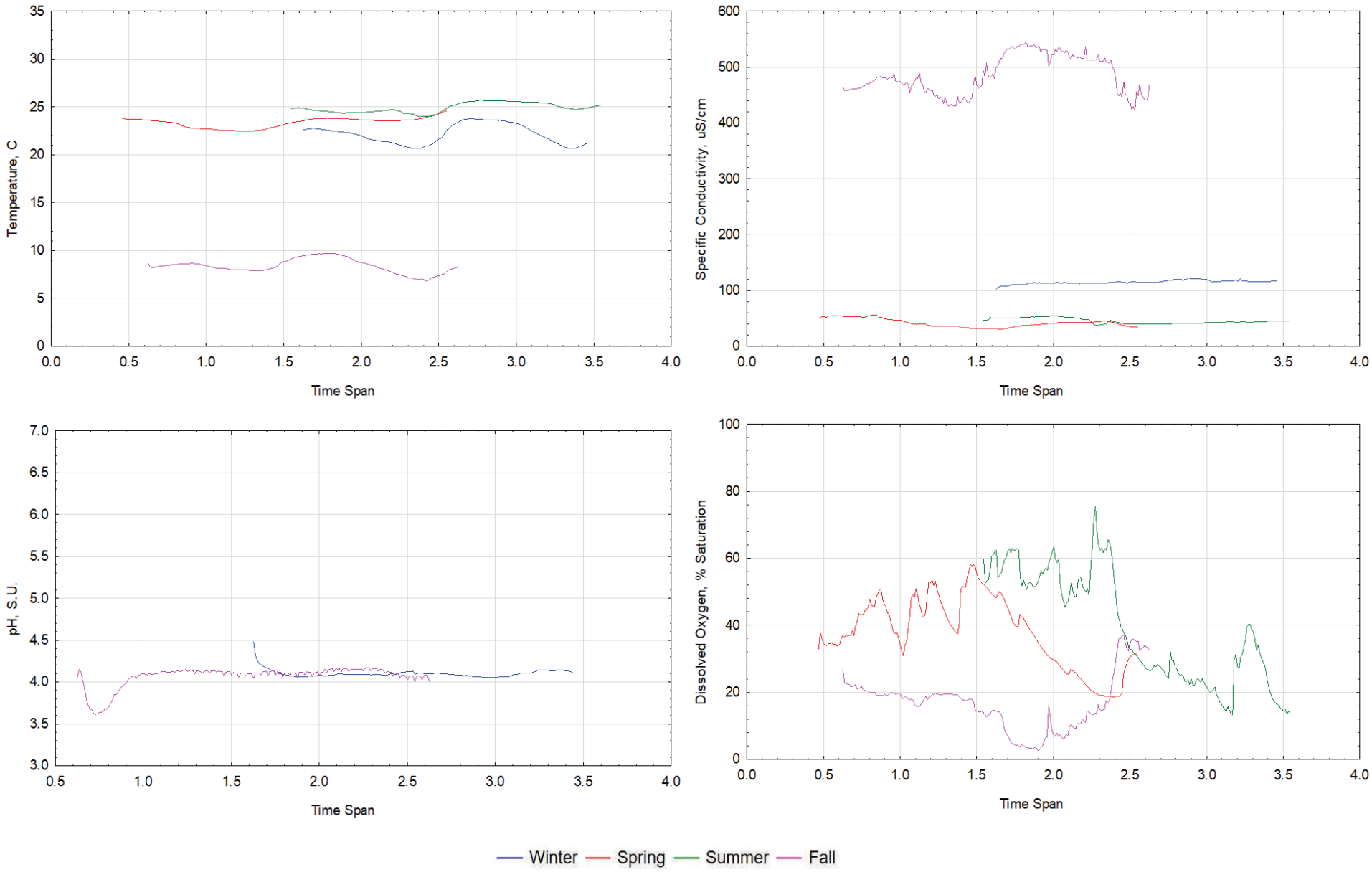


FWC01 2017 diel deployment results.

Deployment Dates: Winter = 3/20—3/23/2017, Spring = 6/20—6/22/2017, Summer = 8/28—8/31/2017, Fall = 12/11—12/13/2017.

Time Span (Days) of 0.0 was set to the midnight of the night prior to deployment.

No QA/QC failures occurred during calibrations.

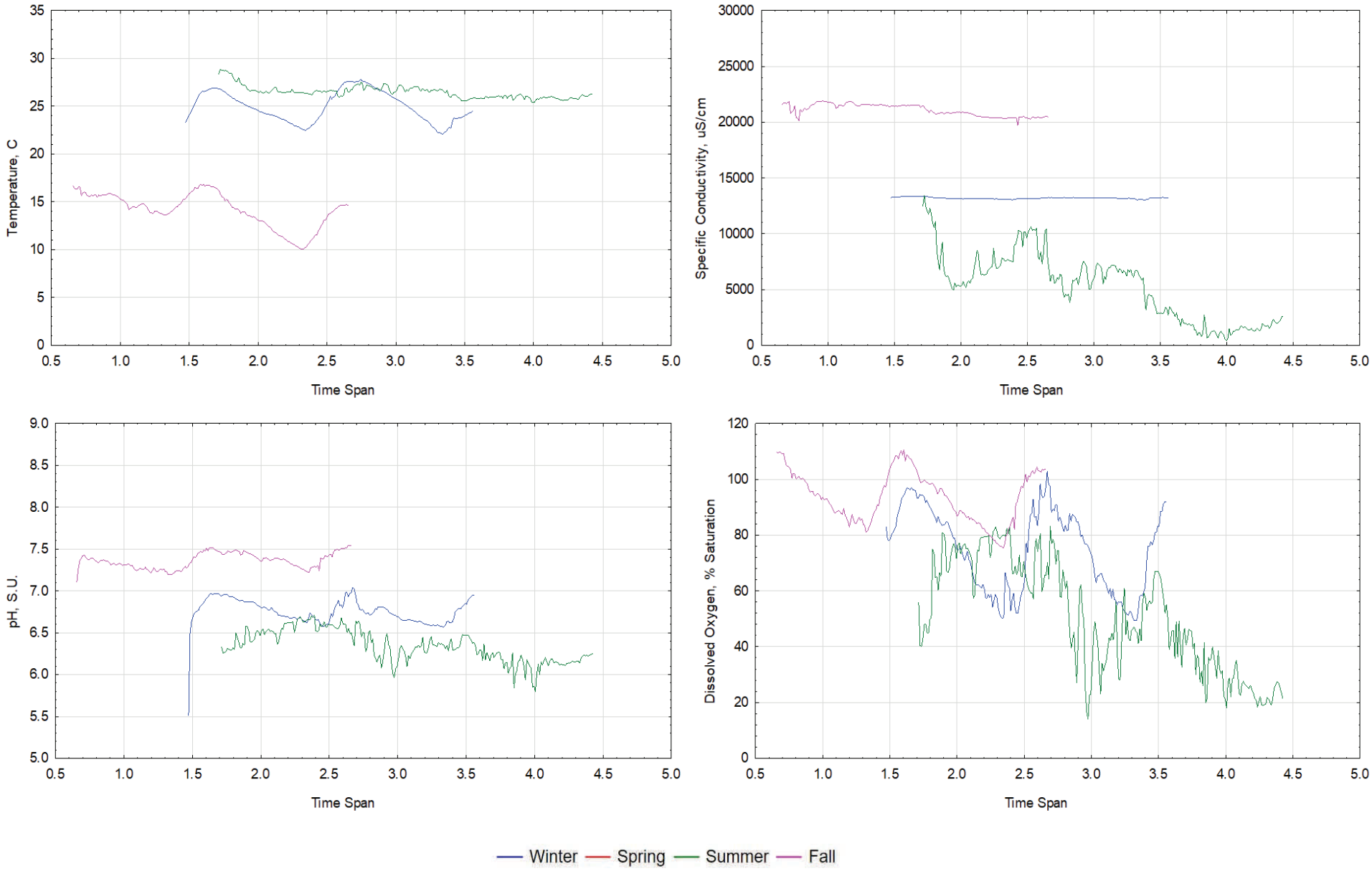


SWR01 2017 diel deployment results.

Deployment Dates: Winter = 3/20—3/23/2017, Spring = 6/20—6/22/2017, Summer = 8/28—8/31/2017, Fall = 12/11—12/13/2017.

Time Span (Days) of 0.0 was set to the midnight of the night prior to deployment.

QA/QC failures for pH occurred during spring and summer events and DO, % Sat occurred during winter event; no other QA/QC failures occurred.

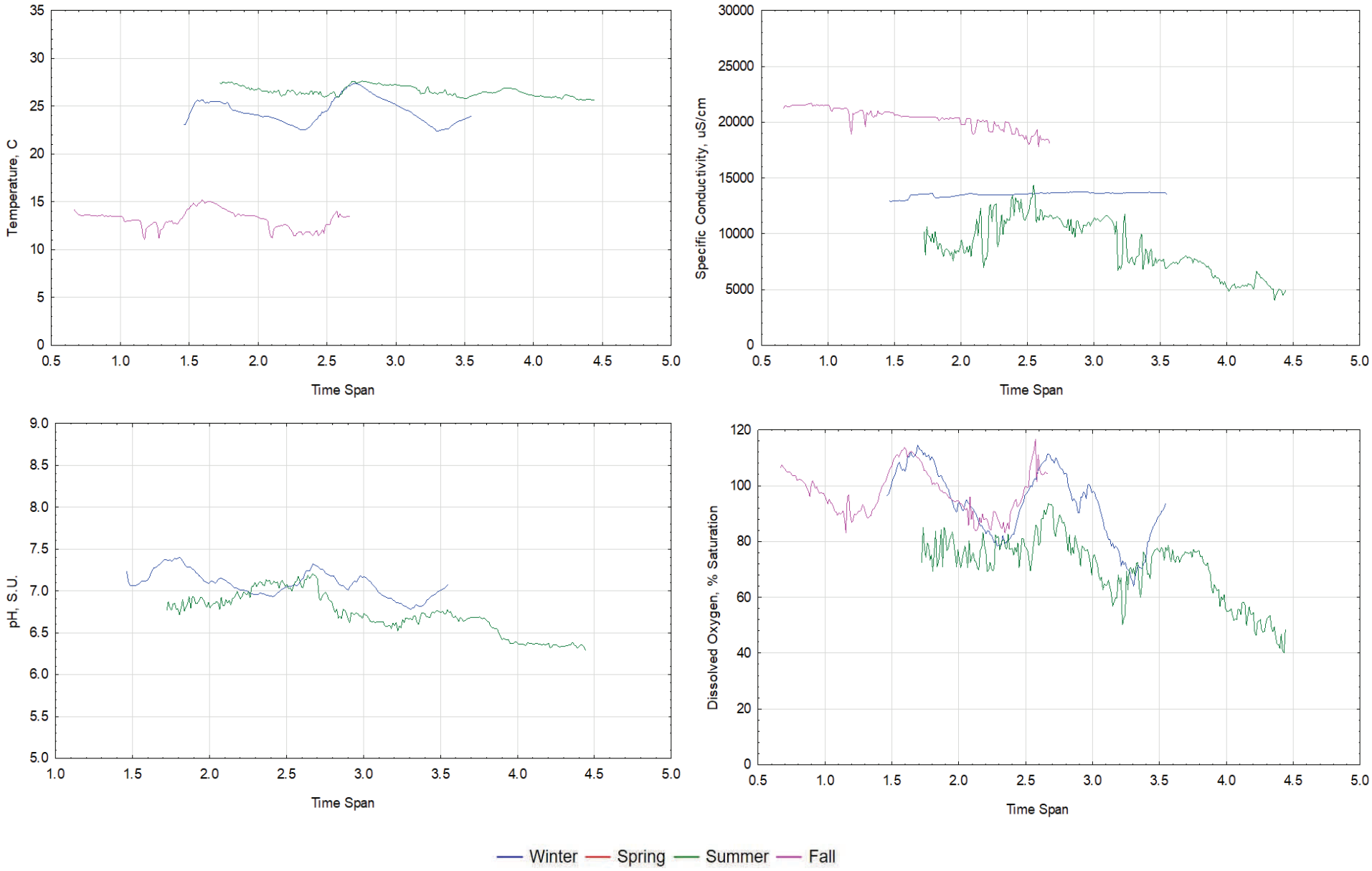


TWT01 2017 diel deployment results.

Deployment Dates: Winter = 3/20—3/23/2017, Spring = None due to Tropical Storm, Summer = 8/28—8/31/2017, Fall = 12/11—12/13/2017.

Time Span (Days) of 0.0 was set to the midnight of the night prior to deployment.

No QA/QC failures occurred during calibrations.



TWT02 2017 diel deployment results.

Deployment Dates: Winter = 3/20—3/23/2017, Spring = None due to Tropical Storm, Summer = 8/28—8/31/2017, Fall = 12/11—12/13/2017.

Time Span (Days) of 0.0 was set to the midnight of the night prior to deployment.

QA/QC failures for pH occurred during fall event; no other QA/QC failures occurred.

6.0 FRESHWATER ANALYTICAL WATER QUALITY

Pursuant to the monitoring goals established in the Framework for Monitoring the Combined Effluent Distribution Project (CEDP) (Updated 2008), analytical surface water quality was monitored at select stations quarterly throughout the 2017 monitoring year (Figure 6-1). The 2017 monitoring year represents the fifth year that the effluent distribution system (EDS) was in full operation at 100% discharge for the entire year. Analytical water quality monitoring has been conducted since 2003 prior to the introduction of effluent into the EDS in 2012 (pre-effluent years). Quarterly water quality monitoring was also conducted during the initiation of ramp-up effluent flows in monitoring year 2012, and during 100% discharge in years 2013 through 2017 (post-effluent years). Where appropriate, comparisons are made to pre-effluent, 2012 ramp-up, and 2013-2016 post-effluent analytical water quality monitoring data. In contrast to previous post-effluent annual monitoring reports, results and analysis for the marine waters including the tidal lakes, tidal creeks, and Upper Perdido Bay stations are detailed in Chapter 10, although some results from tidal creek and tidal lake analytical water quality sampling were used in the zonal analysis of specific water quality constituents in this chapter. The following chapter describes the methodologies and results for full operational discharge analytical surface water quality monitoring conducted in freshwater portions of the EDS and freshwater reference wetlands in 2017.

6.1 Analytical Water Quality Methods

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 SOP related to pH (FT 1100), specific conductivity (FT1200), salinity (FT 1300), dissolved oxygen (FT 1500), and turbidity (FT 1600). Quality control procedures followed guidelines outlined in DEP-SOP-001/01 FQ 1000 Field Quality Control Requirements.

6.1.1 Field and Laboratory Methods

Surface water samples collected for laboratory analysis were collected as grab samples at two freshwater reference, four freshwater EDS multivariate stations within the CEDP, and at a station along Berm 1 just downstream of the effluent discharge pipe (Outfall station) (Figure 6-1; Table 6-1). Samples were also collected at a tidal creek station (GS05) and at tidal lakes stations TWT01 and TWT02. Tidal receiving waters receive discharge from freshwater portions of the EDS. Stations are identified by their location, and whether they are an EDS (treatment) or reference station in Table 6-1. Station nomenclature is described in Chapter 2.

Samples were collected at mid-depth or at approximately one (1) foot below the surface in deeper waters. Sample parameters along with analytical methods are presented in Table 6-2. All samples were preserved according to analytical test methods. Sample containers were placed in a cooler with ice to maintain samples at a temperature of 4 °C or less until they were received by the analytical laboratory. A chain of custody form noting sample identification, date, time, number of containers, sample matrix, sample parameters, preservatives, name of laboratory, sampling personnel, and project manager were completed and accompanied the samples to the laboratory. Following completion of each sample event, water quality samples

were transported to Test America Laboratories in Pensacola, Florida for analysis within designated hold times specified for the analytical methods listed in Table 6-2. All quality control procedures were adhered to and field duplicates, equipment blanks, and field blanks were collected as necessary. Field measurements of turbidity were conducted during grab samples to evaluate water clarity. Turbidity was measured in the field using a turbidimeter that was calibrated in advance of monitoring. In many cases, secchi depths could not be accurately measured at wetland stations due to shallow water depths.

6.1.2 Analysis Methods

Analytical water quality was evaluated using several methods to determine the overall water quality trends and effectiveness of the effluent distribution system (EDS) during the 2017 monitoring year. Where the laboratory reported method detection limits (MDL) for individual analytes were not detected in a given analysis, the reported MDL values were divided by two for analysis and summary purposes. Nutrient data including total phosphorus (TP) and total nitrogen (TN), and 5-day biochemical oxygen demand (BOD) concentrations collected during the 2017 monitoring year were also combined and evaluated by zone within the EDS to determine if changes in these parameters were occurring as effluent moved through the EDS.

Additional results and analyses of tidal lakes and tidal creek station water quality beyond specific zonal analyses covered in this chapter are given in Chapter 10. The four water quality zones of the EDS are depicted in Figure 6-2 and station zone identifiers are given in Table 6-3. The outfall data is considered the input to Zone 1, represented by Zone 0. Zone 1 includes the EDS area north of Berm 4; Zone 2 includes the EDS between Berms 4 and tidal areas; Zone 3 includes a tidal creek station (GS05) that lies between Zone 2 and the tidal lakes, and stations TWT01 and TWT02 in the tidal lakes (Figure 6-2; Table 6-3). The tidal creek GS05 and the TWT stations were treated separately in Zone 3 as GS05 anecdotally appears to receive more effluent from the freshwater portions of the EDS than the tidal lakes, and appears to be less influenced by marine waters of the Perdido Bay. In addition, the zones were compared to reference conditions. Analytical water quality monitoring has been conducted at various locations at the International Paper CEDP since 2003. A matrix of all pre-effluent sampling dates is presented in Table 6-4.

Due to the lack of flowing water conditions and easily disturbed substrates characteristic of the EDS and reference wetland monitoring locations, anomalous water quality results were periodically observed within the data set due to the capture of disturbed bottom substrates in water quality grab samples. When an anomalous result was identified within the data set, the associated laboratory result was flagged and removed from further analysis. The identification of these results was evaluated by comparing the anomalous result to the historic parameter-specific data distribution, other laboratory parameter results (namely, total suspended solids and total organic carbon), and field notes collected during the sampling.

6.2 Nutrient Results

Annual summary nutrient data collected from the CEDP through calendar year 2017 are presented in Table 6-5. Laboratory reports for each monitoring event conducted in 2017 are included on the attached DVD.

Phosphorus species analyzed during 2017 included total phosphorus (TP), and orthophosphate (OP). Nitrogen species analyzed included total kjeldahl nitrogen (TKN), ammonia (NH_3), nitrite as N (NO_2), nitrate as N (NO_3), and nitrite + nitrate (NO_x). Sulfate concentrations were also analyzed at all multivariate stations. All phosphorus species, nitrogen species, and sulfate annual summary statistic results are given in Table 6-5 and individual station sample results are provided in the attached lab reports on the DVD. Where appropriate, the following section makes comparisons to previous annual monitoring results and reference wetland monitoring results.

6.2.1 Total Phosphorus (TP)

6.2.1.1 Phosphorus in the Freshwater EDS

In general, TP and OP concentrations were lower than 2016 values, but slightly higher than previous post-effluent and pre-effluent monitoring years in the freshwater portions of the EDS (Figures 6-3 and 6-4; Table 6-5). Median TP concentrations at the outfall in 2017 (0.57 mg/L) were higher than TP concentrations between 2013 and 2016 and the same as TP concentrations in 2012 (Table 6-5). TP concentrations at the outfall ranged between 0.16 and 0.74 mg/L, excluding outliers, whereas concentrations at the EDS multivariate stations ranged between 0.11 and 0.54 mg/L during the 2017 monitoring year (Table 6-5; Figure 6-3). OP concentrations in the EDS had similar patterns to TP concentrations, showing a slight decrease in median OP concentrations in 2017 over 2016 (Table 6-5; Figure 6-4). However, OP concentrations in 2017 were slightly higher than all other previous post-effluent monitoring years (Table 6-5; Figure 6-4). As with previous post-effluent monitoring years, median EDS phosphorus concentrations were higher and more varied than reference stations in 2016 (Table 6-5; Figures 6-3 and 6-4).

6.2.1.2 EDS Zonal Analysis of Total Phosphorus

During post effluent monitoring years, TP concentrations decreased moving from the outfall through the tidal lakes in the EDS (Table 6-6; Figure 6-5). The median TP concentration at the outfall (Zone 0) in 2017 was 0.57 mg/L (Table 6-6; Figure 6-5). In Zone 1 between the outfall and Berm 4, the 2017 median TP concentration fell 37% over the Zone 0 outfall median concentration to 0.36 mg/L (Table 6-6; Figure 6-5). In Zone 2 between Berm 4 and the tidal receiving waters, the median TP concentration fell 42% over Zone 1 concentrations to 0.21 mg/L (Table 6-6; Figure 6-5). In the Zone 3 tidal receiving waters, the median TP concentration fell 67% over Zone 2 concentrations to 0.07 mg/L (Table 6-6; Figure 6-5). The overall decline in TP concentrations moving from the outfall to Zone 3 was 88% (Table 6-6; Figure 6-5). The zonal analysis for TP shows that the phosphorus concentrations of the pulp mill discharge are decreasing as effluent moves through the wetland system and eventually into tidal receiving waters. Retention or processing of phosphorus in the EDS is likely occurring through a variety of processes including dilution, microbial processing, soil absorption, and plant uptake.

6.2.2 Total Nitrogen (TN)

6.2.2.1 Total Nitrogen in the Freshwater EDS

Within the freshwater portions of the EDS in 2016, the overall median TN concentration was 1.57 mg/L, which was slightly higher than 2016 values, but within the range of median TN

values recorded between 2012 and 2016 (Table 6-5; Figure 6-6). The constituents of EDS TN concentrations in 2017 included a median total kjeldahl nitrogen concentration of 1.1 mg/L, and a median nitrite-nitrate nitrogen concentration of 0.31 mg/L (Table 6-5; Figures 6-7 and 6-8). Reference wetland TN concentrations in 2017 were less than previous monitoring years with a median TN concentration of 0.57 mg/L in 2017 (Table 6-5; Figure 6-6). In general, the effluent has fairly high TN concentrations as evidenced by samples taken near the outfall with a median concentration of 4.0 mg/L (Table 6-5; Figure 6-6).

6.2.2.2 EDS Zonal Analysis of Total Nitrogen

Median TN concentrations follow similar zonal patterns to those of TP concentrations through the EDS, with drops in concentrations moving from Zone 1 through the tidal creek and lakes (Table 6-6; Figure 6-9). The median TN concentration at the outfall in 2017 was 4.0 mg/L (Table 6-6; Figure 6-9). In Zone 1 between the outfall and Berm 4, median TN concentrations fell 52% over the outfall median concentration to 1.94 mg/L (Table 6-6; Figure 6-9). In Zone 2 between Berm 4 and the tidal receiving waters, median TN concentration fell 41% below the Zone 1 concentration to 1.14 mg/L (Table 6-6; Figure 6-9). In the Zone 3 tidal receiving waters the median TN concentration fell 50% over Zone 2 concentrations to 0.57 mg/L (Table 6-6; Figure 6-9). The overall decline in TN concentrations moving from the outfall to Zone 3 was 86% (Table 6-6; Figure 6-9). The zonal analysis for TN shows that the nitrogen concentrations of the pulp mill discharge are decreasing as effluent moves through the wetland system and eventually into tidal receiving waters.

6.2.2.3 Ammonia Concentrations

Ammonia concentrations in 2017 were similar to previous post-effluent monitoring years with a median value of 0.06 mg/L (Table 6-5; Figure 6-10). Most samples collected in the EDS in 2017 were below detection limits (MDL) so statistics presented in Table 6-5 reflect half the MDL value in most cases (Table 6-5; Figure 6-10). The outfall station had a median ammonia concentration of 1.1 mg/L in 2017 with a maximum concentration of 1.6 mg/L (Table 6-5; Figure 6-10). Median ammonia concentrations in the EDS were only slightly higher than the freshwater reference wetland median concentrations (0.01 mg/L) in 2017 (Table 6-5; Figure 6-10).

6.2.3 Sulfate (SO_4)

6.2.3.1 Sulfate in the Freshwater EDS

Sulfate concentrations have decreased sharply since discharge to the EDS began in 2012 (Table 6-5; Figure 6-11). In 2017, the EDS median sulfate concentration was 210 mg/L, a 90 mg/L decline since 2016, and 200 mg/L lower than the overall post-effluent median sulfate concentration between 2013 and 2016 (Table 6-5; Figure 6-11). Despite year over year decreases in EDS sulfate concentrations, concentrations are still substantially higher than reference and pre-effluent conditions (Table 6-5; Figure 6-11).

6.3 Other Water Quality Parameters

Several other analytical and *in-situ* water quality parameters were analyzed in 2017. These included measures of transparency such as color and turbidity, as well as BOD, total suspended solids (TSS), and total organic carbon (TOC). The following discussion details the results of these constituents. Depths in the EDS are often too shallow to accurately measure secchi depth and therefore, secchi depth has been excluded from the discussion of EDS transparency. A zonal analysis for BOD was also conducted to determine if BOD is being exported from the EDS and is presented in the following section. A matrix of pre-effluent sampling data is presented in Table 6-4. Data for these water quality constituents recorded during pre-effluent and 2012 through 2017 monitoring years are summarized in Table 6-5.

6.3.1 Biochemical Oxygen Demand

Median BOD concentration in 2017 for the combined EDS stations was 2.2 mg/L and most samples collected were less than the MDL (2.0 mg/L) with a maximum single value of 9.4 mg/L (Table 6-5; Figure 6-12). Median EDS station BOD concentration was 0.2 mg/L higher than the overall average concentrations in pre-effluent years and the 2013 through 2016 post-effluent monitoring period. At the Outfall monitoring station in 2017, median BOD concentration was 5.8 mg/L with a maximum single value of 19 mg/L (Table 6-5). The median BOD concentration at the Outfall in 2017 was 1.55 mg/L less than the overall post-effluent median concentrations from years 2013 through 2016 (Table 6-5). In Zone 1 between the outfall and Berm 4, median BOD concentration fell 52% over the Zone 0 outfall median concentration to 2.8 mg/L (Table 6-6; Figure 6-13). In Zone 2 between Berm 4 and the tidal receiving waters, median BOD concentration fell 64% below Zone 1 to half the MDL concentration of 1.0 mg/L (Table 6-6; Figure 6-13). South of Zone 2 in the tidal creek and tidal lakes, the median and range of BOD concentrations were recorded as half the MDL (1.0 mg/L), meaning that during the course of the 2017 monitoring year, all BOD samples in the tidal creek and lakes were returned as non-detects (Table 6-6; Figure 6-13). Essentially, freshwater portions of the EDS are processing BOD coming from the Outfall at Berm 1 and no BOD export to tidal areas appears to be occurring based on 2017 and previous post-effluent monitoring years (Table 6-6; Figure 6-13).

6.3.2 Transparency, Suspended Solids, and Organic Carbon

Transparency within the EDS is measured by color and turbidity values and to some degree also described by total suspended solids (TSS). The overall median color value in the combined EDS stations for 2017 was 210 color units (C.U.) (Table 6-5; Figure 6-14). The 2017 monitoring year had similar median color values to previous post-effluent monitoring years and was only 60 color units higher than pre-effluent monitoring years (Table 6-5; Figure 6-14). The freshwater reference median color value in 2017 was 85 C.U., which is consistent with previous monitoring years (Table 6-5; Figure 6-14). The outfall had color values similar to the EDS, with a median of 215 (Table 6-5). However, one extraneously high color value of 1,200 C.U. was recorded at the Outfall during 2017 monitoring (Table 6-5). Turbidity values in the EDS were higher than previous post-effluent monitoring years, but similar to ramp-up monitoring year 2012, with a median turbidity value in 2017 of 13.2 NTU (Table 6-5; Figure 6-15). Outfall turbidity values in 2017 were higher than 2013, 2015, and 2016, with a median turbidity of 13 NTU (Table 6-5). Total suspended solids (TSS) were also similar to previous years and the reference wetland, with a 2017 median concentration of 5.0 mg/L (Table 6-5; Figure 6-16). The Outfall TSS median

concentration was 17 mg/L, which is consistent with previous post-effluent monitoring years (Table 6-5). The Total organic carbon (TOC) median concentration in the EDS was 16.5 mg/L, which was similar to the reference median concentration of 13.5 mg/L (Table 6-5; Figure 6-17). The median TOC concentration at the outfall was 24 mg/L, indicating fairly low TOC concentrations coming from the effluent (Table 6-5).

6.4 Conclusions

Based on analytical water quality monitoring of 100% operational flows to the EDS in 2013 through 2017, it appears that the removal of effluent discharge from the headwaters of Elevenmile Creek and subsequent application to the EDS wetlands has resulted in beneficial improvements to water quality within the tidal receiving waters. Values for nutrients and other water quality variables have remained similar to other post-effluent monitoring years. Zonal analyses also indicated declines in TP, TN, and BOD concentrations as water moves through the EDS. Based on the 2017 monitoring record, it appears that the EDS is functioning as designed and water quality is improving to the tidal receiving waters and Upper Perdido Bay as a result of removing effluent discharge from the Elevenmile Creek headwaters and applying effluent to the EDS wetlands.

Table 6-1. Location Identifiers for the analytical water quality stations.

Station	Location Identifier
DWT01	Freshwater EDS
DWT02	
FWT03	
SWT03	
FWC01	Freshwater Reference
SWR01	
GS05	Tidal EDS
TWT01	
TWT02	
TWR01	Tidal Reference

Table 6-2. Water quality parameter, test methods, and reporting limits.

Parameter	Method[1]	Method Detection Limit (MDL)	Practical Quantification Limit (PQL)	Location
		mg/L except as noted		
Secchi Depth (feet or meters)	DEP-SOP-FT1720	-	-	Field
Turbidity (NTU)	DEP-SOP-FT1600	-	-	
Total Kjeldahl Nitrogen	MCAWW 351.2	0.26	0.5	Lab
Ortho-phosphate	EPA 365.1	0.015	0.050	
Total Phosphorus	EPA 365.4	0.032	0.10	
Ammonia	SM 4500 NH3 H	0.022	0.050	
Color (Color Units)	SM 2120B	1.5	5.0	
Nitrite as N	SM 4500 NO2 B	0.018	0.10	
Nitrate as N	SM 4500 NO3 F	0.018	0.050	
Nitrate Nitrite as N	SM 4500 NO3 F	0.018	0.050	
Sulfate	SM 4500 SO4 E	1.4	5.0	
Biochemical Oxygen Demand, 5-day	SM 5210B	2.0	2.0	
Total Suspended Solids	SM 2540D	5.0	5.0	
Chlorophyll-a (mg/m^3)	SM 10200H	0.50	0.50	

[1] Protocol References:
EPA = US Environmental Protection Agency
MCAWW = "Methods For Chemical Analysis of Water and Wastes", EPA-600/4-79-020, March 1983 And Subsequent Revisions
SM = "Standard Methods For the Determination of Water and Wastewate

Table 6-3. Zonal identifiers for the stations used in the 2017 water quality zonal analyses.

EDS Zone	Area
Zone 0	Effluent pipe outfall / Initial EDS effluent inflow location
Zone 1	All areas north of Berm 4 - Stations DWT02 and FWT03
Zone 2	Areas south of Berm 4 to brackish tidal lakes - Stations DWT01 and SWT03
Zone 3	Tidal lakes, creek and wetlands immediately adjacent to Perdido Bay - Stations GS05, TWT01 and TWT02

Table 6-4. Pre-effluent (2003-2008) sampling matrix. The letter "X" denotes that grab samples were collected during that sampling event.

Station	Fall 2003	Winter 2004	Spring 2004	Summer 2004	Fall 2005	Spring 2006	Summer 2006	Fall 2006	Winter 2007	Spring 2007	Winter 2008	Spring 2008	Summer 2008
DWT-01	X	X	X	X	X		X		X		X		
DWT-02	X	X	X	X					X		X	X	X
FWC-01									X		X	X	X
FWT-03									X		X	X	
SWR-01	X	X	X	X	X	X	X	X	X		X	X	X
SWT-03	X	X	X	X	X	X	X	X	X		X	X	X
GS-05										X	X	X	
TWR01	X	X	X	X		X			X	X	X	X	
TWT01	X	X	X	X		X			X	X	X	X	
TWT02													

Table 6-5. Annual surface water quality results collected during pre-effluent and 2012 through 2017 monitoring years for the combined effluent distribution project.

Variable	Wetland Type	Time Period	Valid N	Mean	Std. Dev.	Minimum	20th Percentile	Median	80th Percentile	Maximum
Total Phosphorus (TP), mg/L	Freshwater EDS	Pre-effluent	29	0.088	0.117	0.025	0.050	0.069	0.088	0.680
		2012	16	0.189	0.143	0.012	0.055	0.155	0.300	0.500
		2013	15	0.303	0.084	0.220	0.225	0.290	0.375	0.520
		2014	16	0.207	0.133	0.088	0.098	0.200	0.260	0.610
		2015	15	0.239	0.120	0.140	0.155	0.180	0.330	0.570
		2016	16	0.437	0.329	0.270	0.290	0.330	0.420	1.60
		2017	16	0.305	0.128	0.110	0.210	0.315	0.380	0.540
	Freshwater Reference	Pre-effluent	17	0.082	0.056	0.025	0.050	0.064	0.088	0.280
		2012	6	0.025	0.026	0.012	0.012	0.013	0.024	0.077
		2013	6	0.062	0.068	0.015	0.015	0.040	0.071	0.190
		2014	5	0.057	0.033	0.015	0.025	0.064	0.086	0.100
		2015	8	0.032	0.016	0.015	0.016	0.035	0.046	0.058
		2016	8	0.052	0.025	0.016	0.016	0.058	0.075	0.079
		2017	8	0.016	0.000	0.016	0.016	0.016	0.016	0.016
	Outfall	2012	4	0.550	0.200	0.310	0.310	0.565	0.760	0.760
		2013	4	0.538	0.015	0.530	0.530	0.530	0.560	0.560
		2014	4	0.340	0.179	0.170	0.170	0.325	0.540	0.540
		2015	3	0.420	0.181	0.230	--	--	--	0.590
		2016	4	0.530	0.115	0.410	0.410	0.525	0.660	0.660
		2017	4	0.508	0.249	0.160	0.160	0.565	0.740	0.740
Ortho-phosphate, mg/L	Freshwater EDS	Pre-effluent	29	0.020	0.013	0.006	0.013	0.016	0.025	0.050
		2012	16	0.090	0.080	0.007	0.013	0.082	0.150	0.240
		2013	15	0.191	0.063	0.088	0.140	0.180	0.250	0.310
		2014	16	0.102	0.058	0.029	0.055	0.089	0.140	0.250
		2015	16	0.137	0.073	0.064	0.081	0.105	0.230	0.280
		2016	12	0.213	0.050	0.140	0.190	0.200	0.260	0.310
		2017	16	0.203	0.053	0.130	0.160	0.185	0.240	0.300
	Freshwater Reference	Pre-effluent	17	0.025	0.017	0.006	0.013	0.016	0.050	0.050
		2012	7	0.007	0.001	0.007	0.007	0.007	0.008	0.008
		2013	8	0.008	0.000	0.008	0.008	0.008	0.008	0.008
		2014	6	0.013	0.004	0.008	0.008	0.015	0.015	0.017
		2015	8	0.008	0.000	0.008	0.008	0.008	0.008	0.008
		2016	6	0.022	0.022	0.008	0.008	0.009	0.050	0.050
		2017	8	0.008	0.000	0.008	0.008	0.008	0.008	0.008
	Outfall	2012	4	0.323	0.124	0.210	0.210	0.290	0.500	0.500
		2013	4	0.300	0.076	0.190	0.190	0.325	0.360	0.360
		2014	4	0.177	0.124	0.087	0.087	0.130	0.360	0.360
		2015	4	0.223	0.078	0.110	0.110	0.250	0.280	0.280
		2016	3	0.193	0.050	0.140	--	--	--	0.240
		2017	4	0.288	0.142	0.170	0.170	0.250	0.480	0.480

Table 6-5. Annual surface water quality results collected during pre-effluent and 2012 through 2017 monitoring years for the combined effluent distribution project (continued).

Variable	Wetland Type	Time Period	Valid N	Mean	Std. Dev.	Minimum	20th Percentile	Median	80th Percentile	Maximum
Total Nitrogen (TN), mg/L	Freshwater EDS	Pre-effluent	27	1.11	0.72	0.34	0.49	0.94	1.45	3.41
		2012	16	1.61	1.22	0.12	0.54	1.79	2.41	4.24
		2013	15	1.40	0.47	0.97	1.02	1.24	1.61	2.49
		2014	15	2.08	1.60	0.70	0.84	1.99	2.85	6.70
		2015	15	1.66	0.69	0.73	1.08	1.76	1.92	3.20
		2016	12	1.97	1.78	0.39	0.66	1.43	2.70	6.80
		2017	16	1.48	0.66	0.52	0.77	1.57	2.08	2.71
	Freshwater Reference	Pre-effluent	16	1.20	0.78	0.42	0.66	0.95	1.41	3.50
		2012	6	2.16	1.65	0.82	0.83	1.59	3.21	4.91
		2013	8	1.20	0.85	0.52	0.62	1.06	1.21	3.21
		2014	5	0.80	0.46	0.14	0.37	0.86	1.21	1.31
		2015	8	0.78	0.23	0.39	0.62	0.76	1.01	1.11
		2016	6	0.83	0.37	0.36	0.60	0.79	1.02	1.42
		2017	8	0.56	0.29	0.14	0.28	0.57	0.79	0.99
	Outfall	2012	4	3.87	1.89	1.25	1.25	4.30	5.63	5.63
		2013	4	4.14	0.09	4.10	4.10	4.10	4.27	4.27
		2014	4	3.76	2.22	2.10	2.10	3.06	6.80	6.80
		2015	2	4.40	0.57	4.00	--	--	--	4.80
		2016	3	3.44	1.06	2.53	--	--	--	4.60
		2017	4	4.03	0.55	3.40	3.40	4.00	4.72	4.72
Nitrite + Nitrate as N (NOx), mg/L	Freshwater EDS	Pre-effluent	28	0.036	0.046	0.005	0.010	0.011	0.050	0.180
		2012	16	0.079	0.126	0.006	0.006	0.011	0.110	0.460
		2013	15	0.210	0.262	0.009	0.016	0.120	0.290	0.910
		2014	16	0.880	1.022	0.009	0.038	0.655	1.30	3.50
		2015	16	0.460	0.453	0.036	0.100	0.375	0.660	1.80
		2016	16	0.458	0.558	0.018	0.036	0.260	0.900	1.90
		2017	16	0.365	0.248	0.036	0.210	0.305	0.530	0.810
	Freshwater Reference	Pre-effluent	16	0.046	0.045	0.005	0.011	0.027	0.100	0.130
		2012	7	0.006	0.001	0.006	0.006	0.006	0.006	0.009
		2013	8	0.009	0.000	0.009	0.009	0.009	0.009	0.009
		2014	6	0.009	0.000	0.009	0.009	0.009	0.009	0.009
		2015	8	0.009	0.000	0.009	0.009	0.009	0.009	0.009
		2016	8	0.011	0.003	0.009	0.009	0.009	0.016	0.016
		2017	8	0.009	0.000	0.009	0.009	0.009	0.009	0.009
	Outfall	2012	4	0.444	0.351	0.006	0.006	0.485	0.800	0.800
		2013	4	1.218	0.236	0.870	0.870	1.30	1.40	1.40
		2014	4	1.880	1.851	0.700	0.700	1.11	4.60	4.60
		2015	3	1.400	0.400	1.000	--	--	--	1.80
		2016	4	0.681	0.458	0.043	0.043	0.790	1.10	1.10
		2017	4	0.705	0.302	0.370	0.370	0.675	1.10	1.10

Table 6-5. Annual surface water quality results collected during pre-effluent and 2012 through 2017 monitoring years for the combined effluent distribution project, Pensacola, Florida (continued).

Variable	Wetland Type	Time Period	Valid N	Mean	Std. Dev.	Minimum	20th Percentile	Median	80th Percentile	Maximum
Total Kjeldahl Nitrogen (TKN), mg/L	Freshwater EDS	Pre-effluent	28	1.1	0.71	0.25	0.47	0.89	1.4	3.4
		2012	16	1.5	1.2	0.12	0.53	1.6	2.4	4.2
		2013	15	1.2	0.28	0.83	0.97	1.1	1.5	1.8
		2014	16	1.2	0.61	0.63	0.83	0.97	1.3	3.2
		2015	16	1.2	0.38	0.69	0.88	1.1	1.4	2.3
		2016	16	1.4	1.4	0.36	0.66	1.2	1.6	6.5
		2017	16	1.1	0.46	0.46	0.73	1.1	1.4	2.0
	Freshwater Reference	Pre-effluent	16	1.5	1.2	0.41	0.59	0.88	1.4	3.4
		2012	5	1.6	1.1	0.81	0.82	0.97	2.7	3.2
		2013	8	1.2	0.85	0.51	0.61	1.1	1.2	3.2
		2014	5	0.79	0.46	0.13	0.36	0.85	1.2	1.3
		2015	8	0.77	0.23	0.38	0.61	0.75	1.0	1.1
		2016	8	0.74	0.34	0.34	0.52	0.61	1.0	1.4
		2017	8	0.53	0.31	0.13	0.13	0.56	0.78	0.98
	Outfall	2012	4	3.4	2.10	0.61	0.61	3.9	5.3	5.3
		2013	4	2.9	0.32	2.7	2.7	2.8	3.4	3.4
		2014	4	1.9	0.56	1.4	1.4	1.8	2.5	2.5
		2015	4	2.5	1.0	1.5	1.5	2.3	3.8	3.8
		2016	4	2.8	1.1	1.6	1.6	2.9	3.7	3.7
		2017	4	3.3	0.72	2.3	2.3	3.5	4.0	4.0
TN:TP Ratio	Freshwater EDS	Pre-effluent	27	18.5	12.8	4.5	9.7	14.4	28.4	55.2
		2012	15	7.4	3.2	1.2	6.0	6.9	9.7	13.8
		2013	15	4.6	0.8	3.2	4.1	4.6	5.3	6.2
		2014	16	9.7	2.8	5.8	7.4	9.3	11.0	15.5
		2015	15	7.7	4.0	4.8	5.1	6.1	11.0	17.8
		2016	12	7.5	6.3	1.4	3.6	5.7	9.7	21.4
		2017	16	5.2	1.6	2.2	4.3	4.9	5.8	9.5
	Freshwater Reference	Pre-effluent	16	17.3	8.3	8.4	10.7	14.2	23.9	38.8
		2012	6	167	164	12.7	34.4	123	279	427
		2013	8	22.0	18.9	0.0	0.1	17.0	41.3	51.9
		2014	5	13.7	2.9	9.3	11.2	13.4	16.3	17.1
		2015	8	28.4	12.2	10.7	21.9	26.1	41.2	49.9
		2016	6	10.7	7.2	0.2	7.2	10.9	13.1	21.9
		2017	8	31.2	20.1	8.7	8.7	27.1	49.3	61.8
	Outfall	2012	4	6.7	1.9	4.0	4.0	7.3	8.3	8.3
		2013	4	7.7	0.1	7.6	7.6	7.7	7.7	7.7
		2014	4	11.0	1.8	9.1	9.1	11.2	12.6	12.6
		2015	3	5.8	4.9	0.1	--	--	--	9.1
		2016	3	7.0	1.3	5.5	--	--	--	7.8
		2017	4	11.4	9.7	4.6	4.6	7.6	25.8	25.8

Table 6-5. Annual surface water quality results collected during pre-effluent and 2012 through 2017 monitoring years for the combined effluent distribution project, Pensacola, Florida (continued).

Variable	Wetland Type	Time Period	Valid N	Mean	Std. Dev.	Minimum	20th Percentile	Median	80th Percentile	Maximum
Ammonia (NH_3), mg/L	Freshwater EDS	Pre-effluent	28	0.084	0.16	0.006	0.012	0.028	0.080	0.77
		2012	16	0.12	0.18	0.008	0.008	0.008	0.19	0.58
		2013	15	0.076	0.067	0.006	0.008	0.064	0.15	0.18
		2014	16	0.12	0.40	0.008	0.008	0.008	0.008	1.60
		2015	16	0.019	0.022	0.010	0.010	0.010	0.011	0.082
		2016	16	0.034	0.049	0.011	0.011	0.011	0.042	0.16
		2017	16	0.14	0.20	0.011	0.011	0.061	0.19	0.77
	Freshwater Reference	Pre-effluent	16	0.16	0.29	0.006	0.014	0.034	0.10	0.91
		2012	7	0.008	0.000	0.008	0.008	0.008	0.008	0.008
		2013	8	0.040	0.059	0.008	0.008	0.008	0.13	0.14
		2014	7	0.017	0.023	0.008	0.008	0.008	0.008	0.07
		2015	8	0.010	0.000	0.010	0.010	0.010	0.011	0.011
		2016	8	0.029	0.036	0.011	0.011	0.011	0.055	0.11
		2017	8	0.060	0.090	0.011	0.011	0.011	0.19	0.22
	Outfall	2012	4	0.74	0.43	0.17	0.17	0.79	1.20	1.20
		2013	4	0.36	0.21	0.16	0.16	0.32	0.64	0.64
		2014	4	0.11	0.10	0.035	0.035	0.075	0.25	0.25
		2015	4	0.28	0.28	0.022	0.022	0.26	0.60	0.60
		2016	4	0.50	0.47	0.24	0.24	0.28	1.2	1.2
		2017	4	1.0	0.54	0.35	0.35	1.1	1.6	1.6
Sulfate (SO_4), mg/L	Freshwater EDS	Pre-effluent	29	2.3	2.2	0.2	0.3	1.1	5.0	6.2
		2012	16	384	182	20	160	455	550	570
		2013	15	410	122	50	355	470	500	520
		2014	15	507	94	390	415	530	570	690
		2015	16	378	97	220	270	415	470	480
		2016	16	316	58	240	280	300	400	420
		2017	16	237	121	26	120	210	390	410
	Freshwater Reference	Pre-effluent	17	7.9	9.8	0.2	0.3	2.5	12.0	32.0
		2012	7	2.3	3.8	0.7	0.7	0.7	1.7	11.0
		2013	8	0.5	1.2	0.1	0.1	0.1	0.1	3.6
		2014	6	2.1	3.2	0.1	0.1	0.1	5.6	6.7
		2015	8	1.9	2.4	0.7	0.7	0.7	3.2	7.4
		2016	8	1.7	1.8	0.7	0.7	0.7	2.3	6.0
		2017	8	1.6	1.9	0.7	0.7	0.7	1.7	6.3
	Outfall	2012	4	528	56	490	490	505	610	610
		2013	4	490	42	430	430	505	520	520
		2014	4	505	34	470	470	500	550	550
		2015	4	425	75	340	340	420	520	520
		2016	4	340	53	290	290	330	410	410
		2017	4	333	109	190	190	350	440	440

Table 6-5. Annual surface water quality results collected during pre-effluent and 2012 through 2017 monitoring years for the combined effluent distribution project, Pensacola, Florida (continued).

Variable	Wetland Type	Time Period	Valid N	Mean	Std. Dev.	Minimum	20th Percentile	Median	80th Percentile	Maximum
5-Day Biochemical Oxygen Demand (BOD), mg/L	Freshwater EDS	Pre-effluent	28	2.2	1.7	1.0	1.0	2.0	2.4	7.7
		2012	16	4.7	4.4	1.0	1.0	2.9	6.5	18
		2013	15	4.3	3.4	1.0	1.5	3.7	6.7	12
		2014	16	3.3	3.8	1.0	1.0	1.0	3.2	12
		2015	16	1.5	1.0	1.0	1.0	1.0	2.2	4.3
		2016	16	2.3	1.5	1.0	1.0	2.3	3.3	5.6
		2017	16	2.5	2.2	1.0	1.0	2.2	3.2	9.4
	Freshwater Reference	Pre-effluent	17	3.0	2.6	1.0	1.0	2.0	4.2	10
		2012	7	4.4	4.2	1.0	1.0	2.3	6.8	12
		2013	8	6.5	7.3	1.0	1.0	4.2	13	22
		2014	6	2.8	3.0	1.0	1.0	1.7	2.9	8.7
		2015	8	1.0	0.0	1.0	1.0	1.0	1.0	1.0
		2016	8	1.0	0.0	1.0	1.0	1.0	1.0	1.0
		2017	8	1.0	0.0	1.0	1.0	1.0	1.0	1.0
	Outfall	2012	4	12	2.3	8.7	8.7	13	14	14
		2013	3	9.2	2.3	6.7	6.7	10	11	11
		2014	4	5.8	3.5	2.0	2.0	5.7	9.8	9.8
		2015	4	5.4	2.5	3.3	3.3	4.7	8.7	8.7
		2016	4	9.5	3.1	6.4	6.4	9.2	13	13
		2017	4	9.0	6.7	5.5	5.5	5.8	19	19
Color, color units	Freshwater EDS	Pre-effluent	31	231	201	24	82	150	370	930
		2012	16	588	408	56	220	545	980	1,300
		2013	15	275	117	140	195	250	360	540
		2014	16	218	48	140	190	210	250	300
		2015	16	244	47	180	210	230	290	350
		2016	16	180	28	130	150	185	200	220
		2017	16	208	34	150	170	210	240	260
	Freshwater Reference	Pre-effluent	18	251	168	48	120	205	390	680
		2012	7	225	111	94	160	190	380	380
		2013	8	147	77	44	76	140	230	250
		2014	6	91	53	30	73	81	89	190
		2015	8	128	73	65	68	115	160	290
		2016	8	180	191	72	73	110	210	640
		2017	8	123	96	37	56	85	230	310
	Outfall	2012	4	268	61	200	200	265	340	340
		2013	4	167	79	79	79	165	260	260
		2014	4	203	24	170	170	210	220	220
		2015	4	188	70	110	110	180	280	280
		2016	4	163	39	120	120	165	200	200
		2017	4	438	511	120	120	215	1,200	1,200

Table 6-5. Annual surface water quality results collected during pre-effluent and 2012 through 2017 monitoring years for the combined effluent distribution project (continued).

Variable	Wetland Type	Time Period	Valid N	Mean	Std. Dev.	Minimum	20th Percentile	Median	80th Percentile	Maximum
Turbidity, NTU	Freshwater EDS	Pre-effluent	0	--	--	--	--	--	--	--
		2012	5	11	4.4	4.4	7.7	11	15	16
		2013	11	4.4	2.0	2.0	2.7	4.1	5.8	7.6
		2014	3	3.9	1.1	2.6	--	--	--	4.7
		2015	7	2.5	0.6	1.4	2.3	2.4	2.8	3.4
		2016	4	4.0	0.9	3.1	3.1	3.9	5.2	5.2
		2017	12	13	8.5	2.2	3.3	13	24	24
	Freshwater Reference	Pre-effluent	0	--	--	--	--	--	--	--
		2012	2	2.5	1.5	1.4	--	--	--	3.5
		2013	2	3.0	1.0	2.3	--	--	--	3.7
		2014	1	0.8	--	--	--	--	--	--
		2015	5	2.9	1.6	1.5	1.8	2.3	4.3	5.7
		2016	2	1.4	0.9	0.8	--	--	--	2.0
		2017	6	5.0	2.3	2.6	3.5	4.6	4.9	9.9
	Outfall	2012	2	27	1.4	26.0	--	--	--	28
		2013	3	14	5.6	9.8	--	--	--	20
		2014	3	13	6.8	5.1	--	--	--	18
		2015	2	8.6	3.5	6.1	--	--	--	11
		2016	1	7.7	--	--	--	--	--	--
		2017	3	17	8.2	10.1	--	--	--	29
Total Suspended Solids (TSS), mg/L	Freshwater EDS	Pre-effluent	28	20	23	1.4	3.0	11.0	33	82
		2012	15	15	26	1.0	2.5	5.0	22	100
		2013	15	4.3	2.5	2.5	2.5	2.5	7.5	9.0
		2014	16	16	31	2.5	5.0	9.5	12	130
		2015	16	9.3	13	2.5	2.5	5.5	11	56
		2016	16	11	12	2.5	5.0	6.0	14	41
		2017	16	12	16	2.5	2.5	5.0	17	63
	Freshwater Reference	Pre-effluent	15	9.7	15	2.5	2.5	4.0	13	59
		2012	5	30	40	2.5	2.5	13.0	66	98
		2013	7	24	20	2.5	6.0	17.0	43	51
		2014	5	5.5	4.2	2.5	2.5	2.5	10	11
		2015	8	13	10	2.5	2.5	11.5	26	28
		2016	8	12	17	2.5	2.5	6.0	15	52
		2017	8	5.2	4.7	2.5	2.5	2.5	7.0	16
	Outfall	2012	4	27	4.8	20	20	29	30	30
		2013	4	18	6.9	13	13	15	28	28
		2014	4	16	4.8	11	11	15	21	21
		2015	4	19	6.2	11	11	20	26	26
		2016	4	26	17	9.0	9.0	23	46	46
		2017	4	18	6.1	12	12	17	26	26

Table 6-5. Annual surface water quality results collected during pre-effluent and 2012 through 2017 monitoring years for the combined effluent distribution project (continued).

Variable	Wetland Type	Time Period	Valid N	Mean	Std. Dev.	Minimum	20th Percentile	Median	80th Percentile	Maximum
Total Organic Carbon (TOC), mg/L	Freshwater EDS	Pre-effluent	0	--	--	--	--	--	--	--
		2012	0	--	--	--	--	--	--	--
		2013	4	20	0.5	20	20	20	21	21
		2014	16	19	2.9	14	16	20	21	22
		2015	16	23	3.2	18	20	24	26	27
		2016	15	20	3.0	17	17	19	24	26
		2017	16	18	5.4	12	14	17	24	30
	Freshwater Reference	Pre-effluent	0	--	--	--	--	--	--	--
		2012	0	--	--	--	--	--	--	--
		2013	2	20	6.4	15	--	--	--	24
		2014	6	18	8.9	8.0	12	18	19	34
		2015	8	25	7.9	16	16	23	31	39
		2016	7	26	17	16	17	18	27	63
		2017	8	17	7.3	11	12	14	25	31
	Outfall	2012	0	--	--	--	--	--	--	--
		2013	1	26	--	--	--	--	--	--
		2014	4	18	8.7	5.0	5.0	21	24	24
		2015	4	26	5.4	20	20	27	31	31
		2016	3	24	4.0	20	--	--	--	28
		2017	4	25	8.1	17	17	24	36	36

Table 6-6. Zonal Analysis of nutrient concentrations in the EDS during pre-effluent, 2013-2016 combined, and 2017 monitoring years.

Variable	Zone	Time Period	Valid N	Mean	Std. Dev.	Minimum	20th Percentile	Median	80th Percentile	Maximum
Total Phosphorus (TP), mg/L	Freshwater Reference	Pre-effluent	17	0.082	0.056	0.025	0.050	0.064	0.088	0.28
	1		10	0.061	0.018	0.025	0.047	0.066	0.075	0.085
	2		19	0.10	0.14	0.025	0.050	0.069	0.11	0.68
	3 – GS05		26	0.14	0.083	0.050	0.068	0.14	0.19	0.42
	3 - TWT		13	0.081	0.024	0.050	0.055	0.087	0.10	0.12
	Freshwater Reference	2013-2016	29	0.065	0.072	0.015	0.016	0.046	0.075	0.34
	Outfall		15	0.46	0.15	0.17	0.32	0.53	0.58	0.66
	1		30	0.36	0.28	0.091	0.19	0.30	0.47	1.6
	2		32	0.24	0.077	0.088	0.16	0.24	0.31	0.37
	3 – GS05		16	0.20	0.055	0.11	0.14	0.22	0.25	0.27
	3 - TWT		32	0.066	0.034	0.015	0.036	0.066	0.092	0.16
	Freshwater Reference	2017	8	0.016	0.000	0.016	0.016	0.016	0.016	0.016
	Outfall		4	0.51	0.25	0.16	0.16	0.57	0.74	0.74
	1		8	0.38	0.10	0.24	0.31	0.36	0.52	0.54
	2		8	0.23	0.11	0.110	0.12	0.21	0.38	0.38
	3 – GS05		3	0.24	0.074	0.18	--	--	--	0.32
	3 - TWT		6	0.043	0.029	0.016	0.016	0.039	0.070	0.075
Total Nitrogen (TN) mg/L	Freshwater Reference	Pre-effluent	16	1.2	0.78	0.42	0.66	0.95	1.4	3.5
	1		10	1.0	0.44	0.34	0.64	0.97	1.4	1.6
	2		17	1.2	0.84	0.36	0.43	0.94	1.6	3.4
	3 – GS05		24	1.5	0.63	0.30	1.0	1.3	2.0	3.2
	3 - TWT		12	0.68	0.23	0.12	0.60	0.73	0.78	1.0
	Freshwater Reference	2013-2016	27	0.92	0.55	0.14	0.60	0.86	1.1	3.2
	Outfall		14	3.9	1.2	2.1	2.5	4.1	4.6	6.8
	1		29	2.1	1.5	0.39	1.0	1.7	2.9	6.8
	2		30	1.4	0.65	0.58	0.83	1.2	1.9	3.2
	3 – GS05		15	1.1	0.38	0.60	0.71	1.14	1.3	1.9
	3 - TWT		30	0.75	0.32	0.17	0.49	0.72	1.1	1.4
	Freshwater Reference	2017	8	0.56	0.29	0.14	0.28	0.57	0.79	0.99
	Outfall		4	4.0	0.55	3.4	3.4	4.0	4.7	4.7
	1		8	1.8	0.68	0.76	0.99	1.9	2.5	2.7
	2		8	1.1	0.44	0.52	0.70	1.1	1.6	1.6
	3 – GS05		3	1.0	0.33	0.71	0.71	1.1	1.4	1.4
	3 - TWT		6	0.51	0.07	0.41	0.46	0.51	0.57	0.61

Table 6-6. Zonal Analysis of nutrient concentrations in the EDS during pre-effluent, 2013-2016 combined, and 2017 monitoring years (continued).

Variable	Zone	Time Period	Valid N	Mean	Std. Dev.	Minimum	20th Percentile	Median	80th Percentile	Maximum
5-Day Biochemical Oxygen Demand (BOD), mg/L	Freshwater Reference	Pre-effluent	17	3.0	2.6	1.0	1.0	2.0	4.2	10
	1		10	2.4	2.1	1.0	1.0	2.0	3.2	7.7
	2		18	2.1	1.4	1.0	1.0	2.0	2.1	6.2
	3 – GS05		3	2.4	1.6	1.0	1.0	2.0	4.2	4.2
	3 - TWT		13	2.0	1.1	1.0	1.0	2.0	2.1	5.1
	Freshwater Reference	2013-2016	30	2.8	4.5	1.0	1.0	1.0	3.4	22
	Outfall		15	7.3	3.3	2.0	3.8	7.3	11	13
	1		31	3.5	3.3	1.0	1.0	2.6	4.9	12
	2		32	2.2	2.1	1.0	1.0	1.0	2.8	10
	3 – GS05		16	1.4	1.0	1.0	1.0	1.0	1.0	4.4
	3 - TWT		32	1.4	0.9	1.0	1.0	1.0	1.0	5.4
	Freshwater Reference	2017	8	1.0	0.0	1.0	1.0	1.0	1.0	1.0
	Outfall		4	9.0	6.7	5.5	5.5	5.8	19	19
	1		8	3.5	2.8	1.0	1.0	2.8	5.0	9.4
	2		8	1.5	0.7	1.0	1.0	1.0	2.4	2.4
	3 – GS05		3	1.4	0.7	1.0	1.0	1.0	2.2	2.2
	3 - TWT		6	1.4	0.6	1.0	1.0	1.0	2.2	2.3

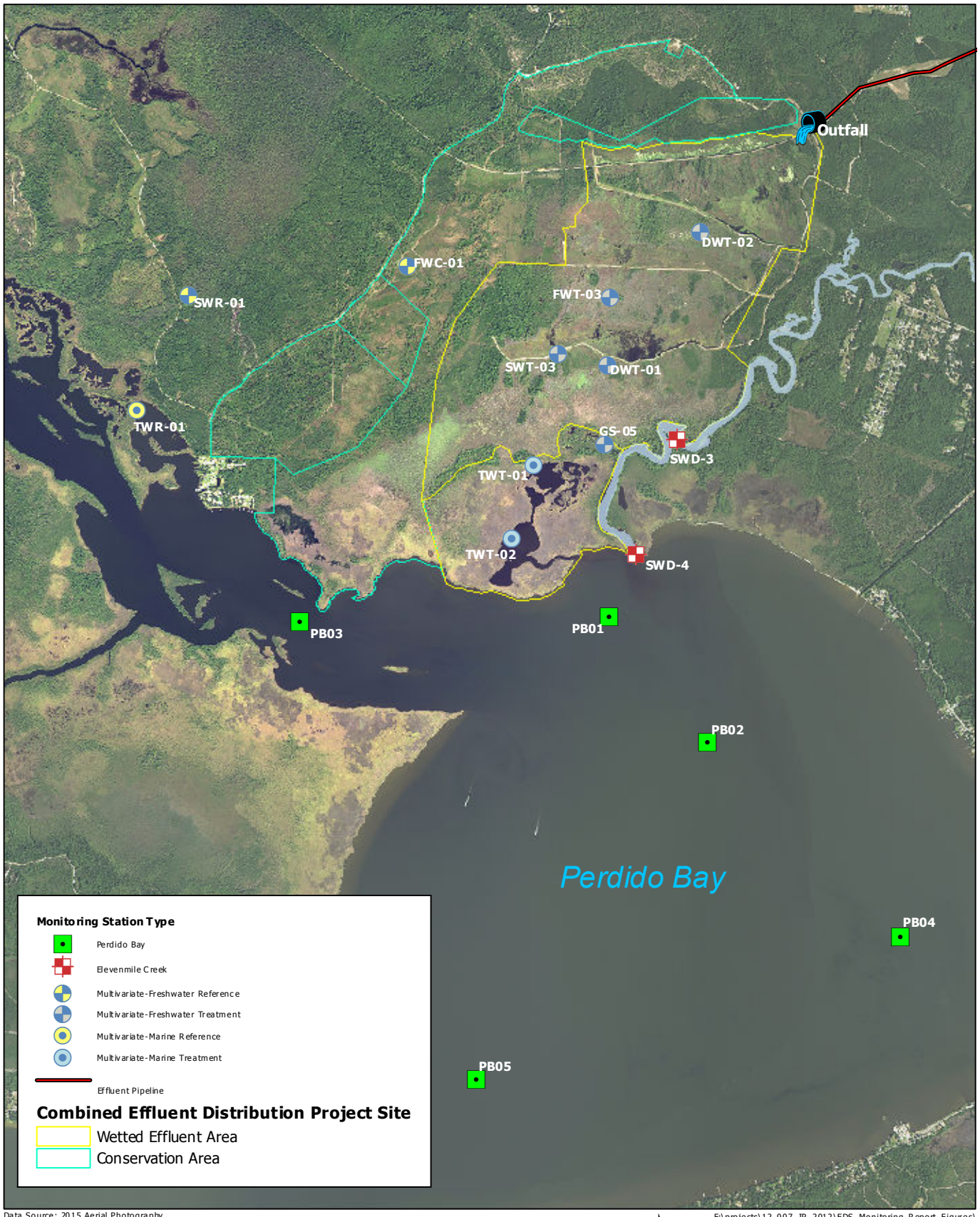


Figure 6-1. Location of analytical water quality grab stations.

Nutter & Associates
environmental consultants

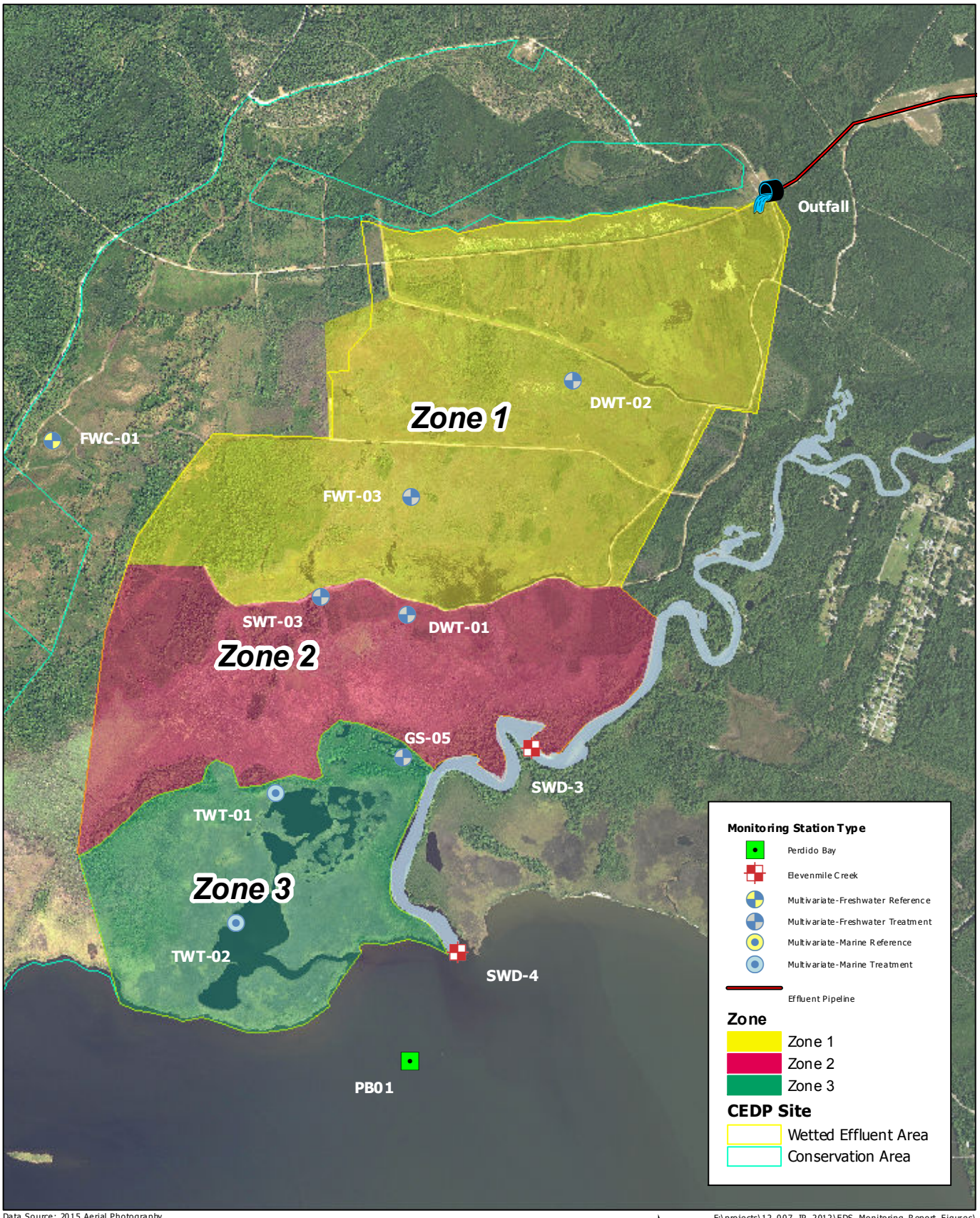


Figure 6-2. Delineation of EDS zones used for analysis of water quality variables.

Nutter & Associates
environmental consultants

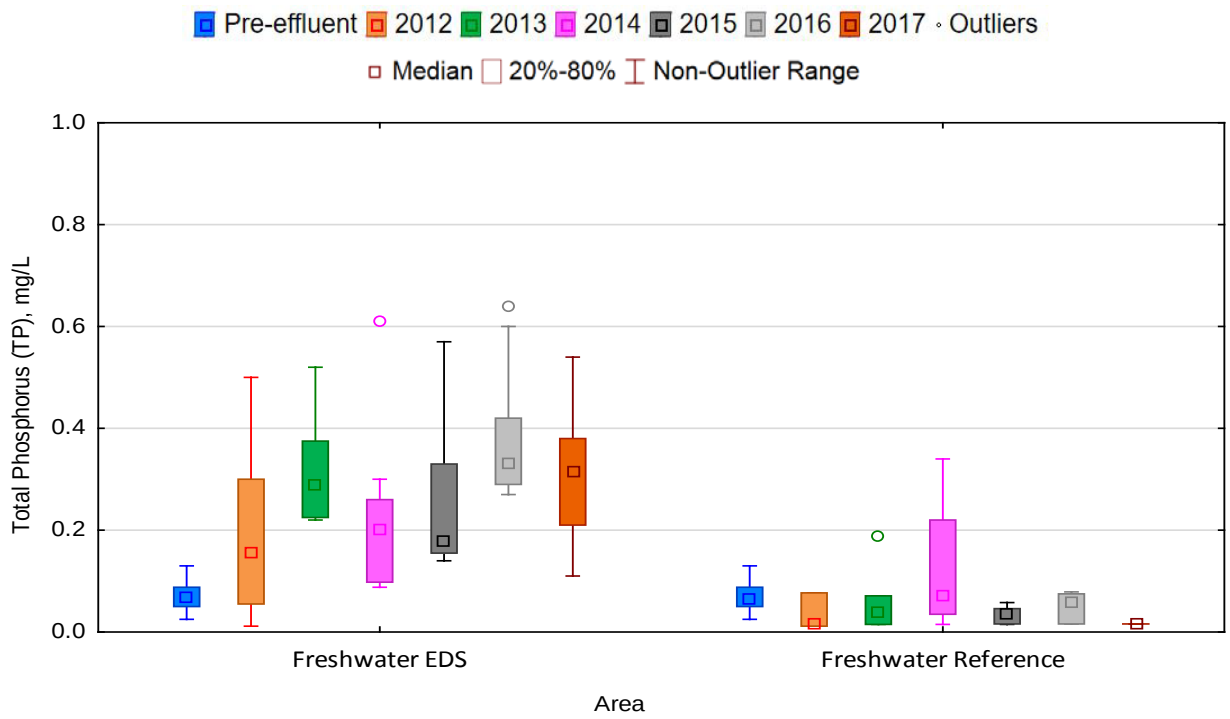


Figure 6-3. Annual summary total phosphorus concentrations for freshwater portions of the EDS and freshwater reference wetlands from pre-effluent and post-effluent 2012 through 2017 monitoring years.

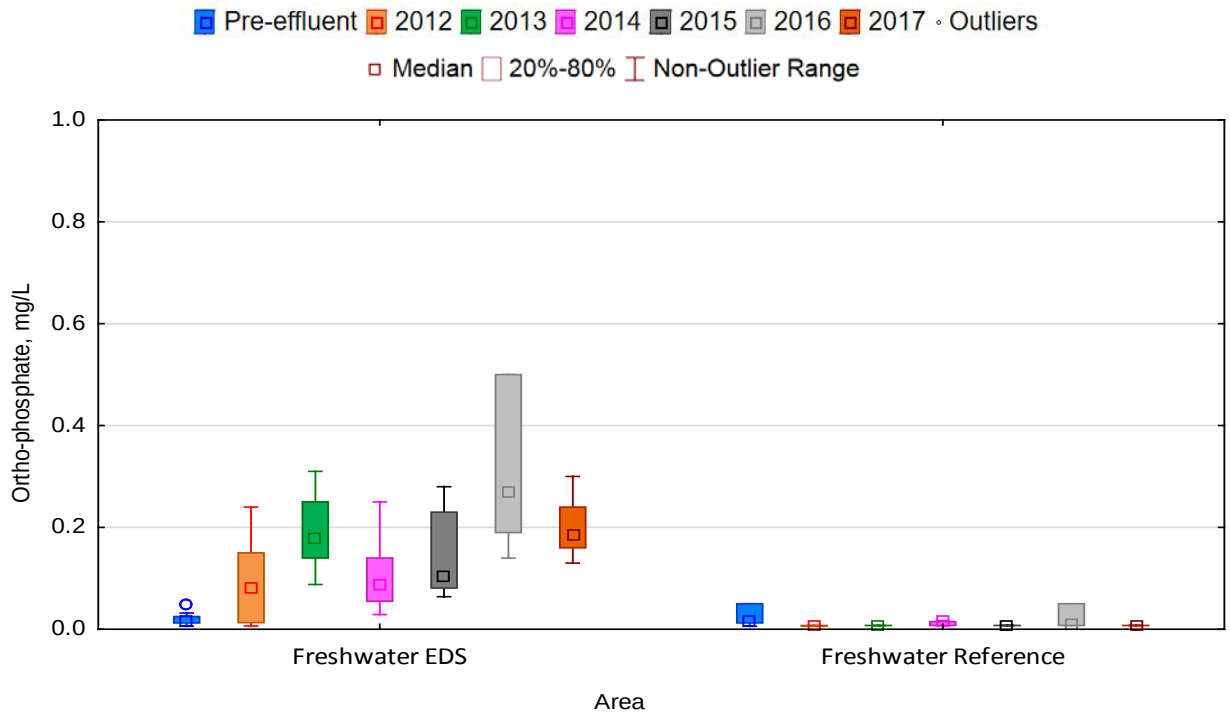


Figure 6-4. Annual summary orthophosphate concentrations for freshwater portions of the EDS and freshwater reference wetlands from pre-effluent and post-effluent 2012 through 2017 monitoring years.

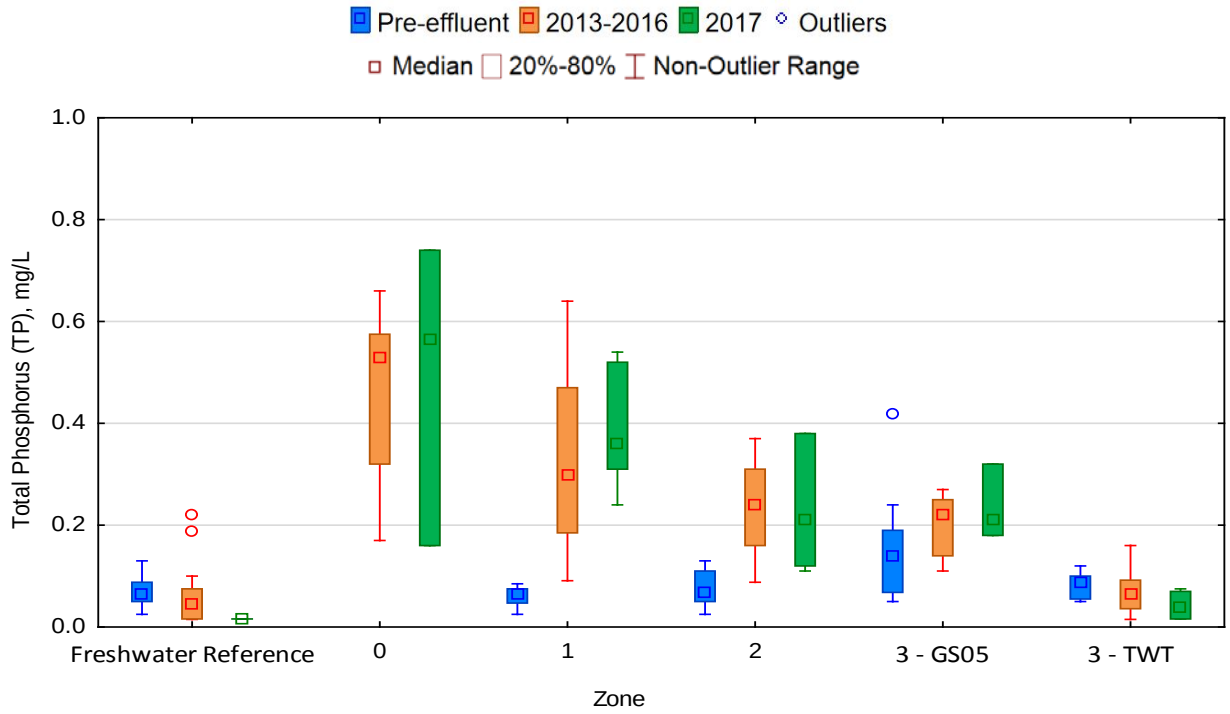


Figure 6-5. Total phosphorus concentrations moving from the outfall through Zones 1 and 2 of freshwater portions of the EDS and into the Zone 3 tidal creek (GS05) and tidal lake (TWT) portions of the EDS.

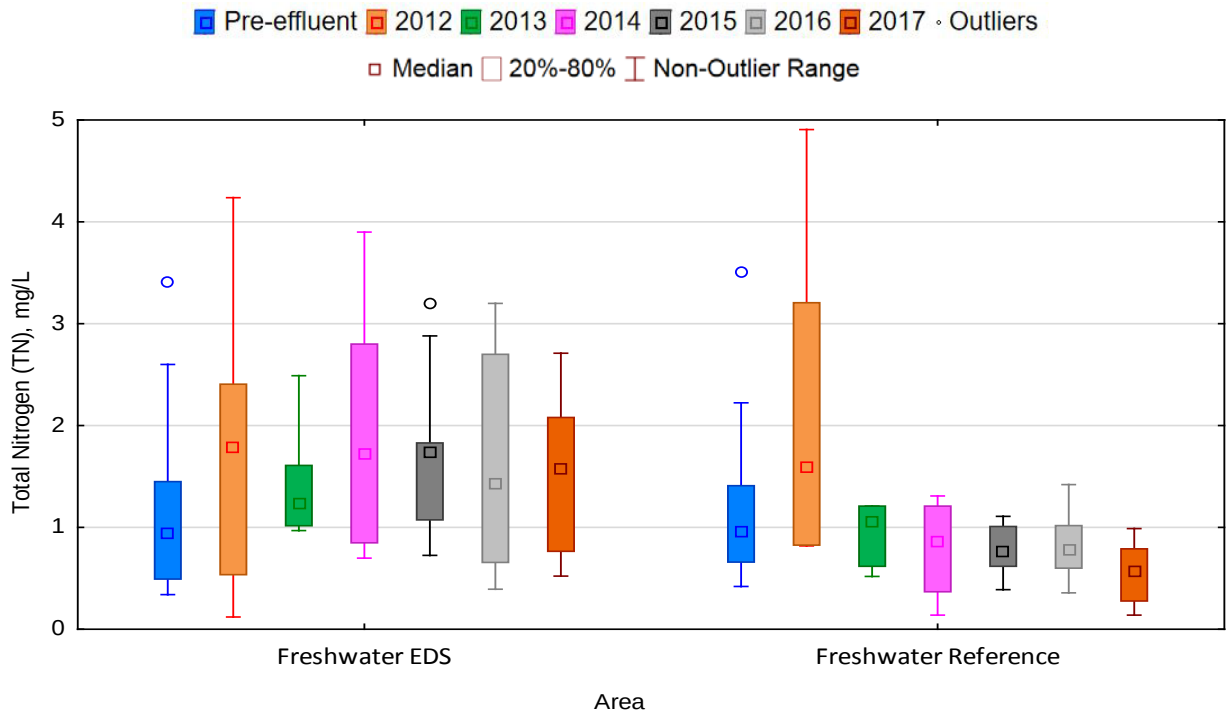


Figure 6-6. Annual summary total nitrogen concentrations for freshwater portions of the EDS and freshwater reference wetlands from pre-effluent and post-effluent 2012 through 2017 monitoring years.

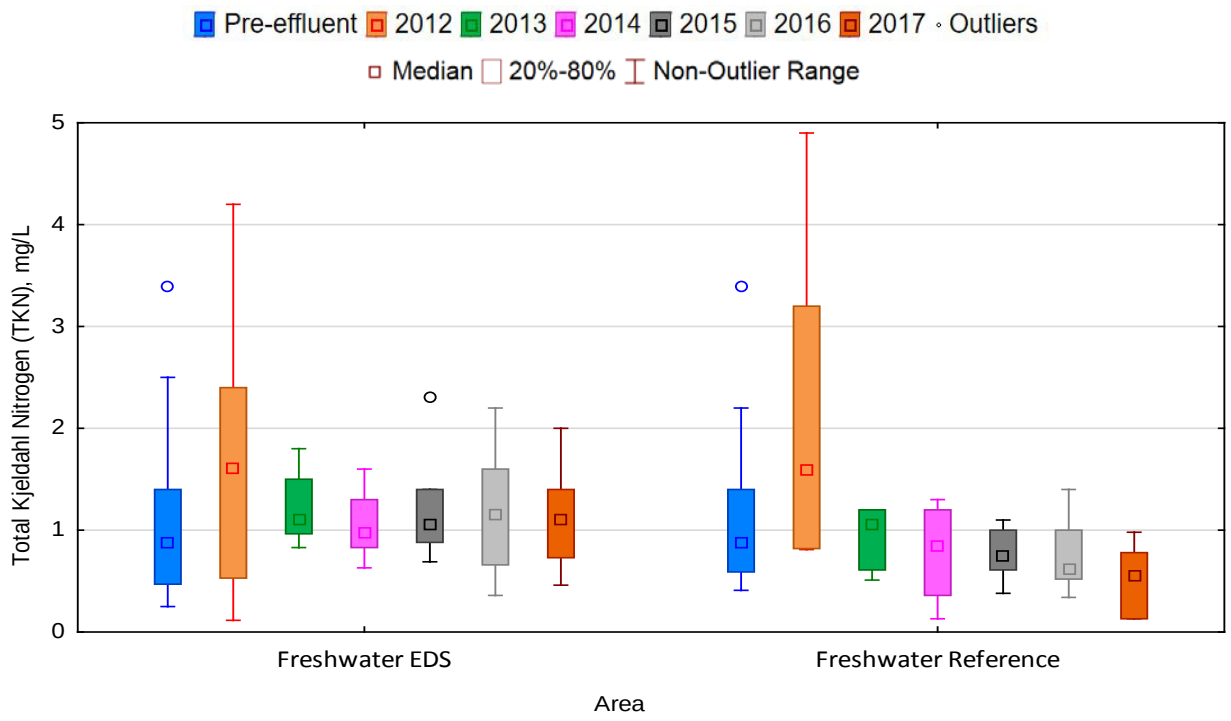


Figure 6-7. Annual summary total kjeldahl nitrogen (TKN) concentrations for freshwater portions of the EDS and freshwater reference wetlands from pre-effluent and post-effluent 2012 through 2017 monitoring years.

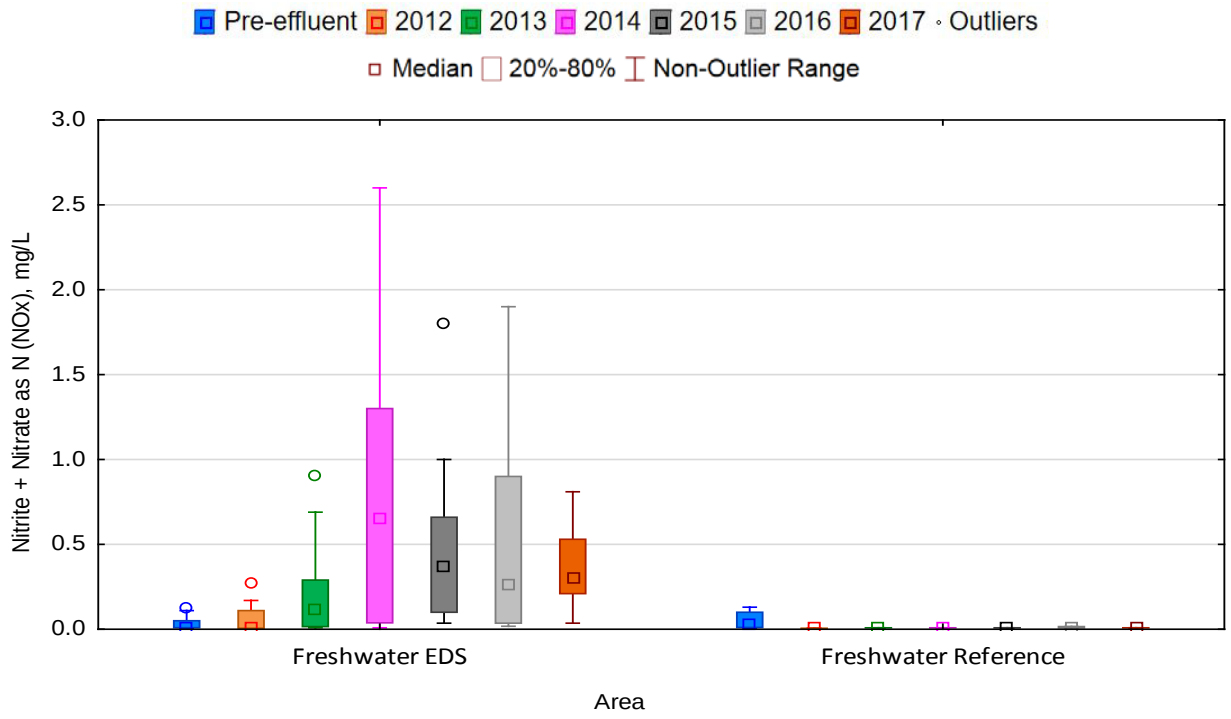


Figure 6-8. Annual summary nitrite+nitrate concentrations for freshwater portions of the EDS and freshwater reference wetlands from pre-effluent and post-effluent 2012 through 2017 monitoring years.

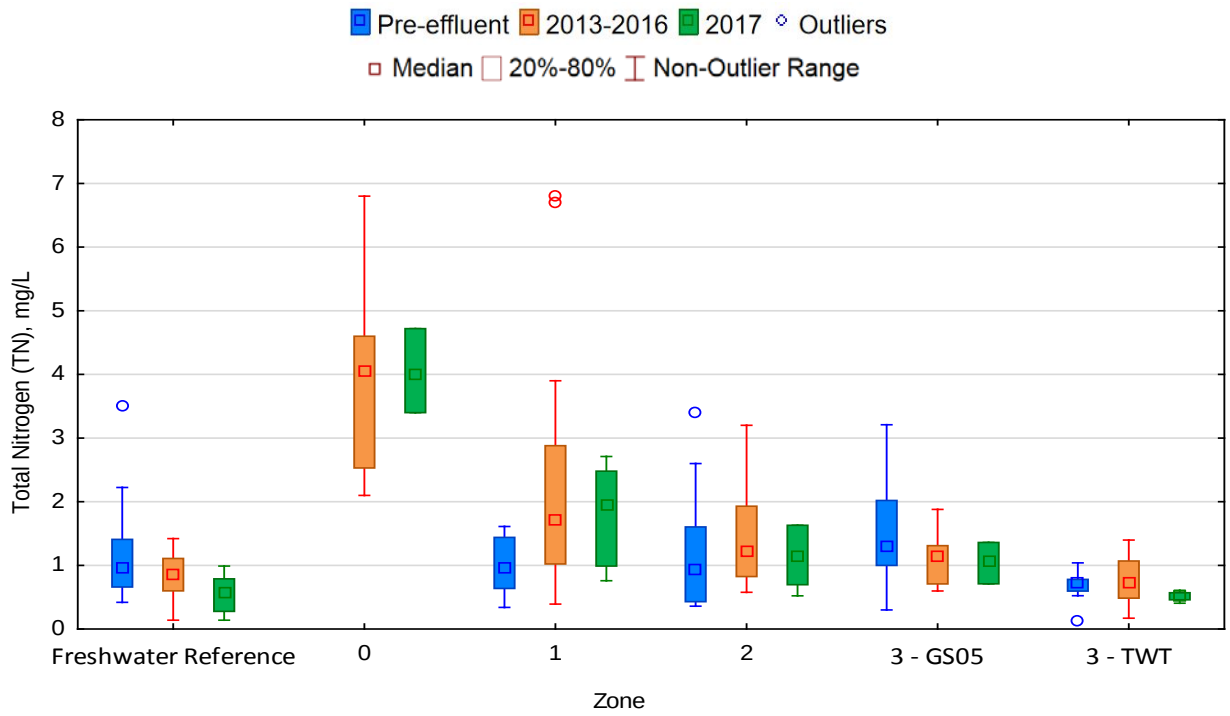


Figure 6-9. Total nitrogen concentrations moving from the outfall through Zones 1 and 2 of freshwater portions of the EDS and into the Zone 3 tidal creek (GS05) and tidal lake (TWT) portions of the EDS.

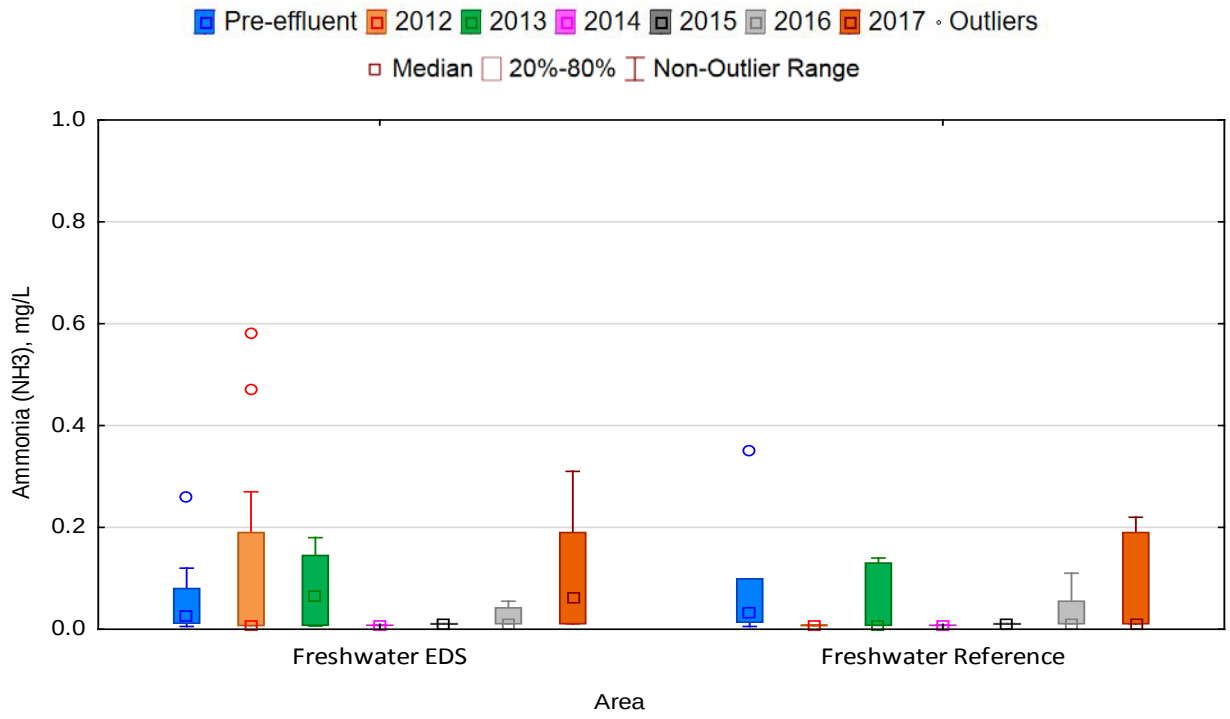


Figure 6-10. Annual summary ammonia concentrations for freshwater portions of the EDS and freshwater reference wetlands from pre-effluent and post-effluent 2012 through 2017 monitoring years.

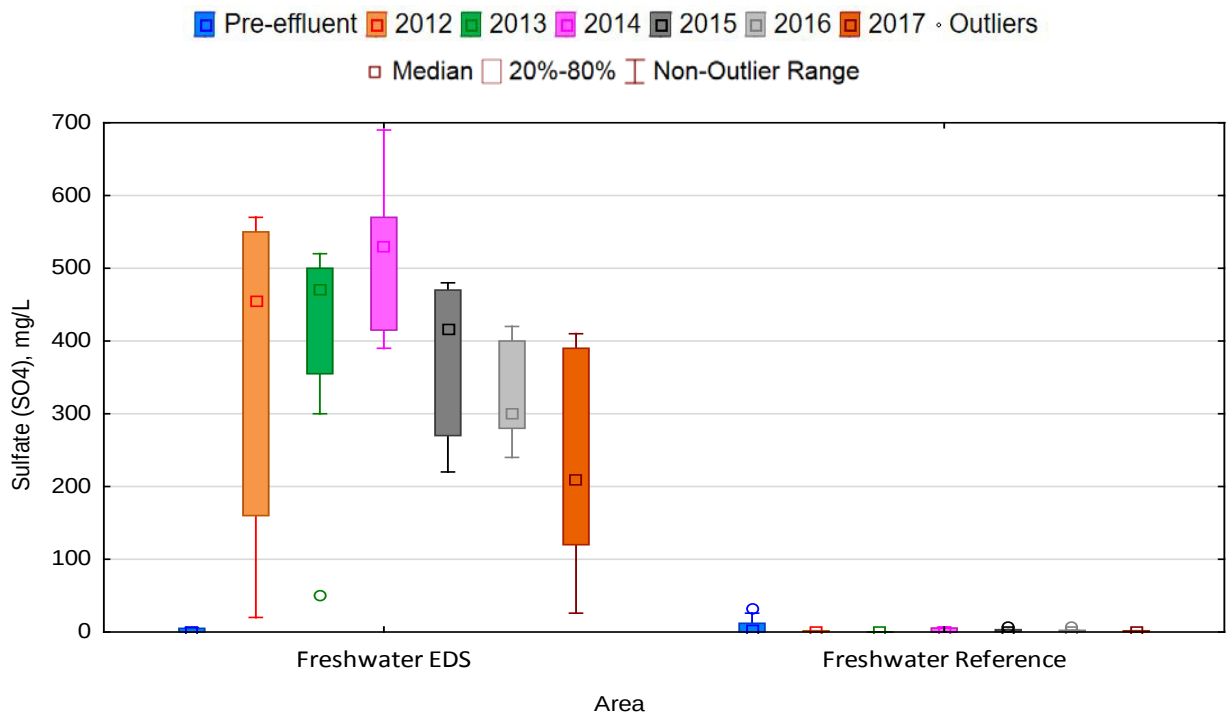


Figure 6-11. Annual summary sulfate concentrations for freshwater portions of the EDS and freshwater reference wetlands from pre-effluent and post-effluent 2012 through 2017 monitoring years.

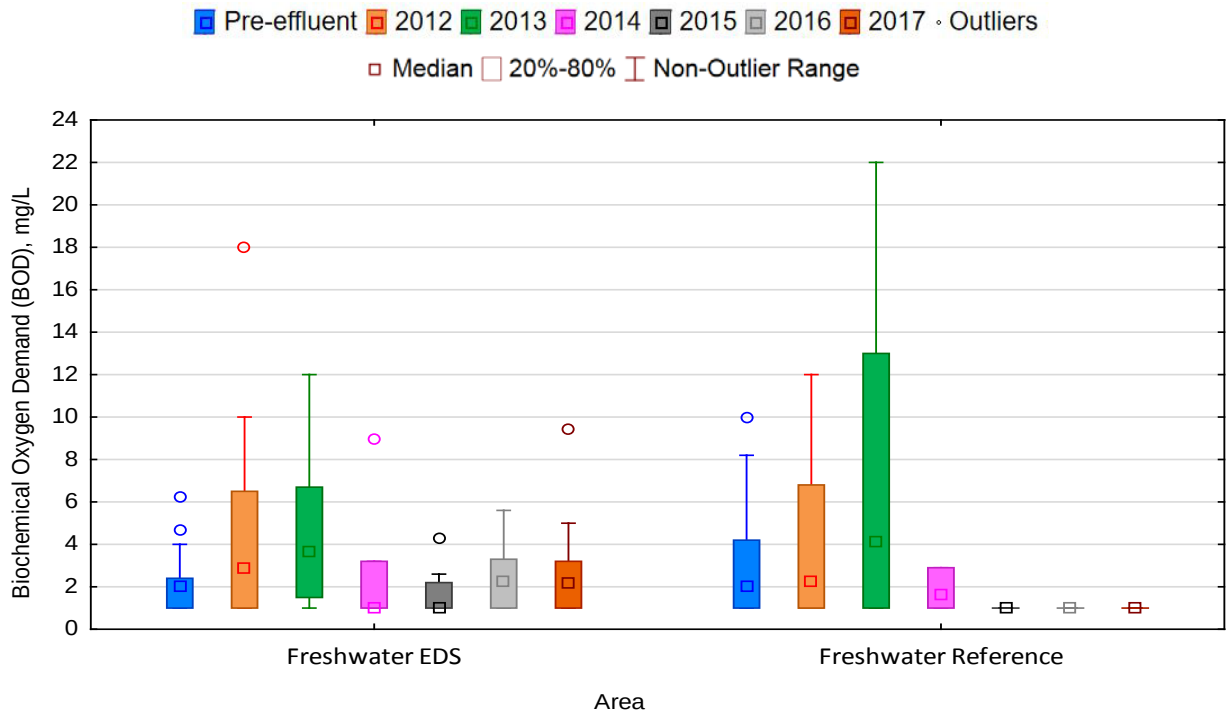


Figure 6-12. Annual summary 5-day biochemical oxygen demand concentrations for freshwater portions of the EDS and freshwater reference wetlands from pre-effluent and post-effluent 2012 through 2017 monitoring years.

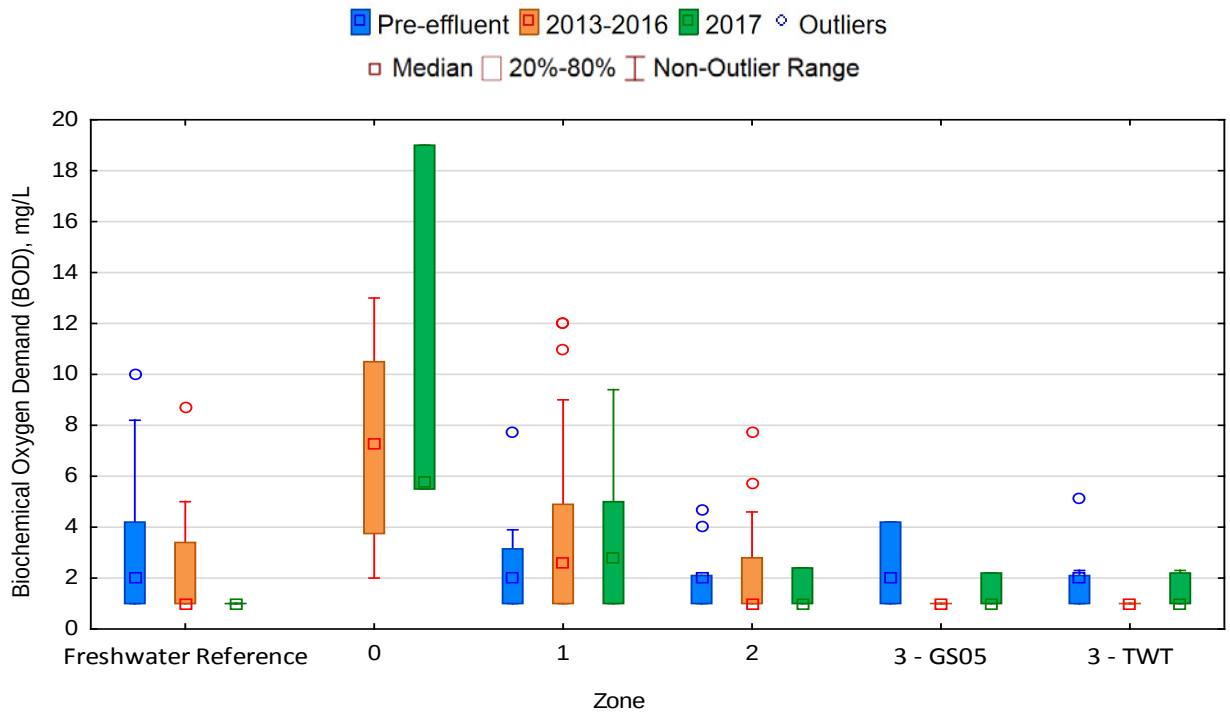


Figure 6-13. 5-day biochemical oxygen demand concentrations moving from the outfall through Zones 1 and 2 of freshwater portions of the EDS and into the Zone 3 tidal creek (GS05) and tidal lake (TWT) portions of the EDS.

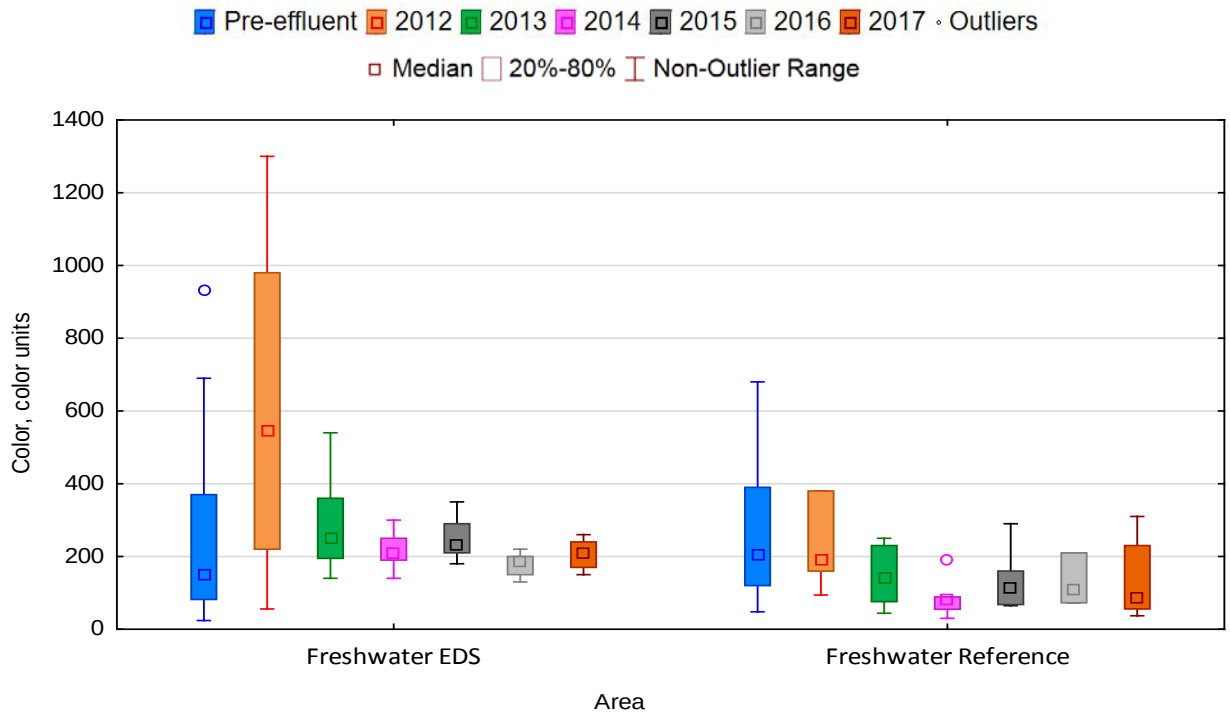


Figure 6-14. Annual summary color values for freshwater portions of the EDS and freshwater reference wetlands from pre-effluent and post-effluent 2012 through 2017 monitoring years.

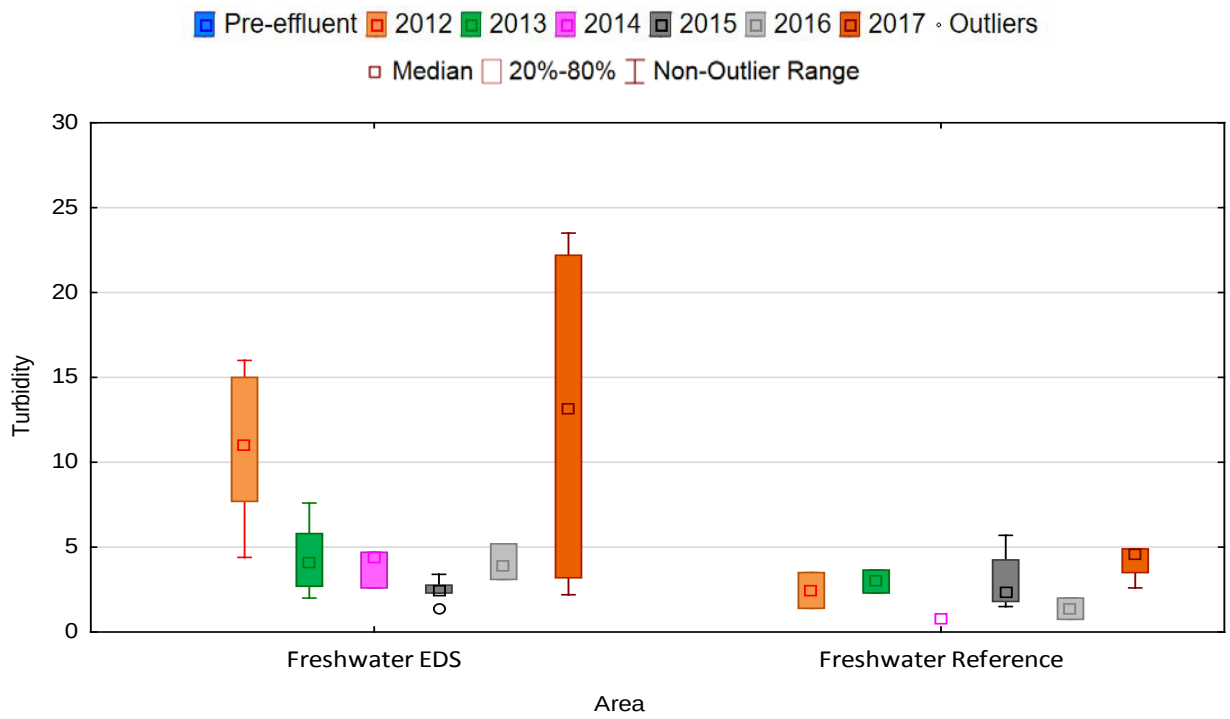


Figure 6-15. Annual summary turbidity values for freshwater portions of the EDS and freshwater reference wetlands from pre-effluent and post-effluent 2012 through 2017 monitoring years.

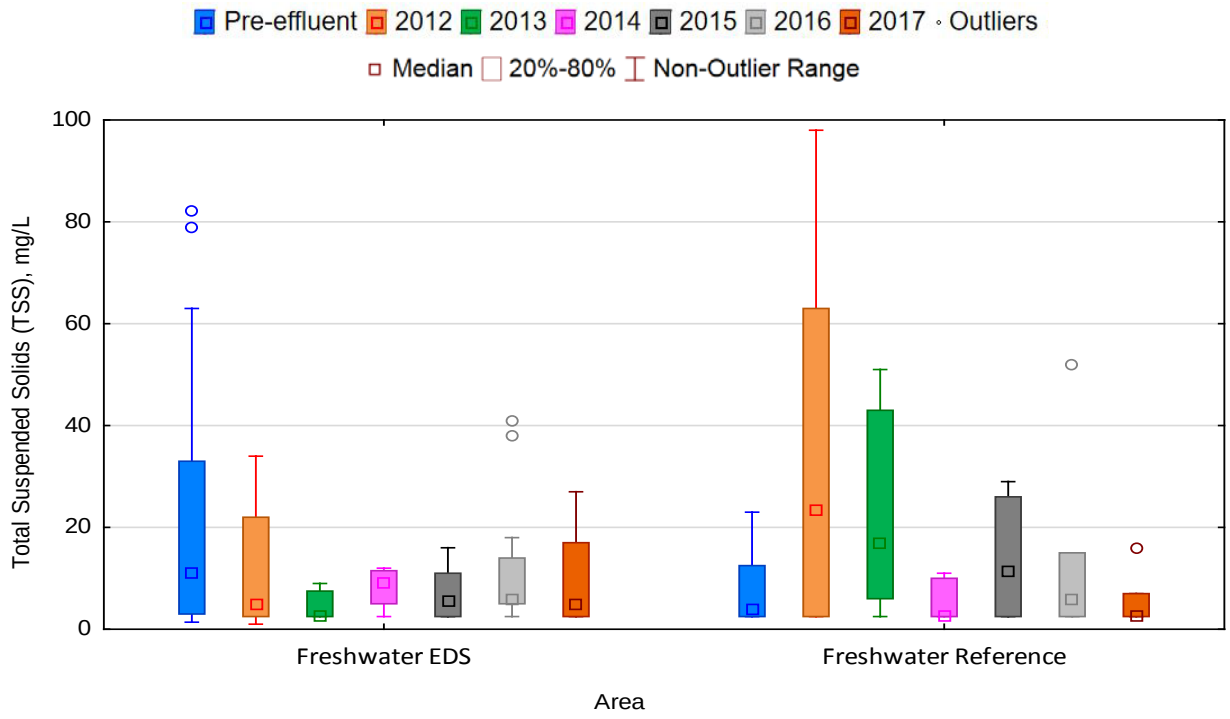


Figure 6-16. Annual summary total suspended solids concentrations for freshwater portions of the EDS and freshwater reference wetlands from pre-effluent and post-effluent 2012 through 2017 monitoring years.

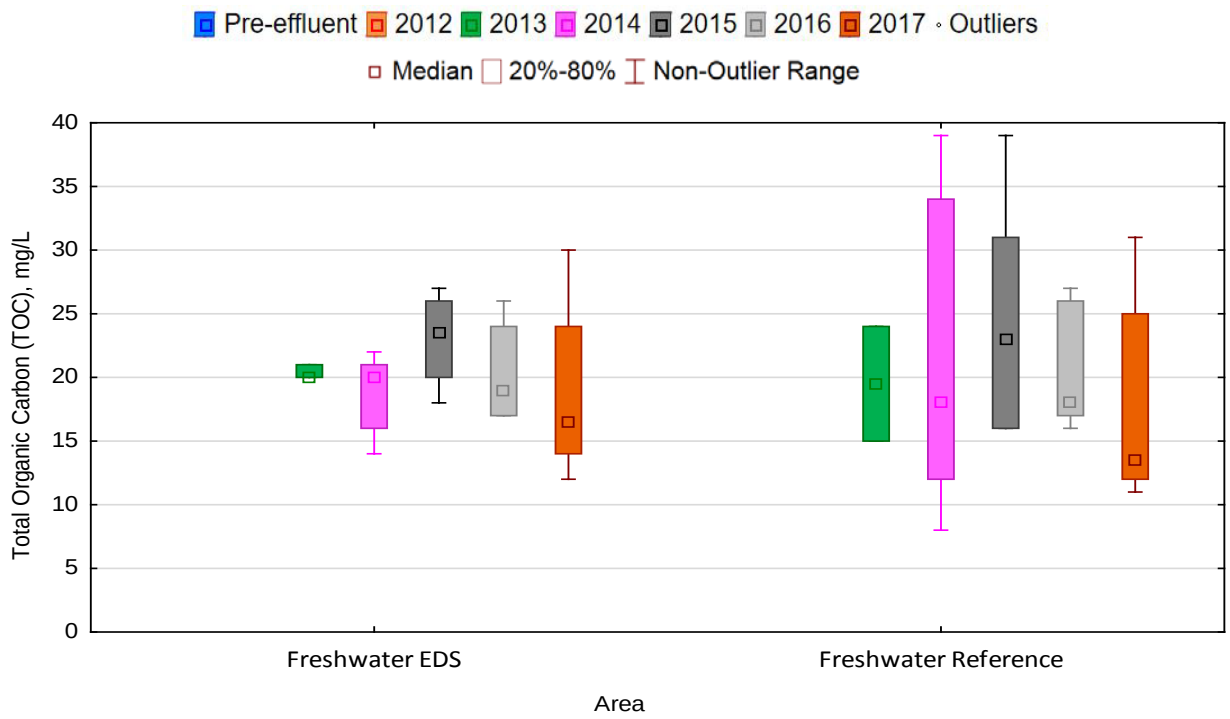


Figure 6-17. Annual summary total organic carbon concentrations for freshwater portions of the EDS and freshwater reference wetlands from pre-effluent, and post-effluent 2012 through 2017 monitoring years.

7.0 SOILS

Soils within the Effluent Distribution System (EDS) site are typical of those in Coastal lowlands formed from marine sediments. Soils mapped on the EDS site include the Dorovan, Pelham, Albany, Yemassee, and Hurricane series (Williams, 2004). In 2008, a hand auger boring was advanced at each soil sample station to verify published soil mapping. These borings confirmed that the Dorovan soils are not as prevalent as indicated on the published soil maps for the site. Portions of the site consist of mineral soil rather than the deep muck material characteristic of Dorovan soils. The borings also confirmed that geographically associated soils such as the Pickney series are more prevalent in the northern zones. The Dorovan and other more organic soils are predominately in the southern zones. It is important to note that as a part of EDS construction activities, silvicultural timber harvest and hummock construction were implemented within the inundation areas. These activities resulted in changes in soil properties and characteristics within the designed inundation areas.

Soil samples were collected prior to construction of the EDS (2008), during the ramp-up period (2012), and during the first five years of operation at the design flow (2013 through 2017). Samples were analyzed for chemical properties to monitor soil quality with regards to nutrient balance and availability. This chapter describes the methods and results of the chemical analyses.

7.1 Sampling Methodology and Analyses

Originally, 28 soil monitoring stations were proportionally allocated to extant vegetative community classifications within the EDS (Figure 7-1). At each of these monitoring stations, a paired soil-monitoring plot was established along a randomly selected bearing approximately 50 feet from the northwestern corner of the vegetation monitoring plot. At each paired soil-monitoring plot, composite samples from 0 to 6 inch and 6 to 12 inch depth increments were collected for the 2008, 2012, 2013 and 2014 sampling events. For the 2015 and 2016 sampling events, composite samples were collected from 0 to 12 inches. Fifteen representative stations were selected and sampled in 2017 as noted on Figure 7-1. Each composite sample consisted of ten individual samples randomly located within 15 feet of the plot center. Samples, collected using an Oakfield tube, were thoroughly mixed in the field, bagged, and placed in an ice-filled cooler. Upon completion of sampling, samples were transported to the selected analytical laboratory for analysis.

Composite samples were analyzed for the following: soil pH, cation exchange capacity (CEC), base saturation (BS), plant available nutrients including phosphorus (P), potassium (K), calcium (CA), magnesium (Mg), sulfur (S), manganese (Mn), iron (Fe), copper (Cu), zinc (Zn), and boron (B), exchangeable aluminum (Al) and sodium (Na), total nitrogen (N), organic matter (OM) content, carbon to nitrogen (C:N) ratio, and soluble salts (SS). The sodium adsorption ratio (SAR) was calculated based on laboratory analyses of Na, Mg and Ca. The P fixation or sorption capacity for the soil was calculated using a Langmuir isotherm (Olsen and Watanabe, 1957) based on laboratory phosphorus adsorption analyses.

Nine soil sampling events have been completed as described above, including:

- Autumn of 2008 - pre-effluent sampling prior to EDS construction;
- Spring of 2012 - ramp-up period sampling during initial EDS operation (less than the design flow);
- Autumn of 2012 - ramp-up period sampling during initial EDS operation (less than the design flow);
- Spring of 2013 - year one sampling during the first year of operation at the design flow;
- Autumn of 2013 - year one sampling during the first year of operation at the design flow;
- Autumn of 2014 - year two sampling during the second year of operation at the design flow;
- Autumn of 2015 - year three sampling during the third year of operation at the design flow;
- Autumn of 2016 - year four sampling during the fourth year of operation at the design flow; and
- Autumn of 2017 - year five sampling during the fifth year of operation at the design flow (subset of fifteen stations).

Samples collected in 2008 were analyzed by A&L laboratories, and did not include P adsorption analyses. Samples collected in 2012 through 2017 were analyzed by Agro Services International.

For the purposes of discussion, references to a particular time period (pre-effluent, ramp-up period, or operation year) of the site's development and operation allude to analyses from the corresponding sampling event(s) as indicated above. Note the analyses and results discussed below include only the Autumn sampling events.

7.2 Results and Discussion

Summary statistics for each soil parameter are provided in Tables 7-1 through 7-21 for the annual autumn sampling events by zone. Figures 7-2 through 7-5 present the range of select key parameters (pH, CEC, BS, and C:N) by zone and autumn sampling event through the use of box and whisker plots. The results of pH, CEC, BS, TN, OM content, C:N ratio, SS, SAR and P sorption capacity are discussed below; however, the results of available and/or exchangeable plant macro- or micro-nutrients are not discussed individually, but are addressed via the discussion of the listed parameters. Note that plant nutrient content is reported in lbs/acre, based on the standard depth (eight inches) of an acre-furrow slice.

Soils in portions of the site were significantly modified during construction of the EDS. Although pre-and post-construction conditions are presented and compared, differences noted are not conclusively attributed to either the applied effluent or modifications to the site. Analyses from post-construction sampling events presented in this report serve to document change(s) in soil chemistry, if any, that occur on the EDS site over time.

7.2.1 Soil pH and Nutrient Availability

Changes in soil pH can impact solubility and availability of nutrients in the soil. At a more acidic pH, soil minerals dissolve, which increases the availability of metals (particularly Al) to levels that could potentially inhibit plant growth. At a more alkaline pH many soil minerals become insoluble and thus unavailable to plants. A soil pH between 5.8 and 6.5 (standard units) is the optimal range to maximize availability of plant nutrients. The soils on the EDS site are naturally acidic and thus typically have a low availability of plant nutrients. Under pre-effluent conditions, median soil pH across all zones ranged from 4.4 to 4.8 (Table 7-1). In year five of operation at the design flow, the median soil pH ranged from 6.4 to 6.8 across all zones. It is notable that there was a general decrease in soil pH moving south under pre-effluent conditions through the separate zones (Figures 7-1 and 7-2), but this has not held true for post-construction and operations conditions.

There has been an overall increase in soil pH, which has contributed to an increase in availability of the majority of the analyzed plant available and/or exchangeable macro- and micro-nutrient content during the ramp-up period and first five years of operation (Tables 7-2 through 7-13). In 2017, all plant nutrients were generally within the ranges observed during the ramp-up period and past operation years with the exception of Mn, Ca and Na. It is likely that the available Mn increase observed is due to saturated conditions, which cause the reduction of Mn oxides to a soluble form (Table 7-9). The increase in available Ca (Table 7-4) corresponds to the decrease in available Na (Table 7-9) as it likely has replaced Na on soil exchange sites.

7.2.2 Cation Exchange Capacity and Base Saturation

Cation exchange capacity (CEC) is an indicator of the soil's ability to retain cations on soil surfaces. Cations include essential plant nutrients which are retained as part of CEC in the upper soil profile in a plant available form. Soils within the EDS site naturally have a low CEC (generally < 5 meq/100 cc, pre-effluent) (Table 7-14 and Figure 7-3). In some cases CEC may be slightly higher due to the presence of negatively charged organic particles. The CEC on the site has remained low during the ramp-up period and during the first five years of operation. Note that CEC is reported in meq/100 g for the pre-effluent sampling event. Bulk density data were not collected as part of this sampling event so the data could not be converted accurately to meq/100 cc. The CEC values as reported for the pre-effluent sample event may be up to 15 and 25 percent lower if converted.

Base saturation (BS) is the percentage of CEC that is occupied by basic cations such as calcium, magnesium, potassium and sodium. The BS and soil pH are interrelated, and in general BS increases with increasing soil pH. A higher BS indicates that a greater portion of basic cations are available to plants. As shown in Figure 7-4, BS has increased significantly from pre-effluent conditions to the ramp-up period and during the first five years of operation (Table 7-15 and Figure 7-4). The increase in BS corresponds to the reduction in exchangeable aluminum held by the soil (Table -13).

7.2.3 Total Nitrogen, Organic Matter and Carbon: Nitrogen Ratio

Total N includes both plant available and organic N. Organic N can be mineralized to a plant available form as microbes break down organic matter. Whether plant available N is produced through mineralization or N in the soil is immobilized through microbial uptake is

dependent on the C:N ratio. A lower C:N ratio facilitates N mineralization while a higher C:N ratio leads to microbial uptake (N immobilization). It is not uncommon to have shifts in the C:N ratio as microbial communities adjust to deriving their nitrogen from organic matter and/or the soil; thus the ratio varies naturally over time.

Total N has varied on the EDS site throughout the ramp-up period and first five years of operation (Table 7-16). Total N in year five was within the range observed during the ramp-up period and past operation years. Variability is expected as nitrogen content can be affected by a number of processes such as uptake, volatilization, denitrification, and leaching. The OM content has overall been consistent throughout pre-effluent, ramp-up and first five years of operation (Table 7-17). More variability was observed during the ramp-up period and first year of operation. This was expected as particulate OM was passed through the system during full operation.

The C:N ratio appears to be largely dictated by the total N content given the relative stability of the OM content (Table 7-18; Figure 7-5). A higher total N results in a lower C:N ratio and lower total N results in a higher C:N ratio. In general the C:N ratio has been at, or greater than 30:1 throughout the ramp-up period and first five years of operation, so it is assumed that much of the soil N has been immobilized through uptake.

7.2.4 Soluble Salts

Soluble salts concentration provides an estimate of dissolved salts in the soil solution. Insoluble salts are bound to the soil, and may accumulate depending on CEC. Plant growth is typically affected when soluble salt concentrations are greater than 1,250 ppm. The median soluble salts concentration has ranged from 51 to 65 ppm during the ramp-up period and 87 to 137 ppm during year five, below the concentration that might negatively impact plant growth (Table 7-19).

7.2.5 Sodium Adsorption Ratio

The SAR expresses the balance between Na and other cations (Mg and Ca) and the buildup of sodium within the soil. Sodium impacts soil physical properties as it builds up within the soil. A critical SAR value of 12 is selected to represent the SAR at varied conditions across the site at which soil physical changes may occur (Overcash and Pal, 1979). Note that more sandy soils (e.g., Pickney series) may have a higher critical value. The SAR is less than 12 for all sampling events (Table 7-20) and decreased in year five due to lower sodium concentrations in soil (Table 7-7).

7.2.6 Phosphorus Sorption Capacity

The phosphorus (P) adsorption maxima were determined using the Langmuir isotherm (Olsen and Watanabe, 1957). Using bulk density and depth, the P adsorption maxima was used to calculate a P sorption capacity for the given depth of soil (twelve inches per sample). The sorption capacity may serve as an estimate of the mass of P that can be retained by the soil. If the sorption capacity of the upper foot of soil is reached, it is assumed that P would be soluble and mobile. Under this scenario, P would likely move downward and be retained by the soil deeper in the profile. The median P sorption capacity on the EDS site ranged from 220 to 401 lbs/acre/ft of soil across all zones and depths in

year five, respectively (Table 7-21). This suggests that there is significant P sorption capacity remaining on the site.

7.3 Conclusions

Composite soil samples were collected at fifteen stations in 2017 to monitor soil quality in terms of nutrient balance and availability. Samples were analyzed for soil chemical properties and summarized using basic statistics (median, percentiles, and range). Results were grouped by vegetation zone and sampling event for comparison for the autumn sampling events. Overall, as is typical for soil samples, there was great variability among individual sample stations. Differences in soil chemical properties beyond normal variation were attributed primarily to changes between sampling events (pre-and-post EDS construction conditions, ramp-up and full operations, etc.). There appear to be minimal differences related to zonal designation. Notable differences include an overall increase in soil pH, BS, and nutrient availability, and a decrease in available sodium in year five. The potential impacts of these differences are discussed above.

7.4 Literature Cited

Olsen, S.R, and F.S. Watanabe. 1957. A method to determine a phosphorus adsorption maximum of soils as measured by the Langmuir isotherm. Soil Science Society of America Proceedings 31:144-149.

Overcash, M.R. and P. Dhiraj. 1979. Design of Land Treatment Systems for Industrial Wastes – Theory and Practice. Ann Arbor Science Publishers, Inc. Ann Arbor, Mi. 684 pp.

Williams, C.A. 2004. Soil Survey of Escambia County, Florida. U.S. Department of Agriculture and Natural Resource Conservation Service, in cooperation with the University of Florida and the Florida Department of Agricultural and Consumer Sciences.

Table 7-1. Summary of soil pH by zone and sampling event.

Year	Zone 1			Zone 2			Zone 3		
	Median	20th Percentile	80th Percentile	Median	20th Percentile	80th Percentile	Median	20th Percentile	80th Percentile
	Standard Units								
2008	4.8	4.6	5.0	4.7	4.3	4.7	4.4	4.2	4.6
2012	5.5	4.8	5.7	5.5	4.8	5.6	5.7	4.4	5.9
2013	5.9	5.1	6.4	6.5	6.2	7.1	6.0	5.3	6.7
2014	5.9	5.3	6.1	6.3	5.7	7.1	5.9	4.9	6.6
2015	6.3	6.0	6.6	6.5	6.0	6.7	6.8	5.8	7.0
2016	6.5	5.3	6.7	6.6	6.4	7.2	6.8	5.4	7.0
2017	6.4	5.8	6.7	6.6	6.3	7.7	6.8	6.6	7.2

Table 7-2. Summary of soil phosphorus by zone and sampling event.

Year	Zone 1			Zone 2			Zone 3		
	Median	20th Percentile	80th Percentile	Median	20th Percentile	80th Percentile	Median	20th Percentile	80th Percentile
	lbs/acre								
2008	19	13	30	18	16	20	18	12	21
2012	24	8	43	59	16	102	55	30	77
2013	20	12	32	65	53	94	55	24	77
2014	30	20	51	71	49	102	57	26	86
2015	8	8	18	20	8	49	16	8	22
2016	36	24	40	69	53	81	73	32	88
2017	12	4	45	102	69	209	57	26	59

Table 7-3. Summary of soil potassium by zone and sampling event.

Year	Zone 1			Zone 2			Zone 3		
	Median	20th Percentile	80th Percentile	Median	20th Percentile	80th Percentile	Median	20th Percentile	80th Percentile
	lbs/acre								
2008	43	40	60	38	36	60	42	36	56
2012	84	50	173	156	25	252	63	46	126
2013	38	25	50	109	58	143	63	38	88
2014	21	8	46	84	50	277	42	16	84
2015	33	25	50	67	25	101	67	33	105
2016	67	50	101	218	117	261	109	76	134
2017	92	80	105	88	75	235	126	76	189

Table 7-4. Summary of soil calcium by zone and sampling event.

Year	Zone 1			Zone 2			Zone 3		
	Median	20th Percentile	80th Percentile	Median	20th Percentile	80th Percentile	Median	20th Percentile	80th Percentile
	lbs/acre								
2008	210	179	303	198	162	208	230	172	276
2012	108	72	270	108	108	180	162	108	342
2013	144	90	287	576	432	900	324	144	612
2014	216	126	306	360	216	2340	360	216	594
2015	251	216	378	450	288	1,115	467	414	755
2016	180	144	323	827	144	864	360	198	414
2017	216	180	432	1,026	720	2,880	467	162	738

Table 7-5. Summary of soil magnesium by zone and sampling event.

Year	Zone 1			Zone 2			Zone 3		
	Median	20th Percentile	80th Percentile	Median	20th Percentile	80th Percentile	Median	20th Percentile	80th Percentile
	lbs/acre								
2008	53	50	58	52	46	56	60	51	68
2012	27	16	36	20	17	28	37	30	77
2013	30	20	50	99	95	128	81	50	145
2014	32	22	40	51	30	315	46	27	60
2015	41	28	58	63	47	135	67	55	88
2016	28	21	41	141	28	154	56	40	63
2017	19	15	29	75	19	363	45	17	73

Table 7-6. Summary of soil sulfur by zone and sampling event.

Year	Zone 1			Zone 2			Zone 3		
	Median	20th Percentile	80th Percentile	Median	20th Percentile	80th Percentile	Median	20th Percentile	80th Percentile
	lbs/acre								
2008	32	28	42	30	24	40	25	18	27
2012	40	26	45	40	34	50	40	30	59
2013	56	33	134	155	115	268	114	52	237
2014	39	25	76	63	34	277	34	18	58
2015	34	27	44	52	36	76	59	29	69
2016	56	54	77	88	29	103	49	33	62
2017	94	75	94	139	95	182	121	100	162

Table 7-7. Summary of soil sodium by zone and sampling event.

Year	Zone 1			Zone 2			Zone 3		
	Median	20th Percentile	80th Percentile	Median	20th Percentile	80th Percentile	Median	20th Percentile	80th Percentile
	lbs/acre								
2008	59	50	104	96	44	158	111	49	162
2012	172	97	341	221	157	422	267	112	587
2013	317	169	457	710	534	865	507	296	770
2014	310	178	420	639	426	1,126	480	165	666
2015	347	304	434	440	347	678	600	288	683
2016	389	248	563	583	579	960	583	323	716
2017	140	114	176	118	99	207	120	87	176

Table 7-8. Summary of soil zinc by zone and sampling event.

Year	Zone 1			Zone 2			Zone 3		
	Median	20th Percentile	80th Percentile	Median	20th Percentile	80th Percentile	Median	20th Percentile	80th Percentile
	lbs/acre								
2008	0.4	0.4	1.3	0.4	0.4	0.6	0.7	0.4	1.5
2012	2.2	1.3	2.5	2.0	1.6	2.5	1.7	1.3	1.9
2013	1.4	0.5	2.0	2.8	1.3	4.1	1.8	1.3	3.7
2014	0.4	0.2	0.4	0.3	0.2	1.4	0.2	0.2	0.7
2015	0.7	0.5	1.4	0.5	0.4	0.9	0.4	0.4	1.0
2016	1.1	0.7	2.7	1.3	0.9	6.5	1.6	0.8	2.6
2017	0.4	0.2	0.5	2.3	0.5	4.1	1.1	0.6	3.4

Table 7-9. Summary of soil manganese by zone and sampling event.

Year	Zone 1			Zone 2			Zone 3		
	Median	20th Percentile	80th Percentile	Median	20th Percentile	80th Percentile	Median	20th Percentile	80th Percentile
	lbs/acre								
2008	2.0	2.0	5.0	2.0	2.0	6.0	3.0	2.0	5.0
2012	5.2	3.6	7.4	7.1	6.3	7.9	3.6	2.5	5.9
2013	5.1	1.9	9.6	17.7	10.3	54.5	7.8	2.2	15.9
2014	5.9	4.7	7.7	27.4	14.6	51.1	6.1	5.5	10.5
2015	6.5	2.5	18.8	33.9	13.9	91.8	11.0	2.1	38.6
2016	7.7	6.5	20.7	43.9	4.7	83.9	13.9	8.9	22.3
2017	18.4	7.0	33.0	69.1	37.3	99.7	35.3	16.8	38.3

Table 7-10. Summary of soil iron by zone and sampling event.

Year	Zone 1			Zone 2			Zone 3		
	Median	20th Percentile	80th Percentile	Median	20th Percentile	80th Percentile	Median	20th Percentile	80th Percentile
	lbs/acre								
2008	269	225	356	289	138	512	201	126	274
2012	393	313	510	355	163	538	251	192	344
2013	334	290	528	331	275	478	267	147	400
2014	341	251	449	98	88	233	186	120	350
2015	737	576	742	557	86	773	160	73	377
2016	237	208	239	228	194	273	187	178	215
2017	268	262	313	152	70	251	178	147	259

Table 7-11. Summary of soil copper by zone and sampling event.

Year	Zone 1			Zone 2			Zone 3		
	Median	20th Percentile	80th Percentile	Median	20th Percentile	80th Percentile	Median	20th Percentile	80th Percentile
	lbs/acre								
2008	1.6	1.4	1.7	1.4	1.2	1.6	1.4	1.2	1.7
2012	1.3	1.1	1.7	1.3	0.9	1.8	1.3	0.9	3.1
2013	2.3	2.1	2.9	1.6	1.4	2.9	2.1	1.8	4.1
2014	0.7	0.6	1.3	1.4	0.7	1.8	0.7	0.4	1.7
2015	1.3	1.0	1.3	0.6	0.4	1.1	0.9	0.6	1.1
2016	1.6	1.3	2.0	1.1	0.9	1.3	0.4	0.4	1.7
2017	2.5	2.0	3.1	8.1	2.0	43.4	2.5	2.4	2.7

Table 7-12. Summary of soil boron by zone and sampling event.

Year	Zone 1			Zone 2			Zone 3		
	Median	20th Percentile	80th Percentile	Median	20th Percentile	80th Percentile	Median	20th Percentile	80th Percentile
	lbs/acre								
2008	1.9	1.4	2.7	1.6	1.6	1.8	1.4	1.0	1.6
2012	0.5	0.3	0.5	0.4	0.2	0.5	0.5	0.4	0.8
2013	0.7	0.6	1.3	2.2	1.5	2.5	1.1	0.8	1.8
2014	0.7	0.6	1.0	1.1	0.9	5.9	0.8	0.5	1.3
2015	0.7	0.6	1.1	1.0	0.7	1.3	0.9	0.6	1.2
2016	0.9	0.6	1.0	1.1	0.7	1.7	0.6	0.5	0.9
2017	1.8	1.5	2.2	1.9	1.0	2.4	1.7	1.5	2.0

Table 7-13. Summary of soil aluminum by zone and sampling event.

Year	Zone 1			Zone 2			Zone 3		
	Median	20th Percentile	80th Percentile	Median	20th Percentile	80th Percentile	Median	20th Percentile	80th Percentile
	lbs/acre								
2008	34	29	39	95	61	149	48	42	88
2012	65	40	113	89	65	161	56	0	145
2013	0	0	65	0	0	0	0	0	137
2014	0	0	105	0	0	113	49	0	186
2015	16	0	32	0	0	0	0	0	65
2016	0	0	48	0	0	0	0	0	129
2017	0	0	8	0	0	0	0	0	0

Table 7-14. Summary of soil cation exchange capacity (CEC) by zone and sampling event.

Year	Zone 1			Zone 2			Zone 3		
	Median	20th Percentile	80th Percentile	Median	20th Percentile	80th Percentile	Median	20th Percentile	80th Percentile
	meq/100 cc								
2008	3.4	2.7	4.2	4.2	3.5	4.7	3.7	2.8	4.1
2012	2.4	1.9	2.9	2.9	2.6	3.3	2.9	1.7	3.5
2013	1.8	1.2	2.6	4.1	3.5	4.9	3.7	3.1	5.1
2014	2.0	1.4	3.0	3.3	2.6	11.0	3.4	2.7	4.0
2015	2.1	1.5	2.3	2.7	1.9	5.5	3.3	2.8	4.4
2016	2.1	2.1	2.1	4.6	2.1	5.7	2.8	2.5	3.4
2017	1.2	1.2	1.8	3.7	2.4	10.2	1.8	1.0	2.9

Table 7-15. Summary of soil base saturation by zone and sampling event.

Year	Zone 1			Zone 2			Zone 3		
	Median	20th Percentile	80th Percentile	Median	20th Percentile	80th Percentile	Median	20th Percentile	80th Percentile
	Percent (%)								
2008	30	27	41	25	21	26	31	28	36
2012	47	38	59	49	30	63	75	32	100
2013	100	59	100	100	100	100	100	43	100
2014	100	43	100	100	49	100	100	38	100
2015	100	100	100	100	100	100	100	79	100
2016	100	58	100	100	100	100	100	72	100
2017	100	88	100	100	100	100	100	100	100

Table 7-16. Summary of soil total nitrogen by zone and sampling event.

Year	Zone 1			Zone 2			Zone 3		
	Median	20th Percentile	80th Percentile	Median	20th Percentile	80th Percentile	Median	20th Percentile	80th Percentile
	ppm								
2008	100	100	1,100	100	100	100	1,100	550	1,850
2012	36	13	122	158	64	316	96	15	395
2013	25	24	95	354	221	567	162	54	260
2014	282	235	363	485	382	926	352	262	481
2015	59	42	77	45	38	86	65	51	68
2016	64	58	97	162	130	876	357	97	390
2017	102	78	134	104	87	128	105	76	127

Table 7-17. Summary of soil organic matter by zone and sampling event.

Year	Zone 1			Zone 2			Zone 3		
	Median	20th Percentile	80th Percentile	Median	20th Percentile	80th Percentile	Median	20th Percentile	80th Percentile
	Percent (%)								
2008	1.2	0.7	1.3	2.0	1.6	2.5	1.8	1.3	3.1
2012	1.2	0.9	1.5	2.3	1.7	3.2	2.8	1.2	4.4
2013	1.1	0.7	2.0	3.5	2.4	3.9	2.8	1.1	3.8
2014	1.2	0.9	1.6	2.3	1.4	3.2	1.9	1.4	3.2
2015	1.2	1.0	1.8	2.4	1.6	3.0	2.4	1.4	2.7
2016	0.7	0.5	0.7	2.0	1.9	4.3	2.1	0.9	2.5
2017	1.0	0.8	2.5	1.3	0.6	8.4	1.8	1.3	2.7

Table 7-18. Summary of soil carbon:nitrogen ratio by zone and sampling event.

Year	Zone 1			Zone 2			Zone 3		
	Median	20th Percentile	80th Percentile	Median	20th Percentile	80th Percentile	Median	20th Percentile	80th Percentile
	unitless ratio								
2008	31	6	58	78	66	110	10	5	17
2012	208	85	491	100	56	196	155	46	407
2013	159	105	274	51	40	64	93	51	187
2014	21	20	25	24	17	63	32	21	51
2015	130	106	163	332	111	422	208	119	326
2016	51	39	65	71	29	85	43	35	83
2017	62	43	128	74	27	564	103	81	143

Table 7-19. Summary of soil soluble salts by zone and sampling event.

Year	Zone 1			Zone 2			Zone 3		
	Median	20th Percentile	80th Percentile	Median	20th Percentile	80th Percentile	Median	20th Percentile	80th Percentile
	ppm								
2008	NM	NM	NM	NM	NM	NM	NM	NM	NM
2012	51	35	71	60	46	80	65	44	115
2013	95	49	180	235	210	300	180	97	260
2014	84	54	125	130	90	320	98	43	140
2015	89	82	110	115	92	140	130	72	145
2016	120	120	140	210	88	210	110	73	135
2017	87	65	102	137	96	276	94	70	133

NM = not measured

Table 7-20. Summary of soil sodium adsorption ratio by zone and sampling event.

Year	Zone 1			Zone 2			Zone 3		
	Median	20th Percentile	80th Percentile	Median	20th Percentile	80th Percentile	Median	20th Percentile	80th Percentile
	unitless ratio								
2008	0.7	0.5	1.0	1.2	0.5	2.1	1.2	0.6	1.7
2012	2.9	1.5	4.8	3.5	2.7	5.7	4.1	1.6	6.9
2013	4.3	3.2	4.9	5.3	2.9	6.9	3.9	2.4	6.1
2014	3.8	2.6	5.3	5.1	4.3	6.3	4.2	1.8	6.3
2015	3.9	3.4	4.8	3.8	3.7	4.0	4.5	2.4	5.5
2016	4.1	3.8	7.3	5.9	3.7	8.6	5.7	3.1	7.9
2017	1.6	1.3	2.3	0.7	0.4	1.4	1.0	0.7	2.9

Table 7-21. Summary of soil phosphorus sorption capacity by zone and sampling event.

Year	Zone 1			Zone 2			Zone 3		
	Median	20th Percentile	80th Percentile	Median	20th Percentile	80th Percentile	Median	20th Percentile	80th Percentile
	lbs/acre (upper 1-foot of soil)								
2008	NM	NM	NM	NM	NM	NM	NM	NM	NM
2012	162	126	219	148	103	211	146	127	190
2013	239	197	291	257	227	270	165	137	199
2014	218	199	254	204	178	241	151	112	188
2015	516	385	557	416	303	565	207	163	329
2016	362	341	416	517	391	520	293	175	304
2017	220	195	411	401	266	571	376	171	419

NM = not measured

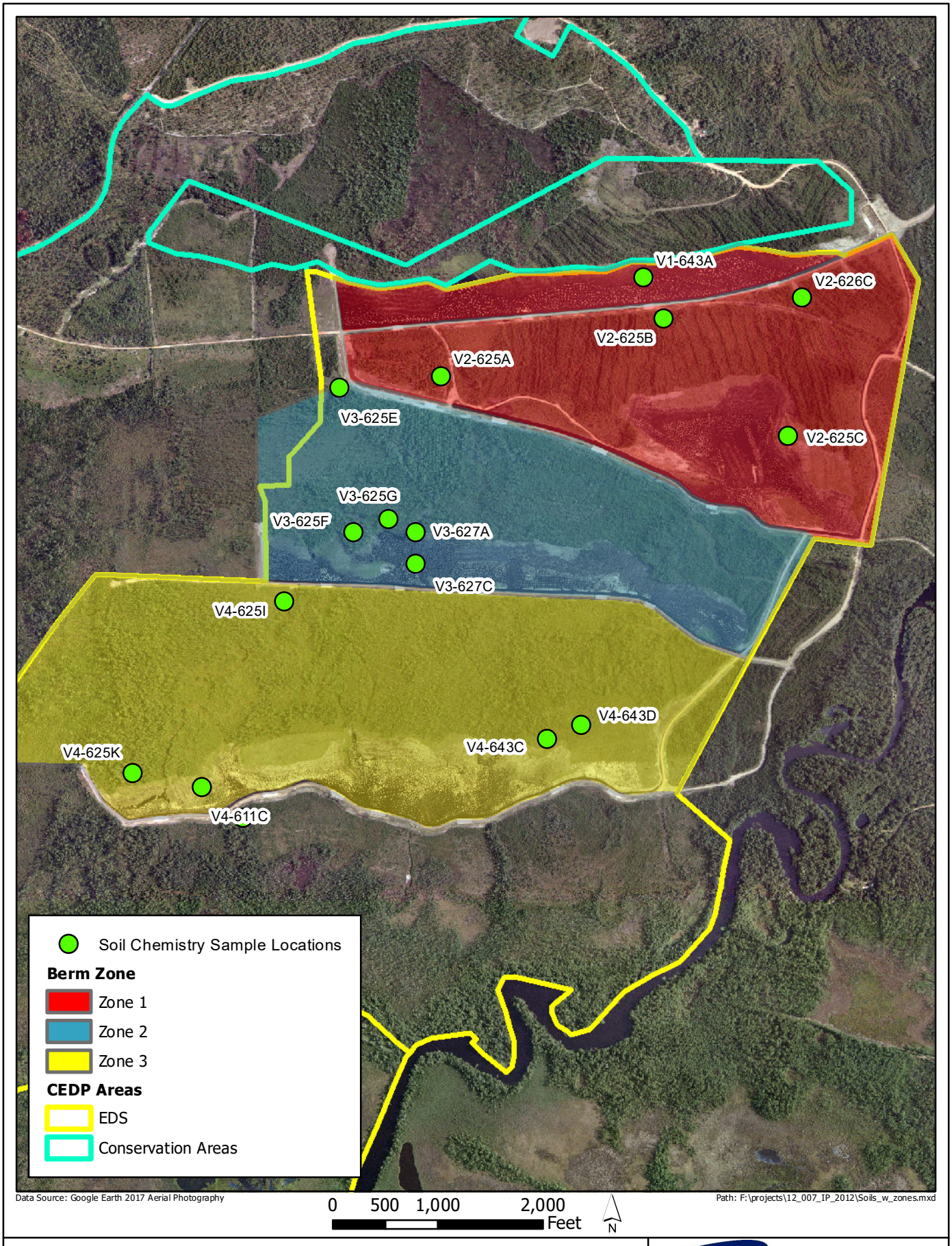


Figure 7-1. Soil chemistry sample locations and corresponding zones used for grouping analysis.

Nutter & Associates
environmental consultants

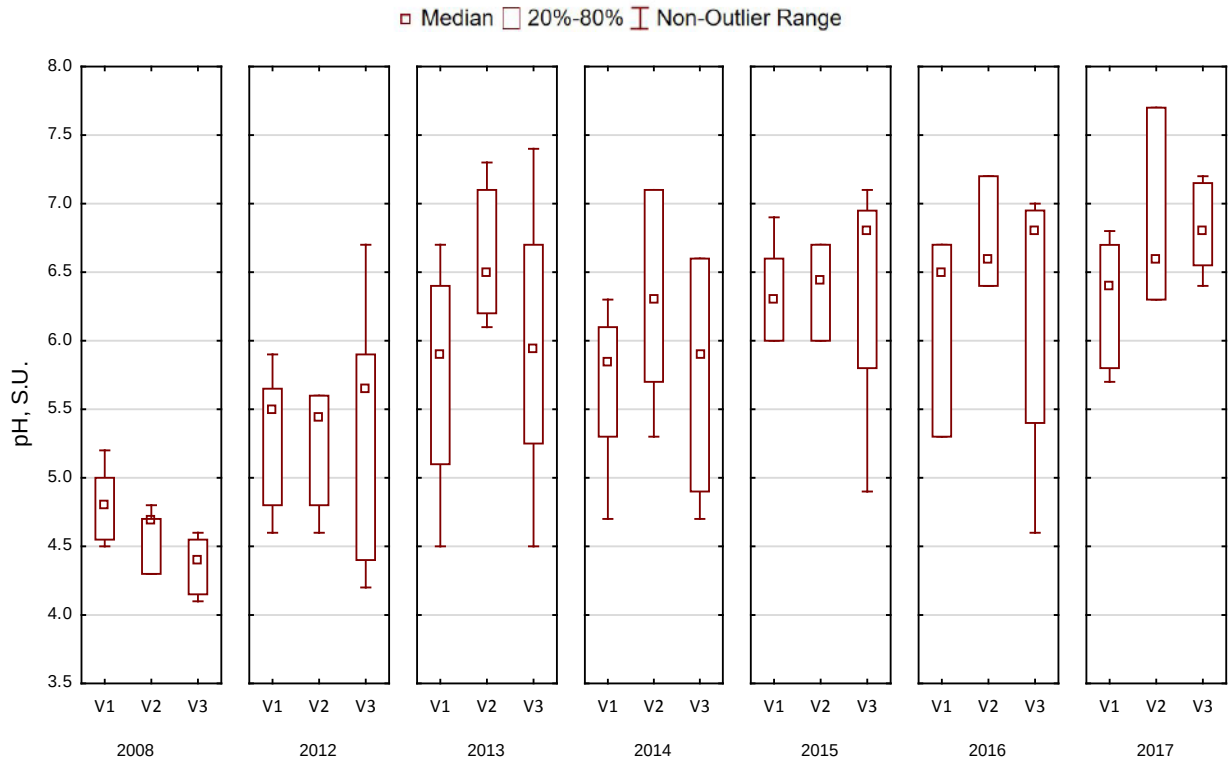


Figure 7-2. Summary of soil pH by zone and sampling event.

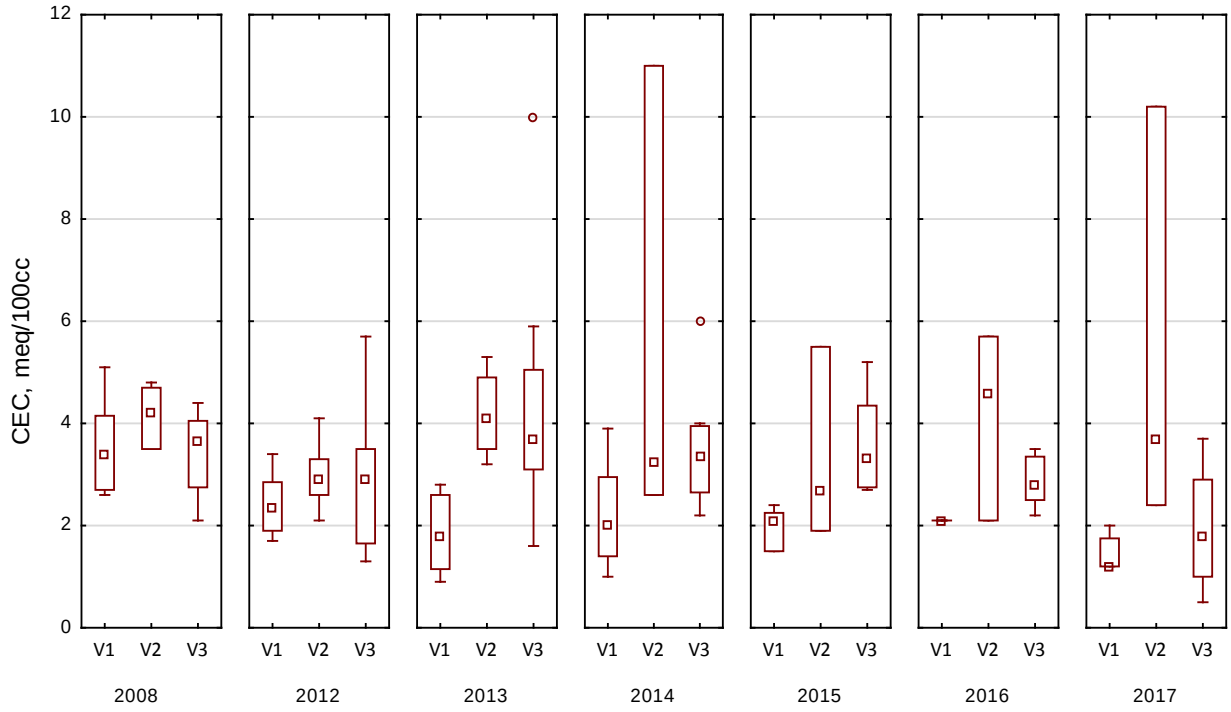


Figure 7-3. Summary of soil cation exchange capacity (CEC) by zone and sampling event

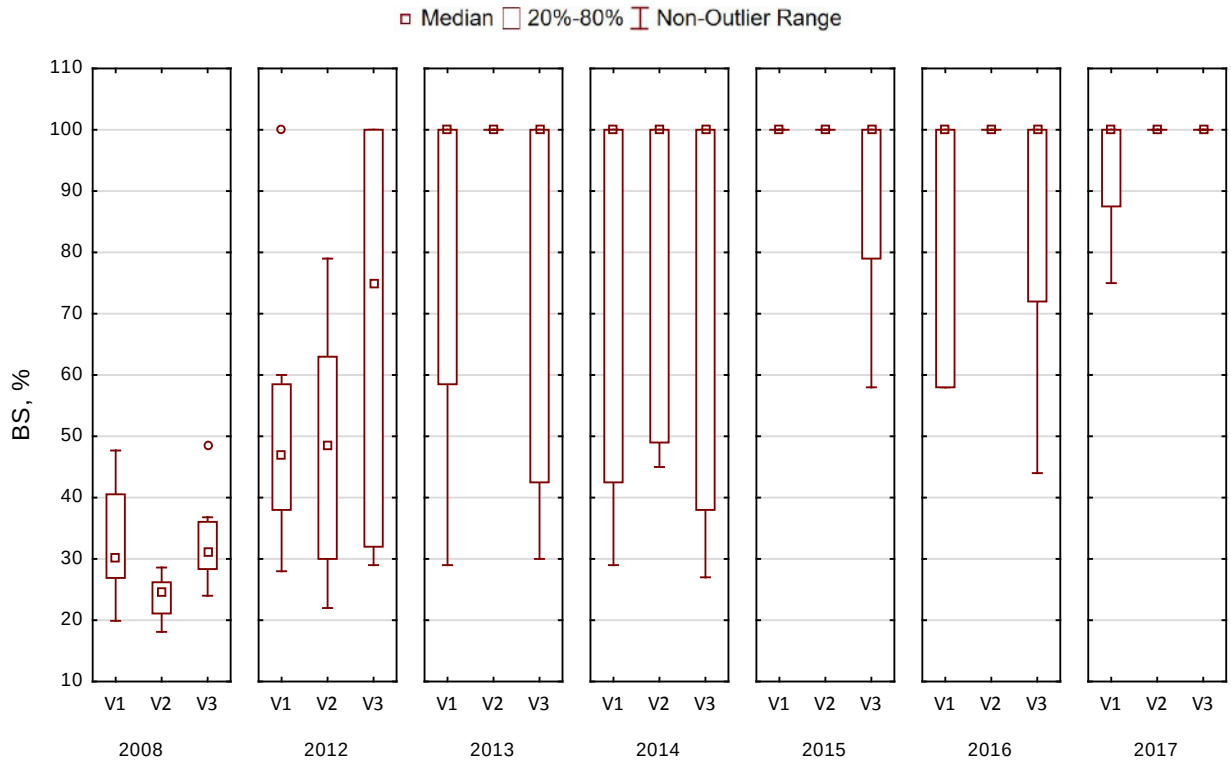


Figure 7-4. Summary of soil base saturation (BS) by zone and sampling event.

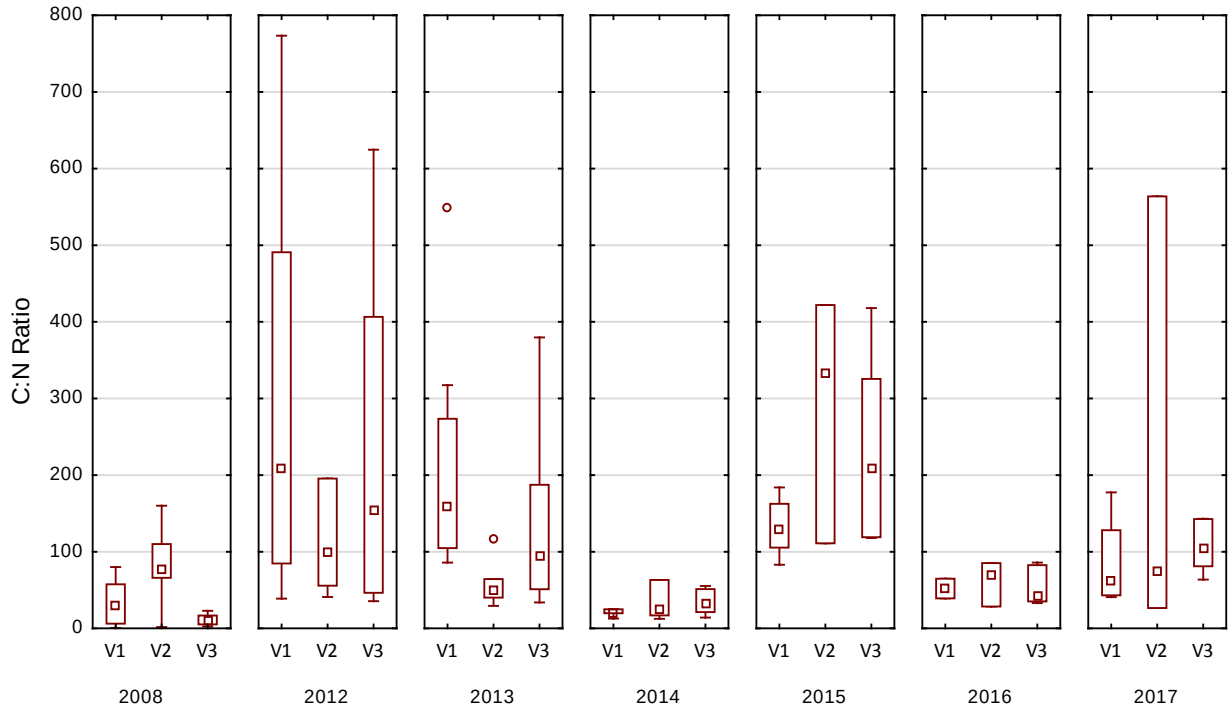


Figure 7-5. Summary of soil carbon to nitrogen (C:N) ratio by zone and sampling event.

8.0 WETLAND MACROINVERTEBRATES

Biological monitoring is an important tool for evaluating the integrity, condition, and ecological function of wetland systems. Aquatic macroinvertebrates are commonly used in biomonitoring because they are widespread, provide an array of responses to environmental disturbances, and can act as continuous indicators of water and habitat quality. Macroinvertebrate data collected during pre-effluent monitoring in 2008 and 2011, during the early stages of the ramp-up effluent flows in 2012, as well as during post effluent years between 2013 and 2017, were analyzed to determine if any changes in community structure had occurred due to the presence of effluent within the effluent distribution system (EDS).

It should be noted that a true control does not exist for the EDS wetland stations due to the major changes in hydrology, habitat, and water quality that have occurred from pre-effluent years (2008 – 2011) to post-effluent years (2013 – 2017). Hydrologic conditions in the EDS prior to the application of effluent flows in 2012 were much shallower and dry conditions periodically occurred at many of the monitoring stations. As well, the reference stations can periodically dry out depending on the antecedent climatic conditions during a given year and this condition has not changed at the reference stations, despite perennial hydrology and greater depths of water in the EDS in post-effluent years. Changes in the hydrology of the EDS are detailed in Chapter 3. Other variables that may have influenced the macroinvertebrate community within the EDS include major shifts in the vegetative community as detailed in Chapter 9, as well as differences in water quality parameters associated with effluent as detailed in Chapters 5 and 6 of this report. Therefore, although reference data is evaluated, the aim of this chapter is to evaluate the EDS macroinvertebrate community based on whether current conditions support an appropriate biological community and whether there have been any changes in relevant benthic community indices of diversity and well-being at the EDS stations between pre-effluent and post-effluent years. The following chapter describes the methods and results of this analysis.

8.1 Macroinvertebrate Station Locations

Macroinvertebrates were sampled at four EDS stations and two reference stations during all years. The location of each sample station monitored in 2017 is shown in Figure 8-1. This chapter details between-year comparisons for only those stations that were sampled in 2017. Comparisons of stations eliminated from collections in 2015 through 2017 are provided in monitoring reports submitted to the FDEP in 2012 through 2014.

Station	Type
FWC01	Reference
SWR01	
DWT01	Effluent Distribution System (EDS)
DWT02	
FWT03	
SWT03	

8.2 Collection and Identification Methods

Macroinvertebrates were semi-quantitatively sampled using multi-habitat sampling methods outlined in the Florida Wetland Condition Index (WCI) SOP (FDEP-SOP-001/01 FS7470). Pre-effluent field collections were conducted in January of 2008 and 2011, and ramp-up flow collections were conducted in January 2012. Post-effluent collections at 100% discharge were conducted in January 2013, February 2014, August 2014, April 2015, February 2016, and March 2017. Samples were preserved in the field and returned to the laboratory for sorting and identification. Identification and enumeration of macroinvertebrates was performed by Broughton Caldwell in 2008, and Water and Air Research, Inc. of Gainesville, Florida in 2011 through 2017. Macroinvertebrates were identified to the lowest possible taxonomic level as specified in FDEP-SOP-002/01 LT7030.

8.3 Data Analysis Methods

For analysis purposes, higher level taxonomic identifications were collapsed to at least the genus level and proportioned to genera in the same order or family that were identified at that station according to methods in FDEP-SOP-002/01 LT7040. Where collapsing to genus could not be accomplished, the higher taxonomic level identification was used. Comparisons of pre-effluent baseline data collected in 2008 and 2011 to data collected during the 2012 ramp-up monitoring year, and during post-effluent years 2013 through 2017 are provided. Two replicate sub-samples of 150 (±10%) species each were identified for each station in 2011 through 2013. Only one replicate of 150 (±10%) species was identified in 2008, and in years 2014 through 2017. For comparative analysis purposes, only the first replicate enumerated in each year from 2011 through 2013 were used in this report.

8.3.1 Diversity Metrics Analysis Methods

Summary statistics including species richness and Shannon-Weiner diversity index were calculated for each station.

$$\text{Shannon-Weiner Index: } H' = \sum_{i=1}^{s} p_i \log(\text{base } 2) p_i$$

Mean diversity metrics were calculated separately for EDS stations and references stations during each year data were collected. Parametric tests were employed using the latest version of Addinsoft's© XLSTAT™ program. One-way analysis of variance (ANOVA) was used and significant differences were established using Tukey pairwise comparison tests at $p < 0.05$. Statistical tests were performed on the diversity metrics and WCI metrics of pre- and post-effluent EDS stations to determine if there were significant differences between treatments. Although there is no true control for the EDS stations, differences between reference stations and EDS treatments were used for comparative purposes.

8.3.2 Wetland Condition Index

A wetland condition index score for each macroinvertebrate station during each year was calculated utilizing standard operating procedures outlined in DEP-SOP-002/01 LT7613 and LT7620. Stations were evaluated using either the forested or herbaceous index depending on the landscape position and vegetative characteristics of the station. The table below details which WCI was used at each station. Freshwater herbaceous wetland stations were

evaluated using multiple metrics to produce a total WCI score based on table scoring metrics in the WCI SOP. Herbaceous macroinvertebrate metrics included percent sensitive genera, percent tolerant genera, percent predator taxa, percent Odonata, and percent Orthocladinae Chironomids. Forested macroinvertebrate metrics included percent tolerant genera, percent sensitive genera, the Florida index, percent Mollusca individuals, percent Noteridae individuals, and percent scraper individuals.

Station	Wetland Condition Index Method
DWT01	Herbaceous
DWT02	
FWC01	
FWT03	
SWR01	Forested
SWT03	

8.3.3 Multivariate Analysis Overview

Macroinvertebrate data collected prior to the application of effluent in 2008 and 2011, during the ramp-up effluent discharge in 2012, and during post-effluent monitoring years 2013 through 2017 were assigned to groups based on the year they were collected and the most parsimonious groupings and compared utilizing various multivariate statistical techniques in PC-ORD. Group assignments were designed to determine whether significant changes in the macroinvertebrate community have occurred post-effluent application.

8.3.3.1 Hierarchical Cluster Analysis

Hierarchical Cluster Analysis is a statistical analysis used to naturally group datasets based upon distance measures calculated between sample units (Stations + Year) and derived from the species composition of each sample unit. In this analysis, sample stations are grouped based upon similarities in the presence or absence of species and the abundance of species present. Several methods for deriving distance measures upon which groups are defined exist, although the Sorenson distance measure utilizing the flexible beta (β=-0.25) method is the preferred analysis for ecological data (McCune and Grace, 2002). The output of the Hierarchical Cluster Analysis is a dendrogram which creates step-wise comparisons between individual stations or groups of stations. Groups of stations that split sooner in the analysis (right side of the dendrogram) are more dissimilar to other groups of stations splitting later in the analysis (left side of the dendrogram). The final number of groups utilized in subsequent analyses requires cutting the dendrogram, which is typically arbitrary but is targeted to the goals of the study (McCune and Grace, 2002). Cutting of the dendrogram was based on comparisons of the a priori groups (year collected). Multi-response Permutation Procedure (MRPP), which is described below, allows for the determination of the statistical significance of the a priori groupings to be tested.

8.3.3.2 Multi-Response Permutation Procedure (MRPP) and Indicator Species Analysis (ISA)

MRPP is a nonparametric procedure for testing the hypothesis of no difference between two or more groups of stations either defined a priori or defined by a hierarchical cluster analysis

(McCune and Grace, 2002). MRPP was utilized to determine the statistical differences and/or similarities between different *a priori* categorical groupings (Year Collected) assigned to the different monitoring stations.

8.3.3.3 Nonmetric Multidimensional Scaling (NMS)

Ordination is most often used in ecological studies to seek and describe a pattern through the placement of datasets along a scale (axis) or multiple axes (McCune and Grace, 2002). Nonmetric multidimensional scaling (NMS) is generally the most effective ordination method for ecological community data (McCune and Grace, 2002). NMS was used to build upon the results of Hierarchical Cluster Analysis and MRPP in order to evaluate differences among a priori groupings (Year Collected) and the distances between these groups based on the community composition of each year sampled.

8.4 Macroinvertebrate Results

Macroinvertebrate data for the 2017 monitoring year are presented in Table 8-1, and data collected during previous monitoring years are presented in Appendix 8-A. Substantial reductions in dominant taxa within the EDS after 2012 included Amphipods from the genus *Crangonyx* sp.; Ceratopogonids from the Bezzia-Palpomyia complex; Chironomids including *Cantopelopia gesta*, *Polypedilum illinoense*, and *Tanytarsus mendax*; Asellids from the genus *Caecidotea*; Oligochaetes from the families Enchytraidae and Lumbriculidae; and Coleopterans from the families Dytiscidae and Hydrophilidae. There have been substantial increases and in some cases, introductions of new species post-2012 that include Amphipods *Gammarus tigrinus* and *Hyalella Azteca*; Elmid riffle beetles; Chironomid midges *Rheotanytarsus exiguous*; Mayflies *Caenis egliensis*; and Caddisflies *Cheumatopsyche* sp. Several factors including increased hydroperiod and habitat availability, changes in water quality, and vegetative habitat changes are likely responsible for shifts in community structure. For instance, increases in mayflies and caddisflies as well as potentially other taxa can be linked to increases in positive flow conditions at some locations. Increases in Biotic factors such as resource competition also contribute to community structural changes. Although changes in dominant taxa and the overall make up of species composition is occurring, some changes would be expected in any system with such a dramatic change in hydrologic and water quality conditions.

8.4.1 Diversity Analysis Results

Shannon-Weiner diversity index scores for the EDS freshwater stations were not statistically different between pre- and post-effluent winter sampling periods, as well as the summer 2014 sampling event, with the exception of the winter 2014 sampling event (Table 8-2; Figure 8-2). The average diversity index score in winter of 2014 was 1.75, representing the lowest diversity score in the EDS in all years when benthic macroinvertebrates were collected (Table 8-2). However, although not statistically different based on Tukey pairwise comparisons, the 2017 Shannon-Weiner diversity average for the EDS was low compared with previous years at 1.95 (Table 8-3). Mean EDS station Shannon-Weiner diversity scores declined in 2017 compared with 2016 by 1.23, and was 0.86 below the overall average of all post-effluent years excluding 2012. (Table 8-2). Average taxa richness for 2017 was lower than any year (12 taxa), and significantly lower than 2013 average (21.8 taxa) and 2015 average (23.8 taxa) taxa richness values (Tables 8-2 and 8-4). Richness values in 2017

were similar to those reported for 2011 (14 taxa) and the summer of 2014 (13.8 taxa) (Table 8-2).

Statistical comparisons were made between pre-effluent samples from the EDS (Pre-EDS, N = 8), post effluent samples from the EDS (Post-EDS, N = 24), and reference samples collected in all years (Reference, N = 18) (Figures 8-2 and 8-3; Tables 8-5 and 8-6). Ramp-up year 2012 data from the EDS were excluded from ANOVA due to variable conditions during the year and to avoid confounding the comparisons of pre-effluent versus post-effluent conditions in the EDS. However, diversity and richness values during 2012 in the EDS are provided in Table 8-2, and were the highest on average (3.61 and 23.5, respectively) of any given EDS yearly average or reference yearly average. Shannon-Weiner diversity and species richness were not significantly different when comparing the post-effluent EDS communities to pre-effluent and reference wetland communities (Tables 8-5 and 8-6; Figure 8-2 and 8-3).

8.4.2 Wetland Condition Index Results

Both herbaceous and forested WCI metrics were variable across all years and sampling events since 2008 and average scores for 2017 showed a 2.25-point decline over 2016, largely due to a substantial WCI decline at DWT01 from 24 in 2016, to 10 in 2017 (Tables 8-2, 8-7 and 8-8; Figures 8-4 and 8-5). However, forested WCI scores have remained similar to previous years, with an increase at SWT03 in 2017 to 29, compared with a WCI score of 28 recorded in 2016 at SWT03 (Figure 8-4). Reference station FWC01 also had declines in 2017 WCI scores (20) over 2016 (47), whereas SWR01 forested WCI scores increased from 32 in 2016 to 45 in 2017 (Figures 8-4 and 8-5).

All WCI total scores were aggregated for pre-effluent EDS stations (Pre-EDS N = 8), post-effluent EDS stations (Post-EDS N = 24), and reference stations in all years (Reference N = 18), and an ANOVA was performed to determine if there were differences between treatments (Table 8-9). Once again, ramp-up EDS data collected in 2012 was not used in the ANOVA analysis to avoid confounding the comparisons between pre- and post-effluent conditions. Based on Tukey pairwise comparisons, there were no significant differences in WCI scores between pre-EDS, post-EDS, and reference collections (Table 8-9; Figure 8-6). The post-effluent EDS WCI average total was 30, Pre-effluent EDS was 27 and the reference WCI average total was 32 (Table 8-9; Figure 8-6). Based on this analysis there has been no discernable departure in WCI metrics since the EDS has been fully operational.

8.4.3 Multivariate Analysis Results

Multivariate analyses were conducted to assess macroinvertebrate community structural changes since initiation of effluent flows in late 2012. Where stations were grouped *a priori* by the year in which they were sampled, comparisons are made to assess broader between year shifts in community structure. Between year shifts in community structure are driven largely by the introduction of effluent to the EDS. Subtle within station macroinvertebrate community structure changes were also evaluated. Community structure changes within stations after 2013 are likely the result of year over year habitat changes and specifically, changes in flow regime due to shifting substrates and changes in the dominant vegetative habitats.

8.4.3.1 A Priori Grouped by Year

Reference station data was excluded from multivariate analyses to compare only pre-effluent versus post-effluent EDS station differences. Each EDS sample station was assigned to a group based on the year in which it was collected. In 2014, samples were collected from EDS stations in winter and summer, and group assignments for 2014 were assigned based on the year and season that they were collected. We chose to interpret a significant ($p = 0.004$) two-dimensional NMS solution with a final stress of 15.84 after verifying the consistency of interpretation among several NMS solutions (Figure 8-7). A three-dimensional solution did produce lower stress, but provided very little information in terms of proportion of variance along the third axis. Additionally, since correlating environmental variables were not applied, explanations for separation along a third dimension would be entirely speculative.

The proportion of variance represented by NMS axis-1 and -2 was 56% and 18% respectively (Figure 8-7). Based on the ordination, there is considerable separation along axis-1 between pre-effluent benthic macroinvertebrate data collected in 2008 and 2011, and post-effluent data collected in years 2013 through 2017. Ramp-up year 2012 resides closer to pre-effluent years as these samples were collected within a month of the initiation of ramp-up effluent flows in 2012, and therefore, large community structural differences in ordination space would not be anticipated. The ordination was not performed with correlating variables considering that in general, it can be assumed that the largest separation along axis-1 is explained by the presence of effluent over time and there would be little advantage in attempting to parse out the multiple concurrent variables (e.g. multiple water quality changes, hydrology, aquatic habitat duration) associated with post-effluent conditions within the EDS. Assumed causes for station separations along axis-2 are likely explained by a combination of more subtle variables such as changing habitat, localized flow alterations and shifting substrates, progressive changes in dominant vegetation since 2012, and potentially, sampling efficiencies affected by habitat changes and an abundance of aquatic vegetation.

Stations from pre-effluent years 2008 and 2011 grouped tightly together to the left of axis 1 and at the bottom of axis 2, and based on MRPP pairwise comparison, 2008 and 2011 samples were statistically similar to one another, and significantly different than all other post effluent years 2012 to 2017 (Table 8-10). Separation from pre-effluent years 2008 and 2011, began in 2012 and 2013, where these groups separate largely along axis-1. Both 2012 and 2013 were significantly different in community structure from each other and all other years based on MRPP results, which explains the separation of these groups in ordination space. Both 2012 and 2013 probably represent transitional years in which the hydrologic regime was changed dramatically in the EDS resulting in a sudden shift in macroinvertebrate community structure in the EDS.

Despite the somewhat tighter grouping of post-EDS years on the right side of axis 1, there is slight separation between years and stations along axis-2, and based on MRPP pairwise comparison, the 2017 data were significantly different between all other years except 2014-summer and the 2016 dataset. Group differences between years within the EDS are also evident in the cluster dendrogram provided in Figure 8-8. Based on the Cluster dendrogram, year grouping fidelity remains roughly intact until the Summer 2014 data. Since the Summer of 2014, less cohesion is evident especially along axis-2 in ordination space, likely the result of shifting habitat conditions in the EDS (Figure 8-7). Post-effluent years versus pre-effluent years separate later to the left side of the cluster dendrogram, indicating some group

cohesion between respective time periods (Figure 8-8). Thus, the cluster analysis corroborates the NMS and MRPP results, together indicating that there has been less change in benthic macroinvertebrate community structure since winter of 2014 compared with the changes that occurred year over year between 2011 and 2014.

8.4.3.2 Ad Hoc Parsimonious Groupings

Station groups were parsed using cluster analysis to determine significant groupings among stations between 2008 and 2017. MRPP was conducted on the six (6) most parsimonious groupings as depicted in Figure 8-9, and all were significantly different from one another (Table 8-11). As expected, group fidelity was maintained between samples collected in 2008 and 2011, with the addition of one sample collected at DWT01 in 2012 (Figure 8-9; Table 8-11). Changes in community structure began separating groups in 2012 and 2013. Group fidelity within a given station began to disperse in the summer of 2014 along axis-2 (Figure 8-7). As stated previously, separation along axis-2 for stations in 2014 through 2017, is likely due to more subtle changes in habitat conditions such as changes in the dominant vegetation, localized flow regimes, and general habitat. However, some station fidelity has remained intact between the summer of 2014 and 2017 (Figure 8-9). Station FWT03 community structure has remained similar since Winter of 2014, as all but one FWT03 sample collected in 2016 fell within Group 5 (Figure 8-9). Station SWT03 also exhibited group fidelity since 2014, except for the winter 2014 sample which fell within Group 6. Stations DWT01 and DWT02 are fairly scattered between Groups 5 and 6, and both landed in Group 5 in 2017 (Figure 8-9). Despite some lack of group fidelity within stations DWT01 and DWT02, overall, it appears that the macroinvertebrate community structure is stabilizing to some degree since initiation of effluent flows in 2012.

Based on the within station fidelity of the parsimonious groupings, it appears that macroinvertebrate community structure has been more stable at SWT03 and FWT03 since 2014. For station SWT03, a stable community structure is not surprising as habitat at this station has changed little since 2014. Station SWT03 quickly developed a small channel below one of the berm outlets soon after ramp-up flows began in 2012, resulting in sustained swamp/stream conditions through 2017. Not surprisingly, high abundances of flow dependent species such as caddisflies *Cheumatopsyche* sp. and *Hydropsyche decalda*, riffle beetles *Stenelmis* sp., and amphipod *Gamarus tigrinus* are typically collected from SWT03. Variation in community structure since 2014 at DWT01 is likely due to shifting habitat conditions at this station. Station DWT01 exhibited significant flow conditions through a single defined channel prior to 2014. While positive flow conditions still exist at DWT01, it is a mix of stagnant water depressions and a lesser-degree of flow in smaller anastomose channels due to shifting sandy substrates and erosional processes. Additionally, cattails have come to dominate the vegetation community at station DWT01, affecting both flow paths and the development of stable habitats such as woody roots. The dynamic community structure at DWT01 might also be explained by changing sampling conditions during a given year, where more positive flow habitat is targeted differently year over year. It is unclear why station FWT03 has remained somewhat stable and DWT02 more variable in terms of community structure since 2014. Habitat conditions at FWT03 and DWT02 have not changed dramatically in terms of flow conditions at the sites. Given the amount of duck weed and various other aquatic plant species that have thrived in more stagnant water conditions at DWT02, the lack of community structure fidelity between years at station DWT02 might be explained simply by increasingly difficult sampling conditions and an inability to see and target specific habitats. Aquatic plant species are less abundant at

station FWT03 due to some positive flow along a fire break adjacent to the station, and shallower water depths.

8.5 Conclusions

Metrics for evaluating the freshwater EDS macroinvertebrate community included established wetland community indices and diversity metrics used commonly in community ecology evaluations of ecological integrity, as well as multivariate analyses assessing community structural differences. The EDS has exhibited year over year upward or downward changes in macroinvertebrate diversity. The 2017 diversity metrics were lower than all other post-effluent years except the summer of 2014, although differences between years other than summer 2014 were not statistically significant. Wetland Condition Index metrics have remained similar to pre-effluent and reference conditions during the course of 100% operational flows since late 2012. It may prove significant that there has been little separation in ordination space and cluster analysis for those data collected in winter and summer of 2014 through 2017. There were dramatic changes in benthic macroinvertebrate community structure that occurred year over year between 2011 and 2014 due to the multiple changes in environmental variables associated with the application of effluent flows. Those variables included changes in the wetland hydroperiod to a perennial hydroperiod with greater depths, changes in vegetative community and habitat availability resulting from large scale vegetation mortality and introductions of new vegetative species, as well as changes in water quality constituents. Dramatic community structural changes did not occur between samples collected between winter 2014 and 2017 suggesting that the macroinvertebrate community within the EDS may be stabilizing compared with the early phases of effluent distribution between 2012 and 2014. Further changes in community structure are expected as the vegetative community transforms to a more mature forested system, however, those changes would likely occur slowly over time.

8.6 Literature Cited

Lane, C.R., M.T. Brown, M. Murray-Hudson, and M.B. Vivas. 2003. The Wetland Condition Index (WCI): Biological Indicators of Wetland Condition for Isolated Depressional Herbaceous Wetlands in Florida. Report submitted to the Florida Department of Environmental Protection. Howard T. Odum Center for Wetlands, University of Florida. pp. 165.

McCune, B., and J.B. Grace. 2002. Analysis of Ecological Communities. MJM Software Design, Gleneden Beach, Oregon.

Reiss, K.C., and M.T. Brown. 2005. The Florida Wetland Condition Index (FWCI): Developing Biological Indicators for Isolated Depressional Forested Wetlands. Report submitted to the Florida Department of Environmental Protection. Howard T Odum Center for Wetlands, University of Florida. pp. 182.

Table 8-1. Results of March 23, 2017 macroinvertebrate monitoring at the four EDS stations (SWT03, DWT01, DWT02, and FWT03) and two reference stations (SWR01 and FWC01).

Order	Family	Taxon	SWR01	SWT03	FWC01	DWT01	DWT02	FWT03
Unspecified	Unspecified	Turbellaria (LPIL)	-	-	-	2	-	-
Haplotaxida	Enchytraeidae	Enchytraeidae (LPIL)	1	-	-	-	-	-
	Naididae	Dero digitata complex Milligan	22	-	-	-	-	-
		Pristina leidyi	2	-	-	-	-	-
		Pristina sp.	-	-	3	-	-	-
		Aulodrilus pigueti	-	-	-	-	1	-
		Tubificoid Naididae (LPIL) imm. w/ hair setae	-	-	-	-	1	-
		Tubificoid Naididae (LPIL) imm. w/o hair setae	-	-	1	-	-	-
Lumbriculida	Lumbriculidae	Eclipidrilus sp.	-	-	3	-	-	-
Amphipoda	Crangonyctidae	Crangonyx serratus	6	-	-	-	-	-
		Crangonyx sp.	-	-	15	-	-	-
	Gammaridae	Gammarus cf tigrinus LeCroy	-	32	-	92	-	-
	Hyalellidae	Hyalella azteca complex LeCroy	-	3	-	15	101	107
Decapoda	Cambaridae	Procambarus sp.	1	-	-	-	-	-
Isopoda	Asellidae	Caecidotea sp.	19	-	107	-	-	-
Coleoptera	Dytiscidae	Neoporus sp.	24	-	-	-	-	-
	Elmidae	Stenelmis sp.	-	18	-	-	-	-
	Hydrochidae	Hydrochus sp.	-	-	1	-	-	-
	Hydrophilidae	Berosus sp.	-	-	1	-	-	-
		Enochrus sp.	1	-	-	-	-	-
	Scirtidae	Scirtes sp.	-	-	-	-	-	1
Diptera	Ceratopogonidae	Atrichopogon sp.	-	-	2	1	-	-
		Bezzia-Palpomyia complex Brigham	-	-	2	1	-	1
		Palpomyia-Sphaeromias group Brigham	-	-	-	-	1	-
	Chironomidae	Cantopelpia gesta	1	-	-	-	-	-
		Chironomini genus III Epler	-	-	1	-	-	-
		Chironomus sp.	24	-	-	-	12	-
		Clinotanypus sp.	-	-	-	-	-	2
		Corynoneura sp.	-	-	-	-	-	1
		Cricotopus politus	-	-	-	-	1	-
		Labrundinia pilosella	-	-	-	-	1	-
		Natarsia sp. A Epler	-	-	-	-	1	-
		Parachironomus tenuicaudatus complex Epler	-	-	1	-	-	-
		Paratendipes subaequalis	-	-	3	-	-	-
		Pentaneura inconspicua	-	1	-	-	-	-
		Polypedilum tritum	2	-	-	-	-	-
		Procladius (Holotanypus) sp.	5	-	2	-	1	-

Table 8-1. Results of March 23, 2017 macroinvertebrate monitoring at the four EDS stations (SWT03, DWT01, DWT02, and FWT03) and two reference stations (SWR01 and FWC01) (continued).

Order	Family	Taxon	SWR01	SWT03	FWC01	DWT01	DWT02	FWT03
Diptera (cont.)	Chironomidae (cont.)	Psectrocladius (Monopsectrocladius) sp.	1	-	-	-	-	-
		Rheotanytarsus exiguus group Epler	-	32	-	5	-	10
		Tanypus carinatus	-	-	-	-	2	-
		Tanytarsus sp.	1	-	-	-	-	-
		Tanytarsus sp. F Epler	-	-	-	-	-	3
		Thienemanniella xena	-	-	-	1	1	1
	Simuliidae	Simulium sp.	-	1	-	4	-	-
	Stratiomyidae	Odontomyia/Hedriodiscus group Merritt	-	-	-	2	-	-
Ephemeroptera	Caenidae	Caenis punctata	-	5	-	8	10	9
Hemiptera	Corixidae	Corixidae (LPIL)	20	-	-	-	-	-
	Corixidae	Palmacorixa sp.	-	-	6	-	-	-
	Naucoridae	Pelocoris balius	1	-	-	-	-	-
	Notonectidae	Notonectidae (LPIL)	4	-	-	-	-	-
	Veliidae	Veliidae (LPIL)	1	-	-	-	-	-
Lepidoptera	Crambidae	Neargyractis sp.	-	-	1	-	-	-
Megaloptera	Corydalidae	Chauliodes sp.	1	-	-	-	-	-
Odonata	Coenagrionidae	Coenagrionidae (LPIL)	-	-	-	2	-	1
	Coenagrionidae	Enallagma sp.	-	1	-	-	-	-
	Libellulidae	Pachydiplax longipennis	3	-	-	-	-	-
	Unspecified	Anisoptera (LPIL)	-	-	-	1	-	-
Trichoptera	Hydropsychidae	Cheumatopsyche sp.	-	43	-	12	15	13
	Hydropsychidae	Hydropsyche decalda	-	6	-	-	-	-
	Hydropsychidae	Hydropsyche sp.	-	-	-	-	-	1
	Leptoceridae	Oecetis sp. F Floyd	-	-	1	-	-	-
Unspecified	Unspecified	Bivalvia (LPIL)	-	2	-	-	-	-
Veneroida	Sphaeriidae	Sphaeriidae (LPIL)	-	-	-	2	-	-
		Total Individuals	**140**	**144**	**150**	**148**	**148**	**150**
		Total Taxa	**20**	**11**	**16**	**14**	**13**	**12**

Table 8-2. Summary of the individual EDS and reference station calculated diversity metrics and the combined average EDS and reference station macroinvertebrate diversity metrics.

Year	DWT01	DWT02	SWT03	FWT03	EDS Mean	SWR01	FWC01	Reference Mean
Shannon-Weiner Diversity Scores								
2008 Winter	3.74	2.44	3.76	3.38	**3.33**	3.34	1.41	**2.38**
2011 Winter	1.17	2.72	3.41	2.88	**2.54**	3.25	2.22	**2.73**
2012 Winter	2.79	3.96	4.36	3.32	**3.61**	3.09	2.05	**2.57**
2013 Winter	2.84	2.98	3.26	3.76	**3.21**	3.64	2.38	**3.01**
2014 Winter	2.08	1.43	2.31	1.18	**1.75**	3.06	3.66	**3.36**
2014 Summer	2.52	3.98	2.49	2.43	**2.86**	2.56	3.31	**2.94**
2015 Winter	2.44	3.35	3.69	2.71	**3.05**	3.15	3.14	**3.14**
2016 Winter	2.80	3.47	3.16	3.25	**3.17**	3.54	1.65	**2.59**
2017 Winter	1.91	1.74	2.49	1.64	**1.95**	3.35	1.68	**2.52**
Species Richness								
2008 Winter	25	14	25	21	**21.3**	19	13	**16.0**
2011 Winter	9	14	17	16	**14.0**	18	13	**15.5**
2012 Winter	20	24	32	18	**23.5**	18	12	**15.0**
2013 Winter	19	22	23	23	**21.8**	23	19	**21.0**
2014 Winter	12	15	17	11	**13.8**	18	21	**19.5**
2014 Summer	21	29	18	15	**20.8**	20	26	**23.0**
2015 Winter	18	26	29	22	**23.8**	21	22	**21.5**
2016 Winter	18	26	18	23	**21.3**	22	13	**17.5**
2017 Winter	12	13	11	12	**12.0**	20	15	**17.5**
WCI								
2008 Winter	26	30	45	34	**33.8**	30	30	**30.0**
2011 Winter	24	25	30	10	**22.1**	39	20	**29.5**
2012 Winter	24	24	41	32	**30.3**	44	32	**38.0**
2013 Winter	29	34	34	34	**32.5**	41	23	**32.0**
2014 Winter	30	30	38	13	**27.9**	30	30	**30.0**
2014 Summer	33	40	35	30	**34.5**	29	36	**32.5**
2015 Winter	26	37	29	37	**32.4**	32	23	**27.4**
2016 Winter	24	30	28	33	**28.8**	32	47	**39.5**
2017 Winter	10	30	29	30	**24.8**	45	20	**32.5**

Table 8-3. Tukey pairwise comparison of within year EDS station (N=4) mean Shannon-Weiner diversity index scores.

Comparison	Difference	Standardized difference	Critical value	Pr > Diff	Significant?
2008 vs 2011	0.785	1.852	3.312	0.593	No
2008 vs 2013	0.119	0.281	3.312	1.000	No
2008 vs 2014 Summer	1.581	3.730	3.312	0.020	Yes
2008 vs 2014 Winter	0.474	1.119	3.312	0.946	No
2008 vs 2015	0.284	0.671	3.312	0.997	No
2008 vs 2016	0.159	0.375	3.312	1.000	No
2008 vs 2017	1.385	3.266	3.312	0.055	No
2011 vs 2014 Summer	0.796	1.877	3.312	0.578	No
2011 vs 2017	0.599	1.414	3.312	0.842	No
2013 vs 2011	0.666	1.571	3.312	0.762	No
2013 vs 2014 Summer	1.462	3.448	3.312	0.037	Yes
2013 vs 2014 Winter	0.355	0.837	3.312	0.989	No
2013 vs 2015	0.165	0.389	3.312	1.000	No
2013 vs 2016	0.040	0.094	3.312	1.000	No
2013 vs 2017	1.266	2.985	3.312	0.099	No
2014 Winter vs 2011	0.311	0.733	3.312	0.995	No
2014 Winter vs 2014 Summer	1.107	2.611	3.312	0.200	No
2014 Winter vs 2017	0.910	2.147	3.312	0.415	No
2015 vs 2011	0.501	1.181	3.312	0.930	No
2015 vs 2014 Summer	1.297	3.059	3.312	0.085	No
2015 vs 2014 Winter	0.190	0.448	3.312	1.000	No
2015 vs 2017	1.100	2.595	3.312	0.206	No
2016 vs 2011	0.626	1.477	3.312	0.812	No
2016 vs 2014 Summer	1.422	3.354	3.312	0.046	Yes
2016 vs 2014 Winter	0.315	0.744	3.312	0.994	No
2016 vs 2015	0.125	0.296	3.312	1.000	No
2016 vs 2017	1.226	2.891	3.312	0.119	No
2017 vs 2014 Summer	0.196	0.463	3.312	1.000	No

Table 8-4. Tukey pairwise comparison of within year EDS station (N=4) mean taxa richness.

Comparison	Difference	Standardized difference	Critical value	Pr > Diff	Significant?
2008 vs 2011	7.25	2.58	3.31	0.211	No
2008 vs 2014 Summer	7.50	2.67	3.31	0.180	No
2008 vs 2014 Winter	0.50	0.18	3.31	1.000	No
2008 vs 2017	9.25	3.29	3.31	0.052	No
2011 vs 2014 Summer	0.25	0.09	3.31	1.000	No
2011 vs 2017	2.00	0.71	3.31	0.996	No
2013 vs 2008	0.50	0.18	3.31	1.000	No
2013 vs 2011	7.75	2.76	3.31	0.153	No
2013 vs 2014 Summer	8.00	2.85	3.31	0.129	No
2013 vs 2014 B	1.00	0.36	3.31	1.000	No
2013 vs 2016	0.50	0.18	3.31	1.000	No
2013 vs 2017	9.75	3.47	3.31	0.035	Yes
2014 Summer vs 2017	1.75	0.62	3.31	0.998	No
2014 Winter vs 2011	6.75	2.40	3.31	0.284	No
2014 Winter vs 2014 Summer	7.00	2.49	3.31	0.245	No
2014 Winter vs 2017	8.75	3.12	3.31	0.076	No
2015 vs 2008	2.50	0.89	3.31	0.984	No
2015 vs 2011	9.75	3.47	3.31	0.035	Yes
2015 vs 2013	2.00	0.71	3.31	0.996	No
2015 vs 2014 Summer	10.00	3.56	3.31	0.029	Yes
2015 vs 2014 Winter	3.00	1.07	3.31	0.957	No
2015 vs 2016	2.50	0.89	3.31	0.984	No
2015 vs 2017	11.75	4.18	3.31	0.007	Yes
2016 vs 2008	0.00	0.00	3.31	1.000	No
2016 vs 2011	7.25	2.58	3.31	0.211	No
2016 vs 2014 Summer	7.50	2.67	3.31	0.180	No
2016 vs 2014 Winter	0.50	0.18	3.31	1.000	No
2016 vs 2017	9.25	3.29	3.31	0.052	No

Table 8-5. Summary analysis of variance results comparing pooled pre-effluent EDS, post-effluent EDS, and freshwater reference wetland macroinvertebrate Shannon-Weiner Diversity.

Comparison	Means	Difference	Standardized difference	Critical value	Pr > Diff	Significant?
Pre-effluent EDS vs Post-effluent EDS	2.94 vs 2.66	0.275	0.882	2.420	0.654	No
Pre-effluent EDS vs Freshwater Reference	2.94 vs 2.80	0.133	0.411	2.420	0.911	No
Post-eflluent EDS vs Freshwater Reference	2.66 vs 2.80	0.141	0.595	2.420	0.824	No

Reference N = 18
Pre-EDS N = 8
Post EDS N = 24

Table 8-6. Summary analysis of variance results comparing pooled pre-effluent EDS, post-effluent EDS, and freshwater reference wetland macroinvertebrate species richness.

Comparison	Means	Difference	Standardized difference	Critical value	Pr > Diff	Significant?
Pre-effluent EDS vs Post-effluent EDS	18 vs 19	1.250	0.604	2.420	0.819	No
Pre-effluent EDS vs Freshwater Reference	18 vs 19	0.375	0.237	2.420	0.969	No
Post-effluent EDS vs Freshwater Reference	19 vs 19	1.625	0.999	2.432	0.581	No

Reference N = 18
Pre-EDS N = 8
Post EDS N = 24

Table 8-7. Herbaceous WCI macroinvertebrate metric scores at each monitoring station during baseline (2008 and 2011), ramp-up (2012), and 100% effluent flow (2013-2017) periods.

Event	Time Period	Metric	DWT01	DWT02	FWC01	FWT03
2008 - Jan	Baseline	% Odonata Individuals	0	3	3	0
2008 - Jan		% Orthocladiinae Individuals	10	10	10	10
2008 - Jan		% Predator Individuals	3	0	0	7
2008 - Jan		% Sensitive Genera	3	7	7	7
2008 - Jan		% Tolerant Genera	10	10	10	10
2008 - Jan		**WCI HERB SCORE**	**26**	**30**	**30**	**34**
2011 - Jan		% Odonata Individuals	0	0	0	0
2011 - Jan		% Orthocladiinae Individuals	10	10	10	0
2011 - Jan		% Predator Individuals	0	5	0	0
2011 - Jan		% Sensitive Genera	4	7	4	0
2011 - Jan		% Tolerant Genera	10	3	7	10
2011 - Jan		**WCI HERB SCORE**	**24**	**25**	**20**	**10**
2012 - Feb	Ramp-up	% Odonata Individuals	0	0	0	5
2012 - Feb		% Orthocladiinae Individuals	10	10	10	10
2012 - Feb		% Predator Individuals	0	0	9	2
2012 - Feb		% Sensitive Genera	4	7	7	9
2012 - Feb		% Tolerant Genera	10	7	7	7
2012 - Feb		**WCI HERB SCORE**	**24**	**24**	**32**	**32**
2013 - Feb	100% Effluent Flow	% Odonata Individuals	7	10	2	10
2013 - Feb		% Orthocladiinae Individuals	10	10	10	10
2013 - Feb		% Predator Individuals	0	5	0	7
2013 - Feb		% Sensitive Genera	10	9	9	7
2013 - Feb		% Tolerant Genera	2	0	3	0
2013 - Feb		**WCI HERB SCORE**	**29**	**34**	**23**	**34**
2014 - Feb		% Odonata Individuals	10	10	0	0
2014 - Feb		% Orthocladiinae Individuals	10	10	10	10
2014 - Feb		% Predator Individuals	0	0	10	0
2014 - Feb		% Sensitive Genera	7	7	7	0
2014 - Feb		% Tolerant Genera	3	3	3	3
2014 - Feb		**WCI HERB SCORE**	**30**	**30**	**30**	**13**
2014 - Aug		% Odonata Individuals	10	10	3	0
2014 - Aug		% Orthocladiinae Individuals	10	10	10	10
2014 - Aug		% Predator Individuals	0	10	10	0
2014 - Aug		% Sensitive Genera	10	7	10	10
2014 - Aug		% Tolerant Genera	3	3	3	10
2014 - Aug		**WCI HERB SCORE**	**33**	**40**	**36**	**30**

Table 8-7. Herbaceous WCI macroinvertebrate metric scores at each monitoring station during baseline (2008 and 2011), ramp-up (2012), and 100% effluent flow (2013-2017) periods (continued).

Event	Time Period	Metric	DWT01	DWT02	FWC01	FWT03
2015 - Apr	100% Effluent Flow	% Odonata Individuals	0	10	0	7
2015 - Apr		% Orthocladiinae Individuals	10	10	10	10
2015 - Apr		% Predator Individuals	3	7	3	0
2015 - Apr		% Sensitive Genera	10	7	7	10
2015 - Apr		% Tolerant Genera	3	3	3	10
2015 - Apr		**WCI HERB SCORE**	**26**	**37**	**23**	**37**
2016 - Feb		% Odonata Individuals	0	10	7	10
2016 - Feb		% Orthocladiinae Individuals	0	3	10	3
2016 - Feb		% Predator Individuals	7	7	10	10
2016 - Feb		% Sensitive Genera	7	7	10	10
2016 - Feb		% Tolerant Genera	10	3	10	0
2016 - Feb		**WCI HERB SCORE**	**24**	**30**	**47**	**33**
2017 - Mar		% Odonata Individuals	0	0	0	0
2017 - Mar		% Orthocladiinae Individuals	10	10	10	10
2017 - Mar		% Predator Individuals	0	0	0	0
2017 - Mar		% Sensitive Genera	0	10	10	10
2017 - Mar		% Tolerant Genera	0	10	0	10
2017 - Mar		**WCI HERB SCORE**	**10**	**30**	**20**	**30**

Table 8-8. Forested WCI macroinvertebrate metric scores at each monitoring station during baseline (2008 and 2011), ramp-up (2012), and 100% effluent flow (2013-2017) periods.

Event	Time Period	Metric	SWR01	SWT03
2008 - Jan	Baseline	% Tolerant Genera	10	10
2008 - Jan		% Sensitive Genera	0	0
2008 - Jan		Florida Index	0	14
2008 - Jan		% Mollusca Individuals	10	10
2008 - Jan		% Noteridae Individuals	0	1
2008 - Jan		% Scraper Individuals	10	10
2008 - Jan		**WCI FORESTED SCORE**	**30**	**45**
2011 - Jan		% Tolerant Genera	10	10
2011 - Jan		% Sensitive Genera	6	0
2011 - Jan		Florida Index	5	0
2011 - Jan		% Mollusca Individuals	9	10
2011 - Jan		% Noteridae Individuals	0	0
2011 - Jan		% Scraper Individuals	10	10
2011 - Jan		**WCI FORESTED SCORE**	**39**	**30**
2012 - Feb	Ramp-up	% Tolerant Genera	10	10
2012 - Feb		% Sensitive Genera	6	3
2012 - Feb		Florida Index	7	9
2012 - Feb		% Mollusca Individuals	10	10
2012 - Feb		% Noteridae Individuals	0	0
2012 - Feb		% Scraper Individuals	10	9
2012 - Feb		**WCI FORESTED SCORE**	**44**	**41**
2013 - Feb	100% Effluent Flow	% Tolerant Genera	6	5
2013 - Feb		% Sensitive Genera	10	7
2013 - Feb		Florida Index	5	10
2013 - Feb		% Mollusca Individuals	10	8
2013 - Feb		% Noteridae Individuals	1	0
2013 - Feb		% Scraper Individuals	9	4
2013 - Feb		**WCI FORESTED SCORE**	**41**	**34**
2014 - Feb		% Tolerant Genera	10	7
2014 - Feb		% Sensitive Genera	3	5
2014 - Feb		Florida Index	5	10
2014 - Feb		% Mollusca Individuals	8	9
2014 - Feb		% Noteridae Individuals	1	0
2014 - Feb		% Scraper Individuals	3	7
2014 - Feb		**WCI FORESTED SCORE**	**30**	**38**

Table 8-8. Forested WCI macroinvertebrate metric scores at each monitoring station during baseline (2008 and 2011), ramp-up (2012), and 100% effluent flow (2013-2017) periods (continued).

Event	Time Period	Metric	SWR01	SWT03
2014 - Aug	100% Effluent Flow	% Tolerant Genera	10	7
2014 - Aug		% Sensitive Genera	0	6
2014 - Aug		Florida Index	2	10
2014 - Aug		% Mollusca Individuals	9	9
2014 - Aug		% Noteridae Individuals	1	0
2014 - Aug		% Scraper Individuals	6	3
2014 - Aug		**WCI FORESTED SCORE**	**29**	**35**
2015 - Apr		% Tolerant Genera	7	8
2015 - Apr		% Sensitive Genera	0	4
2015 - Apr		Florida Index	5	10
2015 - Apr		% Mollusca Individuals	10	7
2015 - Apr		% Noteridae Individuals	0	0
2015 - Apr		% Scraper Individuals	10	0
2015 - Apr		**WCI FORESTED SCORE**	**32**	**29**
2016 - Feb		% Tolerant Genera	10	7
2016 - Feb		% Sensitive Genera	7	3
2016 - Feb		Florida Index	6	10
2016 - Feb		% Mollusca Individuals	8	8
2016 - Feb		% Noteridae Individuals	0	0
2016 - Feb		% Scraper Individuals	0	0
2016 - Feb		**WCI FORESTED SCORE**	**32**	**28**
2017 - Mar		% Tolerant Genera	10	10
2017 - Mar		% Sensitive Genera	5	0
2017 - Mar		Florida Index	10	10
2017 - Mar		% Mollusca Individuals	10	9
2017 - Mar		% Noteridae Individuals	0	0
2017 - Mar		% Scraper Individuals	10	0
2017 - Mar		**WCI FORESTED SCORE**	**45**	**29**

Table 8-9. Summary analysis of variance results comparing pooled pre-effluent EDS, post-effluent EDS, and freshwater reference wetland macroinvertebrate WCI scores.

Comparison	Means	Difference	Standardized difference	Critical value	Pr > Diff	Significant
Pre-effluent EDS vs Post-effluent EDS	27 vs 30	2.464	0.758	2.420	0.731	No
Pre-effluent EDS vs Freshwater Reference	27 vs 32	4.420	1.306	2.420	0.399	No
Post-effluent EDS vs Freshwater Reference	30 vs 32	1.957	0.788	2.420	0.712	No

Reference N = 18
Pre-EDS N = 8
Post EDS N = 24

Table 8-10. Multi Response Permutation Procedure (MRPP) pairwise comparison test of significant differences ($p < 0.05$) of benthic samples collected each year at EDS stations.

Pairwise Comparison	T Value	A Value	p Value
2008 vs 2011	-1.22	0.04	0.116
2008 vs 2012	-2.78	0.08	0.017
2008 vs 2013	-3.68	0.18	0.004
2008 vs 2014 Summer	-4.23	0.22	0.006
2008 vs 2014 Winter	-4.39	0.37	0.005
2008 vs 2015	-4.34	0.27	0.006
2008 vs 2016	-4.33	0.25	0.006
2008 vs 2017	-3.83	0.23	0.005
2011 vs 2012	-2.86	0.10	0.015
2011 vs 2013	-3.79	0.20	0.004
2011 vs 2014 Summer	-4.25	0.24	0.006
2011 vs 2014 Winter	-4.40	0.40	0.005
2011 vs 2015	-4.36	0.29	0.005
2011 vs 2016	-4.35	0.27	0.006
2011 vs 2017	-3.90	0.25	0.005
2012 vs 2013	-2.63	0.11	0.011
2012 vs 2014 Summer	-3.99	0.19	0.007
2012 vs 2014 Winter	-4.32	0.34	0.005
2012 vs 2015	-4.25	0.23	0.005
2012 vs 2016	-4.29	0.23	0.006
2012 vs 2017	-3.69	0.21	0.004
2013 vs 2014 Summer	-2.72	0.13	0.010
2013 vs 2014 Winter	-4.02	0.30	0.004
2013 vs 2015	-3.24	0.17	0.006
2013 vs 2016	-3.43	0.18	0.004
2013 vs 2017	-2.93	0.16	0.005
2014 Summer vs 2015	-1.89	0.09	0.051
2014 Winter vs 2016	-3.95	0.25	0.006
2015 Summer vs 2016	-1.22	0.03	0.100
2015 vs 2016	-3.64	0.16	0.005
2015 vs 2017	-2.38	0.13	0.022
2015 Winter vs 2015	-3.52	0.20	0.006
2016 Summer vs 2017	-1.27	0.07	0.110
2016 vs 2017	-1.58	0.08	0.065
2016 Winter vs 2017	-2.11	0.14	0.026
2017 Winter vs 2014 Summer	-1.98	0.12	0.049

Table 8-11. Multi Response Permutation Procedure (MRPP) pairwise comparison test of significant differences ($p < 0.05$) of benthic samples parsed using cluster analysis.

Pairwise Comparison	T Value	A Value	p Value
1 vs 2	-4.74	0.09	0.001
1 vs 3	-5.37	0.17	0.004
1 vs 4	-5.47	0.16	0.004
1 vs 5	-11.29	0.32	0.000
1 vs 6	-11.72	0.19	0.000
2 vs 3	-2.17	0.29	0.000
2 vs 4	-2.21	0.20	0.000
2 vs 5	-6.89	0.29	0.000
2 vs 6	-6.38	0.14	0.000
3 vs 4	-1.41	0.35	0.000
3 vs 5	-5.88	0.30	0.004
3 vs 6	-4.43	0.12	0.002
4 vs 5	-5.66	0.27	0.003
4 vs 6	-4.59	0.12	0.002
5 vs 6	-9.92	0.16	0.000

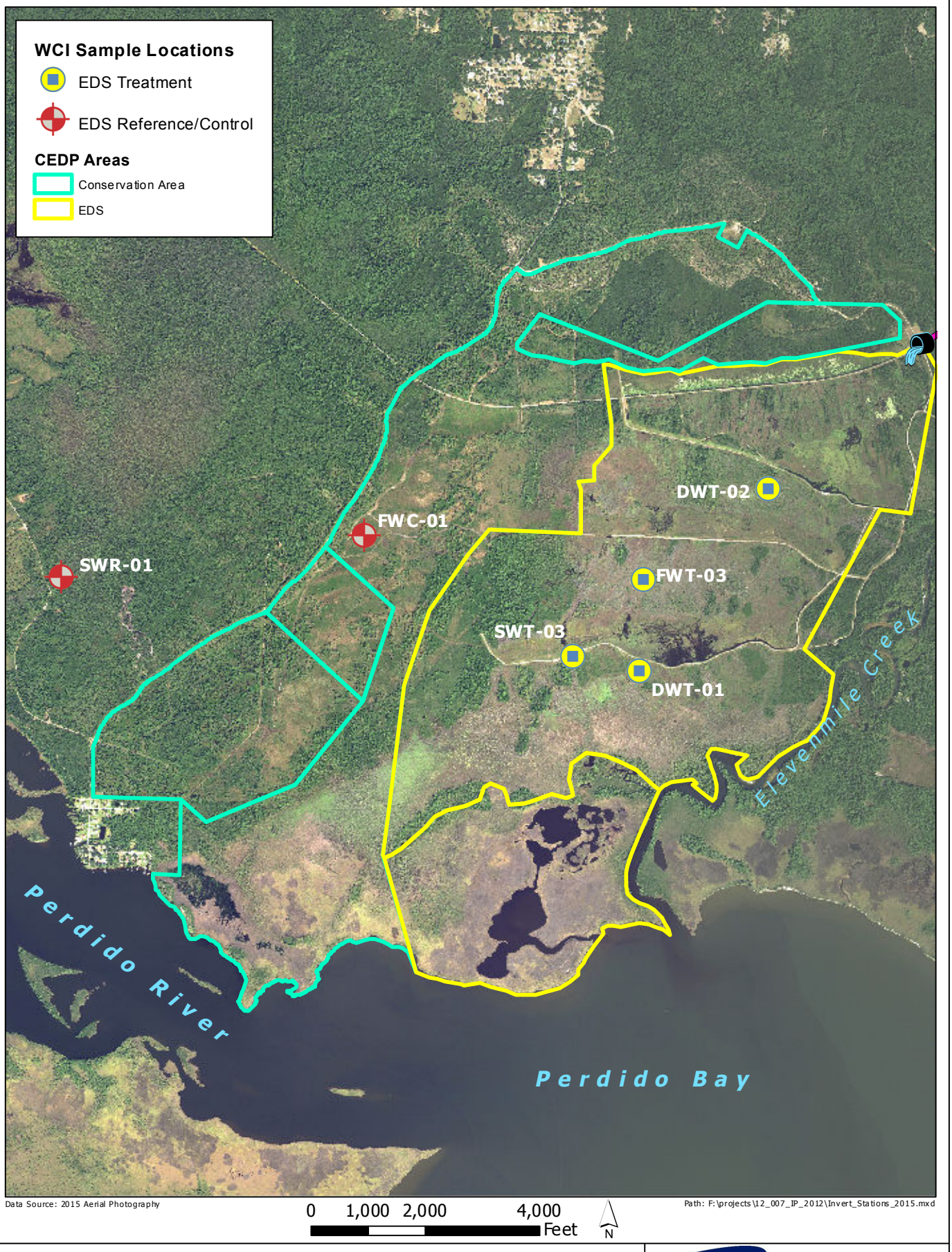


Figure 8-1. Location of wetland macroinvertebrate monitoring stations.

Nutter & Associates
environmental consultants

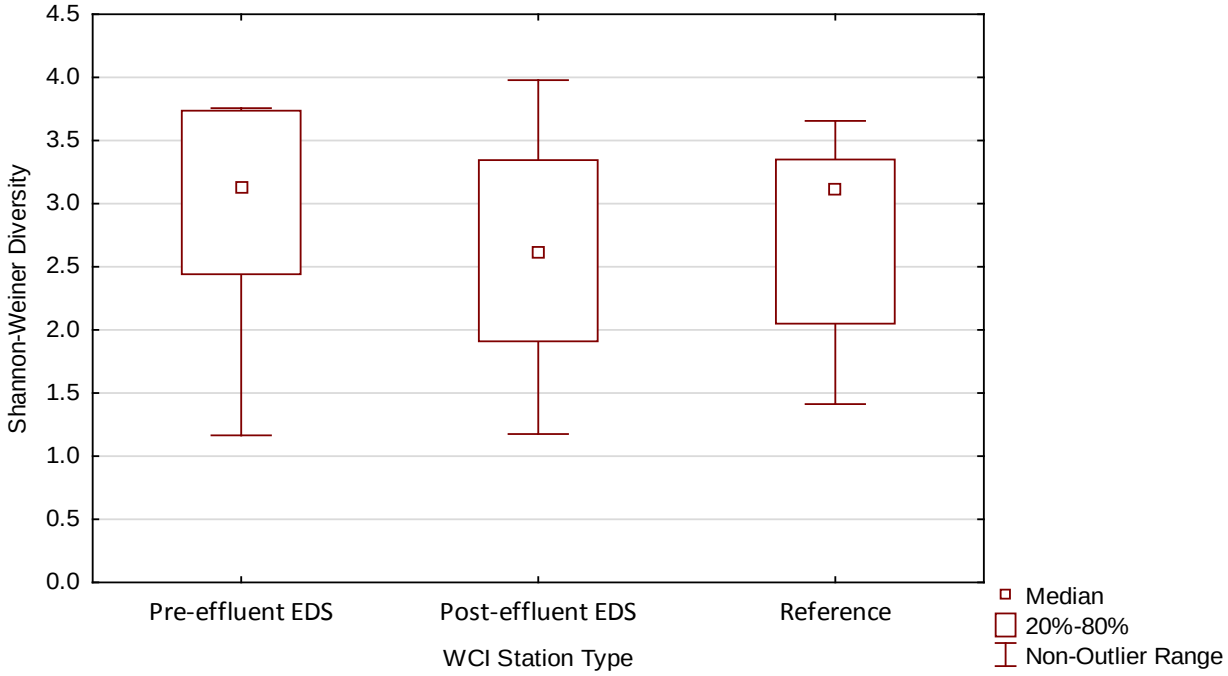


Figure 8-2. Summary macroinvertebrate Shannon-Weiner diversity scores from combined pre-effluent and post-effluent EDS stations, and the freshwater reference stations between 2008 and 2017.

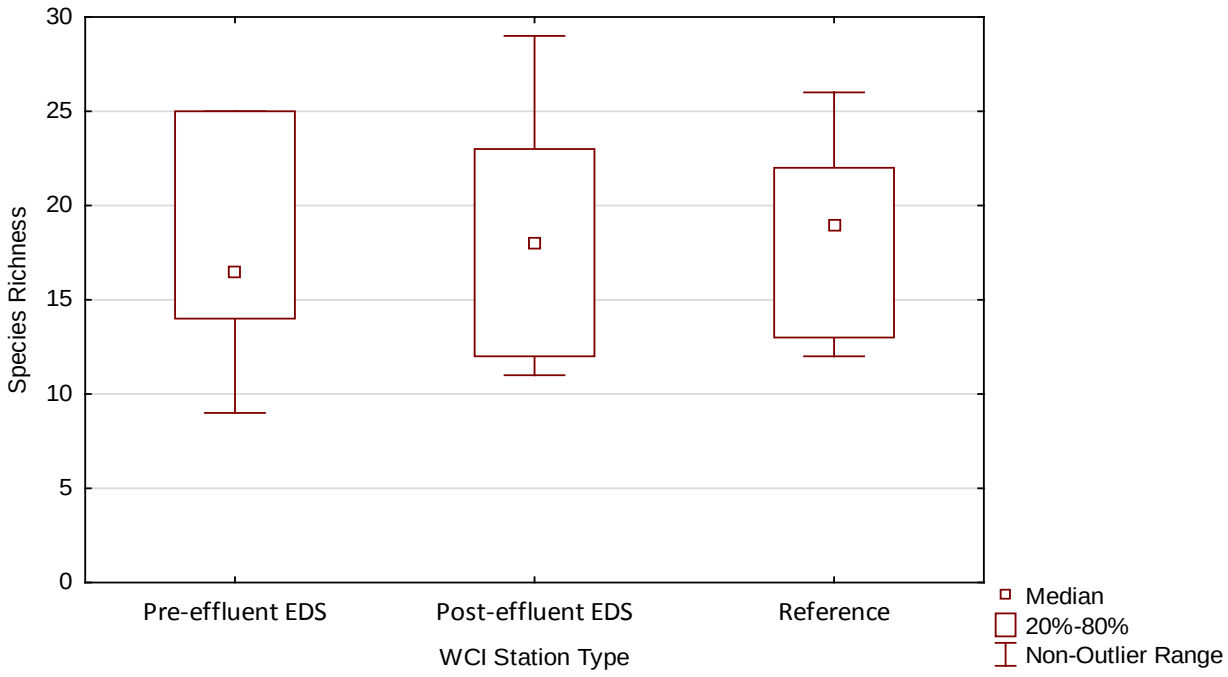


Figure 8-3. Summary macroinvertebrate taxa richness results from combined pre-effluent and post-effluent EDS stations and freshwater reference stations between 2008 and 2017.

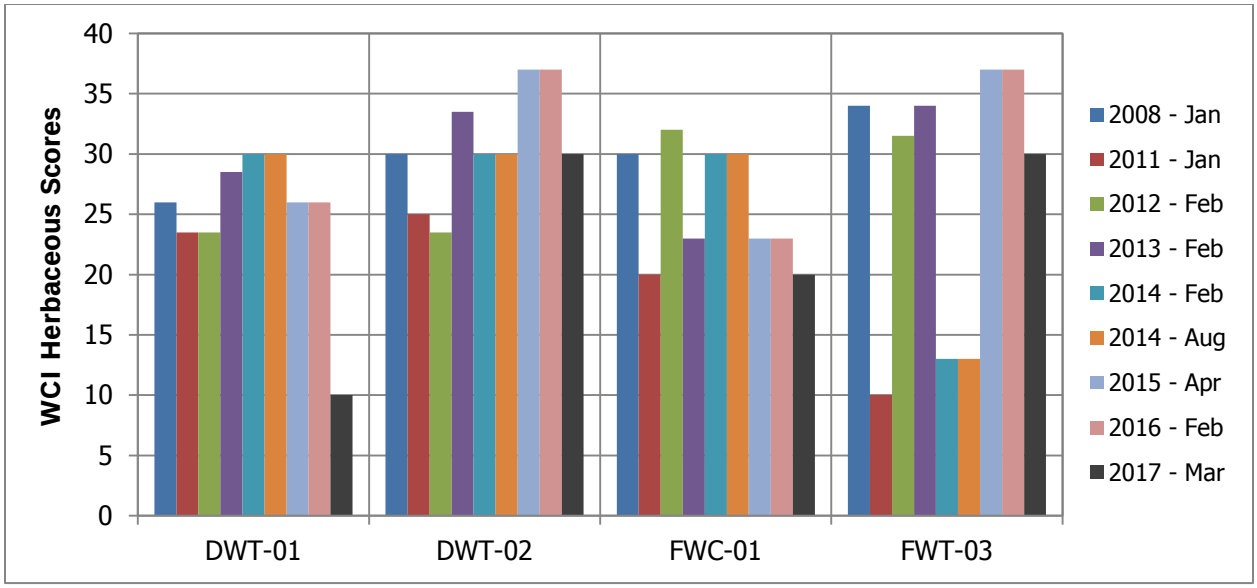


Figure 8-4. Summary of total herbaceous Wetland Condition Index (WCI) scores from the freshwater EDS and reference stations, 2008 to 2017.

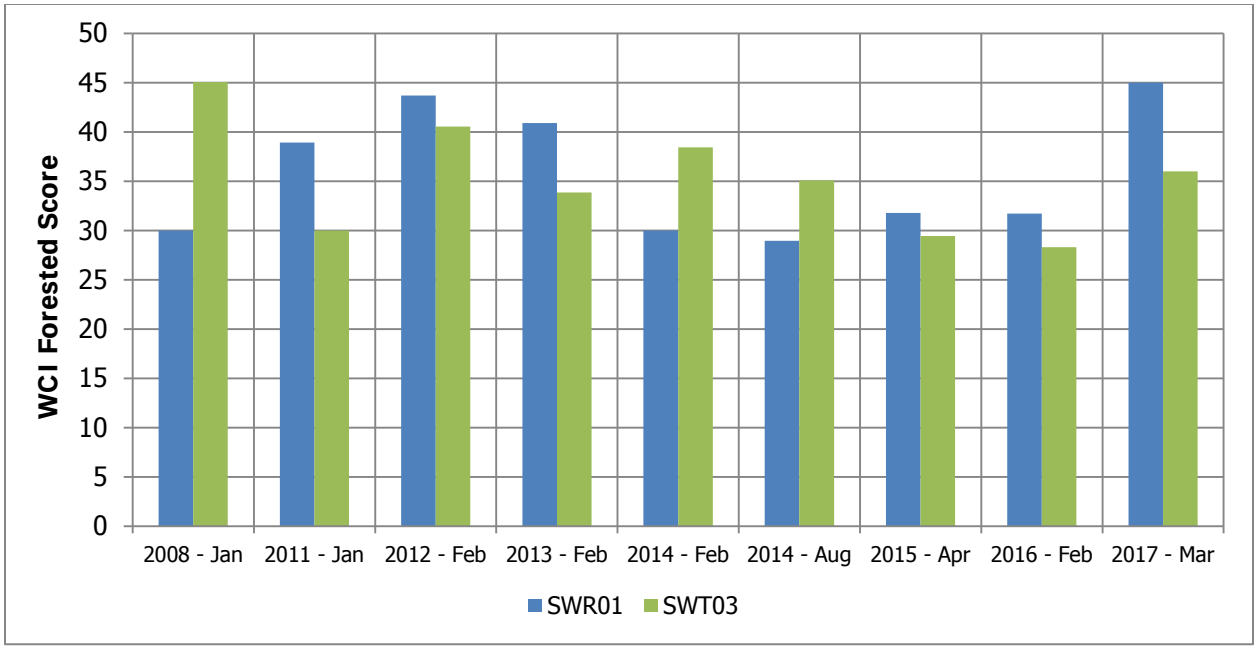


Figure 8-5. Summary of total forested Wetland Condition Index (WCI) scores from the freshwater EDS and reference stations, 2008 to 2017.

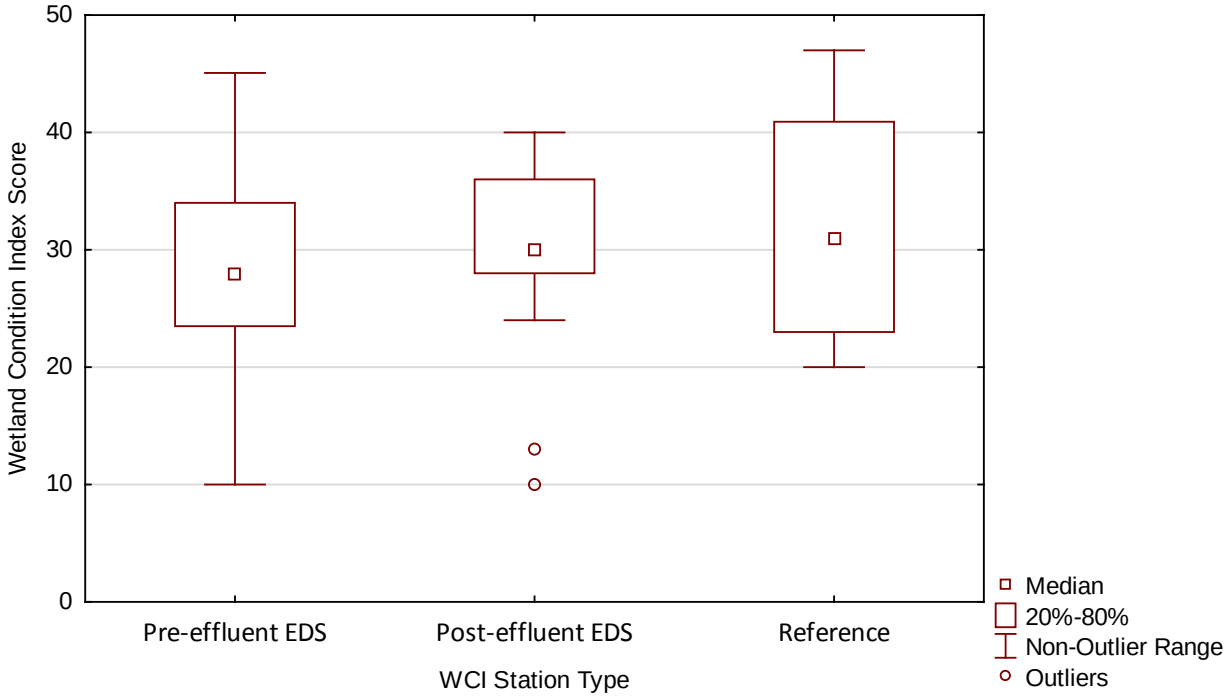


Figure 8-6. Summary macroinvertebrate Wetland Condition Index (WCI) results from combined pre-effluent and post-effluent EDS stations and freshwater reference stations between 2008 and 2017.

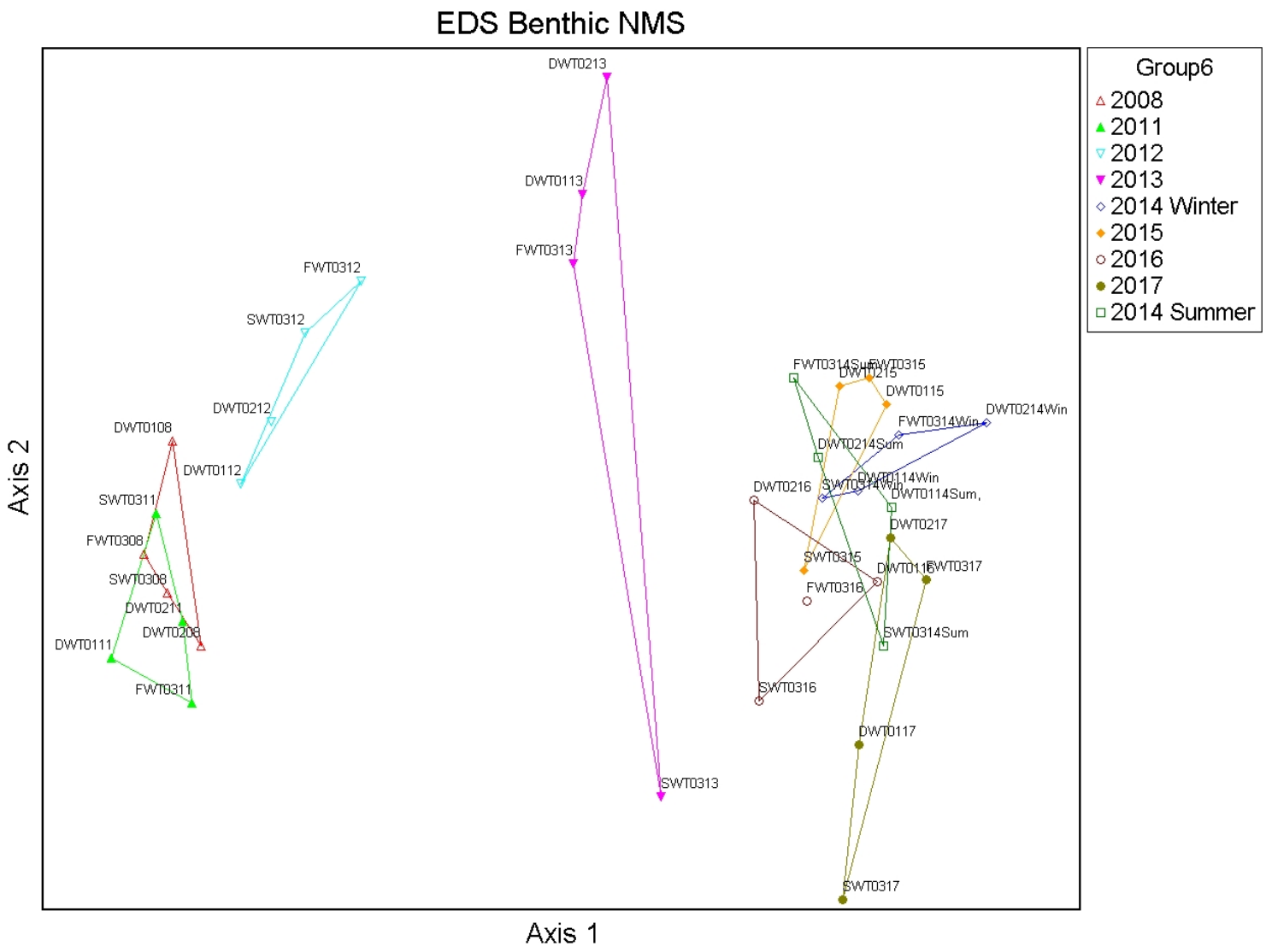


Figure 8-7. Two dimensional NMS bi-plot solution of macroinvertebrate data collected between years at the EDS stations.

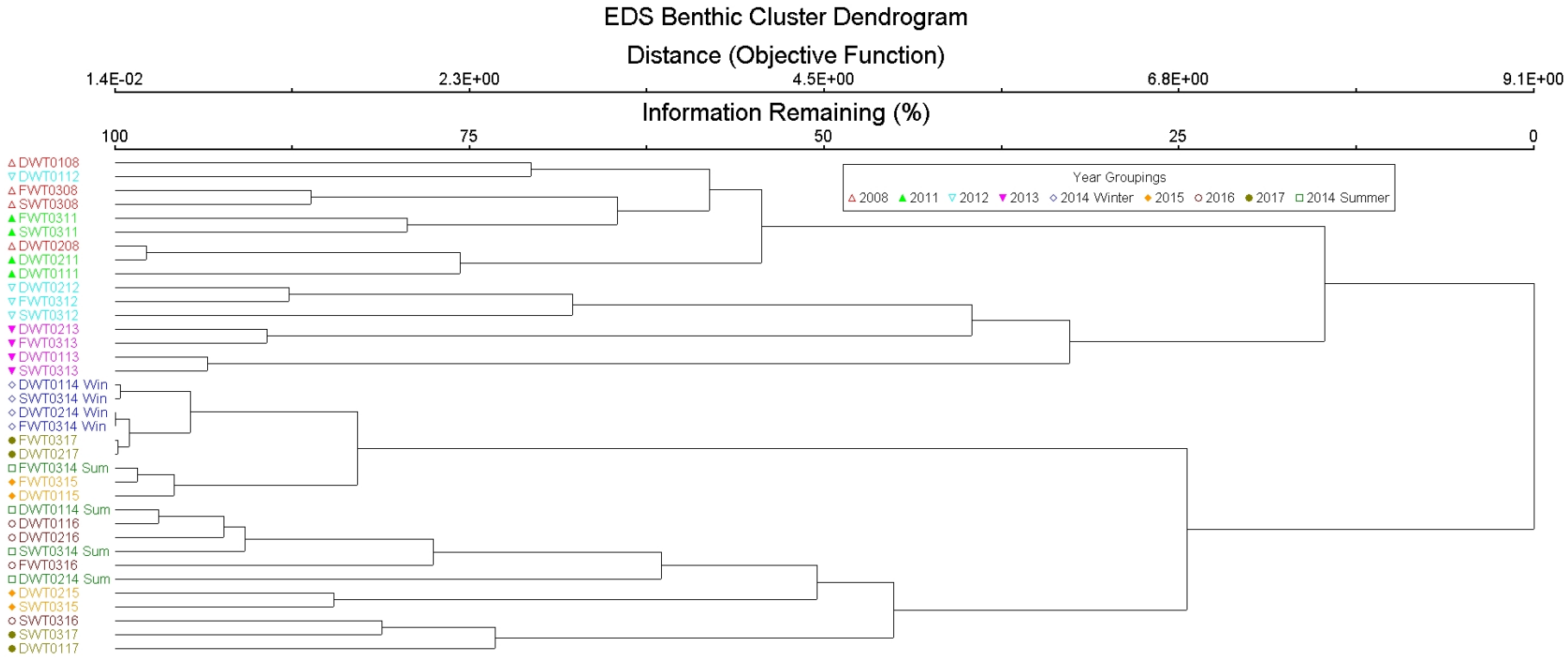


Figure 8-8. Ad hoc group cluster analysis of macroinvertebrate data collected from EDS stations in all years and color coded by year, indicating the within group fidelity of most years.

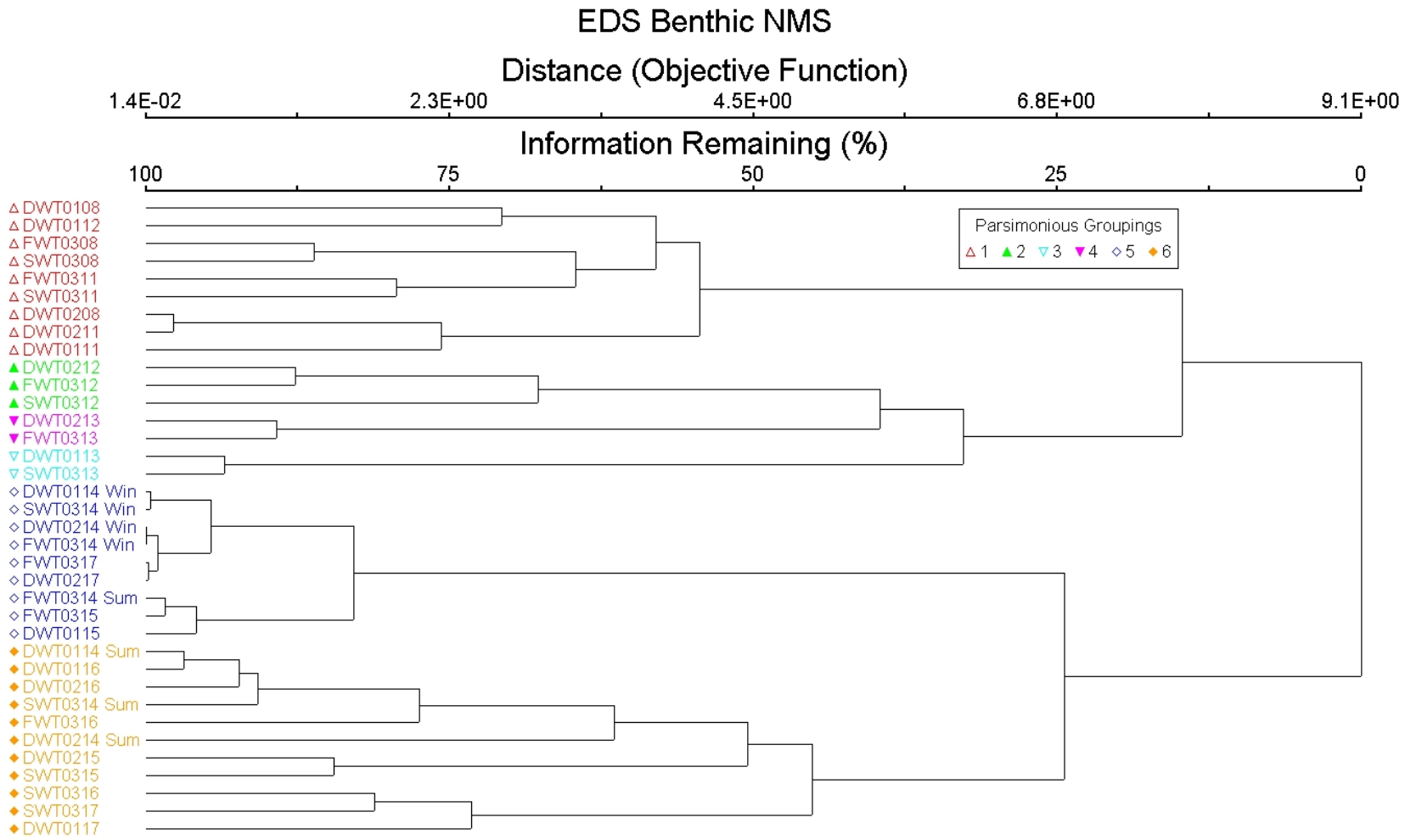


Figure 8-9. Parsimonious group cluster analysis of macroinvertebrate data collected from EDS stations during all monitoring years.

APPENDIX 8-A

2008 THROUGH 2017 WETLAND MACROINVERTEBRATE COLLECTION RESULTS

Table 8-A-1. Results of benthic macroinvertebrate collections for year 2008. Identification Conducted by Broughton Caldwell. Only one (1) replicate was enumerated for 2008.

	DWT-01	DWT-02	SWR-01	SWT-03	FWC-01	FWT-03
Final ID (Taxon)	Rep 1	Rep 1	Rep 1	Rep 1	Rep 1	Rep 1
Crangonyx	3	8	16	18	13	19
Agabus	0	0	1	1	1	2
Colymbetinae	1	0	0	0	0	0
Hydroporinae	0	1	0	0	0	0
Neoporus	1	0	31	1	0	0
Peltodytes	1	0	1	0	0	0
Peltodytes floridensis	0	0	2	0	0	0
Peltodytes oppositus	0	0	1	0	0	0
Berosus	5	0	0	0	0	0
Hydrophilidae	0	1	0	0	0	0
Notomicrus nanulus	0	0	0	2	0	1
Cambaridae	0	2	0	0	1	0
Allulaudomyia	3	0	0	0	0	0
Bezzia/Palpomyia group	4	46	1	4	7	6
Culicoides	6	0	0	2	0	8
Dasyhelea	6	0	1	7	0	0
Probezzia	4	0	0	0	0	0
Ablabesmyia	0	0	0	0	0	1
Cantopelopia gesta	0	5	0	0	1	0
Chironomus decorus gr.	3	0	9	1	0	6
Corynoneura	1	0	0	1	0	0
Cryptochironomus	0	0	0	0	0	1
Kiefferulus dux	0	0	23	0	0	0
Larsia berneri	0	15	0	0	1	21
Larsia indistincta	0	0	0	0	0	4
Natarsia sp. A Epler	2	0	0	2	0	1
Paratendipes subaequalis	2	0	0	0	0	1
Pentaneurini	0	0	1	0	0	0
Polypedilum tritum	10	2	7	7	2	11
Procladius (Holotanypus)	1	0	0	0	0	0
Psectrocladius (Monopsectrocladius)	0	1	0	0	0	0
Psectrocladius psilopterus gr. sp.	0	0	0	1	0	6
Psectrocladius psilopterus gr. sp. 2	0	0	0	1	0	0
Pseudosmittia	0	0	0	1	0	0
Tanypus carinatus	0	0	0	0	0	2
Tanytarsus	0	0	0	1	0	0
Tanytarsus mendax gr.	16	0	16	0	0	6
Tanytarsus sp. V Epler	0	0	0	4	0	0
Zalutschia sp. A Epler	0	0	1	9	0	0
Culicidae	0	0	1	1	0	1
Culicidae - taxon 1*	0	0	0	9	0	0
Culicidae - taxon 2*	0	0	0	1	0	0
Dolichopodidae	1	0	0	19	0	0
Simulium	0	0	0	1	0	0
Enchytraeidae	38	1	0	0	0	0
Corixidae	0	0	1	1	0	0
Buenoa confusa	0	0	0	0	1	0
Caecidotea	23	58	15	35	107	15
Lumbriculidae (cf. Eclipidrilus w/proboscis)	0	0	1	8	0	2
Lumbriculidae	0	0	0	24	0	55

Table 8-A-1. Results of benthic macroinvertebrate collections for year 2008. Identification Conducted by Broughton Caldwell. Only one (1) replicate was enumerated for 2008.

	DWT-01	DWT-02	SWR-01	SWT-03	FWC-01	FWT-03
Final ID (Taxon)	Rep 1	Rep 1	Rep 1	Rep 1	Rep 1	Rep 1
Nematoda	1	0	0	0	0	0
Enallagma	0	1	0	1	1	0
Libellula	0	0	1	0	1	0
Libellulidae	1	1	1	0	0	0
Oxyethir	4	5	0	0	2	0
Naidinae	5	0	8	0	0	0
Pristina leidyi	4	0	0	0	0	2
Tubificinae w/ hair chaetae	0	0	0	5	0	0
Tubificinae w/o hair chaetae	13	0	0	0	1	0
Total Organisms	**159**	**147**	**139**	**168**	**139**	**171**
Total Taxa	**26**	**14**	**21**	**28**	**13**	**21**

Table 8-A-2. Results of benthic macroinvertebrate collections for year 2011. Identification conducted by Water and Air Research, Inc. Two (2) replicates were enumerated for 2011, but REP 1 was only used for analysis.

	DWT01	DWT02	FWT03	FWC01	SWT03	SWR01
Final ID (Taxon)	REP 1	REP 1	REP 1	REP 1	REP 1	REP 1
Enchytraeidae sp. A (LPIL)	5	1	2	5	9	0
Enchytraeidae sp. B (LPIL)	1	2	7	13	3	5
Enchytraeidae sp. C (LPIL)	0	0	5	0	2	0
Enchytraeidae sp. D (LPIL)	0	0	2	2	8	0
Enchytraeidae sp. E (LPIL)	0	0	0	0	2	0
Dero digitata	0	0	0	0	0	0
Dero digitata complex Milligan	0	0	0	0	3	3
Dero sp.	1	0	0	0	1	2
Naidinae (LPIL)	0	2	0	0	0	0
Pristina leidyi	0	6	0	5	0	8
Pristina sp.	0	6	2	0	0	2
Tubificoid Naididae (LPIL)	0	0	3	0	12	0
Tubificoid Naididae imm. w/ hair setae (LPIL)	2	1	0	0	0	0
Tubificoid Naididae imm. w/o hair setae (LPIL)	0	0	0	0	0	0
Eclipidrilus palustris	0	0	0	1	10	0
Eclipidrilus sp.	0	0	1	0	0	0
Crangonyx sp.	22	17	51	49	19	7
Cambaridae (LPIL)	0	1	0	0	0	0
Procambarus sp.	0	0	2	0	0	0
Caecidotea sp.	112	43	12	45	18	0
Matus leechi	1	1	3	0	0	0
Neoporus sp.	0	3	0	0	3	33
Uvarus granarius group	0	0	0	1	1	1
Peltodytes oppositus	0	0	0	0	0	10
Peltodytes sp.	0	0	0	0	0	15
Berosus sp.	0	1	0	3	0	0
Enochrus ochraceus	0	4	0	0	0	1
Hydrophilidae (LPIL)	0	0	0	0	0	0
Hydrocanthus sp.	0	0	0	0	0	0
Scirtes sp.	0	6	0	1	0	0
Scirtidae (LPIL)	0	0	0	0	0	0
Bezzia-Palpomyia complex Brigham	1	39	9	8	12	3
Corynoneura sp. C Epler	0	0	0	0	0	1
Dasyhelea sp.	0	0	0	0	0	0
Apsectrotanypus johnsoni	0	0	1	0	0	0
Chaetocladius sp.	0	0	4	0	0	0
Chironomidae (LPIL)	0	0	0	0	1	0
Chironomini (LPIL)	0	1	0	0	1	0
Chironomini genus III Epler	0	0	0	1	0	0

Table 8-A-2. Results of benthic macroinvertebrate collections for year 2011. Identification conducted by Water and Air Research, Inc. Two (2) replicates were enumerated for 2011, but REP 1 was only used for analysis.

	DWT01	DWT02	FWT03	FWC01	SWT03	SWR01
Final ID (Taxon)	REP 1	REP 1	REP 1	REP 1	REP 1	REP 1
Chironomus Lobochironomus sp.	0	0	0	0	0	29
Chironomus sp.	0	1	0	0	4	0
Corynoneura sp.	0	0	0	1	0	0
Dicrotendipes sp.	1	0	0	0	0	0
Larsia berneri	0	0	0	0	0	3
Larsia sp.	1	5	0	1	0	0
Natarsia sp.	1	0	1	0	0	0
Orthocladiinae (LPIL)	1	0	18	0	0	0
Paraphaenocladius sp.	0	0	1	0	0	0
Paratendipes sp.	0	2	1	0	0	0
Paratendipes subaequalis	0	0	0	0	0	1
Polypedilum scalaenum group Epler	1	0	0	0	0	0
Polypedilum sp.	0	2	0	0	0	0
Polypedilum trigonus	0	4	0	1	1	2
Polypedilum tritum	0	0	1	0	1	13
Psectrocladius psilopterus group Epler	0	0	0	1	0	0
Psectrocladius psilopterus group sp. 1	0	0	8	0	0	0
Psectrocladius sp.	0	0	10	0	0	0
Tanypodinae (LPIL)	0	1	1	0	0	1
Tanytarsus sp.	0	0	0	1	0	0
Tanytarsus sp. V Epler	0	0	0	0	1	1
Zalutschia sp. A Epler	0	0	5	0	19	0
Aedes/Ochlerotatus group	0	0	5	0	0	0
Culex restuans	0	0	0	0	3	0
Culex sp.	0	0	0	0	3	0
Culex territans	0	0	0	0	0	0
Culicidae (LPIL)	0	0	0	0	2	1
Ochlerotatus sp.	0	0	0	0	0	0
Chrysops sp.	0	0	0	0	1	0
Tabanidae (LPIL)	0	0	0	0	0	0
Baetidae (LPIL)	0	0	0	0	0	0
Eurylophella doris	0	0	0	0	0	0
Corixidae (LPIL)	0	1	0	1	0	0
Trichocorixa sexcincta	0	0	0	0	0	0
Trichocorixa sp.	0	0	0	0	0	1
Aeshnidae (LPIL)	0	0	0	0	0	0
Enallagma sp.	0	0	0	0	0	0
Libellulidae (LPIL)	0	0	0	0	0	0
Libellulinae (LPIL)	0	0	0	0	0	4

Table 8-A-2. Results of benthic macroinvertebrate collections for year 2011. Identification conducted by Water and Air Research, Inc. Two (2) replicates were enumerated for 2011, but REP 1 was only used for analysis.

	DWT01	DWT02	FWT03	FWC01	SWT03	SWR01
Final ID (Taxon)	REP 1	REP 1	REP 1	REP 1	REP 1	REP 1
Oxyethira sp.	0	0	0	0	0	0
Oecetis cinerascens	0	0	0	0	0	0
Caecidae (LPIL)	0	0	0	0	0	7
Total Organisms	**150**	**150**	**155**	**140**	**140**	**154**
Total Taxa	**13**	**23**	**24**	**18**	**25**	**24**

Table 8-A-3. Results of benthic macroinvertebrate collections for year 2012. Identification conducted by Water and Air Research, Inc. Two (2) replicates were enumerated for 2012, but REP 1 was only used for analysis.

	DWT01	DWT02	FWC01	FWT03	SWR01	SWT03
Final ID (Taxon)	Rep 1	Rep 1	Rep 1	Rep 1	Rep 1	Rep 1
Enchytraeidae (LPIL)	22	2	4	9	5	16
Dero digitata complex Milligan	0	0	0	0	3	0
Dero sp.	0	3	1	0	0	0
Naidinae (LPIL)	0	0	0	0	0	1
Pristina aequiseta	0	0	0	0	0	0
Pristina jenkinae	0	0	0	0	0	0
Pristina leidyi	0	0	0	0	2	0
Pristina sp.	0	0	1	0	0	0
Limnodrilus hoffmeisteri	0	0	0	0	0	2
Tubificoid Naididae imm. w/ hair setae (LPIL)	0	0	0	0	0	4
Tubificoid Naididae imm. w/o hair setae (LPIL)	0	0	0	0	0	0
Eclipidrilus palustris	2	0	0	0	0	12
Streptocephalus sp.	0	0	0	0	0	0
Crangonyx sp.	18	11	21	1	38	5
Cambaridae (LPIL)	0	0	0	0	0	1
Caecidotea sp.	30	10	87	0	17	2
Lirceus sp.	59	0	0	7	0	3
Anodocheilus exiguus	1	0	0	0	0	0
Dytiscidae (LPIL)	1	0	0	0	0	0
Ilybius sp.	0	0	0	0	4	2
Laccophilus proximus	0	0	0	0	0	0
Matus sp.	0	0	0	0	0	0
Neoporus carolinus	0	0	0	0	12	0
Neoporus lobatus	0	0	0	0	13	0
Neoporus sp.	0	6	2	3	0	16
Platambus sp.	0	0	0	1	0	0
Uvarus granarius group	1	0	0	0	0	0
Uvarus sp.	0	0	0	0	1	0
Gyrinus sp.	0	0	0	0	0	0
Peltodytes sp.	0	0	5	0	0	1
Hydrochus sp.	1	0	0	0	0	1
Berosus sp.	0	2	1	0	0	0
Enochrus consortus	0	0	0	0	1	0
Enochrus ochraceus	0	2	0	0	0	1
Helocombus bifidus	0	0	0	0	0	1
Tropisternus natator	0	1	0	0	0	0
Hydrocanthus sp.	0	0	1	0	0	0
Cyphon sp.	0	2	0	0	0	0
Scirtes sp.	0	5	0	0	0	0

Table 8-A-3. Results of benthic macroinvertebrate collections for year 2012. Identification conducted by Water and Air Research, Inc. Two (2) replicates were enumerated for 2012, but REP 1 was only used for analysis.

	DWT01	DWT02	FWC01	FWT03	SWR01	SWT03
Final ID (Taxon)	Rep 1	Rep 1	Rep 1	Rep 1	Rep 1	Rep 1
Scirtidae (LPIL)	1	0	0	0	0	0
Cecidomyiidae (LPIL)	0	0	0	2	0	0
Atrichopogon sp.	1	1	0	0	0	7
Bezzia-Palpomyia complex Brigham	1	9	3	8	4	1
Ceratopogonidae (LPIL)	0	3	0	0	0	5
Culicoides sp. group Brigham	1	0	0	0	0	0
Dasyhelea sp.	0	0	0	0	0	0
Ablabesmyia rhamphe group Epler	0	0	0	0	0	1
Cantopelpia gesta	5	7	2	14	6	0
Chironomus sp.	0	21	0	24	2	2
Cladopelma sp.	0	0	0	0	0	1
Cladotanytarsus sp. A Epler	0	0	0	0	0	0
Corynoneura sp.	0	1	0	2	0	0
Cryptochironomus sp.	0	0	0	0	0	8
Dicrotendipes sp.	0	0	0	0	0	1
Kiefferulus dux/pungens group Epler	1	0	0	0	0	0
Kiefferulus sp.	0	0	0	0	0	2
Larsia berneri	0	0	2	0	0	0
Larsia decolorata	1	0	0	0	0	0
Larsia sp.	0	1	0	0	0	0
Larsia sp. A Epler	0	0	3	0	0	0
Limnophyes sp.	0	0	0	0	0	0
Nanocladius alternantherae	0	0	0	0	0	4
Nilothauma sp.	0	0	0	0	0	1
Orthocladiinae (LPIL)	1	0	0	0	0	0
Parachironomus chaetoalus complex Epler	0	0	0	0	0	3
Parametriocnemus sp.	0	0	0	0	0	0
Paratendipes subaequalis	0	1	1	3	0	0
Polypedilum trigonus	0	12	15	0	1	0
Polypedilum tritum	2	13	0	25	46	11
Procladius sp.	2	0	0	0	0	8
Procladius (Holotanypus) sp.	0	4	0	0	0	0
Psectrocladius elatus	0	0	0	0	0	0
Pseudosmittia sp.	0	0	0	0	0	0
Tanytarsus sp. B Epler	0	0	0	0	0	0
Tanytarsus sp. G Epler	0	19	0	8	0	13
Tanytarsus sp. L Epler	0	0	0	0	0	2
Tanytarsus sp. V Epler	3	5	0	33	0	0
Zalutschia sp. A Epler	0	0	0	0	0	1

Table 8-A-3. Results of benthic macroinvertebrate collections for year 2012. Identification conducted by Water and Air Research, Inc. Two (2) replicates were enumerated for 2012, but REP 1 was only used for analysis.

	DWT01	DWT02	FWC01	FWT03	SWR01	SWT03
Final ID (Taxon)	Rep 1	Rep 1	Rep 1	Rep 1	Rep 1	Rep 1
Corethrella sp.	0	0	0	0	0	0
Anopheles sp.	0	1	0	0	0	0
Culex sp.	0	6	1	0	0	0
Culicidae (LPIL)	0	0	0	0	0	3
Dolichopodidae (LPIL)	0	0	0	2	0	0
Discocerina sp.	0	0	0	0	0	0
Ephydridae (LPIL)	0	0	0	0	0	0
Simulium sp.	0	0	0	1	0	2
Limoniinae (LPIL)	1	0	0	0	0	0
Ormosia sp.	0	0	0	1	0	0
Pseudolimnophila sp.	0	0	0	2	0	1
Caenis eglinensis	0	0	0	0	0	0
Caenis sp.	0	0	0	0	0	1
Saldidae (LPIL)	1	0	0	0	0	0
Crambidae (LPIL)	1	0	0	0	0	0
Chauliodes rastricornis	0	0	0	0	1	0
Epiaeschna heros	0	0	0	0	1	0
Coenagrionidae (LPIL)	0	0	0	0	0	0
Ischnura sp.	0	0	0	0	1	4
Libellula sp.	0	0	0	0	0	2
Libellulinae (LPIL)	0	0	0	0	0	0
Pachydiplax longipennis	0	0	0	1	1	1
Oxyethira sp.	0	1	0	0	0	0
Oecetis sp.	2	1	0	0	0	0
Total Organisms	**159**	**150**	**150**	**147**	**159**	**153**
Total Taxa	**24**	**27**	**16**	**19**	**19**	**39**

Table 8-A-4. Results of benthic macroinvertebrate collections for year 2013. Identification conducted by Water and Air Research, Inc. Two (2) replicates were enumerated for 2013, but REP 1 was only used for analysis.

	SWR01	FWC01	DWT02	FWT03	DWT01	SWT03
Final ID (Taxon)	Rep 1	Rep 1	Rep 1	Rep 1	Rep 1	Rep 1
Enchytraeidae (LPIL)	30	8	0	0	0	0
Allonais inaequalis	0	0	1	9	2	3
Dero digitata complex Milligan	2	0	0	2	0	0
Dero pectinata	0	0	1	0	0	0
Dero sp.	0	0	6	0	0	2
Pristina sp.	0	0	0	0	0	0
Eclipidrilus palustris	0	0	0	0	0	0
Crangonyx sp.	13	19	0	0	0	0
Hyalella azteca complex LeCroy	0	0	1	0	0	0
Cambaridae (LPIL)	0	0	0	0	0	0
Procambarus sp.	0	0	0	0	0	1
Caecidotea sp.	8	90	0	0	0	0
Lirceus sp.	0	0	0	8	40	5
Curculionidae (LPIL)	0	0	1	0	0	0
Hydroporus sp.	0	0	0	0	0	0
Hydrovatus sp.	0	0	0	0	1	0
Matus sp.	1	0	0	0	0	0
Neoporus sp.	17	0	2	0	0	0
Peltodytes sp.	0	0	1	0	0	0
Hydrochus sp.	0	1	0	0	0	0
Berosus sp.	0	5	0	1	0	0
Enochrus ochraceus	0	1	0	0	0	0
Enochrus sp.	0	0	0	0	0	0
Hydrophilidae (LPIL)	0	0	1	0	0	0
Paracymus sp.	0	0	0	1	0	0
Hydrocanthus oblongus	0	0	0	0	0	0
Hydrocanthus sp.	3	0	0	0	0	0
Cyphon sp.	0	0	0	0	0	0
Scirtes sp.	1	3	0	0	0	0
Scirtidae (LPIL)	0	0	0	0	0	0
Atrichopogon sp.	0	0	0	2	0	0
Bezzia-Palpomyia complex Brigham	3	0	1	5	3	0
Dasyhelea sp.	0	1	0	1	1	0
Palpomyia-Sphaeromias group Brigham	0	0	0	0	2	5
Ablabesmyia aspera	0	1	0	0	0	0
Ablabesmyia rhamphe group Epler	0	0	0	0	6	3
Cantopelpia gesta	6	2	0	0	0	0
Chironomus sp.	19	0	66	37	0	0

Table 8-A-4. Results of benthic macroinvertebrate collections for year 2013. Identification conducted by Water and Air Research, Inc. Two (2) replicates were enumerated for 2013, but REP 1 was only used for analysis.

	SWR01	FWC01	DWT02	FWT03	DWT01	SWT03
Final ID (Taxon)	Rep 1	Rep 1	Rep 1	Rep 1	Rep 1	Rep 1
Chironomus stigmaterus	0	0	0	3	0	0
Corynoneura sp.	0	0	0	0	0	0
Cricotopus bicinctus group Epler	1	0	0	9	0	0
Cryptochironomus sp.	0	0	0	0	0	1
Dicrotendipes leucoscelis	0	1	0	0	0	0
Goeldichironomus holoprasinus	0	0	13	0	0	0
Goeldichironomus natans	0	0	0	0	1	0
Goeldichironomus sp.	0	0	0	0	0	0
Kiefferulus sp.	0	0	1	0	0	0
Larsia decolorata	0	0	14	17	4	6
Larsia sp.	0	2	0	0	0	0
Limnophyes sp.	3	0	1	0	0	0
Monopelopia boliekae	0	0	2	8	0	0
Orthocladiinae (LPIL)	0	0	0	0	0	2
Polypedilum illinoense group Epler	0	0	0	1	2	0
Polypedilum trigonus	0	5	0	0	0	0
Polypedilum tritum	23	0	0	0	0	3
Procladius sp.	1	0	0	0	0	0
Psectrocladius sp.	0	3	0	0	0	0
Tanypus carinatus	0	0	4	8	0	0
Tanypus neopunctipennis	0	0	0	0	2	1
Tanytarsus sp. E Epler	0	0	0	0	0	0
Tanytarsus sp. F Epler	0	0	0	0	0	0
Tanytarsus sp. G Epler	0	0	0	4	0	1
Thienemanniella sp.	0	0	0	1	0	0
Thienemanniella xena	0	0	0	0	0	1
Zavreliella marmorata	0	0	0	0	0	0
Aedes/Ochlerotatus group	0	0	0	0	0	0
Culicidae (LPIL)	1	0	0	0	0	0
Discocerina sp.	0	0	0	0	0	0
Sepedon sp.	0	0	0	0	0	0
Simulium sp.	0	0	0	3	42	28
Odontomyia sp.	0	0	1	0	0	0
Odontomyia/Hedriodiscus group Merritt	0	0	0	1	1	0
Limoniinae (LPIL)	0	0	0	0	0	0
Pseudolimnophila sp.	0	0	0	0	0	1
Tipulidae (LPIL)	0	0	0	0	0	0
Baetidae (LPIL)	0	0	1	0	0	0
Callibaetis sp.	0	0	0	1	0	0

Table 8-A-4. Results of benthic macroinvertebrate collections for year 2013. Identification conducted by Water and Air Research, Inc. Two (2) replicates were enumerated for 2013, but REP 1 was only used for analysis.

	SWR01	FWC01	DWT02	FWT03	DWT01	SWT03
Final ID (Taxon)	Rep 1	Rep 1	Rep 1	Rep 1	Rep 1	Rep 1
Caenis sp.	0	0	0	0	34	38
Ephemeroptera (LPIL)	0	0	0	0	1	0
Abedus immaculatus	0	2	0	0	0	0
Corixidae (LPIL)	1	0	3	0	0	0
Mesovelia mulsanti	0	0	0	0	0	0
Crambidae (LPIL)	0	0	0	0	0	1
Anax junius	0	0	0	0	1	0
Gomphaeschna antilope	1	0	1	0	0	0
Gomphaeschna sp.	0	0	1	0	0	0
Coenagrionidae (LPIL)	0	0	0	0	3	0
Enallagma cardenium	0	0	0	0	0	2
Ischnura posita	0	0	0	13	0	0
Ischnura ramburii	0	0	0	0	0	3
Ischnura sp.	5	0	12	0	0	0
Lestes sp.	0	2	0	0	0	0
Libellula sp.	0	0	0	0	0	0
Libellulinae (LPIL)	2	0	0	0	0	0
Pachydiplax longipennis	7	0	0	0	0	0
Cheumatopsyche sp.	0	0	0	0	1	35
Oecetis inconspicua complex Pescador	0	0	0	0	0	0
Oecetis parva	0	0	0	0	0	0
Oecetis sp. C Floyd	0	2	0	0	0	0
Oecetis sp. E Floyd	1	2	0	3	0	7
Ancylidae (LPIL)	1	0	0	0	0	0
Ferrissia fragilis	0	1	0	0	0	0
Physella cubensis	0	0	20	10	3	1
Total Organisms	**150**	**151**	**155**	**148**	**150**	**150**
Total Taxa	**23**	**19**	**23**	**23**	**19**	**22**

Table 8-A-5. Results of benthic macroinvertebrate collections for year 2014 Feb. Identification conducted by Water and Air Research, Inc. Only one (1) replicate was enumerated for 2014 Feb.

	FWC 01	DWT 02	DWT 01	SWR 01	SWT 03	FWT 03
Final ID (Taxon)	Rep 1	Rep 1	Rep 1	Rep 1	Rep 1	Rep 1
Cernosvitoviella sp.	3	0	0	0	0	0
Enchytraeidae (LPIL)	11	0	0	0	0	0
Dero sp.	1	0	0	0	0	0
Dero nivea	0	0	0	0	1	0
Pristina leidyi	2	0	0	0	4	0
Curculionidae (LPIL)	1	0	0	0	0	0
Celina sp.	0	0	0	1	0	0
Neoporus lobatus	0	0	0	21	0	0
Thermonectus basillaris	0	0	0	1	0	0
Uvarus sp.	8	0	0	0	0	0
Gyrinus sp.	2	0	0	0	0	0
Enochrus ochraceus	15	0	0	0	0	0
Hydrocanthus sp.	0	0	0	2	0	0
Scirtes sp.	12	0	0	0	0	0
Atrichopogon sp.	0	0	0	0	2	1
Bezzia-Palpomyia complex Brigham	6	0	0	3	1	1
Dasyhelea sp.	10	0	0	0	0	0
Palpomyia-Sphaeromias group Brigham	0	0	2	0	0	0
Probezzia sp.	3	0	0	0	0	0
Cantopelpia gesta	9	0	0	1	0	0
Chironomus sp.	0	5	0	52	0	4
Chironomus stigmaterus	0	3	0	0	0	0
Corynoneura sp.	1	1	0	0	0	0
Cricotopus lebetis	0	0	1	0	1	0
Larsia decolorata	37	0	0	0	2	0
Monopelopia boliekae	5	0	0	0	0	0
Orthocladiinae sp. C Epler	1	0	0	0	0	0
Paratendipes subaequalis	4	0	0	0	0	0
Polypedilum illinoense group Epler	0	1	0	0	0	0
Polypedilum trigonus	1	0	0	0	0	0
Polypedilum tritum	0	0	0	2	0	0
Procladius (Holotanypus) sp.	0	0	0	6	0	0
Tanypus sp.	0	3	0	0	0	1
Tanytarsus sp. F Epler	0	2	0	0	0	0
Tanytarsus wirthi	0	2	0	0	0	0
Thienemanniella sp.	0	0	0	0	1	0
Simulium sp.	0	0	0	0	5	0
Odontomyia/Hedriodiscus group Merritt	0	0	0	0	1	0
Limoniinae (LPIL)	1	0	0	0	0	0
Callibaetis floridanus	0	0	3	0	0	0

Table 8-A-5. Results of benthic macroinvertebrate collections for year 2014 Feb. Identification conducted by Water and Air Research, Inc. Only one (1) replicate was enumerated for 2014 Feb.

	FWC 01	DWT 02	DWT 01	SWR 01	SWT 03	FWT 03
Final ID (Taxon)	Rep 1	Rep 1	Rep 1	Rep 1	Rep 1	Rep 1
Baetidae (LPIL)	0	2	0	0	0	1
Caenis sp.	0	0	0	0	0	2
Caenis punctata	0	0	27	0	29	0
Pelocoris sp.	0	0	0	1	0	0
Ranatra buenoi	0	0	0	1	0	0
Notonecta uhleri	0	0	0	1	0	0
Elophila sp.	0	1	1	0	0	1
Gomphaeschna furcillata	0	2	0	0	1	0
Aeshnidae (LPIL)	0	0	2	0	0	0
Enallagma sp.	0	0	0	7	8	0
Ischnura sp.	0	5	0	0	0	9
Ischnura hastata	0	0	4	0	0	0
Coenagrionidae (LPIL)	0	0	8	0	0	0
Erythemis simplicicollis	0	0	0	0	2	0
Libellula sp.	0	0	0	0	0	1
Pachydiplax longipennis	0	2	0	17	0	0
Cheumatopsyche sp.	0	0	0	0	1	0
Oecetis sp. E Floyd	0	0	0	0	0	3
Crangonyx sp.	16	0	0	10	0	0
Hyalella azteca complex LeCroy	0	122	84	0	85	116
Cambaridae (LPIL)	0	0	0	1	0	0
Caecidotea sp.	3	0	2	13	0	0
Lirceus sp.	0	0	13	0	7	11
Physella sp.	0	0	1	0	0	0
Physella cubensis	0	2	0	0	2	0
Hebetancylus excentricus	0	0	0	4	0	0
Total Organisms	**152**	**153**	**148**	**144**	**153**	**151**
Total Taxa	**22**	**14**	**12**	**18**	**17**	**12**

Table 8-A-6. Results of benthic macroinvertebrate collections for year 2014 Aug. Identification conducted by Water and Air Research, Inc. Only one (1) replicate was enumerated for 2014 Aug.

	SWT03	SWR01	FWC01	DWT01	DWT02	FWT03
Final ID (Taxon)	Rep 1	Rep 1	Rep 1	Rep 1	Rep 1	Rep 1
Ablabesmyia rhamphe group Epler	1	0	4	2	1	0
Allonais inaequalis	0	0	0	1	0	0
Atrichopogon sp.	1	0	0	0	0	0
Aulodrilus pigueti	0	0	0	1	0	0
Berosus sp.	0	0	9	0	0	0
Bezzia-Palpomyia complex Brigham	0	1	0	2	1	0
Buenoa sp.	0	1	0	0	0	0
Caecidotea sp.	0	4	0	0	0	0
Caenis eglinensis	0	0	2	0	0	0
Caenis punctata	50	0	0	66	25	0
Caenis sp.	0	0	0	0	0	18
Callibaetis floridanus	0	0	0	3	5	0
Callibaetis sp.	2	0	0	0	0	6
Cambaridae (LPIL)	0	1	0	0	0	0
Celina sp.	0	2	1	0	0	0
Cheumatopsyche sp.	53	0	0	0	0	0
Chironomini genus III Epler	0	0	11	0	1	0
Chironomus sp.	0	73	2	0	3	11
Chironomus stigmaterus	0	0	0	0	0	0
Cladopelma sp.	0	0	0	0	1	0
Cladotanytarsus viridiventris	0	0	0	1	0	0
Clinotanypus sp.	0	0	0	1	0	1
Coenagrionidae (LPIL)	0	0	0	0	0	1
Corixidae (LPIL)	0	0	0	5	0	0
Crangonyx sp.	0	2	0	0	0	0
Cricotopus bicinctus group Epler	1	0	0	1	0	5
Cryptochironomus sp.	0	0	0	0	0	1
Culicoides sp.	0	0	0	0	0	0
Curculionidae (LPIL)	0	0	0	0	5	0
Dasyhelea sp.	0	0	0	0	0	0
Dero digitata complex Milligan	0	3	4	0	2	3
Erythemis simplicicollis	0	0	0	1	19	0
Goeldichironomus cf. natans Epler	0	0	0	0	5	0
Hebetancylus excentricus	0	2	0	0	0	0
Hyalella azteca complex LeCroy	27	0	0	46	20	86
Hydrocanthus oblongus	0	1	0	0	0	1
Hydrocanthus sp.	0	0	2	1	0	1
Hydroporus sp.	0	5	0	0	0	0
Hydrovatus sp.	0	0	0	1	0	0
Ischnura ramburii	5	0	0	8	16	0

Table 8-A-6. Results of benthic macroinvertebrate collections for year 2014 Aug. Identification conducted by Water and Air Research, Inc. Only one (1) replicate was enumerated for 2014 Aug.

	SWT03	SWR01	FWC01	DWT01	DWT02	FWT03
Final ID (Taxon)	Rep 1	Rep 1	Rep 1	Rep 1	Rep 1	Rep 1
Ischnura sp.	0	0	2	0	0	0
Labrundinia neopilosella	0	0	1	1	0	0
Labrundinia virescens	0	0	1	0	0	0
Larsia decolorata	0	0	4	0	6	4
Lestes sp.	0	2	0	0	0	0
Libellula sp.	0	0	1	3	0	0
Libellulidae (LPIL)	0	1	0	0	1	0
Limoniinae (LPIL)	1	0	0	0	0	0
Lirceus sp.	0	0	0	0	0	9
Monopelopia boliekae	0	0	0	0	2	0
Nectopsyche sp.	2	0	0	0	0	0
Notonecta irrorata	0	2	0	0	0	0
Oecetis cinerascens	1	0	0	0	0	0
Oecetis inconspicua complex Pescador	0	0	0	0	1	0
Oecetis sp.	0	0	0	1	0	0
Omisus sp.	0	1	0	0	0	0
Orthocladiinae (LPIL)	2	0	0	0	0	0
Oxyethira sp.	1	0	0	2	0	0
Pachydiplax longipennis	0	37	0	0	11	0
Palmacorixa buenoi	0	0	18	0	0	0
Palpomyia-Sphaeromias group Brigham	0	0	0	0	0	1
Parachironomus chaetoalus complex Epler	1	0	5	0	1	0
Physella cubensis	3	0	0	2	1	0
Polypedilum illinoense group Epler	2	0	1	0	1	0
Pristina leidyi	0	0	0	0	0	3
Procladius (Holotanypus) sp.	0	9	3	0	0	0
Prodaticus bimarginatus	0	1	0	0	0	0
Prostoma sp.	0	0	0	0	0	0
Ranatra australis	1	0	1	0	0	0
Spirosperma sp.	0	0	0	0	0	0
Stenelmis sp.	1	0	0	0	0	0
Suphisellus sp.	0	2	1	0	1	0
Tabanidae (LPIL)	0	0	0	0	2	0
Tanypus carinatus	0	0	59	1	10	0
Tanytarsus sp. F Epler	0	0	0	0	4	1
Tanytarsus sp. G complex Epler	0	0	6	0	0	0
Thermonectus basillaris	0	0	2	0	0	0
Trichocorixa sp.	0	1	0	0	0	0
Total Individuals	**155**	**151**	**140**	**150**	**145**	**152**

Table 8-A-6. Results of benthic macroinvertebrate collections for year 2014 Aug. Identification conducted by Water and Air Research, Inc. Only one (1) replicate was enumerated for 2014 Aug.

	SWT03	SWR01	FWC01	DWT01	DWT02	FWT03
Final ID (Taxon)	Rep 1	Rep 1	Rep 1	Rep 1	Rep 1	Rep 1
Total Taxa	**18**	**20**	**22**	**21**	**25**	**16**

Table 8-A-7. Results of benthic macroinvertebrate collections for year 2015. Identification conducted by Water and Air Research, Inc. Only one (1) replicate was enumerated for 2015.

	DWT01	SWT03	SWR01	FWT03	FWC01	DWT02
Final ID (Taxon)	Rep 1	Rep 1	Rep 1	Rep 1	Rep 1	Rep 1
Ablabesmyia aspera	2	0	5	0	2	0
Ablabesmyia rhamphe group Epler	0	0	0	0	1	0
Aulodrilus pigueti	1	1	0	0	0	2
Berosus	0	0	0	0	3	0
Bezzia-Palpomyia complex Brigham	1	1	1	0	5	1
Caecidotea	0	0	55	0	59	0
Caenis eglinensis	19	35	0	18	0	32
Callibaetis floridanus	5	1	0	0	0	2
Cantopelopia gesta	0	0	2	0	0	0
Chauliodes rastricornis	0	0	1	0	0	0
Cheumatopsyche sp.	0	18	0	1	0	3
Chironomus sp.	0	0	5	11	0	11
Corixidae	1	1	3	0	0	0
Crangonyx sp.	0	0	16	0	26	0
Cricotopus bicinctus group Epler	0	1	0	10	0	0
Culicoides sp. group Brigham	0	0	0	2	1	0
Dineutus sp.	0	1	0	0	0	1
Dytiscidae (LPIL)	1	0	1	0	1	0
Eclipidrilus palustris	0	0	1	0	2	0
Elophila sp.	0	0	0	1	0	0
Enchytraeidae sp. A (LPIL)	0	0	4	0	12	0
Ephydridae (LPIL)	1	0	0	0	0	2
Erythemis simplicicollis	0	2	0	1	0	4
Hexatoma sp.	0	0	1	0	0	0
Hyalella azteca complex LeCroy	72	24	0	81	0	37
Hydrocanthus oblongus	0	0	0	3	0	1
Hydrocanthus sp.	0	0	0	0	1	0
Hydroptila sp.	0	2	0	0	1	0
Hydrovatus sp.	1	0	0	1	0	1
Ischnura posita	0	0	0	0	0	27
Ischnura sp.	0	4	0	3	0	0
Labrundinia neopilosella	1	0	0	0	0	0
Labrundinia virescens	0	3	0	2	0	0

Table 8-A-7. Results of benthic macroinvertebrate collections for year 2015. Identification conducted by Water and Air Research, Inc. Only one (1) replicate was enumerated for 2015.

	DWT01	SWT03	SWR01	FWT03	FWC01	DWT02
Final ID (Taxon)	Rep 1	Rep 1	Rep 1	Rep 1	Rep 1	Rep 1
Larsia berneri	0	0	0	0	2	0
Larsia decolorata	26	2	0	2	0	1
Libellula	1	0	0	0	0	0
Limnodrilus hoffmeisteri	0	14	0	0	0	0
Limoniinae (LPIL)	0	0	2	0	0	0
Lirceus sp.	1	3	0	1	0	0
Matus sp.	0	0	3	0	0	0
Mesovelia mulsanti	0	0	1	0	0	1
Micromenetus dilatatus	0	1	0	0	0	0
Monopelopia boliekae	0	0	0	0	5	0
Neoporus	0	0	26	0	0	0
Nigronia fasciata	0	0	0	1	0	0
Notonecta uhleri	0	0	2	0	0	1
Odontomyia/Hedriodiscus group Merritt	0	1	0	0	0	0
Oecetis cinerascens	1	4	0	0	0	0
Oecetis sp. E Floyd	0	0	0	2	3	2
Orthocladiinae (LPIL)	2	0	0	0	1	0
Oxyethira	0	0	0	0	1	0
Pachydiplax longipennis	0	0	5	0	0	1
Paratanytarsus sp.	1	2	0	0	0	1
Paratendipes subaequalis	0	0	0	0	9	0
Peltodytes sp.	1	0	0	0	2	0
Physella cubensis	4	6	0	0	0	0
Polypedilum illinoense group Epler	0	1	0	0	1	1
Procladius (Holotanypus)	0	0	5	0	0	0
Ranatra buenoi	0	0	0	0	0	1
Scirtes sp.	0	0	1	0	8	0
Sigara sp.	0	0	0	0	3	0
Simulium sp.	0	20	0	2	0	0
Staphylinidae (LPIL)	0	0	0	1	0	0
Suphisellus sp.	0	0	0	7	0	0
Tanypus carinatus	0	0	0	0	0	2
Tanytarsus sp. F Epler	1	0	0	0	0	10
Tanytarsus sp. G Epler	0	0	0	1	0	0
Tipula sp.	0	0	3	0	0	0
Total Individuals	**143**	**148**	**143**	**151**	**149**	**145**
Total Taxa	**20**	**23**	**21**	**20**	**22**	**23**

Table 8-A-8. Results of benthic macroinvertebrate collections for year 2016. Identification conducted by Water and Air Research, Inc. Only one (1) replicate was enumerated for 2016.

	SWT 03	SWR 01	DWT 01	FWT 03	FWC 01	DWT 02
Final ID (Taxon)	Rep 1	Rep 1	Rep 1	Rep 1	Rep 1	Rep 1
Ablabesmyia rhamphe group Epler	0	0	1	1	0	0
Ablabesmyia sp.	0	0	0	0	0	1
Allonais inaequalis	0	0	0	6	0	0
Anax junius	0	0	0	0	2	0
Atrichopogon sp.	0	0	0	1	0	0
Berosus sp.	0	0	0	0	3	0
Bezzia-Palpomyia complex Brigham	4	3	1	3	0	7
Caecidotea sp.	0	31	0	0	97	0
Caenis punctata	23	0	46	11	0	37
Callibaetis floridanus	0	0	1	0	0	0
Cambaridae (LPIL)	0	0	0	0	0	1
Cheumatopsyche sp.	20	0	3	32	0	0
Chironomus sp.	0	6	0	0	0	11
Cladopelma sp.	0	0	0	0	0	1
Coenagrionidae (LPIL)	0	0	1	0	1	0
Corixidae (LPIL)	0	7	0	0	0	0
Corynoneura sp.	0	0	3	0	0	0
Corynoneura sp. C Epler	0	0	0	0	0	9
Crangonyx sp.	0	23	0	0	21	0
Cricotopus bicinctus group Epler	0	0	8	4	0	2
Cryptotendipes sp.	0	0	4	0	0	0
Culicidae (LPIL)	0	0	0	0	1	0
Dineutus serrulatus	1	0	0	0	0	0
Eclipidrilus palustris	0	3	0	0	0	0
Elophila sp.	0	0	1	2	0	1
Enallagma sp.	4	1	0	0	0	0
Erythemis simplicicollis	0	0	0	6	0	1
Erythrodiplax sp.	0	0	0	0	0	1
Hebetancylus excentricus	0	6	0	0	0	5
Helius sp.	0	0	0	0	0	1
Heptageniidae (LPIL)	0	0	1	0	0	0
Hyalella azteca complex LeCroy	13	0	40	42	0	33
Hydaticus cinctipennis	0	1	0	0	0	0
Hydrocanthus oblongus	0	1	0	0	0	0
Hydroptila sp.	3	0	4	0	0	0
Ischnura posita	0	0	0	7	0	13
Ischnura sp.	1	0	0	0	0	0
Labrundinia pilosella	0	0	0	19	0	1
Larsia berneri	0	0	0	0	7	0
Larsia decolorata	1	3	0	0	0	0
Lestes vigilax	0	1	0	0	0	0

Table 8-A-8. Results of benthic macroinvertebrate collections for year 2016. Identification conducted by Water and Air Research, Inc. Only one (1) replicate was enumerated for 2016.

	SWT 03	SWR 01	DWT 01	FWT 03	FWC 01	DWT 02
Final ID (Taxon)	Rep 1	Rep 1	Rep 1	Rep 1	Rep 1	Rep 1
Libellulidae (LPIL)	0	0	0	0	1	0
Lirceus sp.	0	0	1	0	0	0
Matus sp.	0	4	0	0	0	0
Micromenetus dilatatus	0	0	0	0	0	3
Neoporus sp.	0	2	0	0	0	0
Oecetis sp.	0	2	0	0	1	0
Oecetis sp. E Floyd	0	0	0	0	1	0
Pachydiplax longipennis	0	5	0	0	0	5
Palpomyia-Sphaeromias group Brigham	0	0	0	1	0	0
Parapoynx sp.	0	0	0	0	1	0
Paratanytarsus dissimilis	1	0	0	0	0	0
Peltodytes sp.	0	1	0	0	0	0
Pentaneura inconspicua	1	0	0	0	0	0
Physella cubensis	6	0	0	1	0	0
Physidae (LPIL)	0	0	0	0	0	1
Polypedilum illinoense group Epler	0	1	0	0	0	1
Polypedilum trigonus	0	0	0	0	1	0
Polypedilum tritum	0	25	0	0	0	0
Procambarus sp.	1	1	0	0	0	0
Procladius (Holotanypus) sp.	0	0	0	0	1	0
Prostoma sp.	0	0	0	0	0	1
Ranatra australis	0	0	0	1	0	0
Rheotanytarsus exiguus group Epler	53	0	29	4	0	1
Rheotanytarsus pellucidus	7	0	0	0	0	0
Scirtes sp.	0	0	0	1	2	0
Scirtidae (LPIL)	0	0	0	0	0	1
Simulium sp.	10	0	2	2	0	0
Stenelmis sp.	3	0	0	0	0	0
Tanypus punctipennis	0	0	0	0	0	2
Tanytarsini (LPIL)	0	0	1	0	0	0
Tanytarsus sp. F Epler	0	0	0	0	0	1
Tanytarsus sp. G complex Epler	0	1	0	0	0	0
Thienemanniella xena	4	0	3	6	0	2
Uvarus sp.	0	14	0	0	0	0
Zavreliella marmorata	0	1	0	0	0	0
Total Organisms	**156**	**143**	**150**	**150**	**140**	**143**
Total Taxa	**18**	**23**	**18**	**19**	**14**	**26**

Table 8-A-9. Results of benthic macroinvertebrate collections for year 2017. Identification conducted by Water and Air Research, Inc. Only one (1) replicate was enumerated for 2017.

	FWT03	SWT03	SWR01	FWC01	DWT01	DWT02
Final ID (Taxon)	Rep 1	Rep 1	Rep 1	Rep 1	Rep 1	Rep 1
Turbellaria (LPIL)	0	0	0	0	2	0
Enchytraeidae (LPIL)	0	0	1	0	0	0
Dero digitata complex Milligan	0	0	22	0	0	0
Pristina leidyi	0	0	2	0	0	0
Pristina sp.	0	0	0	3	0	0
Aulodrilus pigueti	0	0	0	0	0	1
Tubificoid Naididae (LPIL) imm. w/ hair setae	0	0	0	0	0	1
Tubificoid Naididae (LPIL) imm. w/o hair setae	0	0	0	1	0	0
Eclipidrilus sp.	0	0	0	3	0	0
Crangonyx serratus	0	0	6	0	0	0
Crangonyx sp.	0	0	0	15	0	0
Gammarus cf tigrinus LeCroy	0	32	0	0	92	0
Hyalella azteca complex LeCroy	107	3	0	0	15	101
Procambarus sp.	0	0	1	0	0	0
Caecidotea sp.	0	0	19	107	0	0
Neoporus sp.	0	0	24	0	0	0
Stenelmis sp.	0	18	0	0	0	0
Hydrochus sp.	0	0	0	1	0	0
Berosus sp.	0	0	0	1	0	0
Enochrus sp.	0	0	1	0	0	0
Scirtes sp.	1	0	0	0	0	0
Atrichopogon sp.	0	0	0	2	1	0
Bezzia-Palpomyia complex Brigham	1	0	0	2	1	0
Palpomyia-Sphaeromias group Brigham	0	0	0	0	0	1
Cantopelpia gesta	0	0	1	0	0	0
Chironomini genus III Epler	0	0	0	1	0	0
Chironomus sp.	0	0	24	0	0	12
Clinotanypus sp.	2	0	0	0	0	0
Corynoneura sp.	1	0	0	0	0	0
Cricotopus politus	0	0	0	0	0	1
Labrundinia pilosella	0	0	0	0	0	1
Natarsia sp. A Epler	0	0	0	0	0	1
Parachironomus tenuicaudatus complex Epler	0	0	0	1	0	0
Paratendipes subaequalis	0	0	0	3	0	0
Pentaneura inconspicua	0	1	0	0	0	0
Polypedilum tritum	0	0	2	0	0	0
Procladius (Holotanypus) sp.	0	0	5	2	0	1
Psectrocladius (Monopsectrocladius) sp.	0	0	1	0	0	0
Rheotanytarsus exiguus group Epler	10	32	0	0	5	0
Tanypus carinatus	0	0	0	0	0	2
Tanytarsus sp.	0	0	1	0	0	0
Tanytarsus sp. F Epler	3	0	0	0	0	0
Thienemanniella xena	1	0	0	0	1	1
Simulium sp.	0	1	0	0	4	0
Odontomyia/Hedriodiscus group Merritt	0	0	0	0	2	0
Caenis punctata	9	5	0	0	8	10

Table 8-A-9. Results of benthic macroinvertebrate collections for year 2017. Identification conducted by Water and Air Research, Inc. Only one (1) replicate was enumerated for 2017.

Final ID (Taxon)	FWT03 Rep 1	SWT03 Rep 1	SWR01 Rep 1	FWC01 Rep 1	DWT01 Rep 1	DWT02 Rep 1
Corixidae (LPIL)	0	0	20	0	0	0
Palmacorixa sp.	0	0	0	6	0	0
Pelocoris balius	0	0	1	0	0	0
Notonectidae (LPIL)	0	0	4	0	0	0
Veliidae (LPIL)	0	0	1	0	0	0
Neargyractis sp.	0	0	0	1	0	0
Chauliodes sp.	0	0	1	0	0	0
Coenagrionidae (LPIL)	1	0	0	0	2	0
Enallagma sp.	0	1	0	0	0	0
Pachydiplax longipennis	0	0	3	0	0	0
Anisoptera (LPIL)	0	0	0	0	1	0
Cheumatopsyche sp.	13	43	0	0	12	15
Hydropsyche decalda	0	6	0	0	0	0
Hydropsyche sp.	1	0	0	0	0	0
Oecetis sp. F Floyd	0	0	0	1	0	0
Bivalvia (LPIL)	0	2	0	0	0	0
Sphaeriidae (LPIL)	0	0	0	0	2	0
Total Organisms	150	144	140	150	148	148
Total Taxa	12	11	20	16	14	13

9.0 VEGETATION

9.1 Vegetation Community Monitoring

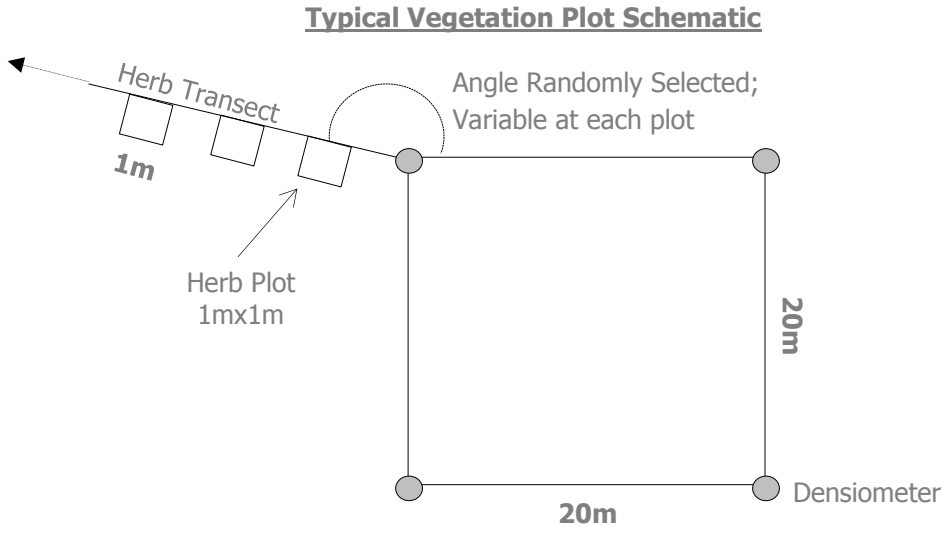
As a part of the original monitoring program for the EDS, a total of 67 vegetation stations were originally established and monitored for herbaceous community composition and canopy speciation and coverage (Figure 9-1). Baseline vegetation monitoring was conducted during spring and autumn 2008 in the EDS and during autumn 2008 and spring 2010 in the conservation areas. Of the 67 total vegetation stations, 37 were located within the EDS, while 30 were located within the Conservation Area (Figure 9-1). As vegetation monitoring progressed through the post-effluent monitoring period, data results indicated that a significant amount of redundancy existed between spring and autumn monitoring results. Thus, the biannual (i.e. twice per year) seasonal sampling was reduced to a single autumn monitoring event beginning in 2015. Further, post-effluent vegetation monitoring results demonstrated that vegetative community composition was becoming more similar between stations. Thus and in conjunction with field health and safety considerations, the total number of vegetative monitoring stations within the EDS was reduced in 2017 from a total of 37 stations to 20 stations. The 20 remaining stations were targeted to assess vegetative communities within each EDS zone (i.e. overland flow, hummock, and downgradient berm areas) which are described in Section 9.2 below. The total number of Conservation Area stations surveyed was reduced from 30 stations to 27 stations in 2017. The three station reduction included the three multivariate stations (FWR01, FWT02, and DWC02) which were also removed from the diel and analytical water quality monitoring program.

Community-scale vegetation sampling was based on permanent fixed-area plots at each monitoring station, including those multivariate stations that included diel and analytical water quality monitoring, in addition to vegetative surveys. A description of the vegetative plot naming conventions is provided in Section 2.2.1 and 2.2.5. During station establishment, 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. Tree speciation and diameter at breast height (dbh) was recorded for all trees (>3-inch dbh) within this 400m^2 plot. Tree speciation and dbh measurements were conducted annually during baseline monitoring (2008) and during post-effluent monitoring (2012 through 2017) events.

Densiometer readings were also collected from the four corners of the 400m^2 plot, and averaged to represent the total percent canopy coverage of the plot itself. Densiometer measurements were conducted at all stations during autumn 2008 and 2012, at 23 of the 67 plots during 2013, at 45 of the 67 plots in 2014, at all plots in 2015, at 65 of the 67 plots in 2016, and at 47 of the 67 plots in 2017. Percent canopy coverage represents the potential sunlight reaching the forest floor and can be used to help interpret herbaceous species coverage and diversity.

During plot establishment, a random bearing and distance from the northwest corner of the plot was used to mark the first 1m^2 herbaceous quadrat, and subsequent quadrats were established along the same bearing spaced at fixed 1-meter intervals along the herbaceous transect.

Percent coverage of all herbaceous and woody perennial species greater than 1-meter in height was visually estimated from these $1m^2$ quadrats. Additional quadrats were sited and sampled until the species-area curve reached a plateau. A minimum of six quadrats were sampled per site. A generalized vegetation monitoring plot schematic is presented below.



9.2 Vegetation Data Analysis

In order to evaluate the effects of effluent application on the different hydrologic gradients within the EDS and land management within the Conservation Area, each vegetative monitoring station was assigned a code based upon its relative geographic location within a particular "zone". For the EDS, stations were assigned to hummock/inundation areas upgradient of each berm (Zone 1), overland flow areas between berms (Zone 2), or areas within 100 meters downgradient of each berm (Zone 3). The location of each zone and vegetation plots are depicted in Figure 9-2. It should be noted that a true control does not exist for the EDS wetland stations due to the major changes in hydrology from pre- to post-effluent. Hydrologic conditions in the EDS pre-effluent were much shallower and dry conditions periodically occurred at many of the sites prior to the application of effluent. As well, the reference sites also have dry conditions during some parts of the year. The EDS now has a perennial hydroperiod with greater depths due to the application of effluent to the site. Changes in the hydrology of the EDS are detailed in Chapter 3. A lack of a true control that takes into account these important habitat variables makes it difficult to make direct comparisons between current EDS conditions and current reference conditions. Therefore, the evaluations of the EDS vegetative community are based on general trends in community composition and changes in species dominance since application of effluent. With this said, some inferences of correlated environmental variables are useful in examining which measured variables most influence the community present during sampling.

Stations within the Conservation Area have been subject to different land management activities and management recurrence. These included areas of mechanical shrub reduction, prescribed burning, and no management. The location of land management implementation areas are depicted in Figure 9-3. Management has been conducted at different intensities, different seasons, and different years across the conservation area. Thus, each monitoring station and the time of vegetation sampling in relation to management were not equivalent. Prescribed burning and mechanical shrub reduction were implemented in 2010 and continued through the autumn 2017 monitoring period.

9.2.1 Canopy Layer Characterization

Canopy layer characterizations, including canopy coverage, tree speciation, and dbh, within each 20m x 20m vegetation plot were completed and summarized. General summary statistics were calculated for each plot and compared within and between stations. Other summary metrics included basal area and stem density calculations.

9.2.2 Herbaceous Vegetation Characterization

In order to conduct station comparisons and statistical analyses, total species' coverages within each individual 1m x 1m herb plot were summed and then divided by the number of plots sampled to determine the average coverage of each herbaceous species along each herb transect. As such, the average coverage of each species was utilized to compare within and between station vegetation trends.

Comparisons of pre-effluent baseline data collected in 2008 to data collected during the post-effluent application (2012 – 2017) monitoring years are provided. Summary statistics including Shannon-Weiner diversity, evenness, species richness and effective species richness (Jost, 2006), were calculated for each station. The effective species richness is obtained by calculating the exponential of the Shannon-Weiner index values (Jost, 2006). The effective species richness is a measure of diversity that takes into account the frequency of species occurrence, and is a more robust representation of diversity than just richness alone. Additionally, importance values and wetland indicator status for each species were calculated for each unique sample event and used to interpret the vegetative community composition across the project site. Species importance values were calculated based upon species occurrence frequency and dominance within the sample plots and can range between 0.0 (rare and low density) to 2.0 (frequent and high density). Wetland indicator status designations were derived from the FDEP Wetland Evaluation and Delineation Program and the Atlas of Florida Vascular Plants webpages. A Weighted Prevalence Index was calculated by multiplying species relative percent dominance by a numeric interpretation of the Wetland Indicator Status (OBL=1, FACW=2, FAC=3, FACU=4, and U=5) to determine the communities relative affinity for wetness. In order to characterize general trends in herbaceous plot diversity metrics and effluent application effects, vegetation stations were grouped based upon their geographic location on the project site. The groups included: EDS freshwater, EDS tidal marsh, and Conservation Area.

9.3 Vegetation Results

9.3.1 Canopy Layer

Canopy layer characteristics were variable both between stations, between years, and between the EDS and conservation areas. Within the EDS in 2017, the canopy layer was dominated by slash pine (*Pinus elliotii*) with various subdominant species including swamp tupelo (*Nyssa biflora*), sweetbay (*Magnolia virginiana*), and black titi (*Cliftonia monophylla*) (Table 9-1, Figure 9-4). Although a canopy layer exists on the project site, it is typically limited in aerial coverage with several plots having little or no canopy coverage. Additionally and during hummock construction between 2010 and 2011 within the inundated areas where hummocks were constructed (Zone 1), all canopy species were mechanically harvested. In 2017, stem densities within the EDS ranged between 233 stems per acre at sampling location v2-626c, to zero (0) stems per acre at 13 of the 20 surveyed EDS plots with an average of 33 stems per acre over the entire EDS (Table 9-2). Between 2008 and 2017, average canopy species density decreased from 203 stems per acre to 33 stems per acre (Table 9-2). While the average density for all observed canopy species decreased between 2008 and 2017, the most significant declines were observed for black titi, swamp tupelo, and loblolly pine (Table 9-1). Similarly, average basal area within the EDS decreased between 2008 and 2017 from an average of 40 ft^2/ac to 7.7 ft^2/ac (Table 9-2). Generally, the reduction in canopy metrics was likely driven by changes in hydrology and specifically, increases in flood frequency and duration across the EDS as a result of effluent application. Prior to effluent application, the two most dominant canopy species were slash pine and black titi, both of which are intolerant to being inundated for long durations (Figure 9-4). Mechanical land clearing as a part of hummock construction also resulted in the significant reduction of canopy species between 2008 and 2012 (Table 9-1, Figure 9-4). The reduction in canopy species as part of hummock construction resulted in nearly 100% removal of canopy species at four of the 20 vegetative plots monitored in 2017 (Figure 9-4). Prior to construction, these 4 stations had an average of 281 stems per acre, whereas the same stations had an average of 5 stems per acre in 2017 (Figure 9-4). It should be noted that the canopy stem density in 2017 increased from measured densities of 0 stems per acre in monitoring years 2013, 2014, 2015, and 2016 as a result of maturing planted tree species atop the constructed hummocks (Figure 9-4). At the remaining 16 vegetation monitoring stations, average canopy species density decreased by 76% between 2008 and 2017 from an average of 171 stems per acre to 41 stems per acre, respectively (Figure 9-4). Although some reduction in canopy density between 2008 and 2017 within the EDS was a result of mechanized clearing, the 2017 monitoring data suggest that planted trees within the hummock areas (Zone 1) are beginning to achieve sizes that provide shading and habitat for aquatic and terrestrial biota.

In the conservation areas, active landscape management, including mechanical shrub reduction and prescribed burning, was conducted at 18 of the 30 vegetation plots and these management practices appear to have somewhat influenced the canopy metrics. Within the wetland portions of the Conservation Area, the canopy layer was dominated by slash pine and swamp tupelo with various subdominant species including sweetbay, black titi, swamp titi, pond cypress, Atlantic white cedar (*Chamaecyparis thyoides*), red maple (*Acer rubrum*) (Table 9-3, Figure 9-5). Longleaf pine (*Pinus palustris*) dominated the xeric sandhill portion of the Conservation Area (Table 9-3, Figure 9-5). In contrast to the EDS plots, a majority of the canopy metrics remained similar between 2008 and 2017 (Table 9-2).

9.3.2 Herbaceous Layer Vegetation

Herbaceous vegetation data collected in 2017 is presented in Appendix 9-A. A cumulative total of 260 species have been inventoried during the autumn 2008, 2010, and 2012 through 2017 herbaceous vegetation monitoring events (Table 9-5). A list of the dominant species inventoried, as based upon importance value calculations, with their respective aerial percent coverage across all stations is included in Tables 9-6 and 9-7 and graphically depicted in Figures 9-10 through 9-13. All species with an importance value greater than at least 0.075 during any given sample event were included.

Between 2008 and 2013 within the EDS and conservation area, black titi was the most dominant taxon inventoried across the site in all years (Tables 9-6 and 9-7). In 2014 through 2017, cattail (*Typha latifolia*) was the most dominant taxon in the EDS comprising 27%, 29%, 39%, and 42% of the total vegetative coverage, respectively, while black titi remained dominant within the conservation areas comprising 14%, 11%, 12%, and 15% of the total vegetative coverage, respectively (Tables 9-6 and 9-7, Figures 9-10 and 9-12). In addition to cattail within the EDS in 2017, largeleaf marshpennywort (*Hydrocotyl bonariensis*), anglestem primrosewillow (*Ludwigia leptocarpa*), purple bluestem (*Andropogon glomeratus var. glaucopis*), and watersprite (*Ceratopteris thalictroides*) all had importance values greater than 0.075 (Table 9-6). Within the EDS, six species were found in greater than 50% of the plots sampled: anglestem primrosewillow (87% of plots), climbing hempvine (*Mikania scandens*) (87% of plots), largeleaf marshpennywort (80% of plots), cattail (80% of plots), purple bluestem (*Andropogon glomeratus var. glaucopsis*) (73% of plots), and watersprite (67% of plots) (Table 9-6, Figure 9-11).

In addition to black titi within the Conservation Area, sphagnum moss (*Sphagnum* spp.), inkberry (*Ilex glabra*), and large gallberry (*Ilex coriacea*) had importance values greater than 0.075 during 2017 monitoring (Table 9-7). Within the conservation area five species were found in greater than 50% of the plots sampled: black titi (81% of plots), large gallberry (69% of plots), inkberry (58% of plots), sphagnum moss (54% of plots), and woolly huckleberry (*Gaylussacia mosieri*) (54% of plots) (Table 9-7, Figure 9-13).

9.3.2.1 Diversity Statistics

Individual plot diversity statistics for the autumn 2017 monitoring event are included in Appendix 9-A, but due to the large number of plots sampled during all monitoring events only summary statistics are discussed below.

9.3.2.1.1 Freshwater EDS

Following the application of effluent to the EDS wetlands in 2012, changes in herbaceous vegetation layer composition have been observed in each subsequent monitoring year as the community transitions based upon the post-effluent hydrologic, soil, and water quality conditions as characterized in Chapters 3, 5, 6, and 7 of this report. Beginning in autumn 2012, all calculated diversity metrics, including Shannon diversity, evenness, species richness, and effective species richness, began to decline in the EDS when compared to 2008 monitoring results (Table 9-8; Figures 9-6 through 9-9). Based upon 2013 through 2017 monitoring results, the same diversity metrics showed year over year increases (Table 9-8; Figures 9-6 through 9-

9). Species richness has increased by 7% from an annual average of 18.1 species per plot in 2008 to 19.3 species per plot in 2017 (Table 9-8). In contrast, effective species richness has declined by 42% from an average of 6.6 species per plot in 2008 to 3.9 species per plot in 2017 which suggests that while, on average, more species are present during post-effluent monitoring that a fewer number of taxa comprise a majority of the aerial coverage across the site (Table 9-8). Shannon Diversity and evenness have both declined by an annual site average of 27% between 2008 and 2017, respectively (Table 9-6). Between 2012 and 2017, diversity metrics within the EDS have steadily increased suggesting that an increasingly more diverse vegetative community is reestablishing following initial effluent application. Species diversity metrics increased between 264% (effective species richness) and 43% (species richness) between autumn 2012 and 2017 within the EDS (Table 9-8). The application of effluent within the EDS has increased wetland hydroperiod (see Chapter 3 for details), which creates conditions more favorable for water tolerant species as suggested by the decrease in Weighted Prevalence Index values from 1.86 in 2008 to 1.41 in 2017 (Table 9-6).

Increased diversity metrics scores are likely being driven by the reestablishment of a characteristic herbaceous vegetative community based upon differing hydroperiod and habitat preferences within the EDS. In autumn 2012, an average of 20% of each herbaceous transect was vegetated. Between 2013 and 2017, the average percent vegetative coverage within each plot increased from 24% to 73%, respectively. This is supported by field observations of herbaceous and graminoid recolonization occurring within areas exposed above the water surface which were once dominated by dense woody vegetation. The decline of woody species, primarily including black titi and coastal plain St. John's-wort, within these areas is allowing sunlight to penetrate to the ground surface which is promoting the growth of once precluded herbaceous vegetation such as climbing hempvine, herb of grace, knotweeds, cattail, and warty panicgrass (*Panicum verrucosum*) (Figures 9-10 and 9-11).

9.3.2.1.2 Freshwater Conservation Area

Diversity metric declines from 2008 baseline inventories within the Conservation Area were observed beginning in autumn 2012 and continued through 2015, with the exception of species richness (Table 9-8, Figures 9-6 through 9-9). In 2016 and 2017, Conservation Area average diversity metric values increased to values similar to our greater than those observed in 2008 (Table 9-8, Figures 9-6 through 9-9). While the 2012 through 2015 decreases in diversity were evident, the magnitude of the decrease was less than that observed within the EDS. Average annual species richness and effective species richness both increased by 7%, while Shannon Diversity and evenness decreased by 6% and 9%, respectively, between 2008 and 2016 (Table 9-8). Although annual and seasonal vegetative community shifts appear to have occurred during the monitoring period, the 2008, 2012, 2013, 2014, 2015, 2016, and 2017 average Weighted Prevalence Index values of 1.86, 1.85, 1.84, 1.80, 1.87, 1.70, and 1.73, respectively, suggest that the community continues to be dominated by obligate and facultative wetland species (Table 9-8). Initial declines between 2008 and 2012 were likely driven by the comparatively large areas of mechanical shrub reduction and burning that occurred during this period (Figure 9-3). Since 2012, the total amount of land management activities has decreased, and many areas previously managed in 2010-2012 as well as in 2013 have been allowed to recover, resulting in the steady increase in diversity metrics between 2012 and 2017 (Table 9-8; Figure 9-3 and Figures 9-6 through 9-9).

9.3.2.1.3 Tidally Influenced Wetlands

Within the tidally influenced portion of the EDS, all overall species diversity metrics decreased between 2008 and 2017, with the exception of species richness which increased by an annual average of 20% (Table 9-9). Herbaceous vegetative communities within the tidally influenced EDS area continue to be dominated by black needlerush (*Juncus roemerianus*) and sawgrass (*Cladium jamaicense*) which comprised 32% and 56% of the community during autumn 2017 monitoring, respectively (Table 9-10). Only two other species had importance values greater than 0.075: wax myrtle (*Morella cerifera*) and knotweeds (Table 9-10). Based on field observations, there does appear to be an increased hydroperiod upgradient of the blackneedle rush dominated marsh surrounding Tee and Wicker Lakes. Although an increase in species richness has been observed between 2008 and 2017, the increased hydroperiod has reduced habitat variability and a more homogeneous wetland system is now present in the transitional wetland area between the tidally influenced and freshwater portions of the EDS.

9.3.2.2 Conservation Area Management

Due to the heterogeneity of environmental conditions, the complexity of vegetative community composition drivers, and differences in land management methods, frequency, and intensity, it is difficult to quantify the effect of management on vegetative communities within the Conservation Area. When combining all conservation area stations, initial diversity metric value declines were measured immediately following management with the exception of species richness (Figures 9-6 through 9-9). Following the initial management activities conducted between 2011 and 2012, diversity metric values increased between 2013 and 2017 to similar ranges as those measured during pre-management monitoring events (Figures 9-6 through 9-9). To assess the effects of land management on vegetative community structure, temporal trends, and diversity metrics, conservation area stations were grouped by stations where land management activities have been implemented and compared to non-managed stations.

For all diversity metrics calculated, land management activities resulted in increased metric scores from 2008 to 2017, while similar or decreased diversity metric scores were observed at stations not subjected to land management (Table 9-11 and 9-12, Figures 9-14 and 9-15). Average species richness increased from 18.2 species per plot to 21.2 species per plot at stations subject to land management (Table 9-12). Average species richness decreased from 15.6 species per plot to 14.2 species per plot at unmanaged stations (Table 9-11). Additionally, average Shannon-Wiener diversity index scores increased between 2008 and 2017 at the managed stations, while scores decreased between 2008 and 2017 at non-managed stations (Tables 9-11 and 9-12; Figure 9-15).

Based upon these comparisons, it appears that the initial land management "disturbance" caused a short-term depression in vegetative community diversity, but since then, diversity has increased in comparison to non-managed areas as species have recolonized after the initial management activities. Both prescribed burning and mechanical shrub reduction have effectively reduced canopy coverage and stimulated herbaceous and graminoid growth.

The pre-management conditions, including hydrology, soil type, and historic and contemporary seed bed, likely influenced the vegetative composition of a particular area and will continue to influence those communities post-management. Due to these factors, direct comparisons of

vegetative community composition within areas subject to different land management strategies cannot be definitively used to determine if community change occurred due to land management or to other unmeasured environmental variables.

9.4 Conclusions

Based upon the results of vegetation community sampling, several vegetative community trends were observed on the overall project site. As was expected, the vegetative communities within the EDS are changing as a result of effluent application, depending on geographic location on the EDS site. Likewise within the Conservation Area, vegetative communities are changing due to land management activities. Due to the short time since respective "disturbance" events (effluent application within the EDS and land management within the Conservation Area), vegetative community composition is changing with the newly created habitats available to opportunistic and pioneer species. Based upon 2017 data analysis results, it appears that the degree of change in vegetative community diversity metrics at the EDS and Conservation Area vegetative monitoring stations is beginning to slow as new vegetative communities are establishing. A summarized list of significant conclusions is included below.

- Increased hydroperiods since 2012 coupled with the historic presence of silviculturally established canopy species (i.e. slash and loblolly pine) within the EDS has resulted in a large decline in canopy species density and abundance between 2008 and 2017 due to mass tree mortality. It is anticipated that canopy species native to the area and tolerant of long periods of inundation (i.e. bald and pond cypress, swamp tupelo, sweetbay, etc) will become reestablished within the EDS. Additionally, initial construction of the EDS in 2011 also contributed to canopy species declines observed since 2012.

- Preliminary results indicate that land management activities within the Conservation Area are resulting in increased vegetative community diversity when compared to non-managed areas. It is anticipated that continued management to maintain an open canopy will continue to stimulate a diverse herbaceous and graminoid community.

- Site heterogeneity the lack of a complete suite of characterization variables, and the lack of true control areas diluted the ability to make strong conclusions about the direction and magnitude of vegetation community shifts.

- Future post-project monitoring events will be compared to both pre-project results in order to document further ongoing changes in vegetation communities within the EDS and Conservation Areas.

9.5 Literature Cited

Dufrene, M., and Legendre, P. 1997. Species assemblages and indicator species: the need for a flexible asymmetrical approach. Ecological Monographs 67: 345-366.

Jost, L. 2006. Entropy and diversity. Oikos 113: 363-375.

McCune, B., and Grace, J.B. 2002. Analysis of Ecological Communities. MJM Software Design, Gleneden Beach, Oregon.

Table 9-1. Average canopy tree density within the EDS by management zone, 2008 (baseline) and 2012 through 2017 (post-effluent).

Species		Common Name	Canopy Tree Density by Year (stems per acre)						
			2008	2012	2013	2014	2015	2016	2017
Un-harvested Areas (Overland Flow Zone)[1]									
	Cliftonia monophylla	Black titi	18.7	1.1	2.2	2.2	1.5	1.9	1.1
	Cyrilla racemiflora	Titi	7.9	1.9	6.4	3.4	0.0	0.0	4.5
	Magnolia virginiana	Sweetbay	0.7	2.2	1.9	1.5	0.7	1.5	4.5
	Nyssa biflora	Swamp tupelo	43.9	6.4	5.2	6.0	5.2	1.9	6.2
	Persea palustrus	Swamp bay	0.0	0.0	0.4	0.7	0.4	0.4	0.0
	Pinus elliottii	Slash pine	43.9	29.2	28.9	13.1	12.0	17.2	18.0
	Pinus taeda	Loblolly pine	15.0	26.6	12.7	12.7	7.9	6.7	0.6
	Quercus virginiana	Live oak	0.0	1.1	1.1	1.1	1.1	1.1	1.7
	Taxodium ascendens	Pond-cypress	0.4	1.5	0.4	0.7	0.4	0.4	0.6
Harvested Areas (Hummock/Inundation Zone)[1]									
	Cliftonia monophylla	Black titi	92.4	0.0	0.0	0.0	0.0	0.0	0.0
	Cyrilla racemiflora	Titi	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Magnolia virginiana	Sweetbay	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Nyssa biflora	Swamp tupelo	125.3	0.0	0.0	0.0	0.0	0.0	0.0
	Persea palustrus	Swamp bay	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Pinus elliottii	Slash pine	125.3	24.0	0.0	1.3	0.0	0.0	6.7
	Pinus taeda	Loblolly pine	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Quercus virginiana	Live oak	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Taxodium ascendens	Pond-cypress	0.0	0.0	0.0	0.0	0.0	0.0	0.0

[1] Permitted pre-construction mechanical tree harvesting was conducted between 2010 and 2011 in order to facilitate construction of the hummocks.

Table 9-2. EDS station canopy metrics, 2008 (baseline) and 2012 through 2017 (post-effluent).

	Average Canopy Coverage							Trees per acre							Basal Area						
	%							No. of stems per acre							(ft^2/ac)						
Station	2008	2012	2013	2014	2015	2016	2017	2008	2012	2013	2014	2015	2016	2017	2008	2012	2013	2014	2015	2016	2017
DWT-01	1.8	0.0	0.0	0.0	0.0	0.0	NM	0	0	0	10	0	0	NM	0.0	0.0	0.0	0.5	0.0	0.0	NM
DWT-02	0.0	0.0	0.0	0.0	0.0	0.0	NM	0	20	30	30	0	0	NM	0.0	1.1	5.2	5.2	0.0	0.0	NM
FWT-03	3.0	6.6	NM	0.0	0.0	0.0	NM	71	40	20	10	0	0	NM	7.7	5.7	4.0	1.6	0.0	0.0	NM
Marsh-1	NM	9.1	NM	0.5	3.3	0.0	NM	0	61	30	10	0	0	NM	NM	13.9	5.9	1.6	0.0	0.0	NM
Marsh-2	NM	0.0	0.0	0.0	0.0	0.0	NM	0	0	0	0	0	0	0	NM	0.0	0.0	0.0	0.0	0.0	0.0
SWT-03	62.4	52.5	NM	NM	21.0	76.5	64.3	638	202	466	375	192	121	0	108.9	40.8	80.1	0.0	40.3	38.3	0.0
TWT-01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0	0	0	NM	0.0	0.0	0.0	0.0	0.0	0.0	NM
v1-626a	11.1	0.0	0.0	0.0	0.0	0.0	NM	243	0	0	0	0	0	NM	17.2	0.0	0.0	0.0	0.0	0.0	28.9
v1-643a	0.0	0.0	0.0	0.0	0.0	0.0	12.8	0	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
v2-625a	0.0	37.6	NM	44.0	32.6	31.8	87.3	0	142	142	142	132	132	NM	0.0	59.0	65.1	72.8	73.1	69.8	NM
v2-625b	3.8	26.0	NM	0.0	0.0	0.0	29.5	61	111	0	0	10	10	20	4.6	13.1	0.0	0.0	0.9	0.0	2.1
v2-625c	2.5	0.5	0.0	0.0	13.1	21.2	38.5	0	0	0	0	0	0	132	0.0	0.0	0.0	0.0	0.0	0.0	69.7
v2-625d	30.6	41.7	NM	5.5	1.0	2.8	NM	314	375	81	61	30	40	10	37.9	76.1	23.0	23.2	7.8	10.4	0.0
v2-626b	2.0	2.0	NM	69.5	0.0	21.2	NM	0	20	0	0	0	10	0	0.0	1.1	0.0	0.0	0.0	0.9	0.0
v2-626c	2.0	13.9	NM	NM	52.5	21.2	78.8	30	142	263	283	172	324	233	2.1	24.2	45.4	52.4	31.8	64.3	NM
v2-643b	0.0	0.0	0.0	0.0	0.0	0.0	NM	0	0	0	0	0	0	NM	0.0	0.0	0.0	0.0	0.0	0.0	NM
v3-611b	24.0	0.0	NM	NM	0.8	0.0	NM	61	40	0	30	40	0	81	6.8	12.2	0.0	2.6	3.2	0.0	16.8
v3-625e	48.2	29.6	NM	NM	23.2	41.4	7.8	304	111	142	51	91	111	NM	125.7	78.3	89.7	30.1	29.2	32.6	NM
v3-625f	63.9	22.0	NM	0.0	NM	0.0	0.0	324	71	30	0	0	0	NM	78.3	25.8	3.5	0.0	0.0	0.0	NM
v3-625g	31.8	1.5	NM	0.0	0.0	0.0	0.0	557	40	20	0	0	0	142	123.5	3.0	2.8	0.0	0.0	0.0	29.0
v3-625h	33.1	0.0	0.0	0.0	0.0	0.0	NM	466	0	0	0	0	0	0	49.4	0.0	0.0	0.0	0.0	0.0	0.0
v3-627a	64.2	2.0	NM	0.0	0.0	NM	0.0	587	20	0	0	0	NM	0	96.2	1.6	0.0	0.0	0.0	NM	0.0
v3-627b	57.6	0.0	0.0	0.0	0.0	0.0	NM	800	0	0	0	0	0	NM	104.9	0.0	0.0	0.0	0.0	0.0	NM
v3-627c	60.4	0.0	0.0	0.0	0.0	0.0	3.3	536	0	0	0	0	0	0	102.6	0.0	0.0	0.0	0.0	0.0	0.0
v4-611c	10.9	0.0	NM	NM	0.0	0.0	NM	91	0	0	0	0	0	NM	6.4	0.0	0.0	0.0	0.0	0.0	NM
v4-611d	71.2	31.8	NM	0.0	NM	NM	NM	1245	40	213	61	NM	NM	0	144.1	12.8	24.2	6.3	NM	NM	0.0
v4-625i	30.8	30.8	NM	NM	0.5	0.0	3.0	385	192	142	10	10	10	NM	85.8	42.9	21.3	1.1	2.1	2.1	NM
v4-625j	8.1	25.3	NM	17.5	0.0	0.0	NM	10	10	10	0	0	0	NM	0.8	0.8	1.4	0.0	0.0	0.0	NM

NC = not calculated due to insufficient data
NM = not measured

Table 9-2. EDS station canopy metrics, 2008 (baseline) and 2012 through 2017 (post-effluent) (continued).

	Average Canopy Coverage							Trees per acre							Basal Area						
	%							No. of stems per acre							(ft^2/ac)						
Station	2008	2012	2013	2014	2015	2016	2017	2008	2012	2013	2014	2015	2016	2017	2008	2012	2013	2014	2015	2016	2017
v4-625k	30.8	20.0	NM	7.0	5.6	23.7	6.5	223	101	152	51	51	20	51	121.9	49.9	58.3	7.0	10.0	4.6	11.0
v4-625l	19.2	40.7	NM	0.0	0.0	0.0	NM	20	172	0	10	0	0	NM	15.6	34.1	0.0	0.6	0.0	0.0	NM
v4-627d	60.1	17.9	NM	NM	0.3	0.0	NM	273	30	0	0	0	0	NM	27.0	6.6	0.0	0.0	0.0	0.0	NM
v4-643c	0.0	0.0	0.0	NM	0.0	0.0	0.0	0	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
v4-643d	0.0	0.0	0.0	NM	0.3	0.0	0.0	0	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
v5-613a	13.6	9.3	NM	NM	0.0	0.0	0.0	111	61	10	0	0	0	0	45.9	22.0	1.3	0.0	0.0	0.0	0.0
v5-613b	26.9	37.9	NM	0.0	0.0	0.0	0.0	162	111	40	20	0	0	0	95.9	50.7	5.4	1.8	0.0	0.0	0.0
v5-625m	0.0	7.8	NM	NM	0.0	0.0	NM	0	10	20	30	20	20	0	0.0	0.8	1.1	1.8	1.2	1.2	0.0
v5-625n	15.9	32.1	NM	NM	29.3	30.6	NM	0	0	0	10	40	40	NM	0.0	0.0	0.0	0.5	2.3	2.7	NM
Average	**23**	**13**	**NC**	**6**	**5**	**8**	**18**	**203**	**57**	**49**	**32**	**22**	**24**	**33**	**40**	**16**	**12**	**6.0**	**5.8**	**6.7**	**7.7**
Median	**14**	**7**	**NC**	**0**	**0**	**0**	**3**	**61**	**20**	**0**	**0**	**0**	**0**	**0**	**8**	**2**	**0**	**0**	**0**	**0**	**0**
Standard Deviation	**24**	**16**	**NC**	**16**	**12**	**16**	**29**	**281**	**80**	**96**	**77**	**48**	**62**	**61**	**49**	**22**	**24**	**15**	**15**	**17**	**17**

NC = not calculated due to insufficient data
NM = not measured

Table 9-3. Average canopy tree density within the Conservation Area by management type, 2008 (baseline) and 2012 through 2017 (post-management).

Species		Common Name	Canopy Tree Density by Year (stems per acre)						
			2008	2012	2013	2014	2015	2016	2017
Entire Conservation Area									
	Acer rubrum	Red maple	0.0	0.4	0.4	0.4	0.4	0.4	0.4
	Cliftonia monophylla	Black titi	9.0	8.2	12.4	7.1	13.9	10.5	17.2
	Cyrilla racemiflora	Titi	2.2	7.5	4.9	2.2	1.9	1.1	2.2
	Ilex myrtifolia	Myrtle dahoon	0.0	0.0	0.4	2.2	0.4	0.4	0.4
	Magnolia virginiana	Sweetbay	18.0	19.1	15.7	12.4	18.0	17.2	18.4
	Nyssa biflora	Swamp tupelo	37.9	34.1	34.1	36.7	32.6	33.0	36.7
	Persea palustrus	Swamp bay	0.4	0.4	0.7	0.7	0.7	0.7	0.7
	Pinus elliottii	Slash pine	68.2	63.7	66.0	77.2	68.6	61.1	54.0
	Pinus palustris	Longleaf pine	19.5	18.0	19.9	17.6	13.5	23.2	25.5
	Taxodium ascendens	Pond-cypress	4.1	3.7	4.9	3.7	4.1	3.0	3.4
Managed Plots Only									
	Acer rubrum	Red maple	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Cliftonia monophylla	Black titi	6.0	1.2	10.1	0.0	4.2	0.0	7.1
	Cyrilla racemiflora	Titi	0.0	6.5	0.0	0.0	0.0	0.0	0.0
	Ilex myrtifolia	Myrtle dahoon	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Magnolia virginiana	Sweetbay	6.0	6.0	2.4	0.0	1.2	1.2	1.2
	Nyssa biflora	Swamp tupelo	2.4	3.0	1.2	0.0	0.6	0.0	0.0
	Persea palustrus	Swamp bay	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Pinus elliottii	Slash pine	34.5	31.6	32.2	48.8	36.3	30.4	27.4
	Pinus palustris	Longleaf pine	31.0	28.6	31.6	28.0	21.4	36.9	40.5
	Taxodium ascendens	Pond-cypress	1.2	0.0	0.6	0.6	0.6	0.6	0.0
Un-managed Plots Only									
	Acer rubrum	Red maple	0.0	1.0	1.0	1.0	1.0	1.0	1.0
	Cliftonia monophylla	Black titi	14.2	20.2	16.2	19.2	30.4	28.3	34.4
	Cyrilla racemiflora	Titi	6.1	9.1	13.2	6.1	5.1	3.0	6.1
	Ilex myrtifolia	Myrtle dahoon	0.0	0.0	1.0	6.1	1.0	1.0	1.0
	Magnolia virginiana	Sweetbay	38.5	41.5	38.5	33.4	46.6	44.5	47.6
	Nyssa biflora	Swamp tupelo	98.2	87.1	90.1	99.2	87.1	89.1	99.2
	Persea palustrus	Swamp bay	1.0	1.0	2.0	2.0	2.0	2.0	2.0
	Pinus elliottii	Slash pine	125.5	118.4	123.5	125.5	123.5	113.4	99.2
	Pinus palustris	Longleaf pine	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Taxodium ascendens	Pond-cypress	9.1	10.1	12.1	9.1	10.1	7.1	9.1

Table 9-4. Conservation Area station canopy metrics, 2008 (baseline) and 2012 through 2017 (post-effluent).

	Average Canopy Coverage							Trees per acre							Basal Area (ft^2/ac)						
	%							No. of stems per acre							(ft^2/ac)						
Station	2008	2012	2013	2014	2015	2016	2017	2008	2012	2013	2014	2015	2016	2017	2008	2012	2013	2014	2015	2016	2017
FWC-01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
SWR-01	68.0	48.2	NM	NM	74.0	83.0	71.3	759	577	709	749	648	698	759	171	149	162	180	172	183	170
TWC-01	0.0	0.0	0.0	NM	30.8	0.0	0.0	0	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
vN-411a	21.5	41.2	NM	44.5	47.0	NM	89.5	91	71	81	101	61	101	91	39.7	34.4	32.0	66.7	41.0	53.9	67.2
vN-412a	23.7	40.9	NM	48.0	43.4	70.5	47.8	202	223	213	192	192	364	445	27.9	44.9	44.7	45.4	45.7	91.3	112
vN-412b	43.2	38.4	NM	51.3	43.2	72.0	64.5	324	263	324	283	283	263	243	69.4	72.8	92.7	93.7	81.9	82.0	80.6
vN-611a	73.0	60.9	NM	NM	65.9	91.8	93.0	709	759	617	587	607	607	648	132	149	126	128	126	134	139
vN-614a	56.6	33.6	NM	0.0	15.2	65.3	56.5	111	152	182	0	91	0	142	9.3	14.6	17.8	0.0	12.2	0.0	16.5
vN-625a	18.7	32.3	NM	23.5	28.0	52.8	30.3	40	30	30	40	30	40	40	43.8	31.7	29.5	46.7	33.2	48.2	23.7
vN-625b	13.4	28.5	NM	24.8	34.4	61.8	30.5	71	61	61	81	71	40	40	25.7	26.0	28.9	39.9	41.3	19.4	31.4
vN-625c	50.0	50.0	NM	NM	29.6	44.8	76.5	213	213	101	0	40	51	30	80.0	80.0	47.1	0.0	22.5	30.8	24.6
vN-626a	22.7	21.5	NM	NM	8.8	17.3	32.5	61	91	91	0	91	81	81	4.4	10.5	11.7	0.0	11.7	10.2	11.4
vW-411a	20.5	14.7	15.9	29.0	17.9	21.8	35.8	61	30	61	51	61	61	61	20.3	14.1	30.1	24.2	33.0	35.1	37.8
vW-611a	29.8	47.5	NM	17.7	NM	74.0	50.0	415	445	354	375	466	304	0	48.6	56.5	58.0	60.9	70.1	54.4	0.0
vW-614a	68.0	29.0	NM	18.4	NM	26.0	76.3	40	71	51	61	91	162	111	8.5	15.6	13.8	16.0	18.1	33.3	18.2
vW-625a	24.8	11.6	NM	10.4	16.9	29.3	54.5	0	30	51	101	71	81	132	0.0	2.3	4.6	9.4	6.9	9.5	18.0
vW-625b	33.6	6.3	28.0	35.1	16.7	25.0	63.5	61	40	40	30	40	40	40	27.3	24.9	27.6	21.5	30.8	33.4	35.8
vW-625c	53.8	43.4	NM	38.6	2.5	60.3	42.8	192	182	314	202	202	162	172	62.7	65.4	147	71.0	73.1	69.0	62.2
vW-625d	12.9	41.7	53.6	37.9	36.1	55.0	68.5	20	40	30	30	10	40	91	14.3	35.4	20.1	20.0	17.7	22.7	29.4
vW-625e	4.3	2.5	NM	NM	1.3	2.3	NM	20	20	10	10	0	10	0	11.1	11.1	4.0	4.1	0.0	5.7	0.0
vW-626a	0.0	0.0	0.0	0.0	NM	0.0	0.5	0	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
vW-626b	4.0	4.8	4.3	4.0	0.0	6.8	7.0	10	10	10	10	10	10	10	7.4	7.4	7.6	7.7	8.1	7.8	8.6
vW-626c	4.5	19.7	7.1	4.3	4.5	9.8	8.8	30	30	30	30	40	30	61	6.5	7.6	8.3	5.9	9.9	9.4	11.5
vW-626d	0.0	6.8	0.0	0.0	0.0	0.0	6.8	0	0	0	0	0	0	0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
vW-626e	15.2	14.9	NM	NM	13.6	18.3	0.0	81	71	91	81	81	81	10	12.4	12.1	16.8	16.3	0.1	18	4.4
vW-627a	36.1	85.6	NM	71.5	NM	76.8	77.0	334	425	496	516	577	506	729	67.2	86.6	101	101	102	118	135
vW-627b	37.1	53.3	51.0	54.3	NM	65.5	65.8	456	364	364	395	395	334	354	72.4	64.0	69.6	77.8	73.4	72	81.6
Average	**27**	**29**	**NC**	**26**	**24**	**40**	**44**	**159**	**156**	**160**	**145**	**154**	**151**	**159**	**36**	**38**	**41**	**38**	**38**	**42**	**41**
Median	**23**	**29**	**NC**	**24**	**17**	**37**	**49**	**61**	**71**	**61**	**51**	**71**	**61**	**61**	**20**	**25**	**28**	**20**	**22**	**31**	**24**
Standard Deviation	**22**	**21**	**NC**	**21**	**21**	**30**	**30**	**207**	**195**	**195**	**202**	**199**	**193**	**223**	**42**	**41**	**46**	**45**	**43**	**46**	**48**

NC = not calculated due to insufficient data
NM = not measured

Table 9-5. Species richness by sampling event and area, 2008 and 2012 through 2017.

Monitoring Year	EDS	Conservation Area
2008	98	111
2012	114	116
2013	122	133
2014	110	115
2015	109	112
2016	98	120
2017	96	109
Area Total - Post-Effluent (2013-2016)	**190**	**174**
Area Total - All Years Combined	**218**	**193**
Project Total - All Years Combined	**260**	

Table 9-6. EDS herbaceous layer vegetative species metrics for all species with an importance value > 0.075 by year, 2008 and 2012 through 2017.

Species Name	FDEP Wetland Indicator Status	Importance Value								Average Plot Occurrence Frequency (%)						
		Max.	2008	2012	2013	2014	2015	2016	2017	2008	2012	2013	2014	2015	2016	2017
Typha latifolia	OBL	0.46	0.00	0.01	0.09	0.32	0.33	0.44	0.46	0%	6%	26%	62%	60%	69%	80%
Cliftonia monophylla	FACW	0.26	0.26	0.25	0.14	0.06	0.05	0.03	0.05	91%	65%	44%	35%	33%	24%	47%
Ludwigia decurrens	FACW	0.17	0.00	0.00	0.04	0.17	0.05	0.00	0.00	0%	0%	32%	53%	23%	0%	0%
Mikania scandens	OBL	0.15	0.00	0.00	0.05	0.12	0.15	0.13	0.06	0%	0%	29%	53%	57%	72%	87%
Cyperus strigosus	FACW	0.13	0.00	0.00	0.13	0.08	0.08	0.03	0.02	0%	0%	62%	59%	57%	38%	33%
Bacopa monnieri	OBL	0.13	0.00	0.00	0.00	0.13	0.05	0.07	0.05	0%	0%	3%	12%	30%	31%	27%
Ludwigia leptocarpa	OBL	0.11	0.00	0.00	0.00	0.00	0.00	0.11	0.10	0%	3%	0%	3%	0%	69%	87%
Hydrocotyle bonariensis	FACW	0.11	0.00	0.00	0.01	0.0	0.06	0.09	0.11	3%	0%	6%	15%	40%	66%	80%
Polygonum spp.	FACW	0.10	0.00	0.01	0.10	0.04	0.09	0.08	0.04	0%	3%	12%	32%	40%	38%	33%
Andropogon glomeratus var glaucopsis	FACW	0.10	0.10	0.05	0.06	0.04	0.06	0.08	0.08	50%	41%	38%	26%	50%	66%	73%
Hypericum brachyphyllum	FACW	0.09	0.09	0.06	0.01	0.02	0.01	0.01	0.01	53%	32%	15%	15%	10%	7%	13%
Rhynchospera cephalantha group	OBL	0.09	0.09	0.06	0.01	0.00	0.00	0.01	0.01	56%	44%	15%	6%	0%	3%	13%
Lyonia lucida	OBL	0.09	0.08	0.09	0.08	0.05	0.05	0.04	0.02	62%	38%	32%	24%	30%	28%	27%
Ilex coriacea	OBL	0.08	0.07	0.08	0.06	0.03	0.04	0.03	0.01	56%	32%	21%	12%	17%	17%	13%
Ceratopteris thalictroides	OBL	0.08	0.00	0.00	0.00	0.0	0.06	0.06	0.08	0%	0%	0%	0%	47%	45%	67%
Cyrilla racemiflora	FACW	0.08	0.08	0.06	0.04	0.0	0.02	0.03	0.03	59%	21%	21%	24%	13%	21%	40%
Nyssa biflora	FACW	0.08	0.08	0.07	0.07	0.03	0.02	0.01	0.02	62%	47%	44%	26%	20%	17%	20%

FDEP Wetland Indicator Status:
OBL=Obligate wetland species
FACW=Facultative wetland species
FAC=Facultative species
FACU=Facultative upland species
U=Upland species

Table 9-6. EDS herbaceous layer vegetative species metrics for all species with an importance value > 0.075 by year, 2008 and 2012 through 2017 (continued).

Species Name	FDEP Wetland Indicator Status	Average Coverage per square meter								Relative Percent Dominance (%)						
		Max.	2008	2012	2013	2014	2015	2016	2017	2008	2012	2013	2014	2015	2016	2017
Typha latifolia	OBL	0.46	0.00	0.00	0.02	0.13	0.13	0.30	0.28	0%	1%	7%	27%	29%	39%	42%
Cliftonia monophylla	FACW	0.26	0.17	0.04	0.03	0.01	0.01	0.01	0.01	21%	20%	11%	3%	2%	1%	2%
Ludwigia decurrens	FACW	0.17	0.00	0.00	0.00	0.06	0.02	0.00	0.00	0%	0%	2%	12%	3%	0%	0%
Mikania scandens	OBL	0.15	0.00	0.00	0.01	0.04	0.05	0.06	0.01	0%	0%	3%	8%	11%	8%	2%
Cyperus strigosus	FACW	0.13	0.00	0.00	0.02	0.01	0.02	0.00	0.00	0%	0%	8%	3%	4%	0%	0%
Bacopa monnieri	OBL	0.13	0.00	0.00	0.00	0.05	0.01	0.04	0.02	0%	0%	0%	12%	3%	5%	4%
Ludwigia leptocarpa	OBL	0.11	0.00	0.00	0.00	0.00	0.00	0.05	0.03	0%	0%	0%	0%	0%	6%	5%
Hydrocotyle bonariensis	FACW	0.11	0.00	0.00	0.00	0.00	0.01	0.03	0.04	0%	0%	0%	1%	3%	4%	7%
Polygonum spp.	FACW	0.10	0.00	0.00	0.02	0.01	0.03	0.04	0.01	0%	0%	9%	2%	6%	5%	2%
Andropogon glomeratus var glaucopsis	FACW	0.10	0.06	0.00	0.01	0.01	0.01	0.03	0.03	7%	1%	3%	2%	3%	3%	4%
Hypericum brachyphyllum	FACW	0.09	0.05	0.01	0.00	0.00	0.00	0.00	0.00	7%	3%	0%	0%	0%	0%	0%
Rhynchospera cephalantha group	OBL	0.09	0.05	0.01	0.00	0.00	0.00	0.01	0.00	6%	3%	0%	0%	0%	1%	1%
Lyonia lucida	OBL	0.09	0.04	0.01	0.01	0.01	0.01	0.02	0.01	5%	6%	6%	3%	3%	2%	1%
Ilex coriacea	OBL	0.08	0.03	0.01	0.01	0.01	0.01	0.01	0.00	4%	6%	5%	2%	2%	2%	0%
Ceratopteris thalictroides	OBL	0.08	0.00	0.00	0.00	0.00	0.01	0.02	0.03	0%	0%	0%	0%	3%	2%	4%
Cyrilla racemiflora	FACW	0.08	0.04	0.01	0.00	0.01	0.00	0.01	0.01	5%	4%	2%	1%	1%	1%	1%
Nyssa biflora	FACW	0.08	0.04	0.01	0.01	0.00	0.00	0.00	0.00	4%	4%	3%	1%	0%	0%	1%

FDEP Wetland Indicator Status:
OBL=Obligate wetland species
FACW=Facultative wetland species
FAC=Facultative species
FACU=Facultative upland species
U=Upland species

Table 9-7. Conservation Area herbaceous layer vegetative species metrics for all species with an importance value > 0.07 by year, 2008 and 2012 through 2017.

Species Name	FDEP Wetland Indicator Status	Importance Value								Average Plot Occurrence Frequency (%)						
		Max	2008	2012	2013	2014	2015	2016	2017	2008	2012	2013	2014	2015	2016	2017
Cliftonia monophylla	FACW	0.23	0.23	0.22	0.17	0.17	0.15	0.16	0.19	79%	82%	79%	68%	85%	81%	81%
Gaylussacia mosieri	FACW	0.08	0.04	0.05	0.04	0.05	0.08	0.04	0.05	39%	68%	50%	50%	62%	38%	54%
Hypericum brachyphyllum	FACW	0.08	0.07	0.03	0.04	0.06	0.06	0.08	0.07	39%	54%	50%	54%	42%	46%	42%
Ilex coriacea	OBL	0.10	0.10	0.07	0.10	0.07	0.07	0.06	0.08	64%	64%	68%	61%	62%	65%	69%
Ilex glabra	FACW	0.11	0.05	0.07	0.10	0.09	0.08	0.09	0.11	36%	43%	43%	43%	54%	46%	58%
Rhynchospera cephalantha group	OBL	0.09	0.07	0.06	0.09	0.06	0.05	0.06	0.04	46%	46%	54%	43%	42%	46%	38%
Sphagnum spp.	OBL	0.23	0.12	0.16	0.13	0.19	0.22	0.21	0.23	36%	64%	50%	57%	54%	58%	54%

Species Name	FDEP Wetland Indicator Status	Average Coverage per square meter							Relative Percent Dominance (%)						
		2008	2012	2013	2014	2015	2016	2017	2008	2012	2013	2014	2015	2016	2017
Cliftonia monophylla	FACW	0.16	0.09	0.09	0.11	0.08	0.11	0.12	18%	18%	13%	14%	11%	12%	15%
Gaylussacia mosieri	FACW	0.02	0.01	0.01	0.02	0.03	0.02	0.02	2%	2%	2%	3%	5%	2%	3%
Hypericum brachyphyllum	FACW	0.04	0.00	0.01	0.02	0.03	0.05	0.04	5%	1%	2%	3%	4%	5%	4%
Ilex coriacea	OBL	0.06	0.02	0.05	0.03	0.03	0.03	0.04	6%	4%	7%	4%	4%	3%	4%
Ilex glabra	FACW	0.02	0.03	0.05	0.05	0.04	0.06	0.07	3%	5%	8%	6%	5%	7%	8%
Rhynchospera cephalantha group	OBL	0.04	0.02	0.05	0.03	0.02	0.04	0.02	4%	4%	7%	4%	3%	4%	2%
Sphagnum spp.	OBL	0.09	0.07	0.07	0.13	0.13	0.17	0.17	10%	13%	11%	16%	19%	18%	20%

FDEP Wetland Indicator Status:
OBL=Obligate wetland species
FACW=Facultative wetland species
FAC=Facultative species
FACU=Facultative upland species
U=Upland species

Table 9-8. Average herbaceous layer vegetation diversity statistics, 2008 (baseline) and 2012 through 2017 (post-effluent), EDS and Conservation Area freshwater areas.

Diversity Metric (Average Values)	2008	2012	2013	2014	2015	2016	2017	Percent Change 2008 to 2017	Percent Change 2012 to 2017
EDS-Freshwater									
Richness	18.1	13.4	13.3	12.3	13.9	13.7	19.3	7%	43%
Shannon Diversity	1.750	0.652	0.673	0.911	1.085	1.321	1.282	-27%	97%
Effective Richness	6.6	2.1	2.2	2.7	3.4	4.4	3.9	-42%	264%
Evenness	0.61	0.25	0.26	0.38	0.45	0.52	0.45	-27%	124%
WPI[1]	1.86	1.85	1.83	1.50	1.60	1.49	1.41	-24%	-24%
Conservation Area									
Richness	17.6	20.8	21.3	20.3	19.9	20.4	18.8	7%	-10%
Shannon Diversity	1.765	1.342	1.619	1.672	1.592	1.920	1.664	-6%	24%
Effective Richness	7.2	4.7	6.6	7.9	6.3	10.2	7.6	7%	64%
Evenness	0.62	0.44	0.53	0.56	0.53	0.64	0.56	-9%	28%
WPI[1]	1.79	1.81	1.80	1.69	1.87	1.70	1.73	-3%	-5%

Notes: [1] WPI = Weighted Prevalence Index

Table 9-9. Average herbaceous layer vegetation diversity statistics, 2008 (baseline) and 2012 through 2017 (post-effluent), EDS marine areas.

Diversity Metric (Average Values)	2008	2012	2013	2014	2015	2016	2017	TWC01-Avg (2008-2017)	Percent Change 2008 to 2017	Percent Difference TWC-Avg vs 2017
Richness	6.3	8.8	10.6	15.0	9.8	7.6	7.6	5.6	20%	36%
Effective Richness	2.1	2.2	2.1	4.0	2.2	1.8	2.1	1.9	-2%	10%
Shannon Diversity	0.722	0.770	0.701	1.047	0.764	0.569	0.693	0.630	-4%	10%
Evenness	0.41	0.36	0.30	0.38	0.36	0.30	0.38	0.39	-6%	-1%

Table 9-10. EDS marine area herbaceous layer vegetative species metrics for all species with an importance value > 0.075 by year, 2008 and 2012 through 2017.

Species Name	Importance Value								Average Plot Occurrence Frequency (%)						
	Max	2008	2012	2013	2014	2015	2016	2017	2008	2012	2013	2014	2015	2016	2017
Cladium jamaicense	0.76	0.31	0.52	0.55	0.41	0.72	0.76	0.69	1.00	1.00	1.00	0.80	1.00	1.00	1.00
Juncus roemerianus	0.54	0.54	0.46	0.43	0.30	0.32	0.34	0.37	0.33	0.40	0.40	0.40	0.40	0.40	0.40
Lyonia lucida	0.12	0.12	0.06	0.04	0.06	0.04	0.03	0.03	0.67	0.40	0.40	0.40	0.40	0.20	0.20
Morella cerifera	0.09	0.05	0.00	0.00	0.04	0.07	0.09	0.00	0.33	0.00	0.00	0.60	0.60	0.60	0.00
Morella caroliniensis	0.11	0.08	0.08	0.05	0.02	0.00	0.00	0.11	0.33	0.60	0.20	0.40	0.00	0.00	0.60
Nymphaea odorata	0.11	0.00	0.11	0.07	0.01	0.03	0.03	0.00	0.00	0.60	0.60	0.20	0.20	0.20	0.00
Paspalum dilatatum	0.22	0.22	0.02	0.06	0.00	0.00	0.00	0.00	0.67	0.20	0.60	0.00	0.00	0.00	0.00
Polygonum spp.	0.10	0.00	0.02	0.06	0.03	0.07	0.10	0.08	0.00	0.20	0.60	0.40	0.60	0.60	0.40
Solidago leavenworthii	0.09	0.00	0.00	0.02	0.04	0.09	0.03	0.03	0.00	0.00	0.20	0.60	0.80	0.20	0.20
Spartina patens	0.11	0.00	0.11	0.03	0.01	0.02	0.00	0.07	0.00	0.80	0.20	0.20	0.20	0.00	0.40
Woodwardia aerolata	0.13	0.00	0.13	0.00	0.00	0.00	0.00	0.00	0.00	0.80	0.00	0.00	0.00	0.00	0.00
Woodwardia virginica	0.27	0.27	0.02	0.06	0.02	0.02	0.03	0.05	0.67	0.20	0.60	0.40	0.20	0.20	0.40

Species Name	Average Coverage per square meter							Relative Percent Dominance (%)						
	2008	2012	2013	2014	2015	2016	2017	2008	2012	2013	2014	2015	2016	2017
Cladium jamaicense	0.09	0.28	0.33	0.32	0.59	0.68	0.51	0.15	0.41	0.45	0.37	0.62	0.63	0.56
Juncus roemerianus	0.30	0.28	0.29	0.24	0.27	0.31	0.29	0.49	0.41	0.39	0.28	0.28	0.28	0.32
Lyonia lucida	0.01	0.01	0.00	0.03	0.00	0.00	0.00	0.01	0.01	0.00	0.04	0.00	0.00	0.00
Morella cerifera	0.00	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.00
Morella caroliniensis	0.02	0.01	0.03	0.00	0.00	0.00	0.03	0.02	0.01	0.03	0.00	0.00	0.00	0.03
Nymphaea odorata	0.00	0.03	0.01	0.00	0.01	0.00	0.00	0.00	0.04	0.02	0.00	0.01	0.00	0.00
Paspalum dilatatum	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.12	0.00	0.00	0.00	0.00	0.00	0.00
Polygonum spp.	0.00	0.00	0.01	0.00	0.00	0.03	0.03	0.00	0.00	0.01	0.00	0.00	0.03	0.03
Solidago leavenworthii	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
Spartina patens	0.00	0.01	0.01	0.00	0.00	0.00	0.01	0.00	0.02	0.01	0.00	0.00	0.00	0.01
Woodwardia aerolata	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00	0.00
Woodwardia virginica	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.17	0.00	0.00	0.00	0.00	0.00	0.00

Table 9-11. Conservation area diversity metric summary statistics at non-managed vegetative monitoring plots, 2008 (pre-management) and 2012 through 2017 (post- and/or on-going-management).

Diversity Metric	Year	Land Management Type[1]	Valid N	Mean	Minimum	20th Percentile	Median	80th Percentile	Maximum
Shannon-Wiener Diversity	2008	PN	9	1.468	0.922	0.955	1.300	1.972	2.244
	2012	NN	9	0.985	0.177	0.573	0.912	1.412	1.860
	2013		9	0.935	0.124	0.462	0.948	1.597	1.736
	2014		9	1.113	0.093	0.566	1.116	1.587	2.428
	2015		9	0.883	0.117	0.522	1.002	1.097	1.542
	2016		9	1.102	0.108	0.574	1.069	1.588	2.332
	2017		9	0.847	0.126	0.550	0.657	0.990	2.365
Evenness	2008	PN	9	0.55	0.33	0.40	0.59	0.65	0.67
	2012	NN	9	0.34	0.11	0.21	0.41	0.47	0.49
	2013		9	0.35	0.08	0.27	0.31	0.47	0.56
	2014		9	0.41	0.07	0.28	0.47	0.57	0.65
	2015		9	0.35	0.08	0.31	0.34	0.50	0.51
	2016		9	0.42	0.10	0.30	0.47	0.53	0.65
	2017		9	0.32	0.09	0.25	0.31	0.41	0.62
Species Richness	2008	PN	9	15.6	6.0	9.0	13.0	24.0	28.0
	2012	NN	9	18.9	5.0	7.0	18.0	21.0	46.0
	2013		9	16.0	5.0	5.0	12.0	22.0	45.0
	2014		9	15.7	4.0	5.0	12.0	23.0	43.0
	2015		9	13.0	4.0	5.0	13.0	19.0	20.0
	2016		9	14.3	3.0	6.0	14.0	20.0	37.0
	2017		9	14.2	4.0	7.0	10.0	18.0	45.0
Effective Species Richness	2008	PN	9	4.8	2.5	2.6	3.7	7.2	9.4
	2012	NN	9	3.0	1.2	1.8	2.5	4.1	6.4
	2013		9	2.9	1.1	1.6	2.6	4.9	5.7
	2014		9	3.8	1.1	1.8	3.1	4.9	11.3
	2015		9	2.6	1.1	1.7	2.7	3.0	4.7
	2016		9	3.7	1.1	1.8	2.9	4.9	10.3
	2017		9	2.9	1.1	1.7	1.9	2.7	10.6

[1] Land Management Type: PN = Baseline at non-managed plots
NN = Non-managed plots during post-management monitoring period (2012 – 2017)

Table 9-12. Conservation area diversity metric summary statistics at managed vegetative monitoring plots, 2008 (pre-management) and 2012 through 2017 (post- and/or on-going-management).

Diversity Metric	Year	Land Management Type[1]	Valid N	Mean	Minimum	20th Percentile	Median	80th Percentile	Maximum
Shannon-Wiener Diversity	2008	PY	17	1.905	0.758	1.300	2.071	2.443	2.953
	2012	YY	17	1.592	0.724	1.124	1.568	2.085	2.646
	2013		17	2.024	0.968	1.464	2.127	2.666	2.986
	2014		17	2.015	0.735	1.284	2.017	2.378	3.700
	2015		17	1.967	0.931	1.498	1.860	2.510	2.822
	2016		17	2.353	1.011	1.579	2.548	2.928	3.836
	2017		17	2.097	0.773	1.403	2.160	2.665	3.157
Evenness	2008	PY	17	0.65	0.33	0.50	0.66	0.80	0.90
	2012	YY	17	0.51	0.28	0.43	0.51	0.60	0.77
	2013		17	0.65	0.44	0.50	0.66	0.75	0.95
	2014		17	0.65	0.26	0.47	0.63	0.86	1.04
	2015		17	0.63	0.34	0.55	0.67	0.72	0.93
	2016		17	0.75	0.35	0.59	0.72	0.91	1.12
	2017		17	0.65	0.34	0.47	0.71	0.78	0.93
Species Richness	2008	PY	17	18.2	8.0	12.0	17.0	26.0	30.0
	2012	YY	17	22.3	12.0	14.0	22.0	30.0	40.0
	2013		17	23.8	9.0	16.0	21.0	31.0	44.0
	2014		17	22.6	9.0	17.0	20.0	33.0	36.0
	2015		17	23.6	11.0	15.0	22.0	30.0	44.0
	2016		17	23.6	13.0	17.0	20.0	29.0	49.0
	2017		17	21.2	10.0	14.0	21.0	27.0	43.0
Effective Species Richness	2008	PY	17	8.4	2.1	3.7	7.9	11.5	19.2
	2012	YY	17	5.8	2.1	3.1	4.8	8.0	14.1
	2013		17	8.9	2.6	4.3	8.4	14.4	19.8
	2014		17	10.6	2.1	3.6	7.5	10.8	40.4
	2015		17	8.2	2.5	4.5	6.4	12.3	16.8
	2016		17	13.6	2.7	4.8	12.8	18.7	46.3
	2017		17	10.1	2.2	4.1	8.7	14.4	23.5

[1] Land Managment Type: PY = Baseline at managed plots
YY = Managed plots during post-management monitoring period (2012-2017)

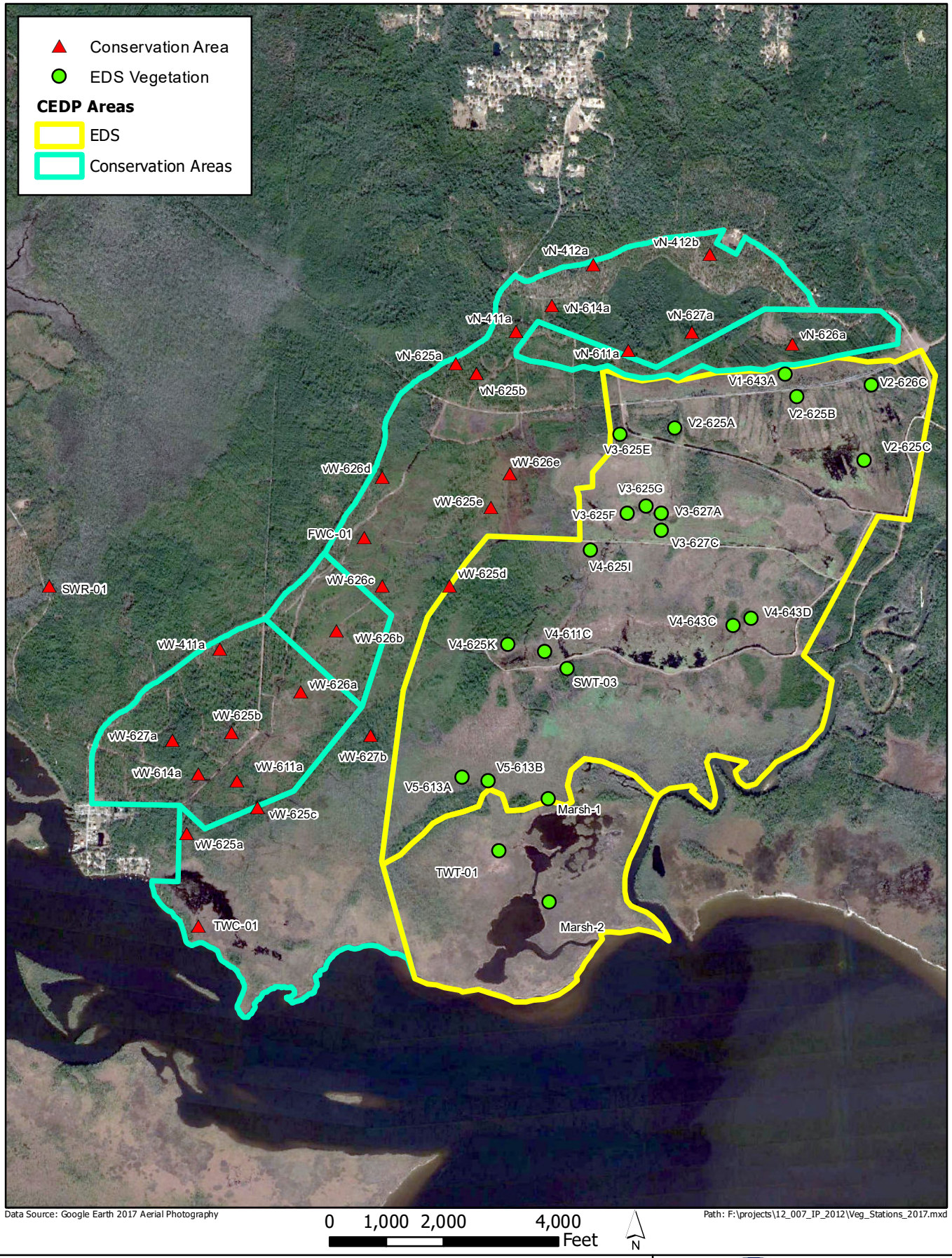


Figure 9-1. Location of vegetation monitoring stations.

Nutter & Associates
environmental consultants

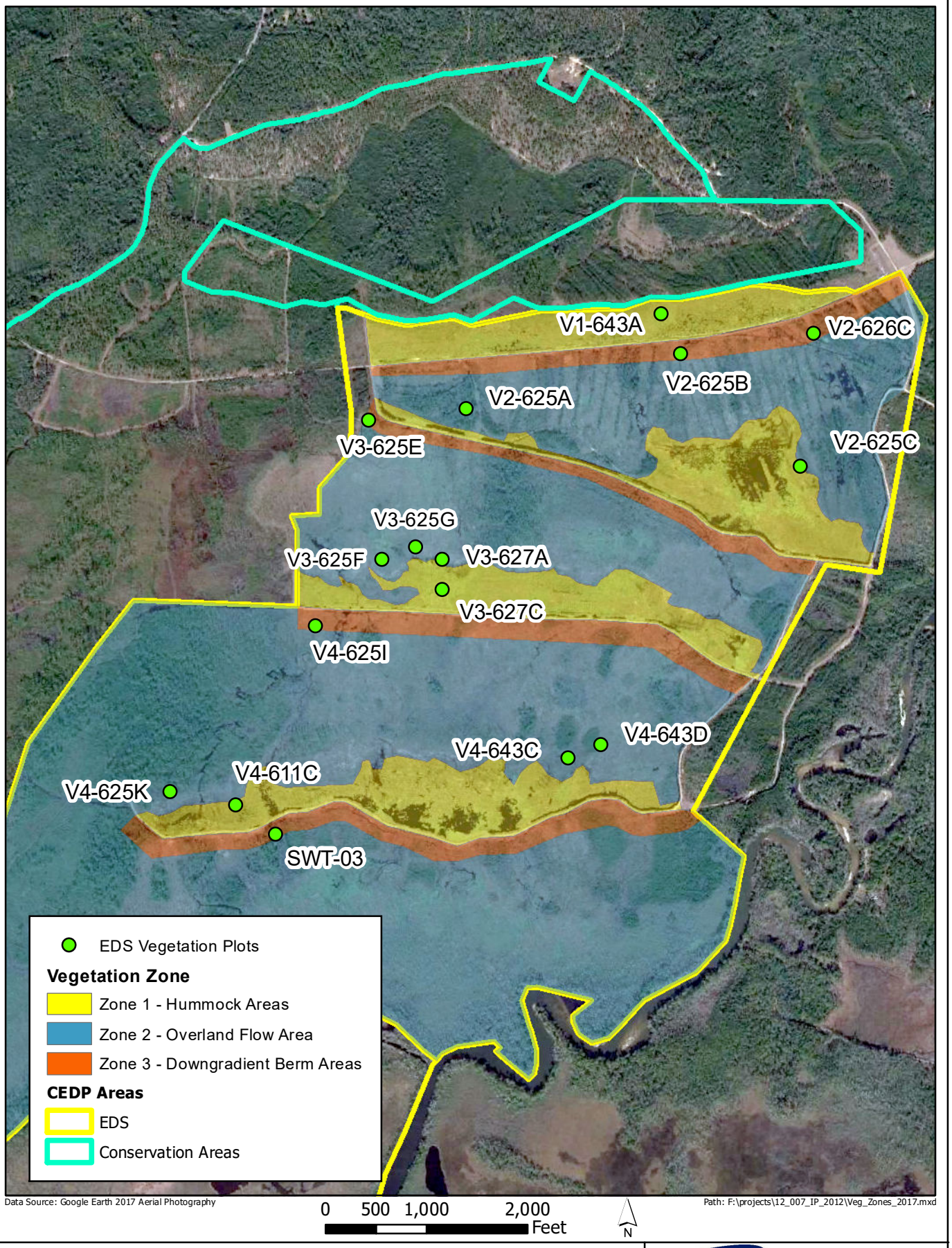


Figure 9-2. Location of vegetation monitoring stations and vegetation zones.

Nutter & Associates
environmental consultants

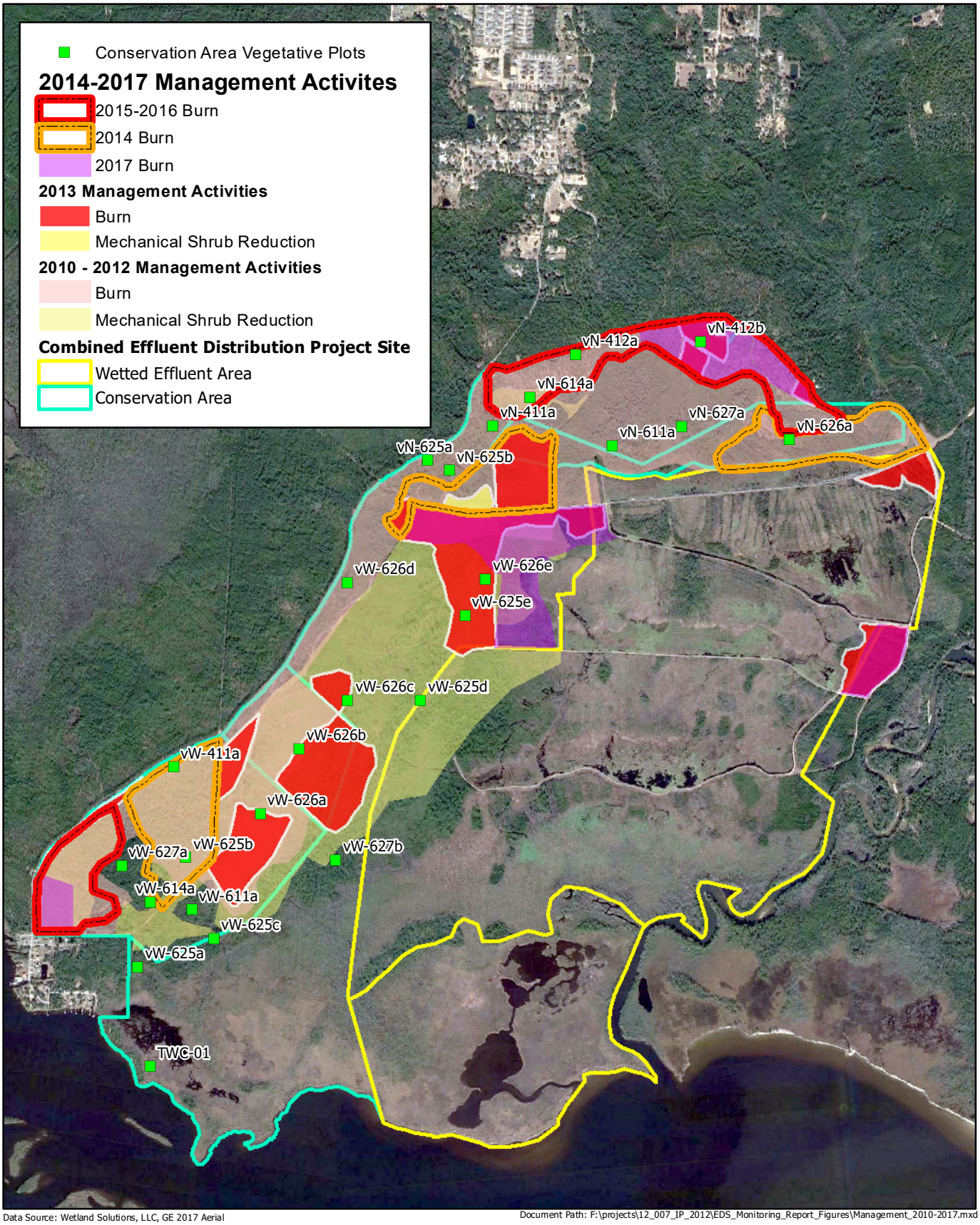


Figure 9-3. Conservation management areas and vegetation monitoring plots.

Nutter & Associates
environmental consultants

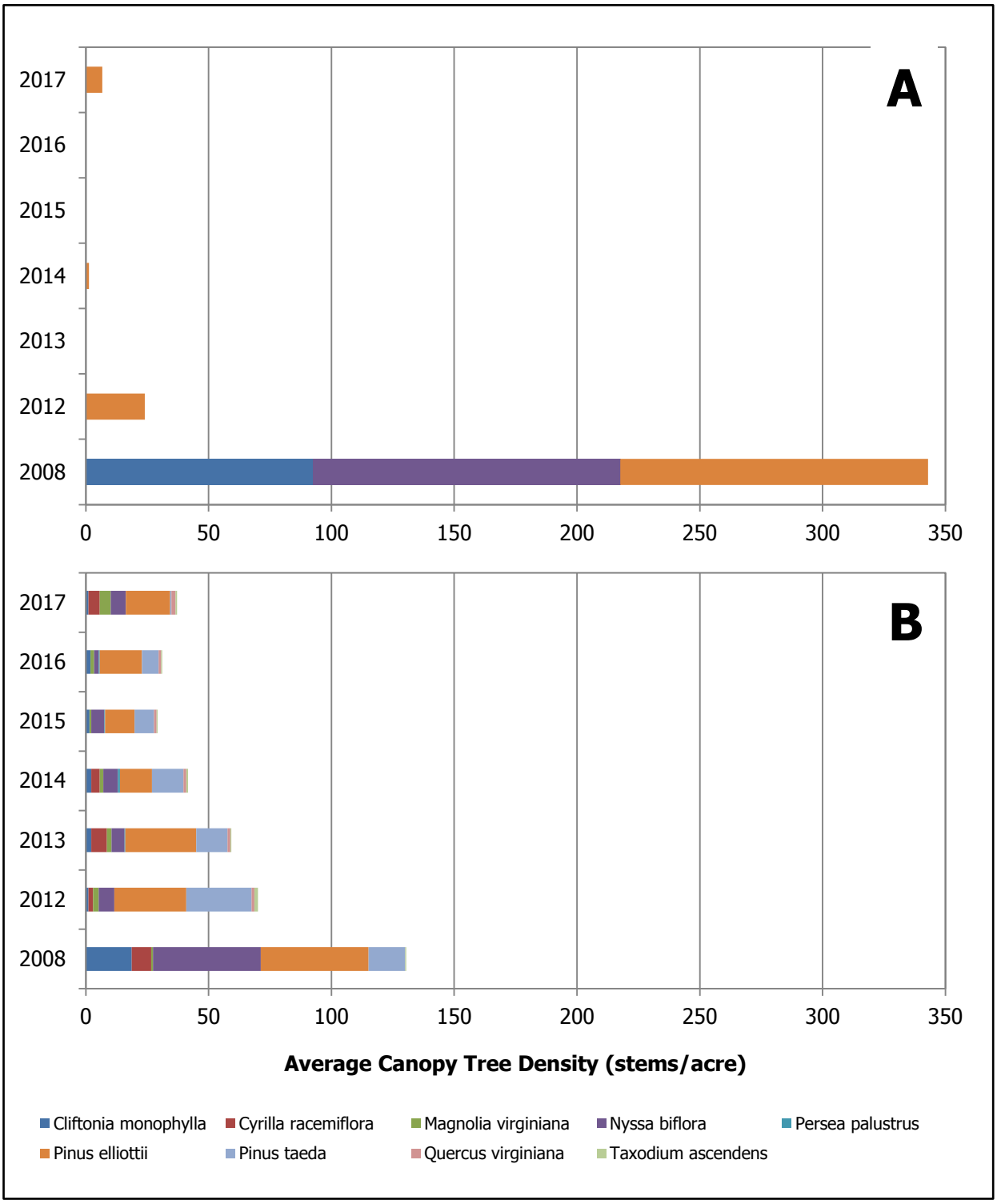


Figure 9-4. EDS average canopy species densities between 2008 and 2017: A) Harvested stations within Zone 1 (n=8); B) Non-harvested stations within Zones 2 and 3 (n=29).

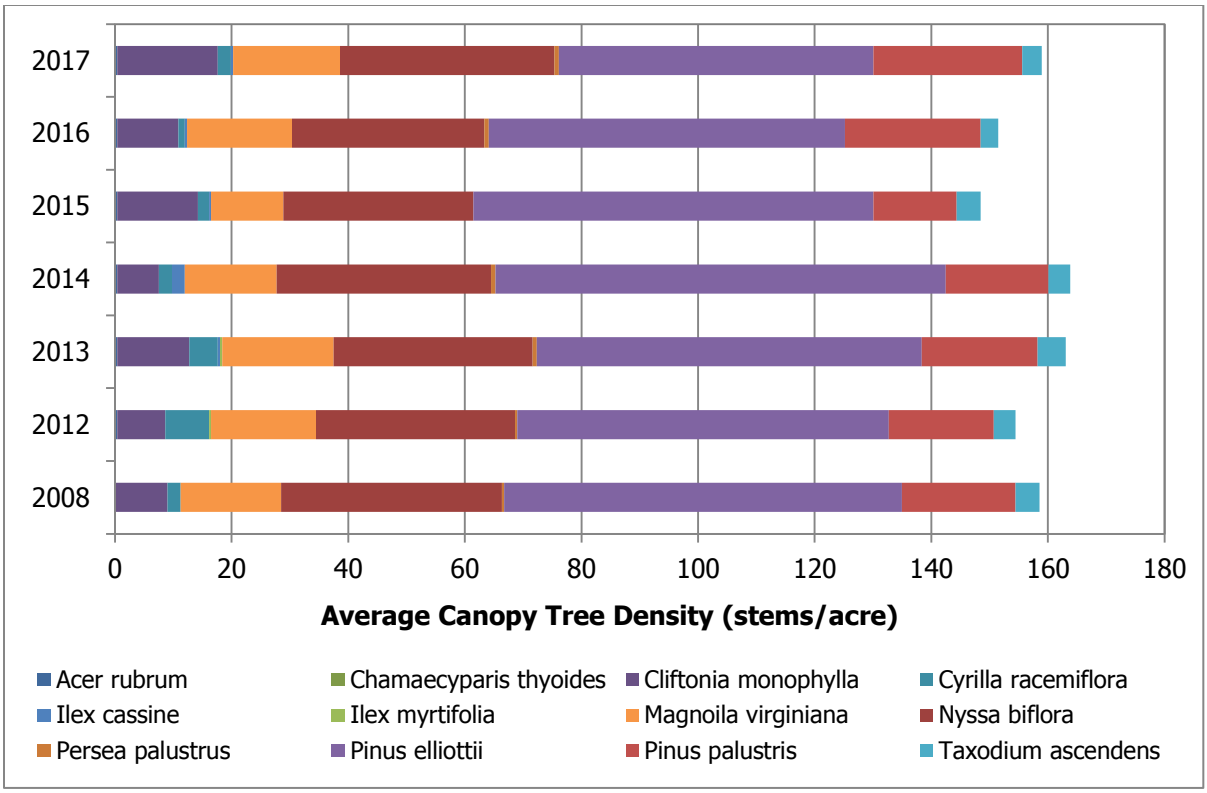


Figure 9-5. Conservation Area canopy species characterization, 2008 through 2017.

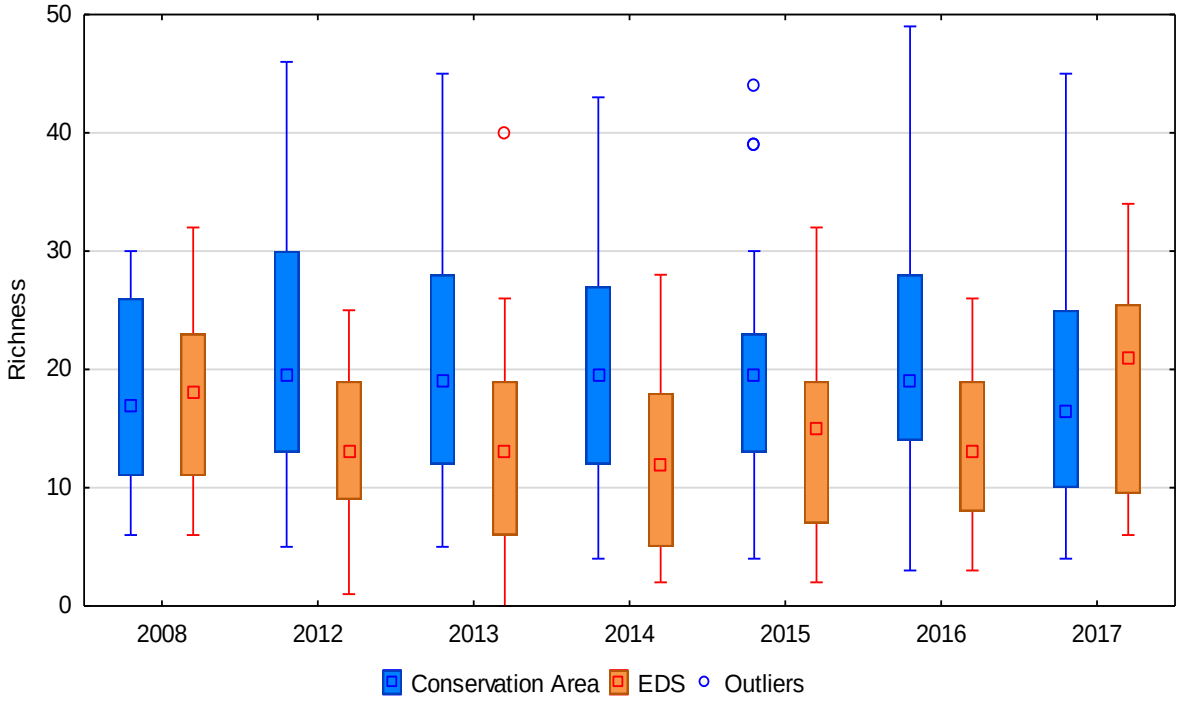


Figure 9-6. EDS and Conservation Area freshwater station species richness by year. Box plots present the median ± 20th and 80th percentiles (box) and non-outlier range (whisker).

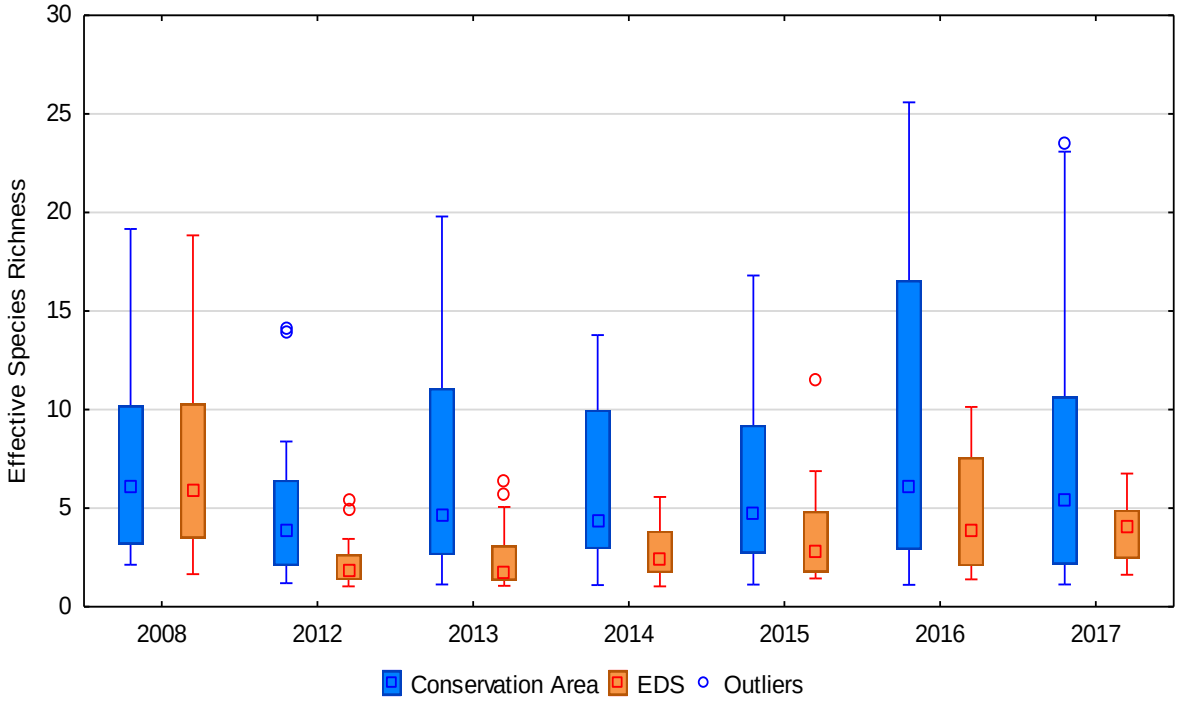


Figure 9-7. EDS and Conservation Area freshwater station effective species richness by year. Box plots present the median ± 20th and 80th percentiles (box) and non-outlier range (whisker).

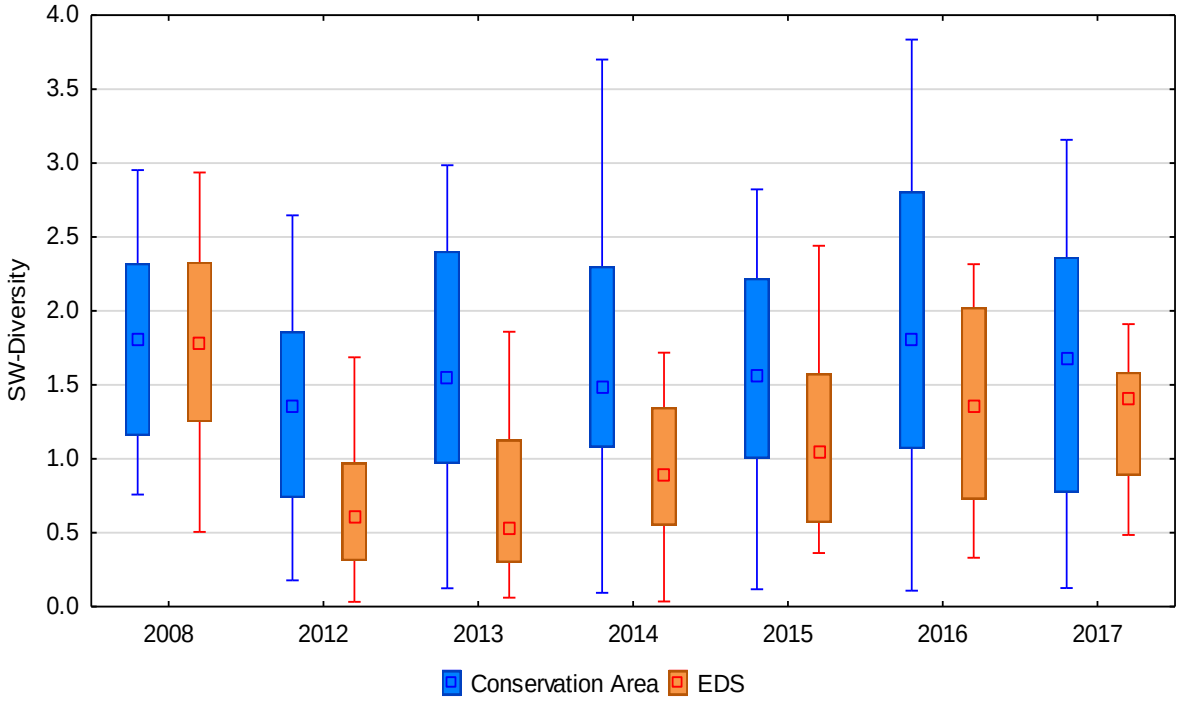


Figure 9-8. EDS and Conservation Area freshwater station Shannon-Wiener diversity by year. Box plots present the median ± 20th and 80th percentiles (box) and non-outlier range (whisker).

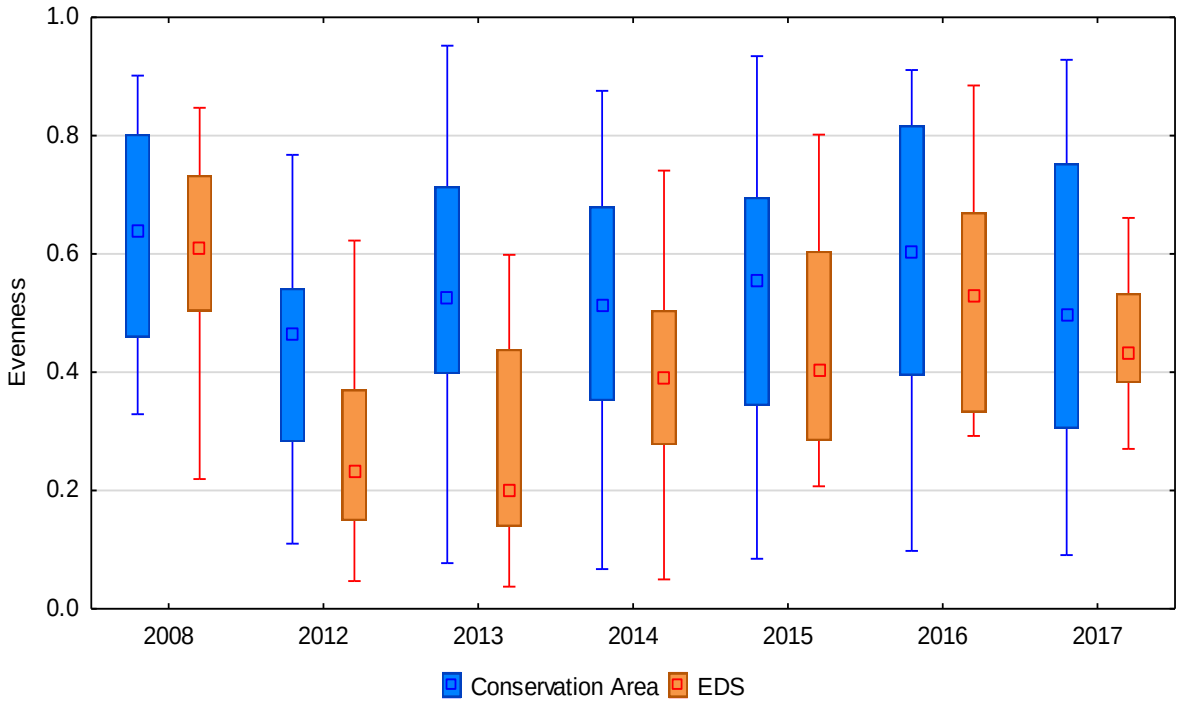


Figure 9-9. EDS and Conservation Area freshwater station evenness by year. Box plots present the median ± 20th and 80th percentiles (box) and non-outlier range (whisker).

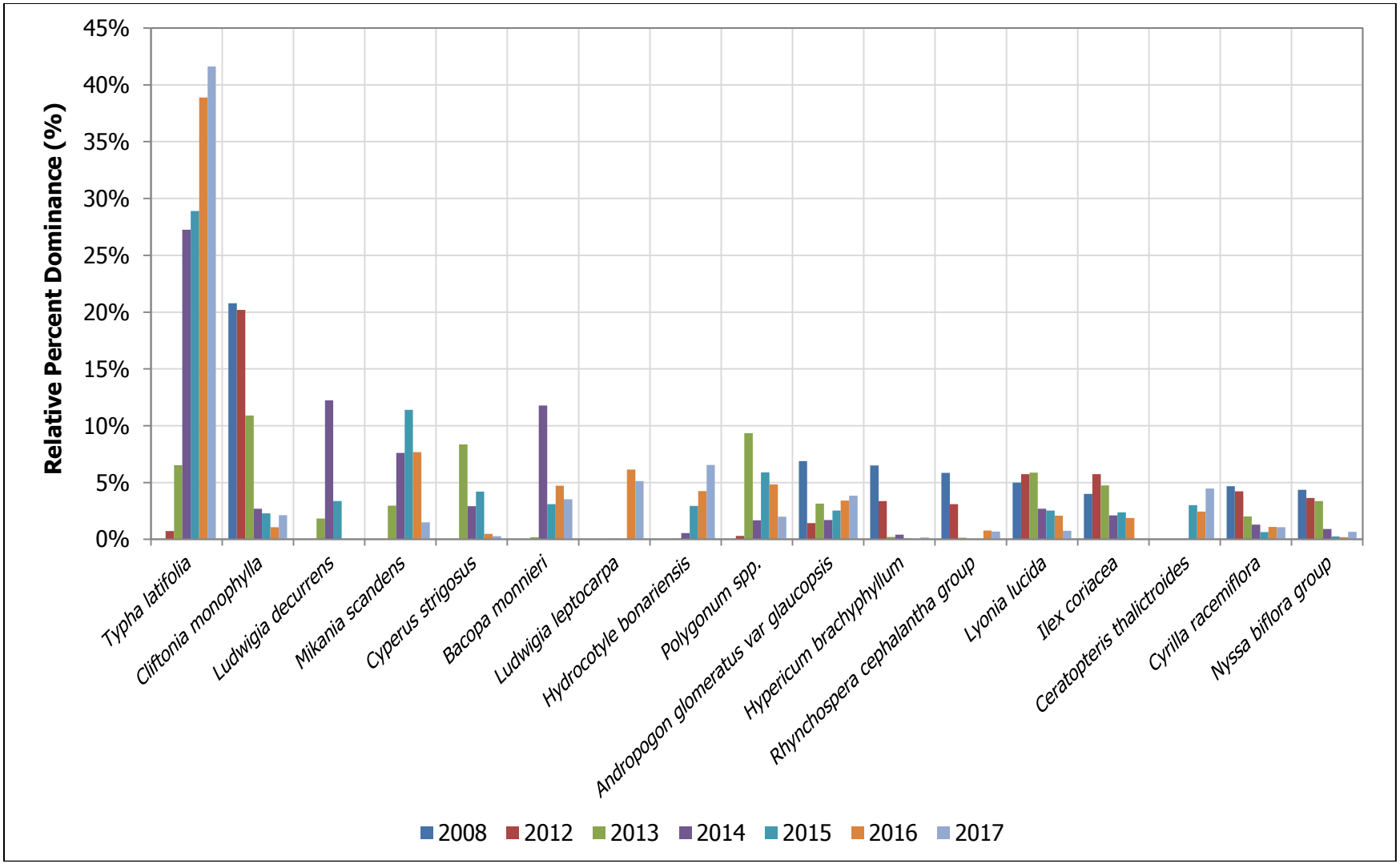


Figure 9-10. Autumn relative percent dominance for species with importance values > 0.075 within the EDS.

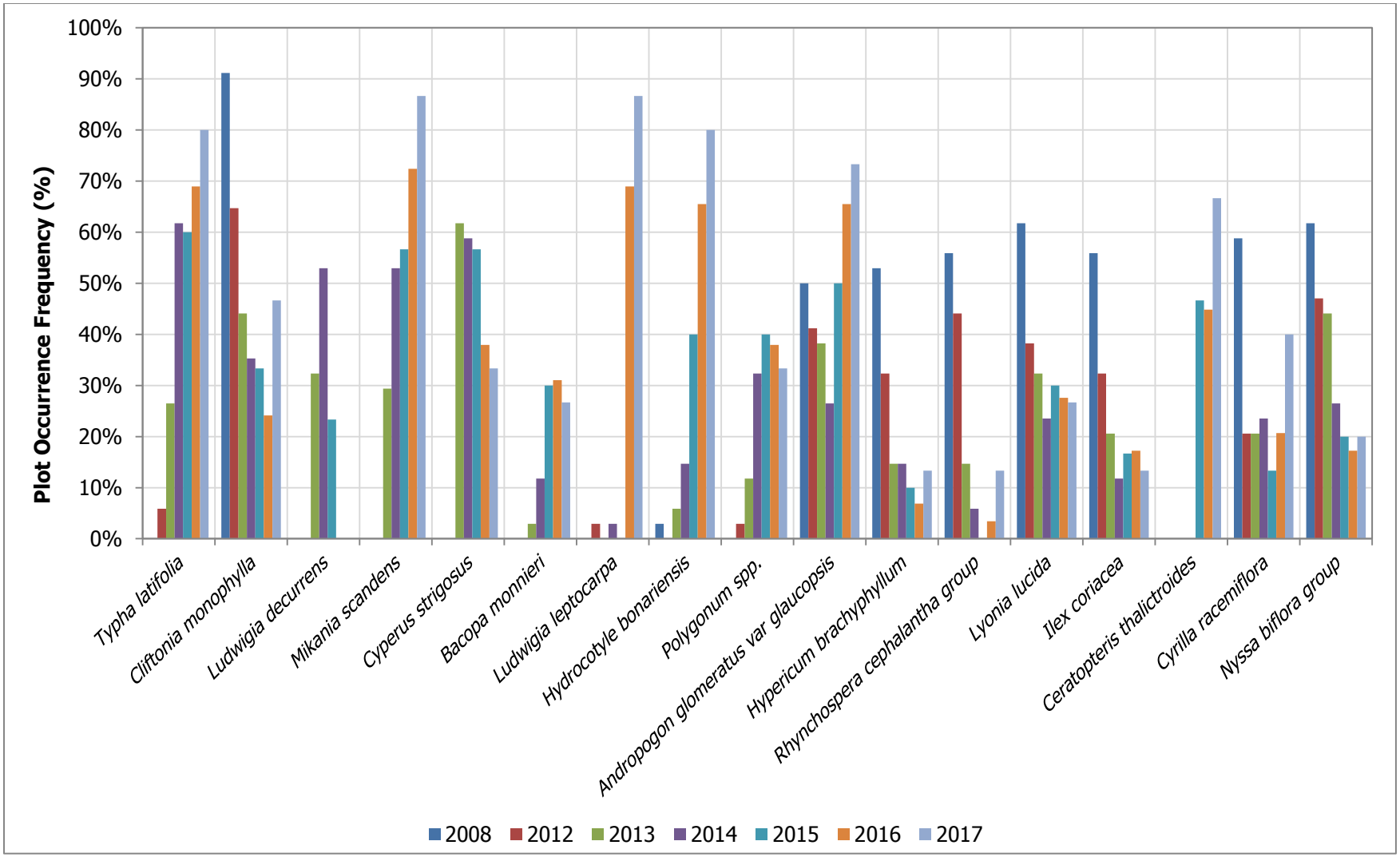


Figure 9-11. Autumn average plot occurrence frequency for species with importance values > 0.075 within the EDS.

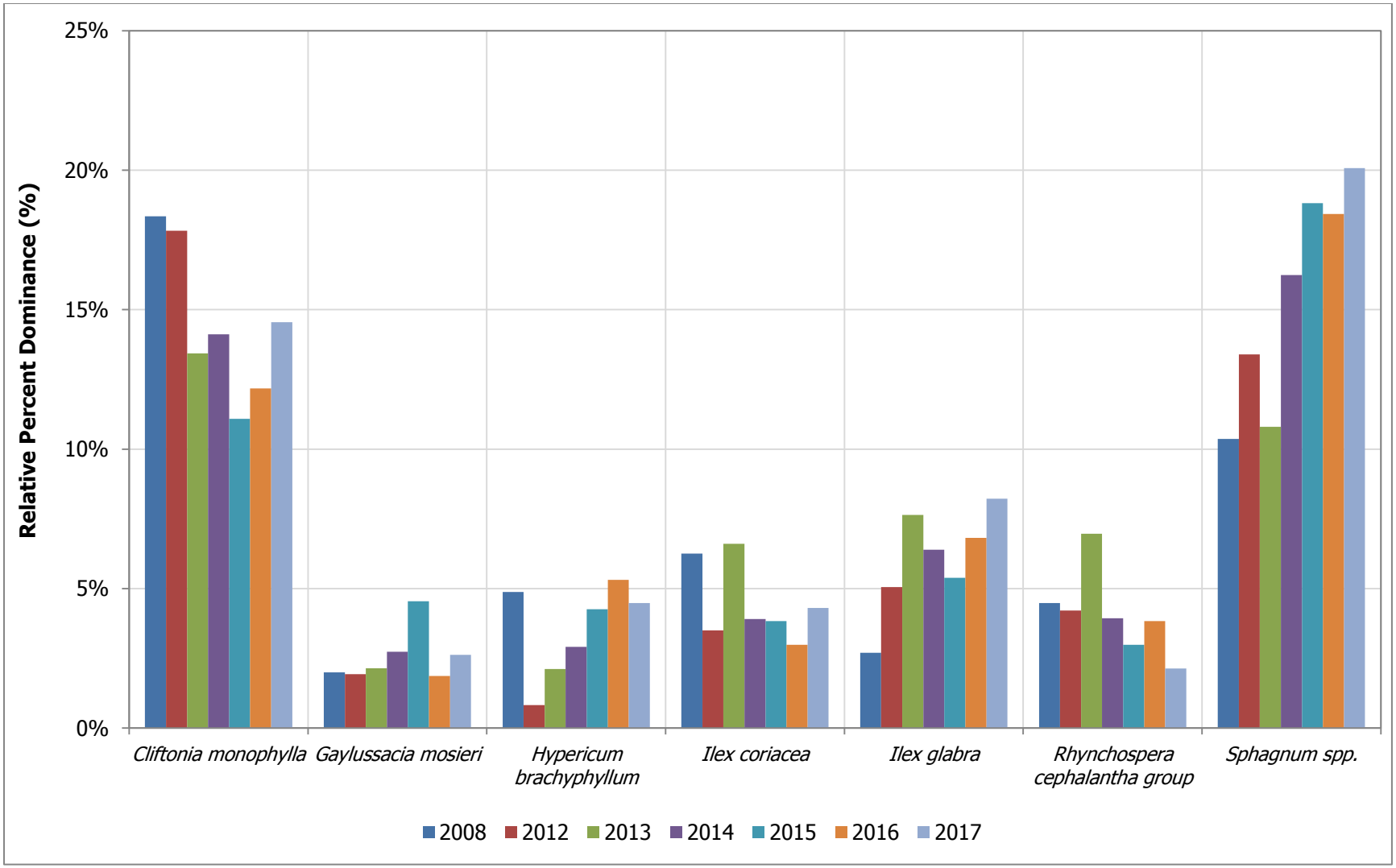


Figure 9-12. Autumn relative percent dominance for species with importance values > 0.075 within the Conservation Area.

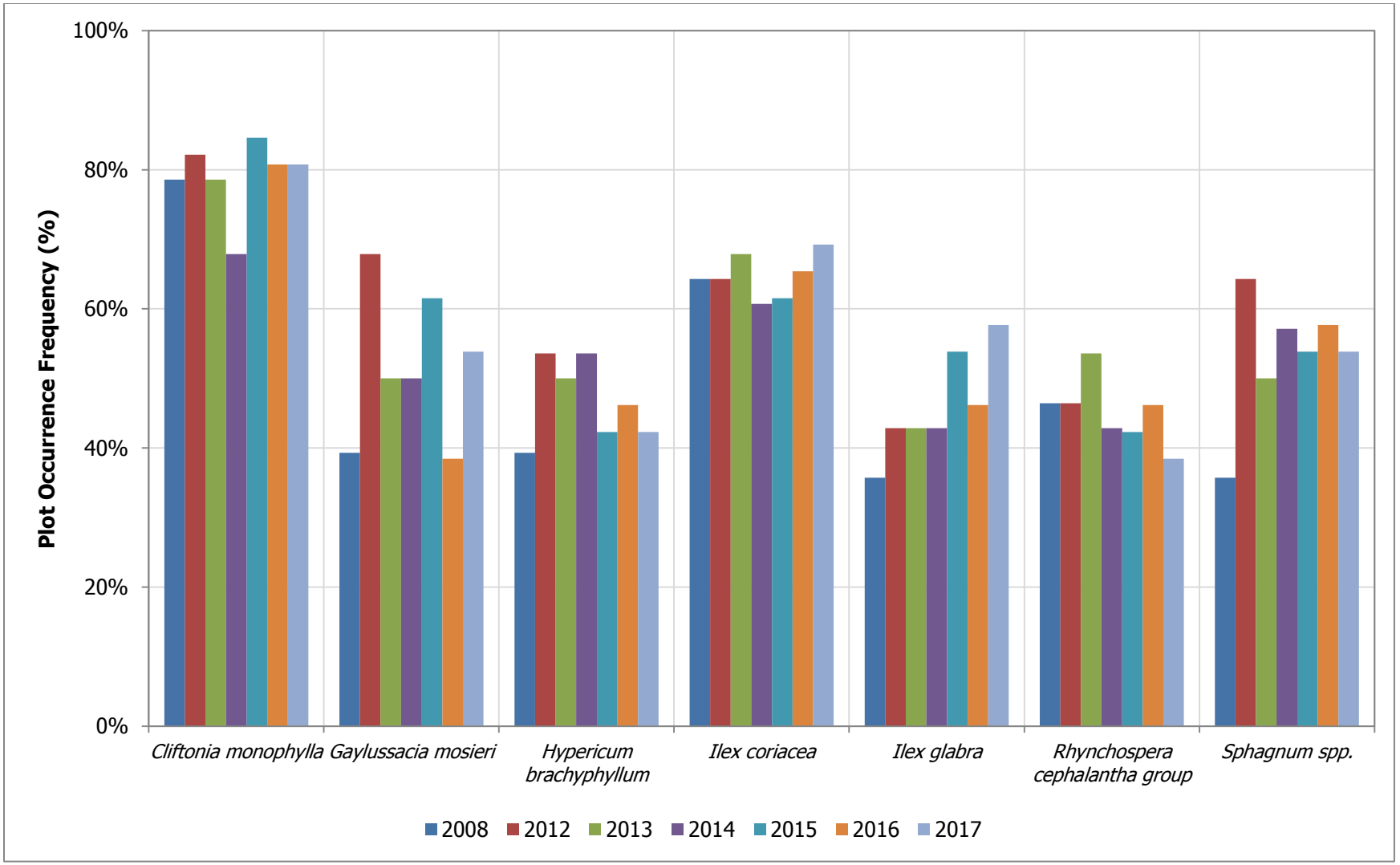


Figure 9-13. Autumn average plot occurrence frequency for species with importance values > 0.075 within the Conservation Area.

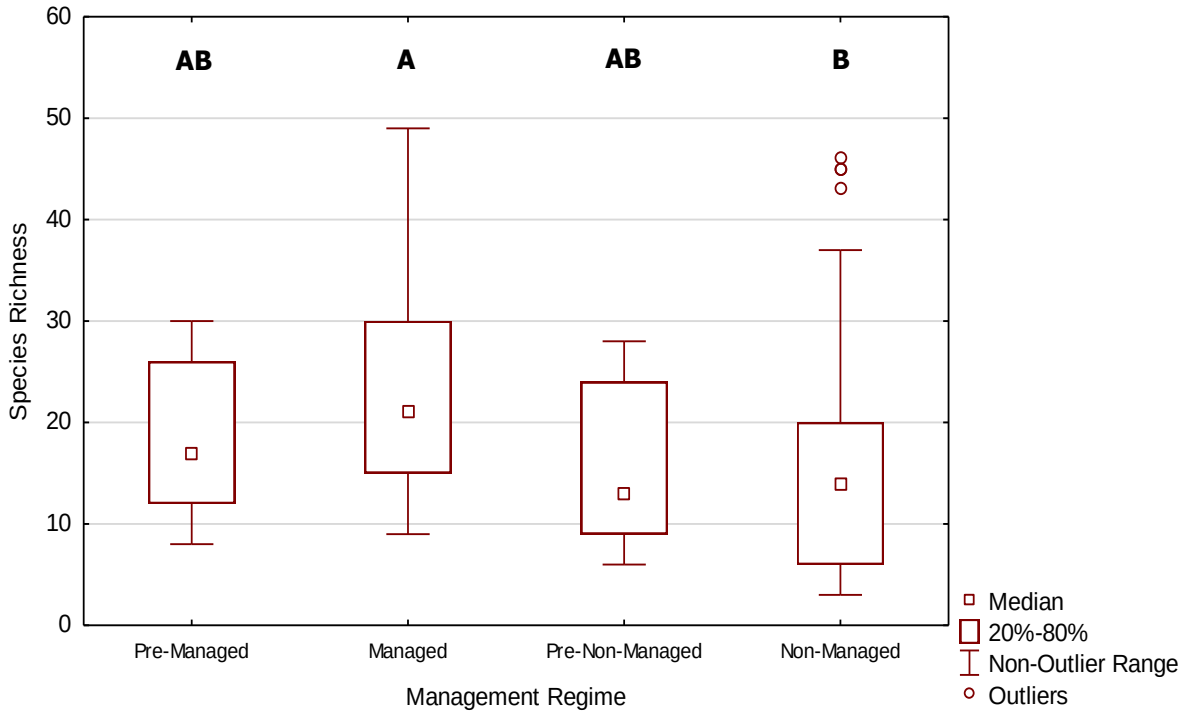


Figure 9-14. Conservation area species richness trends by land management type between 2008 and 2017. Letter groups denote statistical similarity or difference at $p<0.05$ based upon Kruskal-Wallis median test.

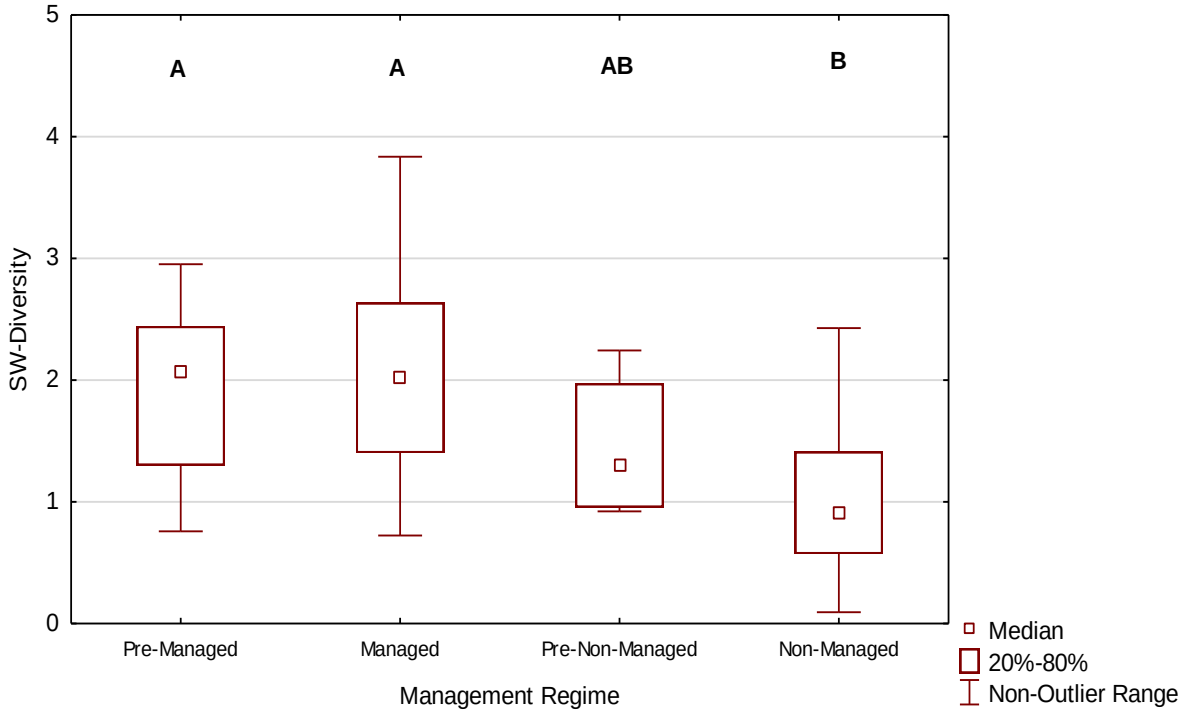


Figure 9-15. Conservation area Shannon-Wiener diversity trends by land management type between 2008 and 2017. Letter groups denote statistical similarity or difference at $p<0.05$ based upon Kruskal-Wallis median test.

APPENDIX 9-A

Results of Autumn 2017 Vegetation Monitoring

Plot	DWT01	FWC01	Marsh1	Marsh2	SWR01	SWT03	TWC01	TWT01	V1-643a	V2-625a	V2-625c	V2-626c	V3-625e	V3-625f	V3-625g	V3-627a	V3-627c	V4-625k	V4-643c	V4-643d	V5-613a	V5-613b	V5-625m
Open Water (avg cover/m2)			0.0	0.0	0.2								0.1	0.1	0.5	0.7	0.6	1.0	0.4	0.3			0.6
Open Water (avg % cover)			0.6	2.5	21.4								6.1	10.0	46.7	73.0	63.8	98.1	38.8	29.4			56.3
Total Avg Vegetated Cover/m2		1.4	0.9	1.0	0.3	0.4	0.7	0.8	0.8	0.6	0.9	0.4	0.4	0.9	1.2	1.0	0.4	0.3	0.4	0.6	1.0	0.8	0.8
Avg Plot % Vegetated		141.6	94.9	101.5	30.1	42.4	67.1	76.3	76.8	59.8	88.1	38.2	37.0	88.0	119.0	104.4	38.8	33.5	36.3	60.0	96.0	83.5	84.8
Species Richness		20	15	4	18	26	5	3	21	25	34	34	22	9	6	6	18	16	16	22	6	10	24
Avg Sphagnum Coverage (m2)		0.7			0.0							0.0						0.1					
Species (Cover/m2)																							
Acer rubrum					0.005		0.001																
Andropogon glomeratus var glaucopsis									0.015	0.093	0.040	0.028	0.004				0.071	0.004	0.071	0.009			0.044
Andropogon glomeratus var glomeratus						0.002						0.006	0.017							0.044			
Andropogon mohrii																							
Andropogon virginicus																							
Anthaenantia rufa																							
Apios americana						0.006																	
Aristida palustris												0.001											
Aristida spp.																							
Aristida stricta											0.010												
Aronia arbutifolia										0.002													
Baccharis halimifolia						0.006			0.034				0.006				0.016			0.014			0.004
Bacopa monnieri									0.033		0.260		0.056						0.006				
Balduina uniflora											0.004	0.001											
Boehmeria cylindrica						0.002																	
Carex glaucescens		0.060			0.013	0.004						0.003					0.036	0.028					
Carex spp.																							
Centella erecta						0.003					0.002												
Ceratopteris thalictroides						0.002					0.112	0.003	0.002	0.014	0.185	0.028			0.038	0.050			0.018
Chamaecyparis thyoides																							0.009
Cladium jamaicense			0.781	0.179			0.372	0.122													0.913	0.531	
Clethra alnifolia					0.003				0.036	0.006													
Cliftonia monophylla		0.151			0.004	0.002			0.008			0.106					0.013	0.009		0.065			
Cyperus spp.																			0.001				
Cyperus strigosus										0.001	0.020	0.003											0.004
Cyrilla racemiflora					0.021						0.024	0.004	0.002				0.032	0.016					0.030
Dichanthelium dichotomum												0.018											
Dichanthelium scabriusculum																							
Dichanthelium scoparium					0.003	0.021														0.003			
Dichanthelium spp.																							
Dichanthelium spretum											0.005	0.005											
Difference																							
Diodia teres													0.006										0.003
Drosera capillaris																							
Drosera tracyi																							
Eclipta prostrata									0.006	0.001	0.001									0.001		0.003	0.004
Eleocharis albida						0.046																	
Eriocaulon compressum																							
Eriocaulon decangulare										0.001	0.001	0.006						0.019					
Eriocaulon spp.																							
Eupatorium capillifolium						0.013			0.002	0.004			0.006							0.001			

Plot	DWT01	FWC01	Marsh1	Marsh2	SWR01	SWT03	TWC01	TWT01	V1-643a	V2-625a	V2-625c	V2-626c	V3-625e	V3-625f	V3-625g	V3-627a	V3-627c	V4-625k	V4-643c	V4-643d	V5-613a	V5-613b	V5-625m
Eupatorium semiserratum											0.001												
Euthamia caroliniana						0.006			0.058		0.026	0.003					0.007		0.051	0.019			
Fuirena breviseta											0.003	0.003						0.003					
Fuirena scirpoidea																							
Fuirena spp																			0.001				
Gaylussacia mosieri		0.012			0.003					0.070		0.023	0.003							0.004			0.003
Gelsemium rankinii			0.003			0.021											0.002						
Habenaria repens												0.009											
Hydrocotyle bonariensis			0.005			0.050			0.025		0.006		0.133	0.236	0.030	0.008	0.002		0.021	0.031		0.023	0.020
Hypericum brachyphyllum		0.144										0.016						0.001					
Hypericum crux-andreae											0.002												
Ilex cassine		0.003			0.006	0.010																0.013	
Ilex coriacea		0.013			0.010								0.002										0.001
Ilex glabra		0.017								0.156	0.020								0.025				
Ilex myrtifolia		0.011										0.010					0.022						
Ilex vomitoria									0.001	0.034													
Ipomoea sagittata				0.008			0.002	0.002															
Juncus dichotomus											0.001												
Juncus effusus																							0.001
Juncus marginatus																							
Juncus roemerianus				0.796			0.289	0.639															
Kosteletzkya virginica			0.008																				
Lachnanthes caroliniana																							
Lachnocaulon anceps											0.005	0.003											
Lilaeopsis carolinensis									0.001				0.002	0.043		0.002			0.004				
Lobelia brevifolia											0.001												
Ludwigia leptocarpa						0.006			0.005	0.002	0.004	0.003		0.336	0.050	0.090	0.004		0.003	0.008			0.001
Ludwigia pilosa																							
Ludwigia spp.			0.009																				
Lycopodiella alopecuroides																							
Lycopodiella caroliniana																							
Lycopus spp.						0.009														0.010			
Lygodium japonicum												0.003											
Lyonia lucida		0.073			0.136								0.011				0.017			0.018	0.014		0.031
Magnolia virginiana													0.006										
Mikania scandens			0.010			0.006			0.002	0.004	0.001	0.001	0.014	0.044	0.008	0.006	0.027			0.016			0.004
Mitchella repens																							
Morella caroliniensis		0.002			0.021																		
Morella cerifera		0.128	0.038							0.047		0.008	0.019				0.033				0.010	0.106	0.100
Morella inodora																							
Nyssa biflora										0.003		0.023						0.040					
Nyssa sylvatica																							
Osmunda regalis			0.009		0.019		0.007							0.004			0.074					0.005	0.003
Oxypolis filiformis																							
Panicum rigidulum										0.067													
Panicum verrucosum			0.005						0.050	0.049	0.005						0.008						
Panicum virgatum																				0.006			
Persea palustris			0.025	0.016		0.017							0.023					0.008			0.014		

Plot	DWT01	FWC01	Marsh1	Marsh2	SWR01	SWT03	TWC01	TWT01	V1-643a	V2-625a	V2-625c	V2-626c	V3-625e	V3-625f	V3-625g	V3-627a	V3-627c	V4-625k	V4-643c	V4-643d	V5-613a	V5-613b	V5-625m
Phyllanthus urinaria						0.010																	
Pinus elliottii		0.003								0.002		0.001											
Pinus taeda																		0.005					
Pluchea foetida						0.004								0.004						0.003			
Pluchea odorata										0.002	0.001				0.008								
Polygala brevifolia																							
Polygala cruciata																							
Polygala cymosa											0.001												
Polygonum hydropiperoides			0.009			0.147					0.005		0.004									0.125	0.006
Polygonum punctatum																			0.039				
Pontederia cordata					0.009																		
Proserpinaca pectinata																							
Pteridium aquilinum										0.001													
Quercus laevis																							
Quercus michauxii									0.019														
Quercus spp.																			0.006				
Quercus virginicus																							
Rhexia alifanus																							
Rhexia petiolata																							
Rhexia spp.																							
Rhus copallina																							
Rhynchospora baldwinii																							
Rhynchospora brevisita																							
Rhynchospora cephalantha																							
Rhynchospora chapmanii																							
Rhynchospora compressa																							
Rhynchospora corniculata						0.002																	
Rhynchospora fascicularis																							
Rhynchospora glomerata																							
Rhynchospora gracilenta		0.028			0.002													0.008		0.103			0.014
Rhynchospora macra																							
Rhynchospora microcephala		0.016										0.008						0.061					
Rhynchospora oligantha																							
Rhynchospora plumosa											0.002												
Rhynchospora spp.									0.001			0.030											
Rubus spp.			0.003			0.021					0.002								0.003		0.003		0.006
Saccharum giganteum										0.006													
Salvia coccinea																							
Sarracenia leucophylla																							
Sarracenia psittacina																							
Scirpus cyperinus											0.001	0.005											
Scleria ciliata																							
Scleria reticularis																							
Scleria triglomerata																							0.001
Scoparia dulcis									0.002	0.007	0.002												
Serenoa repens										0.026										0.015			
Sericocarpus tortifolius																							
Smilax bona-nox																							

Plot	DWT01	FWC01	Marsh1	Marsh2	SWR01	SWT03	TWC01	TWT01	V1-643a	V2-625a	V2-625c	V2-626c	V3-625e	V3-625f	V3-625g	V3-627a	V3-627c	V4-625k	V4-643c	V4-643d	V5-613a	V5-613b	V5-625m
Smilax glauca									0.001	0.008													
Smilax laurifolia		0.030			0.004					0.004		0.006	0.002				0.013		0.039	0.004			0.003
Smilax pumila																							
Solidago leavenworthii			0.013														0.008						
Solidago spp.						0.004			0.012				0.018										
Spartina patens			0.031																			0.025	
Sphagnum spp.		0.694			0.026							0.016						0.128					
Styrax americanus																							
Symphyotrichum subulatum										0.001	0.016												
Taxodium ascendens											0.001												
Taxodium distichum									0.004														
Thelypteris sp.														0.187						0.004			0.003
Toxicodendron radicans			0.003		0.006								0.001									0.003	
Typha latifolia									0.454		0.286	0.005	0.032	0.011	0.908	0.910	0.004		0.053	0.175			0.538
Utricularia juncea																		0.002					
Vaccinium corymbosum																							
Vaccinium elliottii																							
Viola spp.																							
Vitis rotundifolia						0.004																	
Woodwardia aerolata																			0.003				
Woodwardia virginica		0.004			0.009							0.001									0.006	0.003	
Xyris ambigua		0.003									0.010	0.025											
Xyris baldwinii																							
Xyris caroliniana																							
Xyris fimbriata		0.018										0.001						0.004					
Xyris serotina																							
Xyris spp																							
Xyris stricta		0.003																0.001					
Zigadenus glaberrimus																							

Plot	VN-411a	VN-412a	VN-412b	VN-611a	VN-614a	VN-625a	VN-625b	VN-625c	VN-626a	VW-411a	VW-611a	VW-614a	VW-625a	VW-625b	VW-625c	VW-625d	VW-625e	VW-626a	VW-626b	VW-626c	VW-626d	VW-626e	VW-627a	VW-627b
Open Water (avg cover/m2)														0.1	0.3		0.1							
Open Water (avg % cover)														5.0	31.5		7.5							
Total Avg Vegetated Cover/m2	1.2	0.4	0.5	0.3	1.6	0.9	0.9	0.6	0.8	1.4	0.3	0.2	0.8	1.0	0.2	0.2	1.5	1.3	1.7	1.2	1.4	1.2	0.0	0.6
Avg Plot % Vegetated	118.0	35.0	49.2	25.9	156.1	88.6	88.6	58.3	84.5	139.6	34.3	20.5	78.4	102.9	16.8	17.5	147.8	126.1	167.6	119.0	135.8	116.7	2.8	59.9
Species Richness	13	14	14	14	21	23	27	25	24	14	9	7	46	27	14	7	15	31	19	11	22	44	4	10
Avg Sphagnum Coverage (m2)				0.0	0.1						0.1		0.0	0.0	0.0		0.7		0.9	1.0	0.6	0.1		0.0
Species (Cover/m2)																								
Acer rubrum						0.009	0.002																	
Andropogon glomeratus var glaucopsis	0.035		0.042			0.013	0.011	0.013	0.018	0.041			0.005	0.107			0.166	0.014		0.019	0.103	0.005		
Andropogon glomeratus var glomeratus													0.003											
Andropogon mohrii																						0.013		
Andropogon virginicus		0.014	0.007			0.012			0.006									0.020				0.016		
Anthaenantia rufa																						0.004		
Apios americana																								
Aristida palustris							0.002						0.022								0.005	0.006		
Aristida spp.								0.006																
Aristida stricta			0.006						0.163	0.107			0.215					0.072						
Aronia arbutifolia				0.002		0.020	0.013			0.026			0.006						0.001					
Baccharis halimifolia																								
Bacopa monnieri																								
Balduina uniflora									0.003				0.015					0.002						
Boehmeria cylindrica																								
Carex glaucescens				0.099			0.004	0.047	0.018				0.093	0.055	0.015		0.033		0.069		0.011	0.005		0.006
Carex spp.				0.020																				
Centella erecta									0.001				0.012					0.003						
Ceratopteris thalictroides												0.001												
Chamaecyparis thyoides																								
Cladium jamaicense																								
Clethra alnifolia										0.121			0.002	0.008										
Cliftonia monophylla	0.105			0.004	0.421		0.243	0.300	0.431		0.147	0.120	0.060	0.235	0.054	0.033	0.058	0.047	0.007		0.075	0.119	0.002	0.531
Cyperus spp.																								
Cyperus strigosus																								
Cyrilla racemiflora						0.205		0.001																
Dichanthelium dichotomum				0.004		0.001		0.047	0.010				0.008					0.263						
Dichanthelium scabriusculum		0.001												0.027								0.002		
Dichanthelium scoparium			0.001				0.001																	
Dichanthelium spp.																						0.001		
Dichanthelium spretum			0.004			0.002	0.007	0.004					0.027	0.001								0.004		
Difference																								
Diodia teres																								
Drosera capillaris					0.003			0.002	0.003					0.001								0.030		
Drosera tracyi					0.009																			
Eclipta prostrata																								
Eleocharis albida																								

Plot	VN-411a	VN-412a	VN-412b	VN-611a	VN-614a	VN-625a	VN-625b	VN-625c	VN-626a	VW-411a	VW-611a	VW-614a	VW-625a	VW-625b	VW-625c	VW-625d	VW-625e	VW-626a	VW-626b	VW-626c	VW-626d	VW-626e	VW-627a	VW-627b
Eriocaulon compressum								0.040						0.001										
Eriocaulon decangulare					0.011				0.110				0.001					0.078				0.079		
Eriocaulon spp.							0.004																	
Eupatorium capillifolium																								
Eupatorium semiserratum																		0.001						
Euthamia caroliniana			0.010						0.001									0.031						
Fuirena breviseta						0.002																0.007		
Fuirena scirpoidea					0.086																			
Fuirena spp																								
Gaylussacia mosieri	0.150			0.015	0.093	0.067	0.058			0.071		0.011	0.020			0.005		0.001	0.014		0.047			
Gelsemium rankinii													0.004		0.001								0.004	
Habenaria repens																								
Hydrocotyle bonariensis																								
Hypericum brachyphyllum					0.024		0.010	0.004	0.013				0.021	0.118			0.183		0.063		0.224	0.167		
Hypericum crux-andreae													0.008					0.002						
Ilex cassine																					0.034			
Ilex coriacea	0.060			0.062		0.194	0.077	0.052		0.226	0.043	0.004	0.061	0.002	0.016	0.045		0.003	0.036				0.020	0.009
Ilex glabra	0.620	0.021	0.033			0.090	0.198			0.336			0.002	0.008	0.010			0.178	0.071	0.036	0.159	0.001		
Ilex myrtifolia						0.043	0.082						0.012		0.005		0.007		0.043		0.004	0.024		
Ilex vomitoria	0.023	0.004	0.108			0.009							0.008											
Ipomoea sagittata																								
Juncus dichotomus																								
Juncus effusus																								
Juncus marginatus													0.005											
Juncus roemerianus																								
Kosteletzkya virginica																								
Lachnanthes caroliniana					0.091	0.002	0.011	0.001	0.001					0.004					0.050	0.007	0.013	0.002		
Lachnocaulon anceps					0.011		0.002																	
Lilaeopsis carolinensis																								
Lobelia brevifolia													0.001											
Ludwigia leptocarpa																								
Ludwigia pilosa														0.020										
Ludwigia spp.																								
Lycopodiella alopecuroides							0.018		0.003				0.001					0.076			0.019	0.002		
Lycopodiella caroliniana					0.004				0.006									0.026						
Lycopus spp.																								
Lygodium japonicum																								
Lyonia lucida	0.075				0.140			0.024		0.083	0.047	0.060		0.166	0.028	0.055	0.009			0.004	0.022			
Magnolia virginiana				0.001			0.011	0.004					0.015					0.050	0.004					
Mikania scandens																								
Mitchella repens		0.006		0.004				0.001																0.001
Morella caroliniensis													0.031											
Morella cerifera				0.008			0.017			0.029		0.006	0.020	0.004					0.064			0.025		
Morella inodora															0.002							0.005		
Nyssa biflora										0.043	0.003		0.013	0.050			0.025	0.020	0.047			0.106		0.003

Plot	VN-411a	VN-412a	VN-412b	VN-611a	VN-614a	VN-625a	VN-625b	VN-625c	VN-626a	VW-411a	VW-611a	VW-614a	VW-625a	VW-625b	VW-625c	VW-625d	VW-625e	VW-626a	VW-626b	VW-626c	VW-626d	VW-626e	VW-627a	VW-627b
Nyssa sylvatica						0.063																		
Osmunda regalis																								
Oxypolis filiformis																						0.003		
Panicum rigidulum						0.005	0.002						0.002	0.021								0.004		
Panicum verrucosum														0.007										
Panicum virgatum																								
Persea palustris	0.011			0.001		0.090	0.006	0.001					0.005											
Phyllanthus urinaria																								
Pinus elliottii					0.001			0.006	0.001				0.016	0.002			0.023	0.009	0.021	0.009	0.013	0.001		0.001
Pinus taeda						0.001																		
Pluchea foetida																								
Pluchea odorata																								
Polygala brevifolia																						0.001		
Polygala cruciata					0.001				0.001															
Polygala cymosa																								
Polygonum hydropiperoides																								
Polygonum punctatum																								
Pontederia cordata																								
Proserpinaca pectinata							0.001							0.006								0.000		
Pteridium aquilinum		0.056	0.116							0.229						0.013								
Quercus laevis		0.044	0.003																					
Quercus michauxii																								
Quercus spp.																								
Quercus virginicus	0.005	0.032	0.006																					
Rhexia alifanus									0.001													0.005		
Rhexia petiolata							0.003						0.001	0.002										
Rhexia spp.								0.004	0.003				0.001					0.011			0.003	0.002		
Rhus copallina													0.001											
Rhynchospora baldwinii					0.093																	0.018		
Rhynchospora brevisita										0.001												0.001		
Rhynchospora cephalantha																			0.097	0.049				
Rhynchospora chapmanii								0.003	0.013									0.014			0.003			
Rhynchospora compressa													0.001											
Rhynchospora corniculata																								
Rhynchospora fascicularis																		0.039				0.001		
Rhynchospora glomerata				0.001							0.001									0.034				
Rhynchospora gracilenta					0.036		0.037	0.002	0.001		0.017		0.006	0.100	0.004		0.036	0.102	0.059	0.006	0.007	0.091		0.004
Rhynchospora macra					0.021																			
Rhynchospora microcephala								0.002						0.007			0.109				0.011	0.135		
Rhynchospora oligantha					0.186													0.044						
Rhynchospora plumosa																		0.050				0.040		
Rhynchospora spp.																								
Rubus spp.								0.001					0.002	0.014										
Saccharum giganteum																								
Salvia coccinea		0.018																						

Plot	VN-411a	VN-412a	VN-412b	VN-611a	VN-614a	VN-625a	VN-625b	VN-625c	VN-626a	VW-411a	VW-611a	VW-614a	VW-625a	VW-625b	VW-625c	VW-625d	VW-625e	VW-626a	VW-626b	VW-626c	VW-626d	VW-626e	VW-627a	VW-627b
Sarracenia leucophylla					0.121																	0.016		
Sarracenia psittacina					0.064																	0.014		
Scirpus cyperinus																								
Scleria ciliata			0.007																					
Scleria reticularis									0.006													0.006		
Scleria triglomerata						0.005															0.004			
Scoparia dulcis																								
Serenoa repens	0.033	0.015																						
Sericocarpus tortifolius		0.001																						
Smilax bona-nox		0.050	0.067																					
Smilax glauca	0.015					0.015							0.005											
Smilax laurifolia	0.014			0.005		0.015	0.026	0.013			0.006	0.003	0.013	0.038	0.005	0.003	0.062	0.022	0.021	0.016	0.007	0.020		0.001
Smilax pumila		0.072	0.083																					
Solidago leavenworthii																								
Solidago spp.																								
Spartina patens																								
Sphagnum spp.				0.033	0.121						0.076		0.012	0.023	0.015		0.746		0.907	0.964	0.588	0.129		0.007
Styrax americanus													0.010									0.003		
Symphyotrichum subulatum																								
Taxodium ascendens																								
Taxodium distichum																								
Thelypteris sp.																								
Toxicodendron radicans																								
Typha latifolia																								
Utricularia juncea																								
Vaccinium corymbosum						0.024	0.033			0.047			0.006										0.003	
Vaccinium elliottii	0.034	0.017								0.036														
Viola spp.													0.001											
Vitis rotundifolia								0.001							0.003									
Woodwardia aerolata															0.001									
Woodwardia virginica													0.008	0.003	0.009	0.020		0.001	0.056	0.047	0.005			0.034
Xyris ambigua					0.021				0.006				0.002				0.016	0.037				0.017		
Xyris baldwinii									0.028															
Xyris caroliniana							0.006	0.001										0.003				0.005		
Xyris fimbriata																	0.003		0.044					
Xyris serotina																						0.008		
Xyris spp						0.002												0.003						
Xyris stricta											0.003						0.004	0.037			0.004	0.026		
Zigadenus glaberrimus													0.001											

10.0 TIDAL EDS AND PERDIDO BAY

Pursuant to the monitoring goals established in the Framework for Monitoring the Combined Effluent Distribution Project (CEDP) (Updated 2008), analytical surface water quality was monitored at select stations in the tidally influenced areas of Tee and Wicker Lakes, Lower Elevenmile Creek and Upper Perdido Bay quarterly throughout the 2017 monitoring year (Figure 10-1). The following chapter describes the hydrological and climate dynamics observed in Upper Perdido Bay and the methodologies and results for analytical surface water quality monitoring conducted in 2017. Where appropriate, comparisons are made to pre-effluent (prior to fall 2011) and 2012–2016 post-effluent analytical water quality monitoring data.

10.1 Hydrologic Dynamics in Upper Perdido Bay

The spatial orientation of Upper Perdido Bay, which is long and narrow, results in a dynamic hydrologic regime which 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. However, freshwater inputs from the Perdido River and Elevenmile Creek do not appear to have a large impact on overall water elevations in the tidal receiving waters except in the short term, and during extreme precipitation events. Freshwater inflows do have a large impact on water quality and specifically, salinity concentrations in Tee and Wicker Lake, reducing salinity and specific conductivity as discharge increases from the Perdido River or Elevenmile Creek (see Section 10.3 below). Salinity concentrations in the tidal creek at station GS05 are impacted to a lesser extent, as this creek is predominately tidal freshwater even at baseflow. For the most part, freshwater inflows affect salinities and specific conductivities in the EDS receiving waters (Tee & Wicker Lakes and lower Elevenmile Creek) to a somewhat greater degree than the marine waters of the Perdido Bay. However, stratification of salinities is almost always prevalent in the upper Perdido Bay and to a lesser extent, in Tee and Wicker Lakes, and freshwater inflows typically have 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 occur at both tidal stations (see Chapter 3, Figure 3-10). For instance, during the month of December in any year depicted in Figure 3-10, water elevations trend downwards and begin trending upwards in the spring of each year. This large-scale pattern is mostly independent of discharges from Perdido River and Elevenmile Creek as evidenced by the fact that several late annual fall discharge records were higher than average, and several annual spring discharges were lower than average (Table 10-1; Figure 10-2).

Astronomical tides are not a dominant factor in Gulf of Mexico Bays, and seasonal water elevation oscillations are largely driven by meteorological forcing, and specifically seasonal differences in wind direction (Orlando, et al., 1993). The variations 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). Indeed, the oscillations depicted in Figure 3-4 (See Chapter 3) for TWT01 and GS05 appear to corroborate a bimodal fluctuation in water elevations throughout

the year. The larger declines in tidal area water elevations starting in the late fall 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, 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 in the tidal receiving waters 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, we could expect to find lower salinities and more influence of freshwater during the winter low elevations in the Upper Bay, and higher salinities during the late summer and early fall.

10.2 Analytical Water Quality Methods

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 SOP 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.

Individual *in situ* water quality measurements of pH, specific conductivity, salinity, dissolved oxygen (DO) percent saturation, and DO concentration were collected at the tidal creek at GS05, in lower Elevenmile Creek at SWD3 and SWD4, and at the five Perdido Bay (PB) stations using a hand-held multiparameter sensor. Measurements were collected at the water surface (0.5 ft below surface) and at depth near the bottom (0.5 ft from bottom). Individual *in situ* measurements were not made at the TWT stations; however the same *in situ* water quality parameters were measured at those stations using unattended sondes deployed for a 48 hour period and at the time of each quarterly sampling event (see Chapter 5).

Surface water samples collected for laboratory analysis were collected as grab samples at a tidal creek EDS station that flows into lower Elevenmile Creek (GS05), at two tidal EDS lake stations in the Tee (TWT02) and Wicker (TWT01) lake complex, at a reference tidal station located at the confluence of the Perdido River and Perdido Bay (TWR), and at five stations in the Upper Perdido Bay (PB) (Figure 10-1). Station nomenclature is described in Chapter 2. In addition and as a part of the NPDES permit (FL0002526) requirements, sampling was conducted at two stations in lower Elevenmile Creek (SWD). These included stations SWD3 located approximately one (1) mile upstream of the mouth of Elevenmile Creek, and SWD4 located at the mouth of Elevenmile Creek (Figure 10-1). See Chapter 6, Section 6.1.1 of this report for a detailed description of field sample collection methods.

Phytoplankton samples were also collected at the five Perdido Bay stations, PB01, PB02, PB03, PB04, and PB05 as well as at the two Tee and Wicker Lake complex stations, TWT01 and TWT02, in August and December 2016. Two separate one liter samples were collected from within 1 foot of the surface and individually preserved with a 4% formalin solution used in the first sample and 3 mL of Lugols solution used in the second sample. Analysis of the

phytoplankton samples was conducted by Water & Air Research, Inc., Gainesville, FL, and followed the standard procedure for inverted microscope analyses.

Analytical water quality was evaluated using boxplots and basic summary statistics to determine the overall water quality trends and effectiveness of the effluent distribution system (EDS) during the 2016 monitoring year. Prior to 2012, water quality data was only collected at stations TWT01 and TWR01, therefore, the following analyses list data beginning in 2012 and compare it to results from 2016. Where the laboratory report listed a test result as below the method detection limits (MDL) for individual analytes, the reported MDL values were divided by two (2) for analysis and summary purposes.

10.3 In-situ Water Quality Monitoring Results

Diel *in situ* monitoring was conducted at the Tee and Wicker Lakes stations TWT01 and TWT02 in 2017. Results of the diel monitoring events are described in Chapter 5.

Summary statistics for *in situ* water quality monitoring at tidal creek station GS05, Elevenmile Creek stations (SWD), and upper Perdido Bay stations (PB) are presented in Tables 10-2 through 10-4. No *in situ* data were collected at any stations during the spring 2017 monitoring event (June 21 – 22, 2017) due to tropical storm Cindy which prohibited safe access to the monitoring stations by boat. Bottom water column *in situ* samples were not collected during the winter monitoring event at the Elevenmile Creek and Perdido Bay stations due to equipment malfunction. In order to examine seasonal trends, calculations were made separately for each season, and quarterly data collected annually from 2012 – 2016 were combined to compare with quarterly data collected in 2017.

Water quality statistics for station GS05 are given in Table 10-2. Water temperatures at station GS05 in 2017 were higher during the winter event and lower during the summer and fall events compared to previous monitoring years. Specific conductivities and salinities at GS05 in 2017 were above previous data average in the winter and near the minimum of 2012 – 2016 data in the summer, which is likely the result of precipitation events that increased the amount of freshwater inputs to the creek from the EDS wetland and from Elevenmile Creek. Measured pH levels were similar to previous years' data. Dissolved oxygen values at GS05 were higher in 2017 than previous years, especially in the summer and fall, which is related to the lower water temperatures that occurred during those events.

Water quality statistics for the lower Elevenmile Creek stations are given in Table 10-3. Median water temperatures at the SWD stations in 2017 were similar to previous monitoring years except during the fall monitoring event. Surface specific conductivities and salinities were higher than previous years during the summer and fall monitoring events. Dissolved oxygen and pH values were similar to previous monitoring years.

Water quality statistics for the upper Perdido Bay stations are given in Table 10-4. Median water temperatures in Perdido Bay vary as expected throughout the year with the highest temperatures measured during summer monitoring events (August), and the lowest temperatures measured during winter events (typically February). The winter 2017 monitoring event occurred in late March, and therefore higher water temperatures were measured in the Bay during that event. The highest specific conductivities and salinities measured in 2017 at the

Perdido Bay monitoring stations were measured during the fall monitoring event (December) and the lowest salinities were measured during the summer monitoring event (August). During previous monitoring years, the lowest salinities were measured during the spring event; however, the 2017 results are not unexpected due to the high rainfall totals for August of 2017. Salinity stratification was present during all monitoring events in 2017 for which data was collected, with lower salinities at the surface and higher salinities at the bottom, which is typical for a shallow estuary such as Perdido Bay. Over all monitoring periods, median pH values in the bay varied little throughout the year, but were slightly lower during summer monitoring events (6.6 – 6.8 SU) than during fall events (7.2 – 7.7 SU). Results of dissolved oxygen (DO) monitoring in 2017 were similar to previous monitoring years, rarely falling below 90 percent saturation. Dissolved oxygen (DO) stratification was evident during the summer 2017 monitoring event, with a median DO of 33.0% at the bottom of the water column.

10.4 Nutrient and Chlorophyll-a Results

Samples collected in the tidal areas and Upper Perdido Bay during 2017 monitoring were analyzed for the following phosphorus and nitrogen species: total phosphorus (TP), orthophosphate, total kjeldahl nitrogen (TKN), ammonia (NH_3), and nitrite + nitrate (NO_x). Chlorophyll-a samples were collected at the tidal stations (TW) and the bay stations (PB) quarterly during the 2017 monitoring season. No samples were collected in tidal areas or Perdido Bay during the spring 2017 sampling event due to tropical storm Cindy which prohibited safe access to the monitoring stations by boat. For data summary and year-to-year comparisons, analytical results from all stations were grouped into areas as detailed in the table below (see Table 10-5 for summary statistics of all data for pre-effluent years and 2012 – 2017; see Figures 10-3 through 10-15 for summary box plots of all data; see attached data disc for lab reports with individual sample results):

Group	Stations Included
Elevenmile Creek	SWD3
	SWD4
Tidal Creek	GS05
Tee & Wicker Lakes	TWT01
	TWT02
Tidal Reference	TWR01
Perdido Bay	PB01
	PB02
	PB03
	PB04
	PB05

Geometric mean calculations for Bay station total phosphorus, total nitrogen and chlorophyll-a, and comparison to Upper Perdido Bay numeric nutrient criteria are presented in Table 10-6. For brevity, the following sections include discussion of total phosphorus, total nitrogen, and chlorophyll-a results only.

10.4.1 Total Phosphorus

Total phosphorus concentration statistics for tidal creeks and the bay stations are given in Table 10-5 and depicted in Figure 10-3. The median total phosphorus (TP) value for GS05 in 2017 was 0.21 mg/L, which is equal to the median for the previous post-effluent monitoring years. Median TP for the two Lower Elevenmile Creek stations was 0.03 mg/L, which is lower than the overall median value collected between 2012 and 2016 of 0.08 mg/L. In Tee and Wicker lakes, median TP concentration was 0.04 mg/L which was lower than the median of 0.06 mg/L for 2012 – 2016. Samples from the tidal reference station TWR01 followed the same trend as Tee & Wicker lakes. Finally, median TP concentrations in Upper Perdido Bay were also lower in 2017 (0.02 mg/L) compared with 2012 – 2016 median (0.04 mg/L). Station GS05 is the only station to have slightly higher median TP in post effluent years than in pre-effluent years.

Geometric mean calculations and comparisons to numeric nutrient criteria are given in Table 10-6. The overall TP geomean for the five Upper Perdido Bay stations in 2017 was 0.018 mg/L. Overall geomeans from previous years ranged from 0.027 – 0.046 mg/L. In 2017, seasonal geomeans of TP varied little between seasons. The highest TP value measured in 2017 was 0.041 mg/L at station PB05 during the winter monitoring event, and the lowest values were measured during the summer and fall, when samples from all five stations had a concentration of 0.016 mg/L. None of the TP samples collected between 2012 and 2017 have ever exceeded the numeric nutrient criteria for Upper Perdido Bay of 0.102 mg/L (0 out of 107 total samples for 2012 – 2017; see Table 10-6).

10.4.2 Total Nitrogen

Total nitrogen statistics are provided in Table 10-5 and depicted in Figure 10-5. The median total nitrogen (TN) value for GS05 in 2017 was 1.06 mg/L, which is 0.04 mg/L lower than the over median for 2012 – 2016, and 0.25 mg/L lower than the median value for pre-effluent years. Concentrations of TN measured in lower Elevenmile Creek had a median of 0.70 mg/L for 2017, which was 0.13 mg/L lower than overall median values for 2012 – 2016. In 2017, median TN concentrations in Tee and Wicker Lakes was 0.51 mg/L. Total nitrogen values measured in Tee and Wicker lakes have decreased as median value for pre-effluent years was 0.73 mg/L and for post effluent years 2012 – 2016 was 0.72 mg/L. Median TN values for TWR01 were consistent with tidal lake and Perdido Bay concentrations. Median TN values for the Perdido Bay stations ranged from 0.39 – 0.56 mg/L in 2017.

Geometric mean calculations and comparisons to numeric nutrient criteria are given in Table 10-6. The overall TN geomean for all Perdido Bay stations in 2017 was 0.47 mg/L. Overall geomeans from previous monitoring years ranged from 0.32 – 0.60 mg/L. In 2017, seasonal geomeans of TN were similar for the three events, and ranged from 0.44 – 0.50 mg/L. Only four TN geomeans, measured at stations PB02 and PB03 in spring 2012, and at stations PB04 and PB05 in winter 2016 (possibly inaccurate data, see the corresponding section in the 2016 Monitoring Report) exceeded the numeric nutrient criteria for upper Perdido Bay of 1.27 mg/L. The criteria rule states that less than ten percent of single samples may exceed the TN criteria over a seven year period. Therefore, TN criteria have not been exceeded in Perdido Bay, since only 3.7 percent of samples collected since 2012 have exceeded 1.27 mg/L (including anomalous values from winter 2016, see Table 10-6).

10.4.3 Chlorophyll-a

Summary statistics for chlorophyll-a monitoring are given in Table 10-5 and depicted in Figure 10-9. Chlorophyll-a samples from Tee and Wicker Lakes in 2017 had a median value of 3.0 µg/L, which was lower than the median of 6.3 µg/L measured at the tidal reference station TWR01. Samples from the Perdido Bay stations also had a lower median value (2.1 µg/L) than TWR01 in 2017. Median chlorophyll-a values for Tee and Wicker Lakes and Perdido Bay samples in 2017 were lower than the median for 2012 – 2016. Although the median value for Perdido Bay samples in 2017 was lower than 2012 - 2016, the mean value was slightly higher due to high chlorophyll-a measured in the bay during the summer 2017 monitoring event (see discussion below and Table 10-5, Figure 10-9).

Geometric mean calculations and comparisons to numeric nutrient criteria are given in Table 10-6. The overall chlorophyll-a geomean for all Perdido Bay stations in 2017 was 3.3 µg/L. Geomeans from previous monitoring years ranged from 2.7 – 7.2 µg/L. In 2017, seasonal geomeans of chlorophyll-a ranged from 1.3 – 15.7 µg/L, with the lowest value measured in the fall and the highest value measured in the summer. Four of five samples collected in the bay on August 30, 2017 during the summer monitoring event had chlorophyll-a concentrations that exceeded the chlorophyll-a numeric nutrient criteria (NNC) for upper Perdido Bay of 11.5 µg/L. The Pensacola Regional Airport weather station recorded 5.46 inches of rain on the date of the summer monitoring event and 1.40 inches the previous day associated with the remnants of Hurricane Harvey. Samples were collected in the afternoon immediately following the 5.46 inch precipitation event. No precipitation was recorded for twelve consecutive days preceding the rain event. The lack of rainfall and high temperatures preceding the large rain event may have allowed for algal growth in the bay as well as in the watershed, and excessive runoff from the rain event may have contributed to the high chlorophyll-a values measured during the sampling event. Geomeans for the winter and fall 2017 monitoring events were 1.7 and 1.3 µg/L, respectively, which were lower than geomeans for all previous monitoring events except winter 2015 (1.2 µg/L) and fall 2016 (1.1 µg/L). Prior to 2017, eleven samples exceeded the NNC criteria between 2012 – 2016. Overall, 15 percent of the samples collected over the five monitoring years have exceeded the criteria value of 11.5 µg/L, which is above the criterion's limit of no more than 10% measurement exceedance in the most recent seven years. Outside of the summer 2017 monitoring event, which may be an anomaly due to the preceding weather conditions, chlorophyll-a concentrations in upper Perdido Bay appear to be declining with each year of monitoring (Table 10-6).

10.5 Other Water Quality Parameters

Several other analytical and *in-situ* water quality parameters were analyzed in 2017. These included measures of transparency such as color, secchi depth, and turbidity, as well as 5-day biochemical oxygen demand (BOD), total organic carbon (TOC), and total suspended solids (TSS). Annual summary statistics for monitoring years 2012 – 2017 for all other parameters are presented in Table 10-7, and summary box plots are presented in Figures 10-12 – 10-15. Transparency results (color and turbidity measurements) are discussed in the following sections. Secchi depths were also recorded for the tidal receiving waters and the Bay stations in 2017. However, total water depths in Perdido Bay are shallow and secchi depths are frequently

greater than total depths (see Table 10-8 for secchi depth results for all tidal receiving waters for monitoring years 2012 – 2016).

Samples collected from lower Elevenmile Creek, Tee and Wicker Lakes, and Perdido Bay in 2017 had lower median color values relative to monitoring years 2012 – 2016 (Table 10-7; Figure 10-12). Median turbidity values measured in all tidal waters in 2017 were low and ranged from 2 - 8 NTU. The 2017 median turbidity values for each sampling area were within the range measured during previous monitoring years (Table 10-7, Figure 10-13). Perdido Bay stations had their highest clarity during the fall sampling event based on secchi depths (5.2 – 6.2 ft), which coincides with high salinities for all tidal areas (Tables 10-4 and 10-6). Based on turbidity and secchi depth measurements, water clarity in the tidal receiving waters of the EDS in 2017 was similar to previous monitoring years 2012 – 2016 (Tables 10-7 and 10-8). Color values measured at GS05 were similar to previous years. Total suspended solids (TSS) concentrations in all sampling areas in 2017 were comparable to previous monitoring years (Table 10-7; Figure 10-14).

Biological oxygen demand (BOD) concentrations in tidal receiving waters have declined since 2012. In fact, 2017 samples had the lowest maximum BOD values in each sampling area compared to 2012 – 2016 and pre-effluent monitoring periods (Table 10-7; Figure 10-15). Median total organic carbon (TOC) concentrations in all areas were lower in 2017 than medians for all samples collected in 2012 – 2016. The highest TOC values were measured at station GS05 and the lowest values were measured at TWR01.

10.6 Phytoplankton

The majority of taxa present in the August and December 2017 samples were freshwater and brackish water phytoplankton species. In August at the Perdido Bay stations (PB01 – PB05), cyanobacteria in the genus *Pseudanabaena* were the most abundant (by density) group across all stations, and comprised 69% of the total biovolume of cells at those five stations (Table 10-9). Cyanobacteria were also the most abundant group at station TWT01 while Chlorophyta were the most abundant at TWT02 in August. Total cells per mL in the August samples from Perdido Bay and Tee and Wicker lakes were higher than the samples collected in August during the previous two monitoring years (Table 10-10). The higher number of *Pseudanabaena* sp. cells present in the Perdido Bay samples may account for the elevated chlorophyll-a measured in the samples at those stations in August 2017. The analysis laboratory noted that the organisms identified as *Pseudanabaena* sp. may have been *Pseudanabaena limnetica*, a bloom-forming species that can produce toxins, but were noted as being in poor condition or stressed. Total biovolumes of cells were much lower at all stations in December 2017 compared to August. The cyanobacteria *Merismopedia tenuissima* was the most abundant species in samples from stations PB01 and PB02 in December 2017, while various species of Cryptomonads were most abundant from stations PB03, PB04, PB05, TWT01 and TW02 during the same sampling event.

Although increased algal biomass in the warm summer months would be expected, high rainfall totals in August 2017 likely contributed to the observed increase in biomass due to excess runoff and nutrient inputs from the Bay's watershed as a whole. Total biovolumes at the Perdido Bay stations ranged between 352,000 and 1,898,000 cubic microns/mL in August 2017 and between 72,000 and 141,000 cubic microns/mL in December 2017. Although total

biovolume of cells was higher in August, Shannon diversity and evenness were higher for the December sampling event (Table 10-10).

10.7 Conclusions

Effects of typical hydrologic dynamics as well as regional climate conditions were evident in 2017 monitoring data collected in the tidal receiving waters of the EDS, including lower Elevenmile Creek, Tee and Wicker Lakes, and upper Perdido Bay. The Pensacola area received over 92 inches of rainfall for 2017, with a surplus of 28 inches above average, which affected results of water quality monitoring in 2017. No samples were collected in tidal receiving waters in June 2017 due to tropical storm Cindy. The August 2017 samples were collected following a rain event of over 6 inches and likely contributed high chlorophyll-a concentration in the bay. Despite the heavy rainfall events, total phosphorus and total nitrogen concentrations were lower in 2017 than previous years in tidal receiving waters directly adjacent to the EDS including lower Elevenmile Creek and Tee and Wicker Lakes. The numeric nutrient criteria for the upper Perdio Bay has continued to be met for total phosphorus and total nitrogen but was exceeded for chlorophyll-a by 15% since 2012. Based on color, turbidity, and transparency data collected in 2017, the EDS tidal receiving waters are not impaired due to high concentrations of sediments or other particulate matter in the water column. Transparency was highest during the fall monitoring event, probably due to low rainfall totals in October and November. Phytoplankton cell densities and biovolumes have varied over the 2012 – 2017 monitoring years. Although increased algal biomass in the warm summer months would be expected, high rainfall totals in August 2017 likely contributed to the observed increase in biomass due to excess runoff and nutrient inputs from the Bay's watershed. Based on the 2017 monitoring record, the EDS is functioning as designed and water quality is improving in the tidal receiving waters and Upper Perdido Bay due to the diversion of effluent flows from the Elevenmile Creek headwaters to the EDS wetlands.

Table 10-1. Historic and yearly freshwater inflow statistics to Upper Perdido Bay.

Location and Time Range	Average Monthly Discharge (cfs)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Styx River at Elsanor, AL (USGS 02377570)												
Monthly Average (1987-2009)	565	513	558	455	362	401	465	385	486	296	389	395
2011	313	288	329	157	98	117	296	142	503	100	109	150
2012	157	404	204	127	198	464	196	325	347	195	115	239
2013	217	712	306	272	392	518	651	497	265	162	168	369
2014	349	427	609	1447	1254	538	516	238	256	195	145	262
2015	337	226	517	798	261	224	157	147	110	163	449	596
2016	498	406	832	606	266	224	226	420	195	115	110	396
2017	997	302	216	270	485	1636	560	638	462	1696	319	294
Perdido River at Barrineau Park, FL (USGS 02376500)												
Monthly Average (1940-2009)	932	949	1073	979	696	671	704	692	736	509	609	734
2011	657	622	582	338	230	243	625	262	438	216	229	339
2012	377	997	466	295	262	884	302	427	490	333	230	402
2013	395	1177	549	515	719	500	631	593	483	265	280	784
2014	676	824	994	1353	1870	767	730	354	322	299	267	549
2015	690	438	673	1276	762	420	324	267	301	447	938	1305
2016	1036	840	1358	1113	520	589	472	790	466	245	229	659
2017	2010	602	488	568	1062	2541	1186	1059	834	1662	592	662
Elevenmile Creek near Pensacola, FL (USGS 02376115)												
Monthly Average (1987-2009)	107	103	123	109	76	98	115	104	118	89	99	100
2011	66	73	81	58	52	49	87	57	75	52	57	65
2012	54	72	53	41	35	68	66	94	34	28	20	22
2013	22	67	32	30	30	58	164	80	50	31	33	32
2014	41	69	75	161	97	58	50	33	38	40	29	37
2015	51	36	29	77	32	33	25	37	27	46	82	66
2016	69	72	101	80	37	47	36	74	48	27	24	77
2017	221	24	37	43	57	238	63	114	52	87	44	44

Table 10-1. Historic and yearly freshwater inflow statistics to Upper Perdido Bay (continued).

Location and Time Range	Discharge Percent Deviation from Long-term Average (%)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Styx River at Elsanor, AL (USGS 02377570)												
Monthly Average (1987-2009)	565	513	558	455	362	401	465	385	486	296	389	395
2011	-44%	-44%	-41%	-65%	-73%	-71%	-36%	-63%	3%	-66%	-72%	-62%
2012	-72%	-21%	-63%	-72%	-45%	16%	-58%	-15%	-29%	-34%	-70%	-40%
2013	-61%	39%	-45%	-40%	8%	29%	40%	29%	-46%	-45%	-57%	-7%
2014	-38%	-17%	9%	218%	246%	34%	11%	-38%	-47%	-34%	-63%	-34%
2015	-40%	-56%	-7%	75%	-28%	-44%	-66%	-62%	-77%	-45%	15%	51%
2016	-12%	-21%	49%	33%	-27%	-44%	-51%	9%	-60%	-61%	-72%	0%
2017	77%	-41%	-61%	-41%	34%	308%	20%	66%	-5%	473%	-18%	-26%
Perdido River at Barrineau Park, FL (USGS 02376500)												
Monthly Average (1940-2009)	932	949	1073	979	696	671	704	692	736	509	609	734
2011	-30%	-34%	-46%	-66%	-67%	-64%	-11%	-62%	-41%	-58%	-62%	-54%
2012	-60%	5%	-57%	-70%	-62%	32%	-57%	-38%	-34%	-35%	-62%	-45%
2013	-58%	24%	-49%	-47%	3%	-26%	-10%	-14%	-34%	-48%	-54%	7%
2014	-27%	-13%	-7%	38%	169%	14%	4%	-49%	-56%	-41%	-56%	-25%
2015	-26%	-54%	-37%	30%	10%	-37%	-54%	-61%	-59%	-12%	54%	78%
2016	11%	-11%	27%	14%	-25%	-12%	-33%	14%	-37%	-52%	-62%	-10%
2017	116%	-37%	-55%	-42%	53%	279%	68%	53%	13%	227%	-3%	-10%
Elevenmile Creek near Pensacola, FL (USGS 02376115)												
Monthly Average (1987-2009)	107	103	123	109	76	98	115	104	118	89	99	100
2011	-39%	-29%	-34%	-47%	-32%	-50%	-25%	-45%	-36%	-42%	-42%	-35%
2012	-50%	-30%	-57%	-62%	-53%	-31%	-42%	-10%	-71%	-69%	-80%	-78%
2013	-79%	-35%	-74%	-73%	-60%	-40%	43%	-23%	-58%	-65%	-67%	-68%
2014	-61%	-33%	-39%	48%	28%	-41%	-57%	-68%	-68%	-56%	-71%	-63%
2015	-52%	-65%	-76%	-29%	-58%	-66%	-78%	-65%	-77%	-49%	-17%	-34%
2016	-36%	-30%	-18%	-27%	-52%	-52%	-68%	-29%	-59%	-70%	-75%	-23%
2017	107%	-77%	-70%	-61%	-25%	143%	-45%	10%	-56%	-2%	-56%	-56%

Table 10-2. Summary statistics for *in situ* monitoring at tidal creek station GS05.

Water Quality Parameter	Season	Time Period	Valid N	Mean	Median	Minimum	Maximum
Temperature (°C)	Winter	2012 - 2016	4	18.4	17.0	16.1	23.7
		2017	1	20.9	--	--	--
	Spring	2012 - 2016	5	24.4	24.3	22.2	27.2
		2017	Not measured				
	Summer	2012 - 2016	5	27.8	28.0	27.1	28.3
		2017	1	25.8	--	--	--
	Fall	2012 - 2016	5	17.4	16.6	15.4	19.5
		2017	1	9.9	--	--	--
Specific Conductivity (µS/cm)	Winter	2012 - 2016	4	823	731	403	1426
		2017	1	962	--	--	--
	Spring	2012 - 2016	5	1529	1569	1173	1832
		2017	Not measured				
	Summer	2012 - 2016	5	1159	1032	967	1686
		2017	1	944	--	--	--
	Fall	2012 - 2016	5	1650	1684	1262	2069
		2017	1	1658	--	--	--
Salinity (ppt)	Winter	2012 - 2016	4	0.41	0.34	0.21	0.75
		2017	1	0.48	--	--	--
	Spring	2012 - 2016	5	0.75	0.80	0.60	0.86
		2017	Not measured				
	Summer	2012 - 2016	5	0.61	0.54	0.48	0.90
		2017	1	0.47	--	--	--
	Fall	2012 - 2016	5	0.87	0.89	0.63	1.10
		2017	1	0.84	--	--	--
pH (SU)	Winter	2012 - 2016	4	6.8	7.1	5.7	7.2
		2017	1	6.4	--	--	--
	Spring	2012 - 2016	5	7.2	7.2	6.9	7.4
		2017	Not measured				
	Summer	2012 - 2016	5	7.0	6.9	6.7	7.3
		2017	1	7.3	--	--	--
	Fall	2012 - 2016	5	7.3	7.4	6.9	7.7
		2017	1	7.8	--	--	--
Dissolved Oxygen (% saturation)	Winter	2012 - 2016	4	50.0	46.9	32.3	74.1
		2017	1	55.2	--	--	--
	Spring	2012 - 2016	5	17.5	15.4	2.2	30.5
		2017	Not measured				
	Summer	2012 - 2016	5	12.3	16.3	0.9	21.7
		2017	1	34.5	--	--	--
	Fall	2012 - 2016	5	33.4	24.0	18.5	52.1
		2017	1	65.9	--	--	--

Table 10-3. Summary statistics for *in situ* monitoring at lower Elevenmile Creek stations SWD3 and SWD4.

Parameter	Season	Time Period	Depth	Valid N	Mean	Std. Dev.	Minimum	20th Percentile	Median	80th Percentile	Maximum
Temperature (°C)	Winter	2012 - 2016	Surface	6	18.6	3.6	13.7	16.4	18.1	22.5	22.9
			Bottom	6	18.3	4.0	13.3	13.9	18.8	21.6	23.2
		2017	Surface	2	21.1	0.3	20.9	--	--	--	21.3
			Bottom	Not measured							
	Spring	2012 - 2016	Surface	8	25.1	2.0	23.0	23.2	24.6	27.2	28.2
			Bottom	8	25.3	2.4	22.2	22.3	25.3	27.6	28.7
		2017	Not measured								
	Summer	2012 - 2016	Surface	14	27.6	1.3	25.5	26.4	27.7	29.1	29.8
			Bottom	14	27.9	2.0	24.3	25.8	28.1	29.9	30.7
		2017	Surface	2	25.4	0.6	24.9	--	--	--	25.8
			Bottom	2	27.1	2.6	25.2	--	--	--	28.9
	Fall	2012 - 2016	Surface	10	18.1	1.3	16.7	16.8	18.0	19.5	20.1
			Bottom	10	19.3	1.8	17.1	17.4	19.5	21.1	22.2
		2017	Surface	2	12.6	0.5	12.2	--	--	--	12.9
			Bottom	2	14.9	0.3	14.7	--	--	--	15.1
Specific Conductivity (µS/cm)	Winter	2012 - 2016	Surface	6	7,987	11,854	178	403	675	19,345	26,645
			Bottom	6	18,430	13,115	167	4,328	23,327	27,832	31,597
		2017	Surface	2	805	766	263	--	--	--	1,346
			Bottom	Not measured							
	Spring	2012 - 2016	Surface	8	2,052	2,814	72	234	603	5,495	7,447
			Bottom	8	7,896	5,714	73	2,009	8,891	12,212	16,285
		2017	Not measured								
	Summer	2012 - 2016	Surface	14	1,071	1,871	91	130	578	1,186	7,375
			Bottom	14	7,280	8,033	149	188	4,789	18,589	20,040
		2017	Surface	2	2,617	1,541	1,527	--	--	--	3,707
			Bottom	2	15,304	14,221	5,248	--	--	--	25,360
	Fall	2012 - 2016	Surface	10	7,915	11,084	733	1,240	3,125	14,321	34,300
			Bottom	10	29,141	6,896	17,730	23,101	28,888	36,574	37,800
		2017	Surface	2	5,257	6,792	454	--	--	--	10,059
			Bottom	2	27,841	3,242	25,548	--	--	--	30,133

Table 10-3. Summary statistics for *in situ* monitoring at lower Elevenmile Creek stations SWD3 and SWD4 (continued).

Parameter	Season	Time Period	Depth	Valid N	Mean	Std. Dev.	Minimum	20th Percentile	Median	80th Percentile	Maximum
Salinity (ppt)	Winter	2012 - 2016	Surface	6	4.5	6.8	0.1	0.2	0.3	10.1	15.9
			Bottom	6	11.2	8.1	0.1	2.2	14.4	16.9	19.4
		2017	Not measured								
	Spring	2012 - 2016	Surface	6	1.5	1.7	0.2	0.2	0.6	3.0	4.2
			Bottom	6	5.7	2.7	1.6	3.8	6.3	7.1	9.1
		2017	Not measured								
	Summer	2012 - 2016	Surface	14	0.6	1.0	0.0	0.1	0.3	0.7	3.9
			Bottom	14	4.3	4.7	0.1	0.1	2.6	11.0	12.0
		2017	Surface	2	1.4	0.8	0.8	--	--	--	2.0
			Bottom	2	9.2	9.2	2.7	--	--	--	15.7
	Fall	2012 - 2016	Surface	10	4.7	6.9	0.4	0.6	1.7	8.5	21.2
			Bottom	10	18.1	4.7	10.7	14.0	17.6	23.3	24.0
		2017	Surface	2	3.0	3.9	0.2	--	--	--	5.7
			Bottom	2	17.2	2.2	15.6	--	--	--	18.7
pH (SU)	Winter	2012 - 2016	Surface	6	7.1	0.4	6.7	6.7	7.0	7.4	7.7
			Bottom	6	7.0	0.5	6.5	6.6	6.8	7.4	7.8
		2017	Surface	2	7.1	0.3	6.9	--	--	--	7.3
			Bottom	Not measured							
	Spring	2012 - 2016	Surface	8	7.1	0.4	6.5	6.7	7.1	7.3	7.6
			Bottom	8	6.7	0.3	6.2	6.4	6.7	7.0	7.1
		2017	Not measured								
	Summer	2012 - 2016	Surface	14	6.8	0.3	6.3	6.5	6.7	7.1	7.5
			Bottom	14	6.7	0.3	6.3	6.4	6.6	7.0	7.5
		2017	Surface	2	7.3	0.2	7.2	--	--	--	7.5
			Bottom	2	7.0	0.5	6.7	--	--	--	7.4
	Fall	2012 - 2016	Surface	10	7.2	0.5	6.3	6.7	7.3	7.5	7.8
			Bottom	10	7.1	0.3	6.7	6.8	7.0	7.4	7.8
		2017	Surface	2	8.0	0.7	7.6	--	--	--	8.5
			Bottom	2	7.2	0.2	7.1	--	--	--	7.3

Table 10-3. Summary statistics for *in situ* monitoring at lower Elevenmile Creek stations SWD3 and SWD4 (continued).

Parameter	Season	Time Period	Depth	Valid N	Mean	Std. Dev.	Minimum	20th Percentile	Median	80th Percentile	Maximum
Dissolved Oxygen (% saturation)	Winter	2012 - 2016	Surface	6	78.5	15.6	55.8	74.1	77.8	81.7	104.1
			Bottom	6	76.1	28.4	27.9	65.2	79.7	93.3	110.6
		2017	Surface	2	85.9	9.7	79.0	--	--	--	92.7
			Bottom	Not measured							
	Spring	2012 - 2016	Surface	8	82.3	19.4	46.7	68.3	80.9	99.2	107.8
			Bottom	8	47.9	32.4	4.4	6.4	51.1	80.4	84.7
		2017	Not measured								
	Summer	2012 - 2016	Surface	14	72.1	10.9	54.8	59.8	74.0	81.4	89.8
			Bottom	14	56.8	23.9	0.9	41.6	65.5	69.7	90.1
		2017	Surface	2	67.5	9.4	60.8	--	--	--	74.1
			Bottom	2	33.9	43.2	3.4	--	--	--	64.5
	Fall	2012 - 2016	Surface	10	74.8	9.6	59.1	65.4	76.9	81.7	90.9
			Bottom	10	48.1	28.6	1.3	29.1	42.7	67.8	104.7
		2017	Surface	2	86.0	2.1	84.5	--	--	--	87.5
			Bottom	2	40.5	22.3	24.7	--	--	--	56.2

Table 10-4. 2017 summary statistics for *in situ* monitoring at Perdido Bay stations PB01, PB02, PB03, PB04, and PB05.

Parameter	Season	Time Period	Depth	Valid N	Mean	Std. Dev.	Minimum	20th Percentile	Median	80th Percentile	Maximum
Temperature (ºC)	Winter	2012 - 2016	Surface	21	16.3	4.1	10.2	13.6	16.8	18.9	23.7
			Bottom	18	16.6	4.5	10.5	11.9	16.2	21.7	23.9
		2017	Surface	5	21.5	0.9	19.9	20.7	21.9	22.1	22.2
			Bottom	Not measured							
	Spring	2012 - 2016	Surface	23	26.3	2.3	21.6	24.1	26.3	28.9	29.2
			Bottom	20	25.1	4.9	6.7	22.7	26.4	28.7	29.4
		2017	Not measured								
	Summer	2012 - 2016	Surface	23	29.1	2.0	25.1	27.1	29.3	30.6	32.6
			Bottom	20	29.0	1.5	25.9	27.5	29.3	30.5	30.9
		2017	Surface	5	27.3	0.3	26.9	27.1	27.2	27.6	27.6
			Bottom	5	28.2	0.4	27.8	27.9	28.2	28.6	28.7
	Fall	2012 - 2016	Surface	22	18.1	2.5	10.7	16.1	18.9	20.2	20.7
			Bottom	22	18.6	1.7	15.8	16.7	19.0	19.8	23.1
		2017	Surface	5	12.1	0.5	11.5	11.6	12.1	12.5	12.7
			Bottom	5	13.0	2.0	11.5	11.7	12.3	14.7	16.4
Specific Conductivity (µS/cm)	Winter	2012 - 2016	Surface	21	11,091	7,327	633	3,906	8,504	18,150	21,200
			Bottom	18	21,228	9,983	5,039	8,502	21,173	29,482	41,500
		2017	Surface	5	11,097	3,062	5,863	8,562	12,190	13,085	13,790
			Bottom	Not measured							
	Spring	2012 - 2016	Surface	23	6,852	4,543	177	2,875	6,103	9,930	18,900
			Bottom	20	14,166	10,233	110	4,659	12,924	21,887	36,536
		2017	Not measured								
	Summer	2012 - 2016	Surface	23	5,779	5,121	270	1,031	4,559	8,894	21,579
			Bottom	20	13,567	10,117	31	3,005	10,935	23,122	32,187
		2017	Surface	5	14,851	4,325	9,106	10,734	15,837	18,476	20,522
			Bottom	5	25,966	2,505	22,008	23,612	26,750	27,930	28,455
	Fall	2012 - 2016	Surface	22	18,952	7,997	6,535	10,717	19,069	26,697	30,850
			Bottom	22	32,257	7,626	8,783	25,700	34,310	38,920	42,103
		2017	Surface	5	17,924	4,260	12,291	14,037	17,385	22,080	22,931
			Bottom	5	24,596	7,392	17,538	19,480	22,937	30,542	37,070

Table 10-4. 2017 summary statistics for in situ monitoring for Perdido Bay stations PB01, PB02, PB03, PB04, and PB05 (continued).

Parameter	Season	Time Period	Depth	Valid N	Mean	Std. Dev.	Minimum	20th Percentile	Median	80th Percentile	Maximum
Salinity (ppt)	Winter	2012 - 2016	Surface	21	6.5	4.5	0.3	2.1	4.8	10.8	12.7
			Bottom	18	12.9	6.6	2.7	4.8	13.0	18.6	26.6
		2017	Not measured								
	Spring	2012 - 2016	Surface	18	4.7	2.6	1.6	3.2	3.9	5.8	11.9
			Bottom	15	10.4	6.1	3.1	5.4	8.3	16.5	23.1
		2017	Not measured								
	Summer	2012 - 2016	Surface	23	3.3	3.1	0.2	0.5	2.5	5.0	13.2
			Bottom	20	9.1	6.6	0.2	2.2	8.7	14.8	20.4
		2017	Surface	5	8.8	2.8	5.2	6.2	9.4	11.1	12.5
			Bottom	5	16.3	1.4	14.2	14.9	16.7	17.5	17.8
	Fall	2012 - 2016	Surface	22	11.6	5.5	3.6	6.5	11.5	16.5	23.3
			Bottom	22	20.3	5.2	4.9	15.7	21.8	24.8	27.3
		2017	Surface	5	10.6	2.7	7.0	8.1	10.2	13.2	13.8
			Bottom	5	15.0	5.0	10.3	11.6	13.8	19.1	23.6
pH (SU)	Winter	2012 - 2016	Surface	21	7.1	0.6	5.5	6.5	7.3	7.5	7.8
			Bottom	18	7.1	0.5	5.9	6.7	7.4	7.6	7.7
		2017	Surface	5	6.8	0.4	6.1	6.4	6.9	7.1	7.2
			Bottom	Not measured							
	Spring	2012 - 2016	Surface	23	7.1	0.5	6.2	6.6	7.2	7.6	7.9
			Bottom	20	7.0	0.5	5.9	6.7	7.1	7.3	8.3
		2017	Not measured								
	Summer	2012 - 2016	Surface	23	6.9	0.7	5.7	6.2	6.8	7.6	8.1
			Bottom	20	6.8	0.4	6.1	6.6	6.7	7.1	7.7
		2017	Surface	5	7.2	0.3	6.7	6.9	7.2	7.5	7.5
			Bottom	5	6.8	0.4	6.3	6.5	6.8	7.2	7.2
	Fall	2012 - 2016	Surface	22	7.6	0.4	6.6	7.3	7.7	8.0	8.0
			Bottom	22	7.7	0.3	7.0	7.5	7.7	7.9	8.1
		2017	Surface	5	7.7	0.0	7.6	7.7	7.7	7.7	7.7
			Bottom	5	7.6	0.2	7.2	7.4	7.6	7.7	7.8

Table 10-4. 2017 summary statistics for in situ monitoring for Perdido Bay stations PB01, PB02, PB03, PB04, and PB05 (continued).

Parameter	Season	Time Period	Depth	Valid N	Mean	Std. Dev.	Minimum	20th Percentile	Median	80th Percentile	Maximum
Dissolved Oxygen (% saturation)	Winter	2012 - 2016	Surface	21	91.8	11.9	66.5	83.4	95.1	101.4	104.7
			Bottom	18	70.8	37.7	0.6	17.1	89.7	103.0	105.3
		2017	Surface	5	111.3	7.6	98.3	105.3	112.7	116.6	117.7
			Bottom	Not measured							
	Spring	2012 - 2016	Surface	23	99.3	10.7	79.0	88.4	98.8	109.2	118.2
			Bottom	20	65.1	29.2	1.1	44.7	66.1	91.1	118.5
		2017	Not measured								
	Summer	2012 - 2016	Surface	23	91.6	16.7	63.6	73.7	90.2	110.3	118.7
			Bottom	20	45.4	31.3	0.0	7.2	58.6	74.9	91.0
		2017	Surface	5	90.9	10.6	73.4	82.4	92.1	98.8	101.7
			Bottom	5	41.4	21.6	21.1	22.6	33.0	64.4	67.8
	Fall	2012 - 2016	Surface	22	99.1	8.2	74.3	96.1	100.7	105.6	107.0
			Bottom	22	80.0	25.8	15.8	58.4	84.9	105.0	115.2
		2017	Surface	5	98.0	3.2	94.7	94.9	98.3	101.1	102.4
			Bottom	5	88.9	32.5	31.0	64.8	102.5	106.2	107.3

Table 10-5. Annual nutrient and chlorophyll-a concentrations measured during pre-effluent (when available) and the 2012-2017 monitoring years in the tidal receiving waters surrounding the International Paper combined effluent distribution project.

Parameter	Area	Monitoring Period	Valid N	Mean	Std. Dev.	Minimum	20th Percentile	Median	80th Percentile	Maximum
Total Phosphorus (TP), mg/L	GS05	Pre-effluent	26	0.14	0.08	0.05	0.07	0.14	0.19	0.42
		2012-2016	20	0.19	0.08	0.02	0.12	0.21	0.26	0.37
		2017	3	0.24	0.07	0.18	--	--	--	0.32
	Elevenmile Creek	2012-2016	38	0.08	0.05	0.02	0.04	0.08	0.11	0.26
		2017	6	0.03	0.02	0.02	0.02	0.03	0.04	0.06
	Tee & Wicker	Pre-effluent	13	0.08	0.02	0.05	0.06	0.09	0.10	0.12
		2012-2016	40	0.06	0.04	0.01	0.02	0.06	0.09	0.16
		2017	6	0.04	0.03	0.02	0.02	0.04	0.07	0.08
	Tidal Reference	Pre-effluent	14	0.08	0.04	0.05	0.05	0.07	0.12	0.15
		2012-2016	20	0.05	0.04	0.01	0.02	0.04	0.07	0.17
		2017	3	0.02	0.00	0.02	--	--	--	0.02
	Perdido Bay	2012-2016	92	0.05	0.03	0.01	0.02	0.04	0.07	0.10
		2017	15	0.02	0.01	0.02	0.02	0.02	0.02	0.04
Ortho-phosphate, mg/L	GS05	Pre-effluent	21	0.05	0.04	0.00	0.02	0.05	0.07	0.14
		2012-2016	20	0.12	0.11	0.01	0.05	0.09	0.15	0.50
		2017	3	0.18	0.03	0.14	--	--	--	0.20
	Elevenmile Creek	2012-2016	37	0.03	0.03	0.01	0.01	0.02	0.04	0.15
		2017	6	0.02	0.02	0.01	0.01	0.02	0.04	0.05
	Tee & Wicker	Pre-effluent	13	0.03	0.02	0.01	0.01	0.03	0.05	0.05
		2012-2016	40	0.02	0.02	0.01	0.01	0.01	0.02	0.10
		2017	6	0.01	0.00	0.01	0.01	0.01	0.01	0.02
	Tidal Reference	Pre-effluent	13	0.02	0.02	0.01	0.01	0.02	0.05	0.05
		2012-2016	20	0.01	0.02	0.01	0.01	0.01	0.02	0.10
		2017	3	0.01	0.00	0.01	--	--	--	0.01
	Perdido Bay	2012-2016	89	0.01	0.01	0.01	0.01	0.01	0.01	0.10
		2017	15	0.01	0.00	0.01	0.01	0.01	0.01	0.01

Table 10-5. Annual nutrient and chlorophyll-a concentrations measured during during pre-effluent (when available) and the 2012-2017 monitoring years in the tidal receiving waters surrounding the International Paper combined effluent distribution project (continued).

Parameter	Area	Monitoring Period	Valid N	Mean	Std. Dev.	Minimum	20th Percentile	Median	80th Percentile	Maximum
Total Nitrogen (TN), mg/L	GS05	Pre-effluent	24	1.46	0.63	0.30	1.00	1.31	2.02	3.21
		2012-2016	20	1.20	0.77	0.12	0.70	1.10	1.52	3.91
		2017	3	1.04	0.33	0.71	--	--	--	1.36
	Elevenmile Creek	2012-2016	38	0.88	0.42	0.23	0.67	0.83	1.01	2.98
		2017	6	0.69	0.12	0.53	0.60	0.70	0.80	0.83
	Tee & Wicker	Pre-effluent	12	0.68	0.23	0.12	0.60	0.73	0.78	1.04
		2012-2016	40	0.86	0.54	0.17	0.49	0.72	1.19	3.17
		2017	6	0.51	0.07	0.41	0.46	0.51	0.57	0.61
	Tidal Reference	Pre-effluent	13	0.67	0.21	0.31	0.55	0.60	0.88	1.01
		2012-2016	20	0.58	0.30	0.17	0.39	0.52	0.75	1.65
		2017	3	0.51	0.12	0.40	--	--	--	0.64
	Perdido Bay	2012-2016	92	0.58	0.36	0.14	0.31	0.57	0.72	2.13
		2017	15	0.47	0.05	0.39	0.45	0.46	0.51	0.56
Nitrite + Nitrate as N (NO_x), mg/L	GS05	Pre-effluent	26	0.30	0.27	0.01	0.09	0.19	0.53	1.10
		2012-2016	20	0.18	0.33	0.01	0.01	0.02	0.27	1.10
		2017	3	0.16	0.18	0.03	--	--	--	0.36
	Elevenmile Creek	2012-2016	38	0.28	0.17	0.01	0.12	0.26	0.40	0.78
		2017	6	0.30	0.14	0.12	0.14	0.33	0.42	0.45
	Tee & Wicker	Pre-effluent	12	0.10	0.06	0.01	0.05	0.09	0.15	0.24
		2012-2016	40	0.05	0.04	0.01	0.01	0.04	0.08	0.20
		2017	6	0.04	0.04	0.01	0.01	0.03	0.09	0.09
	Tidal Reference	Pre-effluent	13	0.16	0.11	0.01	0.08	0.17	0.31	0.35
		2012-2016	20	0.11	0.08	0.01	0.04	0.11	0.17	0.29
		2017	3	0.15	0.08	0.06	--	--	--	0.19
	Perdido Bay	2012-2016	90	0.10	0.08	0.01	0.02	0.08	0.15	0.34
		2017	15	0.13	0.08	0.01	0.05	0.13	0.19	0.30

Table 10-5. Annual nutrient and chlorophyll-a concentrations measured during during pre-effluent (when available) and the 2012-2017 monitoring years in the tidal receiving waters surrounding the International Paper combined effluent distribution project (continued).

Parameter	Area	Monitoring Period	Valid N	Mean	Std. Dev.	Minimum	20th Percentile	Median	80th Percentile	Maximum
Total Kjeldahl Nitrogen (TKN), mg/L	GS05	Pre-effluent	25	1.20	0.51	0.25	0.83	1.10	1.70	2.60
		2012-2016	20	1.02	0.75	0.12	0.70	0.80	1.20	3.90
		2017	3	0.88	0.18	0.68	--	--	--	1.00
	Elevenmile Creek	2012-2016	38	0.61	0.35	0.13	0.38	0.59	0.79	2.20
		2017	6	0.40	0.06	0.32	0.35	0.40	0.43	0.49
	Tee & Wicker	Pre-effluent	13	0.58	0.19	0.11	0.50	0.57	0.69	0.94
		2012-2016	40	0.81	0.54	0.13	0.40	0.66	1.15	3.10
		2017	6	0.47	0.10	0.32	0.41	0.47	0.54	0.59
	Tidal Reference	Pre-effluent	14	0.52	0.28	0.23	0.25	0.50	0.75	1.00
		2012-2016	20	0.48	0.32	0.13	0.27	0.41	0.65	1.60
		2017	3	0.37	0.07	0.31	--	--	--	0.45
	Perdido Bay	2012-2016	92	0.45	0.29	0.12	0.13	0.49	0.64	2.00
		2017	15	0.30	0.14	0.13	0.13	0.36	0.43	0.48
Ammonia (NH_3), mg/L	GS05	Pre-effluent	27	0.22	0.26	0.01	0.05	0.08	0.51	1.00
		2012-2016	20	0.02	0.04	0.01	0.01	0.01	0.03	0.13
		2017	3	0.06	0.09	0.01	--	--	--	0.17
	Elevenmile Creek	2012-2016	40	0.04	0.05	0.01	0.01	0.01	0.08	0.22
		2017	6	0.11	0.09	0.03	0.05	0.07	0.17	0.25
	Tee & Wicker	Pre-effluent	13	0.05	0.03	0.01	0.03	0.05	0.06	0.13
		2012-2016	40	0.02	0.02	0.01	0.01	0.01	0.01	0.10
		2017	6	0.04	0.05	0.01	0.01	0.01	0.07	0.13
	Tidal Reference	Pre-effluent	14	0.04	0.02	0.01	0.03	0.05	0.05	0.08
		2012-2016	20	0.01	0.01	0.01	0.01	0.01	0.01	0.06
		2017	3	0.04	0.05	0.01	--	--	--	0.10
	Perdido Bay	2012-2016	91	0.01	0.01	0.01	0.01	0.01	0.01	0.09
		2017	15	0.04	0.04	0.01	0.01	0.01	0.09	0.11

Table 10-5. Annual nutrient and chlorophyll-a concentrations measured during during pre-effluent (when available) and the 2012-2017 monitoring years in the tidal receiving waters surrounding the International Paper combined effluent distribution project (continued).

Parameter	Area	Monitoring Period	Valid N	Mean	Std. Dev.	Minimum	20th Percentile	Median	80th Percentile	Maximum
Chlorophyll-a, µg/L	Tee & Wicker	Pre-effluent	1	4.9	--	4.9	--	--	--	4.9
		2012-2016	40	7.6	7.9	1.6	2.7	5.1	10.2	36.0
		2017	6	3.5	2.2	0.9	2.7	3.0	3.8	7.5
	Tidal Reference	2012-2016	16	6.4	6.1	1.6	2.1	4.3	9.1	22.0
		2017	2	6.3	6.6	1.6	--	--	--	11.0
	Perdido Bay	2012-2016	86	6.6	8.5	0.5	1.8	4.8	8.5	66.0
		2017	15	6.9	8.3	0.5	1.2	2.1	17.5	24.0
Sulfate (SO_4), mg/L	GS05	Pre-effluent	3	218	218	3.8	--	--	--	440
		2012-2016	20	389	141	120	270	405	520	690
		2017	3	293	97	210	--	--	--	400
	Elevenmile Creek	2012-2016	38	151	158	8.1	25	94	260	680
		2017	6	123	128	16	19	77	210	340
	Tee & Wicker	Pre-effluent	13	435	259	33	190	520	630	920
		2012-2016	40	442	315	53	205	345	665	1300
		2017	6	519	284	91	290	560	800	810
	Tidal Reference	Pre-effluent	14	156	74	4.3	95	155	250	270
		2012-2016	20	220	157	9.2	55	235	310	670
		2017	3	277	107	160	--	--	--	370
	Perdido Bay	2012-2016	92	433	384	9.5	110	300	740	1700
		2017	15	576	182	220	440	570	735	900

Table 10-6. Upper Perdido Bay station nutrient and chlorophyll-a concentrations in 2012-2017 monitoring years for the combined effluent distribution project.

Year	Total Phosphorus (mg/L)						
	Station	**PB01**	**PB02**	**PB03**	**PB04**	**PB05**	**Seasonal Geomean**
	NNC Criterion	0.102 mg/L (Upper Perdido Bay Segment 62-302.532)					
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**
	Summer 2017	0.016	0.016	0.016	0.016	0.016	**0.016**
	Fall 2017	0.016	0.016	0.016	0.016	0.016	**0.016**
	Station Geo Mean	**0.016**	**0.016**	**0.021**	**0.016**	**0.022**	**--**
	Overall TP Geomean 2017						**0.018**
	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%**

Table 10-6. Upper Perdido Bay station nutrient and chlorophyll-a concentrations in 2012-2017 monitoring years for the combined effluent distribution project (continued).

Year	Total Nitrogen (mg/L)						
	Station	**PB01**	**PB02**	**PB03**	**PB04**	**PB05**	**Seasonal Geomean**
	NNC Criterion	1.27 mg/L (Upper Perdido Bay Segment 62-302.532)					
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	No Data	No Data	**No data**
	Summer 2017	0.56	0.39	0.51	0.49	0.45	**0.48**
	Fall 2017	0.45	0.45	0.45	0.39	0.45	**0.44**
	Station Geo Mean	**0.49**	**0.43**	**0.50**	**0.45**	**0.47**	**--**
	Overall TN Geomean 2017						**0.47**
	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 10-6. Upper Perdido Bay station nutrient and chlorophyll-a concentrations in 2012-2017 monitoring years for the combined effluent distribution project (continued).

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	No Data	No Data	No Data	No Data	No Data	**No Data**
	Summer 2017	16.0	19.0	6.6	24.0	20.0	**15.7**
	Fall 2017	2.1	1.9	0.6	0.8	1.9	**1.3**
	Station Geo Mean	**3.8**	**4.2**	**1.3**	**3.6**	**5.1**	**--**
	Overall Chlorophyll-a Geomean 2017						**3.3**
	Number of Chlorophyll-a NNC Exceedances						**4**
	% of Sample Exceeding Chlorophyll-a NNC						**27%**
2012-2017	**Total Number of Chlorophyll-a Samples**						**101**
	Number of Chlorophyll-a NNC Exceedances						**15**
	% of Samples Exceeding Chlorophyll-a NNC						**15%**

Table 10-7. Annual BOD, TOC, color, TSS, and turbidity measurements from pre-effluent (when available) and the 2012 - 2017 monitoring years in the tidal receiving waters surrounding the International Paper combined effluent distribution project.

Parameter	Area	Monitoring Period	Valid N	Mean	Std. Dev.	Minimum	20th Percentile	Median	80th Percentile	Maximum
Biochemical Oxygen Demand (BOD), mg/L	GS05	Pre-effluent	3	2.4	1.6	1.0	--	--	--	4.2
		2012-2016	20	1.6	1.4	1.0	1.0	1.0	2.2	5.5
		2017	3	1.4	0.7	1.0	--	--	--	2.2
	Elevenmile Creek	2012-2016	38	1.9	1.9	1.0	1.0	1.0	2.9	9.8
		2017	6	1.4	0.6	1.0	1.0	1.0	2.0	2.2
	Tee & Wicker	Pre-effluent	13	2.0	1.1	1.0	1.0	2.0	2.1	5.1
		2012-2016	40	1.4	0.9	1.0	1.0	1.0	1.5	5.4
		2017	6	1.4	0.6	1.0	1.0	1.0	2.2	2.3
	Tidal Reference	Pre-effluent	14	2.5	2.2	1.0	1.0	2.0	2.0	7.6
		2012-2016	19	1.3	0.9	1.0	1.0	1.0	1.0	4.5
		2017	3	1.4	0.6	1.0	--	--	--	2.1
	Perdido Bay	2012-2016	92	1.5	1.0	1.0	1.0	1.0	2.0	4.8
		2017	15	1.4	0.6	1.0	1.0	1.0	2.3	2.4
Total Organic Carbon (TOC), mg/L	GS05	2012-2016	13	19.2	3.2	14.0	16.0	19.0	22.0	25.0
		2017	3	18.3	4.9	15.0	--	--	--	24.0
	Elevenmile Creek	2012-2016	24	7.5	3.8	1.6	3.7	7.7	11.0	16.0
		2017	6	5.6	2.4	2.5	2.9	6.5	7.6	7.8
	Tee & Wicker	2012-2016	25	11.3	5.7	3.0	6.8	9.6	18.0	23.0
		2017	6	7.7	5.3	3.9	4.7	5.4	8.5	18.0
	Tidal Reference	2012-2016	13	5.6	3.3	2.5	2.7	4.5	7.6	13.0
		2017	3	4.3	1.3	3.1	--	--	--	5.6
	Perdido Bay	2012-2016	63	6.3	2.8	2.2	4.1	5.9	6.9	13.0
		2017	14	4.7	1.2	2.8	3.5	4.8	5.8	6.2

Table 10-7. Annual BOD, TOC, color, TSS, and turbidity measurements from pre-effluent and the 2012 – 2017 monitoring years in the tidal receiving waters surrounding the International Paper combined effluent distribution project (continued).

Parameter	Area	Monitoring Period	Valid N	Mean	Std. Dev.	Minimum	20th Percentile	Median	80th Percentile	Maximum
Color, color units	GS05	Pre-effluent	3	132	42	87	--	--	--	170
		2012-2016	20	319	360	46	160	200	295	1400
		2017	3	230	50	180	--	--	--	280
	Elevenmile Creek	2012-2016	40	90	61	20	41	75	135	320
		2017	6	61	29	22	33	66	85	94
	Tee & Wicker	Pre-effluent	13	106	93	28	50	61	170	370
		2012-2016	40	204	239	44	59	140	255	1200
		2017	6	71	84	22	24	42	53	240
	Tidal Reference	Pre-effluent	15	39	39	15	19	28	42	170
		2012-2016	20	50	52	7	17	30	73	240
		2017	3	25	13	10	--	--	--	35
	Perdido Bay	2012-2016	92	53	48	15	25	38	75	340
		2017	15	31	11	11	20	32	43	46
Total Suspended Solids (TSS), mg/L	GS05	Pre-effluent	3	5.5	3.3	2.5	--	--	--	9.0
		2012-2016	19	3.5	1.9	2.5	2.5	2.5	6.0	9.0
		2017	3	4.3	3.2	2.5	--	--	--	8.0
	Elevenmile Creek	2012-2016	38	6.5	8.4	2.5	2.5	5.0	8.0	53.0
		2017	6	6.3	4.8	2.5	2.5	4.3	10.0	14.0
	Tee & Wicker	Pre-effluent	11	13.4	6.8	2.5	9.0	14.0	21.0	23.0
		2012-2016	38	9.0	7.3	2.5	2.5	7.0	14.0	30.0
		2017	6	11.8	10.1	2.5	2.5	9.5	19.0	28.0
	Tidal Reference	Pre-effluent	14	7.7	2.8	2.5	6.0	7.0	10.0	13.0
		2012-2016	18	6.4	2.8	2.5	2.5	7.0	9.0	12.0
		2017	3	7.5	6.6	2.5	--	--	--	15.0
	Perdido Bay	2012-2016	87	9.9	7.0	2.5	5.0	8.0	15.0	37.0
		2017	15	7.0	4.3	2.5	2.5	8.0	10.0	17.0

Table 10-7. Annual BOD, TOC, color, TSS, and turbidity measurements from pre-effluent and the 2012 – 2017 monitoring years in the tidal receiving waters surrounding the International Paper combined effluent distribution project (continued).

Parameter	Area	Monitoring Period	Valid N	Mean	Std. Dev.	Minimum	20th Percentile	Median	80th Percentile	Maximum
Turbidity (NTU)	GS05	2012-2016	12	3.7	5.5	0.4	1.0	2.1	3.3	20
		2017	3	3.7	1.3	2.6	--	--	--	5.1
	Elevenmile Creek	2012-2016	25	6.5	5.9	0.8	3.1	4.4	10.3	25
		2017	6	9.5	9.2	3	3.3	4.2	18.4	23.7
	Tee & Wicker	2012-2016	26	4.0	2.8	0.9	2.0	3.0	5.5	13
		2017	5	7.2	2.9	2.8	4.4	7.9	9.7	9.8
	Tidal Reference	2012-2016	8	4.6	4.1	0.3	1.7	3.4	10.5	11
		2017	3	3.1	0.9	2.0	--	--	--	3.6
	Perdido Bay	2012-2016	73	5.0	5.7	0	1.7	3.3	5	33
		2017	15	2.4	0.9	1.4	1.7	2.1	3.5	4.1

Table 10-8. Secchi depths collected at tidal receiving waters and Upper Perdido Bay stations in 2012 through 2016.

Sampling Area	Station	Year	Winter	Spring	Summer	Fall
			feet			
GS05 Tidal Creek	GS05	2012	1.7	--	0.4	0.7
		2013	1.4	2.0	--	2.4
		2014	>2.2	--	>3.0	2.8
		2015	2.9	3.3	2.1	1.7
		2016	2.2	3.4	4.3	3.5
		2017	2.9	--	2.1	1.3
Lower Elevenmile Creek	SWD3	2012	1.5	--	--	2.7
		2013	4.0	4.0	--	>4.8
		2014	>4.1	>0.6	--	5.2
		2015	2.4	2.7	1.4	5.0
		2016	4.2	4.3	2.8	>4.2
		2017	5.5	--	1.7	6.0
	SWD4	2012	1.9	--	--	2.2
		2013	3.3	4.5	--	--
		2014	>5.2	>2.8	--	5.3
		2015	2.4	2.7	1.4	4.1
		2016	--	3.1	2.4	4.3
		2017	4.7	--	--	5.6
Tee & Wicker Lakes	TWT01	2012	1.6	--	0.5	1.6
		2013	--	2.0	1.3	>2.8
		2014	1.9	>1.7	>1.8	>2.7
		2015	1.4	1.9	1.7	> 3.1
		2016	>1.7	>3.0	1.6	>2.2
		2017	>2.0	--	3.3	>2.0
	TWT02	2012	1.7	--	--	2.5
		2013	2.1	2.5	1.7	>2.6
		2014	>2.4	>2.3	>2.5	>2.7
		2015	2.8	> 2.9	1.3	> 3.1
		2016	1.6	>3.2	1.6	>2.3
		2017	>2.0	--	1.7	>2.7
Tidal Reference	TWR01	2012	2.6	--	2.4	4.0
		2013	3.8	--	2.8	>3.7
		2014	>3.5	>3.0	--	>4.2
		2015	2.1	3.2	3.8	> 3.8
		2016	>2.8	3.1	2.6	>3.4
		2017	>3.8	--	3.8	>3.1

Table 10-8. Secchi depths collected at tidal receiving waters and Upper Perdido Bay stations in 2012 through 2017 (continued).

Sampling Area	Station	Year	Winter	Spring	Summer	Fall
			feet			
Upper Perdido Bay	PB01	2012	2.8	--	1.5	4.5
		2013	3.9	3.5	1.7	4.3
		2014	>6.0	>3.4	--	>6.6
		2015	1.9	3.0	3.7	4.3
		2016	4.1	4.5	2.7	5.0
		2017	5.3	--	4.1	>6.0
	PB02	2012	4.1	--	2.0	4.5
		2013	3.9	5.0	2.0	4.3
		2014	>5	>2.5	--	>6.2
		2015	--	2.9	3.1	4.1
		2016	3.3	4.1	3.0	5.1
		2017	>5.4	--	3.4	>5.7
	PB03	2012	2.9	--	3.0	--
		2013	--	4.1	2.0	5.4
		2014	7.5	>2.5	--	--
		2015	2.0	3.9	3.8	5.3
		2016	4.0	3.7	2.7	5.4
		2017	6.0	--	5.2	5.2
	PB04	2012	--	--	--	--
		2013	4.2	4.0	1.8	4.0
		2014	>5.0	>3.0	--	6.8
		2015	2.1	2.8	2.8	5.0
		2016	4.5	4.5	2.8	5.9
		2017	6.2	--	3.9	6.1
	PB05	2012	--	--	--	--
		2013	4.2	5.1	2.0	5.0
		2014	>5.0	>2.5	--	6.7
		2015	2.1	2.8	2.8	4.7
		2016	4.8	3.1	3.1	5.4
		2017	6.0	--	3.6	6.2

> measurements are those where secchi depths are greater than the total depth of water.

Table 10-9. Results of August and December 2017 phytoplankton sampling at the Upper Perdido Bay monitoring stations.

Final Taxa ID	8/30/2017							12/12/2017						
	PB01	PB02	PB03	PB04	PB05	TWT01	TWT02	PB01	PB02	PB03	PB04	PB05	TWT01	TWT02
	cells per mL													
CHLOROPHYTA (GREEN ALGAE)														
ANKISTRODESMUS FALCATUS		16	8	33		33		8						
ANKISTRODESMUS NANNOSELENE	49	16												
ANKISTRODESMUS SPIRALIS	41	16	58		33						4			
CARTERIA SP	353	131	58	559	329	99	16							
CHARACIUM PRINGSHEIMII							8							
CHLAMYDOMONAS SP	288	953	181	1808	1118	1315	1775	140	99	51	74	99	271	173
COSMARIUM SP			8											
CRUCIGENIA QUADRATA		131												
KIRCHNERIELLA LUNARIS			8	33		33								
KIRCHNERIELLA OBESA	8		16	33										
SCENEDESMUS BIJUGA		33	49											
SCENEDESMUS BREVISPINA			33											
SCENEDESMUS QUADRICAUDA			16											
SPERMATOZOPSIS EXSULTANS			8											
CHRYSOPHYTA (GOLDEN ALGAE)														
ACHNANTHIDIUM EXIGUUM							8						16	8
AMPHORA HOLSATICA													8	
AMPHORA SP														8
BACILLARIA PAXILLIFER													25	8
CHAETOCEROS SUBT. V ABNORMIS F SIMPLEX												16		
CYCLOTELLA SP	8		8	33	99		16	8		4		2		8
CYLINDROTHECA CLOSTERIUM												12		
DIPLONEIS SMITHII													8	
DISCOSTELLA PSEUDOSTELLIGERA		33				33								
EUNOTIA BIDENTULA													8	
GYROSIGMA MACRUM													8	
HASLEA SPICULA													8	
HIPPODONTA CAPITATA													16	
HIPPODONTA HUNGARICA													16	

Table 10-9. Results of August and December 2017 phytoplankton sampling at the Upper Perdido Bay monitoring stations (continued).

Final Taxa ID	8/30/2017							12/12/2017						
	PB01	PB02	PB03	PB04	PB05	TWT01	TWT02	PB01	PB02	PB03	PB04	PB05	TWT01	TWT02
	cells per mL													
NAVICULA CRYPTOCEPHALA							8							
NAVICULA GOTTLANDICA						33								
NAVICULA LACUSTRIS		16												
NAVICULA SP (MEDIUM)													41	49
NAVICULA SP (SMALL)							8							
NAVICULA TRIPUNCTATA V SCHIZONEMOIDES														8
NITZSCHIA ACICULARIS													8	8
NITZSCHIA GRACILIS							8							
NITZSCHIA LACUUM													8	
NITZSCHIA REVERSA								8	8				8	8
NITZSCHIA SIGMA														16
NITZSCHIA SP (SMALL)	131	99	33	66	99	33	8				4			
PLACONEIS CLEMENTIOIDES													8	
PLANOTHIDIUM DELICATULUM													25	
TRYBLIONELLA HUNGARICA													8	
TRYBLIONELLA LEVIDENSIS													8	16
UROSOLENIA LONGISETA									8	4	4	2		
CRYPTOPHYTA (CRYPTOMONAD)														
CRYPTOMONAS CAUDATA	148	362	49	263	263	164	58	214	189	8	158	58	945	69
CRYPTOMONAS SP	46	3863	362	46	888	329	66	41	156	14	43	51	181	312
HILLEA FUSIFORMIS								41	8	55	119	136	16	66
TELEAULAX ACUTA								41	16	8	12	2		
CYANOBACTERIA (BLUE-GREEN)														
ANABAENA SP						657	17							
APHANOCAPSA HOLSATICA						723								
CHROOCOCCUS MINIMUS	49		131			152								
COELOSPHAERIUM KUETZINGIANUM														214
DOLICHOSPERMUM SP														33
JAAGINEMA ANGUSTISSIMUM	181		82		263	2367	148	247	247					
MERISMOPEDIA TENUISSIMA								3452	1331	16	181	49		
PHORMIDIUM SP						427								

Table 10-9. Results of August and December 2017 phytoplankton sampling at the Upper Perdido Bay monitoring stations (continued).

Final Taxa ID	8/30/2017							12/12/2017						
	PB01	PB02	PB03	PB04	PB05	TWT01	TWT02	PB01	PB02	PB03	PB04	PB05	TWT01	TWT02
	cells per mL													
PLANKTOLYNGBYA LIMNETICA													123	
PSEUDANABAENA SP	9862	4652	3287	1388	11671	24	123	131	271		35			
EUGLENOPHYTA (EUGLENOID)														
EUGLENA SP	8	49		66										
EUTREPTIA SP						66	16							
PYRRHOPHYTA (DINOFLAGELLATES)														
AMPHIDINIUM SP											2	4		
GLENODINIUM SP		16	8	131			16				8	2		
GYMNODINIUM SP						33		8	33		23	37		
PERIDINIUM SP (MEDIUM)													8	
PERIDINIUM UMBONATUM				66										
PROROCENTRUM MINIMUM									16	4	14	29		16
PROROCENTRUM SP													8	
MISCELLANEOUS ALGAE														
UNIDENTIFIED UNI-FLAGELLATED ALGAE	82	707	49	1545	690	131	49	33	33	62	60	4	8	25
Total (cells/mL)	11,668	11,093	4,452	15,484	15,453	9,928	2,438	4,372	2,415	424	741	503	1,787	1,666
Taxa Richness	14	16	20	14	10	18	17	13	13	10	15	15	25	18

Table 10-10. Upper Perdido Bay station phytoplankton diversity statistics for 2010-2017 monitoring events.

Station	Sample Date	Total	Taxa Richness	Shannon Div.	Pielou's Evenness	Hurlbert Evenness	Biovolume (cubic microns/mL)
PB01	8/1/2012	1,620	17	1.872	0.458	0.444	56,000
	12/1/2012	2,213	20	2.464	0.570	0.530	1,007,000
	8/20/2013	12,274	15	1.739	0.445	0.414	3,330,000
	11/5/2013	2,570	13	2.649	0.716	0.684	434,000
	8/21/2014	176,875	13	1.374	0.371	0.329	2,868
	12/16/2014	2,604	13	2.201	0.595	0.548	584
	8/19/2015	2,440	23	3.471	0.767	0.724	356
	12/2/2015	1,631	15	2.889	0.739	0.713	521,000
	8/16/2016	1,386	38	4.094	0.780	0.724	192,000
	12/13/2016	1,540	16	2.644	0.661	0.623	113,000
	8/30/2017	11,668	14	1.088	0.286	0.265	352,000
	12/12/2017	4,372	13	1.338	0.362	0.318	72,000
	Average	**18,433**	**18**	**2.319**	**0.563**	**0.526**	**506,734**
PB02	8/1/2012	8,800	22	2.618	0.587	0.564	262,000
	12/1/2012	1,328	19	3.039	0.715	0.673	499,000
	8/20/2013	8,610	15	2.144	0.549	0.514	1,532,000
	11/5/2013	3,178	22	2.980	0.668	0.622	1,914,000
	8/21/2014	233,422	13	1.265	0.342	0.307	5,250
	12/16/2014	2,547	15	2.351	0.602	0.550	315
	8/19/2015	1,896	22	3.858	0.865	0.834	741
	12/2/2015	3,211	18	2.870	0.688	0.652	1,934,000
	8/16/2016	1,073	27	3.414	0.718	0.649	160,000
	12/13/2016	1,992	23	2.429	0.537	0.483	181,000
	8/30/2017	11,093	16	2.141	0.535	0.505	1,898,000
	12/12/2017	2,415	13	2.246	0.607	0.560	141,000
	Average	**23,297**	**19**	**2.613**	**0.618**	**0.576**	**710,609**

Table 10-10. Upper Perdido Bay station phytoplankton diversity statistics for 2010-2017 monitoring events (continued).

Station	Sample Date	Total	Taxa Richness	Shannon Div.	Pielou's Evenness	Hurlbert Evenness	Biovolume (cubic microns/mL)
PB03	8/1/2012	4,861	20	2.602	0.602	0.567	681,000
	12/1/2012	1,768	21	2.768	0.630	0.586	588,000
	8/20/2013	1,192	27	3.447	0.725	0.664	184,000
	11/5/2013	1,091	15	2.090	0.535	0.489	311,000
	8/21/2014	160,107	11	1.235	0.357	0.315	2,081
	12/16/2014	757	10	1.836	0.553	0.483	62
	8/19/2015	2,793	29	3.855	0.793	0.752	628
	12/2/2015	867	21	2.877	0.655	0.571	106,000
	8/16/2016	2,660	27	3.672	0.772	0.727	370,000
	12/13/2016	928	18	2.808	0.673	0.640	82,000
	8/30/2017	4,452	20	1.704	0.394	0.338	233,000
	12/12/2017	424	10	2.623	0.789	0.761	81,000
	Average	**15,158**	**19**	**2.626**	**0.623**	**0.574**	**219,898**
PB04	8/20/2013	38,991	17	2.893	0.708	0.685	4,429,000
	11/5/2013	2,910	18	3.131	0.751	0.719	918,000
	8/21/2014	228,489	10	1.244	0.374	0.347	5,140
	12/16/2014	2,275	17	2.575	0.630	0.570	465
	8/19/2015	1,691	16	3.524	0.881	0.857	306
	12/2/2015	2,034	21	3.093	0.704	0.673	1,023,000
	8/16/2016	1,833	22	2.904	0.651	0.609	235,000
	12/13/2016	2,948	13	1.769	0.478	0.427	196,000
	8/30/2017	15,484	14	1.738	0.456	0.413	1,266,000
	12/12/2017	741	15	3.049	0.780	0.756	117,000
	Average	**29,740**	**16**	**2.592**	**0.641**	**0.606**	**818,991**

Table 10-10. Upper Perdido Bay station phytoplankton diversity statistics for 2010-2017 monitoring events (continued).

Station	Sample Date	Total	Taxa Richness	Shannon Div.	Pielou's Evenness	Hurlbert Evenness	Biovolume (cubic microns/mL)
PB05	8/20/2013	9,911	17	2.842	0.695	0.673	1,130,000
	11/5/2013	2,456	15	3.114	0.797	0.770	568,000
	8/21/2014	162,081	16	1.595	0.399	0.347	3,394
	12/16/2014	2,836	17	2.654	0.649	0.604	414
	8/19/2015	3,940	19	3.407	0.802	0.763	537
	12/2/2015	1,790	17	2.925	0.715	0.687	293,000
	8/16/2016	2,935	18	2.994	0.718	0.682	434,000
	12/13/2016	2,613	17	2.703	0.661	0.615	279,000
	8/30/2017	15,453	10	1.448	0.436	0.400	605,000
	12/12/2017	503	15	3.041	0.778	0.743	136,000
	Average	**20,452**	**16**	**2.672**	**0.665**	**0.628**	**344,935**
TWT01	8/1/2012	1,374	18	3.401	0.815	0.790	91,000
	12/1/2012	13,460	11	1.315	0.380	0.336	2,745,000
	8/20/2013	3,473	21	2.860	0.651	0.608	508,000
	11/5/2013	1,637	24	3.389	0.739	0.701	497,000
	8/21/2014	31,428	17	0.837	0.205	0.131	1,228
	12/16/2014	886	20	3.030	0.701	0.630	624
	8/19/2015	2,374	23	3.223	0.712	0.684	587
	12/2/2015	3,040	20	2.332	0.540	0.478	391,000
	8/16/2016	725	21	2.790	0.635	0.528	408,000
	12/13/2016	3,400	18	1.831	0.439	0.377	283,000
	8/30/2017	9,928	18	3.070	0.736	0.696	534,000
	12/12/2017	1,787	25	2.542	0.547	0.422	869,000
	Average	**6,126**	**20**	**2.552**	**0.592**	**0.532**	**527,370**

Table 10-10. Upper Perdido Bay station phytoplankton diversity statistics for 2010-2017 monitoring events (continued).

Station	Sample Date	Total	Taxa Richness	Shannon Div.	Pielou's Evenness	Hurlbert Evenness	Biovolume (cubic microns/mL)
TWT02	8/1/2012	3,749	23	2.523	0.558	0.528	144,000
	12/1/2012	2,016	16	2.666	0.666	0.638	517,000
	8/20/2013	4,207	23	3.078	0.680	0.645	415,000
	11/5/2013	1,394	23	3.374	0.746	0.704	261,000
	8/21/2014	25,574	19	2.078	0.489	0.426	1,879
	12/16/2014	932	14	2.851	0.749	0.707	126
	8/19/2015	1,777	25	2.962	0.638	0.588	324
	12/2/2015	2,525	23	2.569	0.568	0.491	360,000
	8/16/2016	1,160	17	2.384	0.583	0.520	283,000
	12/13/2016	3,295	15	1.783	0.456	0.402	235,000
	8/30/2017	2,438	17	1.737	0.425	0.341	319,000
	12/12/2017	1,666	18	2.695	0.646	0.568	562,000
	Average	**4,228**	**19**	**2.558**	**0.600**	**0.547**	**258,194**
Sample Event Cumulative Average	8/1/2012	4,081	20	2.603	0.604	0.579	246,800
	12/1/2012	4,157	17	2.450	0.592	0.553	1,071,200
	8/20/2013	11,237	19	2.715	0.636	0.600	1,646,857
	11/5/2013	2,177	19	2.961	0.707	0.670	700,429
	8/21/2014	145,425	14	1.375	0.362	0.315	3,120
	12/16/2014	1,834	15	2.500	0.640	0.585	370
	8/19/2015	2,416	22	3.471	0.780	0.743	497
	12/2/2015	2,157	19	2.794	0.658	0.609	661,143
	8/16/2016	1,682	24	3.179	0.694	0.634	297,429
	12/13/2016	2,388	17	2.281	0.558	0.510	195,571
	8/30/2017	10,074	16	1.847	0.467	0.423	743,857
	12/12/2017	1,701	16	2.505	0.644	0.590	282,571

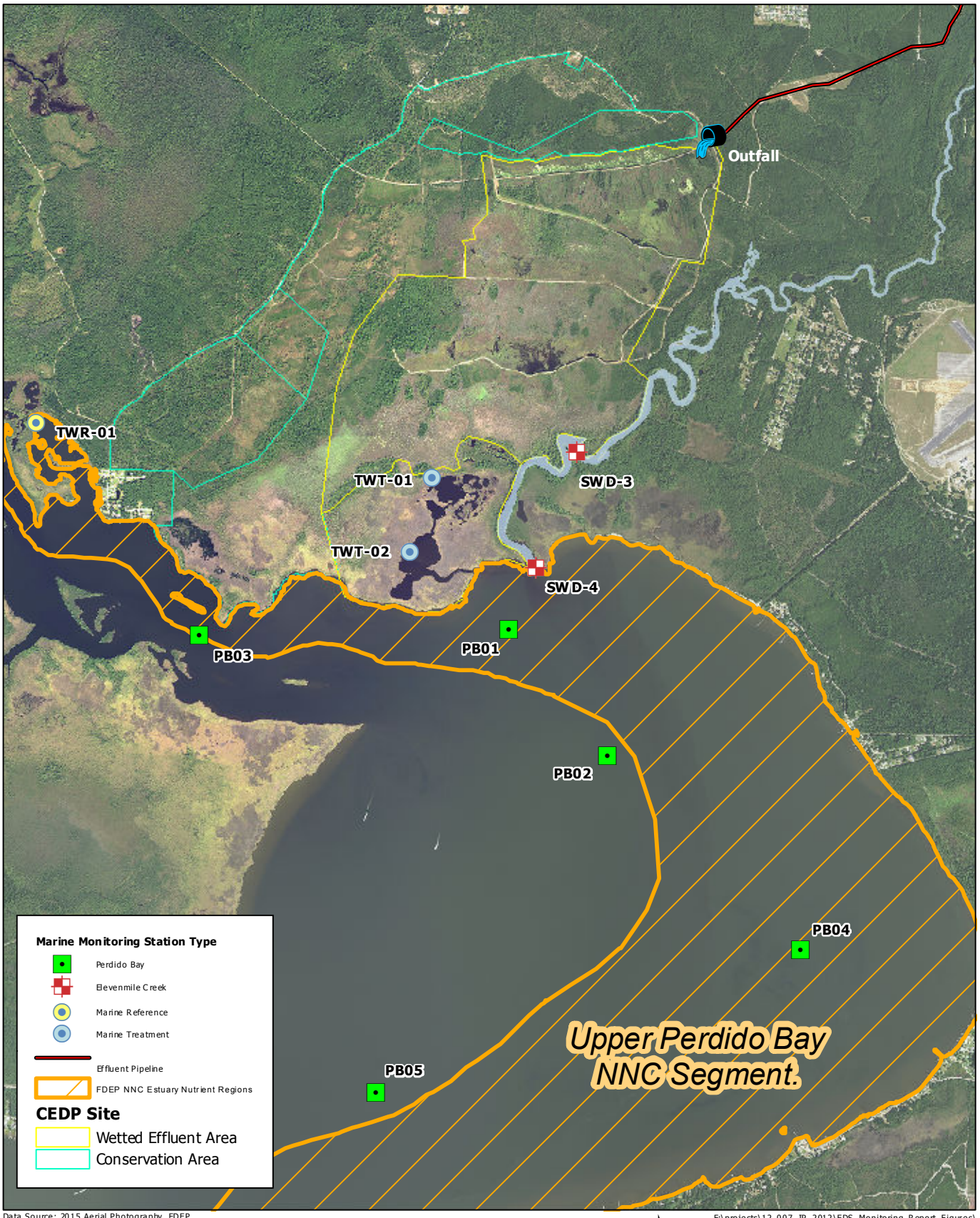


Figure 10-1. Location of marine analytical water quality grab stations.

Nutter & Associates
environmental consultants

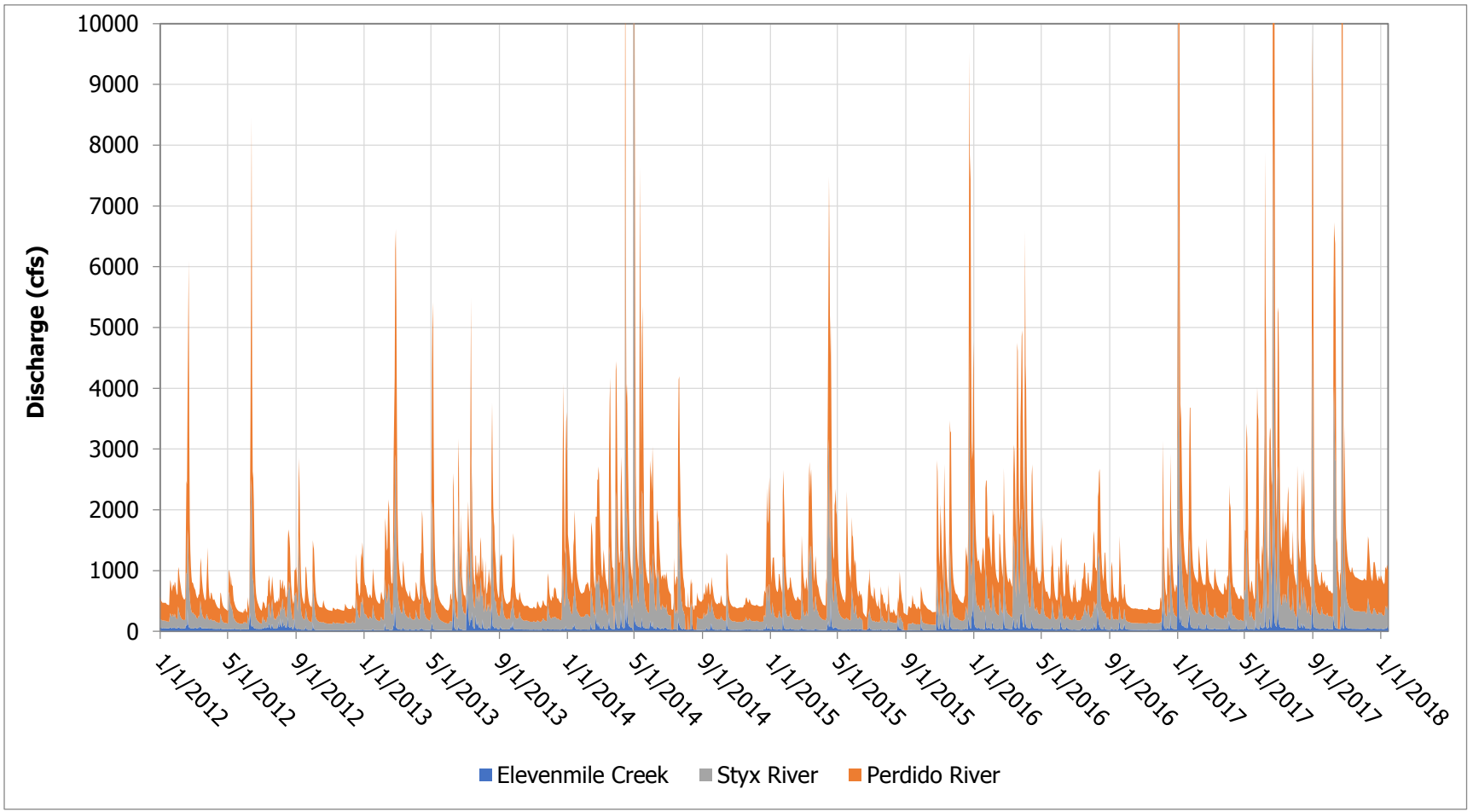


Figure 10-2. Daily discharge by major freshwater inflow to Upper Perdido Bay, 2010–2017.

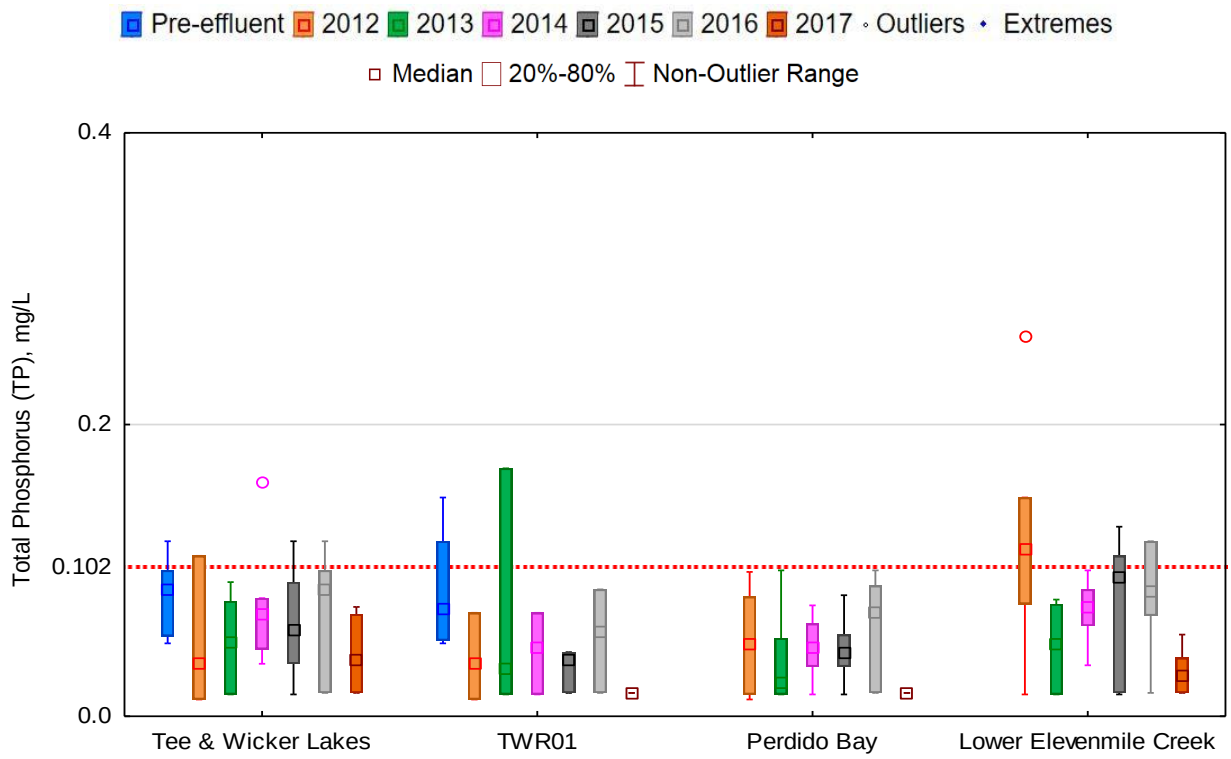


Figure 10-3. Summary total phosphorus concentrations in samples collected from EDS tidal receiving waters during 2012–2017 monitoring events. The red line indicates the numeric nutrient criteria threshold which no more than 10% of samples collected in the most recent seven years can exceed.

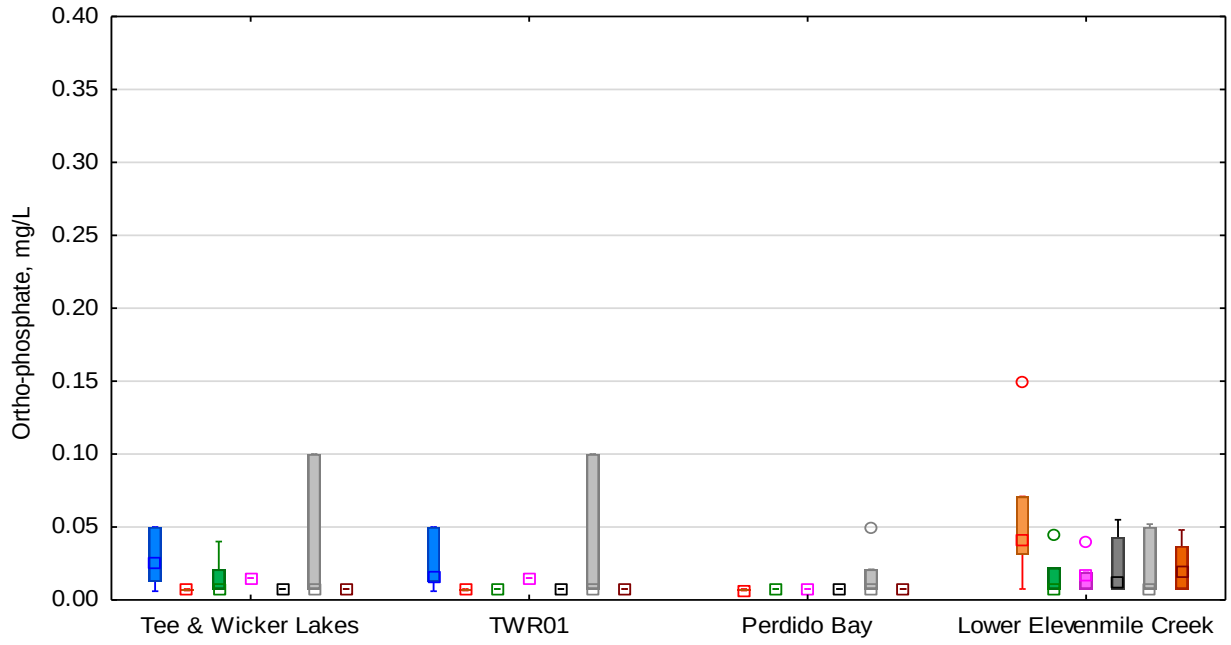


Figure 10-4. Summary ortho-phosphate concentrations in samples collected from EDS tidal receiving waters during 2012–2017 monitoring events.

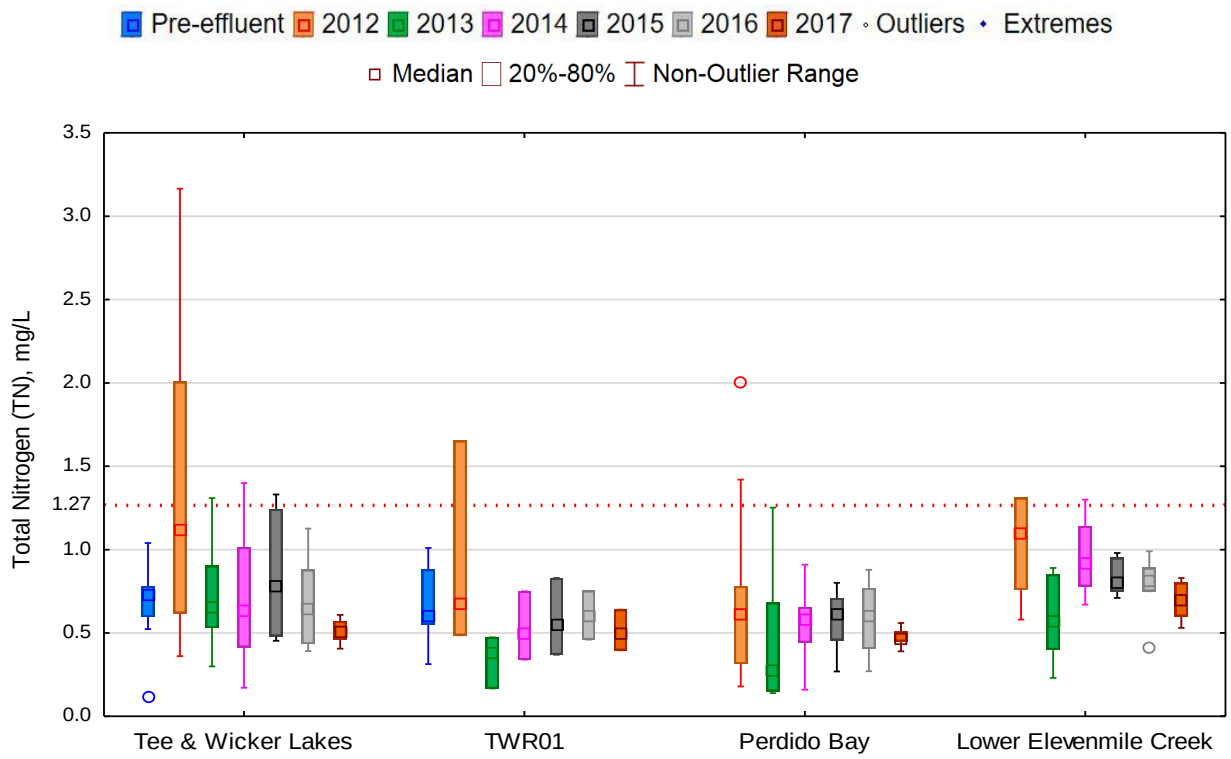


Figure 10-5. Summary total nitrogen concentrations in samples collected from EDS tidal receiving waters during 2012–2017 monitoring events. The red line indicates the numeric nutrient criteria threshold which no more than 10% of samples collected in the most recent seven years can exceed.

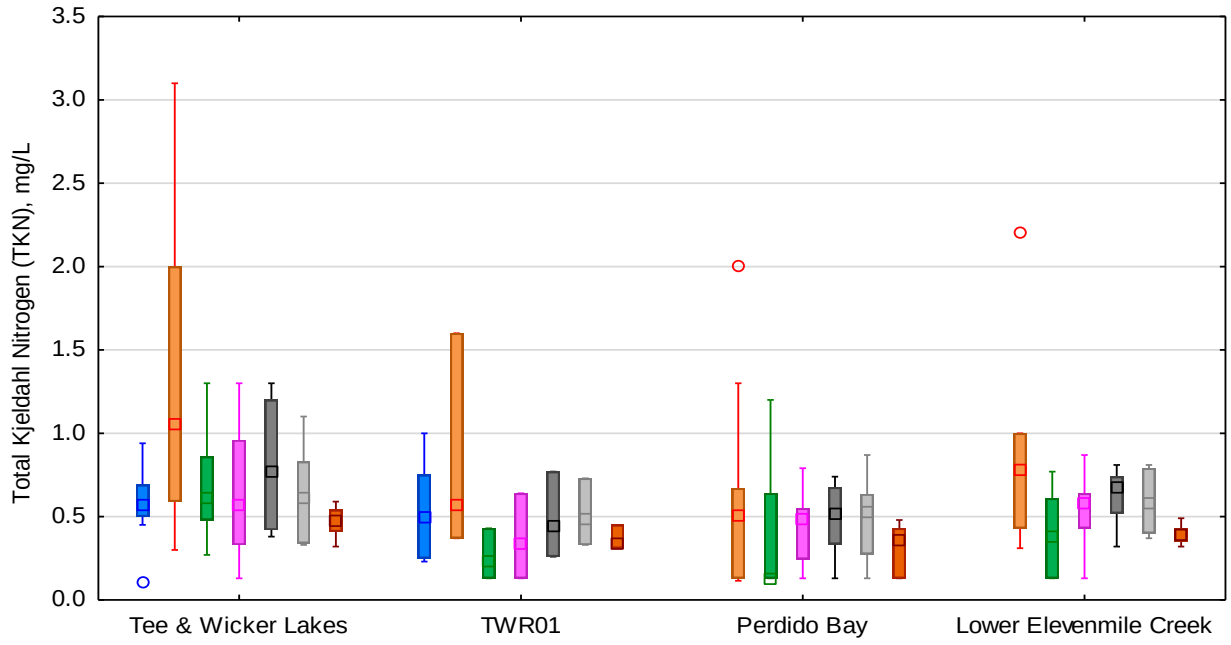


Figure 10-6. Summary total Kjeldahl nitrogen concentrations in samples collected from EDS tidal receiving waters during 2012–2017 monitoring events.

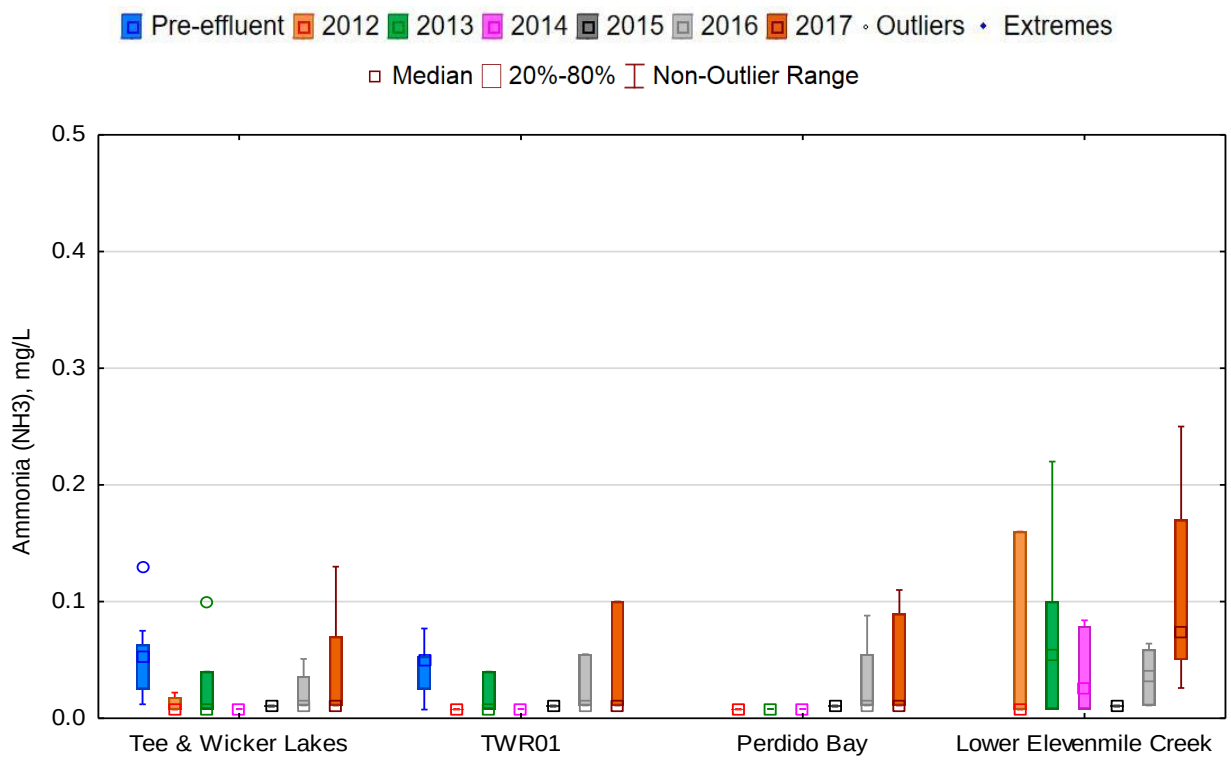


Figure 10-7. Summary total ammonia nitrogen concentrations in samples collected from EDS tidal receiving waters during 2012–2017 monitoring events.

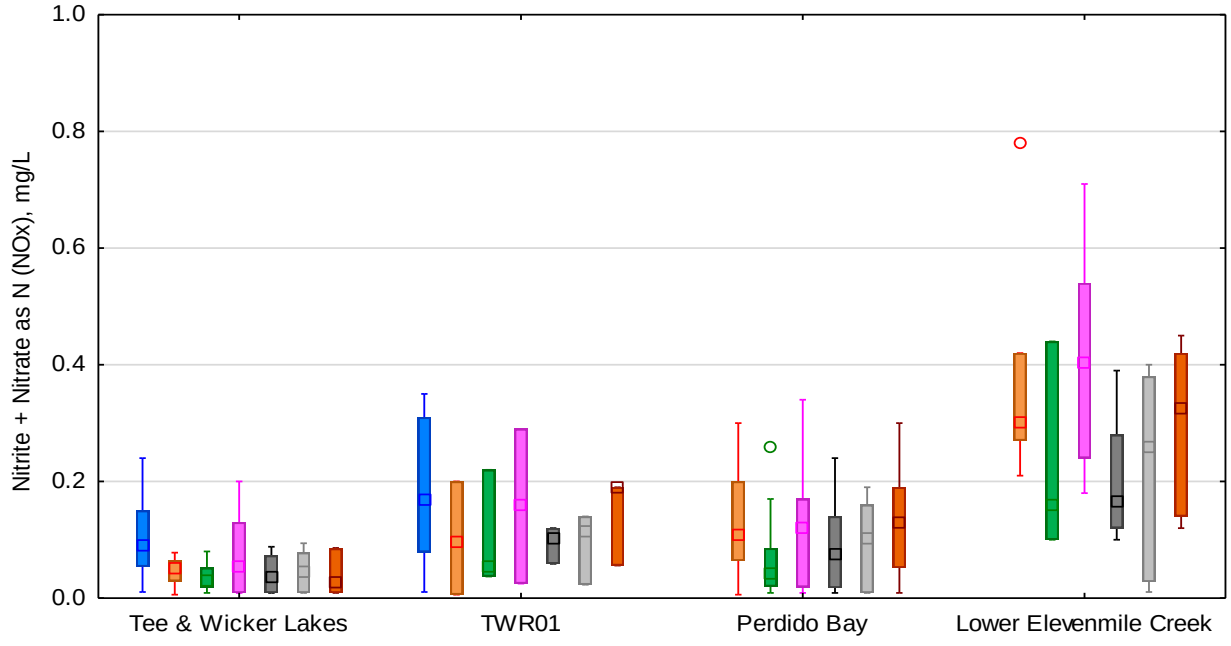


Figure 10-8. Summary total nitrite-nitrate concentrations in samples collected from EDS tidal receiving waters during 2012–2017 monitoring events.

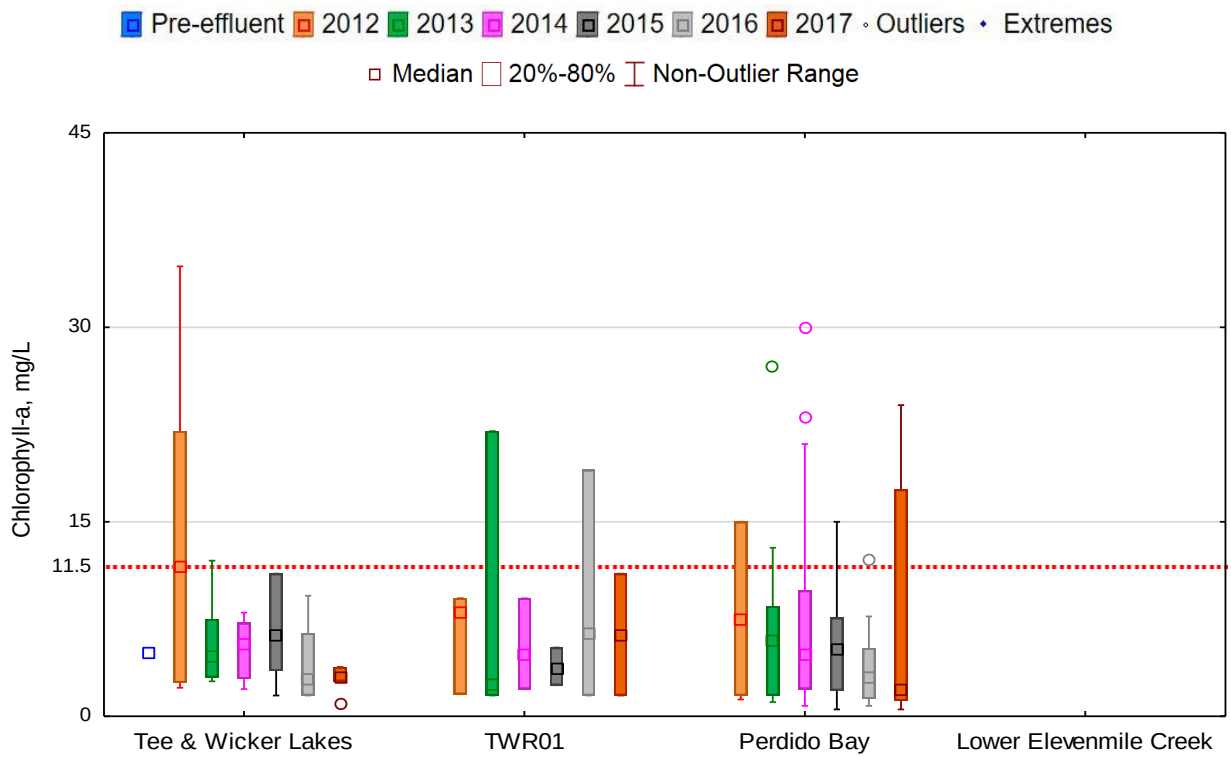


Figure 10-9. Summary chlorophyll-a concentrations in samples collected from EDS tidal receiving waters during 2012–2017 monitoring events. The red line indicates the numeric nutrient criteria threshold which no more than 10% of samples collected in the most recent seven years can exceed.

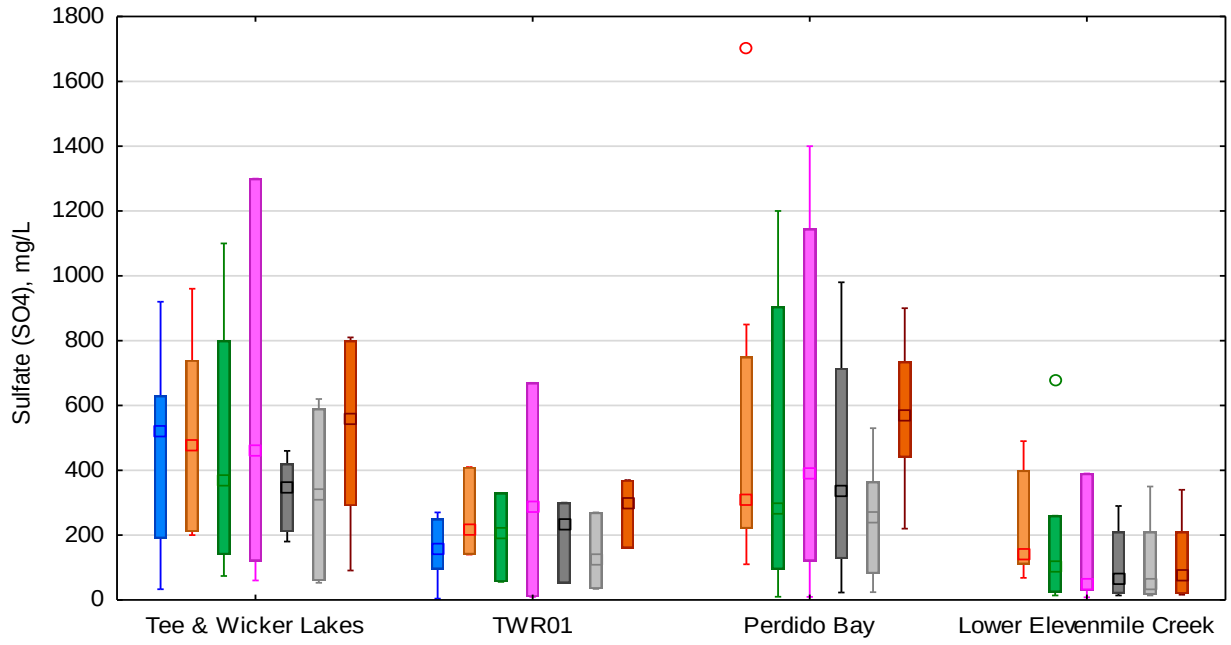


Figure 10-10. Summary sulfate concentrations in samples collected from EDS tidal receiving waters during 2012–2017 monitoring events.

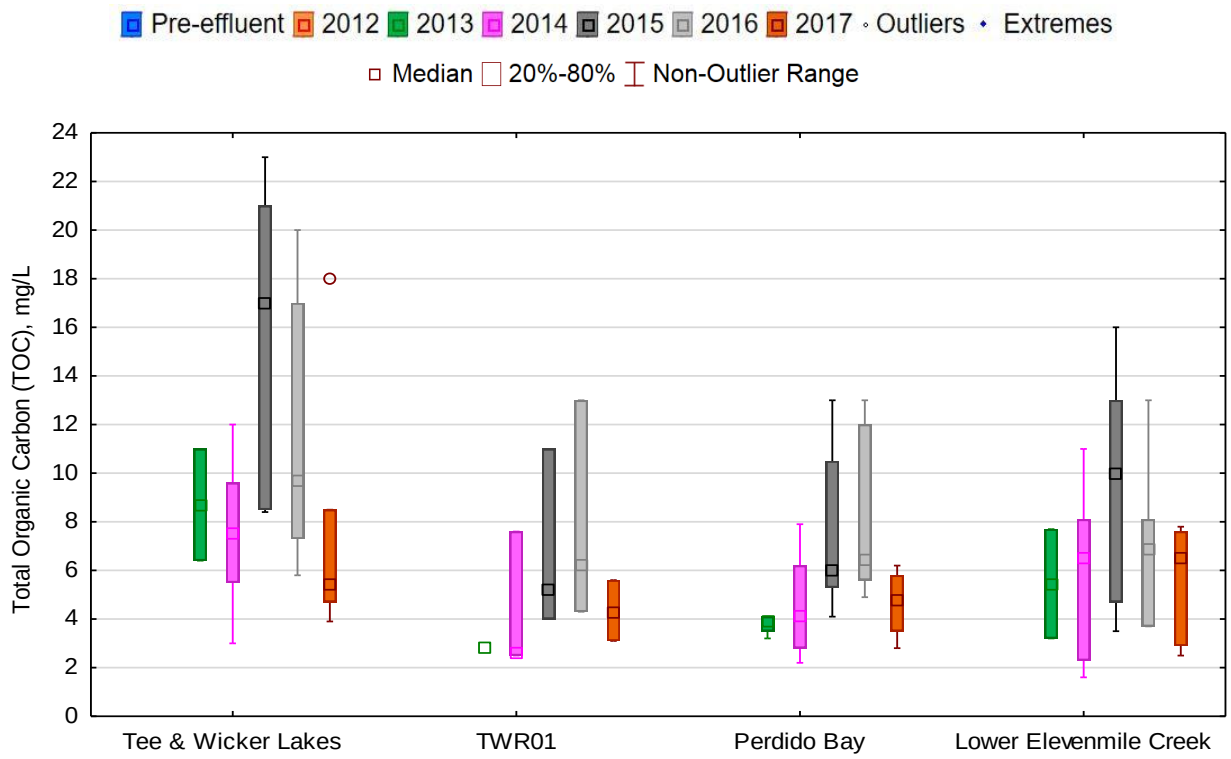


Figure 10-11. Summary total organic carbon concentrations in samples collected from EDS tidal receiving waters during 2012–2017 monitoring events.

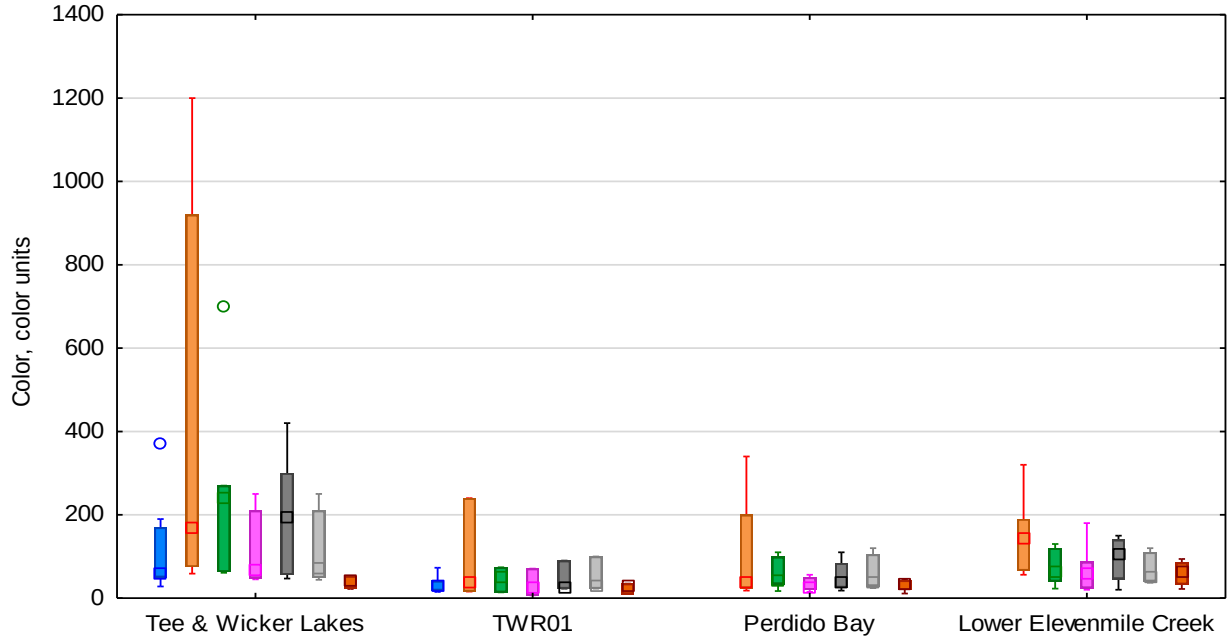


Figure 10-12. Summary color unit values in samples collected from EDS tidal receiving waters during 2012–2017 monitoring events.

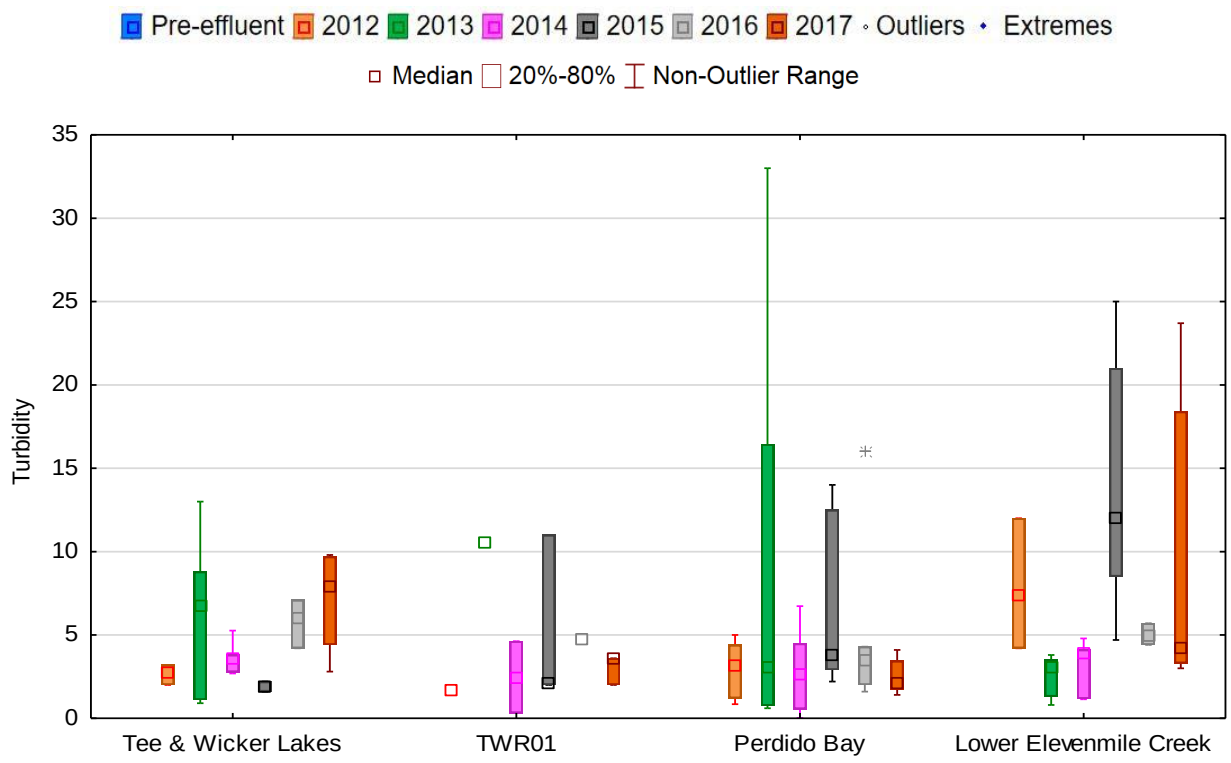


Figure 10-13. Summary turbidity values in samples collected from EDS tidal receiving waters during 2012–2017 monitoring events.

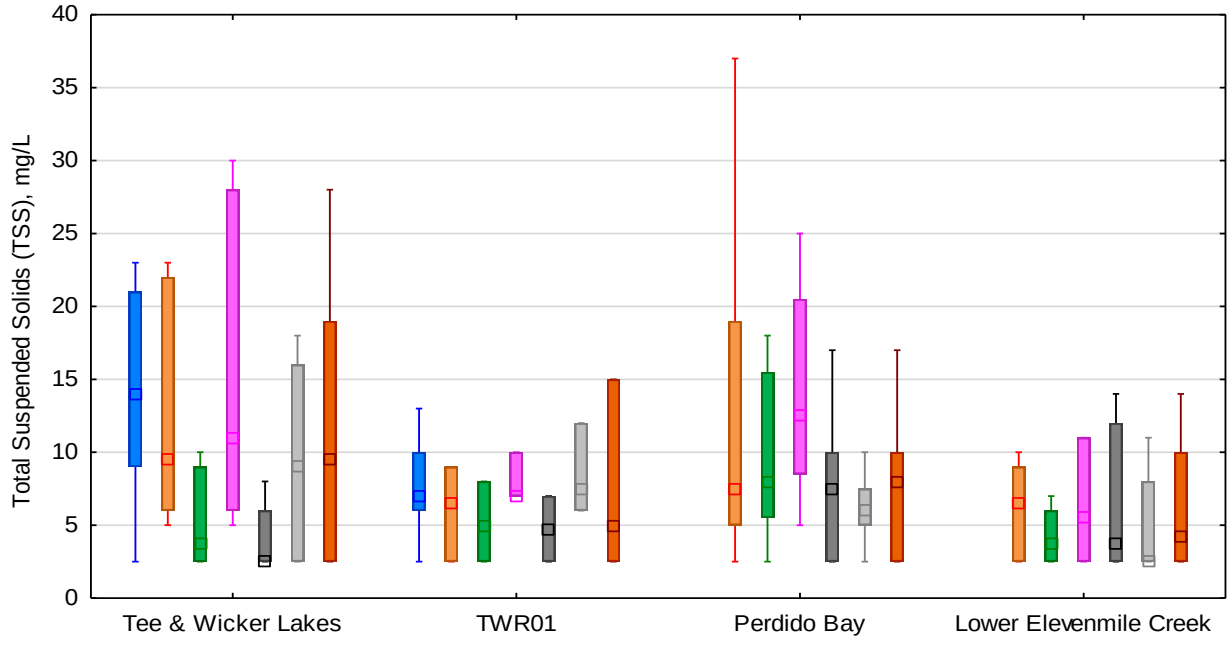


Figure 10-14. Summary total suspended solids concentrations in samples collected from EDS tidal receiving waters during 2012–2017 monitoring events.

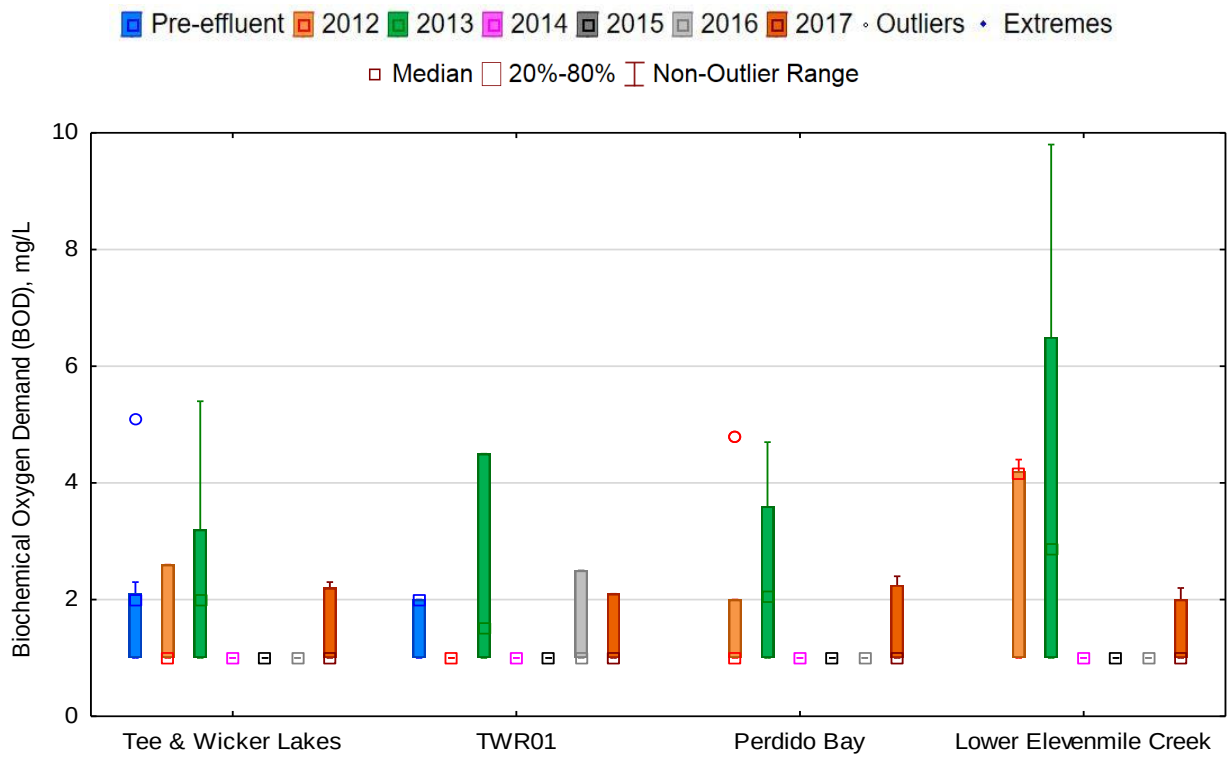


Figure 10-15. Summary BOD concentrations in samples collected from EDS tidal receiving waters during 2012–2017 monitoring events.

11.0 ELEVENMILE CREEK

Water quality and biological monitoring was conducted at five stations on Elevenmile Creek and one station on Coffee Branch (Figure 11-1) pursuant to NPDES Permit No. FL0002526 issued to International Paper Company, Inc. on March, 15, 2010. The sample locations are located generally west and northwest of Pensacola, Escambia County, Florida. As specified in the NPDES permit, monitoring at the six required stations is to be conducted annually between June and August. A majority of water quality and biological sampling for the 2016 monitoring period was conducted on between August 29 and 31, 2017. Biological monitoring of Coffee Branch was conducted on November 7, 2017 due to rain events that prevented sampling in August 2017.

The goal of NPDES permit water quality and biological monitoring requirements is to document the existing ecological and water quality conditions in Elevenmile Creek and monitor the response of the biological communities following the removal of the International Paper effluent discharge in the headwaters of Elevenmile Creek. The Coffee Branch station and one station located upstream of the former Elevenmile Creek discharge location are used as control and background reference sites. During 2010 and 2011, Elevenmile Creek was receiving 100% of the effluent from the International Paper Cantonment mill. In 2012, effluent flow to the EDS wetland site was initiated and correspondingly removed from Elevenmile Creek. Beginning on February 1, 2012, effluent flow to the EDS was initiated and gradually ramped-up over the following 8 months. On October 5, 2012, 100% of effluent flow was allocated to the EDS and thereafter no effluent flow was present in Elevenmile Creek. 100% effluent flow to the EDS has been maintained throughout 2013 and 2017. The August 2017 monitoring event marks the fifth sampling event following 100% removal of effluent flow from Elevenmile Creek. A photochronology is provided for Elevenmile Creek and Coffee Branch in Plates 11-1 and 11-2, respectively.

11.1 Methods

11.1.1 Sample Locations

Station descriptions and geographic locations are presented below and depicted in Figure 11-1. Five water quality and biological stations are located on Elevenmile Creek (Figure 11-1). One station (SWU-1) is located upstream of the former International Paper effluent discharge location. Stations (SWD-1 through SWD-4) are located downstream of the former discharge location along Elevenmile Creek as depicted in Figure 11-1. Stations SWD-3 and SWD-4 are located near the confluence of Elevenmile Creek and Perdido Bay, and are therefore tidally influenced. The remaining stations are not tidally influenced. Reference station (SWB-1) is located on Coffee Branch, a non-tidal tributary that flows into Elevenmile Creek approximately 1.6 miles upstream of station SWD-2 (Figure 11-1).

		Latitude	Longitude
Station ID	**Station Description**	DD	
SWD-1	Elevenmile Creek at County Road 297A	30.5477	-87.3298
SWD-2	Elevenmile Creek at U.S. Highway 90	30.4983	-87.3359
SWD-3	Elevenmile Creek approximately 1 mile upstream of mouth	30.4645	-87.3734
SWD-4	Elevenmile Creek at mouth	30.4574	-87.3770
SWU-1	Elevenmile Creek upstream of effluent discharge	30.5731	-87.3223
SWB-1	Coffee Branch off Jamesville Lane	30.5154	-87.3472

11.1.2 Water Quality Methods

Water Quality sampling methodologies were conducted using all applicable Florida Department of Environmental Protection (FDEP) standard operating procedures detailed in DEP-SOP-001/01: FS2100 *Surface Water Sampling*. Unionized ammonia was calculated based upon total ammonia, pH, temperature, and salinity using the FDEP TAN Criteria Calculator4 spreadsheet. Physiochemical parameters were measured using a multi-parameter sonde calibrated in advance of monitoring. Surface water samples that required collection below 0.5 feet of depth were collected using a Van Dorn sampler. Water collected at each station was partitioned into pre-labeled sample bottles, immediately placed on ice, and delivered to the laboratory within the specified hold times. Test America of Pensacola, Florida was the laboratory responsible for analyzing surface water samples.

At Stations SWD-1, SWD-2, SWB-1, and SWU-1, one sample was taken at mid-channel and mid-depth. At Stations SWD-3 and SWD-4, samples were collected near the surface, at mid-depth, and near the stream bottom.

11.1.3 Biological Methods

Biological community sampling conducted during the monitoring period consisted of a benthic macroinvertebrate community assessment along a 100 meter reach at Station SWD-1 on Elevenmile Creek and Station SWB-1 on Coffee Branch utilizing the FDEP Stream Condition Index (SCI) methods. Biological and water quality sampling methodologies were conducted using all applicable procedures detailed in DEP-SOP-001/01: FS 7000 *General Biological Community Sampling*. SCI sampling and physical habitat assessments were conducted at each SCI station utilizing the procedures detailed in DEP-SOP-003/11 SCI 1000: *Stream Condition Index Methods*. Sampling was conducted by scientists who have completed all applicable FDEP biological assessment training. Samples were transmitted to Water & Air Research, Inc., Gainesville, Florida for taxonomic identification. As described above SCI sampling at SWD-1 was conducted on August 29, 2017 while sampling at SWB-1 was delayed until November 7, 2017. SWB-1 could not be sampled in August 2017 due to heavy rainfall that occurred within the watershed and resulted in a significant increase in stream stage and velocity prior to the sampling. Sampling at SWD-1 was conducted prior to the rain event.

Macroinvertebrate (SCI) taxonomic data were collapsed using methods described in FDEP-SOP-002/01 LT 7040 to make comparisons between stations and across sampling years. SCI scores

from all monitoring years presented here were recalculated using the March 1, 2014 updated metric calculations.

11.2 Results

11.2.1 Water Quality

The results of 2017 Elevenmile Creek water quality monitoring are detailed in Table 11-1. As expected, SWD-3 and SWD-4, which are both tidally influenced, exhibited different water quality conditions compared to the freshwater stations. Dissolved oxygen concentrations were similar between all freshwater stations in 2017 (Table 11-1). Station SWU-1 had higher specific conductivity, pH, color, and turbidity than the other freshwater Elevenmile Creek stations (Table 11-1). The same parameters decreased in a downstream direction from SWU-1 to SWD-1 to SWD-2. Specific conductivity was slightly higher at SWD-1 and SWD-2 compared to SWB-1, however, the same parameters were significantly lower than monitoring results from 2010, 2011, and 2012 at SWD-1 and SWD-2, when effluent discharge from International Paper was present in Elevenmile Creek (Tables 11-1 and 11-2). Likewise, dissolved oxygen levels at SWD-1 and SWD-2 were higher in August 2017 than during earlier monitoring years when effluent was present in the creek (Table 11-2). The complete results of water quality and biological monitoring from 2010 to 2016 can be found in 2012, 2013, 2014, 2015, and 2016 Annual Monitoring Reports submitted per requirements of the NPDES permit. As was described above, water quality sampling at SWB-1 was conducted during elevated stream stage and velocity due to heavy rainfall that occurred prior to the sampling. These conditions likely influenced the data results in comparison to historic sample results conducted during baseflow conditions, especially for parameters such as total suspended solids, turbidity, and total coliform bacteria.

As is typically observed at stations SWD-3 and SWD-4, fresh-brackish water stratification was measured during the August 2017 sampling. Besides specific conductivity and dissolved oxygen variability within the depth profile, no significant additional water quality variability was seen between the surface, mid-depth, and bottom samples (Table 11-1).

Additional water quality measurements were collected at SWB-1 and SWD-1 during biological sampling, including alkalinity and nitrogen and phosphorus parameters. These results are presented in Table 11-3, and discussed further in section 11.2.2 below.

11.2.2 Biology

During the 2017 SCI sampling event, SWD-1 and SWB-1 received physical habitat assessment scores of 102 and 111, respectively, out of a total possible score of 130 (Table 11-4). The 2017 physical habitat scores for both stations were within ranges observed during previous monitoring events (Table 11-4). Along the SWD-1 sampled reach, most habitat parameters were scored in the "Marginal" or "Suboptimal" categories. Primary habitats included snags, undercut banks / roots, and leaf packs. Sand deposition was moderate along the sampled reach, although stable and productive habitats were common. The riparian buffer width was scored in the "Optimal" category, although vegetative community composition included non-native and invasive species such as Chinese privet (*Ligustrum sinense*) and Japanese climbing fern (*Lygodium japonicum*) alongside native species. Along the SWB-1 sampled reach, most habitat parameters scored within the "Suboptimal" category. Primary habitat consisted of

moderately productive snags, leaf packs, and undercut banks / roots. Slight to moderate sand smothering was present. Small areas of stream bank and riparian zone erosion and instability were common along the sampled reach.

11.2.2.1 Stream Condition Index Results

In 2017, SWD-1 and SWB-1 received Stream Condition Index scores of 44 and 76, respectively, with corresponding score interpretations of Category 2 (Healthy) and Category 1 (Exceptional), respectively (Tables 11-5 and 11-6). A total of 297 individuals from 53 taxa were included in the two subsamples collected at SWD-1. In 2017, the macroinvertebrate community at SWD-1 was dominated by the Trichopteran *Cheumatopsyche* sp (13%), the Coleopterans *Stenelmis* sp. (13%) and *Microcylloepus pusillus* (7%), the Ephmeropteran *Baetis intercalaris* (7%), and the Dipteran Rheocricotopus robacki (6%) (Table 11-5, Figure 11-2). A total of 304 individuals from 74 taxa were included in the two subsamples collected from SWB-1 (Table 11-5). The macroinvertebrate community at SWB-1 was dominated by the Coleopteran *Dubiraphia vittata* (8%) and the Dipteran *Polypedilum flavum* (6%) (Table 11-5, Figure 11-2).

2017 SCI scores were compared to scores from 2010-2016 to determine the annual variability in the macroinvertebrate communities at the two sample locations. The average SCI score average for both stations was the highest observed at SWD-1 during any previous monitoring event, while the 2017 SCI score at SWB-1 was one point less than the highest observed SCI score during the monitoring period (Table 11-6). Ten metric indices are used to calculate final SCI scores (Table 11-7). Samples collected at SWD-1 in 2017 had higher total taxa than previous monitoring years, lower percent Filterer taxa, lower percent Tanytarsini taxa, and a higher number of sensitive taxa compared to previous monitoring event metric scores, all of which contributed to the higher SCI score compared to previous events (Table 11-7). Samples collected at SWB-1 in 2017 had similar SCI index results to the sample collected in previous monitoring years, but with higher Ephemeroptera taxa and a lower percentage of dominance in the distribution of species, resulting in the high SCI score compared to previous SCI results (Table 11-7). Sample results from both stations exhibited interannual variability in the relative dominance of the most common taxa (Figure 11-2). For example, at SWD-1, the relative percent dominance of the Coleopterans *Stenelmis* sp. and *M. pusillus* and the Trichopteran *Cheumatopsyche* increased during post-effluent sampling through 2013 but then have decreased in dominance through 2017 (Figure 11-2). The Trichopteran *Hydropsyche rossi* and Dipterans in the *Polypedilum illinoense* group were both dominant taxa when effluent was present in Elevenmile Creek but have since declined to very low dominance or absence since 2012 (Figure 11-2).

11.3 Conclusions

Based upon the results of both water quality and biological monitoring, effluent discharge to Elevenmile Creek through October 2012 resulted in a deviation in various water quality parameters and aquatic biological community characteristics when compared to reference conditions. Since removal of the effluent, water quality parameters measured in Elevenmile Creek are more similar to those measured in Coffee Branch. In monitoring years 2013–2017, water quality in Elevenmile Creek has been relatively stable, and year-to-year variations are attributable to climatic conditions at the time of sampling.

Despite the changes in water quality in Elevenmile Creek since 2013, abundance metrics from macroinvertebrate data from both stations continue to indicate lower biological diversity at SWD-1 compared to SWB-1. Although physical habitat assessment scores for Elevenmile Creek have remained similar across all monitoring years, SCI scores and taxa richness in SCI samples from Elevenmile Creek were significantly higher during 2015 through 2017 compared to all previous monitoring events. SCI index calculations indicate that a higher diversity of more sensitive macroinvertebrate taxa are now present at SWD-1 than in previous years. The observed shift in macroinvertebrate community structure is likely associated with the reduction in nutrients, increase in dissolved oxygen, and overall water quality improvement that has occurred since effluent discharge was removed from Elevenmile Creek. A significant drop in baseflow of Elevenmile Creek occurred after 100% of effluent flow was redirected to the EDS, which resulted in a change to stream morphology and macroinvertebrate habitat availability. As the stream continues to transition to a more stable morphological condition, macroinvertebrate habitat is expected to be variable between years. Based on observed changes in water quality and macroinvertebrate community in Elevenmile Creek in years since effluent removal, it is anticipated that macroinvertebrate communities will continue to shift towards a higher diversity of organisms and a lower abundance of pollution-tolerant filter feeders as water quality continues to improve.

Table 11-1. Results of Elevenmile Creek water quality monitoring, August 2017.

Station	Station Type	Date	Time	Depth	Temp.	Sp. Cond.	Salinity	Dissolved Oxygen		pH	Turbidity
				ft	°C	µS/cm	ppt	%	mg/L	S.U.	NTU
SWB-1	Freshwater	8/31/17	15:15	0.5	24.9	32	0.01	75	6.2	6.1	31
SWU-1		8/29/17	8:30	0.5	24.2	110	0.05	96	8.1	7.5	18
SWD-1		8/29/17	11:15	0.4	23.2	80	0.04	93	7.9	7.0	5
SWD-2		8/29/17	7:50	0.5	22.7	48	0.02	85	7.4	6.4	5
SWD-3U	Tidal	8/30/17	13:20	0.5	24.9	1,527	0.78	74	6.1	7.5	24
SWD-3M		8/30/17	13:25	4.0	24.8	1,610	0.93	73	6.0	7.5	25
SWD-3B		8/30/17	13:30	8.0	25.2	5,248	2.66	65	5.2	7.4	26
SWD-4U		8/30/17	14:00	0.5	25.8	3,707	1.98	61	4.9	7.2	18
SWD-4M		8/30/17	14:05	5.9	26.0	4,349	2.30	59	4.8	7.2	16
SWD-4B		8/30/17	14:10	11.8	28.9	25,360	15.65	3	0.2	6.7	18

Station	Station Type	Date	Time	Depth	NH_4		NH_3 unionized	Color	BOD_5		TSS		Coliform, Fecal
				ft	mg/L	Qualifier	mg/L	PCU	mg/L	Qualifier	mg/L	Qualifier	CFU/100mL
SWB-1	Freshwater	8/31/17	15:15	0.5	0.022	U	0.00002	160	2.0	U	32		240
SWU-1		8/29/17	8:30	0.5	0.042	I	0.00087	93	2.0	U	5.0		80
SWD-1		8/29/17	11:15	0.4	0.022	U	0.00012	42	2.0	U	5.0	U	130
SWD-2		8/29/17	7:50	0.5	0.034	I	0.00004	27	2.0	U	5.0		120
SWD-3U	Tidal	8/30/17	13:20	0.5	0.040	I	0.00077	59	2.0	U	17		800
SWD-3M		8/30/17	13:25	4.0	0.053		0.00111	93	2.0	U	15		700
SWD-3B		8/30/17	13:30	8.0	0.053		0.00082	73	2.0	U	18		730
SWD-4U		8/30/17	14:00	0.5	0.055		0.00055	100	2.0	U	10		600
SWD-4M		8/30/17	14:05	5.9	0.075		0.00094	71	2.0	U	12		470
SWD-4B		8/30/17	14:10	11.8	0.130		0.00053	49	2.0	Q	14		240

Qualifier: "U" - Indicates that the compound was analyzed for but not detected; reported value equals the PQL for the analytical method.
"Q" – Sample held beyond the accepted holding time.
"I" - The reported value is between the laboratory method detection limit and the laboratory practical quantification limit.

Table 11-2. Water quality data from all sampling events at freshwater stations SWU-1, SWB-1, SWD-1, and SWD-2 between 2010 and 2017.

Station	Date	Depth	Temp.	Sp. Cond.	Salinity	Dissolved Oxygen		pH	Turbidity
		ft	°C	µS/cm	ppt	%	mg/L	S.U.	NTU
SWB-1	7/14/2010	0.3	27.8	76	0.03	89.0	7.0	4.4	3.4
	7/19/2011	0.3	26.1	44	0.02	78.0	6.3	5.4	5.8
	8/15/2012	0.3	24.9	39	0.02	97.0	8.7	5.7	15
	8/21/2013	0.5	23.6	35	0.00	87.3	7.4	5.7	11
	8/20/2014	0.5	26.9	42	0.02	105.5	7.0	7.2	3.6
	8/20/2015	0.3	25.4	41	0.00	88.1	7.3	5.8	4.4
	8/17/2016	0.5	25.6	44	0.02	87.3	7.2	6.1	5.3
	8/31/2017	0.5	24.9	32	0.01	75.4	6.24	6.1	31
SWU-1	7/14/2010	0.1	32.6	304	0.14	114.0	8.3	6.7	3.6
	7/19/2011	0.3	29.1	109	0.05	73.0	5.5	7.1	36
	8/15/2012	0.1	27.4	133	0.06	92.0	7.2	6.6	25
	8/21/2013	0.5	27.7	83	0.02	95.7	7.6	6.9	95
	8/20/2014	0.5	29.4	123	0.05	112.2	7.1	8.1	9.8
	8/20/2015	0.5	28.2	133	0.10	93.7	7.3	6.9	18
	8/17/2016	0.5	26.3	141	0.07	94.5	7.7	7.0	45
	8/29/2017	0.5	24.2	110	0.05	96.2	8.06	7.5	18
SWD-1	7/14/2010	0.5	34.1	1,538	0.76	56.0	3.9	6.3	14
	7/19/2011	0.5	31.0	1,219	0.60	62.0	4.5	7.6	53
	8/15/2012	0.5	28.2	903	0.44	77.0	6.0	7.5	24
	8/21/2013	0.5	24.9	91	0.03	91.7	7.6	6.7	22
	8/20/2014	0.5	27.4	90	0.04	119.8	7.9	7.3	5.5
	8/20/2015	0.2	27.5	99	0.00	91.5	7.2	6.9	15
	8/17/2016	0.5	24.3	103	0.05	89.3	7.5	6.8	21
	8/29/2017	0.4	23.2	80	0.04	92.7	7.9	7.0	5.1
SWD-2	7/14/2010	0.7	30.8	1,069	0.52	70.0	5.2	5.7	8.0
	7/19/2011	0.7	28.9	845	0.41	59.0	4.5	7.0	12
	8/15/2012	0.7	27.8	443	0.21	82.0	6.4	6.6	18
	8/21/2013	0.5	27.4	69	0.02	95.2	7.6	6.7	16
	8/20/2014	0.5	27.9	53	0.02	116.0	7.6	6.8	4.1
	8/20/2015	0.2	26.8	67	0.00	90.8	7.3	6.9	11
	8/17/2016	0.5	24.5	69	0.03	86.0	7.2	6.7	11
	8/29/2017	0.5	22.7	48	0.02	85.3	7.35	6.4	4.6

Table 11-3. Results of water quality analyses at SWD-1 and SWB-1 collected during August 2017 monitoring.

Analyte	Units	SWD-1		SWB-1	
		Result	Qualifier	Result	Qualifier
Temperature, Water	°C	23.2		24.9	
Dissolved Oxygen	mg/L	7.9		6.2	
Dissolved Oxygen	% Sat	92.7		75.4	
Specific Conductivity	µS/cm	80		32	
pH	S.U.	7.0		6.1	
Salinity	ppt	0.04		0.01	
Turbidity	NTU	5.1		31	
Total Suspended Solids	mg/L	5		32.0	
Color	PCU	42		160	
Alkalinity	mg/L	26		< 0.98	U
BOD5	mg/L	2.0	U	< 2.0	U
Ammonia	mg/L	< 0.022	U	< 0.022	U
TKN	mg/L	< 0.26	U	< 0.26	U
Phosphorus, Total	mg/L	< 0.032	U	< 0.032	U
ortho-Phosphorus	mg/L	< 0.015	U	< 0.015	U
Nitrate+Nitrite-N	mg/L	0.67		0.081	
Chloride	mg/L	8		5.4	
Total Coliform	CFU	500		2,600	
Fecal Coliform	CFU	130		240	

"U" - Indicates the compound was analyzed for but not detected; reported value equals the PQL for the analytical method.

Table 11-4. Stream Condition Index Habitat Assessment Scores for SWB-1 and SWD-1 between 2010 and 2017.

Habitat Parameter *(DEP Form FD 9000-5)*		**SWB-1 (Coffee Branch)**								**SWD-1 (Elevenmile Creek @ 297a)**							
		2010	2011	2012	2013	2014	2015	2016	2017	2010	2011	2012	2013	2014	2015	2016	2017
Substrate Diversity		11	14	12	13	15	14	13	13	7	13	10	9	13	11	6	11
Substrate Availability		9	8	7	6	11	8	4	6	8	2	2	6	3	3	3	4
Water Velocity		14	13	14	14	18	20	15	18	18	17	18	20	20	19	20	20
Habitat Smothering		11	17	13	16	13	12	14	15	6	18	12	11	12	11	10	11
Artificial Channelization		13	15	15	15	20	19	19	19	11	10	14	11	11	11	11	11
Bank Stability	RB	5	5	5	8	5	7	7	7	4	4	7	5	6	5	5	5
	LB	5	4	5	8	5	7	7	7	5	4	4	5	4	4	4	4
Riparian Buffer Zone Width	RB	7	4	6	6	7	7	4	4	9	10	10	10	10	10	10	10
	LB	7	4	6	5	5	4	7	7	10	10	10	10	10	10	10	10
Riparian Zone Vegetation Quality	RB	7	7	6	6	9	8	8	8	5	2	7	6	7	8	8	8
	LB	7	7	7	6	8	7	7	7	6	2	7	6	7	8	8	8
Total Habitat Assessment Score		**96**	**98**	**96**	**103**	**116**	**113**	**105**	**111**	**89**	**92**	**101**	**99**	**103**	**100**	**95**	**102**

Table 11-5. Results of Stream Condition Index sampling at SWB-1 (November 7, 2017) and SWD-1 (August 29, 2017).

Order	Family	Taxon	SWD-1		SWB-1	
			REP-1	REP-2	REP-1	REP-2
Amphipoda	Hyalellidae	*Hyalella azteca complex LeCroy*	-	1	-	-
Amphipoda	Unspecified	Amphipoda (LPIL)	-	-	-	1
Coleoptera	Elmidae	*Ancyronyx variegatus*	4	-	7	5
Coleoptera	Elmidae	*Dubiraphia vittata*	-	-	9	14
Coleoptera	Elmidae	*Gonielmis dietrichi*	-	-	3	1
Coleoptera	Elmidae	*Microcylloepus pusillus*	9	12	2	4
Coleoptera	Elmidae	*Stenelmis convexula*	17	21	-	-
Coleoptera	Elmidae	*Stenelmis sp.*	-	-	6	7
Coleoptera	Gyrinidae	*Dineutus serrulatus*	-	7	1	-
Coleoptera	Gyrinidae	*Dineutus sp.*	4	-	-	-
Decapoda	Cambaridae	*Procambarus sp.*	1	1	3	2
Decapoda	Palaemonidae	*Palaemonetes paludosus*	-	-	-	3
Diptera	Cecidomyiidae	Cecidomyiidae (LPIL)	-	-	1	-
Diptera	Ceratopogonidae	*Atrichopogon sp.*	1	1	-	-
Diptera	Chironomidae	*Ablabesmyia mallochi*	2	1	1	1
Diptera	Chironomidae	*Ablabesmyia rhamphe group Epler*	1	1	2	2
Diptera	Chironomidae	*Cladotanytarsus daviesi*	-	-	1	-
Diptera	Chironomidae	*Corynoneura sp.*	-	-	-	1
Diptera	Chironomidae	*Cricotopus bicinctus*	3	-	-	-
Diptera	Chironomidae	*Cricotopus sp.*	-	1	-	-
Diptera	Chironomidae	*Cricotopus-Orthocladius group Epler*	-	-	-	2
Diptera	Chironomidae	*Cryptochironomus sp.*	1	1	-	-
Diptera	Chironomidae	*Dicrotendipes neomodestus*	3	3	-	-
Diptera	Chironomidae	*Kribiodorum perpulchrum*	-	-	1	1
Diptera	Chironomidae	*Larsia sp.*	-	1	-	-
Diptera	Chironomidae	*Nanocladius crassicornus cf. rectinervis Epler*	-	1	-	-
Diptera	Chironomidae	*Paracladopelma sp.*	2	-	-	-
Diptera	Chironomidae	*Parametriocnemus sp.*	-	-	-	2
Diptera	Chironomidae	*Paratanytarsus dissimilis*	-	-	-	1
Diptera	Chironomidae	*Pentaneura inconspicua*	3	2	-	-
Diptera	Chironomidae	*Phaenopsectra Tribelos group Epler*	-	-	-	1
Diptera	Chironomidae	*Polypedilum aviceps*	-	-	5	5
Diptera	Chironomidae	*Polypedilum flavum*	8	5	10	6
Diptera	Chironomidae	*Polypedilum illinoense group Epler*	3	6	2	5
Diptera	Chironomidae	*Polypedilum scalaenum group Epler*	5	1	1	-
Diptera	Chironomidae	*Polypedilum trigonus*	-	1	-	-
Diptera	Chironomidae	*Pseudochironomus sp.*	-	-	3	1
Diptera	Chironomidae	*Rheocricotopus robacki*	10	7	1	1
Diptera	Chironomidae	*Rheotanytarsus exiguus group Epler*	3	4	-	1
Diptera	Chironomidae	*Stenochironomus sp.*	-	-	1	3
Diptera	Chironomidae	*Tanytarsus buckleyi*	-	-	1	-
Diptera	Chironomidae	*Tanytarsus messersmithi*	-	-	-	1
Diptera	Chironomidae	*Tanytarsus sp.*	1	1	-	-
Diptera	Chironomidae	*Thienemanniella sp.*	-	-	1	-
Diptera	Chironomidae	*Thienemannimyia group Epler*	1	1	6	3
Diptera	Chironomidae	*Tribelos sp.*	2	-	-	-
Diptera	Chironomidae	*Xylotopus par*	-	-	2	1
Diptera	Empididae	*Hemerodromia sp.*	1	1	-	-
Diptera	Simuliidae	*Simulium sp.*	-	1	8	6

Table 11-5. Results of Stream Condition Index sampling at SWB-1 (November 7, 2017) and SWD-1 (August 29, 2017) (continued).

Order	Family	Taxon	SWD-1		SWB-1	
			REP-1	REP-2	REP-1	REP-2
Diptera	Tipulidae	*Hexatoma sp.*	-	-	1	-
Diptera	Tipulidae	*Limnophila sp.*	-	-	-	1
Diptera	Tipulidae	*Tipula sp.*	1	-	-	1
Ephemeroptera	Baetidae	*Acerpenna pygmaea*	2	-	1	1
Ephemeroptera	Baetidae	*Baetis intercalaris*	9	12	-	-
Ephemeroptera	Baetidae	*Labiobaetis propinquus*	4	6	1	1
Ephemeroptera	Baetidae	*Procloeon viridoculare*	-	1	-	-
Ephemeroptera	Caenidae	*Caenis punctata*	2	2	-	-
Ephemeroptera	Ephemerellidae	*Eurylophella doris*	-	-	1	-
Ephemeroptera	Heptageniidae	*Maccaffertium smithae*	-	-	-	10
Ephemeroptera	Heptageniidae	*Maccaffertium sp.*	-	-	6	-
Ephemeroptera	Leptophlebiidae	Leptophlebiidae (LPIL)	-	-	2	2
Haplotaxida	Enchytraeidae	Enchytraeidae (LPIL)	-	1	3	2
Haplotaxida	Naididae	*Nais communis complex Milligan*	-	-	1	-
Haplotaxida	Naididae	*Nais pardalis*	-	3	-	-
Haplotaxida	Naididae	*Nais sp.*	3	-	-	-
Haplotaxida	Tubificoid Naididae	*Aulodrilus limnobius*	2	2	-	1
Haplotaxida	Tubificoid Naididae	Tubificoid Naididae (LPIL) imm. w/o hair setae	3	5	-	1
Hemiptera	Mesoveliidae	*Mesovelia sp.*	2	-	-	-
Hemiptera	Nepidae	*Ranatra sp.*	1	-	-	-
Hemiptera	Veliidae	*Microvelia sp.*	-	-	1	-
Hemiptera	Veliidae	*Rhagovelia choreutes*	-	5	-	1
Hemiptera	Veliidae	*Rhagovelia obesa*	-	-	1	-
Hemiptera	Veliidae	*Rhagovelia sp.*	1	-	-	-
Isopoda	Asellidae	*Caecidotea sp.*	2	-	-	1
Lumbriculida	Lumbriculidae	*Eclipidrilus palustris*	1	-	-	-
Lumbriculida	Lumbriculidae	*Eclipidrilus sp.*	-	1	-	-
Odonata	Aeshnidae	*Boyeria vinosa*	-	-	-	1
Odonata	Calopterygidae	Calopterygidae (LPIL)	-	-	2	-
Odonata	Calopterygidae	*Calopteryx maculata*	-	-	-	5
Odonata	Calopterygidae	*Hetaerina titia*	4	4	-	-
Odonata	Coenagrionidae	*Argia sp.*	-	-	11	-
Odonata	Coenagrionidae	*Argia tibialis*	-	-	-	6
Odonata	Coenagrionidae	*Enallagma sp.*	2	-	5	4
Odonata	Corduliidae	Corduliidae (LPIL)	1	2	-	-
Odonata	Corduliidae	*Neurocordulia alabamensis*	-	-	5	6
Odonata	Gomphidae	*Gomphus sp.*	-	1	-	1
Odonata	Gomphidae	*Hagenius brevistylus*	-	-	2	1
Odonata	Gomphidae	*Progomphus sp.*	3	3	-	-
Odonata	Macromiidae	*Macromia sp.*	-	-	1	1
Plecoptera	Leuctridae	*Leuctra sp.*	-	-	4	5
Plecoptera	Perlidae	*Acroneuria arenosa/evoluta group Pescador*	-	-	-	3
Plecoptera	Perlidae	Perlidae (LPIL)	-	-	2	-
Trichoptera	Calamoceratidae	*Anisocentropus pyraloides*	-	-	2	-
Trichoptera	Hydropsychidae	*Cheumatopsyche sp.*	20	19	2	2
Trichoptera	Hydropsychidae	*Hydropsyche sp.*	-	-	1	-

Table 11-5. Results of Stream Condition Index sampling at SWB-1 (November 7, 2017) and SWD-1 (August 29, 2017) (continued).

Order	Family	Taxon	SWD-1		SWB-1	
			REP-1	REP-2	REP-1	REP-2
Trichoptera	Leptoceridae	*Nectopsyche pavida*	-	-	-	1
Trichoptera	Leptoceridae	*Triaenodes ignitus*	-	-	4	3
Trichoptera	Leptoceridae	*Triaenodes perna/helo group Pescador*	-	-	1	-
Trichoptera	Philopotamidae	*Chimarra sp.*	-	-	1	2
Trichoptera	Polycentropodidae	*Neureclipsis crepuscularis*	-	-	-	2
Trichoptera	Polycentropodidae	Polycentropodidae (LPIL)	-	-	1	-
Trichoptera	Psychomyiidae	*Lype diversa*	-	-	1	-
Veneroida	Sphaeriidae	*Pisidium sp.*		-	-	1
Total Individuals			148	149	141	147
Taxa Richness			40	39	50	54
Pooled Taxa Richness			53		74	
SCI Score			44	45	80	72
SCI Score Average			44		76	
SCI Score Interpretation			Category 2 (Healthy)		Category 1 (Exceptional)	

Table 11-6. Total individuals, taxa richness and SCI scores at SWB-1 and SWD-1 between 2010 and 2017.

Station - Year			Total Individuals	Taxa Richness	SCI Score	SCI Score Average	SCI Score Interpretation
SWB-1	2010	REP-1	141	52	70	69	Category 1 (Exceptional)
		REP-2	144	46	67		
	2011	REP-1	150	38	52	61	Category 2 (Healthy)
		REP-2	155	49	71		
	2012	REP-1	144	38	50	49	
		REP-2	151	33	49		
	2013	REP-1	147	40	51	52	
		REP-2	150	41	52		
	2014	REP-1	142	31	47	51	
		REP-2	149	31	54		
	2015	REP-1	147	43	80	77	Category 1 (Exceptional)
		REP-2	149	43	74		
	2016	REP-1	146	39	63	68	Category 2 (Healthy)
		REP-2	150	39	73		
	2017	REP-1	141	50	80	76	Category 1 (Exceptional)
		REP-2	147	54	72		
SWD-1	2010	REP-1	149	22	16	15	Category 3 (Impaired)
		REP-2	150	20	13		
	2011	REP-1	151	15	13	11	
		REP-2	150	13	10		
	2012	REP-1	158	15	15	16	
		REP-2	146	11	17		
	2013	REP-1	154	19	18	18	
		REP-2	143	16	17		
	2014	REP-1	151	23	18	20	
		REP-2	146	26	23		
	2015	REP-1	145	27	37	37	Category 2 (Healthy)
		REP-2	150	31	38		
	2016	REP-1	149	38	29	31	Category 3 (Impaired)
		REP-2	143	31	33		
	2017	REP-1	148	40	44	44	Category 2 (Healthy)
		REP-2	149	39	45		

Table 11-7. Raw metric SCI indices used to calculate final SCI scores for SWB-1 and SWD-1 during 2010 to 2017 monitoring events.

SCI Metric	*100% Effluent in Elevenmile*				*~ 50% Effluent*		*No Effluent in Elevenmile*									
	2010		**2011**		**2012**		**2013**		**2014**		**2015**		**2016**		**2017**	
	REP-1	REP-2	REP-1	REP-2	REP-1	REP-2	REP-1	REP-2	REP-1	REP-2	REP-1	REP-2	REP-1	REP-2	REP-1	REP-2
SWB-1																
Total Taxa	52	46	38	49	38	33	40	41	31	32	43	43	40	39	50	54
Ephemeroptera Taxa	1	2	0	2	4	1	1	2	3	3	2	3	0	2	5	4
Trichoptera Taxa	5	5	4	8	4	7	5	5	4	6	10	7	6	7	8	5
% Filterer	12%	18%	16%	14%	6%	8%	9%	6%	1%	6%	12%	20%	11%	12%	10%	9%
Long-Lived Taxa	4	2	3	3	3	4	6	5	4	4	5	5	6	6	6	8
Clinger Taxa	10	7	5	9	7	8	7	8	7	12	10	11	11	13	11	9
% Dominance	14%	9%	19%	20%	22%	31%	27%	30%	32%	29%	11%	13%	20%	19%	8%	10%
% Tanytarsini	12%	17%	9%	10%	3%	1%	1%	0%	0%	1%	2%	1%	1%	4%	1%	2%
Sensitive Taxa	14	13	8	13	8	9	7	10	10	8	13	12	11	12	17	15
% Very Tolerant Taxa	6%	4%	3%	3%	8%	4%	4%	3%	1%	3%	0%	2%	2%	1%	3%	5%
Total SCI Score	70.0	67.4	51.6	70.6	50.0	48.6	51.3	52.2	46.9	54.1	79.6	74.2	62.6	73.2	80.2	71.8
Mean SCI Score	69		61		49		52		51		77		68		76	
SCI Score Interpretation	Category 1 (Exceptional)		Category 2 (Healthy)								Category 1 (Exceptional)		Category 2 (Healthy)		Category 1 (Exceptional)	
SWD-1																
Total Taxa	22	20	15	13	15	11	19	16	23	26	27	31	39	31	40	39
Ephemeroptera Taxa	0	0	0	0	0	0	2	2	1	3	2	4	4	2	4	4
Trichoptera Taxa	2	2	4	3	2	2	1	1	2	1	1	2	2	1	1	1
% Filterer	17%	9%	5%	4%	27%	27%	23%	27%	16%	12%	23%	17%	8%	5%	17%	18%
Long-Lived Taxa	0	0	0	0	0	1	0	1	1	2	2	2	3	4	2	3
Clinger Taxa	3	4	4	4	3	3	4	4	3	3	4	5	4	4	4	5
% Dominance	17%	21%	27%	31%	30%	27%	60%	53%	42%	38%	26%	31%	33%	33%	14%	14%
% Tanytarsini	0.0%	0%	0%	0%	1%	0%	0%	0%	0%	0%	4%	1%	0%	0%	3%	3%
Sensitive Taxa	2	2	1	1	2	2	2	2	3	1	1	2	2	3	5	3
% Very Tolerant Taxa	24%	31%	43%	41%	23%	23%	1%	6%	5%	4%	2%	2%	7%	5%	11%	13%
Total SCI Score	16.4	13.2	12.5	9.7	15.4	16.8	18.0	17.5	17.7	22.9	36.7	37.7	33.3	29.3	43.6	44.96
Mean SCI Score	15		11		16		18		20		37		31		44	
SCI Score Interpretation	Category 3 (Impaired)										Category 2 (Healthy)		Category 3 (Impaired)		Category 2 (Healthy)	

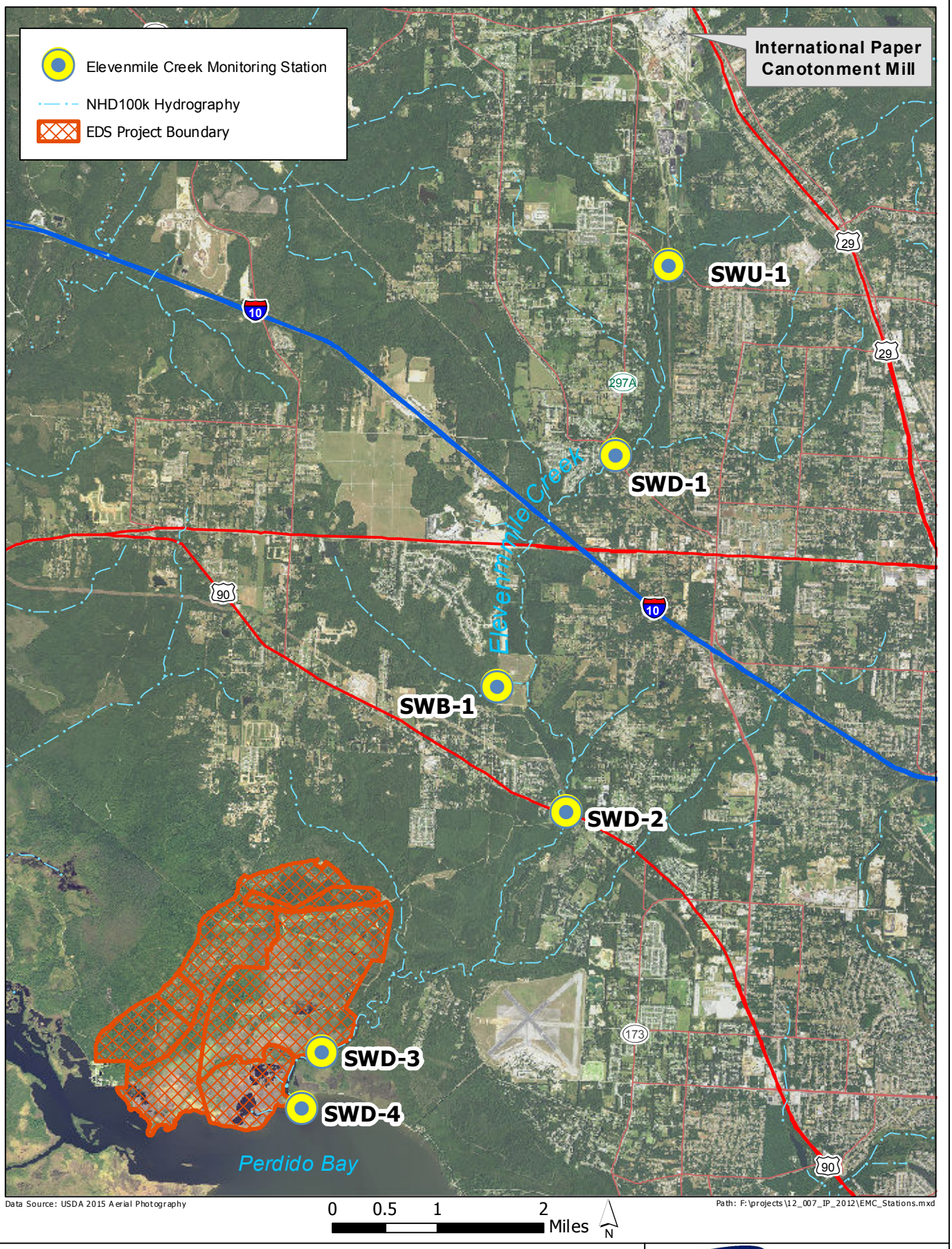


Figure 11-1. Location of Elevenmile Creek water quality and biological monitoring stations.

Nutter & Associates
environmental consultants

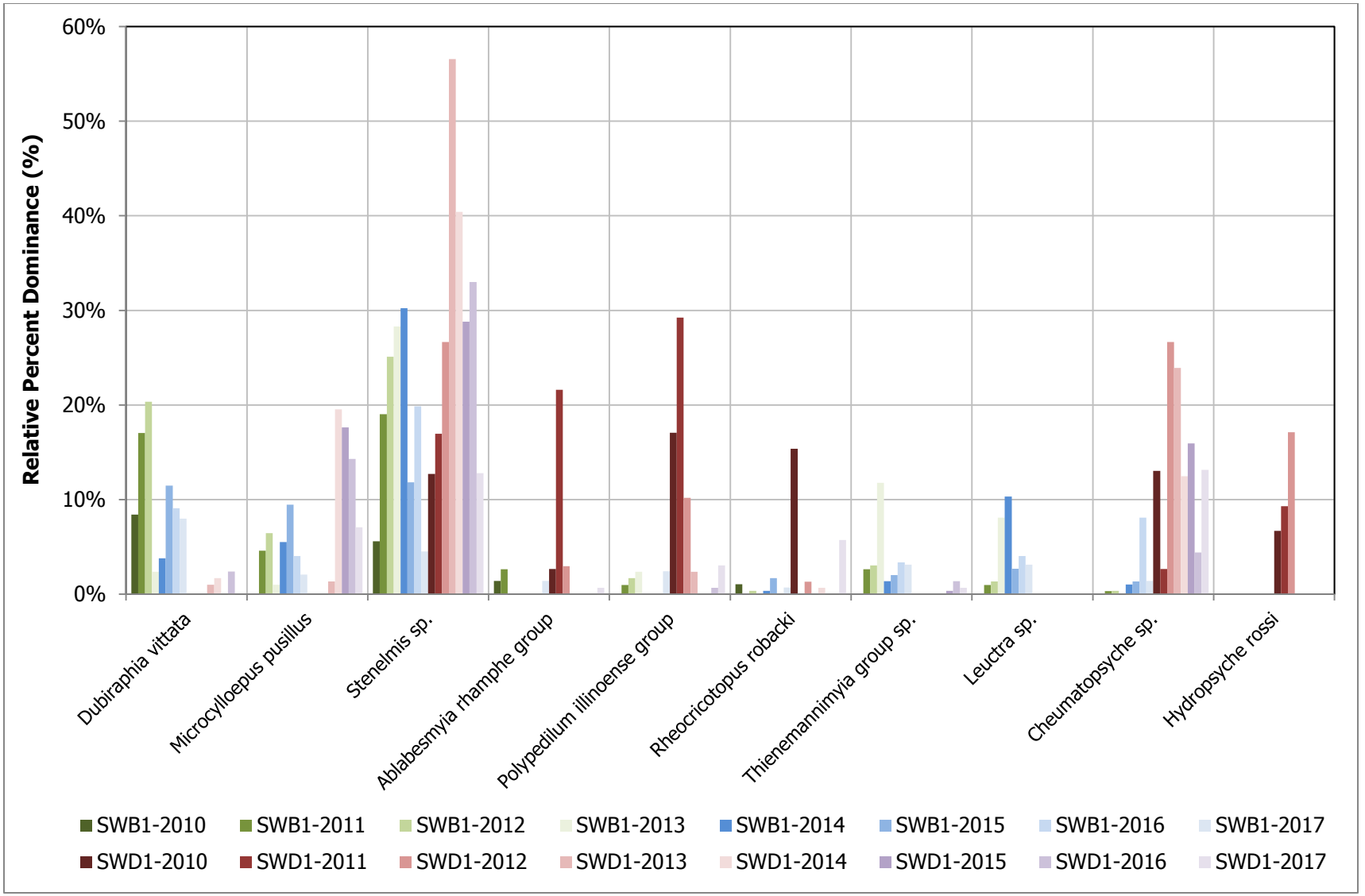


Figure 11-2. Trends in Stream Condition Index macroinvertebrate relative percent dominance for all taxa that represented greater than a 10% relative dominance during a single monitoring event at SWB-1 and SWD-1 between 2010 and 2017.

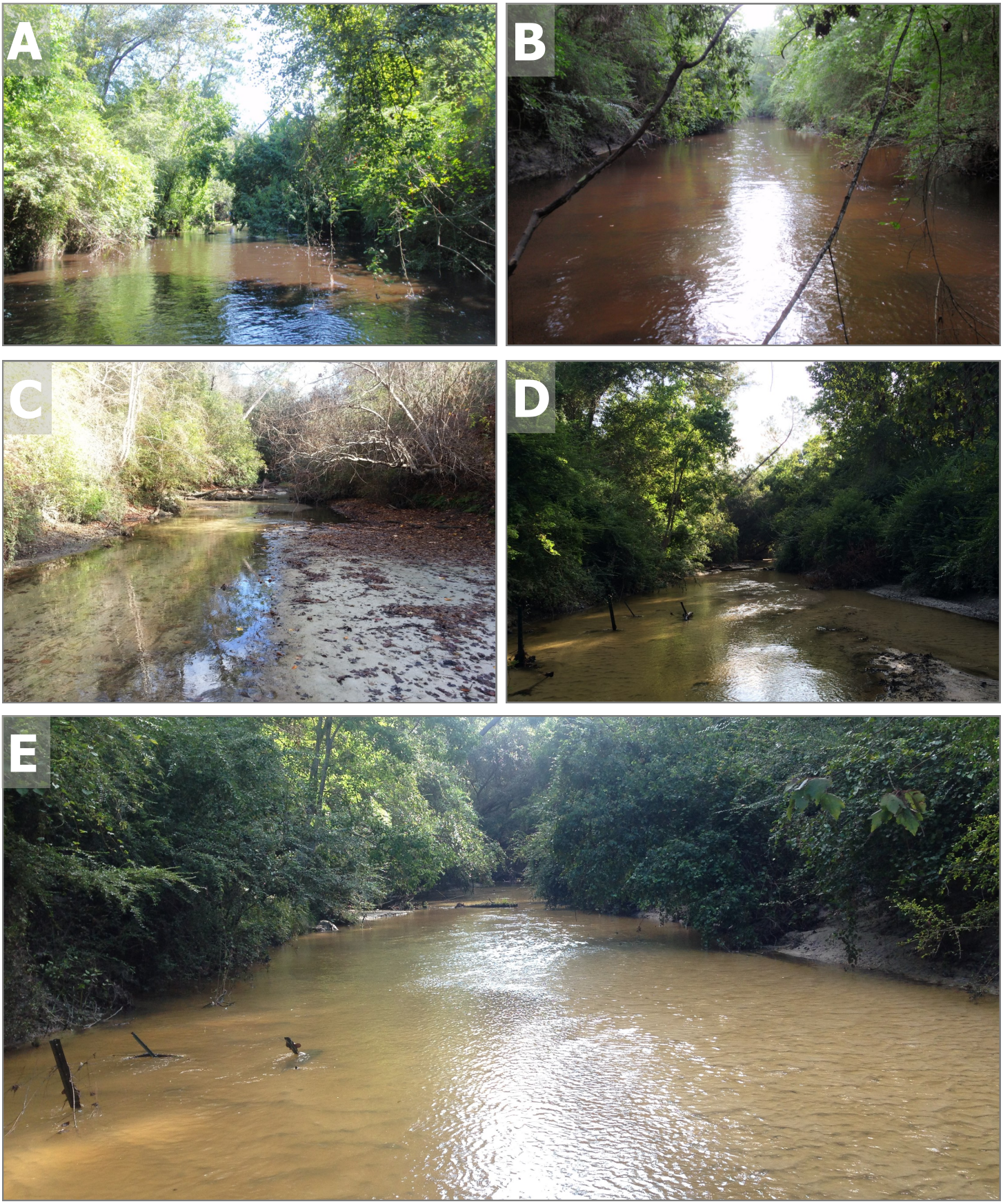


Plate 11-1. Elevenmile Creek upstream of Hwy 297a (SWD-1), (A) August 2011, (B) August 2012, (C) December 2012, (D) August 2014, and (E) August 2016.

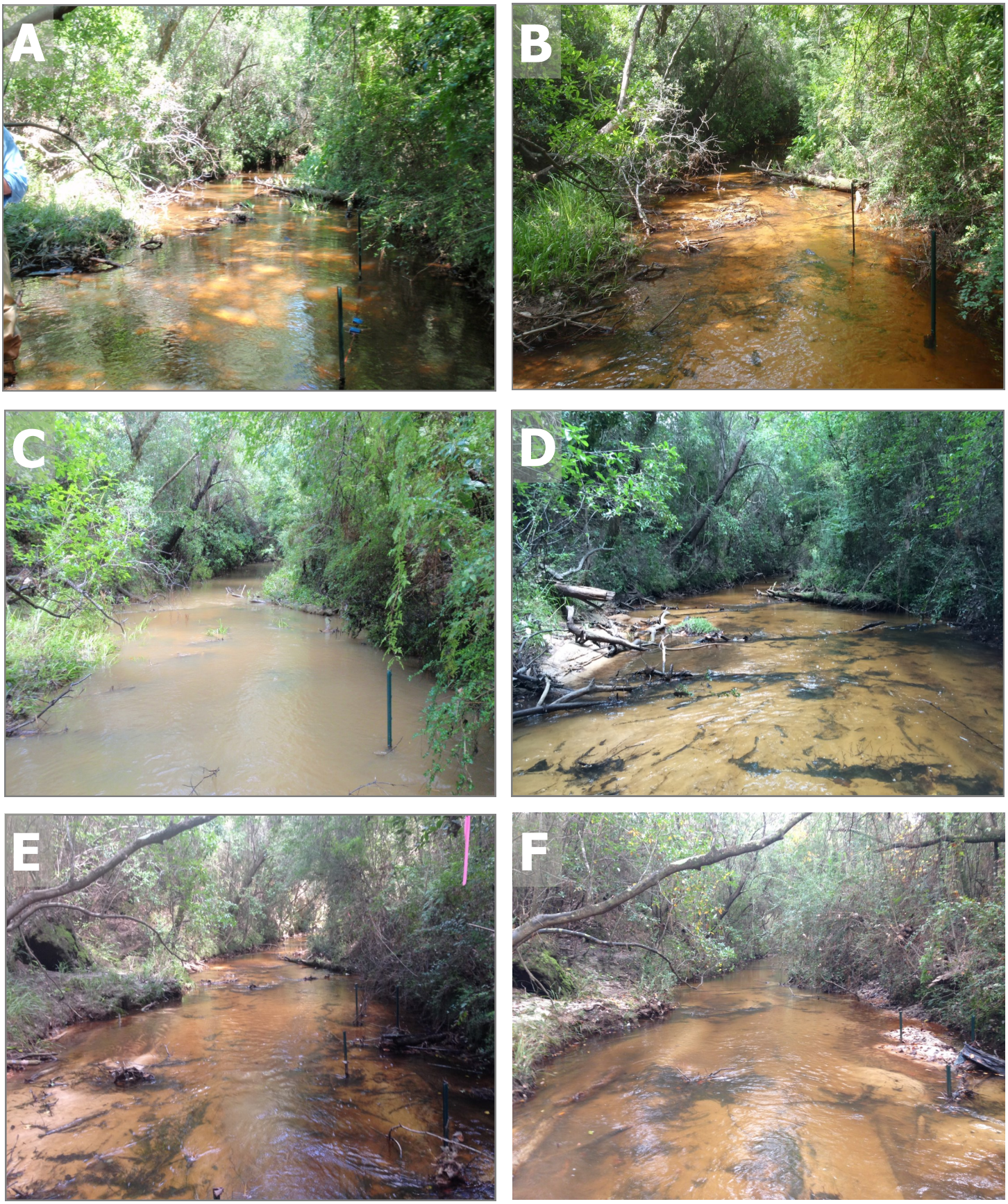


Plate 11-2. Coffee Branch near Jamesville Lane (SWB-1): (A) August 2011, (B) August 2012, (C) December 2012, (D) August 2014, (E) August 2016, and (F) November 2017.