

SUPPORT FOR IMPLEMENTATION OF TMDL COMPLIANCE FOR BEEMAT PILOT BMP PROJECT FOR PATRICK AIR FORCE BASE

PERFORMANCE EFFICIENCY EVALUATION

Pre- vs. Post-Modification Data Summary Report

September 2012

Prepared For:

SpecPro Environmental Services, LLC
1006 Floyd Culler Court
Oak Ridge, TN 37830
Phone: 865-481-7837



Prepared By:

Harvey H. Harper, III, Ph.D., P.E.-President
Environmental Research and Design, Inc.
3419 Trentwood Blvd., Suite 102
Belle Isle (Orlando), FL 32812-4864
Phone: 407-855-9465



TABLE OF CONTENTS

Sections	Page
List of Figures	iii
List of Tables	iv
1. Introduction	1
2. Physical Characteristics of the Western Pond	3
3. Field Monitoring	4
3.1 Inflow and Outflow Monitoring	4
3.2 Groundwater Monitoring	6
3.3 Hydrologic Instrumentation	8
3.4 Surface Water Monitoring	9
4. Laboratory Analyses	9
4.1 Analytical Methods	9
4.2 Quality Control	10
5. Pre-Modification Monitoring	11
5.1 Hydrologic Data	11
5.1.1 Rainfall	11
5.1.2 Surface Water Elevations	12
5.1.3 Inflow/Outflow Hydrographs	13
5.1.4 Evaporation	14
5.1.5 Hydrologic Budget	15
5.2 Vertical Field Profiles	17
5.3 Water Quality Data	17
5.3.1 Inflow and Outflow Samples	19
5.3.2 Bulk Precipitation	25
5.3.3 Shallow Groundwater Samples	25
5.3.4 Comparison of Inflow, Outflow, and Bulk Precipitation	27
5.3.5 Chlorophyll-a	32
5.4 Nutrient Budgets	33

TABLE OF CONTENTS -- CONTINUED

Sections	Page
6. Installation and Monitoring of the Floating Beemat Island	35
6.1 Installation	35
6.2 Analysis of Plant Material	41
6.2.1 Changes in Plant Biomass	41
6.2.2 Nutrient Uptake	45
 7. Pre-Modification Monitoring	 51
7.1 Hydrologic Data	51
7.1.1 Rainfall	51
7.1.2 Surface Water Elevations	52
7.1.3 Inflow/Outflow Hydrographs	53
7.1.4 Evaporation	54
7.1.5 Hydrologic Budget	55
7.2 Vertical Field Profiles	57
7.3 Water Quality Data	57
7.3.1 Inflow and Outflow Samples	59
7.3.2 Bulk Precipitation	65
7.3.3 Shallow Groundwater Samples	65
7.3.4 Comparison of Inflow, Outflow, and Bulk Precipitation	67
7.3.5 Chlorophyll-a	72
7.4 Nutrient Budgets	74
 8. Performance Efficiency of the Beemat System	 75
8.1 Impacts of Hydraulic Detention Time	75
8.2 Comparison of Pre- and Post-Modification Mass Removal Efficiencies	77
8.3 Statistical Comparison of Pre- and Post-Modification Water Quality Characteristics	79
8.4 Comparison of Pre- and Post-Modification Areal Pond Uptake Rates	90
8.5 Direct Plant Uptake	91
 9. Summary	 93

Appendices

A.	Pre- And Post-Modification Rainfall Characteristics from January 2011-April 2012
B.	Field Measurements of Temperature, pH, Conductivity, and Dissolved Oxygen in the PAFB Pond
	B.1 Pre-Modification Field Measurements
	B.2 Post-Modification Field Measurements
	B.3 Groundwater Field Measurements

TABLE OF CONTENTS -- CONTINUED

Appendices (Continued)

- C. Measured Daily Inflows and Outflows to the PAFB Pond
 - C.1 Pre-Modification Period
 - C.2 Post-Modification Modification Period

- D. Chemical Characteristics of Collected Pre-Modification Samples
 - D.1 Inflow Samples
 - D.2 Outflow Samples
 - D.3 Groundwater Samples
 - D.4 Bulk Precipitation Samples
 - D.5 Pond Samples

- E. Calculated Monthly Concentrations, Mass Inputs, and Mass Losses for the PAFB Pond Under Pre- and Post-Modification Conditions

- F. Chemical Characteristics of Collected Post-Modification Samples
 - F.1 Inflow Samples
 - F.2 Outflow Samples
 - F.3 Groundwater Samples
 - F.4 Bulk Precipitation Samples
 - F.5 Pond Samples

LIST OF FIGURES

Figure No.	Page
1. General Location Map of the Patrick Air Force Base Monitoring Site	2
2. Location of the Golf Course Pond at the Patrick Air Force Base Monitoring Site	2
3. Bathymetric Contours for the Western Pond	3
4. Field Monitoring Equipment Installed at the PAFB Pond Site	5
5. Photograph of Inflow/Outflow Equipment Shelter and Bulk Precipitation Collector	5
6. Construction Details for Groundwater Monitoring Wells	7
7. Location of Rain Gauge and Evaporimeter Pan at the Golf Course Site	8
8. Comparison of Average and Measured Rainfall in the Vicinity of the PAFB Beemat Pond During the Pre-Modification Monitoring	12
9. Measured Water Surface and Adjacent Groundwater Elevations at the PAFB Pond During Pre-Modification Monitoring	13
10. Measured Inflow and Outflow Hydrographs for the PAFB Pond from January-April 2011	14
11. Comparison of Measured Monthly Lake Evaporation at the PAFB Pond Site from January-April 2011	15
12. Mean Monthly Vertical Field Profiles Collected in the PAFB Pond During the Pre-Modification Field Monitoring Program from January-April 2011	18
13. Trends in Inflow and Outflow Concentrations of pH, Alkalinity, Conductivity, and TSS in the PAFB Pond During the Pre-Modification Monitoring Program from January-April 2011	20
14. Trends in Inflow and Outflow Concentrations of Nitrogen Species in the PAFB Pond During the Pre-Modification Monitoring Program from January-April 2011	21
15. Trends in Inflow and Outflow Concentrations of Phosphorus Species in the PAFB Pond During the Pre-Modification Monitoring Program from January-April 2011	23
16. Trends in Inflow and Outflow Concentrations of Turbidity and Color in the PAFB Pond During the Pre-Modification Monitoring Program from January-April 2011	24

LIST OF FIGURES -- CONTINUED

Figure No.	Page
17. Statistical Comparison of Measured Concentrations of pH, Alkalinity, Conductivity, and TSS in Inflow, Outflow, and Bulk Precipitation Samples During Pre-Modification Monitoring	28
18. Statistical Comparison of Measured Concentrations of Nitrogen Species in Inflow, Outflow, and Bulk Precipitation Samples During Pre-Modification Monitoring	29
19. Statistical Comparison of Measured Concentrations of Phosphorus Species in Inflow, Outflow, and Bulk Precipitation Samples During Pre-Modification Monitoring	31
20. Statistical Comparison of Measured Concentrations of Turbidity and Color in Inflow, Outflow, and Bulk Precipitation Samples During Pre-Modification Monitoring	32
21. Trends in Chlorophyll-a Concentrations in the PAFB Pond During the Pre-Modification Monitoring Program	33
22. Construction of the Floating Beemat Island	36
23. Examples of Aquatic Plants Installed in the Floating Beemat Islands	37
24. Installation of the Floating Beemat Islands in the Pond	37
25. Examples of Waterfowl Damage and Protective Netting	38
26. Birds and Waterfowl Attracted to the Site	39
27. Removal of the Floating Beemat Systems at the Completion of the Monitoring Program	40
28. Changes in Mean Plant Biomass (wet weight basis) Over Time During the Post-Modification Period	43
29. Changes in Mean Plant Biomass (dry weight basis) Over Time During the Post-Modification Period	44
30. Comparison of Total Wet and Dry Plant Biomass by Species	47
31. Changes in Total Mass of Nitrogen and Phosphorus Over Time for the Floating Beemat Islands	50
32. Comparison of Average and Measured Rainfall in the Vicinity of the PAFB Beemat Pond During the Post-Modification Monitoring	52
33. Measured Water Surface and Adjacent Groundwater Elevations at the PAFB Pond During Post-Modification Monitoring	53
34. Measured Inflow and Outflow Hydrographs for the PAFB Pond from May 2011-April 2012	

LIST OF FIGURES -- CONTINUED

Figure No.	Page
35. Comparison of Measured Monthly Lake Evaporation at the PAFB Pond Site from May 2011-April 2012	55
36. Mean Monthly Vertical Field Profiles Collected in the PAFB Pond During the Post-Modification Field Monitoring Program from May 2011-April 2012	58
37. Trends in Inflow and Outflow Concentrations of pH, Alkalinity, Conductivity, and TSS in the PAFB Pond During the Post-Modification Monitoring Program from May 2011-April 2012	60
38. Trends in Inflow and Outflow Concentrations of Nitrogen Species in the PAFB Pond During the Post-Modification Monitoring Program from May 2011-April 2012	61
39. Trends in Inflow and Outflow Concentrations of Phosphorus Species in the PAFB Pond During the Post-Modification Monitoring Program from May 2011-April 2012	63
40. Trends in Inflow and Outflow Concentrations of Turbidity and Color in the PAFB Pond During the Post-Modification Monitoring Program from May 2011-April 2012	64
41. Statistical Comparison of Measured Concentrations of pH, Alkalinity, Conductivity, and TSS in Inflow, Outflow, and Bulk Precipitation Samples During Post-Modification Monitoring	68
42. Statistical Comparison of Measured Concentrations of Nitrogen Species in Inflow, Outflow, and Bulk Precipitation Samples During Post-Modification Monitoring	69
43. Statistical Comparison of Measured Concentrations of Phosphorus Species in Inflow, Outflow, and Bulk Precipitation Samples During Post-Modification Monitoring	71
44. Statistical Comparison of Measured Concentrations of Turbidity and Color in Inflow, Outflow, and Bulk Precipitation Samples During Post-Modification Monitoring	72
45. Trends in Chlorophyll-a Concentrations in the PAFB Pond During the Post-Modification Monitoring	73

LIST OF TABLES

Table No.	Page
1. Stage-Area-Volume Relationships for the Western Pond	4
2. Analytical Methods and Detection Limits for Laboratory Analyses	10
3. QA/QC Procedures Used by ERD	10
4. Summary of Rainfall Characteristics Measured at the PAFB Pond Site from January -April 2011	11
5. Monthly Hydrologic Budget for the PAFB Pond During the Pre-Modification Monitoring Program	16
6. Summary of Water Quality Samples Collected at the PAFB Pond Site During the Pre-Modification Monitoring Program	17
7. Comparison of Mean Inflow and Outflow Concentrations in the PAFB Pond During the Pre-Modification Monitoring Program	24
8. Mean Characteristics of Bulk Precipitation Concentrations in the PAFB Pond During the Pre-Modification Monitoring Program	26
9. Mean Characteristics of Shallow Groundwater Samples Collected in the PAFB Pond During the Pre-Modification Monitoring Program	26
10. Summary of Measured Chlorophyll-a Concentrations During the Pre-Modification Monitoring Program	32
11. Summary of Mass Inputs, Losses, and Removal Efficiencies for the PAFB Pond During the Pre-Modification Monitoring Program	34
12. Summary of Plant Species Planted in the Initial Beemat Islands During May 2011	36
13. Summary of Physical Characteristics of the Beemat Plants During the Post-Modification Period from May 2011-April 2012	42
14. Assumed Changes in Wet and Dry Plant Biomass During the Post-Modification Monitoring Period	46
15. Summary of Total Wet and Dry Plant Biomass During the Post-Modification Monitoring Period	48
16. Summary of Nutrient Concentrations in Beemat Plant Material During the Post-Modification Period	49

LIST OF TABLES -- CONTINUED

Table No.	Page
17. Summary of Rainfall Characteristics Measured at the PAFB Pond Site from May 2011-April 2012	51
18. Monthly Hydrologic Budget for the PAFB Pond During the Post-Modification Monitoring Program	56
19. Summary of Water Quality Samples Collected at the PAFB Pond Site During the Post-Modification Monitoring Program	57
20. Comparison of Mean Inflow and Outflow Concentrations in the PAFB Pond During the Post-Modification Monitoring Program	64
21. Mean Characteristics of Bulk Precipitation Concentrations in the PAFB Pond During the Post-Modification Monitoring Program	66
22. Mean Characteristics of Shallow Groundwater Samples Collected in the PAFB Pond During the Post-Modification Monitoring Program	66
23. Summary of Measured Chlorophyll-a Concentrations During the Post-Modification Monitoring	73
24. Summary of Mass Inputs, Losses, and Removal Efficiencies for the PAFB Pond During the Post-Modification Monitoring Program	75
25. Calculated Detention Times for the PAFB Pond During Pre- and Post-Modification Conditions	76
26. Comparison of Mass Removal Efficiencies for the PAFB Pond During the Pre- and Post-Modification Periods	77
27. Comparison of Mass Removal Periods from January-April Under Pre- and Post-Modification Conditions	79
28. ANOVA Comparison of Pre- vs. Post-Modification Field Measurements Collected at the PAFB Beemat Pond Site from January 2011-April 2012	80
29. ANOVA Comparison of Pre- vs. Post-Modification Field Measurements Collected at the PAFB Beemat Pond Site from January-April	82
30. ANOVA Comparison of Pre- vs. Post-Modification Water Quality Characteristics of Inflow Samples Collected at the PAFB Beemat Pond Site from January 2011-April 2012	83
31. ANOVA Comparison of Pre- vs. Post-Modification Water Quality Characteristics of Inflow Samples Collected at the PAFB Beemat Pond Site from January-April	84

LIST OF TABLES -- CONTINUED

Table No.		Page
32.	ANOVA Comparison of Pre- vs. Post-Modification Water Quality Characteristics of Bulk Precipitation Samples Collected at the PAFB Beemat Pond Site from January 2011-April 2012	85
33.	ANOVA Comparison of Pre- vs. Post-Modification Water Quality Characteristics of Bulk Precipitation Samples Collected at the PAFB Beemat Pond Site from January-April	87
34.	ANOVA Comparison of Pre- vs. Post-Modification Water Quality Characteristics of outflow Samples Collected at the PAFB Beemat Pond Site from January 2011-April 2012	88
35.	ANOVA Comparison of Pre- vs. Post-Modification Water Quality Characteristics of Outflow Samples Collected at the PAFB Beemat Pond Site from January-April	89
36.	Comparison of Pre- vs. Post-Modification Areal Nutrient Uptake by the PAFB Pond System	90
37.	Changes in Total Mass Uptake of Nitrogen and Phosphorus During the Post-Modification Monitoring Period	92
38.	Calculated Areal Nutrient Uptake Rates for the Floating Beemat Islands	92
39.	Comparison of Plant Nutrient Uptake with Nutrient Loading to the Pond	93

1. Introduction

This document provides a summary of hydrologic and water quality data collected by Environmental Research & Design, Inc. (ERD) from January 2011-April 2012 to evaluate the performance efficiency of an existing wet detention pond with and without a floating Beemat wetland system. The pond is part of a wet detention storm water treatment system which receives runoff primarily from residential and roadway areas located west of the pond site. The pond is located adjacent to the golf course area within Patrick Air Force Base (PAFB). The golf course area is heavily irrigated with wastewater reuse. Soils in the vicinity of the pond and within the watershed are classified in Hydrologic Soil Group (HAS) A which reflects sandy soils with a high infiltration rate and a low runoff potential. A general location map for PAFB is given on Figure 1, with the location of the golf course pond indicated on Figure 2.

The monitoring program was designed to evaluate the performance efficiency of the golf course pond under existing conditions prior to installation of a floating Beemat wetland system and compare with the efficiency of the pond after retrofitting with the Beemat system. The results of the field monitoring program discussed in this report are used to quantify pre-modification performance efficiency within the pond and document changes in the performance efficiency of the pond following modification with the Beemat system. Pre-modification field monitoring was conducted for a period of 4 months from January-April 2011. At the completion of the pre-modification monitoring, the pond was retrofitted with a floating Beemat wetland system, and the performance efficiency was evaluated for an additional period of 12 months to quantify potential enhancement in pollutant removal effectiveness resulting from the Beemat installation.

This document provides a summary of all hydrologic and water quality data collected by ERD during the pre- and post-modification field monitoring programs conducted from January 2011-April 2012. Hydrologic and water quality monitoring and collection equipment were installed at the site by ERD during December 2010 to evaluate the performance efficiency of the wet detention pond under existing and post-modification conditions. The specific objectives of this project are to:

1. Evaluate the hydrologic and pollutant removal effectiveness of the wet detention pond under pre-modification conditions; and
2. Evaluate changes in system performance following installation of the Beemat wetland system and quantify changes in pond efficiency performance as the density of the plant communities increase over time.

Field monitoring at the PAFB site is divided into pre-modification and post-modification phases. The pre-modification phase was conducted over a period of four months to evaluate system performance efficiency under existing conditions. The post-modification phase began at the completion of the pre-modification phase and extended over a period of 12 months to monitor changes in performance efficiency following installation of the Beemat system.

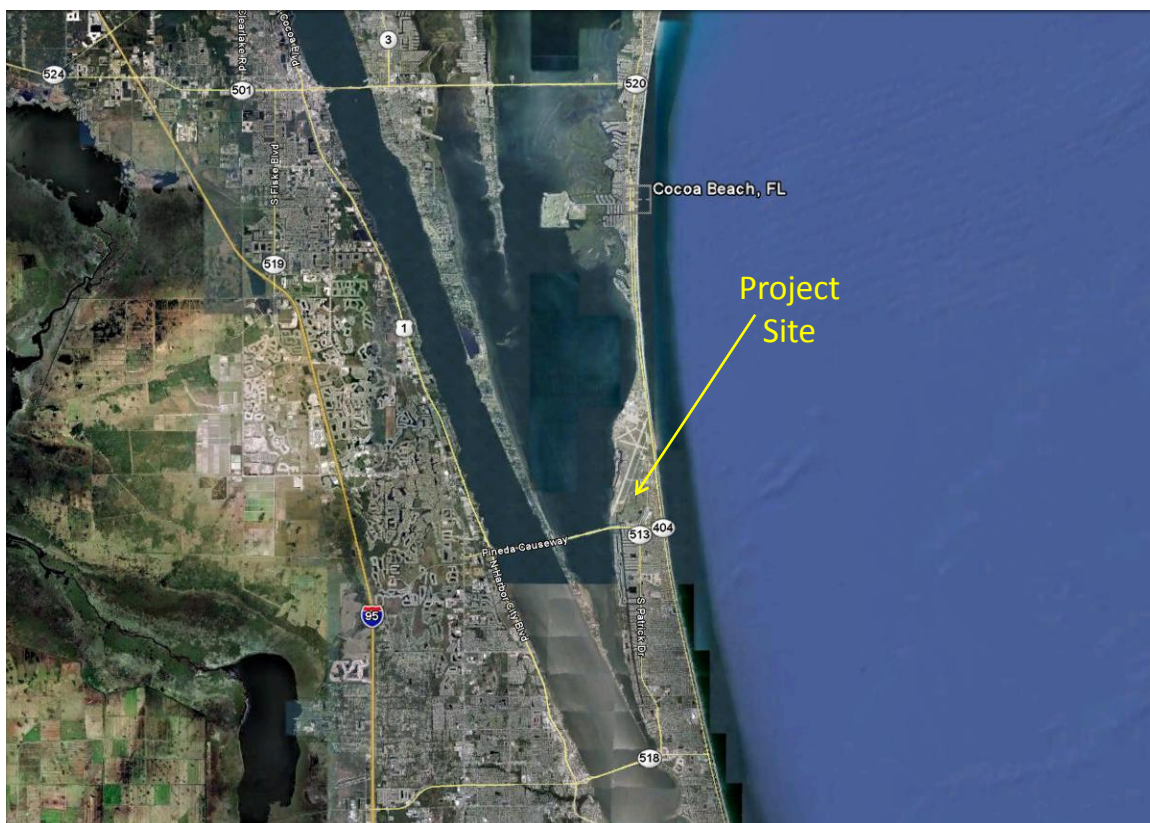


Figure 1. General Location Map of the Patrick Air Force Base Monitoring Site.



Figure 2. Location of the Golf Course Pond at the Patrick Air Force Base Monitoring Site.

2. Physical Characteristics of the Western Pond

A bathymetric contour map of the western pond was developed by ERD based upon approximately 100 spot elevations conducted within the pond and the adjacent sloped sides of the pond. Bathymetric information is needed to calculate stage-area-volume relationships for the pond and for use in estimating residence time. A summary of bathymetric contours for the western pond is given on Figure 3. The contour intervals summarized on this figure reflect elevations referenced to mean sea level (MSL). According to the as-built survey for the pond, the control water elevation for the outfall structure is approximately 1.96 ft. A summary of stage-area-volume relationships for the west pond is given on Table 1. At the control water elevation of approximately 1.96 ft, the surface area of the west pond is approximately 0.59 acres, with an approximate volume of 2.22 ac-ft.



Figure 3. Bathymetric Contours for the Western Pond (Elevation, MSL).

TABLE 1
STAGE-AREA-VOLUME RELATIONSHIPS
FOR THE WESTERN POND

STAGE (Elev., MSL)	AREA (acres)	VOLUME (ac-ft)
4	0.73	3.54
3	0.66	2.84
2	0.59	2.22
1	0.52	1.66
0	0.46	1.17
-1	0.40	0.74
-2	0.32	0.38
-3	0.20	0.12
-4	0.04	0

3. Field Monitoring

3.1 Inflow and Outflow Monitoring

An overview of field monitoring equipment installed at the PAFB pond site is given on Figure 4. Runoff from the adjacent residential and roadway areas initially enters a wet detention pond, referred to as the eastern pond in this document. Discharges from the eastern pond travel through a 36-inch HDPE into the western pond which is the subject of the pre- and post-modification monitoring discussed in this document.

Continuous monitoring of inflows and outflows from the pond was conducted during the pre- and post-modification monitoring programs using identical refrigerated Sigma Model 900MAX autosamplers with integral flowmeters. Each of the autosamplers was operated on 120 VAC which was extended to the monitoring site by PAFB personnel. The inflow and outflow autosamplers were located inside an insulated equipment shelter which was installed on the east side of the pond near the point of inflow for the 36-inch HDPE. A photograph of the equipment shelter is given on Figure 5.

An area-velocity flowmeter and sample intake tubing were inserted approximately 15 ft into the 36-inch HDPE and connected to one of the refrigerated Sigma autosamplers located inside the equipment shelter. The flowmeter was programmed to provide a continuous record of discharges through the 36-inch HDPE, with measurements stored into internal memory at 10-minute intervals. The automatic sampler contained a single 20-liter polyethylene bottle and was programmed to collect samples in a flow-weighted mode. The inflow samples were collected as a weekly composite with 500 ml sample aliquots collected for every predetermined volume of inflow. Flow monitoring was conducted using an area-velocity flowmeter which conducts simultaneous measurements of the water velocity and depth of flow, with the discharge calculated using the Continuity Equation, as follows:



Figure 4. Field Monitoring Equipment Installed at the PAFB Pond Site.



Figure 5.

Photograph of
Inflow/Outflow
Equipment Shelter and
Bulk Precipitation
Collector.

$$Q = V \times A$$

where: Q = discharge (cfs)
 V = velocity (ft/sec)
 A = cross-sectional area (ft²)

A second identical refrigerated Sigma Model 900MAX autosampler was also installed inside the equipment shelter shown on Figure 5 to collect pond discharge samples on a flow-weighted basis. Sample intake tubing was extended along the pond bottom from the autosampler to the pond outflow structure. The sample tubing was placed inside 1-inch PVC piping to prevent light penetration into the tubing. Discharge measurements at the outfall structure were calculated based on the height of water above the rectangular weir in the outfall structure using a pressure transducer probe attached to the outflow sampler. The water level sensor was placed in the pond adjacent to the equipment shelter housing. Discharge was calculated using a standard horizontal weir equation based on water height above the weir insert. The outfall flowmeter was programmed to provide a continuous record of discharges from the pond, with measurements stored into internal memory at 10-minute intervals. The automatic sampler contained a single 20-liter polyethylene bottle and was programmed to collect samples in a flow-weighted mode, with 500-ml aliquots pumped into the collection bottle with every programmed increment of flow. A staff gauge and sensitive water level recorders (Global Water Model WL16U-3) were installed in both the east and west ponds to assist in developing a hydrologic budget for the system.

3.2 Groundwater Monitoring

Shallow groundwater monitoring wells were also installed on each of the four sides of the western pond to evaluate the quantity and quality of groundwater inflow into the pond. Each of the groundwater monitoring wells consisted of a 2-inch slotted casing which was hand-augered to a depth of approximately 3-4 ft below the surficial groundwater table at the time of installation. Typical details for groundwater monitoring wells are given in Figure 6. Each of the wells contained a bottom slotted PVC screen, approximately 3 ft in length, with slot widths of 0.01 inches. The bore hole for each well was constructed using a 4-inch diameter hand auger.

The void space around the well was filled with 20-30 silica sand to a level above the slotted PVC screen. Soil backfill from the excavated hole was then placed around the well to a level approximately 6 inches below the ground surface. A 6-inch thick bentonite pellet seal was then added to prevent short-circuiting of water through the well bore hole. The 2-inch PVC riser extended 24 inches above the ground, with a vented PVC cap placed on the top to prevent contamination of the well between monitoring events. Each of the wells was installed an equal distance of 15 ft from the water line in the pond at the time of installation. The top elevation of each groundwater monitoring well was surveyed by ERD using a known reference elevation adjacent to the pond.

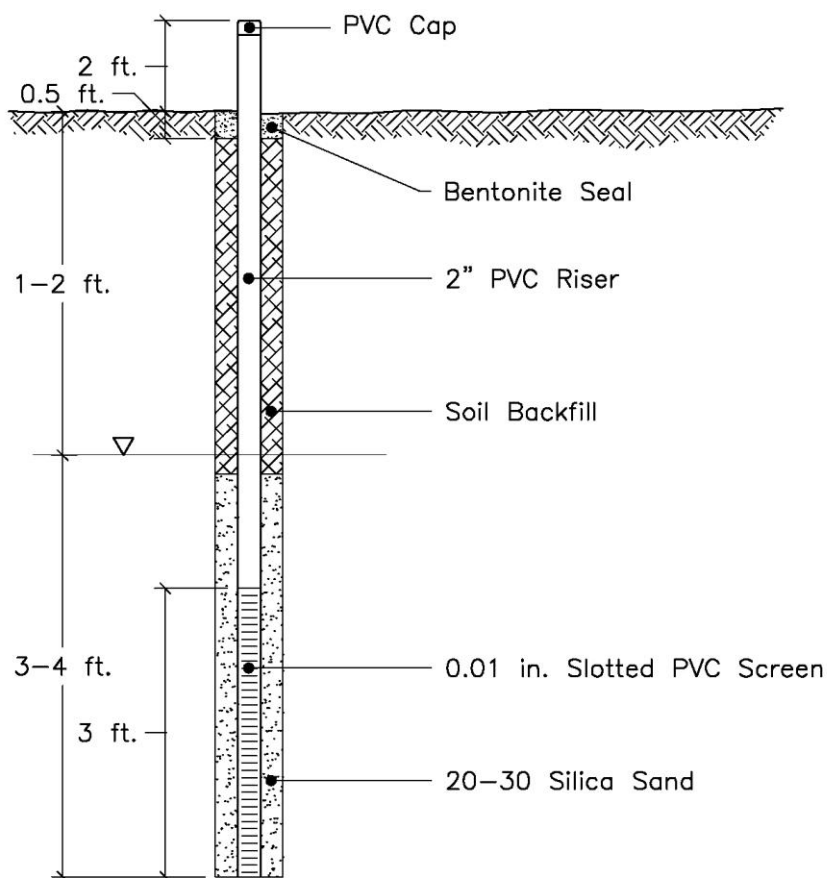


Figure 6.
Construction Details for
Groundwater Monitoring
Wells.

During each weekly monitoring event, the depth to the groundwater table was measured at each of the four wells using a Global Water Model WL-500 water level sounder, consisting of a submersible pressure transducer with an accuracy of 0.008%. This information was converted to an elevation for comparison with measured water surface elevations within the pond.

Monitoring for groundwater characteristics was conducted on a monthly basis. During each monitoring event, the depth to the surficial groundwater table was measured and the approximately water volume within the well was calculated. The well was then purged by removing a water volume equivalent to three times the initial well volume. After the purging was completed, the well was allowed to equilibrate and the groundwater was pumped through a flow-through cell attached to a Hydrolab H20 water quality monitor for field measurement of pH, temperature, conductivity, dissolved oxygen, and ORP. The flow-through cell was then removed, and a groundwater sample was collected using a submersible battery-powered centrifugal pump. The groundwater sample was field filtered using a disposable 0.45-micron groundwater filter. The filtered samples were placed in ice and returned to the ERD Laboratory for analysis of selected parameters.

3.3 Hydrologic Instrumentation

In addition to the field monitoring equipment outlined previously, a recording rain gauge (ISCO Model 674), with a resolution of 0.01 inch, was installed adjacent to the maintenance facility for the golf course area. The rainfall recorder produced a continuous record of all rainfall which occurred at the site, with a resolution of 0.01 inch. Rainfall data were stored inside a digital storage device (Hobo Event Rainfall Logger) which was attached to the support posts for the rain gauge inside a waterproof enclosure. The rain gauge was installed at this location to avoid impacts from irrigation activities which occur periodically in the vicinity of the pond site. The rainfall record is used to provide information on general rainfall characteristics in the vicinity of the monitoring site and to assist in evaluation of hydrologic inputs from the watershed areas as well as direct inputs onto the pond surface.

In addition, a Class A evaporimeter pan was also installed adjacent to the rain gauge to provide estimates of evaporation rates at the pond site. Measurements of water level within the evaporation pan were recorded on a weekly basis and corrected for measured rainfall to provide estimates of evaporation from the pond surface. Information stored in the rainfall data logger, as well as evaporimeter water level measurements, were retrieved on a weekly basis. Locations of the rain gauge and evaporimeter pan are indicated on Figure 7.

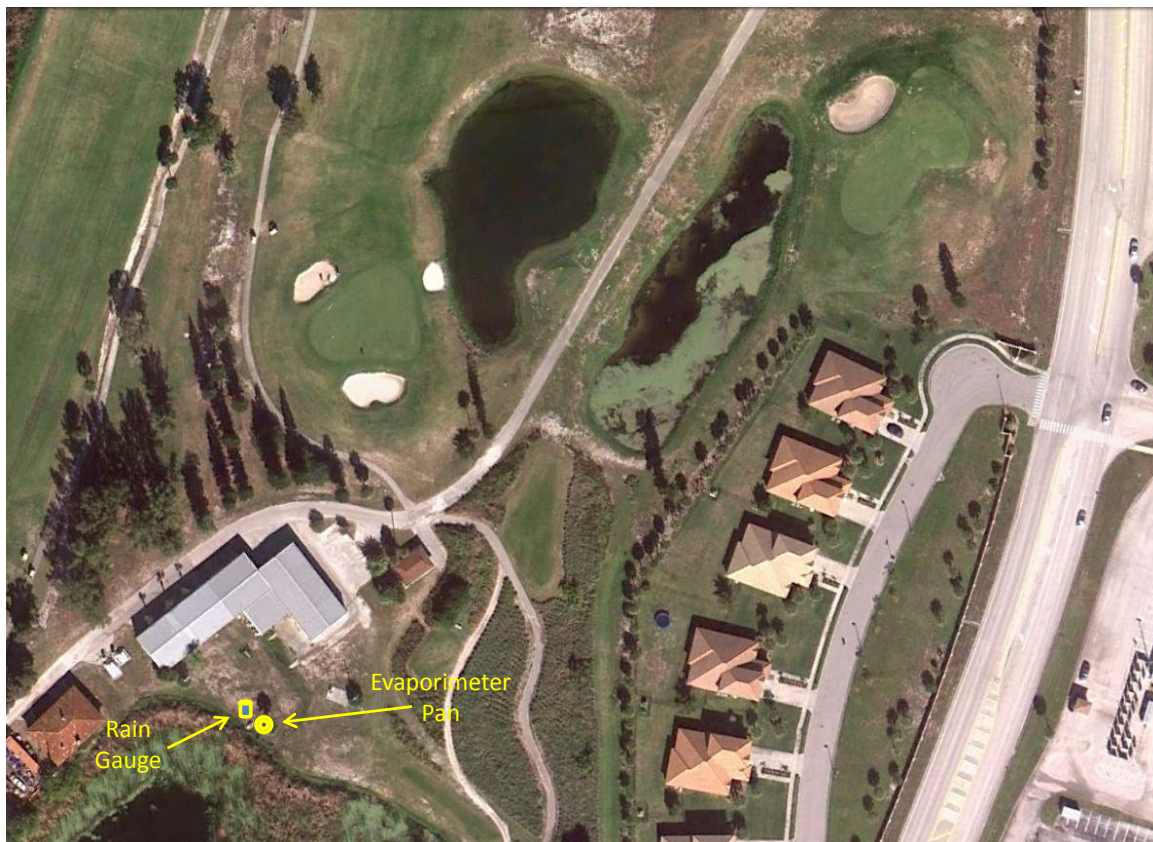


Figure 7. Location of the Rain Gauge and Evaporimeter Pan at the Golf Course Site.

During the period from January 2011-April 2012, ERD personnel visited the PAFB pond site on at least a weekly basis to collect water quality samples and retrieve stored hydrologic data from each of the automatic samplers as well as the rain gauge, evaporimeter, and water level recorders. This information was evaluated for quality control purposes and compiled into a continuous data set for use in evaluating the hydrologic performance efficiency of the system.

3.4 Surface Water Monitoring

In addition to the activities outlined previously, ERD field personnel also collected surface sample samples and field measurements from the pond water column during each weekly monitoring site visit. A multi-port sampling device was constructed from a 2-inch PVC pipe which was inserted approximately 4 ft into the bottom of the pond. Separate sample ports were attached at water depths of 0.5 m below the water surface (top), middle of the water column (middle), and 0.25 m from the pond bottom (bottom). Each of the sample ports was connected to individual lengths of 3/8-inch ID polyethylene tubing which was extended from the sample ports to the shoreline through additional lengths of 2-inch PVC pipe to avoid sunlight reaching the sample collecting tubing.

The sample port apparatus was installed near the center of the pond adjacent to one of the Beemat islands so that water quality could be monitored without having to physically enter and disturb the pond water. A battery-operated peristaltic pump was connected to the tubing, and separate field measurements and samples were collected from top, middle, and bottom portions of the water column. For field measurements, the peristaltic pump was connected individually to the ends of the polyethylene tubing, and water was pumped from either the top, middle, or bottom portion of the water column into a flow-through cell attached to a Hydrolab Model H20 water quality monitor for field measurements of pH, temperature, dissolved oxygen, specific conductivity, and ORP. After the field measurements were completed for a specific depth, the flow-through cell was removed, and a sample was collected for laboratory analysis. The peristaltic pump tubing was then connected to the next piece of polyethylene tubing, and the process was repeated for the remaining two water depths. This process was used to monitor potential changes in field measurements within the pond under pre- and post-modification conditions. The water samples collected from each of the three sample ports were analyzed for the same parameters used for inflow and outflow samples, with the addition of chlorophyll-a.

4. Laboratory Analyses

4.1 Analytical Methods

A summary of laboratory methods and MDLs for analyses conducted on water samples collected during this project is given in Table 2. All laboratory analyses were conducted in the ERD Laboratory which is NELAC-certified (No. 1031026). Additional details on field operations, laboratory procedures, and quality assurance methodologies are provided in the FDEP-approved Comprehensive Quality Assurance Plan for Environmental Research & Design, Inc. In addition, a Quality Assurance Project Plan (QAPP), outlining the specific field and laboratory procedures to be conducted for this project, was submitted to and approved by FDEP prior to initiation of any field and laboratory activities.

TABLE 2
ANALYTICAL METHODS AND DETECTION
LIMITS FOR LABORATORY ANALYSES

PARAMETER	METHOD OF ANALYSIS ¹	METHOD DETECTION LIMITS (MDLs) ²
pH	SM-21, Sec. 4500-H ⁺ B	N/A
Conductivity	SM-21, Sec. 2510 B	2 µmho/cm
Alkalinity	SM-21, Sec. 2320 B	0.7 mg/l
Ammonia	SM-21, Sec. 4500-NH ₃ G	0.005 mg/l
NO _x	SM-21, Sec. 4500-NO ₃ F	0.005 mg/l
Total Nitrogen	SM-21, Sec. 4500-N C	0.03 mg/l
Ortho-P (SRP)	SM-21, Sec. 4500-P F	0.001 mg/l
Total Phosphorus	SM-21, Sec. 4500-P B.5/F	0.001 mg/l
Turbidity	SM-21, Sec. 2130 B	0.1 NTU
Color	SM-21, Sec. 2120 C	1 Pt-Co Unit
TSS	SM-21, Sec. 2540 D	0.7 mg/l
Chlorophyll-a	SM-21, Sec. 10200 H.1.3	0.6 mg/m ³

1. Standard Methods for the Examination of Water and Wastewater, 21st ed., 2005.
2. MDLs are calculated based on the EPA method of determining detection limits

4.2 Quality Control

Multiple QA/QC procedures were used by ERD during this project. A summary of QA/QC procedures is given in Table 3. The listed QA/QC procedures are designed to evaluate both the field and laboratory systems. Approximately 90 additional laboratory QA/QC samples were evaluated by ERD in addition to the 193 collected surface water samples and 48 collected groundwater samples. In addition, more than 30 field QA/QC samples were collected and analyzed to address potential field contamination.

TABLE 3
QA/QC PROCEDURES USED BY ERD

QC ITEM	FREQUENCY
Continuous Calibration Verification Standards	Every 10 samples
Continuing Calibration Blanks	Every 10 samples
Lab Control Samples (Check Standards)	Every 20 samples and beginning/end of each run
Method Blank	Every 20 samples and beginning/end of each run
Duplicate Samples (Precision)	Every 10 samples
Spiked Samples (Accuracy)	Every 20 samples
Initial Calibration Verification (pH)	Every run
Field Equipment Blanks	Every 10 samples
Pre-Cleaned Equipment Blank	Every 10 samples

5. Pre-Modification Monitoring

5.1 Hydrologic Data

5.1.1 Rainfall

A complete listing of measured rainfall events at the PAFB pond site during the field monitoring program from January-April 2011 is given in Appendix A.1. A total of 7.27 inches of rainfall was measured at the pond site during the 120-day monitoring period from a total of 27 monitored rain events. A summary of rainfall characteristics measured at the PAFB site from January-April 2011 is given in Table 4. Individual rain events at the site ranged from a minimum of 0.01 inches to a maximum of 1.25 inches, with an overall mean of 0.27 inch per event. Antecedent dry periods between rain events ranged from 0.2-18.6 days.

TABLE 4

**SUMMARY OF RAINFALL CHARACTERISTICS MEASURED
AT THE PAFB POND SITE FROM JANUARY - APRIL 2011**

PARAMETER	UNITS	MINIMUM VALUE	MAXIMUM VALUE	MEAN EVENT VALUE
Event Rainfall	inches	0.01	1.25	0.27
Event Duration	hours	< 0.01	14.5	3.3
Average Intensity	inches/hour	0.04	0.86	0.20
Antecedent Dry period	days	0.20	18.6	4.5

A graphical comparison of average and measured rainfall in the vicinity of the PAFB Beemat pond is given on Figure 8. Graphical comparisons are provided for the pre-modification monitoring period from January-April 2011. The “measured” rainfall reflects the actual measurements conducted at the PAFB site by ERD. The “normal” rainfall reflects the monthly mean rainfall at the Melbourne Meteorological Station over the period from 1971-2000. As indicated on Figure 8, slightly greater than normal rainfall occurred at the site during January 2011, with slightly lower than normal rainfall measured during March 2011. Substantially lower than normal rainfall occurred at the site during the months of February and April 2011. The field measured rainfall of 7.27 inches during the pre-modification monitoring program is approximately 28% less than the normal rainfall of 10.06 inches which typically occurs in the general area during the months of January-April.

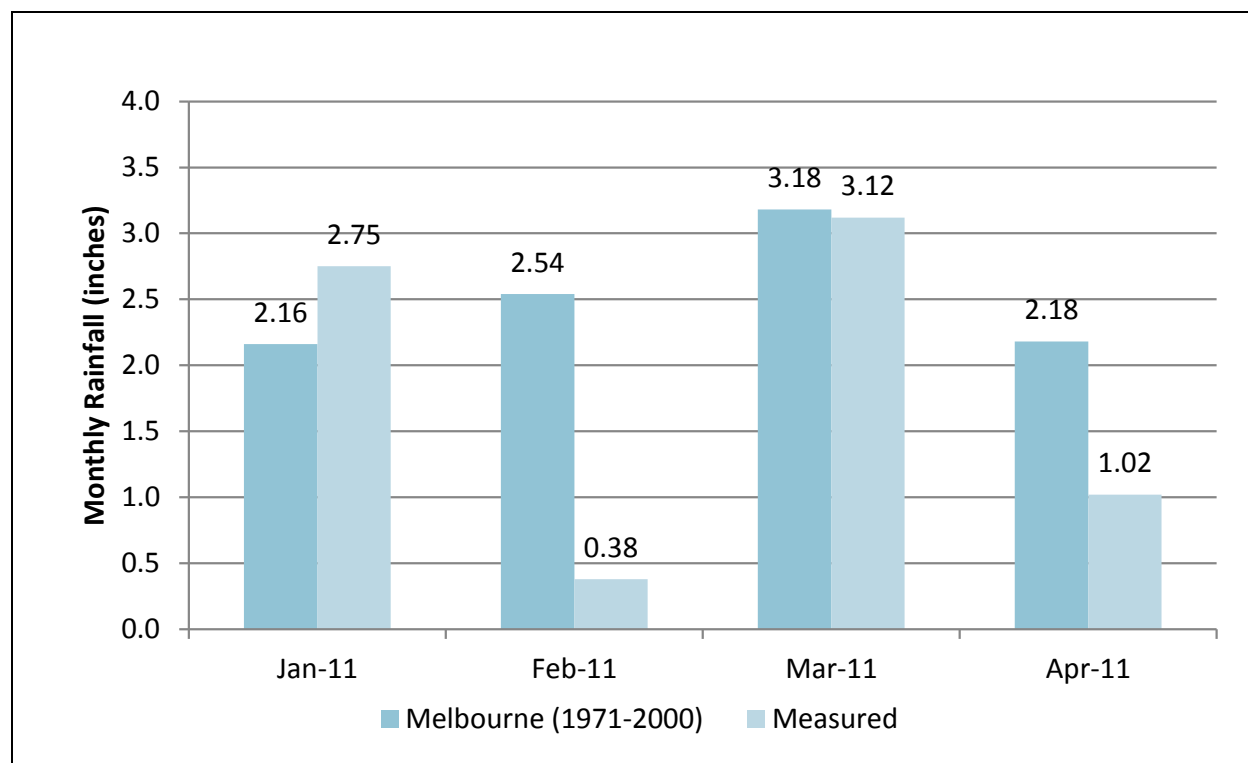


Figure 8. Comparison of Average and Measured Rainfall in the Vicinity of the PAFB Beemat Pond During the Pre-Modification Monitoring.

5.1.2 Surface Water Elevations

A graphical summary of measured water elevations in the western pond is given on Figure 9. Measurements of groundwater elevations in the adjacent shallow monitoring wells are also included on Figure 9 for comparison purposes. Measured water elevations in the western pond ranged from approximately 1.4-2.4 ft during the field monitoring program, representing a water level fluctuation of approximately one foot. Water levels in the pond exceeded the control elevation on 86 of the 120 days included in the pre-modification field monitoring program. Recorded rainfall is also plotted on the top of Figure 9. In general, the pond elevation responded rather quickly to rain events in the watershed.

In general, groundwater elevations in the adjacent monitoring well were equal to or slightly less than the measured pond elevations throughout the majority of the field monitoring program, suggesting that groundwater inflow into the pond was relatively low during the pre-modification monitoring period. Groundwater elevations at monitoring well Site 2, located on the southern end of the western pond, were consistently lower than elevations measured in the pond or the other groundwater monitoring wells despite frequent irrigation of the golf course area with wastewater reuse. Based upon the information summarized in Figure 9, groundwater inflow into the pond appears to be minimal, with the primary direction of water movement occurring from the pond into the adjacent groundwater during a majority of the pre-modification monitoring period.

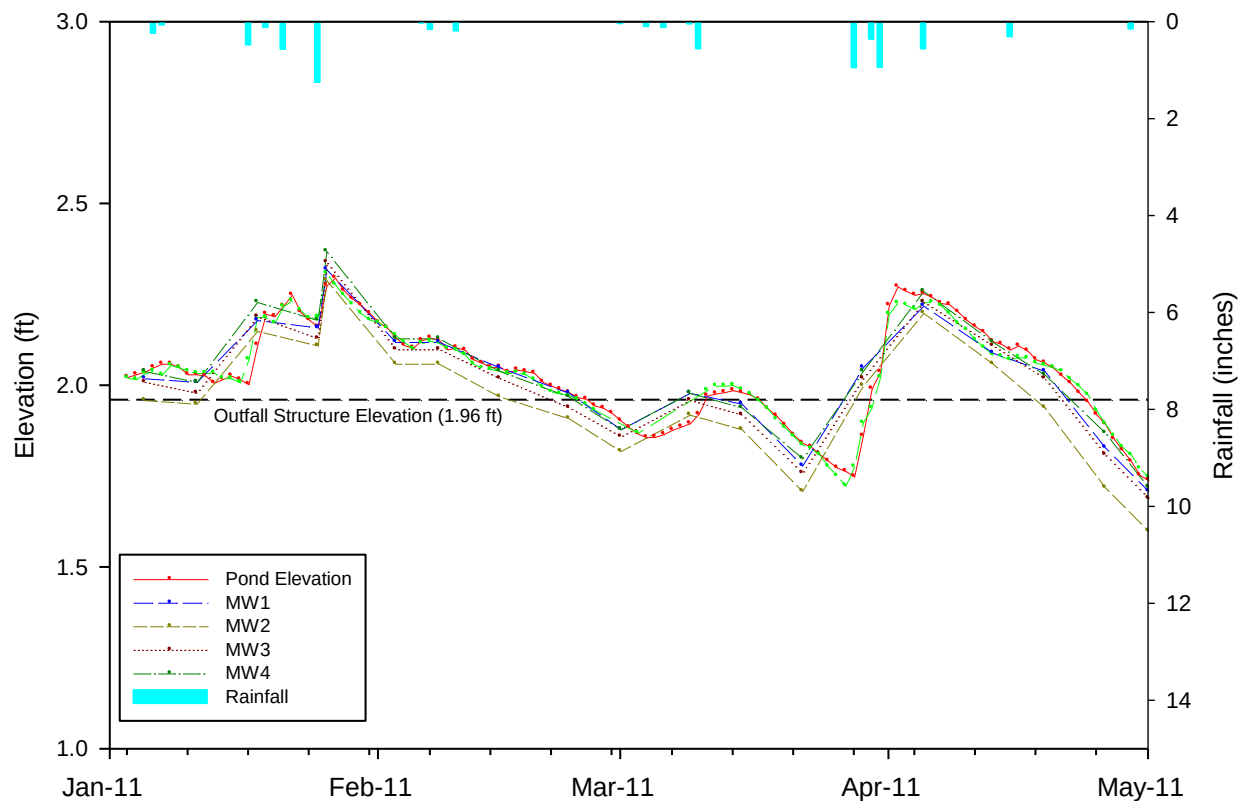


Figure 9. Measured Water Surface and Adjacent Groundwater Elevations at the PAFB Pond During Pre-Modification Monitoring.

5.1.3 Inflow/Outflow Hydrographs

Field measured inflow and outflow hydrographs for the western pond during the pre-modification field monitoring program from January-April 2011 are summarized on Figure 10. The inflow hydrograph represents the inflow into the western pond through the 36-inch HDPE, with the outflow hydrographs reflecting discharges through the outfall structure. In general, inflow and outflow hydrographs appear to be relatively similar which would be anticipated given the relatively small size of the western pond. Inflows into the western pond ranged from 0.0-0.2 cfs, with a similar range of values measured at the outfall. In general, inflow hydrographs into the pond appear to correspond very closely with measured rainfall events at the site. Inflow into the pond was observed on almost a continuous basis during the field monitoring program. However, discharges from the pond did not occur continuously with periods of little or no discharge observed from February 26-March 10, March 18-29, and from April 25-30.

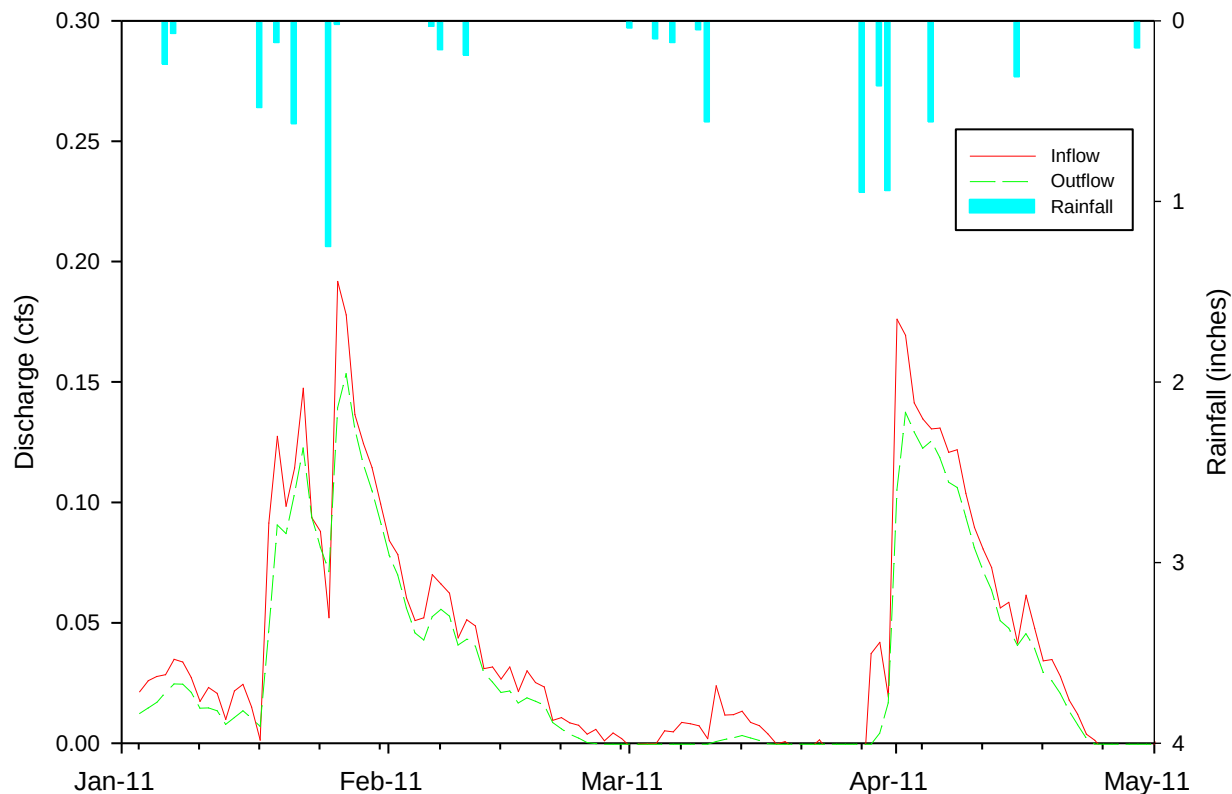


Figure 10. Measured Inflow and Outflow Hydrographs for the PAFB Pond from January-April 2011.

5.1.4 Evaporation

As discussed in Section 3.3, a Class A pan evaporimeter was installed near the pond site to provide estimates of surface evaporation rates from the pond. Changes in water level within the evaporation pan were recorded on a weekly basis and corrected for measured rainfall to provide estimates of surface evaporation. The evaporation measurements were then summarized on a monthly basis and used in calculations for the hydrologic budget for the pond.

A graphical comparison of measured monthly pond evaporation during the pre-modification monitoring program is given on Figure 11. Measured monthly surface evaporation rates ranged from a low of 2.25 inches during January 2011 to a high of 4.78 inches during April 2011.

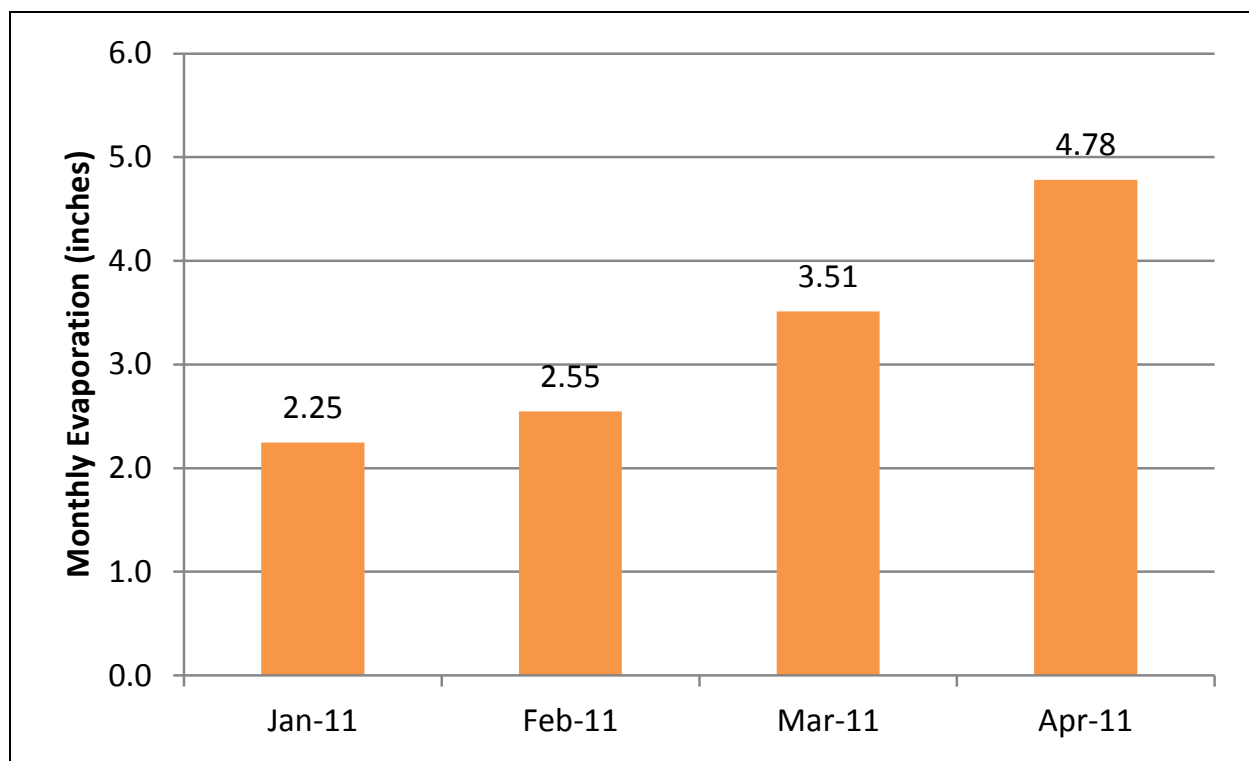


Figure 11. Comparison of Measured Monthly Lake Evaporation at the PAFB Pond Site from January-April 2011.

5.1.5 Hydrologic Budget

A complete hydrologic budget was developed for the PAFB pond over the pre-modification period from January-April 2011. The hydrologic budget includes inputs to the pond from runoff inflows, direct precipitation, and groundwater inflow (if applicable), with losses from the pond occurring as a result of discharges through the outfall structure, surface evaporation, and groundwater losses (if applicable). The hydrologic budget can be expressed mathematically according to the following relationship:

$$RO + Precip + GW_{in} = Outfall + Evap + GW_{out} \pm \Delta Storage$$

where:

RO	=	Runoff inflow
Precip	=	Direct rainfall on pond surface
GW	=	Groundwater inflow or loss
Outfall	=	Losses through outfall structure
Evap	=	Pond evaporation

A pre-modification hydrologic budget was developed for the pond on a daily basis over the period from January-April 2011. Inputs into the pond from stormwater runoff through the 36-inch HDPE, as well as losses from the pond as a result of discharges through the outfall structure, were obtained by integrating the inflow and outflow hydrographs shown on Figure 10 on a daily basis. Inputs into the pond from direct precipitation were obtained using the rainfall data summarized in Appendix A.1 and the surface area of the pond at the time of each rainfall event. Losses as a result of evaporation were calculated by multiplying the estimated daily evaporation loss times the mean pond surface area for each day. Change in storage within the pond is calculated based upon the measured surface water elevations illustrated on Figure 9. Groundwater inflows or losses are calculated as the difference in the hydrologic budget after consideration of the calculated inflows and outflows and change in storage. Each of the inflows and outflows were calculated on a daily basis with the pre-modification data provided in Appendix C.1.

A tabular summary of monthly hydrologic budgets for the western pond during the pre-modification period is given on Table 5. Inflows through the 36-inch HDPE contributed approximately 8.91 ac-ft of water during the pre-modification monitoring period, with 0.32 ac-ft contributed by direct rainfall. Discharges through the outfall structure resulted in a loss of approximately 7.05 ac-ft of water, with 0.56 ac-ft lost from surface evaporation. The monthly mass hydrologic budgets indicated that a net loss to groundwater occurred during each of the four monthly periods. Overall, the pond received a total input of approximately 9.23 ac-ft, with a total loss of 9.39 ac-ft. The difference of -0.16 ac-ft between the inputs and losses reflects the decrease in water storage from the beginning to the end of the pre-modification period.

TABLE 5

**MONTHLY HYDROLOGIC BUDGET
FOR THE PAFB POND DURING THE PRE-
MODIFICATION MONITORING PROGRAM**

MONTH	INPUTS (ac-ft)		LOSSES (ac-ft)			CHANGE IN STORAGE (ac-ft)
	INFLOW	DIRECT RAINFALL	OUTFLOW	EVAPORATION	GROUNDWATER	
January	3.65	0.13	2.96	0.10	0.62	0.10
February	1.73	0.02	1.38	0.11	0.42	-0.16
March	0.37	0.13	0.07	0.15	0.22	0.06
April	3.16	0.04	2.64	0.20	0.52	-0.16
TOTAL:	8.91	0.32	7.05	0.56	1.78	-0.16

5.2 Vertical Field Profiles

Field measurements of temperature, pH, conductivity, and dissolved oxygen in the western pond during the pre-modification monitoring program are given in Appendix B.1. Vertical field profiles were conducted in top, middle, and bottom portions of the pond during each monitoring event using the multi-port device described in Section 3.4. Measurements of vertical field profiles were conducted during each weekly site visit.

A graphical summary of vertical field profiles collected in the western pond during the pre-modification field monitoring program is given on Figure 12. The profiles summarized in this figure reflect the mean of weekly vertical profiles summarized on a monthly basis. In general, no significant thermal stratification was observed within the pond during any of the field monitoring events. Measured pH values in the western pond ranged from approximately 8-8.5 with relatively uniform values throughout the water column, with the exception of slightly higher surface pH values measured during April. Measured conductivity values within the pond ranged from approximately 1100-1200 $\mu\text{mho/cm}$, with relatively uniform values during most monitoring events. Dissolved oxygen within the pond was typically good, with measured values ranging from approximately 6-12 mg/l. No significant decrease in dissolved oxygen with increasing water depth was observed during any event.

5.3 Water Quality Data

A summary of water quality samples collected at the PAFB pond site during the pre-modification monitoring program is given in Table 6. A total of 68 separate water quality samples was collected and submitted to the ERD Laboratory for analysis from January-April 2011. A complete listing of the characteristics of inflow samples collected at the pond site is given in Appendix D.1, with the chemical characteristics of outflow samples summarized in Appendix D.2, groundwater samples summarized in Appendix D.3, and bulk precipitation samples summarized in Appendix D.4. A listing of chlorophyll analyses conducted on pond samples is given in Appendix D.5.

TABLE 6
SUMMARY OF WATER QUALITY SAMPLES
COLLECTED AT THE PAFB POND SITE DURING
THE PRE-MODIFICATION MONITORING PROGRAM

SITE	SAMPLES COLLECTED
Inflow	13
Outflow	13
Groundwater	24
Pond Samples ¹	14
Bulk Precipitation	4
TOTAL:	68

1. Chlorophyll-a measurements only

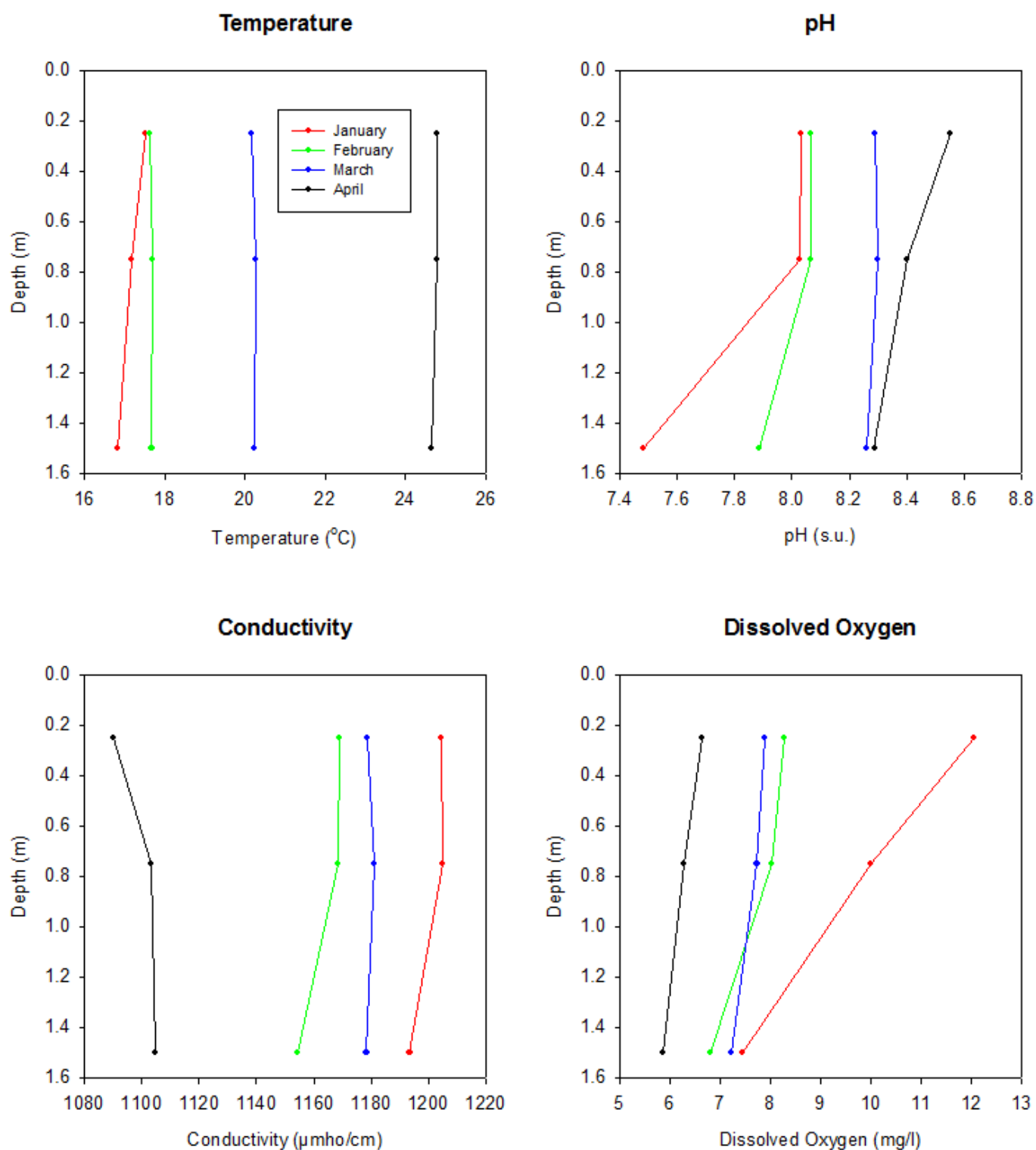


Figure 12. Mean Monthly Vertical Field Profiles Collected in the PAFB Pond During the Pre-Modification Field Monitoring Program from January-April 2011.

5.3.1 Inflow and Outflow Samples

A graphical summary of trends in inflow and outflow concentrations of pH, alkalinity, conductivity, and TSS in the western pond during the pre-modification monitoring program is given on Figure 13. In general, both the inflow and outflow samples were slightly alkaline in pH, ranging in value from approximately 7.3-8.2. A general trend of slightly higher pH values was observed at the pond outfall compared with the pond inflow, presumably due to pH increases caused by algal productivity within the pond. Measured inflows and outflows for the pond were well buffered, with measured alkalinity values ranging from approximately 75-220 mg/l. A general decrease in alkalinity was observed within the western pond between the inflow and outflow which may be related to uptake of inorganic carbon by photosynthetic algae within the pond.

Measured conductivity values in the inflow and outflow samples were somewhat elevated, ranging from approximately 725-1200 $\mu\text{mho/cm}$. However, conductivity values in this range are commonly observed in pond systems located in coastal areas. In general, measured conductivity values in the outflow samples appear to be somewhat lower than conductivity values measured at the inflow to the pond. Measured concentrations of TSS in the inflow and outflow samples ranged from low to moderate in value during the pre-modification monitoring program. In general, discharges from the pond were characterized by higher TSS concentrations than observed in the inflow, presumably due to algal production within the pond which is measured as TSS at the pond outfall.

Trends in inflow and outflow concentrations of nitrogen species in the western pond during the pre-modification monitoring program are indicated on Figure 14. Measured concentrations of ammonia in the inflow and outflow samples ranged from low to moderate in value. In general, inflow samples appear to exhibit higher levels of ammonia than measured at the outflow, suggesting uptake of ammonia within the pond. Measured concentrations of NO_x were typically low in value in both the inflow and outflow samples, with a slight trend of lower concentrations at the pond outfall during a majority of the monitoring events, suggesting uptake of NO_x within the pond.

Measured concentrations of particulate nitrogen ranged from low to elevated during the pre-modification field monitoring program. In general, outflow concentrations of particulate nitrogen were higher in value during a majority of the monitoring period compared with the inflow concentrations. The observed increases in particulate nitrogen are likely related to incorporation of nitrogen in algal biomass within the pond. Measured concentrations of total nitrogen ranged from moderate to elevated during the field monitoring program. Outflow concentrations of total nitrogen exceeded the inflow concentrations in most of the collected samples, suggesting a net export of total nitrogen from the pond compared with the measured inputs.

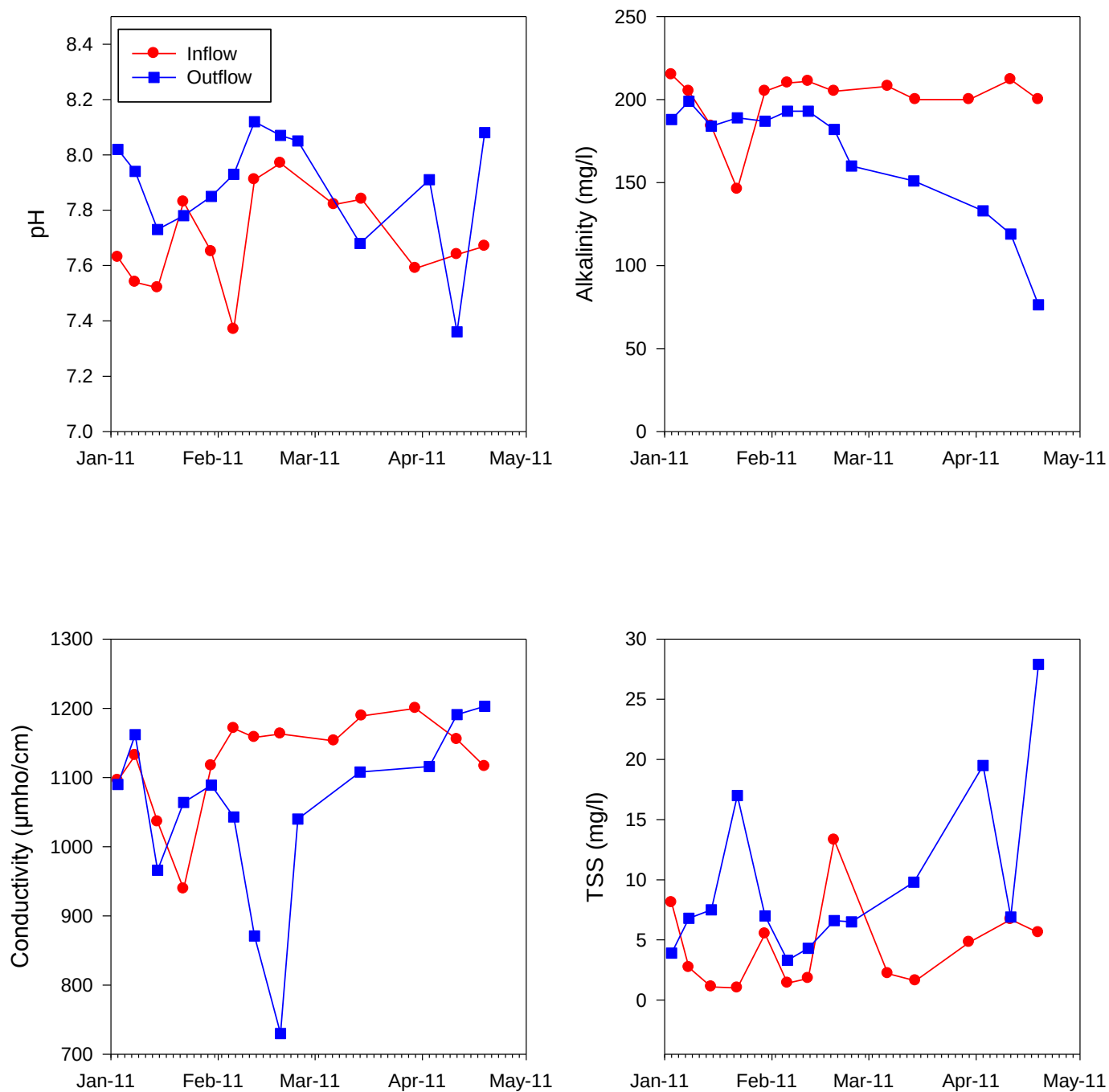


Figure 13. Trends in Inflow and Outflow Concentrations of pH, Alkalinity, Conductivity, and TSS in the PAFB Pond During the Pre-Modification Monitoring Program from January-April 2011.

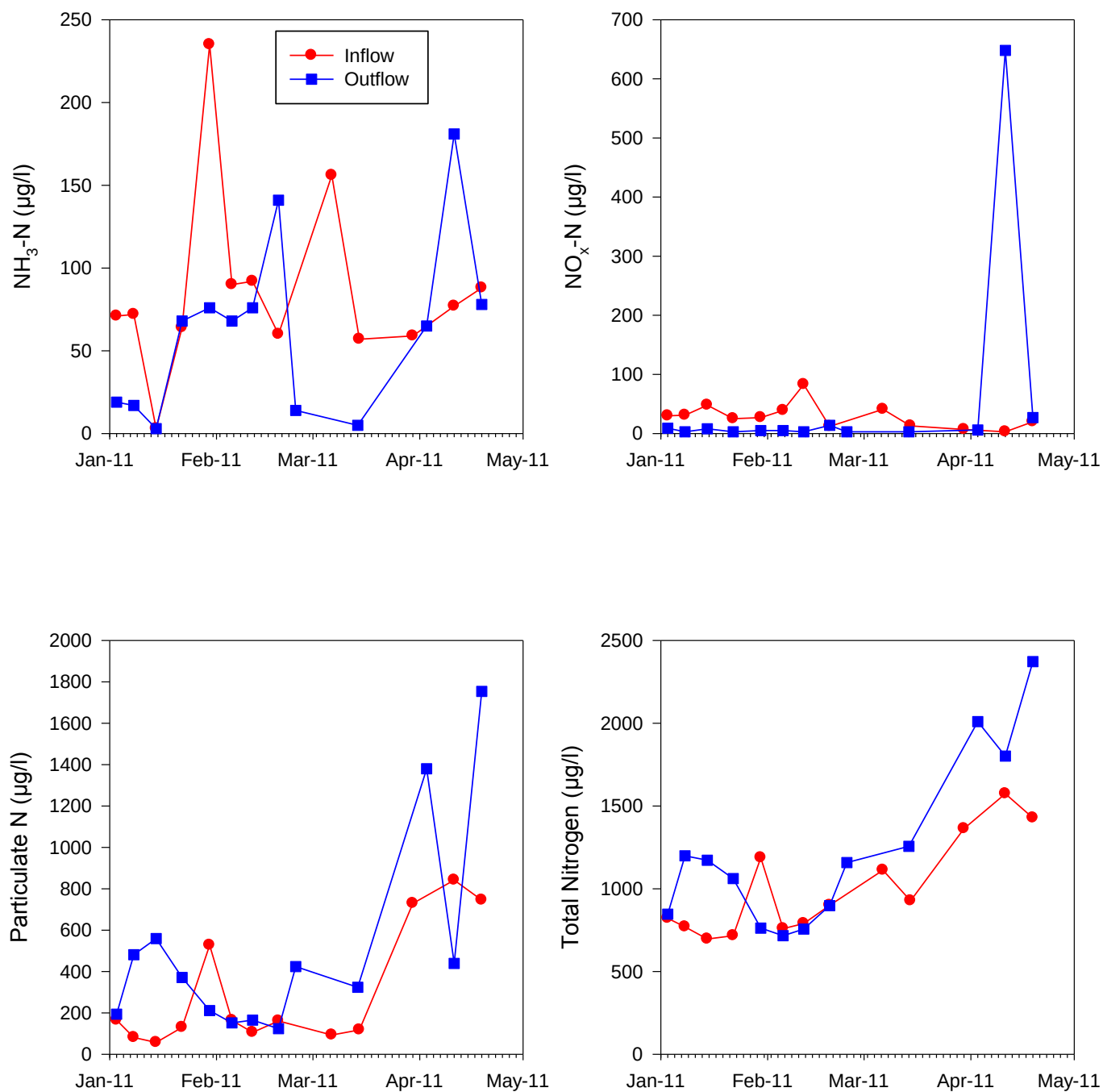


Figure 14. Trends in Inflow and Outflow Concentrations of Nitrogen Species in the PAFB Pond During the Pre-Modification Monitoring Program from January-April 2011.

Trends in inflow and outflow concentrations of phosphorus species in the western pond during the pre-modification monitoring program are illustrated on Figure 15. Inflow concentrations of SRP into the pond were relatively elevated, ranging from approximately 125-275 µg/l. A substantial uptake of SRP occurred within the pond with outflow samples ranging from approximately 1-70 µg/l. Measured concentrations of dissolved organic phosphorus in the inflow and outflow samples ranged from low to moderate in value during the field monitoring program. In general, it appears that inflow concentrations of dissolved organic phosphorus are higher in most samples than observed in the outflow, suggesting a net uptake of organic phosphorus within the pond.

Measured concentrations of particulate phosphorus in the inflow and outflow samples were highly variable, ranging from approximately 5-180 µg/l. Particulate phosphorus concentrations in the outflow samples appear to exceed the inflow concentrations throughout much of the field monitoring program. The additional particulate phosphorus measured at the outflow appears to be related to incorporation of phosphorus into algal biomass within the pond. Overall, a net loss of total phosphorus was observed between the inflow and outflow samples, resulting primarily from the large observed uptake of SRP. Inflow total phosphorus concentrations ranged from approximately 190-380 µg/l, compared with outflow concentrations ranging from approximately 50-200 µg/l.

Trends in inflow and outflow concentrations of turbidity and color in the western pond during the pre-modification monitoring program are illustrated on Figure 16. Measured turbidity values in the inflow and outflow samples ranged from low to moderate in value, with higher turbidity concentrations observed in the outflow samples throughout much of the pre-modification monitoring program, likely related to generation of algae within the pond. Measured color concentrations in the inflow and outflow samples were moderate in value, with lower concentrations of color measured in the outflow samples compared with the inflow.

A comparison of mean inflow and outflow concentrations in the western pond during the pre-modification monitoring program is given on Table 7. The mean inflow and outflow concentrations summarized in this table reflect the log-normal mean values for the collected samples summarized in Appendix D.1 and Appendix D.2. In general, inflow and outflow samples were slightly alkaline in pH and well buffered, with measured conductivity values indicating borderline brackish water conditions within the pond. Net decreases in alkalinity and conductivity were observed between the inflow and outflow, with a slight increase in pH.

Relatively low concentrations of ammonia and NO_x were observed in both the inflow and outflow samples, with a net reduction in concentration for each of these parameters within the pond. The dominant nitrogen species within both the inflow and outflow samples was dissolved organic nitrogen which comprised more than half of the total nitrogen measured. Concentrations of dissolved organic nitrogen remained relatively unchanged during migration through the pond. Particulate nitrogen concentrations increased during migration through the pond, resulting in a net increase in total nitrogen concentrations of approximately 19%.

More than half of the inflow phosphorus concentrations into the pond was comprised of dissolved SRP, with relatively small contributions from dissolved organic phosphorus and particulate phosphorus. Substantial reductions in concentrations of SRP and dissolved organic phosphorus were observed within the pond, with a corresponding increase in particulate phosphorus. Overall, total phosphorus concentrations decreased by approximately 58%.

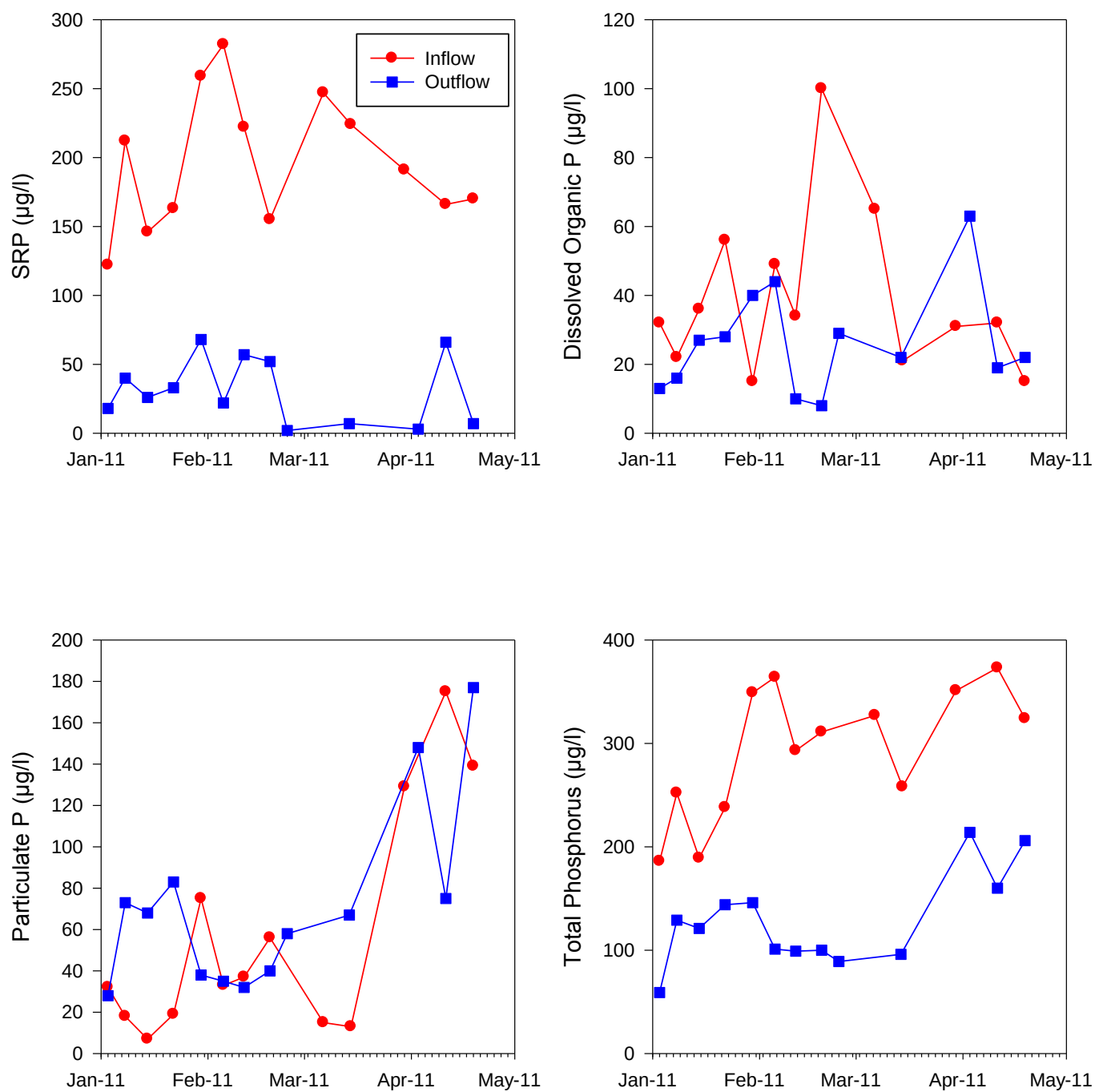


Figure 15. Trends in Inflow and Outflow Concentrations of Phosphorus Species in the PAFB Pond During the Pre-Modification Monitoring Program from January-April 2011.

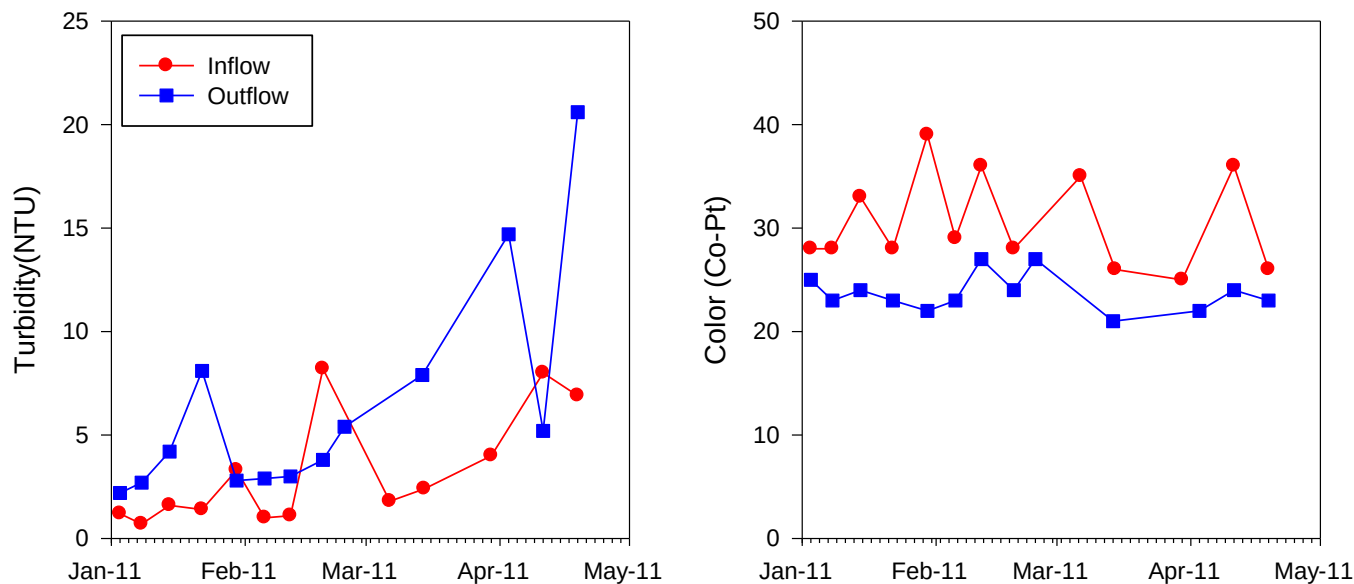


Figure 16. Trends in Inflow and Outflow Concentrations of Turbidity and Color in the PAFB Pond During the Pre-Modification Monitoring Program from January-April 2011.

TABLE 7

**COMPARISON OF MEAN INFLOW AND OUTFLOW
CONCENTRATIONS IN THE PAFB POND DURING THE
PRE-MODIFICATION MONITORING PROGRAM**

PARAMETER	UNITS	MEAN INFLOW CONCENTRATION	MEAN OUTFLOW CONCENTRATION	PERCENT CHANGE (%)
pH	s.u.	7.69	7.88	3
Alkalinity	mg/l	199	161	-19
Conductivity	µmho/cm	1123	1043	-7
NH ₃ -N	µg/l	65	37	-44
NO _x -N	µg/l	22	8	-63
Dissolved Organic N	µg/l	576	596	3
Particulate N	µg/l	198	362	83
Total N	µg/l	966	1145	19
SRP	µg/l	191	19	-90
Dissolved Organic P	µg/l	34	22	-33
Particulate P	µg/l	37	61	64
Total P	µg/l	286	121	-58
Turbidity	NTU	2.3	5.0	117
Color	Pt-Co	30	24	-22
TSS	mg/l	3.1	8.0	155

Substantial increases in turbidity and TSS were observed between the inflow and outflow of the pond, presumably resulting from algal production within the pond. A slight decrease in color was observed between the inflow and outflow.

The comparison of mean inflow and outflow concentrations summarized in Table 7 do not reflect the performance efficiency of the pond, but merely differences between inflow and outflow concentrations. The performance efficiency of the pond will be discussed in a subsequent section which provides an overall mass loading comparison of inputs and losses during the pre-modification program.

5.3.2 Bulk Precipitation

A tabular summary of mean characteristics of bulk precipitation samples collected during the pre-modification monitoring program is given in Table 8. The mean concentrations summarized in this table reflect the log-normal mean values for bulk precipitation summarized in Appendix D.4. In general, bulk precipitation samples were slightly acidic and poorly buffered. Bulk precipitation contained moderate levels of both ammonia and NO_x which were higher in value than concentrations measured in the inflow or outflow for the pond. The dominant nitrogen species in bulk precipitation was ammonia which comprised approximately 25% of the total nitrogen measured. The mean total nitrogen concentration of 360 $\mu\text{g/l}$ appears to be similar to bulk precipitation characteristics measured by ERD in other parts of Central Florida.

Elevated levels of phosphorus species were also measured in bulk precipitation samples, particularly for particulate phosphorus. Measured concentrations of turbidity, color, and TSS in bulk precipitation were relatively low.

5.3.3 Shallow Groundwater Samples

A tabular summary of the mean characteristics of shallow groundwater samples collected during the pre-modification monitoring program is given in Table 9. The values summarized in this table reflect the log-normal mean concentrations for groundwater samples summarized in Appendix D.3. In general, groundwater samples collected adjacent to the pond were approximately neutral in pH and well buffered, with mean alkalinity values ranging from 180-254 mg/l . Measured conductivity values between the four monitoring wells were highly variable and likely reflect impacts from adjacent golf course activities, depending upon the location of the monitoring well.

TABLE 8

**MEAN CHARACTERISTICS OF BULK PRECIPITATION
CONCENTRATIONS IN THE PAFB POND DURING
THE PRE-MODIFICATION MONITORING PROGRAM**

PARAMETER	UNITS	MEAN CONCENTRATION
pH	s.u.	6.11
Alkalinity	mg/l	10.3
Conductivity	µmho/cm	35
NH ₃ -N	µg/l	97
NO _x -N	µg/l	71
Dissolved Organic N	µg/l	76
Particulate N	µg/l	85
Total N	µg/l	360
SRP	µg/l	20
Dissolved Organic P	µg/l	11
Particulate P	µg/l	77
Total P	µg/l	159
Turbidity	NTU	2.8
Color	Pt-Co	24
TSS	mg/l	4.4

TABLE 9

**MEAN CHARACTERISTICS OF SHALLOW GROUNDWATER
SAMPLES COLLECTED IN THE PAFB POND DURING
THE PRE-MODIFICATION MONITORING PROGRAM**

PARAMETER	UNITS	MW-1	MW-2	MW-3	MW-4
pH	s.u.	7.19	7.39	7.32	7.29
Alkalinity	mg/l	254	180	227	248
Conductivity	µmho/cm	2453	1402	1389	593
NH ₃ -N	µg/l	282	131	58	569
NO _x -N	µg/l	4	52	2	3
Dissolved Organic N	µg/l	1432	372	393	1039
Total N	µg/l	1726	891	469	1627
SRP	µg/l	481	360	241	501
Dissolved Organic P	µg/l	30	42	430	37
Total P	µg/l	515	406	712	548
Color	Pt-Co	98	34	347	168

A high degree of variability was also observed in measured concentrations of nitrogen species in each of the four monitoring wells. The most elevated concentrations were observed at monitoring well sites 1 and 4 which are located on the eastern and northern sides of the pond, with substantially lower nitrogen concentrations measured on the southern and western sides of the pond. This difference in concentration was also apparent in color measurements conducted at the four monitoring well sites. In contrast, measured phosphorus concentrations in the four monitoring wells appear to be relatively similar.

5.3.4 Comparison of Inflow, Outflow, and Bulk Precipitation

A graphical summary of historical field and laboratory data was generated in the form of Tukey box plots, also often called "box and whisker plots". The bottom of the box portion of each plot represents the lower quartile, with 25% of the data points falling below this value. The upper line of the box represents the 75% upper quartile, with 25% of the data falling above this value. The horizontal line within the box represents the median value, with 50% of the data falling both above and below this value. The vertical lines, also known as "whiskers", represent the 5 and 95 percentiles for the data sets. Individual values which fall outside of the 5-95 percentile range are indicated as **red dots**.

A statistical comparison of measured concentrations of pH, alkalinity, conductivity, and TSS in inflow, outflow, and bulk precipitation samples collected during the pre-modification monitoring program is given on Figure 17. Measured pH values in the inflow and outflow were relatively similar, with a slightly greater pH measured in outflow samples. Measured pH values in bulk precipitation, however, were substantially lower, typically ranging from about 6-6.5.

Measured alkalinity values were generally higher in the inflow samples, with a relatively low degree of variability. Measured alkalinity values in the outflow were typically lower in value and exhibited a higher degree of variability. Relatively low levels of alkalinity were observed in bulk precipitation.

Measured conductivity in the inflow samples typically ranged from approximately 1100-1200 $\mu\text{mho/cm}$. Slightly lower conductivity values were observed in the outflow which also exhibited a slightly greater degree of variability. Measured conductivity values in bulk precipitation were relatively low.

Measured TSS concentrations in the inflow were generally low in value, ranging from approximately 1-6 mg/l. An increase in TSS appears to occur within the pond, with higher concentrations and a higher degree of variability observed for TSS in the outflow. Measured concentrations of TSS in bulk precipitation appear to be similar to values measured in the outflow samples.

A statistical comparison of measured concentrations of nitrogen species in inflow, outflow, and bulk precipitation samples collected during the pre-modification monitoring program is given on Figure 18. As indicated on Figure 18, inflow and outflow concentrations of ammonia exhibited a relatively low degree of variability, with slightly lower concentrations of ammonia observed at the outflow compared with the inflow. In contrast, a high degree of variability was observed in measured concentrations for bulk precipitation, with a median concentration greater than that observed in the inflow and outflow. Measured concentrations of NO_x were relatively similar in the inflow and outflow during the pre-modification monitoring program, with substantially lower concentrations for bulk precipitation.

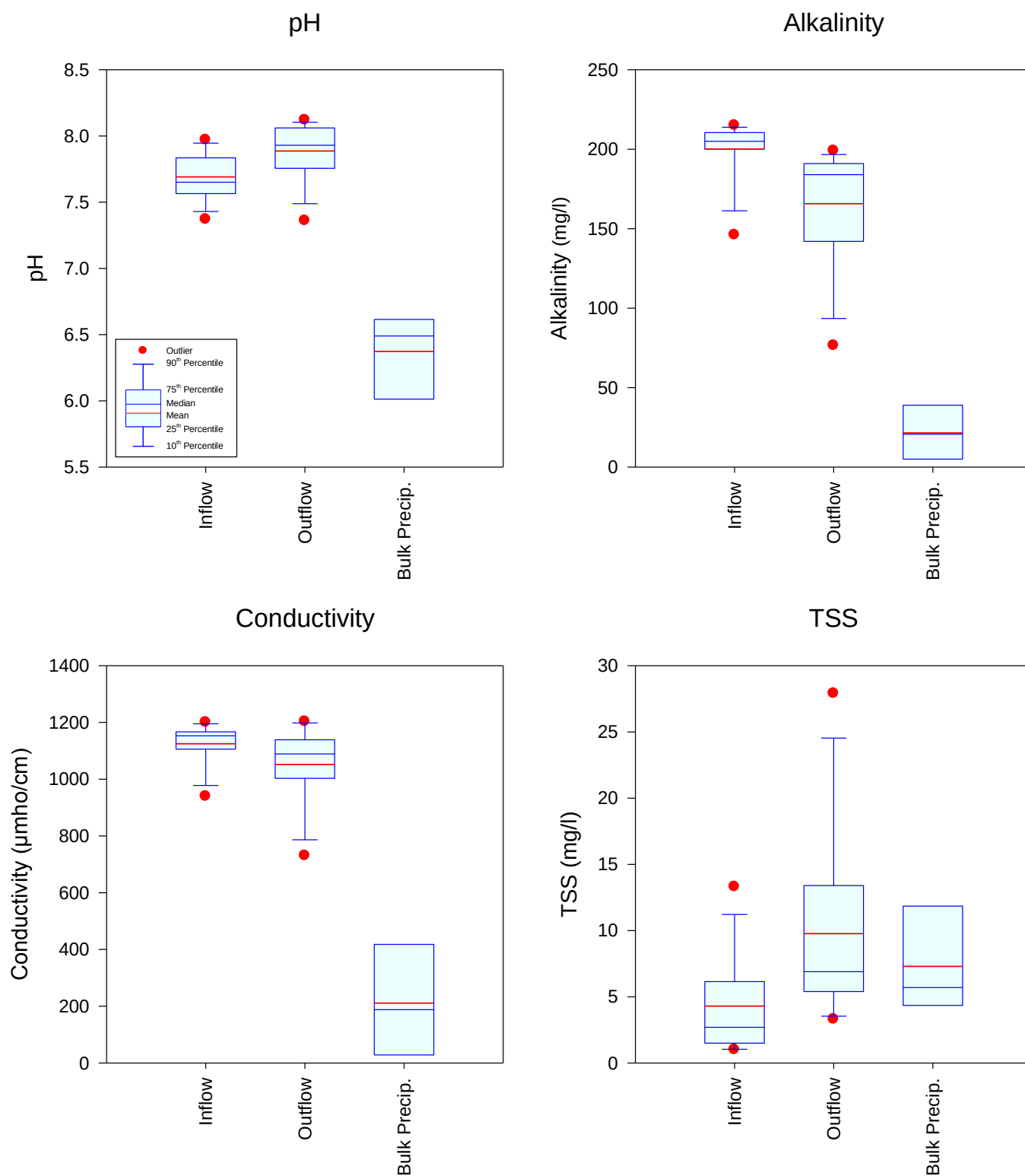


Figure 17. Statistical Comparison of Measured Concentrations of pH, Alkalinity, Conductivity, and TSS in Inflow, Outflow, and Bulk Precipitation Samples During Pre-Modification Monitoring.

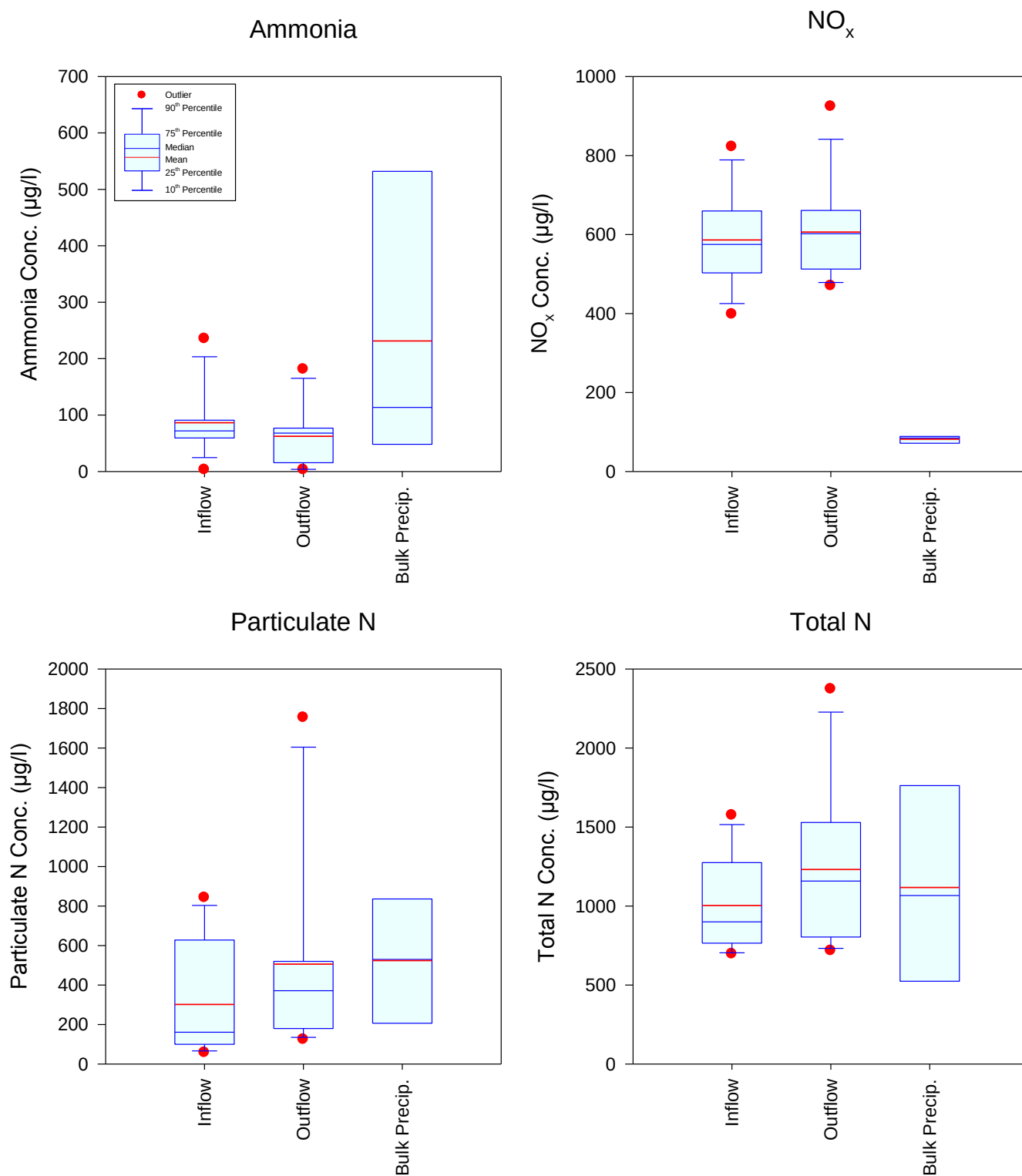


Figure 18. Statistical Comparison of Measured Concentrations of Nitrogen Species in Inflow, Outflow, and Bulk Precipitation Samples During Pre-Modification Monitoring.

Measured concentrations of particulate nitrogen in the inflow ranged from approximately 100-600 µg/l in a majority of the collected samples. Measured particulate nitrogen concentrations in the outflow ranged from approximately 200-500 µg/l in a majority of the collected samples, although the median concentration in the outflow is greater than that in the inflow. Bulk precipitation samples ranged from approximately 200-800 µg/l, with a higher median concentration than in either inflow or outflow samples. Overall, total nitrogen concentrations in the inflow ranged from approximately 750-1250 µg/l in a majority of the collected samples. Outflow samples ranged from approximately 800-1500 µg/l in a majority of the samples and had a higher median concentration than measured in the inflow. A somewhat higher range of values was observed for bulk precipitation, although the median total nitrogen concentration appears to be mid-way between the inflow and outflow values.

A statistical comparison of measured concentrations of phosphorus species in inflow, outflow, and bulk precipitation samples collected during the pre-modification monitoring program is given on Figure 19. Measured SRP concentrations in the outflow appear to be lower in value and have a lower degree of variability than observed in the inflow samples. In contrast, bulk precipitation samples were characterized by a wide degree of variability although the median concentration appears to be relatively low. Measured dissolved organic phosphorus concentrations were generally low in value in both the inflow and outflow, with a trend of slightly lower concentrations observed in the inflow. Median concentrations for the outflow in bulk precipitation appear to be relatively similar.

Measured particulate phosphorus concentrations in the inflow ranged from approximately 15-100 µg/l in a majority of the collected inflow samples. The outflow samples were characterized by a more narrow range of values, although the median concentration appears to be greater. Particulate phosphorus concentrations in bulk precipitation were substantially greater than observed in either the inflow or outflow samples. Overall, a reduction in total phosphorus appears to occur within the pond, with lower concentrations in the outflow than observed in the inflow. Total phosphorus concentrations in bulk precipitation were highly variable, with a median concentration between the inflow and outflow concentrations.

A statistical comparison of measured concentrations of turbidity and color in the inflow, outflow, and bulk precipitation samples during the pre-modification monitoring program is given in Figure 20. A slight increase in turbidity appears to occur within the pond, with higher measured concentrations in the inflow compared with the outflow. Turbidity in bulk precipitation samples is relatively similar to inflow and outflow values.

A slight reduction in color concentrations appears to occur within the pond, with lower concentrations and a lower degree of variability in color measured at the outflow compared with the inflow. Color concentrations in bulk precipitation were highly variable, although the median concentration appears to be slightly lower than measured in the inflow and outflow samples.

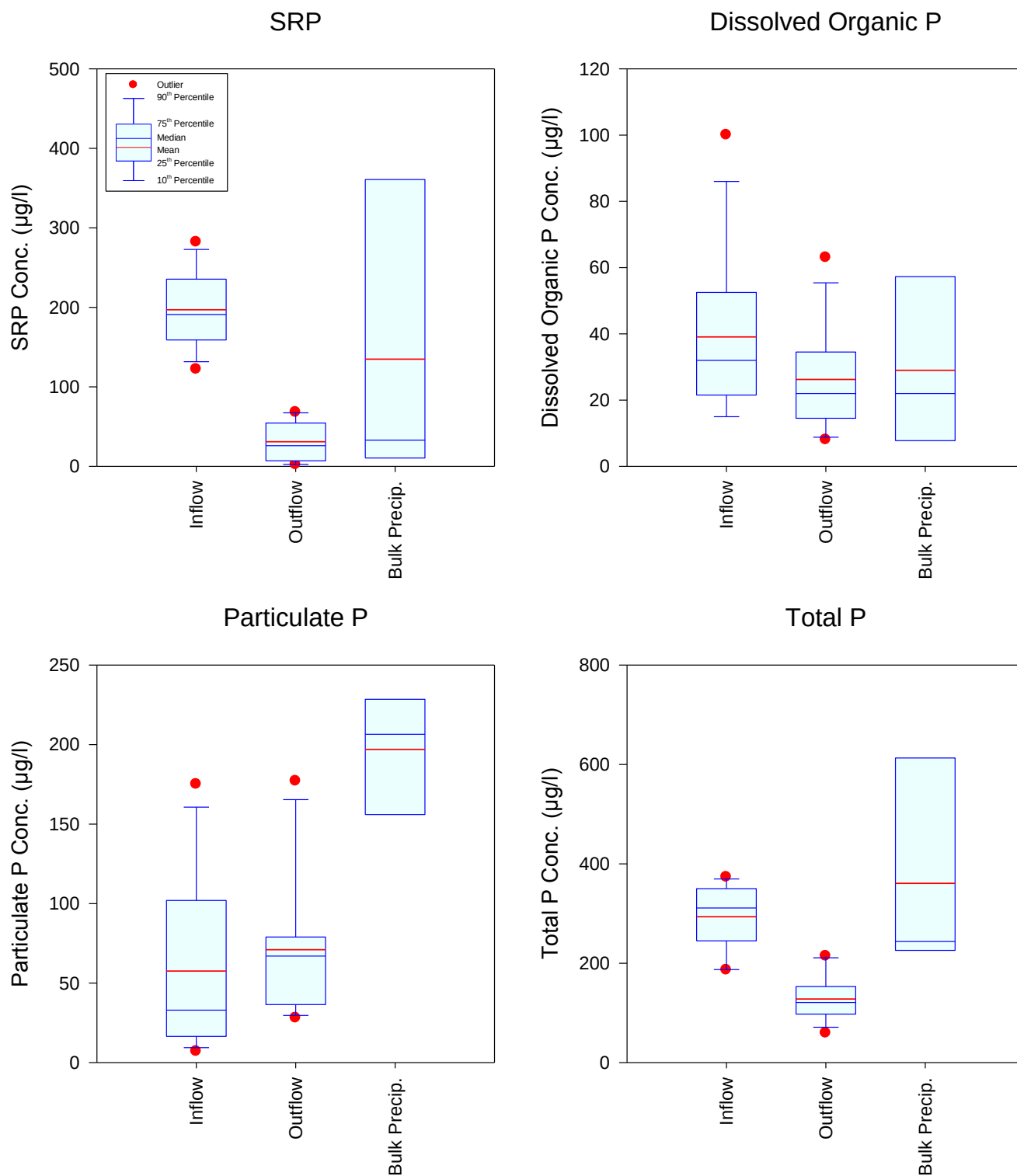


Figure 19. Statistical Comparison of Measured Concentrations of Phosphorus Species in Inflow, Outflow, and Bulk Precipitation Samples During Pre-Modification Monitoring.

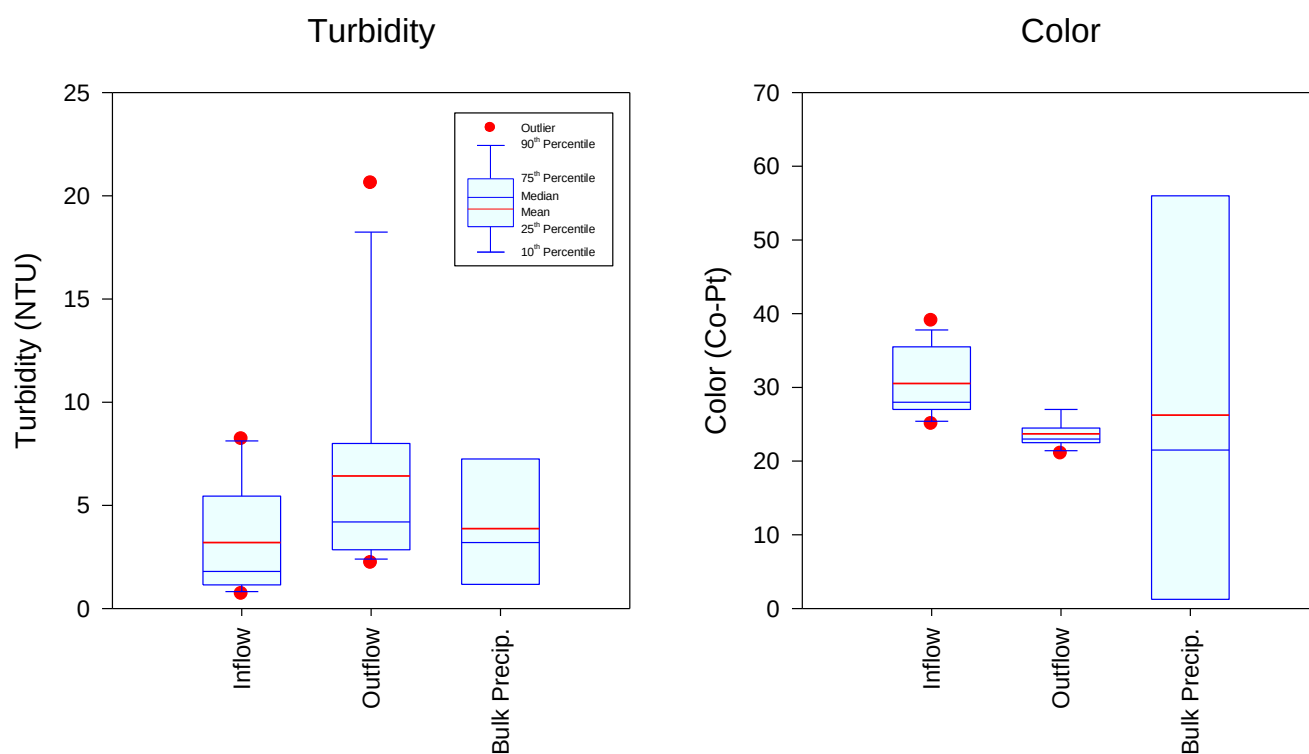


Figure 20. Statistical Comparison of Measured Concentrations of Turbidity and Color in Inflow, Outflow, and Bulk Precipitation Samples During Pre-Modification Monitoring.

5.3.5 Chlorophyll-a

A graphical summary of trends in chlorophyll-a concentrations in the PAFB pond during the pre-modification monitoring program is given on Figure 21. Chlorophyll-a concentrations within the pond ranged from approximately 10-15 mg/m³ or less during the first three months of the pre-modification monitoring program. A sharp increase in chlorophyll-a concentrations occurred during April 2011, with measured concentrations reaching a peak of 277 mg/m³. Overall, the geometric mean chlorophyll-a concentration during the pre-modification monitoring program was approximately 23.9 mg/m³. A summary of measured chlorophyll-a concentrations during the pre-modification monitoring period is given in Table 10.

TABLE 10

SUMMARY OF MEASURED CHLOROPHYLL-A CONCENTRATIONS DURING THE PRE-MODIFICATION MONITORING PROGRAM

PARAMETER	UNITS	VALUE
Minimum Value	mg/m ³	4.0
Maximum Value	mg/m ³	277
Geometric Mean Value	mg/m ³	23.9

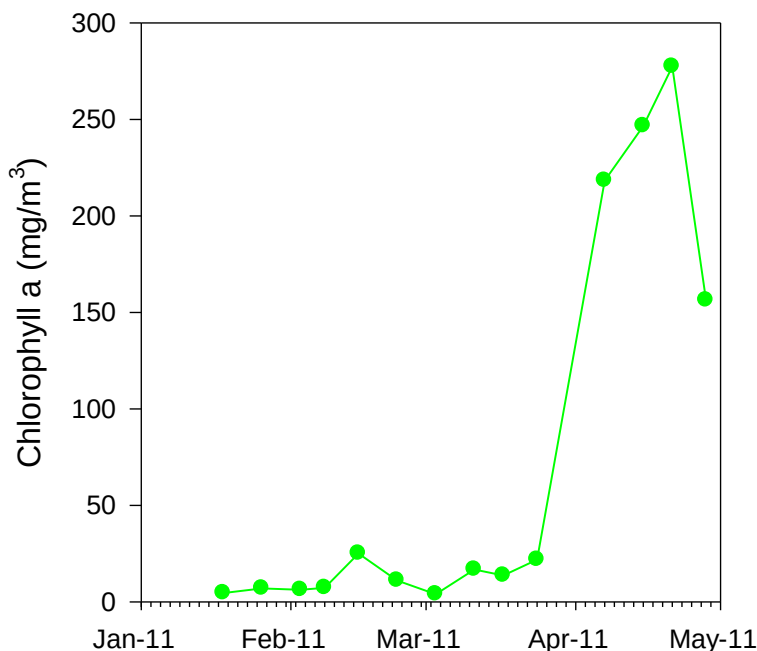


Figure 21. Trends in Chlorophyll-a Concentrations in the PAFB Pond During the Pre-Modification Monitoring Program.

5.4 Nutrient Budgets

Estimates of mass inputs and losses to the pond during the four-month pre-modification monitoring program were conducted for the evaluated species of nitrogen and phosphorus, as well as TSS. Mass inputs into the pond from inflow and direct rainfall were calculated by multiplying the mean monthly hydrologic inputs for these sources (summarized in Table 5) times the mean monthly concentration for each evaluated parameter in the inflow and bulk precipitation samples. Mean monthly characteristics were calculated for the inflow samples (summarized in Appendix D.1) and the bulk precipitation samples (summarized in Appendix D.4). Samples which had collection periods that overlapped two different monthly periods were assigned to the monthly period which reflected the largest portion of the monitoring interval. Monthly mass loadings were calculated for the inflow and bulk precipitation inputs and summed to reflect total mass loadings over the pre-modification monitoring period. A similar process was used to calculate mass loadings through the pond outfall. Mean monthly concentrations were calculated for discharges from the pond which were multiplied by the mean monthly hydrologic discharges (summarized in Table 5). Mass loadings were calculated on a monthly basis and summed to reflect total mass discharge from the pond during the four-month pre-modification monitoring period. Mass losses as a result of infiltration into groundwater were obtained by multiplying the monthly hydrologic groundwater losses (summarized in Table 5) times the mean monthly outflow concentrations. This analyses assumes that discharges into groundwater are similar to the characteristics of pond discharge samples measured at the outflow. A summary of calculated monthly concentrations, mass inputs, and mass losses for the PAFB pond under pre- and post-modification conditions is given in Appendix E.

A summary of mass inputs, losses, and removal efficiencies for the western pond during the pre-modification monitoring program is given on Table 11. Overall, the pond removed approximately 25% of the mass inputs of ammonia and 19% of the mass inputs of NO_x. However, a mass export of approximately 1% was observed for dissolved organic nitrogen and 55% for particulate nitrogen, presumably due to inorganic nitrogen incorporated into algal biomass which discharged through the outfall structure. This export of particulate nitrogen resulted in a net export of approximately 28% for total nitrogen during the pre-modification monitoring program.

TABLE 11
SUMMARY OF MASS INPUTS, LOSSES, AND
REMOVAL EFFICIENCIES FOR THE PAFB POND DURING
THE PRE-MODIFICATION MONITORING PROGRAM

PARAMETER	INPUTS (kg)			LOSSES (kg)			REMOVAL EFFICIENCY (%)
	Inflow	Bulk Precipitation	Total	Outflow	Groundwater	Total	
NH ₃ -N	0.83	0.04	0.86	0.52	0.12	0.64	25
NO _x -N	0.23	0.03	0.27	0.18	0.04	0.22	19
Diss. Org. N	6.26	0.03	6.29	5.01	1.32	6.34	-1
Part. N	3.92	0.03	3.95	4.99	1.12	6.11	-55
Total N	11.5	0.14	11.6	12.0	2.86	14.8	-28
SRP	1.86	0.01	1.87	0.28	0.07	0.35	81
Diss. Org. P	0.25	0.01	0.26	0.13	0.04	0.17	33
Part. P	0.70	0.04	0.74	0.78	0.18	0.96	-30
Total P	3.06	0.06	3.12	1.32	0.31	1.63	48
TSS	40.7	1.7	42.4	87.7	20.6	108	-155

The western pond exhibited excellent removal efficiency for SRP, with a 81% reduction in loadings, with dissolved organic phosphorus loadings into the pond reduced by approximately 33%. However, a mass export of particulate phosphorus of approximately 30% was observed, presumably due to incorporation of inorganic phosphorus into an algal biomass which discharged through the outfall structure. Overall, the pond removed approximately 48% of the total phosphorus loadings.

The western pond exhibited a net export of TSS of approximately 155%. This export of TSS is presumably related to the observed mass exports for particulate nitrogen and particulate phosphorus resulting from incorporation of inorganic nitrogen and inorganic phosphorus into algal biomass.

The mass removal efficiencies summarized on Table 10 for the pre-modification period are compared with the pond removal efficiencies measured during the post-modification monitoring program to evaluate potential enhancement in pond performance efficiencies resulting from implementation of the Beemat floating wetland system.

6. Installation and Monitoring of the Floating Beemat Island

This section provides a discussion of installation, monitoring, and removal of the floating Beemat islands in the PAFB pond. A discussion of each of these activities is given in the following sections.

6.1 Installation

Installation of the floating Beemat island was conducted on May 1, 2011 following completion of the pre-modification monitoring program from January-April 2011. Installation of the Beemat floating wetland islands, also referred as Managed Aquatic Plant Systems (MAPS) was conducted by Beemats, LLC. of New Smyrna Beach under the direction of Steve Beeman.

Photographs of construction activities of the floating Beemat islands are given on Figure 22. The plant material was delivered to the site in an open trailer along with the foam rubber floating mats. The mats were delivered with pre-drilled 3-inch diameter holes used to secure the plastic pots containing the plants. Smaller plants were inserted around the perimeter of the floating island, with progressively larger species planted towards middle portions of the island. Two separate floating islands were deployed with a total area of approximately 1000 ft². The plants were inserted with a density of approximately 2.5 plants/ft², resulting in a total of 2500 plants.

A summary of plant species planted in the initial Beemat island is given in Table 12. The initial planting included 1000 redbow bentgrass, 750 soft rush, and 250 each of yellow canna, pickerelweed, and arrowhead. Photographs of each of the aquatic plant species are given on Figure 23 to illustrate the approximate size of the plants at the time of initial planting. Each of the plants had root systems that extended well outside the plastic pots used to contain the base of the plant.

Photographs of the actual installation of the floating Beemat islands within the pond are given in Figure 24. After each of the two floating islands was filled with the appropriate number of plants, the islands were towed into the open water portion of the pond using a small boat. The islands were then secured to the shoreline using cables to maintain the mats in the desired positions. A photograph of the completed installation is given on Figure 23d which shows the two completed Beemat floating islands, each of which had an area of approximately 500 ft², for a total of 1000 ft² overall.

Within weeks of installation of the floating islands, a variety of bird species and waterfowl began to forage on the floating islands for food. The birds began to remove the pots inserted into the floating mat to feed upon the numerous organisms which live on the extensive root structure for each of the plants. By mid-July 2011, many of the smaller plant species had been uprooted from the floating island and were no longer in contact with the water. A number of other plant species had also been damaged by birds through either uprooting or direct consumption of the plant material. Near the end of July 2011, Beemat replaced approximately 200 yellow canna and 600 redbow bentgrass that had been damaged by birds, many of which were under stress as a result of bird damage. In addition, Beemat also replaced another 700-800 plants that had been pulled out of the mats but were still green and potentially viable.



a. Plants delivered to site in open trailer



b. Plants inserted into floating mat



c. Mats attached together to create desired size



d. Completed Beemat system

Figure 22. Construction of the Floating Beemat Islands.

TABLE 12

**SUMMARY OF PLANT SPECIES PLANTED IN
THE INITIAL BEEMAT ISLANDS DURING MAY 2011**

PLANT NAME	COMMON NAME	NUMBER PLANTED
<i>Agrostis alba</i>	Redtop bentgrass	1000
<i>Juncus effusus</i>	Soft rush	750
<i>Canna flaccida</i>	Yellow canna	250
<i>Pontederia cordata</i>	Pickerelweed	250
<i>Sagittaria lancifolia</i>	Arrowhead	250



a. Redtop bentgrass



b. Soft rush



c. Yellow canna



d. Pickerelweed



e. Arrowhead

Figure 23.

Examples of Aquatic Plants
Installed in the Floating
Beemat Islands.



a. Completed Beemat islands



b. Islands towed into place in pond



c. Mats attached to shoreline using rope



d. Completed installation

Figure 24. Installation of the Floating Beemat Islands in the Pond.

Photographs of waterfowl damage and the protective netting are given on Figure 25. Examples of plants uprooted from the floating mats are evident on Figure 25a. Photographs of the protective netting placed over the floating islands are given on Figures 25b and 25c. The netting was supported by PVC posts placed in central portions of the island. A photograph of the protective netting near the end of the project is given on Figure 25d. By the end of the project, much of the netting had collapsed into the vegetation; however, by this time, the vegetation was too large to be uprooted by waterfowl.



a. Pots uprooted by birds to eat organisms on roots



b. Plants replaced and netting placed over plants to discourage birds



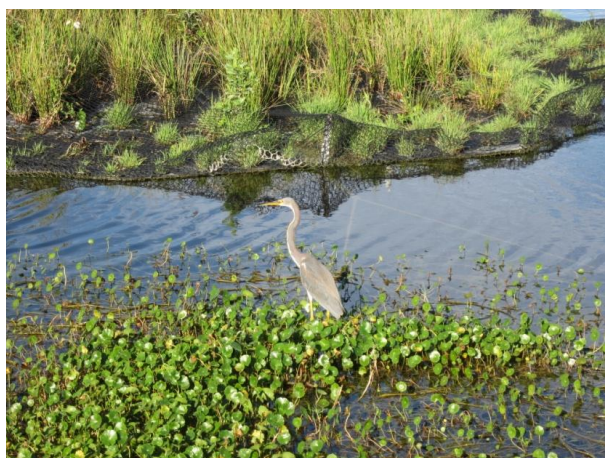
c. Photo of netting as installed



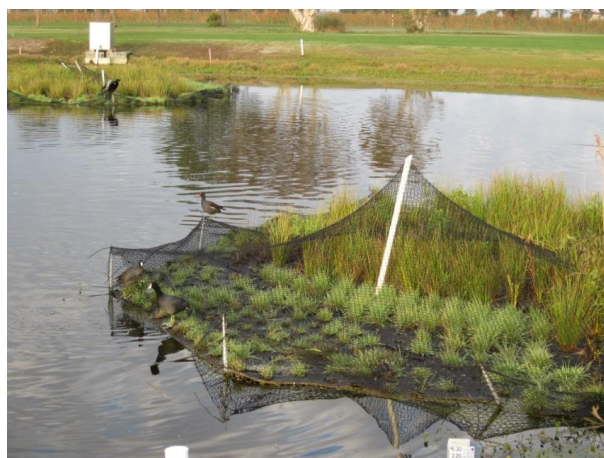
d. Netting collapsed near end of project.

Figure 25. Examples of Waterfowl Damage and Protective Netting.

During the post-modification monitoring period, the Beemat islands attracted a variety of birds which foraged around and on the floating islands. Even with the protective netting in place, birds would roost around the perimeter of the floating islands throughout much of the day. Examples of whitish bird waste can be seen on Figure 26a around the edge of the protective netting. The wide variety of waterfowl which roosted on the floating islands created an additional input of nutrients and suspended solids into the pond which is in excess of the monitored loadings into the pond from stormwater runoff and bulk precipitation. The variety of waterfowl around the Beemat island also attracted predators (Figure 26c) which used some of the smaller waterfowl as food sources (Figure 26d).



a. Beemat islands attracted a variety of birds



b. Birds roosting on Beemat islands



c. Birds attracted predators



d. Some birds became food sources for predators

Figure 26. Birds and Waterfowl Attracted to the Site.

At the completion of the 12-month post-modification monitoring program, the floating Beemat islands were removed during early-May 2012. Photographs of a Beemat island at the end of Year 1 is given in Figures 27a and 27b. The grasses around the perimeter of the island had become quite dense, although vegetation in central portions of the island was less dense, and some of it appeared to be stressed. The islands were also showing initial signs of colonization by primrose willow in central portions of the islands. The floating islands were pulled to the shoreline area, and the protective netting was removed. The islands were disassembled and the plants were removed from the islands for final weighing. The plants were removed from the island by Beemat, LLC and weighed on a truck scale. The final wet plant weight was approximately 1160 lbs for the 1000 ft² of Beemats.



a. Beemat island at end of 1 year



b. Colonization by primrose willow



c. Netting removed and islands disassembled



d. Plants removed from islands for weighing

Figure 27. Removal of the Floating Beemat Systems at the Completion of the Monitoring Program.

6.2 Analysis of Plant Material

Analysis of the plant material was conducted by ERD on a periodic basis during the post-modification field monitoring program to monitor changes in plant density and nutrient uptake. Monitoring of plant material was conducted on six separate occasions for analysis of physical and chemical characteristics. Due to the small size of the initial plants, five plants of each species were removed for initial analyses. After the initial event, two representative plants from each species were removed from the islands during each plant monitoring event and returned to the ERD Laboratory for evaluation. Upon reaching the laboratory, each of the collected plants was dissected into root material and leaf material. The wet weight of root and leaf material was measured separately for each sample plant. Analysis of moisture content was then conducted on the root and leaf material to determine the dry weight of the plant matter. The dry plant matter was then digested and analyzed for total nitrogen and total phosphorus so that uptake of nutrients by the plants could be quantified over time.

6.2.1 Changes in Plant Biomass

A summary of physical characteristics of the Beemat plants during the post-modification period from May 2011-April 2012 is given on Table 13. Information is provided for the mean plant wet weight, with separate measurements provided for leaves and root material, for each species during each of the six plant monitoring events. Information is also provided on moisture content and mean plant mass on a dry weight basis for each species. In general, wet plant mass and dry plant mass increased consistently for each plant species during the 12-month post-modification monitoring program, with the exception of substantial decreases in the mass of yellow canna during the February 2012 monitoring event. Measured moisture contents for the leaf and root portions of the plants remained relatively constant during the monitoring program, with slightly more elevated moisture contents associated with roots compared with leaves during a majority of the monitoring events.

A graphical comparison of changes in mean plant biomass on a wet weight basis during the post-modification period is given on Figure 28. Wet plant mass for yellow canna remained relatively consistent from May-September 2011, with a slight increase in biomass measured during November 2011, followed by a decrease in biomass during February 2012. However, a substantial rebound in plant biomass occurred by the end of the monitoring program in April 2012. Overall, wet plant biomass increased approximately four-fold for yellow canna between the beginning and end of the monitoring program. Mean plant wet biomass for soft rush increased steadily during the monitoring program, reaching a peak in biomass at the conclusion of the post-modification monitoring. Biomass for soft rush increased approximately 15-fold during the 12-month monitoring program.

Mean plant wet biomass for duck potato increased steadily from May-September 2011 before decreasing slightly during November 2011 and February 2012, particularly for leaf material. However, by the end of the monitoring program, leaf material had increased approximately four-fold, with a two-fold increase in root material compared with initial biomass. Mean plant biomass for pickerelweed increased relatively slowly during the initial 4-5 months of the monitoring program. However, beginning in November 2011, pickerelweed biomass began to increase steadily with final biomass measurements approximately 10 times greater than the initial biomass estimate. A similar pattern was observed for redtop bentgrass which increased relatively slowly during the initial 5-6 months of the field monitoring program. However, substantial increases (particularly for root matter) occurred during February and April 2012, with final biomass values approximately 20 times greater than the initial biomass estimates.

TABLE 13

**SUMMARY OF PHYSICAL CHARACTERISTICS OF
THE BEEMAT PLANTS DURING THE POST- MODIFICATION
PERIOD FROM MAY 2011 - APRIL 2012**

COMMON NAME	SPECIES	DATE	MEAN PLANT WET WEIGHT (g/plant)			MOISTURE CONTENT (%)		MEAN PLANT DRY WEIGHT (g/plant)		
			Leaves	Roots	Total	Leaves	Roots	Leaves	Root	Total
Yellow Canna	Canna flaccida	5/3/11	12.5	18.5	31.0	77.4	80.6	2.82	3.58	6.40
		8/2/11	15.1	8.7	23.8	83.5	81.3	2.49	1.63	4.12
		9/30/11	17.2	10.6	27.8	78.4	82.1	3.73	1.91	5.63
		11/8/11	23.7	23.2	46.9	82.3	80.2	4.21	4.60	8.81
		2/7/12	4.3	7.7	12.0	80.5	79.4	0.84	1.58	2.42
		4/30/12	54.7	63.8	118.5	81.4	81.1	10.20	12.06	22.26
Soft Rush	Juncus effusus	5/3/11	11.7	8.6	20.3	72.4	79.3	3.23	1.78	5.01
		8/2/11	19.9	24.0	43.9	77.6	83.1	4.45	4.06	8.51
		9/30/11	19.8	32.6	52.4	75.7	80.3	4.81	6.44	11.25
		11/8/11	53.6	61.1	114.7	77.0	78.4	12.36	13.17	25.53
		2/7/12	147.7	145.9	293.7	76.1	81.3	35.27	27.33	62.60
		4/30/12	216.9	166.8	383.6	74.5	80.2	55.33	32.99	88.32
Duck Potato	Sagittaria lancifolia	5/3/11	11.1	32.3	43.4	81.6	82.2	2.05	5.73	7.78
		8/2/11	16.2	47.9	64.1	82.1	84.1	2.90	7.62	10.52
		9/30/11	33.2	76.4	109.6	80.1	83.6	6.60	12.52	19.12
		11/8/11	59.0	25.9	84.8	82.4	84.9	10.39	3.91	14.30
		2/7/12	60.6	37.3	98.0	82.7	85.4	10.51	5.46	15.97
		4/30/12	59.4	66.4	125.8	81.9	84.4	10.76	10.36	21.12
Pickerelweed	Pontederia cordata	5/3/11	12.1	13.5	25.6	74.9	80.0	3.03	2.68	5.71
		8/2/11	17.5	16.4	33.9	80.6	82.2	3.47	2.84	6.31
		9/30/11	18.5	21.6	40.1	77.0	81.2	4.27	4.17	8.44
		11/8/11	38.7	42.2	80.8	79.6	79.3	8.28	8.89	17.17
		2/7/12	76.0	76.8	152.8	78.3	80.4	18.05	14.46	32.51
		4/30/12	135.8	115.3	251.1	77.9	80.7	32.77	22.52	55.29
Redtop Bentgrass	Agrostis alba	5/3/11	5.1	13.5	18.6	82.4	78.6	0.89	2.89	3.78
		8/2/11	16.3	26.4	42.7	82.5	85.8	2.85	3.75	6.60
		9/30/11	25.1	32.1	57.2	82.0	83.3	4.53	5.37	9.90
		11/8/11	30.0	24.7	54.7	82.2	82.4	5.32	4.35	9.68
		2/7/12	65.4	98.5	163.8	81.9	80.7	11.84	18.97	30.81
		4/30/12	167.0	233.1	400.1	82.5	82.2	29.30	41.53	70.82

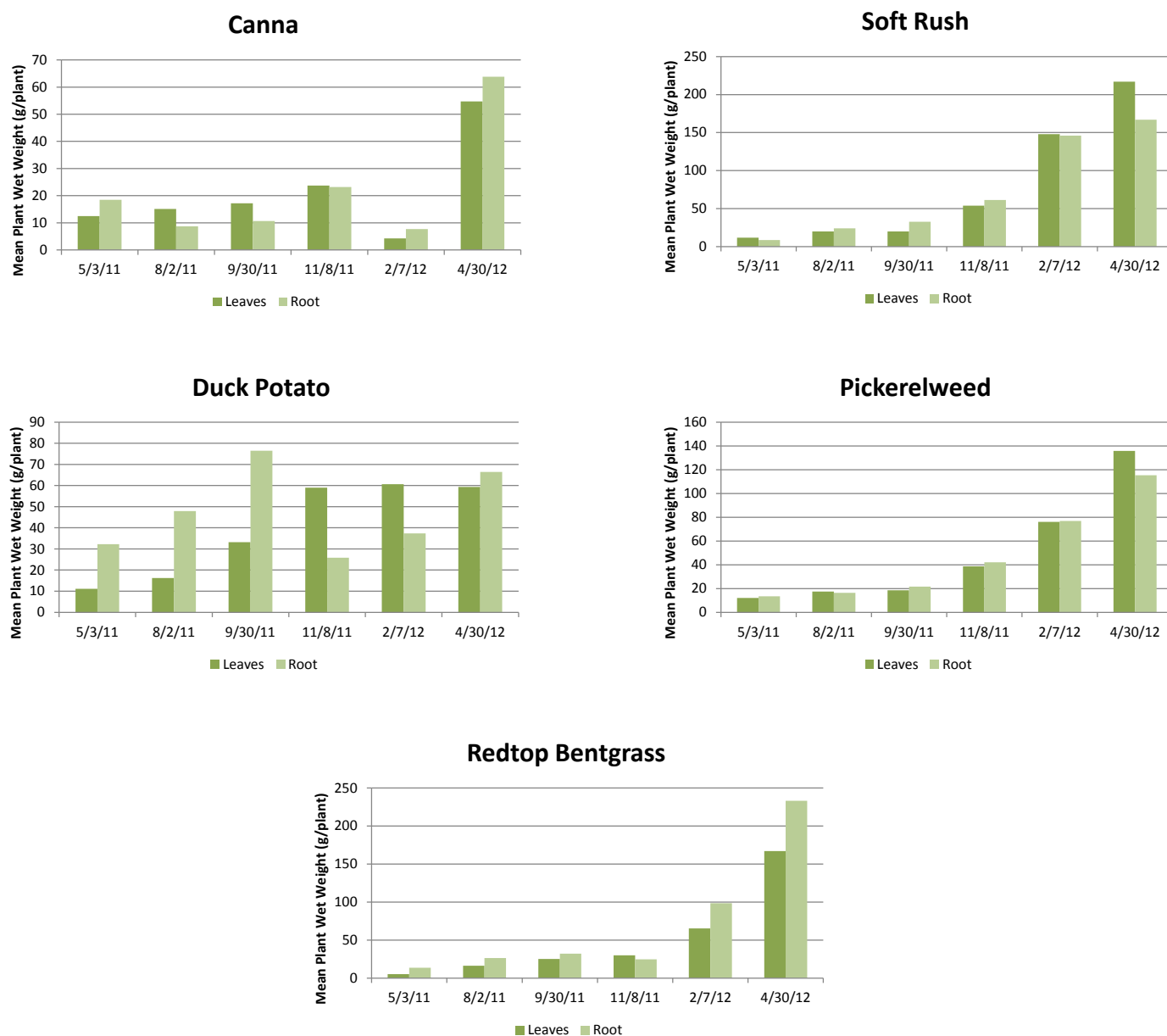


Figure 28. Changes in Mean Plant Biomass (wet weight basis) Over Time During the Post-Modification Period.

A graphical summary of changes in mean plant dry weight biomass over time during the post-modification program is given on Figure 29. In general, the patterns illustrated on Figure 29 are similar to the patterns previously observed on Figure 28 for wet biomass rates. The values illustrated on Figure 29 are used to estimate nutrient uptake by the plants since nutrient concentrations were measured on dry plant material.

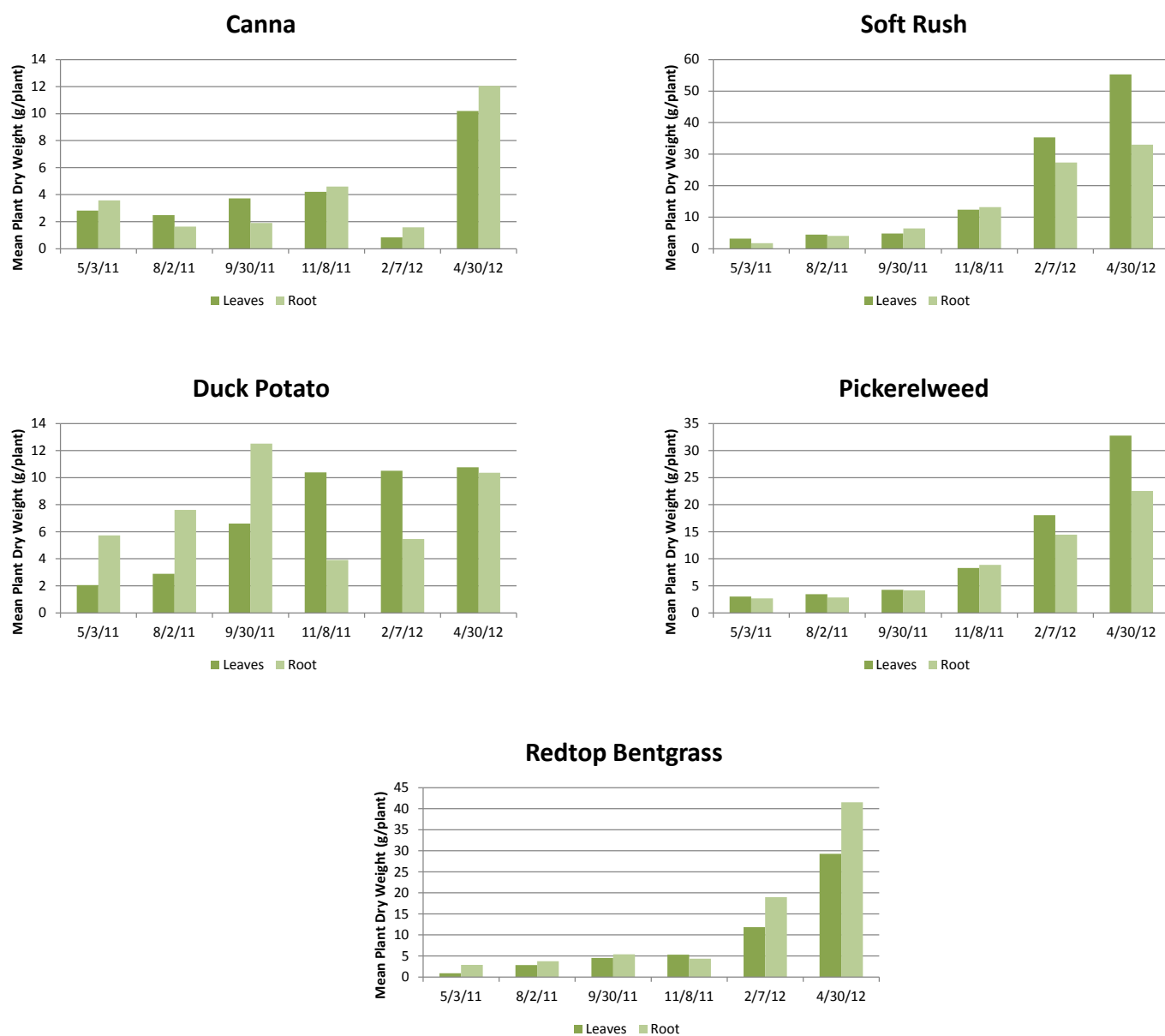


Figure 29. Changes in Mean Plant Biomass (dry weight basis) Over Time During the Post-Modification Period.

6.2.2 Nutrient Uptake

An estimate of the theoretical wet plant biomass at the completion of the post-modification monitoring program was conducted by multiplying the final mean plant wet weight values for each of the five species (summarized on Figure 28) times the number of individual plants for each species on the floating island. For this analysis, the mean wet weight for leaves and roots were combined together to estimate the total weight for each individual plant. This analysis resulted in a final total plant biomass of approximately 820 kg or 1808 lbs. This value is well in excess of the 1160 lbs of wet plant material which was removed by Beemat, Inc. from the floating island at the end of the post-modification monitoring program. An explanation for this rather large difference between the estimated and actual measured weight may be found in the photographs provided on Figure 27. As seen in Figures 27b, 27c, and 27d, the redtop bentgrass appeared to do extremely well, with the vast majority of the initially planted species still present and in apparent good health. However, central portions of the floating island which contained the larger species (such as canna, duck potato, soft rush, and pickerelweed) appear to be substantially less dense, and it appears that many of the initial plantings may have died or are no longer viable. Unfortunately, specific numbers of individual plants removed from the floating island at the end of the post-modification program were not available.

A number of iterations were conducted which included gradually reducing the number of remaining viable plants for canna, soft rush, duck potato, and pickerelweed in an attempt to match the measured final wet plant weight of 1160 lbs. Since the redtop bentgrass appeared to be quite viable at the end of the post-modification monitoring program, no changes were made to the estimated number of plants of that species. After a number of iterations, the calculated final plant biomass matched the actual measured plant biomass if the number of individual plants of canna, soft rush, duck potato, and pickerelweed were gradually decreased over the monitoring program to a final value equivalent to one-third of the original number of plants placed on the floating island. The reduction in plant numbers were pro-rated for each of the monitoring events based upon the number of days since the initial start of the monitoring program. This analysis resulted in a final estimate of 82 individual plants for canna, 250 soft rush, 82 duck potato, 82 pickerelweed, and 1000 redtop bentgrass which produced an estimated final biomass weight of 1183 lbs which corresponds closely to the actual measured plant weight of 1160 lbs. Therefore, all resulting analyses are conducted assuming this gradual decrease in the number of individual plants for the larger species.

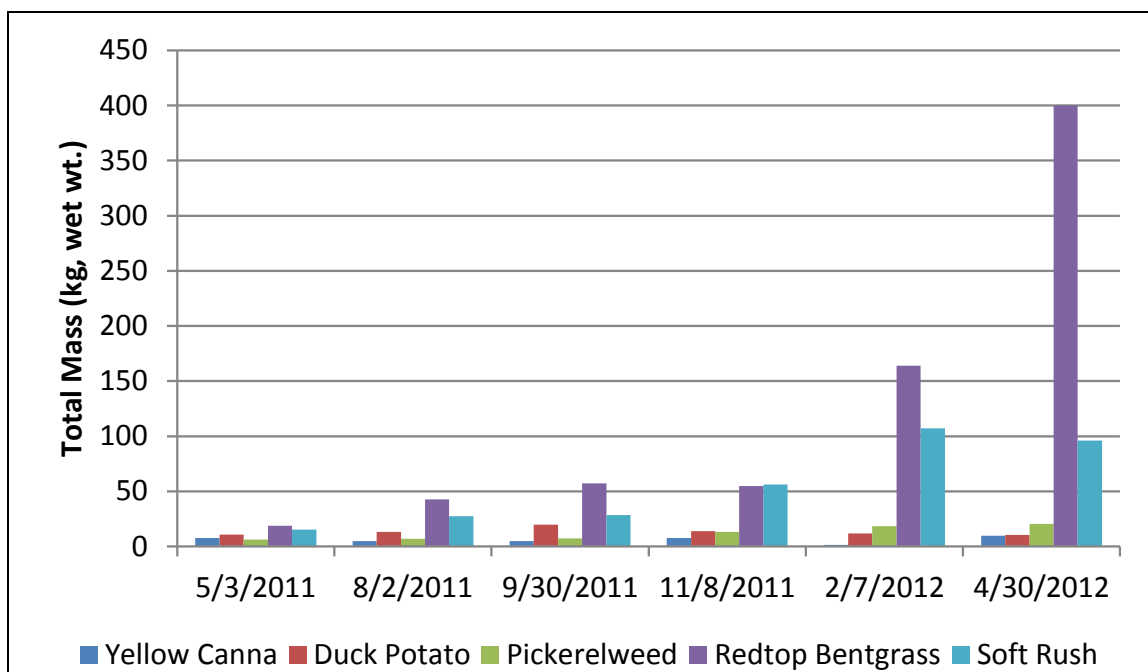
A tabular summary of assumed changes in wet and dry plant biomass during the post-modification monitoring period is given on Table 14. Information is provided for each of the five plant species and each of the six individual monitoring dates conducted for each species. The assumed number of plants present for each species is also provided based upon the analysis discussed previously. Estimates of total wet and dry plant biomass are also included for each species and each monitoring date.

A graphical comparison of total wet and dry plant biomass material by species is given on Figure 30. The largest increases in wet plant mass occurred as a result of redtop bentgrass and soft rush which reflect the dominant plant mass present throughout the entire monitoring program. Plant mass contributed by the remaining species appears to be relatively minimal in comparison. A similar pattern is apparent for dry plant mass which is illustrated on Figure 29b. The mass of redtop bentgrass and soft rush appears to dominate the plant community, particularly at the end of the monitoring program where these two species reflect a majority of plant mass which was generated.

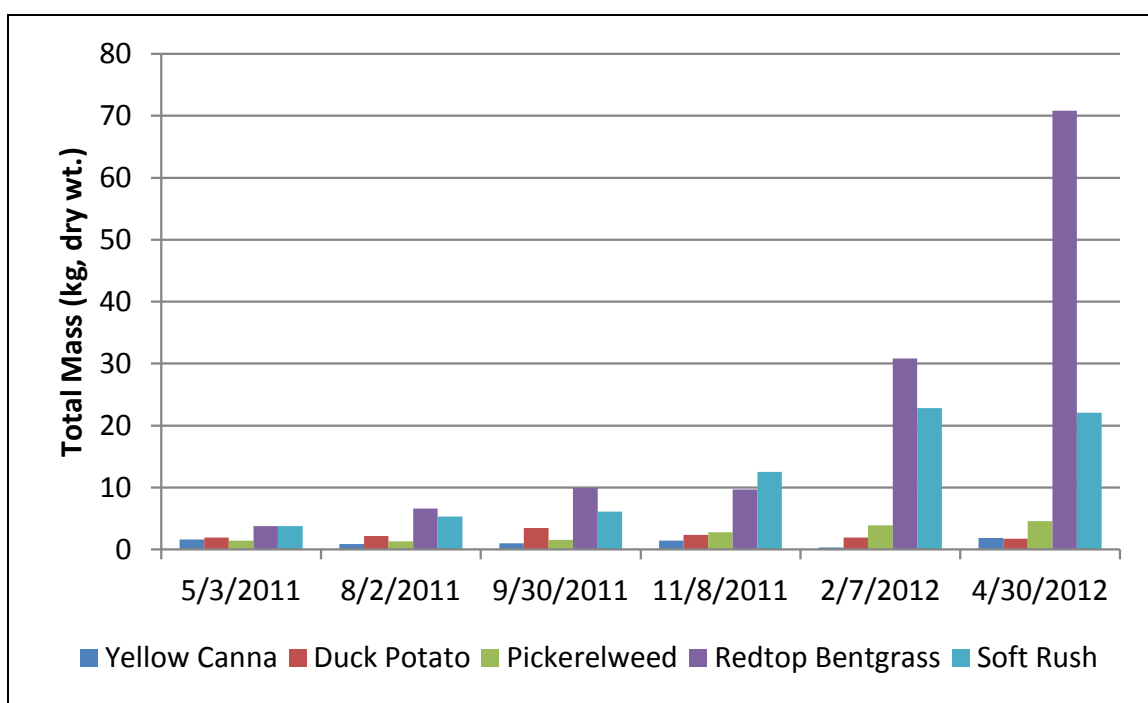
TABLE 14

**ASSUMED CHANGES IN WET AND DRY PLANT BIOMASS
DURING THE POST-MODIFICATION MONITORING PERIOD**

COMMON NAME	SPECIES	DATE	NUMBER OF PLANTS	TOTAL MASS (kg, wet wt.)	TOTAL MASS (dry wt.)
Canna	Canna flaccida	5/3/11	250	7.7	1.6
		8/2/11	208	5.0	0.9
		9/30/11	181	5.0	1.0
		11/8/11	163	7.6	1.4
		2/7/12	120	1.4	0.3
		4/30/12	82	9.7	1.8
Soft Rush	Juncus effusus	5/3/11	750	15.2	3.8
		8/2/11	625	27.4	5.3
		9/30/11	543	28.5	6.1
		11/8/11	490	56.2	12.5
		2/7/12	364	107	22.8
		4/30/12	250	96	22.1
duck potato	Sagittaria lancifolia	5/3/11	250	10.8	1.9
		8/2/11	208	13.3	2.2
		9/30/11	181	19.8	3.5
		11/8/11	163	13.8	2.3
		2/7/12	120	11.8	1.9
		4/30/12	82	10.3	1.7
Pickerelweed	Pontederia cordata	5/3/11	250	6.4	1.4
		8/2/11	208	7.0	1.3
		9/30/11	181	7.2	1.5
		11/8/11	163	13.1	2.8
		2/7/12	120	18.4	3.9
		4/30/12	82	20.6	4.5
redtop bentgrass	Agrostis alba	5/3/11	1,000	18.6	3.8
		8/2/11	1,000	42.7	6.6
		9/30/11	1,000	57.2	9.9
		11/8/11	1,000	54.7	9.7
		2/7/12	1,000	164	30.8
		4/30/12	1,000	400	70.8
TOTALS:		5/3/11	2,500	59	12.5
		8/2/11	2,248	95	16.3
		9/30/11	2,085	118	22.0
		11/8/11	1,977	145	28.7
		2/7/12	1,726	302	59.7
		4/30/12	1,496	537	101



a. Wet Plant Mass



b. Dry Plant Mass

Figure 30. Comparison of Total Wet and Dry Plant Biomass by Species.

A tabular summary of total wet and total dry plant biomass present during each of the six plant monitoring events is given on Table 15. This analysis is based upon the changes in the number of plants for each species summarized in Table 14. The total wet plant biomass increased from an initial value of approximately 59 kg to a final value of 537 kg, an increase of approximately 810%. Total plant dry biomass increased from an initial value of approximately 12.5 kg to a final value of 101 kg, an increase of approximately 700%.

TABLE 15

**SUMMARY OF TOTAL WET AND DRY PLANT BIOMASS
DURING THE POST-MODIFICATION MONITORING PERIOD**

MONITORING DATE	NUMBER OF PLANTS	TOTAL WET PLANT BIOMASS (kg)	TOTAL DRY PLANT BIOMASS (kg)
5/3/11	2500	59	12.5
8/2/11	2248	95	16.3
9/30/11	2085	118	22.0
11/8/11	1977	145	28.7
2/7/12	1726	302	59.7
4/30/12	1496	537	101

A summary of measured nutrient concentrations in Beemat plant material during the post-modification period is given on Table 16. Measured concentrations are provided for nitrogen and phosphorus in both leaves and roots on a dry weight basis in terms of $\mu\text{g/g}$ of dry plant matter for each of the six monitoring dates. Overall, it appears that many species store more nutrients in the roots than in the leaves. A significant loss of nutrient content was observed in canna, soft rush, duck potato, and pickerelweed during late-fall and winter conditions. However, a rebound in nutrient content occurred by the end of the 12-month post-modification monitoring program. The loss of phosphorus during fall and winter conditions is substantially less pronounced than observed for nitrogen. In general, phosphorus concentrations increased relatively steadily in both leaves and roots for most species during the monitoring program.

A graphical comparison of changes in total nutrient concentrations for each of the five species is given in Figure 31. The vast majority of the total stored mass of nitrogen and phosphorus appear to be in the redbow bentgrass and soft rush.

TABLE 16

**SUMMARY OF NUTRIENT CONCENTRATIONS IN BEEMAT
PLANT MATERIAL DURING THE POST-MODIFICATION PERIOD**

COMMON NAME	SPECIES	DATE	NITROGEN CONCENTRATION (mg/g dry weight)		PHOSPHORUS CONCENTRATION (mg/g dry weight)		NITROGEN MASS (g)			PHOSPHORUS MASS (g)		
			Leaves	Roots	Leaves	Roots	Leaves	Roots	Total	Leaves	Roots	Total
Canna	Canna flaccida	5/3/11	24,328	22,289	25,404	10,354	17.2	19.9	37.1	17.9	9.3	27.2
		8/2/11	13,477	35,220	8,085	6,539	6.96	11.9	18.9	4.18	2.2	6.4
		9/30/11	20,442	38,802	8,790	12,595	13.8	13.3	27.1	5.91	4.3	10.2
		11/8/11	2,088	59,295	16,614	18,357	1.43	44.4	45.8	11.4	13.7	25.1
		2/7/12	10,237	34,400	24,697	12,377	1.03	6.56	7.59	2.49	2.4	4.8
		4/30/12	27,975	52,745	8,269	14,062	23.4	52.2	75.6	6.92	13.9	20.8
Soft Rush	Juncus effusus	5/3/11	22,851	38,716	19,620	16,255	55.4	51.6	107	47.6	21.7	69.2
		8/2/11	23,336	53,737	6,452	10,245	64.9	136	201	17.9	26.0	43.9
		9/30/11	17,106	42,474	5,510	9,582	44.7	149	193	14.4	33.5	47.9
		11/8/11	35,363	13,432	12,350	12,409	214	87	301	74.7	80.0	155
		2/7/12	1,016	1,518	12,671	15,603	13.1	15	28	163	155	318
		4/30/12	27,564	54,897	11,092	17,869	381	453	834	153	147	301
duck potato	Sagittaria lancifolia	5/3/11	28,196	30,034	20,899	11,711	14.4	43.0	57.4	10.7	16.8	27.5
		8/2/11	23,577	46,605	10,301	11,029	14.2	73.8	88.0	6.20	17.5	23.7
		9/30/11	23,937	46,684	10,541	13,557	28.5	106	134	12.6	30.7	43.2
		11/8/11	8,954	5,384	20,387	16,240	15.1	3.4	18.5	34.4	10.3	44.7
		2/7/12	4,290	2,296	17,613	14,108	5.4	1.5	6.9	22.3	9.3	31.6
		4/30/12	23,207	74,100	29,001	27,734	20.5	62.9	83.4	25.6	23.6	49.1
Pickernelweed	Pontederia cordata	5/3/11	42,775	21,099	18,679	6,047	32.4	14.1	46.5	14.1	4.0	18.2
		8/2/11	21,736	35,199	13,872	12,506	15.7	20.8	36.5	10.0	7.4	17.4
		9/30/11	23,893	52,456	12,999	15,884	18.4	39.5	57.9	10.0	12.0	22.0
		11/8/11	1,806	1,031	22,768	18,462	2.4	1.5	3.9	30.7	26.7	57.3
		2/7/12	797	1,004	10,633	12,619	2	1.7	3.5	23.1	22.0	45.1
		4/30/12	21,758	63,206	20,020	23,765	58	117	175	53.8	43.9	97.7
redtop bentgrass	Agrostis alba	5/3/11	26,579	44,692	20,492	18,484	23.7	129	153	18.3	53.5	71.7
		8/2/11	45,203	70,818	15,562	17,660	129	265	394	44.4	66.1	110
		9/30/11	39,295	54,943	19,608	17,623	178	295	473	88.7	94.6	183
		11/8/11	48,187	1,023	36,982	16,540	257	4.5	261	197	72.0	269
		2/7/12	40,884	1,530	28,920	16,255	484	10.1	494	342	308	651
		4/30/12	16,103	62,074	24,947	27,082	472	2,578	3049	731	1125	1855

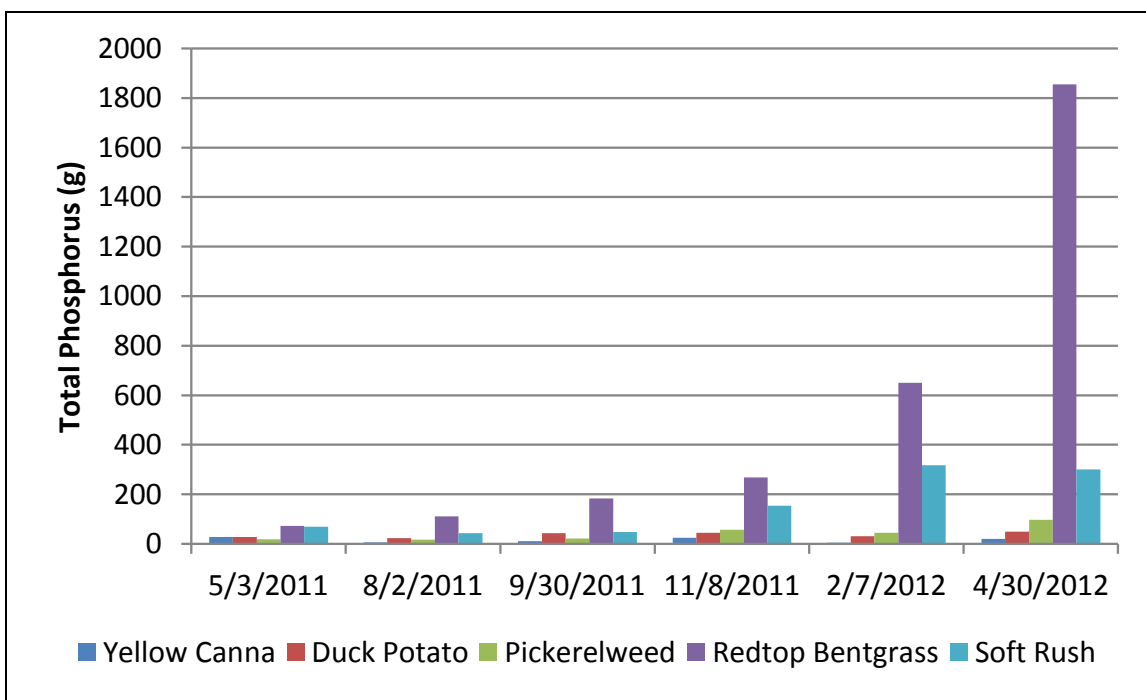
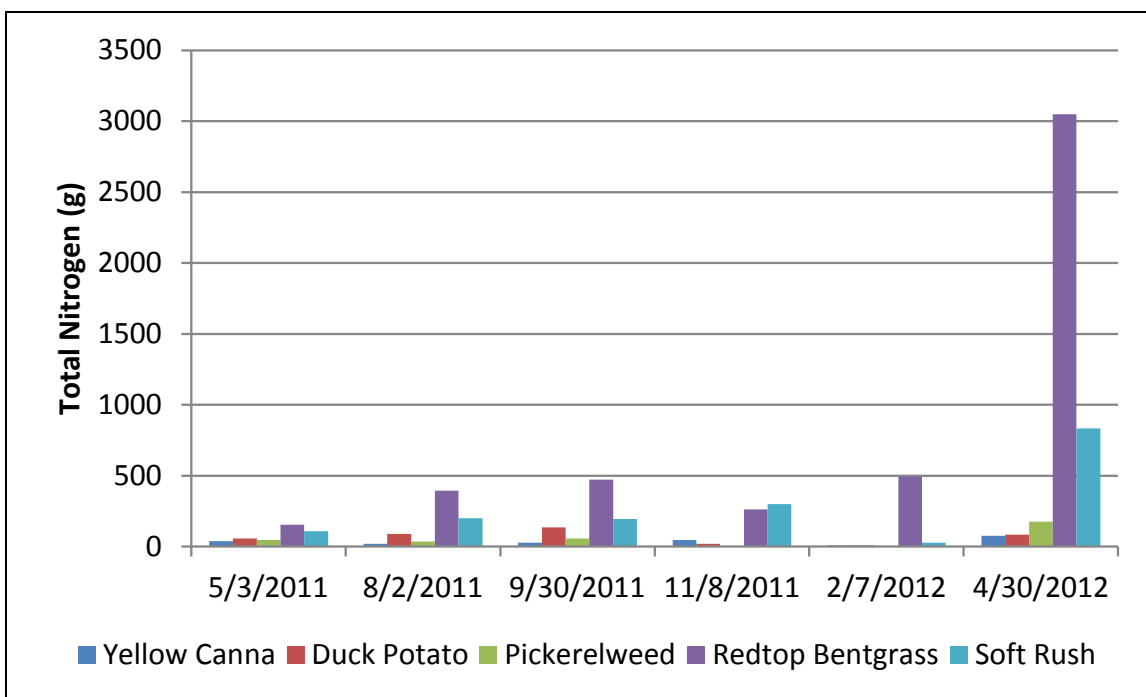


Figure 31. Changes in Total Mass of Nitrogen and Phosphorus Over Time for the Floating Beemat Islands.

7. Post-Modification Monitoring

7.1 Hydrologic Data

7.1.1 Rainfall

A complete listing of measured rainfall events at the PAFB pond site during the post-modification field monitoring program from May 2011-April 2012 is given in Appendix A.2. A total of 40.37 inches of rainfall was measured at the pond site during the 365-day monitoring period from a total of 122 monitored rain events. A summary of rainfall characteristics measured at the PAFB site from May 2011-April 2012 is given in Table 17. Individual rain events at the site ranged from a minimum of 0.01 inches to a maximum of 7.96 inches, with an overall mean of 0.33 inch per event. Antecedent dry periods between rain events ranged from 0.13-26.6 days.

TABLE 17

**SUMMARY OF RAINFALL CHARACTERISTICS MEASURED
AT THE PAFB POND SITE FROM MAY 2011 - APRIL 2012**

PARAMETER	UNITS	MINIMUM VALUE	MAXIMUM VALUE	MEAN EVENT VALUE
Event Rainfall	inches	0.01	7.96	0.33
Event Duration	hours	< 0.01	32.5	2.5
Average Intensity	inches/hour	0.01	1.80	0.37
Antecedent Dry period	days	0.13	26.6	2.8

A graphical comparison of average and measured rainfall in the vicinity of the PAFB Beemat pond is given on Figure 32. Graphical comparisons are provided for the post-modification monitoring period from May 2011-April 2012. The “measured” rainfall reflects the actual measurements conducted at the PAFB site by ERD. The “normal” rainfall reflects the monthly mean rainfall at the Melbourne Meteorological Station over the period from 1971-2000. As indicated on Figure 32, greater than normal rainfall occurred at the site during October and December 2011 and March 2012, with lower than normal rainfall measured during the remaining months. Substantially lower than normal rainfall occurred at the site during the months of May, July, and November 2011 and January 2012. The field measured rainfall of 40.37 inches during the post-modification monitoring program is approximately 19% less than the normal rainfall of 50.03 inches which typically occurs in the general area during the months of May-April.

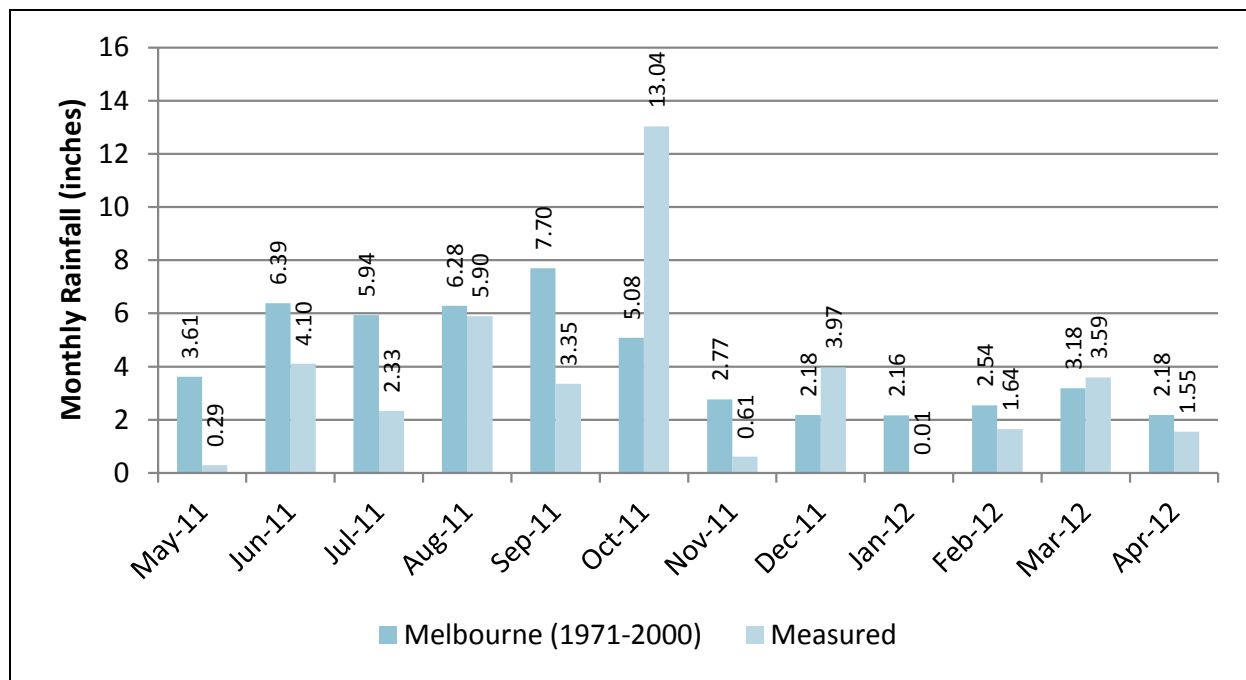


Figure 32. Comparison of Average and Measured Rainfall in the Vicinity of the PAFB Beemat Pond During the Post-Modification Monitoring.

7.1.2 Surface Water Elevations

A graphical summary of measured water elevations in the western pond is given on Figure 33. Measurements of groundwater elevations in the adjacent shallow monitoring wells are also included on Figure 33 for comparison purposes. Measured water elevations in the western pond ranged from approximately 1.35-3.7 ft during the field monitoring program, representing a water level fluctuation of approximately 2.35 ft. Water levels in the pond exceeded the control elevation on 292 of the 365 days included in the post-modification field monitoring program.

In general, groundwater elevations in the adjacent monitoring well were equal to or slightly less than the measured pond elevations throughout the majority of the field monitoring program, suggesting that groundwater inflow into the pond was relatively low during the post-modification monitoring period. Groundwater elevations at monitoring well Site 2, located on the southern end of the western pond, were consistently lower than elevations measured in the pond or the other groundwater monitoring wells, a trend which was also observed during the pre-modification monitoring period. Based upon the information summarized in Figure 31, groundwater inflow into the pond appears to be minimal, with the primary direction of water movement occurring from the pond into the adjacent groundwater during a majority of the post-modification monitoring period.

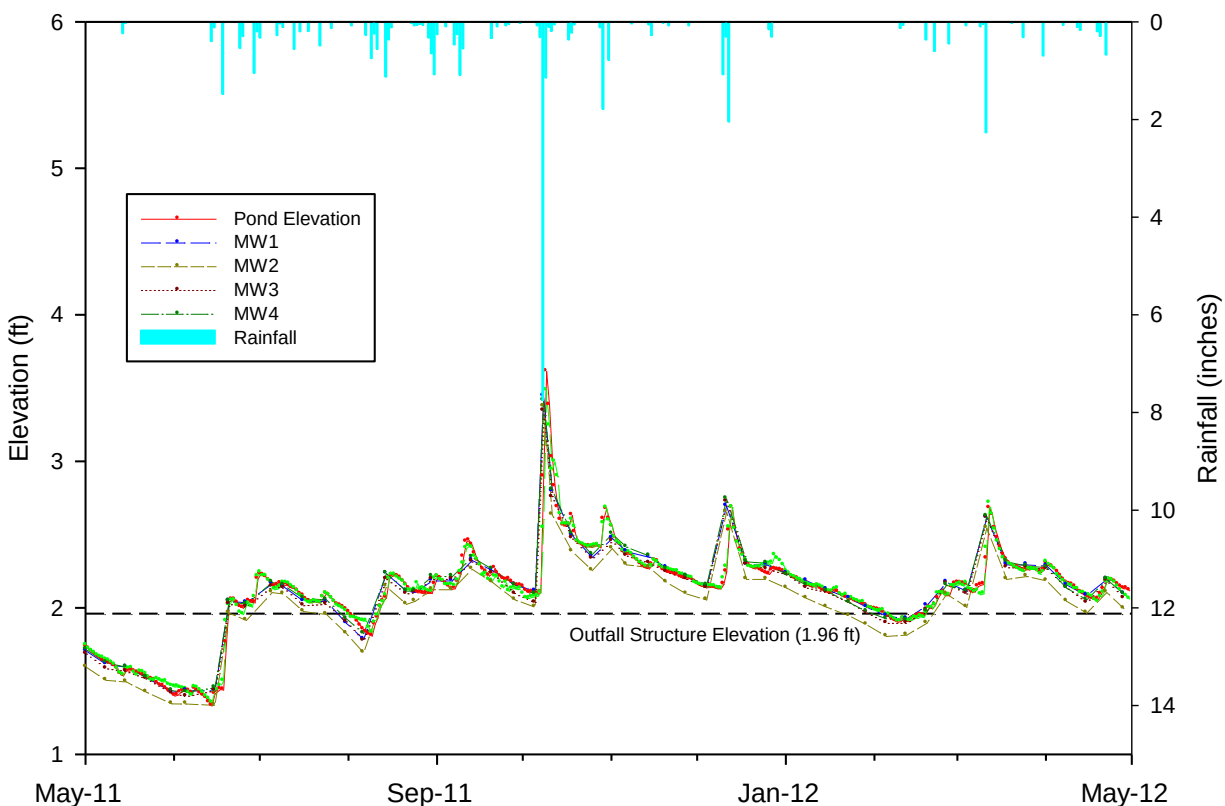


Figure 33. Measured Water Surface and Adjacent Groundwater Elevations at the PAFB Pond During Post-Modification Monitoring.

7.1.3 Inflow/Outflow Hydrographs

Field measured inflow and outflow hydrographs for the western pond during the post-modification field monitoring program from May 2011-April 2012 are summarized on Figure 34. The inflow hydrograph represents the inflow into the western pond through the 36-inch HDPE, with the outflow hydrographs reflecting discharges through the outfall structure. In general, inflow and outflow hydrographs appear to be relatively similar which would be anticipated given the relatively small size of the western pond. Inflows into the western pond ranged from 0.0-2.0 cfs, with a similar range of values measured at the outfall. In general, inflow hydrographs into the pond appear to correspond very closely with measured rainfall events at the site. Inflow into the pond was observed on almost a continuous basis during the field monitoring program. However, discharges from the pond did not occur continuously with periods of little or no discharge observed from April 25-June 19, August 2-11, and February 5-18.

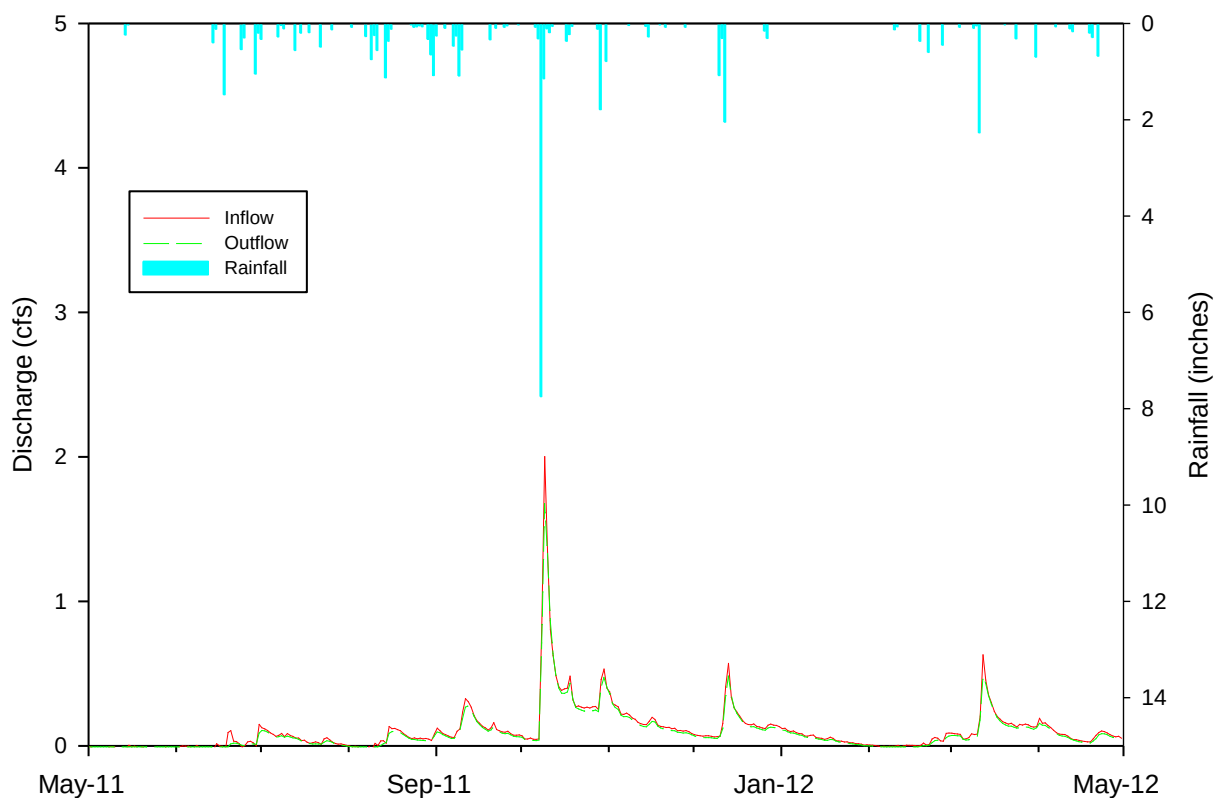


Figure 34. Measured Inflow and Outflow Hydrographs for the PAFB Pond from May 2011-April 2012.

7.1.4 Evaporation

As discussed in Section 3.3, a Class A pan evaporimeter was installed near the pond site to provide estimates of surface evaporation rates from the pond. Changes in water level within the evaporation pan were recorded on a weekly basis and corrected for measured rainfall to provide estimates of surface evaporation. The evaporation measurements were then summarized on a monthly basis and used in calculations for the hydrologic budget for the pond.

A graphical comparison of measured monthly pond evaporation during the post-modification monitoring program is given on Figure 35. Measured monthly surface evaporation rates ranged from a low of 2.74 inches during January 2012 to a high of 5.66 inches during May 2011.

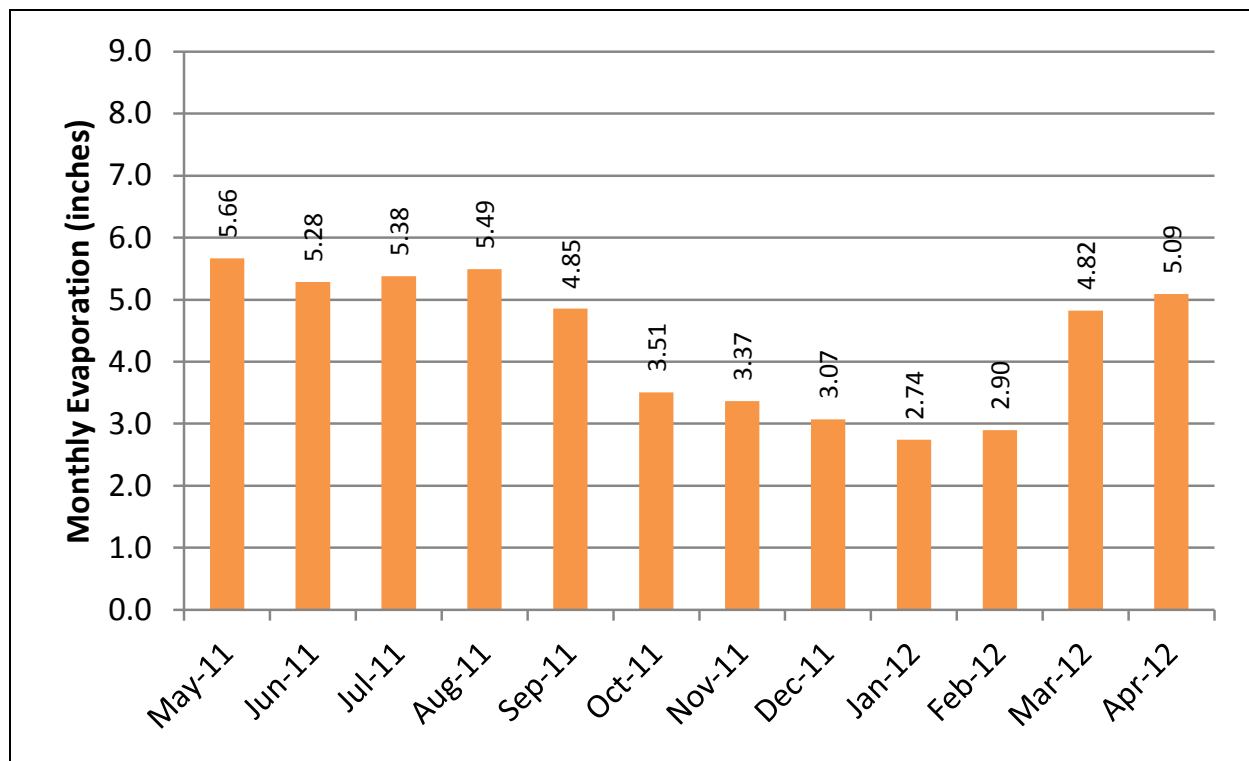


Figure 35. Comparison of Measured Monthly Lake Evaporation at the PAFB Pond Site from May 2011-April 2012.

7.1.5 Hydrologic Budget

A complete hydrologic budget was developed for the PAFB pond over the post-modification period from May 2011-April 2012. The hydrologic budget includes inputs to the pond from runoff inflows, direct precipitation, and groundwater inflow (if applicable), with losses from the pond occurring as a result of discharges through the outfall structure, surface evaporation, and groundwater losses (if applicable). The hydrologic budget can be expressed mathematically according to the following relationship:

$$RO + Precip + GW_{in} = Outfall + Evap + GW_{out} \pm \Delta Storage$$

where:

RO	=	Runoff inflow
Precip	=	Direct rainfall on pond surface
GW	=	Groundwater inflow or loss
Outfall	=	Losses through outfall structure
Evap	=	Pond evaporation

A post-modification hydrologic budget was developed for the pond on a daily basis over the period from May 2011-April 2012. Inputs into the pond from stormwater runoff through the 36-inch HDPE, as well as losses from the pond as a result of discharges through the outfall structure, were obtained by integrating the inflow and outflow hydrographs shown on Figure 32 on a daily basis. Inputs into the pond from direct precipitation were obtained using the rainfall data summarized in Appendix A.2 and the surface area of the pond at the time of each rainfall event. Losses as a result of evaporation were calculated by multiplying the estimated daily evaporation loss times the mean pond surface area for each day. Change in storage within the pond is calculated based upon the measured surface water elevations illustrated on Figure 31. Groundwater inflows or losses are calculated as the difference in the hydrologic budget after consideration of the calculated inflows and outflows and change in storage. Each of the inflows and outflows were calculated on a daily basis with the post-modification data provided in Appendix C.2.

A tabular summary of monthly hydrologic budgets for the western pond during the post-modification period is given on Table 18. Inflows through the 36-inch HDPE contributed approximately 68.09 ac-ft of water during the post-modification monitoring period, with 1.80 ac-ft contributed by direct rainfall. Discharges through the outfall structure resulted in a loss of approximately 59.05 ac-ft of water, with 2.24 ac-ft lost from surface evaporation. The monthly mass hydrologic budgets indicated that a net loss to groundwater occurred during 11 of the 12 monthly periods. Overall, the pond received a total input of approximately 69.89 ac-ft, with a total loss of 69.57 ac-ft. The difference of 0.32 ac-ft between the inputs and losses reflects the decrease in water storage from the beginning to the end of the post-modification period.

TABLE 18

**MONTHLY HYDROLOGIC BUDGET FOR THE PAFB POND
DURING THE POST-MODIFICATION MONITORING PROGRAM**

MONTH	INPUTS (ac-ft)			LOSSES (ac-ft)				CHANGE IN STORAGE (ac-ft)
	Inflow	Direct Rainfall	Total	Outflow	Evaporation	Groundwater	Total	
May	-0.07	0.01	-0.06	0.00	0.23	-0.10	0.13	-0.19
June	1.06	0.17	1.23	0.48	0.22	0.07	0.77	0.46
July	3.11	0.10	3.21	2.53	0.23	0.58	3.34	-0.13
August	2.67	0.25	2.92	2.08	0.24	0.50	2.82	0.10
September	6.55	0.15	6.70	5.66	0.21	0.83	6.70	0.00
October	22.31	0.61	22.92	20.62	0.16	1.79	22.57	0.35
November	8.03	0.03	8.06	7.17	0.15	1.01	8.33	-0.27
December	7.54	0.18	7.72	6.54	0.13	0.99	7.66	0.06
January	3.36	0.00	3.36	2.79	0.12	0.61	3.52	-0.16
February	1.16	0.07	1.23	0.66	0.12	0.35	1.13	0.10
March	7.93	0.16	8.09	6.81	0.21	0.99	8.01	0.08
April	4.44	0.07	4.51	3.71	0.22	0.66	4.59	-0.08
TOTAL:	68.09	1.80	69.89	59.05	2.24	8.28	69.57	0.32

7.2 Vertical Field Profiles

Field measurements of temperature, pH, conductivity, and dissolved oxygen in the western pond during the post-modification monitoring program are given in Appendix B.2. Vertical field profiles were conducted in top, middle, and bottom portions of the pond during each monitoring event using the multi-port device described in Section 3.4. Measurements of vertical field profiles were conducted during each weekly site visit.

A graphical summary of vertical field profiles collected in the western pond during the post-modification field monitoring program is given on Figure 36. The profiles summarized in this figure reflect the mean of weekly vertical profiles summarized on a monthly basis for each of the 12 months of the post-modification monitoring. In general, no significant thermal stratification was observed within the pond during any of the field monitoring events, indicating a well mixed water column throughout the year. Measured pH values in the pond ranged from approximately 7.4-8.4 with relatively uniform values throughout the water column, with the exception of slightly higher surface pH values measured during May 2011. In general, water column pH appears to be lower during the post-modification period than observed during the pre-modification period. Measured conductivity values within the pond ranged from approximately 1200-1350 $\mu\text{mho/cm}$, with relatively uniform values during most monitoring events. Dissolved oxygen within the pond was low to moderate, with measured values ranging from approximately 3-8 mg/l. No significant decrease in dissolved oxygen with increasing water depth was observed during any event. Post-modification dissolved oxygen values appear to be lower than pre-modification measurements.

7.3 Water Quality Data

A summary of water quality samples collected at the PAFB pond site during the post-modification monitoring program is given in Table 19. A total of 287 separate water quality samples was collected and submitted to the ERD Laboratory for analysis from May 2011-April 2012. A complete listing of the characteristics of inflow samples collected at the pond site is given in Appendix F.1, with the chemical characteristics of outflow samples summarized in Appendix F.2, groundwater samples summarized in Appendix F.3, and bulk precipitation samples summarized in Appendix F.4. A listing of chlorophyll analyses conducted on pond samples is given in Appendix F.5.

TABLE 19

**SUMMARY OF WATER QUALITY SAMPLES
COLLECTED AT THE PAFB POND SITE DURING
THE POST-MODIFICATION MONITORING PROGRAM**

SITE	SAMPLES COLLECTED
Inflow	46
Outflow	42
Groundwater	48
Pond Samples ¹	131
Bulk Precipitation	20
TOTAL:	287

1. Chlorophyll-a measurements only

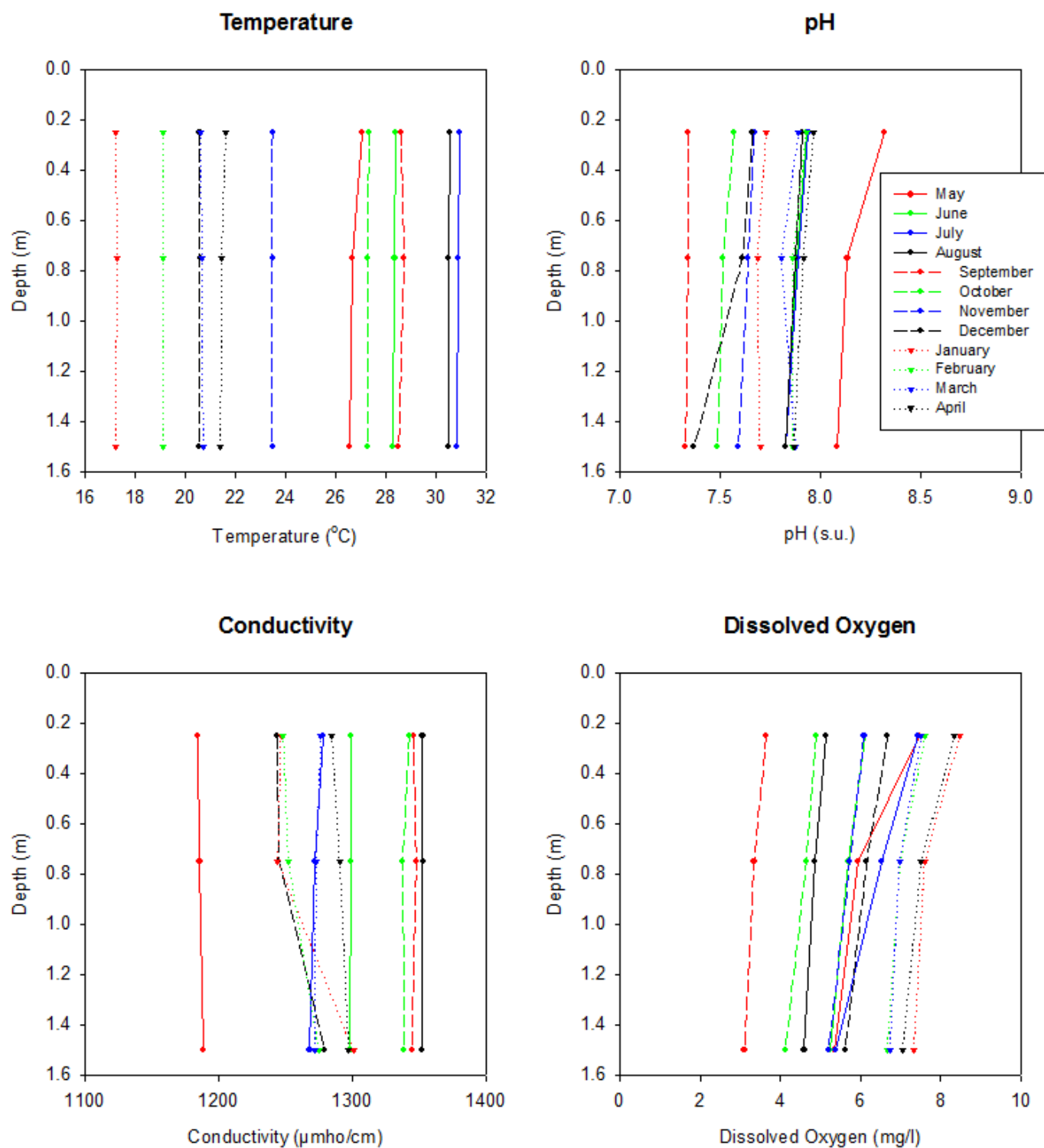


Figure 36. Mean Monthly Vertical Field Profiles Collected in the PAFB Pond During the Post-Modification Field Monitoring Program from May 2011-April 2012.

7.3.1 Inflow and Outflow Samples

A graphical summary of trends in inflow and outflow concentrations of pH, alkalinity, conductivity, and TSS in the western pond during the post-modification monitoring program is given on Figure 37. In general, both the inflow and outflow samples were slightly alkaline in pH, ranging in value from approximately 7.2-7.8. A trend of slightly higher pH values was observed on occasion at the pond outfall compared with the pond inflow, presumably due to pH increases caused by algal productivity within the pond. It appears that pH values in both the inflow and outflow may be slightly lower during the post-modification period than during the pre-modification period. Measured inflows and outflows for the pond were well buffered, with measured alkalinity values ranging from approximately 100-220 mg/l. A general decrease in alkalinity was observed within the western pond between the inflow and outflow which may be related to uptake of inorganic carbon by photosynthetic algae within the pond.

Measured conductivity values in the inflow and outflow samples were somewhat elevated, ranging from approximately 1100-1400 $\mu\text{mho/cm}$. However, conductivity values in this range are commonly observed in pond systems located in coastal areas. In general, measured conductivity values in the outflow samples appear to be slightly higher than conductivity values measured at the inflow to the pond. Measured concentrations of TSS in the inflow and outflow samples ranged from low to moderate in value during the post-modification monitoring program. In general, discharges from the pond were characterized by higher TSS concentrations than observed in the inflow, presumably due to algal production within the pond which is measured as TSS at the pond outfall.

Trends in inflow and outflow concentrations of nitrogen species in the western pond during the post-modification monitoring program are indicated on Figure 38. Measured concentrations of ammonia in the inflow and outflow samples ranged from low to moderate in value. In general, inflow samples appear to exhibit slightly higher levels of ammonia than measured at the outflow, suggesting uptake of ammonia within the pond. Measured concentrations of NO_x were typically low in value in both the inflow and outflow samples, with a slight trend of lower concentrations at the pond outfall during many of the monitoring events, suggesting uptake of NO_x within the pond.

Measured concentrations of particulate nitrogen ranged from low to elevated during the post-modification field monitoring program. In general, outflow concentrations of particulate nitrogen were higher in value during a majority of the monitoring period compared with the inflow concentrations. The observed increases in particulate nitrogen are likely related to incorporation of nitrogen in algal biomass within the pond. Measured concentrations of total nitrogen ranged from low to moderate during the field monitoring program. Outflow concentrations of total nitrogen exceeded the inflow concentrations in most of the collected samples, suggesting a net export of total nitrogen from the pond compared with the measured inputs.

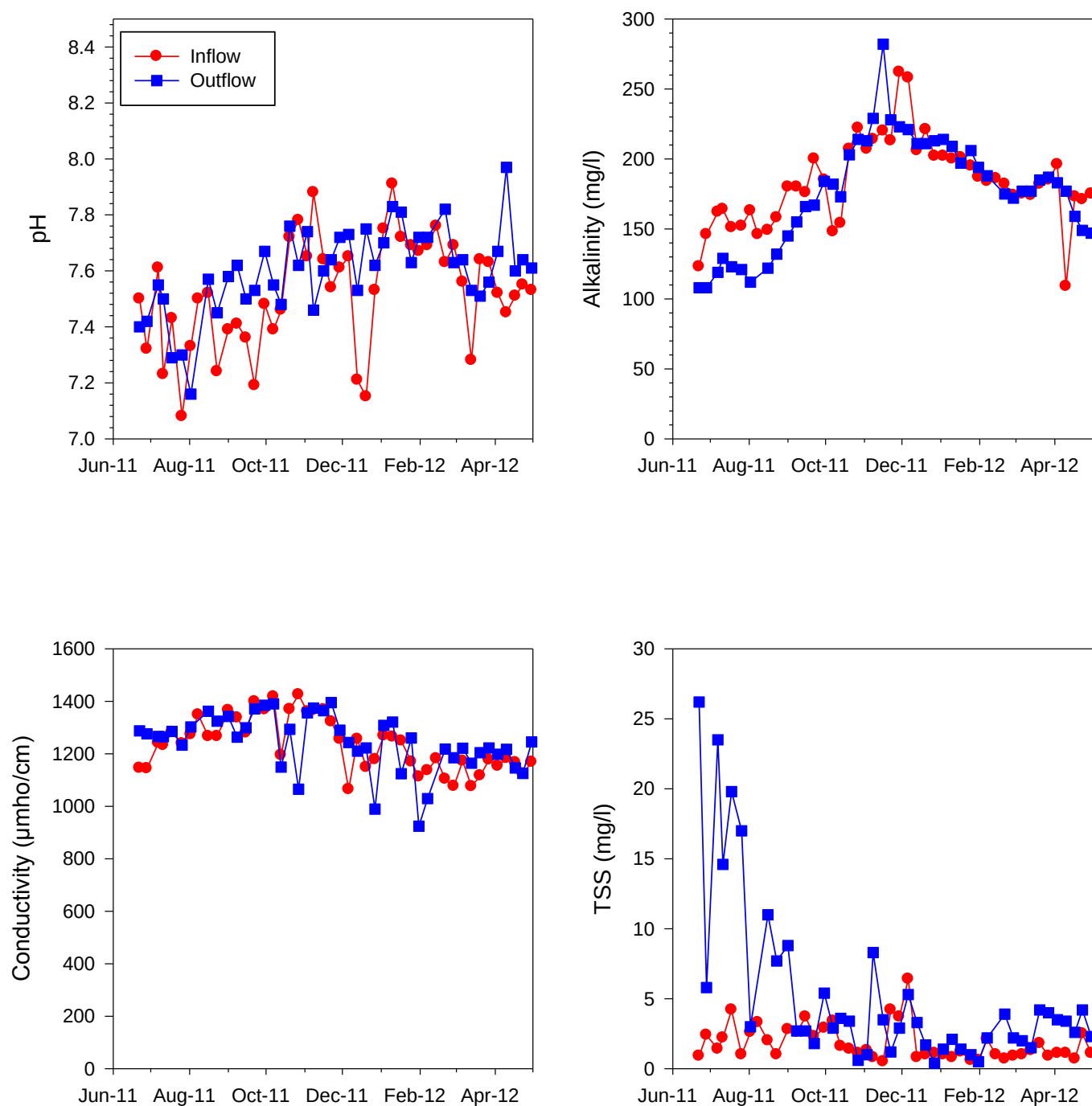


Figure 37. Trends in Inflow and Outflow Concentrations of pH, Alkalinity, Conductivity, and TSS in the PAFB Pond During the Post-Modification Monitoring Program from May 2011-April 2012.

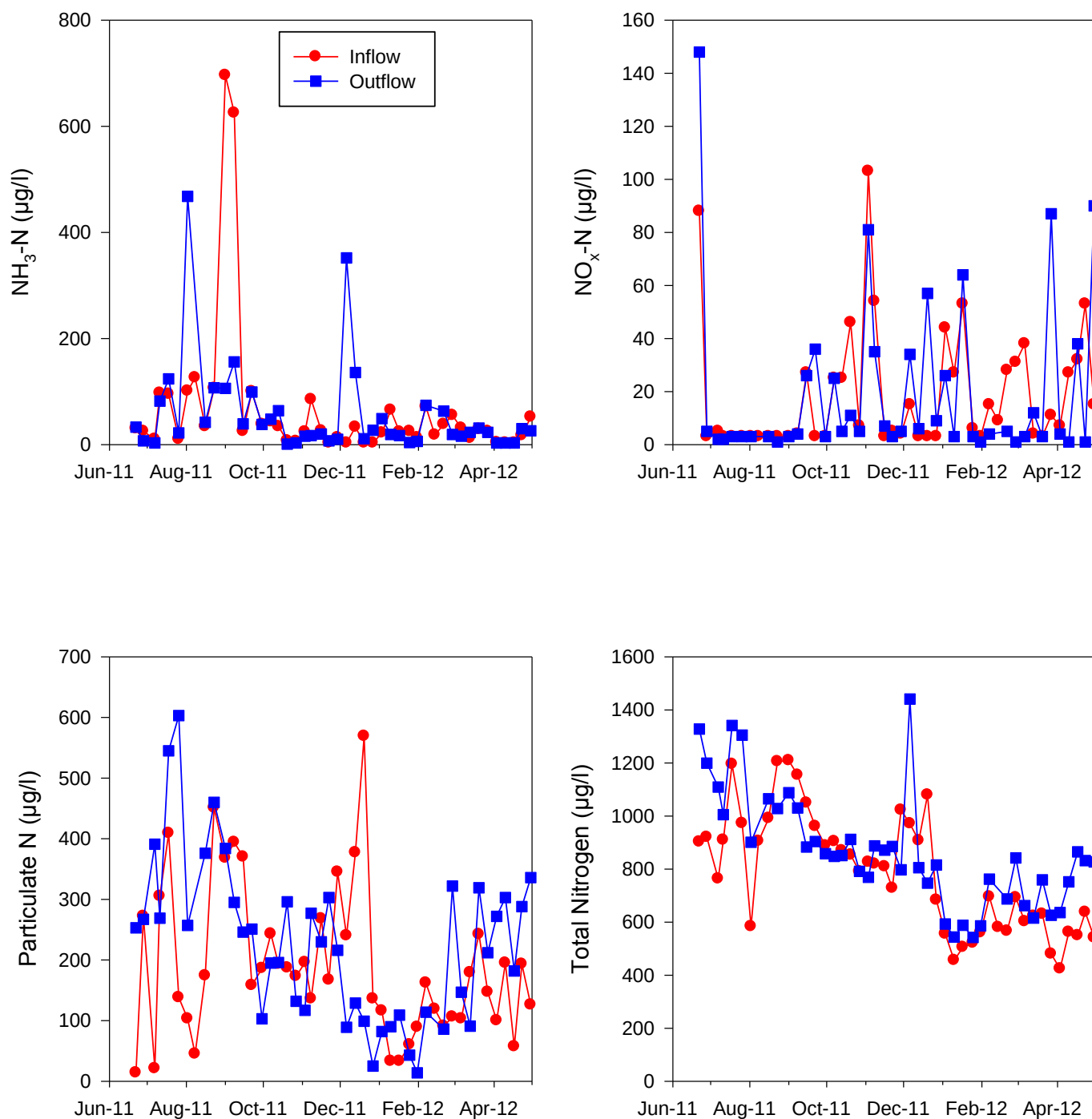


Figure 38. Trends in Inflow and Outflow Concentrations of Nitrogen Species in the PAFB Pond During the Post-Modification Monitoring Program from May 2011-April 2012.

Trends in inflow and outflow concentrations of phosphorus species in the western pond during the post-modification monitoring program are illustrated on Figure 39. Inflow concentrations of SRP into the pond ranged from low to elevated, ranging from approximately 10-550 µg/l. A substantial uptake of SRP occurred within the pond with outflow samples ranging from approximately 1-450 µg/l. Measured concentrations of dissolved organic phosphorus in the inflow and outflow samples ranged from low to moderate in value during the field monitoring program. In general, it appears that inflow concentrations of dissolved organic phosphorus are higher in most samples than observed in the outflow, suggesting a net uptake of organic phosphorus within the pond.

Measured concentrations of particulate phosphorus in the inflow and outflow samples were highly variable, ranging from approximately 5-170 µg/l. Particulate phosphorus concentrations in the outflow samples appear to exceed the inflow concentrations throughout much of the field monitoring program. The additional particulate phosphorus measured at the outflow appears to be related to incorporation of phosphorus into algal biomass within the pond. Overall, a net loss of total phosphorus was observed between the inflow and outflow samples on many monitoring dates, resulting primarily from the observed uptake of SRP and dissolved organic phosphorus. Inflow total phosphorus concentrations ranged from approximately 50-700 µg/l, compared with outflow concentrations ranging from approximately 40-400 µg/l in most samples.

Trends in inflow and outflow concentrations of turbidity and color in the western pond during the post-modification monitoring program are illustrated on Figure 40. Measured turbidity values in the inflow and outflow samples ranged from low to moderate in value, with higher turbidity concentrations observed in the outflow samples throughout much of the post-modification monitoring program, likely related to generation of algae within the pond. Measured color concentrations in the inflow and outflow samples were moderate in value, with lower concentrations of color measured in the outflow samples compared with the inflow during most events.

A comparison of mean inflow and outflow concentrations in the western pond during the post-modification monitoring program is given on Table 20. The mean inflow and outflow concentrations summarized in this table reflect the log-normal mean values for the collected samples summarized in Appendix F.1 and Appendix F.2. In general, inflow and outflow samples were slightly alkaline in pH and well buffered, with measured conductivity values indicating borderline brackish water conditions within the pond. A small decrease in alkalinity and increase in conductivity were observed between the inflow and outflow, with a slight increase in pH.

Relatively low concentrations of ammonia and NO_x were observed in both the inflow and outflow samples, with a net reduction in concentration for each of these parameters within the pond. The dominant nitrogen species within both the inflow and outflow samples was dissolved organic nitrogen which comprised more than half of the total nitrogen measured. Concentrations of dissolved organic nitrogen increased by 13% during migration through the pond. Particulate nitrogen concentrations increased by 23% during migration through the pond, resulting in a net increase in total nitrogen concentrations of approximately 12%.

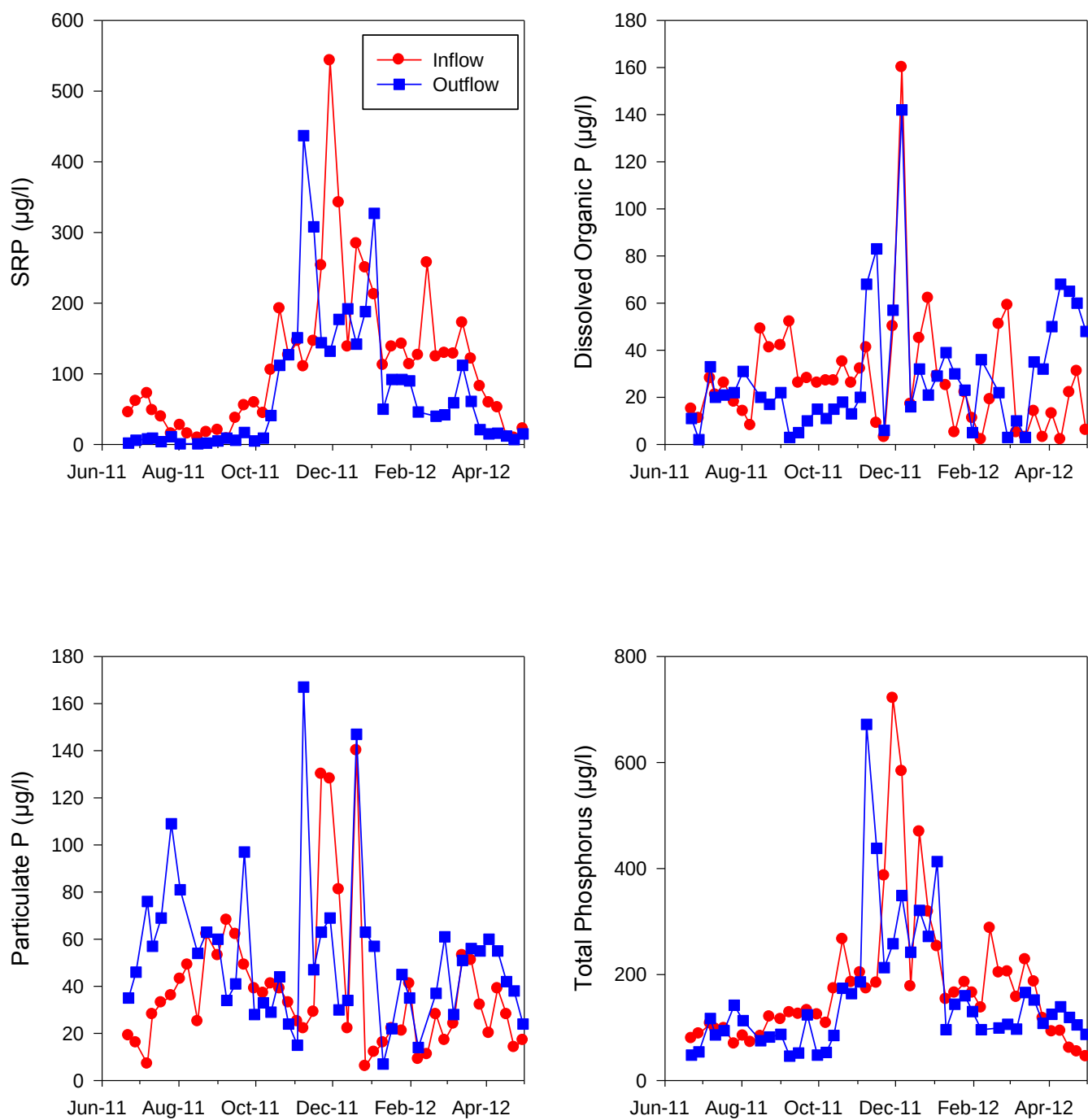


Figure 39. Trends in Inflow and Outflow Concentrations of Phosphorus Species in the PAFB Pond During the Post-Modification Monitoring Program from May 2011-April 2012.

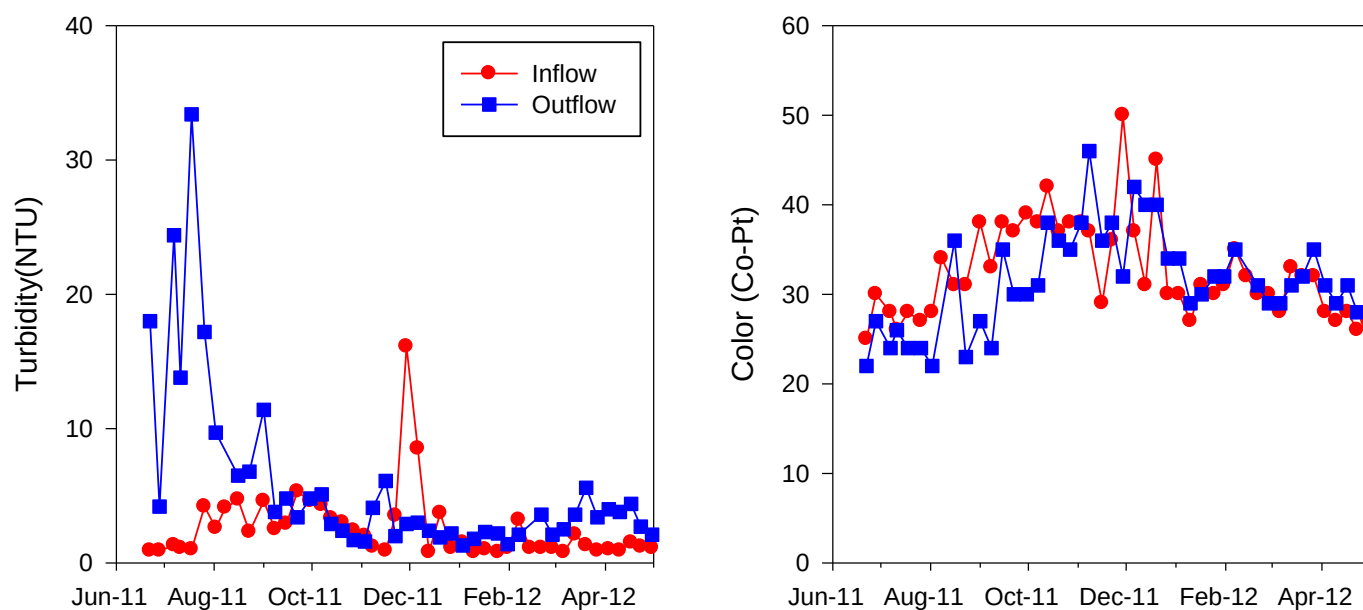


Figure 40. Trends in Inflow and Outflow Concentrations of Turbidity and Color in the PAFB Pond During the Post-Modification Monitoring Program from May 2011-April 2012.

TABLE 20

**COMPARISON OF MEAN INFLOW AND OUTFLOW
CONCENTRATIONS IN THE PAFB POND DURING THE
POST-MODIFICATION MONITORING PROGRAM**

PARAMETER	UNITS	MEAN INFLOW CONCENTRATION	MEAN OUTFLOW CONCENTRATION	PERCENT CHANGE (%)
pH	s.u.	7.52	7.60	-1
Alkalinity	mg/l	181	173	4
Conductivity	µmho/cm	1231	1239	-1
NH ₃ -N	µg/l	25	24	5
NO _x -N	µg/l	9	7	23
Dissolved Organic N	µg/l	480	543	-13
Particulate N	µg/l	148	182	-23
Total N	µg/l	753	842	-12
SRP	µg/l	70	28	59
Dissolved Organic P	µg/l	19	20	-7
Particulate P	µg/l	30	45	-47
Total P	µg/l	145	128	12
Turbidity	NTU	1.9	3.9	-112
Color	Pt-Co	32	31	3
TSS	mg/l	1.5	3.3	-120

Approximately half of the inflow phosphorus concentrations into the pond was comprised of dissolved SRP, with relatively small contributions from dissolved organic phosphorus and particulate phosphorus. Substantial reductions in concentrations of SRP were observed within the pond, with corresponding increases in dissolved organic phosphorus and particulate phosphorus. Overall, total phosphorus concentrations decreased by approximately 12%.

Substantial increases in turbidity and TSS were observed between the inflow and outflow of the pond, presumably resulting from algal production within the pond. A slight decrease in color was observed between the inflow and outflow.

The comparison of mean inflow and outflow concentrations summarized in Table 20 do not reflect the performance efficiency of the pond, but merely differences between inflow and outflow concentrations. The performance efficiency of the pond will be discussed in a subsequent section which provides an overall mass loading comparison of inputs and losses during the post-modification program.

7.3.2 Bulk Precipitation

A tabular summary of mean characteristics of bulk precipitation samples collected during the post-modification monitoring program is given in Table 21. The mean concentrations summarized in this table reflect the log-normal mean values for bulk precipitation summarized in Appendix F.4. In general, bulk precipitation samples were slightly acidic and poorly buffered. Bulk precipitation contained moderate levels of both ammonia and NO_x which were higher in value than concentrations measured in the inflow or outflow for the pond. The dominant nitrogen species in bulk precipitation was ammonia which comprised approximately 33% of the total nitrogen measured. The mean total nitrogen concentration of 413 $\mu\text{g/l}$ appears to be similar to bulk precipitation characteristics measured by ERD in other parts of Central Florida.

Elevated levels of phosphorus species were also measured in bulk precipitation samples, particularly for particulate phosphorus. Measured concentrations of turbidity, color, and TSS in bulk precipitation were relatively low.

7.3.3 Shallow Groundwater Samples

A tabular summary of the mean characteristics of shallow groundwater samples collected during the post-modification monitoring program is given in Table 22. The values summarized in this table reflect the log-normal mean concentrations for groundwater samples summarized in Appendix F.3. In general, groundwater samples collected adjacent to the pond were approximately neutral in pH and well buffered, with mean alkalinity values ranging from 189-244 mg/l . Measured conductivity values between the four monitoring wells were somewhat variable and likely reflect impacts from adjacent golf course activities, depending upon the location of the monitoring well.

TABLE 21

**MEAN CHARACTERISTICS OF BULK PRECIPITATION
CONCENTRATIONS IN THE PAFB POND DURING THE
POST-MODIFICATION MONITORING PROGRAM**

PARAMETER	UNITS	MEAN CONCENTRATION
pH	s.u.	6.04
Alkalinity	mg/l	14.8
Conductivity	µmho/cm	26
NH ₃ -N	µg/l	98
NO _x -N	µg/l	23
Dissolved Organic N	µg/l	48
Particulate N	µg/l	160
Total N	µg/l	413
SRP	µg/l	22
Dissolved Organic P	µg/l	16
Particulate P	µg/l	73
Total P	µg/l	134
Turbidity	NTU	2.8
Color	Pt-Co	16
TSS	mg/l	4.1

TABLE 22

**MEAN CHARACTERISTICS OF SHALLOW GROUNDWATER
SAMPLES COLLECTED IN THE PAFB POND DURING THE
POST-MODIFICATION MONITORING PROGRAM**

PARAMETER	UNITS	MW-1	MW-2	MW-3	MW-4
pH	s.u.	7.22	7.51	7.34	7.37
Alkalinity	mg/l	244	189	224	234
Conductivity	µmho/cm	1721	1565	1552	1321
NH ₃ -N	µg/l	193	71	97	272
NO _x -N	µg/l	3	4	3	3
Dissolved Organic N	µg/l	1145	543	580	1316
Total N	µg/l	1444	702	710	1666
SRP	µg/l	366	479	411	508
Dissolved Organic P	µg/l	14	27	234	17
Total P	µg/l	389	522	686	535
Color	Pt-Co	107	52	213	141

A high degree of variability was also observed in measured concentrations of nitrogen species in each of the four monitoring wells. The most elevated concentrations were observed at monitoring well sites 1 and 4 which are located on the eastern and northern sides of the pond, with substantially lower nitrogen concentrations measured on the southern and western sides of the pond. Differences in concentrations were also apparent in color measurements conducted at the four monitoring well sites. In contrast, measured phosphorus concentrations in the four monitoring wells appear to be relatively similar.

7.3.4 Comparison of Inflow, Outflow, and Bulk Precipitation

A statistical comparison of measured concentrations of pH, alkalinity, conductivity, and TSS in inflow, outflow, and bulk precipitation samples collected during the post-modification monitoring program is given on Figure 41. Measured pH values in the inflow and outflow were relatively similar, with a slightly greater pH measured in outflow samples. Measured pH values in bulk precipitation, however, were substantially lower, typically ranging from about 5.5-6.5.

Measured alkalinity values were slightly higher in the inflow samples, with a relatively low degree of variability. Measured alkalinity values in the outflow were typically lower in value and exhibited a higher degree of variability. Relatively low levels of alkalinity were observed in bulk precipitation.

Measured conductivity in the inflow samples typically ranged from approximately 1100-1300 $\mu\text{mho/cm}$. Slightly higher conductivity values were observed in the outflow which exhibited a lower greater degree of variability. Measured conductivity values in bulk precipitation were low in value.

Measured TSS concentrations in the inflow were generally low in value, ranging from approximately 1-4 mg/l in most samples. An increase in TSS appears to occur within the pond, with higher concentrations and a higher degree of variability observed for TSS in the outflow. Measured concentrations of TSS in bulk precipitation appear to be similar to values measured in the outflow samples.

A statistical comparison of measured concentrations of nitrogen species in inflow, outflow, and bulk precipitation samples collected during the post-modification monitoring program is given on Figure 42. As indicated on Figure 40, inflow and outflow concentrations of ammonia exhibited a relatively low degree of variability, with slightly lower concentrations of ammonia observed at the outflow compared with the inflow. In contrast, a high degree of variability was observed in measured concentrations for bulk precipitation, with a median concentration greater than that observed in the inflow and outflow. Measured concentrations of NO_x were relatively similar in the inflow and outflow during the pre-modification monitoring program, with slightly higher concentrations for bulk precipitation.

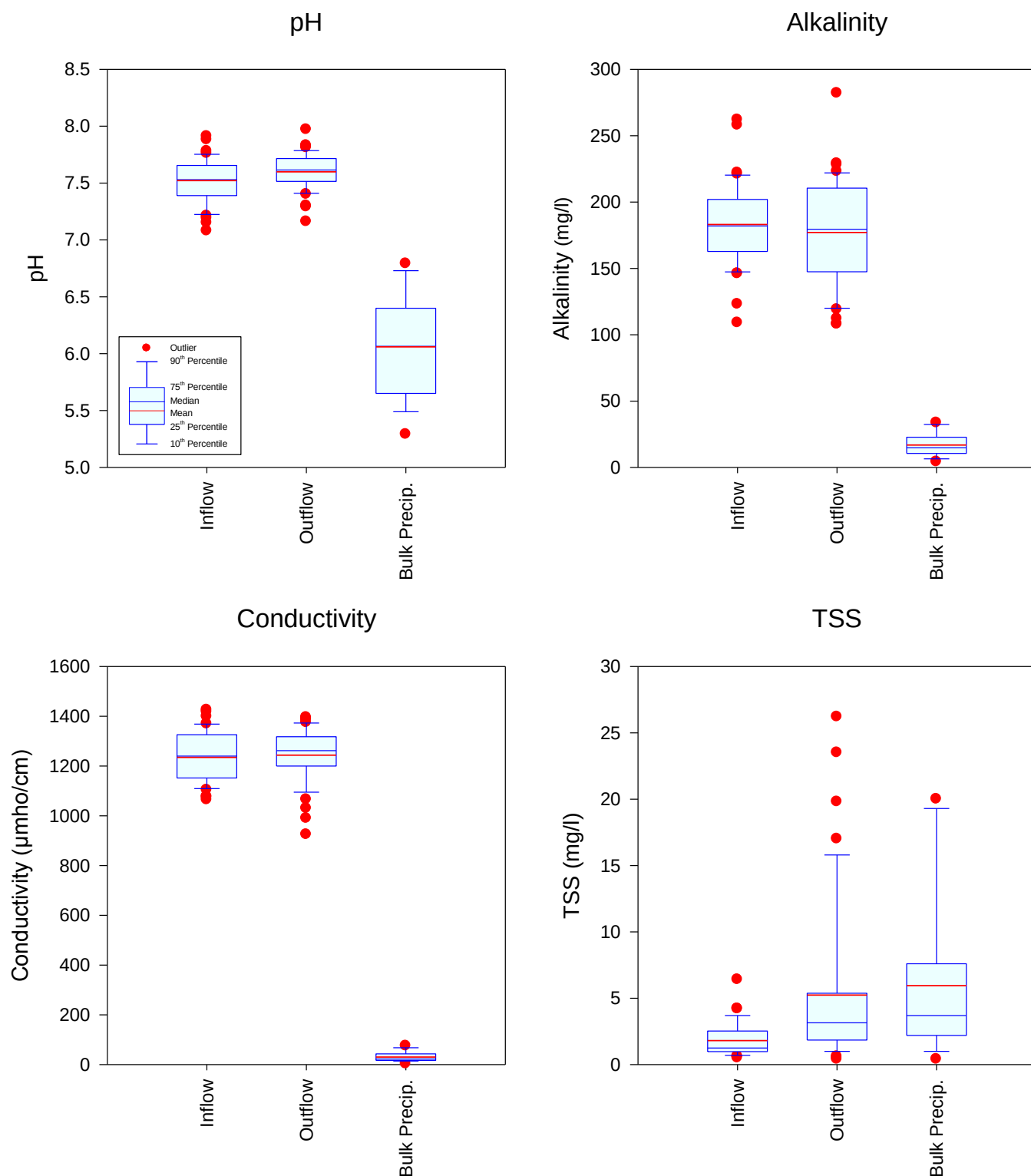


Figure 41. Statistical Comparison of Measured Concentrations of pH, Alkalinity, Conductivity, and TSS in Inflow, Outflow, and Bulk Precipitation Samples During Post-Modification Monitoring.

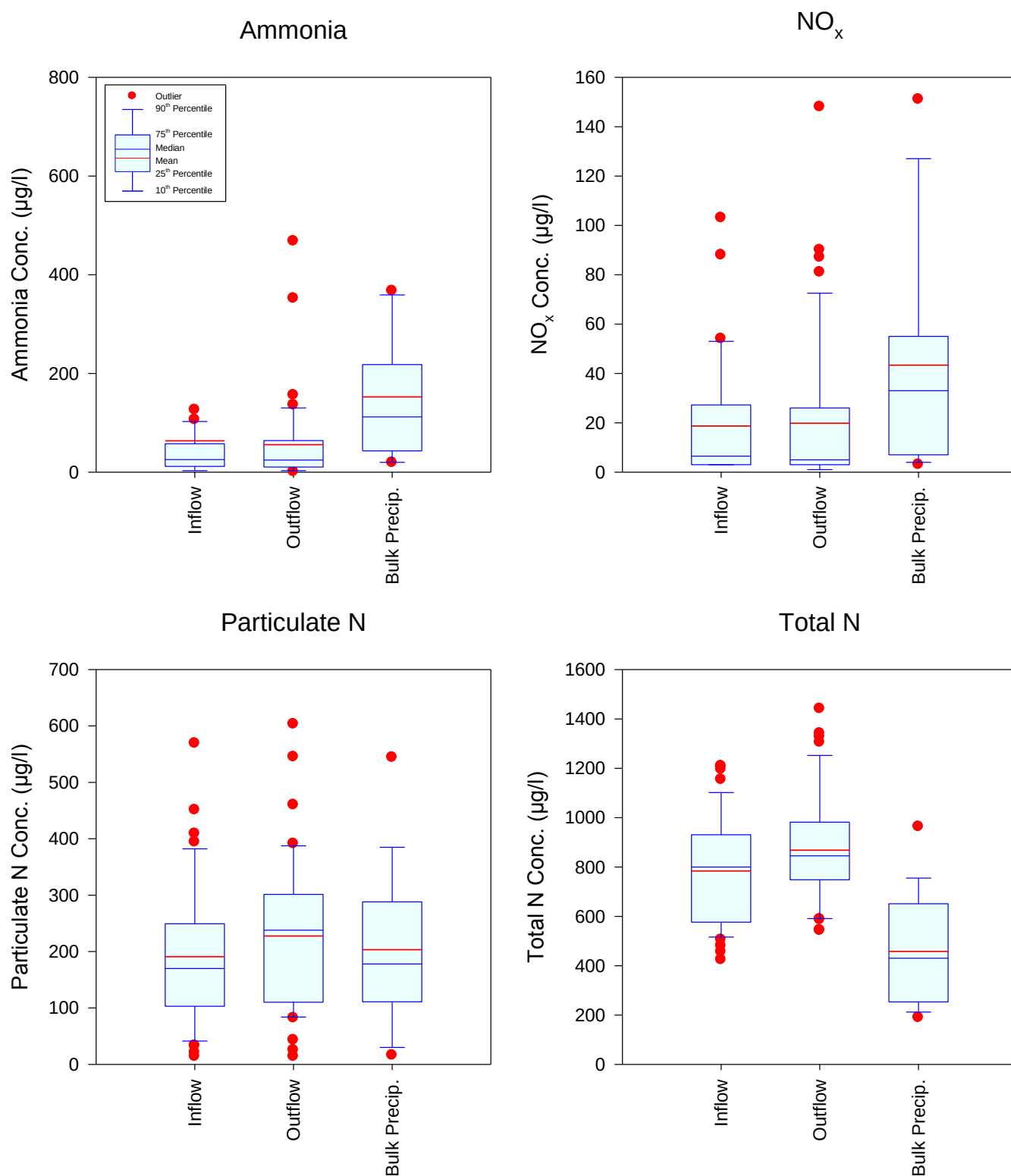


Figure 42. Statistical Comparison of Measured Concentrations of Nitrogen Species in Inflow, Outflow, and Bulk Precipitation Samples During Post-Modification Monitoring.

Measured concentrations of particulate nitrogen in the inflow ranged from approximately 100-250 $\mu\text{g/l}$ in a majority of the collected samples. Measured particulate nitrogen concentrations in the outflow ranged from approximately 100-300 $\mu\text{g/l}$ in a majority of the collected samples, although the median concentration in the outflow is greater than that in the inflow. Bulk precipitation samples ranged from approximately 100-300 $\mu\text{g/l}$, with a median concentration similar to the inflow samples. Overall, total nitrogen concentrations in the inflow ranged from approximately 500-900 $\mu\text{g/l}$ in a majority of the collected samples. Outflow samples ranged from approximately 700-900 $\mu\text{g/l}$ in a majority of the samples and had a higher median concentration than measured in the inflow. A somewhat lower range of values was observed for bulk precipitation, with a median total nitrogen concentration lower than the inflow and outflow values.

A statistical comparison of measured concentrations of phosphorus species in inflow, outflow, and bulk precipitation samples collected during the post-modification monitoring program is given on Figure 43. Measured SRP concentrations in the outflow appear to be lower in value but a higher degree of variability than observed in the inflow samples. In contrast, bulk precipitation samples were characterized by a low degree of variability with a median concentration lower than either the inflow or outflow. Measured dissolved organic phosphorus concentrations were generally low in value in both the inflow and outflow, with a trend of slightly lower concentrations observed in the outflow. Median concentrations of dissolved organic phosphorus in bulk precipitation appear to be lower in value than either the inflow or outflow.

Measured particulate phosphorus concentrations in the inflow ranged from approximately 20-50 $\mu\text{g/l}$ in a majority of the collected inflow samples. The outflow samples were characterized by a more narrow range of values, although the median concentration appears to be greater. Particulate phosphorus concentrations in bulk precipitation were substantially greater than observed in either the inflow or outflow samples. Overall, a reduction in total phosphorus appears to occur within the pond, with lower concentrations in the outflow than observed in the inflow. Total phosphorus concentrations in bulk precipitation were highly variable, with a median concentration similar to inflow concentrations.

A statistical comparison of measured concentrations of turbidity and color in the inflow, outflow, and bulk precipitation samples during the post-modification monitoring program is given in Figure 44. A slight increase in turbidity appears to occur within the pond, with higher measured concentrations in the inflow compared with the outflow. Turbidity in bulk precipitation samples is relatively similar to inflow and outflow values.

A slight reduction in color concentrations appears to occur within the pond, with lower concentrations and a lower degree of variability in color measured at the outflow compared with the inflow. Color concentrations in bulk precipitation were highly variable, although the median concentration appears to be lower than measured in the inflow and outflow samples.

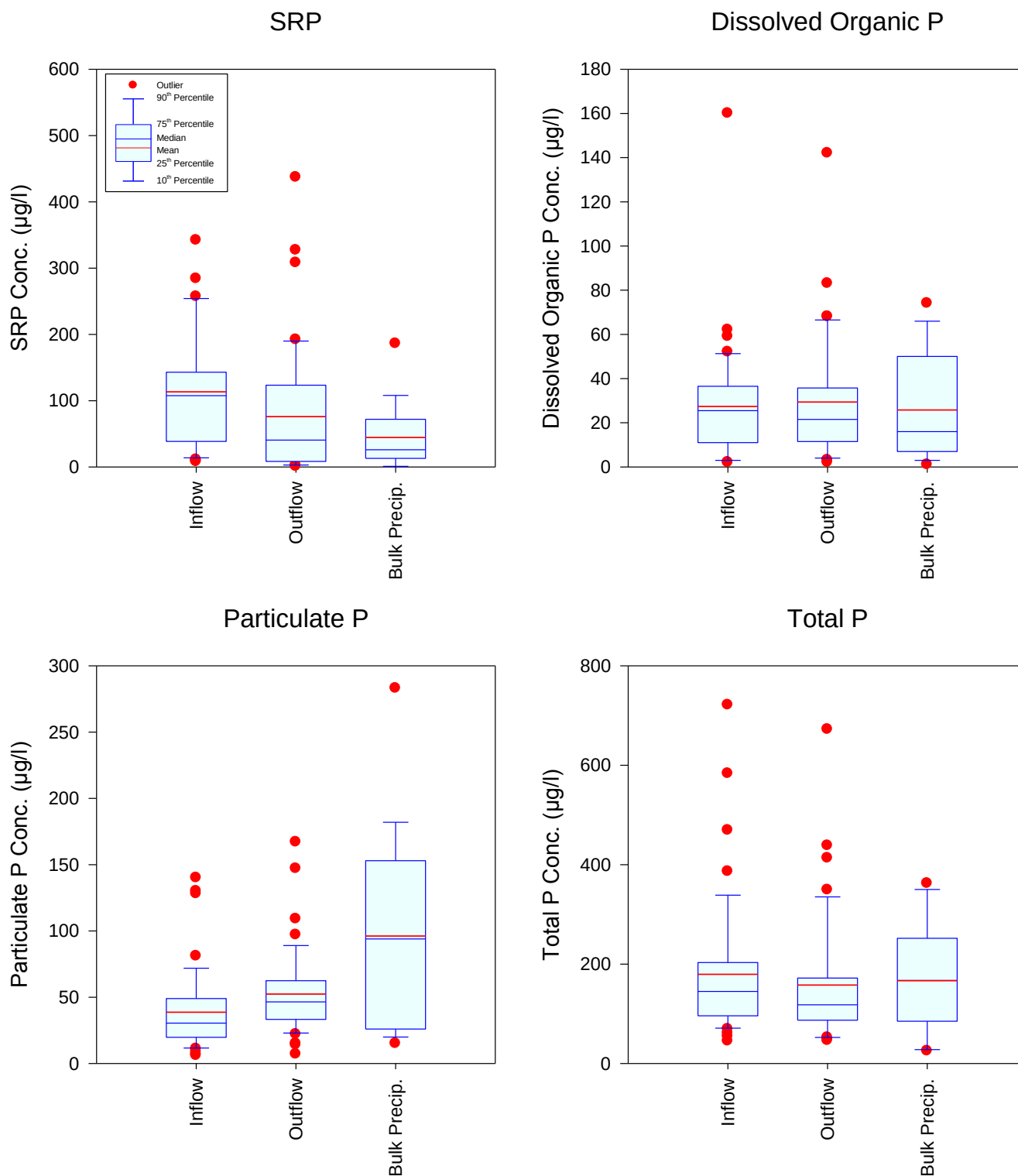


Figure 43. Statistical Comparison of Measured Concentrations of Phosphorus Species in Inflow, Outflow, and Bulk Precipitation Samples During Post-Modification Monitoring.

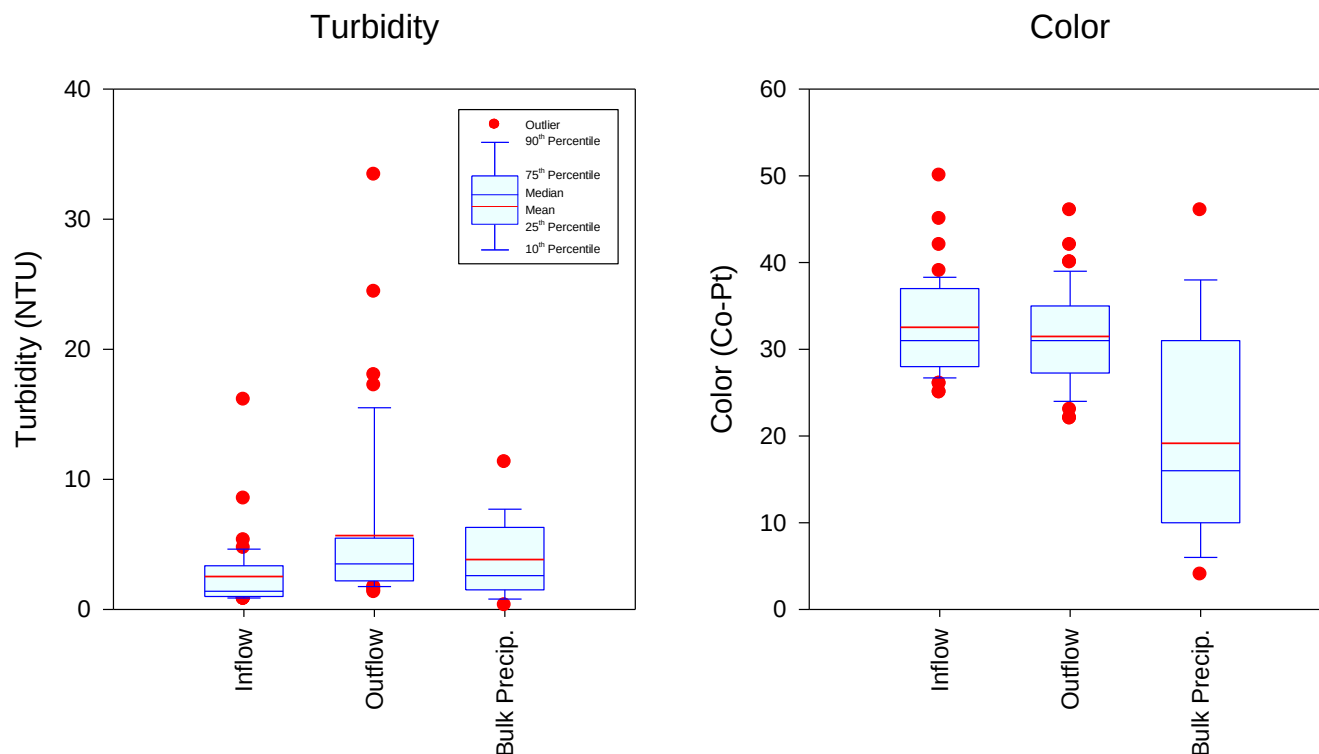


Figure 44. Statistical Comparison of Measured Concentrations of Turbidity and Color in Inflow, Outflow, and Bulk Precipitation Samples During Post-Modification Monitoring.

7.3.5 Chlorophyll-a

A graphical summary of trends in chlorophyll-a concentrations in the PAFB pond during the post-modification monitoring program is given on Figure 45. A relatively elevated chlorophyll-a concentration of 192 mg/m³ was measured at the start of the post-modification monitoring period which reflects the continuation of the algal bloom which was initiated in the pond during April 2011, as indicated on Figure 21. However, after the algal bloom died off, chlorophyll-a concentrations were relatively consistent and low in value during the post-modification monitoring program, with the majority of measured concentrations equal to approximately 25 mg/m³ or less. A tabular summary of measured chlorophyll-a concentrations during the post-modification monitoring period is given on Table 23. The overall geometric mean value for chlorophyll-a of 15.3 mg/m³ during the post-modification monitoring program is approximately 36% less than the pre-modification monitoring geometric mean value of 23.9 mg/m³.

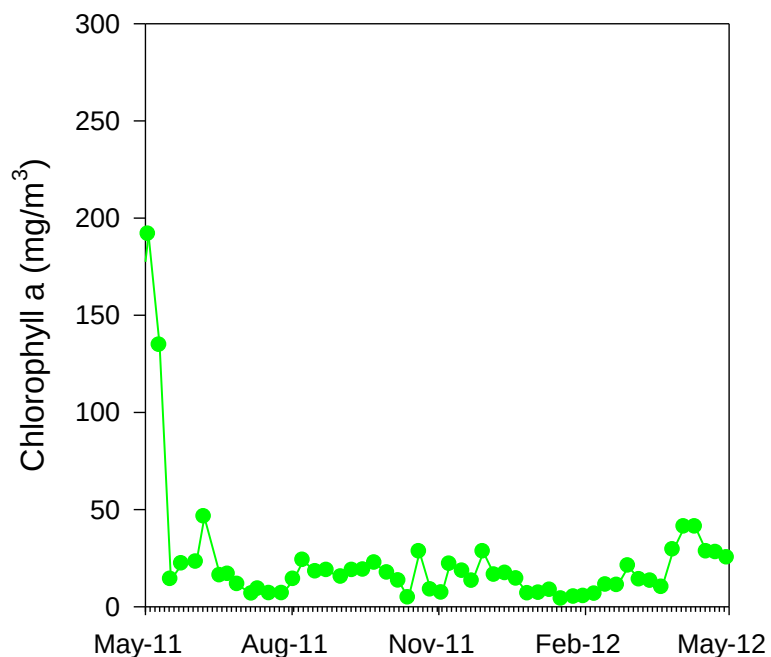


Figure 45. Trends in Chlorophyll-a Concentrations in the PAFB Pond During the Post-Modification Monitoring Program.

TABLE 23

**SUMMARY OF MEASURED CHLOROPHYLL-A
CONCENTRATIONS DURING THE POST-MODIFICATION
MONITORING PROGRAM**

PARAMETER	UNITS	VALUE
Minimum Value	mg/m ³	3.7
Maximum Value	mg/m ³	192
Geometric Mean Value	mg/m ³	15.3

7.4 Nutrient Budgets

Estimates of mass inputs and losses to the pond during the 12-month post-modification monitoring program were conducted for the evaluated species of nitrogen and phosphorus, as well as TSS. Mass inputs and losses to the pond were calculated on a monthly basis for inflow, bulk precipitation, outflow, and losses to shallow groundwater. Mass inputs and losses during the post-modification monitoring program were calculated in the same manner used for estimation of inputs and losses during the pre-modification monitoring program (summarized in Section 5.4). Mean monthly concentrations were calculated for each evaluated parameter and each input or loss from the pond. The mean concentrations were then multiplied by the monthly hydrologic inputs or losses (summarized in Table 16). Each of the calculated monthly inputs and losses were summed to provide estimates of inputs and losses for inflow, bulk precipitation, outflow, and groundwater losses during the 12-month post-modification monitoring program. This analyses assumes that discharges into groundwater are similar to the characteristics of pond discharge samples measured at the outflow. A summary of calculations used to estimate monthly concentrations, mass inputs, and mass losses during the post-modification monitoring program is given in Appendix E.

A summary of mass inputs, losses, and removal efficiencies for the western pond during the post-modification monitoring program is given on Table 24. Overall, the pond removed approximately 15% of the mass inputs of ammonia and 33% of the mass inputs of NO_x. However, a mass export of approximately 8% was observed for dissolved organic nitrogen and 1% for particulate nitrogen, presumably due to inorganic nitrogen incorporated into algal biomass which discharged through the outfall structure. This export of particulate nitrogen resulted in a net export of approximately 2% for total nitrogen during the post-modification monitoring program.

The PAFB pond exhibited a good removal efficiency for SRP, with a 36% reduction in loadings, with dissolved organic phosphorus loadings reduced by approximately 14%, and particulate phosphorus reduced by 11%. Overall, the pond removed approximately 20% of the total phosphorus loadings.

The PAFB pond exhibited a net export of TSS of approximately 88%. This export of TSS is presumably related to the observed mass exports for particulate nitrogen and particulate phosphorus resulting from incorporation of inorganic nitrogen and inorganic phosphorus into algal biomass.

The mass removal efficiencies summarized on Table 24 for the pre-modification period are compared with the pond removal efficiencies measured during the post-modification monitoring program to evaluate potential enhancement in pond performance efficiencies resulting from implementation of the Beemat floating wetland system.

TABLE 24

**SUMMARY OF MASS INPUTS, LOSSES, AND
REMOVAL EFFICIENCIES FOR THE PAFB POND DURING
THE POST-MODIFICATION MONITORING PROGRAM**

PARAMETER	INPUTS (kg)			LOSSES (kg)			REMOVAL EFFICIENCY (%)
	Inflow	Bulk Precipitation	Total	Outflow	Groundwater	Total	
NH ₃ -N	2.71	0.32	3.04	2.21	0.37	2.58	15
NO _x -N	1.13	0.08	1.21	0.71	0.09	0.81	33
Dissolved Organic N	43.6	0.14	43.7	41.3	5.74	47.1	-8
Particulate N	16.1	0.46	16.6	14.6	2.12	16.7	-1
Total N	68.0	1.04	69.0	61.8	8.78	70.5	-2
SRP	9.65	0.06	9.71	5.44	0.76	6.20	36
Dissolved Organic P	2.09	0.04	2.13	1.58	0.24	1.82	14
Particulate P	3.11	0.20	3.31	3.19	0.48	3.66	-11
Total P	15.7	0.31	16.0	11.1	1.60	12.7	20
TSS	138	11.5	150	241	39.8	281	-88

8. Performance Efficiency of the Beemat Systems

Estimates of the performance efficiency of the Beemat floating island systems are provided in this section. Performance efficiencies were evaluated using four separate methods which included: (1) a comparison of pre- and post-modification mass removal efficiencies; (2) a statistical comparison of pre- and post-modification water quality characteristics of the inflow, outflow, and bulk precipitation samples; (3) a comparison of pre- and post-modification areal uptake rates for the pond; and (4) an analysis of direct plant uptake. A discussion is also provided of hydraulic detention times in the pond under pre- and post-modification conditions. Each of these evaluations is discussed in the following sections.

8.1 Impacts of Hydraulic Detention Time

Research conducted by ERD as well as others has indicated that the single most important factor affecting the performance efficiency of wet detention ponds is the detention time for the runoff within the pond. Hydraulic detention time is defined as:

$$d_t = PPV \div RO$$

where:

d_t	=	detention time
PPV	=	permanent pool volume (ac-ft)
RO	=	runoff inputs/unit time

Calculations were conducted to estimate the mean detention time for the PAFB pond during the pre- and post-modification periods. A summary of this analysis is given in Table 25. The pre-modification monitoring program lasted for a period of 120 days. As indicated on Table 5, the total runoff inflow entering the pond during the pre-modification period was approximately 8.91 ac-ft. An estimate of the mean pond volume during the pre-modification period was conducted using the stage-area-volume relationships for the pond (summarized in Table 1). Based upon the measured water surface elevation summarized in Figure 9, the mean pond elevation during the pre-modification monitoring program was approximately 2.03 ft, corresponding to a mean pond volume of 2.24 ac-ft. Using the relationship for detention time presented previously, the average detention time for runoff inputs in the PAFB pond during the pre-modification period was approximately 30 days.

TABLE 25
CALCULATED DETENTION TIMES FOR THE PAFB
POND DURING PRE- AND POST-MODIFICATION CONDITIONS

CONDITION	DURATION (days)	RUNOFF INFLOW (ac-ft)	MEAN POND ELEVATION (ft)	MEAN POND VOLUME (ac-ft)	AVERAGE DETENTION TIME (days)
Pre	120	8.91	2.03	2.24	30
Post	365	68.09	2.11	2.29	12

A summary of the post-modification detention time calculations is given in the last row of Table 25. The post-modification program lasted for a period of 365 days. As indicated on Table 18, the total runoff inflow into the pond during this period was approximately 68.09 ac-ft. Based upon the measured surface water elevations during the post-modification monitoring period (summarized on Figure 33), the mean pond elevation was approximately 2.11 ft which corresponds to a mean pond volume of 2.29 ac-ft and a calculated mean detention time of 12 days.

A summary of the calculated average detention time within the PAFB pond under pre- and post-modification conditions is given in the final column of Table 25. During the pre-modification period, the mean residence time for runoff inputs was approximately 30 days, compared with an average detention time of only 12 days for runoff inputs during the post-modification program. Since the performance efficiency of wet detention ponds is a function of detention time, the pond would be expected to exhibit a greater removal efficiency under pre-modification conditions than under post-modification conditions. However, the relationship between removal efficiency and detention time is non-linear and the difference in removal efficiencies cannot be estimated as a simple ratio of the detention times. However, all other things being equal, it would be expected that the pond would exhibit a greater removal efficiency during pre-treatment conditions than during post-treatment conditions in the absence of the Beemat systems.

8.2 Comparison of Pre- and Post-Modification Mass Removal Efficiencies

A discussion of pre-modification mass removal efficiencies for the PAFB pond was given in Section 5.4, with a discussion of post-modification mass removal efficiencies provided in Section 7.4. A comparison of mass removal efficiencies for the PAFB pond during pre- and post-modification periods is given on Table 26. The pre-modification removal efficiencies summarized in this table reflect the monitoring period from January-April 2011, while the post-modification removal efficiencies reflect the post-modification monitoring period from May 2011-April 2012. During the post-modification period, the performance efficiency at the pond was enhanced, compared with the pre-modification period, for NO_x, particulate nitrogen, total nitrogen, particulate phosphorus, and TSS. However, each of these parameters except NO_x still exhibited a net increase in loadings through the outfall structure compared with the monitored inputs from stormwater runoff and bulk precipitation, except the magnitude of the increases in loadings through the outfall structure were less than observed during pre-modification conditions. The monitored removal efficiencies within the pond decreased under post-modification conditions for ammonia, dissolved organic nitrogen, SRP, dissolved organic phosphorus, and total phosphorus. Some of these differences may be related to the observed differences in mean detention times under pre- and post-modification conditions.

TABLE 26
COMPARISON OF MASS REMOVAL
EFFICIENCIES FOR THE PAFB POND DURING THE
PRE- AND POST-MODIFICATION PERIODS

PARAMETER	MASS REMOVAL (%)		CHANGE IN REMOVAL (%)
	Pre-Modification	Post-Modification	
Ammonia	25	15	-40
NO _x	19	33	74
Dissolved Organic N	-1	-8	-700
Particulate N	-55	-1	98
Total N	-28	-2	93
SRP	81	36	-56
Dissolved Organic P	33	14	-58
Particulate P	-30	-11	63
Total P	48	20	-58
TSS	-155	-88	43

The fact that the pond appears to export more total nitrogen, particulate phosphorus, and TSS through the outfall than enters the pond through stormwater runoff and bulk precipitation suggests a significant additional source of nutrients into the pond which is not included in the estimates for runoff and bulk precipitation. One potential additional source of nutrient loadings into the pond is influx from shallow groundwater. However, the comparative water level elevations for the pond and shallow groundwater discussed in previous sections indicate that groundwater influx into the pond is minimal and, in many cases, the data reflect a net movement of water from the pond into the adjacent groundwater.

A more likely explanation for the additional un-quantified nutrient inputs is waterfowl. As discussed in Section 6, a wide variety of waterfowl were attracted to the floating Beemat islands which used the islands as both a source of food and a roosting place. ERD has conducted multiple previous projects that have indicated that waterfowl can contribute significant nutrient loadings to waterbodies, and on at least two occasions, waterfowl have been shown to create a larger nutrient loading to the receiving water than stormwater runoff. There was no method to account for the additional loadings created by waterfowl as part of this project. The presence of waterfowl is highly consistent with the reductions in removal efficiencies observed for the nutrient species common in waterfowl wastes, such as ammonia, dissolved organic nitrogen, SRP, and dissolved organic phosphorus. If the waterfowl had not been present, the post-modification loadings discharging from the pond would have been less, resulting in improvements in the calculated post-modification efficiency estimates. However, the attraction of the waterfowl to the Beemat islands must be considered as part of the overall effectiveness of this technique since waterfowl appear to be an unavoidable consequence of this technology. Although waterfowl are a logical source of the additional un-quantified nutrient loadings, other potential sources include landscaping activities on the golf course and irrigation over-spray and direct runoff into the pond.

The mass removal efficiencies summarized in Table 26 are based upon different periods of the year since the pre-modification monitoring occurred over a four-month period from January-April 2011, while the post-modification monitoring occurred over a 12-month period from May 2011-April 2012. A more comparable comparison may be to compare the pre-modification period from January-April with the same period under post-modification conditions. A tabular comparison of mass removals from the pond under pre-modification and post-modification conditions for the period from January-April is given in Table 27. Although the calculated post-modification removal efficiencies are different when only the period from January-April is considered, the overall conclusions remain relatively unchanged. Decreases in performance efficiencies under post-modification conditions were observed for dissolved organic nitrogen, SRP, dissolved organic phosphorus, particulate phosphorus, and total phosphorus. A slight increase in removal efficiency for ammonia was observed compared with a decrease in removal efficiency summarized in Table 26. However, the data summarized in Table 27 provide further evidence of additional nutrient loadings which are not considered in the inflow and bulk precipitation monitoring.

Based on the discussion provided above, it appears that the presence of additional nutrient loadings, presumably from waterfowl, are off-setting nutrient uptake achieved by the Beemat systems. However, if waterfowl are attracted to these systems, then the impacts of the waterfowl will have to be considered in evaluating the overall performance efficiency of the floating islands. Based upon the information summarized in Tables 26 and 27, it appears that the additional nutrient inputs by waterfowl exceeds the uptake by the plants, resulting in an overall reduction in performance efficiency under post-modification conditions.

TABLE 27

**COMPARISON OF MASS REMOVAL
PERIODS FROM JANUARY-APRIL UNDER PRE-
AND POST-MODIFICATION CONDITIONS**

PARAMETER	MASS REMOVAL ¹ (%)		CHANGE IN REMOVAL (%)
	Pre-Modification	Post-Modification	
Ammonia	25	26	4
NO _x	19	49	158
Dissolved Organic N	-1	-14	-1300
Particulate N	-55	-33	40
Total N	-28	-18	36
SRP	81	50	-38
Dissolved Organic P	33	-167	-606
Particulate P	-30	-33	-10
Total P	48	14	-71
TSS	-155	-106	32

1. Using pre-modification(January-April) and post-modification (January-April) periods

8.3 Statistical Comparison of Pre- and Post- Modification Water Quality Characteristics

Statistical comparisons of pre- and post-modification water quality characteristics were evaluated using analysis of variance (ANOVA) techniques to determine if statistically significant differences exist between measured characteristics for field and laboratory parameters under pre- and post-modification conditions. These ANOVA comparisons were conducted using the PROC GLM (general linear model) module of the Statistical Analysis System (SAS) which is best suited for statistical comparison of unbalanced data sets.

A summary of ANOVA comparisons of pre- vs. post-modification field measurements collected at the PAFB pond from January 2011-April 2012 is given on Table 28. This analysis assumes a four-month pre-modification period from January-April 2011 and a 12-month post-modification period from May 2011-April 2012. For each comparison, information is provided on the model significance level, with values less than 0.05 indicating a statistically significant difference at the 95% confidence level. Mean values are provided for the evaluated parameter under pre- and post-modification conditions along with the number of samples included in the analysis. A Tukey grouping procedure is provided in the final column of Table 28, with different letters indicating statistically significant differences between the pre- and post- measurements. Separate statistical analyses were conducted for field measurements collected at top, middle, and bottom measurement locations within the pond using the multi-port sampling device described in Section 3.4.

TABLE 28

**ANOVA COMPARISON OF PRE- vs. POST-MODIFICATION
FIELD MEASUREMENTS COLLECTED AT THE PAFB BEEMAT
POND SITE FROM JANUARY 2011 - APRIL 2012**

DEPTH	PARAMETER	UNITS	MODEL SIGNIFICANCE LEVEL	TREATMENT TYPE ¹	MEAN VALUE	NUMBER OF SAMPLES	TUKEY GROUPING
Top	Temperature	°C	0.0008	Post Pre	24.55 20.03	53 17	A B
	pH	s.u.	0.0001	Pre Post	8.24 7.81	17 53	A B
	Conductivity	µmho/cm	0.0001	Post Pre	1,291 1,162	53 17	A B
	Diss. Oxygen	mg/l	0.0008	Pre Post	8.7 6.6	17 53	A B
	D.O. Saturation	%	0.0082	Pre Post	94 78	17 53	A B
	ORP	mV	0.5585	Pre Post	468 459	17 53	A A
Middle	Temperature	°C	0.0008	Post Pre	24.52 20.00	53 17	A B
	pH	s.u.	0.0001	Pre Post	8.20 7.76	17 53	A B
	Conductivity	µmho/cm	0.0001	Post Pre	1,291 1,165	53 17	A B
	Diss. Oxygen	mg/l	0.0001	Pre Post	7.99 6.00	17 53	A B
	D.O. Saturation	%	0.0003	Pre Post	87 71	17 53	A B
	ORP	mV	0.0001	Pre Post	461 307	17 53	A B
Bottom	Temperature	°C	0.0006	Post Pre	24.46 19.87	53 17	A B
	pH	s.u.	0.0016	Pre Post	8.00 7.71	17 53	A B
	Conductivity	µmho/cm	0.0001	Post Pre	1,300 1,159	53 17	A B
	Diss. Oxygen	mg/l	0.0028	Pre Post	6.9 5.5	17 53	A B
	D.O. Saturation	%	0.0200	Pre Post	75 65	17 53	A B
	ORP	mV	0.0001	Pre Post	428 255	17 53	A B

1. Pre: Pre-modification period from January-April 2011
Post: Post-modification period from May 2011-April 2012

As indicated on Table 28, statistically significant differences were observed between pre- and post-modification conditions for each of the evaluated parameters at the top, middle, and bottom monitoring locations with the exception of ORP measured in the top sample port. However, many of the statistically significant differences observed between pre- and post-modification conditions are due simply to seasonal differences resulting from the longer period of time included in the post-monitoring program compared with the pre-monitoring program. The post-development samples were characterized by a higher temperature, lower dissolved oxygen, lower dissolved oxygen saturation, and a slightly lower ORP value, all of which are temperature-related parameters reflecting the wider range and generally higher temperatures measured under the post-modification period compared with the pre-modification period.

An ANOVA comparison of pre-modification vs. post-modification field measurements including only the common period from January-April is given on Table 29. Based upon this comparison, statistically significant differences under pre- and post- conditions were observed for pH at the top and middle monitoring depths, both of which are indicative of a lower overall level of productivity within the pond under post-modification conditions. Statistically significant differences were also observed between conductivity measurements under pre- and post-modification conditions, although these differences are more likely related to differences in inflow characteristics than impacts from the floating vegetation.

An ANOVA comparison of water quality characteristics of inflow samples under pre- and post-modification conditions is given on Table 30. This analysis compares the four-month pre-modification period with the 12-month post-modification period. Inflow concentrations of conductivity were statistically lower during the pre-modification period than during post-modification conditions which also explains the statistically significant differences observed for conductivity measurements conducted in the pond. The 12-month post-modification monitoring program was characterized by statistically lower inflow concentrations for particulate nitrogen, total nitrogen, SRP, total phosphorus, and TSS. Since plant nutrient uptake is a concentration-based process, the lower input concentrations for species of nitrogen and phosphorus under post-modification conditions may have impacted the rate of uptake of nutrients by the plant species.

An ANOVA comparison of pre- and post-modification inflow samples over the common period from January-April is given in Table 31. When only the overlapping periods of January-April are included in the analysis, the post-modification inflow samples exhibited statistically lower levels for alkalinity, ammonia, dissolved organic nitrogen, particulate nitrogen, total nitrogen, SRP, total phosphorus, TSS, and turbidity. The performance efficiency of the pond was likely impacted by the statistically lower concentrations which occurred during the post-modification monitoring period from January-April. Removal processes within the pond as well as nutrient uptake by plants are both concentration-based processes which would occur at a lower rate given the lower inflow concentrations during the common period from January-April.

An ANOVA comparison of pre- vs. post-modification characteristics of bulk precipitation samples is given in Table 32. No statistically significant differences were observed in bulk precipitation samples with the exception of NO_x which was statistically lower during post-modification monitoring than during pre-modification monitoring.

TABLE 29

**ANOVA COMPARISON OF PRE- vs. POST-
MODIFICATION FIELD MEASUREMENTS COLLECTED AT
THE PAFB BEEMAT POND SITE FROM JANUARY - APRIL**

DEPTH	PARAMETER	UNITS	MODEL SIGNIFICANCE LEVEL	TREATMENT TYPE ¹	MEAN VALUE	NUMBER OF SAMPLES	TUKEY GROUPING
Top	Temperature	°C	0.7289	Pre Post	20.03 19.62	17 18	A A
	pH	s.u.	0.0001	Pre Post	8.24 7.88	17 18	A B
	Conductivity	µmho/cm	0.0001	Post Pre	1,264 1,162	18 17	A B
	Diss. Oxygen	mg/l	0.3645	Pre Post	8.7 8.0	17 18	A A
	D.O. Saturation	%	0.2489	Pre Post	94 87	17 18	A A
	ORP	mV	0.3293	Post Pre	486 468	18 17	A A
Middle	Temperature	°C	0.7398	Pre Post	20.00 19.60	17 18	A A
	pH	s.u.	0.0001	Pre Post	8.20 7.81	17 18	A B
	Conductivity	µmho/cm	0.0001	Post Pre	1,265 1,165	18 17	A B
	Diss. Oxygen	mg/l	0.1546	Pre Post	8.0 7.3	17 18	A A
	D.O. Saturation	%	0.0520	Pre Post	87 79	17 18	A A
	ORP	mV	0.0001	Pre Post	461 161	17 18	A B
Bottom	Temperature	°C	0.8091	Pre Post	19.87 19.59	17 18	A A
	pH	s.u.	0.0806	Pre Post	8.00 7.82	17 18	A A
	Conductivity	µmho/cm	0.0001	Post Pre	1,287 1,159	18 17	A B
	Diss. Oxygen	mg/l	0.7934	Post Pre	7.0 6.9	18 17	A A
	D.O. Saturation	%	0.8578	Post Pre	75 75	18 17	A A
	ORP	mV	0.0001	Pre Post	428 127	17 18	A B

1. Pre: Pre-modification period from January-April 2011
Post: Post-modification period from May 2011-April 2012

TABLE 30

**ANOVA COMPARISON OF PRE- vs. POST-
MODIFICATION WATER QUALITY CHARACTERISTICS
OF INFLOW SAMPLES COLLECTED AT THE PAFB BEEMAT
POND SITE FROM JANUARY 2011 - APRIL 2012**

PARAMETER	UNITS	MODEL SIGNIFICANCE LEVEL	TREATMENT TYPE ¹	MEAN CONCENTRATION	NUMBER OF SAMPLES	TUKEY GROUPING
pH	s.u.	0.0060	Pre Post	7.69 7.52	13 46	A B
Conductivity	µmho/cm	0.0005	Post Pre	1,235 1,125	46 13	A B
Alkalinity	mg/l	0.0588	Pre Post	200 183	13 46	A A
Ammonia	µg/l	0.4716	Pre Post	91 63	13 46	A A
NO _x	µg/l	0.2167	Pre Post	28 19	13 46	A A
Diss. Organic N	µg/l	0.1163	Pre Post	587 511	13 46	A A
Particulate N	µg/l	0.0488	Pre Post	302 191	13 46	A B
Total N	µg/l	0.0040	Pre Post	1,007 784	13 46	A B
SRP	µg/l	0.0175	Pre Post	188 113	13 46	A B
Diss. Organic P	µg/l	0.1746	Pre Post	42 27	13 46	A A
Particulate P	µg/l	0.2867	Pre Post	51 39	13 46	A A
Total P	µg/l	0.0106	Pre Post	281 179	13 46	A B
TSS	mg/l	0.0002	Pre Post	4.3 1.8	13 46	A B
Color	Pt-Co	0.2349	Post Pre	33 31	46 13	A A
Turbidity	NTU	0.4222	Pre Post	3.2 2.5	13 46	A A

1. Pre: Pre-modification period from January-April 2011
Post: Post-modification period from May 2011-April 2012

TABLE 31

**ANOVA COMPARISON OF PRE- vs. POST-
MODIFICATION WATER QUALITY CHARACTERISTICS
OF INFLOW SAMPLES COLLECTED AT THE PAFB
BEEMAT POND SITE FROM JANUARY - APRIL**

PARAMETER	UNITS	MODEL SIGNIFICANCE LEVEL	TREATMENT TYPE ¹	MEAN CONCENTRATION	NUMBER OF SAMPLES	TUKEY GROUPING
pH	s.u.	0.2244	Pre Post	7.69 7.62	13 18	A A
Conductivity	µmho/cm	0.1315	Post Pre	1,161 1,125	18 13	A A
Alkalinity	mg/l	0.0106	Pre Post	200 181	13 18	A B
Ammonia	µg/l	0.0002	Pre Post	91 28	13 18	A B
NO _x	µg/l	0.4735	Pre Post	27 23	13 18	A A
Diss. Organic N	µg/l	0.0001	Pre Post	587 395	13 18	A B
Particulate N	µg/l	0.0153	Pre Post	301 120	13 18	A B
Total N	µg/l	0.0001	Pre Post	1,007 565	13 18	A B
SRP	µg/l	0.0025	Pre Post	188 112	13 18	A B
Diss. Organic P	µg/l	0.0749	Pre Post	42 18	13 18	A A
Particulate P	µg/l	0.0729	Pre Post	51 25	13 18	A A
Total P	µg/l	0.0001	Pre Post	281 155	13 18	A B
TSS	mg/l	0.0009	Pre Post	4.3 1.1	13 18	A B
Color	Pt-Co	0.5377	Pre Post	31 30	13 18	A A
Turbidity	NTU	0.0063	Pre Post	3.2 1.3	13 18	A B

1. Pre: Pre-modification period from January-April 2011
Post: Post-modification period from May 2011-April 2012

TABLE 32

**ANOVA COMPARISON OF PRE- vs. POST-
MODIFICATION WATER QUALITY CHARACTERISTICS OF
BULK PRECIPITATION SAMPLES COLLECTED AT THE PAFB
BEEMAT POND SITE FROM JANUARY 2011 - APRIL 2012**

PARAMETER	UNITS	MODEL SIGNIFICANCE LEVEL	TREATMENT TYPE ¹	MEAN CONCENTRATION	NUMBER OF SAMPLES	TUKEY GROUPING
pH	s.u.	0.8024	Pre Post	6.12 6.06	4 20	A A
Conductivity	µmho/cm	0.7735	Pre Post	36 33	4 20	A A
Alkalinity	mg/l	0.5985	Post Pre	16.6 14.0	20 4	A A
Ammonia	µg/l	0.5772	Post Pre	147 112	20 4	A A
NO _x	µg/l	0.0487	Pre Post	119 42	4 20	A B
Diss. Organic N	µg/l	0.3313	Pre Post	80 60	4 20	A A
Particulate N	µg/l	0.1467	Post Pre	212 100	20 4	A A
Total N	µg/l	0.6859	Post Pre	460 410	20 4	A A
SRP	µg/l	0.5510	Post Pre	43 29	20 4	A A
Diss. Organic P	µg/l	0.3009	Post Pre	28 14	20 4	A A
Particulate P	µg/l	0.2709	Pre Post	148 100	4 20	A A
Total P	µg/l	0.7255	Pre Post	191 171	4 20	A A
TSS	mg/l	0.9813	Post Pre	5.9 5.8	20 4	A A
Color	Pt-Co	0.1634	Pre Post	31 20	4 20	A A
Turbidity	NTU	0.9775	Pre Post	3.9 3.8	4 20	A A

1. Pre: Pre-modification period from January-April 2011
Post: Post-modification period from May 2011-April 2012

An ANOVA comparison of pre-modification vs. post-modification bulk precipitation characteristics for the common monitoring period from January-April is given on Table 33. No statistically significant differences were observed in bulk precipitation concentrations for any evaluated parameter over the common period from January-April. In general, it appears that bulk precipitation was statistically similar during the pre- and post-modification periods.

An ANOVA comparison of pre-modification vs. post-modification water quality characteristics of outflow samples from the PAFB pond from January 2011-April 2012 is given on Table 34. When the entire pre- and post-modification periods are included, post-modification samples were characterized by significantly lower concentrations for pH, particulate nitrogen, total nitrogen, particulate phosphorus, and TSS, with pre-modification concentrations found to be statistically lower for conductivity and color. However, many of these parameters were also found to be statistically lower in the inflows during post-modification conditions, so it cannot be determined whether the statistically lower concentrations of these parameters under post-modification conditions is due to the lower inflows or a result of the floating Beemat islands.

As indicated on Table 34, statistically significant differences were observed in chlorophyll-a concentrations within the pond under pre- and post-modification conditions, with significantly lower chlorophyll-a concentrations during the post-modification period. As indicated on Figure 21, pre-modification chlorophyll-a concentrations within the pond were relatively low in value over the period from January-March 2011. However, a significant microcystis algal bloom occurred within the pond during April 2011, with peak concentrations in excess of 250 mg/m³. The significant algal bloom resulted in a substantial increase in the mean chlorophyll-a concentration during the pre-modification monitoring program. As indicated on Figure 45, the late spring algal bloom did not occur during the post-modification monitoring program, resulting in a substantially lower mean chlorophyll-a concentration. Other studies have also observed that introduction of floating wetland islands reduces the frequency of algal blooms within ponds, and this phenomenon also appears to have occurred in the PAFB pond. Although changes in nutrient concentrations within the pond could not be detected analytically, the water column may have been more aesthetically pleasing under post-modification conditions due to the absence of significant algal blooms.

An ANOVA comparison of pre-modification vs. post-modification outflow characteristics over the common monitoring period from January-April is given on Table 35. Post-modification samples were characterized by statistically lower values for pH, ammonia, dissolved organic nitrogen, particulate nitrogen, total nitrogen, particulate phosphorus, TSS, and turbidity compared with pre-modification outflow samples. However, as indicated previously, many of these parameters also were statistically lower in the inflows, making it difficult to determine if the observed statistically significant differences are due to differences in inflow characteristics or a result of impacts from the floating vegetation.

As indicated on Table 35, chlorophyll-a concentrations within the pond were significantly lower during the period from January-April under post-modification conditions than under pre-modification conditions. This phenomenon was also observed in Table 34 which compared the entire pre- and post-modification periods. The data suggests that the presence of the floating vegetation islands reduces the potential for significant algal blooms within the pond.

The analysis of variance tests summarized previously reveal statistically significant differences in inflows and outflows under pre- and post-modification conditions. The fact that statistically significant differences were observed in the inflows under these conditions makes it difficult to determine if the statistically significant differences observed in the outflow are simply due to differences in inflow characteristics or impacts from the floating wetland systems.

TABLE 33

**ANOVA COMPARISON OF PRE- vs. POST-
MODIFICATION WATER QUALITY CHARACTERISTICS
OF BULK PRECIPITATION SAMPLES COLLECTED AT THE
PAFB BEEMAT POND SITE FROM JANUARY - APRIL**

PARAMETER	UNITS	MODEL SIGNIFICANCE LEVEL	TREATMENT TYPE ¹	MEAN CONCENTRATION	NUMBER OF SAMPLES	TUKEY GROUPING
pH	s.u.	0.9822	Post	6.13	5	A
			Pre	6.12	4	A
Conductivity	µmho/cm	0.1180	Pre	36	4	A
			Post	25	5	A
Alkalinity	mg/l	0.4130	Post	19.8	5	A
			Pre	14.0	4	A
Ammonia	µg/l	0.2122	Post	217	5	A
			Pre	112	4	A
NO _x	µg/l	0.5211	Pre	119	4	A
			Post	72	5	A
Diss. Organic N	µg/l	0.1455	Pre	80	4	A
			Post	41	5	A
Particulate N	µg/l	0.8461	Pre	100	4	A
			Post	89	5	A
Total N	µg/l	0.9591	Post	418	5	A
			Pre	410	4	A
SRP	µg/l	0.1034	Post	66	5	A
			Pre	29	4	A
Diss. Organic P	µg/l	0.0998	Post	44	5	A
			Pre	14	4	A
Particulate P	µg/l	0.1091	Pre	148	4	A
			Post	58	5	A
Total P	µg/l	0.7193	Pre	191	4	A
			Post	168	5	A
TSS	mg/l	0.7500	Post	7.3	5	A
			Pre	5.8	4	A
Color	Pt-Co	0.3481	Pre	31	4	A
			Post	18	5	A
Turbidity	NTU	0.8092	Post	4.5	5	A
			Pre	3.9	4	A

1. Pre: Pre-modification period from January-April 2011
Post: Post-modification period from May 2011-April 2012

TABLE 34

**ANOVA COMPARISON OF PRE- vs. POST-
MODIFICATION WATER QUALITY CHARACTERISTICS
OF OUTFLOW SAMPLES COLLECTED AT THE PAFB BEEMAT
POND SITE FROM JANUARY 2011 - APRIL 2012**

PARAMETER	UNITS	MODEL SIGNIFICANCE LEVEL	TREATMENT TYPE ¹	MEAN CONCENTRATION	NUMBER OF SAMPLES	TUKEY GROUPING
pH	s.u.	0.0001	Pre Post	7.89 7.60	13 44	A B
Conductivity	µmho/cm	0.0001	Post Pre	1,243 1,044	44 13	A B
Alkalinity	mg/l	0.3573	Post Pre	177 166	44 13	A A
Ammonia	µg/l	0.7946	Pre Post	62 56	13 44	A A
NO _x	µg/l	0.1882	Pre Post	57 20	13 44	A A
Diss. Organic N	µg/l	0.3570	Pre Post	607 565	13 44	A A
Particulate N	µg/l	0.0013	Pre Post	506 228	13 44	A B
Total N	µg/l	0.0005	Pre Post	1,232 868	13 44	A B
SRP	µg/l	0.3306	Post Pre	76 48	44 13	A A
Diss. Organic P	µg/l	0.1018	Post Pre	29 17	44 13	A A
Particulate P	µg/l	0.0320	Pre Post	80 52	13 44	A B
Total P	µg/l	0.7175	Post Pre	158 145	44 13	A A
TSS	mg/l	0.0272	Pre Post	9.8 5.2	13 44	A B
Chlorophyll-a	mg/m ³	0.0025	Pre Post	72.6 22.1	14 53	A B
Color	Pt-Co	0.0001	Post Pre	31 24	44 13	A B
Turbidity	NTU	0.7046	Pre Post	6.4 5.7	13 44	A A

1. Pre: Pre-modification period from January-April 2011
Post: Post-modification period from May 2011-April 2012

TABLE 35

**ANOVA COMPARISON OF PRE- vs. POST-
MODIFICATION WATER QUALITY CHARACTERISTICS
OF OUTFLOW SAMPLES COLLECTED AT THE PAFB
BEEMAT POND SITE FROM JANUARY - APRIL**

PARAMETER	UNITS	MODEL SIGNIFICANCE LEVEL	TREATMENT TYPE ¹	MEAN CONCENTRATION	NUMBER OF SAMPLES	TUKEY GROUPING
pH	s.u.	0.0023	Pre Post	7.89 7.68	13 17	A B
Conductivity	µmho/cm	0.0021	Post Pre	1,183 1,044	17 13	A B
Alkalinity	mg/l	0.1237	Post Pre	182 166	17 13	A A
Ammonia	µg/l	0.0111	Pre Post	62 24	13 17	A B
NO _x	µg/l	0.4140	Pre Post	57 20	13 17	A A
Diss. Organic N	µg/l	0.0011	Pre Post	607 468	13 17	A B
Particulate N	µg/l	0.0127	Pre Post	506 177	13 17	A B
Total N	µg/l	0.0002	Pre Post	1,232 689	13 17	A B
SRP	µg/l	0.5174	Post Pre	65 48	17 13	A A
Diss. Organic P	µg/l	0.0136	Post Pre	33 17	17 13	A B
Particulate P	µg/l	0.0164	Pre Post	80 40	13 17	A B
Total P	µg/l	0.7896	Pre Post	145 138	13 17	A A
TSS	mg/l	0.0003	Pre Post	9.8 2.5	13 17	A B
Chlorophyll-a	mg/m ³	0.0298	Pre Post	72.6 17.0	14 18	A B
Color	Pt-Co	0.0001	Post Pre	31 24	17 13	A B
Turbidity	NTU	0.0142	Pre Post	6.4 2.9	13 17	A B

1. Pre: Pre-modification period from January-April 2011
Post: Post-modification period from May 2011-April 2012

8.4 Comparison of Pre- and Post-Modification Areal Pond Uptake Rates

Another method of comparing the performance efficiency of the pond system is to conduct a comparison of pre- vs. post-modification areal nutrient uptake rates. This analysis provides an estimate of the removal or uptake by the overall pond system in terms of $\text{mg/m}^2\text{-day}$ for each evaluated parameter. This analysis allows an evaluation and comparison of nutrient uptake which is normalized for the period of time over which the evaluation was performed. This analysis was conducted by subtracting nutrient losses through the outfall structure from the sum of nutrient inputs into the pond from runoff inflow and bulk precipitation. The mass removal is then divided by the area of the pond (m^2) and the number of days over which the evaluations were conducted.

A tabular comparison of pre- vs. post-modification areal nutrient uptake by the PAFB pond system is given on Table 36. Uptake values are provided for the pre-modification period from January-April 2011, the overall post-modification period from May 2011-April 2012, and the post-modification period from January-April 2012 only.

TABLE 36
COMPARISON OF PRE- VS. POST-MODIFICATION
AREAL NUTRIENT UPTAKE BY THE PAFB POND SYSTEM

PARAMETER	PRE-MODIFICATION (January-April 2011)			POST-MODIFICATION (May 2011-April 2012)			POST-MODIFICATION (January-April 2012)		
	Inputs (kg)	Losses (kg)	Uptake ($\text{mg/m}^2\text{-day}$)	Inputs (kg)	Losses (kg)	Uptake ($\text{mg/m}^2\text{-day}$)	Inputs (kg)	Losses (kg)	Uptake ($\text{mg/m}^2\text{-day}$)
Ammonia	0.86	0.64	0.76	3.04	2.58	0.52	0.50	0.37	0.46
NO_x	0.27	0.22	0.17	1.21	0.81	0.46	0.32	0.16	0.54
Diss. Org. N	6.3	6.3	-0.17	43.7	47.1	-3.9	7.92	9.06	-4.0
Particulate N	4.0	6.1	-7.53	16.6	16.7	-0.11	2.66	3.54	-3.1
Total N	11.6	14.8	-11.3	69.0	70.5	-1.8	11.8	13.9	-7.4
SRP	1.87	0.35	5.3	9.71	6.20	4.0	2.14	1.08	3.7
Diss. Org. P	0.25	0.17	0.30	2.13	1.82	0.35	0.20	0.54	-1.2
Particulate P	0.74	0.96	-0.77	3.31	3.66	-0.40	0.61	0.82	-0.71
Total P	3.12	1.63	5.2	16.0	12.7	3.7	3.09	2.65	1.5
TSS	42.4	108	-230	150	281	-151	24.6	50.6	-91

During the four-month pre-modification monitoring period, the pond exhibited a net uptake for ammonia, NO_x , SRP, dissolved organic phosphorus, and total phosphorus, with net export from the pond for dissolved organic nitrogen, particulate nitrogen, total nitrogen, particulate phosphorus, and TSS. These data suggest that even under pre-modification conditions, additional nutrient inputs occurred into the pond which resulted in an increase in total nitrogen. Potential sources of these additional nutrient inputs include golf course activities, overspray of irrigation water onto the pond surface, and waterfowl roosting in the emergent vegetation around the perimeter of the pond. The observed increases in particulate nitrogen, particulate phosphorus, and TSS are consistent with algal growth within the pond which is measured as particulate matter in the outfall.

Under post-modification conditions, considering the 12-month monitoring program, a net uptake within the pond was observed for ammonia, NO_x, SRP, dissolved organic phosphorus, and total phosphorus, all of which exhibited a net uptake during the pre-modification program as well. Based upon the 12-month post-modification monitoring program, the net uptake of ammonia, dissolved organic nitrogen, SRP, and total phosphorus was reduced compared with uptake observed during pre-modification conditions. Net areal uptake of NO_x, particulate nitrogen, total nitrogen, particulate phosphorus, and TSS increased, although there was still a net increase in loadings between the inputs and losses.

When the post-modification period from January-April only is considered, the pond appears to exhibit a net increase in uptake for NO_x, particulate nitrogen, total nitrogen, particulate phosphorus, and TSS compared with the pre-modification uptake values, although each of these except NO_x still reflects a condition where losses from the pond exceed the monitored inputs.

As discussed in the previous section, additional un-quantified nutrient inputs into the pond appear to be masking potential water quality improvements achieved by the floating Beemat systems. The additional nutrient loadings are also apparent under pre-modification conditions, and sources such as waterfowl, golf course maintenance activities, and irrigation over-spray cannot be eliminated.

8.5 Direct Plant Uptake

Each of the performance efficiency evaluation methods discussed previously are inconclusive regarding the additional benefits of the floating wetland system. As a result, the most applicable method of evaluating the nutrient uptake by the floating wetland system is the direct measurement of changes in nutrient content within the plants during the 12-month post-modification program. A summary of changes in nutrient concentrations in plant matter during the post-modification monitoring program was previously provided in Section 6.2.2.

A tabular summary in changes of total mass uptake of nitrogen and phosphorus during the post-modification period is given on Table 37. The information summarized in this table is obtained from the analysis of plant uptake discussed in Section 6.2. Information on the assumed number of plants is provided for each of the six monitoring dates, along with the total wet and dry mass of plant material. A summary of nitrogen and phosphorus contained in the plant material over time is given in the final two columns of Table 37. Overall, the plant material contained approximately 4217 g (4.2 kg) of nitrogen and 2324 g (2.3 kg) of phosphorus at the end of the 12-month post-modification period.

A summary of calculated areal nutrient uptake rates for the floating Beemat islands is given in Table 38. These values were calculated by dividing the total estimated uptake for nitrogen and phosphorus by the total area of Beemat island (1000 ft²) placed in the PAFB pond. During the 12-month post-modification monitoring period, the floating Beemat islands exhibited an uptake of approximately 45.4 g/m²-year for nitrogen and 25.0 g/m²-year for phosphorus.

TABLE 37

**CHANGES IN TOTAL MASS UPTAKE
OF NITROGEN AND PHOSPHORUS DURING THE
POST-MODIFICATION MONITORING PERIOD**

DATE	NUMBER OF PLANTS	TOTAL MASS (kg, wet weight)	TOTAL MASS (kg, dry weight)	NITROGEN (g)	PHOSPHORUS (g)
5/3/11	2,500	59	12.5	401	214
8/2/11	2,248	95	16.3	738	202
9/30/11	2,085	118	22.0	885	307
11/8/11	1,977	145	28.7	630	551
2/7/12	1,726	302	59.7	540	1,050
4/30/12	1,496	537	101	4,217	2,324

TABLE 38

**CALCULATED AREAL NUTRIENT UPTAKE
RATES FOR THE FLOATING BEEMAT ISLANDS**

NUTRIENT	MEAN AREAL UPTAKE (g/m²-year)
Nitrogen	45.4
Phosphorus	25.0

A comparison of plant nutrient uptake with overall nutrient loadings to the pond is given in Table 39. During the 12-month post-modification monitoring period, the quantified nitrogen loading to the pond was approximately 69 kg, with a loading of 16.0 kg for total phosphorus. The final plant uptake values represent approximately 6.1% of the total nitrogen loadings and 14.5% of the total phosphorus loadings to the pond. However, these values may over-estimate the impacts of the plants since there appear to be unidentified additional loadings into the pond from waterfowl and other sources. When these additional inputs are considered, the actual removal by the floating Beemat system may be more in the range of approximately 5% for total nitrogen and 10% for total phosphorus.

TABLE 39
COMPARISON OF PLANT NUTRIENT UPTAKE
WITH NUTRIENT LOADINGS TO THE POND

PARAMETER	TOTAL NITROGEN (kg)	TOTAL PHOSPHORUS (kg)
Final Plant Uptake	4.22	2.32
Total Mass Load to Pond	69.0	16.0
Percentage of Incoming Loading Removed	6.1%	14.5%

9. Summary

A performance efficiency evaluation was conducted to quantify potential water quality benefits resulting from installation of a floating Beemat system on a golf course pond at PAFB. A four-month pre-modification monitoring program was conducted to evaluate the performance efficiency of the pond under existing conditions. Approximately 1000 ft² of floating Beemat islands were installed, reflecting approximately 4% of the surface area of the 0.59-acre pond, during May 2011. A 12-month post-modification monitoring program was then conducted to evaluate the performance efficiency of the system following installation of the Beemats.

Complete hydrologic and nutrient budgets were conducted for the pond under pre- and post-modification conditions. Several parameters exhibited increases in loadings in discharges from the pond compared with quantified inflows, suggesting that significant unidentified additional loadings of nutrients may be present. Likely sources for these additional nutrient sources include waterfowl, golf course activities, and irrigation over-spray. No significant differences were observed in water quality characteristics within the pond under pre- and post-modification conditions, with the possible exception of substantially lower chlorophyll-a concentrations observed under post-modification conditions. Impacts from the unidentified nutrient sources appear to have masked the potential water quality improvements in nutrient concentrations resulting from the Beemat islands.

Overall, the floating Beemat islands removed approximately 4.2 kg of total nitrogen and 2.3 kg of total phosphorus during the post-modification monitoring period, with areal uptakes of 45.4 g/m²-year for nitrogen and 25.0 g/m²-year for phosphorus. These values reflect approximately 6% of the total mass loading of total nitrogen and 14.5% of the overall mass loading of total phosphorus to the pond. However, in view of the unidentified additional loadings, the actual load reductions to the pond by the Beemat systems is likely in the range of approximately 5% for total nitrogen and 10% for total phosphorus. These values are similar to nutrient uptake values measured in other Beemat evaluation projects.

APPENDICES

APPENDIX A

PRE- AND POST-MODIFICATION RAINFALL CHARACTERISTICS FROM JANUARY 2011 - APRIL 2012

Summary of Rainfall Measured at Patrick Air Force Base from January 2011 - April 2012

Event Start		Event End		Rainfall (inches)	Duration (hrs)	Ant. Dry Period (days)	Avg. Intensity (in/hr)
Date	Time	Date	Time				
1/6/11	4:49	1/6/11	8:02	0.24	3.22	11.13	0.07
1/7/11	9:24	1/7/11	9:34	0.03	0.17	1.06	0.18
1/7/11	23:21	1/7/11	23:32	0.04	0.17	0.57	0.24
1/17/11	12:12	1/17/11	17:36	0.48	5.40	9.53	0.09
1/19/11	7:43	1/19/11	10:41	0.12	2.97	1.59	0.04
1/21/11	5:28	1/21/11	9:03	0.57	3.58	1.78	0.16
1/25/11	12:16	1/25/11	12:16	0.01	---	4.13	---
1/25/11	19:00	1/26/11	0:21	1.25	5.36	0.28	0.23
1/26/11	10:08	1/26/11	10:08	0.01	---	0.41	---
Total:				2.75			
2/6/11	6:41	2/6/11	6:41	0.01	---	10.86	---
2/6/11	11:26	2/6/11	11:26	0.01	---	0.20	---
2/6/11	21:03	2/6/11	21:03	0.01	---	0.40	---
2/7/11	19:31	2/7/11	20:22	0.16	0.85	0.94	0.19
2/10/11	10:12	2/10/11	12:02	0.13	1.83	2.58	0.07
2/10/11	19:31	2/10/11	20:15	0.06	0.72	0.31	0.08
Total:				0.38			
3/1/11	11:07	3/1/11	11:45	0.04	0.64	18.62	0.06
3/4/11	20:27	3/4/11	21:51	0.10	1.40	3.36	0.07
3/6/11	1:08	3/6/11	1:34	0.06	0.44	1.14	0.14
3/6/11	14:23	3/6/11	14:30	0.06	0.11	0.53	0.54
3/9/11	23:18	3/10/11	2:27	0.18	3.15	3.37	0.06
3/10/11	8:49	3/10/11	19:18	0.43	10.48	0.27	0.04
3/28/11	8:23	3/28/11	22:53	0.95	14.50	17.54	0.07
3/30/11	17:47	3/30/11	23:31	0.36	5.73	1.79	0.06
3/31/11	12:21	3/31/11	20:28	0.94	8.11	0.54	0.12
Total:				3.12			
4/5/11	10:43	4/5/11	13:37	0.56	2.90	4.59	0.19
4/15/11	14:22	4/15/11	14:43	0.31	0.36	10.03	0.86
4/29/11	9:38	4/29/11	9:48	0.15	0.18	13.79	0.84
Total:				1.02			

Summary of Rainfall Measured at Patrick Air Force Base from January 2011 - April 2012

Event Start		Event End		Rainfall (inches)	Duration (hrs)	Ant. Dry Period (days)	Avg. Intensity (in/hr)
Date	Time	Date	Time				
5/14/11	17:58	5/14/11	18:26	0.24	0.47	15.34	0.51
5/15/11	15:26	5/15/11	15:27	0.03	0.02	0.88	1.80
5/30/11	20:29	5/30/11	20:31	0.02	0.03	15.21	0.62
Total:				0.29			
6/14/11	21:14	6/14/11	22:47	0.40	1.55	15.03	0.26
6/15/11	15:40	6/15/11	15:58	0.12	0.30	0.70	0.40
6/18/11	20:44	6/18/11	23:46	1.48	3.04	3.20	0.49
6/24/11	18:47	6/24/11	23:28	0.54	4.68	5.79	0.12
6/25/11	11:55	6/25/11	16:04	0.30	4.15	0.52	0.07
6/28/11	16:02	6/28/11	16:02	0.01	---	3.00	---
6/29/11	10:12	6/29/11	19:03	1.05	8.85	0.76	0.12
6/30/11	14:04	6/30/11	19:58	0.20	5.90	0.79	0.03
Total:				4.10			
7/1/11	14:17	7/1/11	18:37	0.33	4.33	0.76	0.08
7/7/11	7:38	7/7/11	8:45	0.02	1.12	5.54	0.02
7/7/11	14:46	7/7/11	14:46	0.25	---	0.25	---
7/7/11	22:31	7/7/11	22:31	0.01	---	0.32	---
7/8/11	19:42	7/8/11	21:12	0.04	1.50	0.88	0.03
7/9/11	16:58	7/9/11	18:58	0.11	2.00	0.82	0.05
7/13/11	19:02	7/13/11	20:03	0.56	1.02	4.00	0.55
7/15/11	19:26	7/15/11	22:49	0.20	3.37	1.97	0.06
7/18/11	3:50	7/18/11	6:00	0.19	2.17	2.21	0.09
7/22/11	19:14	7/22/11	19:35	0.49	0.35	4.55	1.39
7/26/11	18:45	7/26/11	18:57	0.13	0.20	3.96	0.65
Total:				2.33			

Summary of Rainfall Measured at Patrick Air Force Base from January 2011 - April 2012

Event Start		Event End		Rainfall (inches)	Duration (hrs)	Ant. Dry Period (days)	Avg. Intensity (in/hr)
Date	Time	Date	Time				
8/2/11	21:49	8/2/11	22:17	0.08	0.46	7.12	0.17
8/7/11	14:41	8/7/11	17:23	0.27	2.69	4.68	0.10
8/9/11	12:28	8/9/11	15:17	0.75	2.82	1.79	0.27
8/10/11	10:42	8/10/11	11:27	0.25	0.75	0.81	0.33
8/11/11	14:21	8/11/11	16:16	0.56	1.93	1.12	0.29
8/13/11	21:53	8/13/11	21:53	0.01	---	2.23	---
8/14/11	18:19	8/14/11	20:27	1.13	2.15	0.85	0.53
8/15/11	12:38	8/15/11	12:38	0.01	---	0.67	---
8/15/11	15:41	8/15/11	15:53	0.36	0.20	0.13	1.78
8/16/11	15:08	8/16/11	15:50	0.12	0.70	0.97	0.17
8/23/11	15:05	8/23/11	16:11	0.03	1.11	6.97	0.03
8/24/11	2:03	8/24/11	4:01	0.08	1.97	0.41	0.04
8/25/11	17:18	8/25/11	17:40	0.03	0.37	1.55	0.08
8/25/11	21:55	8/25/11	21:57	0.04	0.04	0.18	0.91
8/26/11	1:46	8/26/11	1:48	0.04	0.03	0.16	1.40
8/26/11	5:57	8/26/11	5:57	0.01	---	0.17	---
8/27/11	15:14	8/27/11	15:23	0.07	0.15	1.39	0.48
8/29/11	15:33	8/29/11	16:05	0.33	0.53	2.01	0.62
8/30/11	17:26	8/30/11	21:58	0.65	4.53	1.06	0.14
8/31/11	20:49	8/31/11	21:58	1.08	1.15	0.95	0.94
Total:				5.90			
9/1/11	11:37	9/1/11	16:18	0.26	4.68	0.57	0.06
9/4/11	21:50	9/4/11	23:55	0.10	2.08	3.23	0.05
9/6/11	12:53	9/6/11	12:56	0.02	0.05	1.54	0.37
9/7/11	16:23	9/7/11	23:44	0.47	7.34	1.14	0.06
9/8/11	17:02	9/8/11	17:31	0.26	0.48	0.72	0.54
9/9/11	18:10	9/9/11	22:03	1.09	3.88	1.03	0.28
9/10/11	17:51	9/10/11	18:45	0.55	0.90	0.83	0.61
9/20/11	3:39	9/20/11	9:31	0.34	5.87	9.37	0.06
9/22/11	2:20	9/22/11	2:40	0.05	0.33	1.70	0.15
9/22/11	7:53	9/22/11	7:53	0.01	---	0.22	---
9/22/11	11:48	9/22/11	12:52	0.04	1.07	0.16	0.04
9/25/11	18:04	9/25/11	18:42	0.08	0.63	3.22	0.13
9/26/11	10:07	9/26/11	10:07	0.01	---	0.64	---
9/26/11	19:45	9/26/11	19:57	0.04	0.19	0.40	0.21
9/30/11	17:54	9/30/11	18:15	0.03	0.34	3.91	0.09
Total:				3.35			

Summary of Rainfall Measured at Patrick Air Force Base from January 2011 - April 2012

Event Start		Event End		Rainfall (inches)	Duration (hrs)	Ant. Dry Period (days)	Avg. Intensity (in/hr)
Date	Time	Date	Time				
10/6/11	22:47	10/6/11	22:52	0.08	0.09	6.19	0.86
10/7/11	5:11	10/7/11	10:03	0.11	4.87	0.26	0.02
10/7/11	15:23	10/8/11	23:55	7.96	32.54	0.22	0.24
10/9/11	5:34	10/9/11	21:06	1.15	15.53	0.24	0.07
10/10/11	20:38	10/10/11	20:48	0.11	0.17	0.98	0.66
10/11/11	14:43	10/11/11	14:55	0.02	0.20	0.75	0.10
10/11/11	19:50	10/11/11	19:58	0.17	0.13	0.21	1.35
10/12/11	14:24	10/12/11	14:26	0.06	0.04	0.77	1.62
10/13/11	19:24	10/13/11	19:25	0.02	0.02	1.21	1.22
10/17/11	22:46	10/18/11	2:31	0.58	3.75	4.14	0.15
10/18/11	22:08	10/18/11	23:09	0.02	1.02	0.82	0.02
10/19/11	2:59	10/19/11	4:05	0.05	1.09	0.16	0.05
10/19/11	7:53	10/19/11	7:53	0.01	---	0.16	---
10/28/11	3:47	10/28/11	3:47	0.01	---	8.83	---
10/28/11	15:59	10/28/11	16:48	0.02	0.82	0.51	0.02
10/28/11	20:09	10/29/11	11:26	1.88	15.28	0.14	0.12
10/31/11	1:19	10/31/11	1:19	0.01	---	1.58	---
10/31/11	5:12	10/31/11	11:42	0.78	6.50	0.16	0.12
Total:				13.04			
11/6/11	11:48	11/6/11	11:49	0.02	0.02	6.00	0.95
11/8/11	19:18	11/8/11	19:32	0.04	0.23	2.31	0.17
11/14/11	19:47	11/14/11	20:06	0.06	0.31	6.01	0.19
11/15/11	3:54	11/15/11	6:05	0.28	2.19	0.32	0.13
11/19/11	15:03	11/19/11	15:07	0.03	0.05	4.37	0.56
11/21/11	17:15	11/21/11	17:19	0.02	0.06	2.09	0.32
11/21/11	21:03	11/21/11	21:34	0.06	0.52	0.16	0.12
11/22/11	3:15	11/22/11	5:53	0.02	2.65	0.24	0.01
11/28/11	6:03	11/28/11	6:03	0.01	---	6.01	---
11/28/11	14:36	11/28/11	14:39	0.05	0.06	0.36	0.81
11/28/11	20:55	11/28/11	21:04	0.02	0.16	0.26	0.12
Total:				0.61			
12/5/11	21:51	12/5/11	21:54	0.02	0.06	7.03	0.35
12/10/11	0:09	12/10/11	4:46	0.66	4.61	4.09	0.14
12/10/11	8:59	12/10/11	11:20	0.21	2.35	0.18	0.09
12/10/11	16:26	12/10/11	21:20	0.21	4.89	0.21	0.04
12/11/11	11:42	12/11/11	15:43	0.25	4.02	0.60	0.06
12/11/11	22:21	12/11/11	22:27	0.06	0.11	0.28	0.54
12/12/11	5:04	12/12/11	10:10	1.86	5.09	0.28	0.37
12/12/11	15:40	12/12/11	20:06	0.19	4.43	0.23	0.04
12/13/11	5:46	12/13/11	5:46	0.01	---	0.40	---
12/13/11	17:29	12/13/11	17:29	0.01	---	0.49	---
12/20/11	9:18	12/20/11	9:18	0.01	---	6.66	---
12/26/11	18:15	12/27/11	2:50	0.29	8.59	6.37	0.03
12/27/11	16:11	12/27/11	16:46	0.18	0.58	0.56	0.31
Total:				3.96			

Summary of Rainfall Measured at Patrick Air Force Base from January 2011 - April 2012

Event Start		Event End		Rainfall (inches)	Duration (hrs)	Ant. Dry Period (days)	Avg. Intensity (in/hr)
Date	Time	Date	Time				
1/10/12	9:13	1/10/12	9:13	0.01	---	13.69	---
Total:				0.01			
2/5/12	23:26	2/5/12	23:30	0.02	0.08	26.59	0.25
2/10/12	22:46	2/11/12	4:01	0.20	5.24	4.97	0.04
2/19/12	13:28	2/19/12	13:43	0.37	0.25	8.39	1.50
2/22/12	18:58	2/22/12	19:49	0.60	0.86	3.22	0.70
2/27/12	15:47	2/27/12	20:08	0.45	4.35	4.83	0.10
Total:				1.64			
3/4/12	7:42	3/4/12	7:52	0.08	0.15	5.48	0.52
3/8/12	14:23	3/8/12	16:36	0.02	2.21	4.27	0.01
3/9/12	20:29	3/9/12	23:04	0.10	2.59	1.16	0.04
3/10/12	23:52	3/11/12	13:58	2.32	14.11	1.03	0.16
3/20/12	17:28	3/20/12	17:39	0.03	0.19	9.15	0.16
3/24/12	19:10	3/24/12	20:55	0.32	1.76	4.06	0.18
3/25/12	11:12	3/25/12	11:14	0.02	0.03	0.59	0.61
3/31/12	15:39	3/31/12	16:41	0.70	1.03	6.18	0.68
Total:				3.59			
4/4/12	20:38	4/4/12	20:38	0.01	---	4.16	---
4/5/12	6:30	4/5/12	6:30	0.01	---	0.41	---
4/6/12	13:18	4/6/12	13:18	0.01	---	1.28	---
4/7/12	3:58	4/7/12	4:06	0.07	0.13	0.61	0.53
4/12/12	20:04	4/12/12	20:11	0.11	0.12	5.67	0.94
4/13/12	20:09	4/13/12	20:21	0.17	0.19	1.00	0.88
4/19/12	17:08	4/19/12	17:35	0.20	0.46	5.87	0.44
4/20/12	14:20	4/20/12	14:27	0.02	0.13	0.86	0.16
4/20/12	18:11	4/20/12	18:54	0.27	0.71	0.16	0.38
4/22/12	3:42	4/22/12	5:33	0.68	1.85	1.37	0.37
Total:				1.55			

Total Pre: 7.27

Total Post: 40.37

APPENDIX B

FIELD MEASUREMENTS OF TEMPERATURE, pH, CONDUCTIVITY, AND DISSOLVED OXYGEN IN THE PAFB POND

B.1 Pre-Modification Field Measurements

B.2 Post-Modification Field Measurements

B.3 Groundwater Field Measurements

B.1 Pre-Modification Field Measurements

Pre-Modification Field Measurements Collected in the PAFB Pond from January - April 2011

Date	Time	Depth (m)	Temp (°C)	pH (s.u.)	Cond (µmho/cm)	Salinity (ppt)	DO (mg/L)	DO Satn. (%)	ORP (mV)
1/5/11	9:21	Top	17.07	8.02	1,241	0.65	12.2	126	495
1/5/11	9:22	Middle	16.84	8.02	1,242	0.65	10.1	104	492
1/5/11	9:24	Bottom	16.61	7.46	1,236	0.65	7.8	80	425
1/11/11	11:17	Top	17.11	8.07	1,226	0.65	14.7	152	611
1/11/11	11:18	Middle	16.72	8.07	1,228	0.65	10.2	105	606
1/11/11	11:21	Bottom	16.56	7.37	1,219	0.64	7.4	76	485
1/18/11	8:42	Top	17.36	8.01	1,183	0.62	11.9	124	442
1/18/11	8:43	Middle	16.90	8.00	1,182	0.62	10.5	108	440
1/18/11	8:46	Bottom	16.55	7.46	1,176	0.62	8.2	84	390
1/26/11	8:27	Top	18.54	8.03	1,168	0.61	9.4	100	462
1/26/11	8:27	Middle	18.26	8.02	1,167	0.61	9.2	98	459
1/26/11	8:29	Bottom	17.63	7.64	1,143	0.60	6.3	66	389
2/3/11	10:34	Top	19.86	8.05	1,164	0.61	8.5	93	417
2/3/11	10:34	Middle	19.85	8.06	1,163	0.61	8.2	90	419
2/3/11	10:36	Bottom	19.77	7.51	1,131	0.59	4.9	53	349
2/8/11	10:12	Top	19.20	7.86	1,173	0.62	7.3	79	557
2/8/11	10:13	Middle	19.21	7.86	1,173	0.62	6.7	73	553
2/8/11	10:16	Bottom	19.14	7.80	1,166	0.61	5.8	62	529
2/15/11	10:18	Top	15.08	8.28	1,177	0.62	9.1	90	574
2/15/11	10:18	Middle	15.29	8.28	1,176	0.62	9.1	91	570
2/15/11	10:21	Bottom	15.43	8.22	1,163	0.61	8.7	88	553
2/23/11	9:13	Top	16.36	8.08	1,162	0.61	8.3	84	489
2/23/11	9:14	Middle	16.40	8.06	1,162	0.61	8.1	83	486
2/23/11	9:16	Bottom	16.39	8.01	1,158	0.61	7.9	80	471
3/3/11	8:29	Top	16.84	8.18	1,173	0.62	8.0	82	504
3/3/11	8:30	Middle	16.90	8.17	1,173	0.62	7.9	82	502
3/3/11	8:33	Bottom	16.86	8.14	1,173	0.62	7.2	74	484
3/11/11	9:37	Top	17.21	8.18	1,183	0.62	7.8	81	526
3/11/11	9:38	Middle	17.46	8.18	1,183	0.62	7.5	78	524
3/11/11	9:40	Bottom	17.45	8.16	1,181	0.62	7.1	74	502
3/17/11	8:16	Top	21.36	8.20	1,191	0.63	8.4	94	326
3/17/11	8:17	Middle	21.36	8.19	1,205	0.63	7.9	89	342
3/17/11	8:19	Bottom	21.35	8.13	1,201	0.63	7.2	81	347

Pre-Modification Field Measurements Collected in the PAFB Pond from January - April 2011

Date	Time	Depth (m)	Temp (°C)	pH (s.u.)	Cond (µmho/cm)	Salinity (ppt)	DO (mg/L)	DO Satn. (%)	ORP (mV)
3/24/11	8:52	Top	22.43	8.43	1,187	0.62	8.7	100	362
3/24/11	8:53	Middle	22.51	8.44	1,187	0.62	8.6	99	324
3/24/11	8:58	Bottom	22.51	8.41	1,181	0.62	8.2	95	318
3/31/11	9:17	Top	22.95	8.45	1,160	0.61	6.6	76	466
3/31/11	9:18	Middle	23.09	8.52	1,158	0.61	6.8	79	473
3/31/11	9:20	Bottom	22.99	8.46	1,156	0.61	6.5	76	467
4/7/11	8:28	Top	21.81	8.47	1,140	0.60	8.4	95	399
4/7/11	8:29	Middle	21.92	8.31	1,161	0.61	7.1	81	379
4/7/11	8:33	Bottom	21.91	8.20	1,173	0.62	6.5	74	368
4/15/11	8:48	Top	24.66	8.34	1,064	0.56	6.1	74	489
4/15/11	8:49	Middle	24.63	8.36	1,062	0.56	6.3	75	487
4/15/11	8:51	Bottom	24.52	8.33	1,060	0.56	6.1	74	463
4/21/11	8:40	Top	25.68	8.62	1,077	0.57	5.9	72	397
4/21/11	8:41	Middle	25.67	8.33	1,080	0.57	6.8	84	367
4/21/11	8:44	Bottom	25.36	8.11	1,083	0.57	6.5	79	337
4/28/11	8:39	Top	26.94	8.77	1,079	0.57	6.2	77	440
4/28/11	8:40	Middle	26.93	8.61	1,109	0.58	4.9	61	419
4/28/11	8:44	Bottom	26.83	8.51	1,103	0.58	4.3	54	404

B.2 Post-Modification Field Measurements

Post Modification Field Measurements Collected in the PAFB Pond from May 2011 - April 2012

Date	Time	Depth (m)	Temp (°C)	pH (s.u.)	Cond (µmho/cm)	Salinity (ppt)	DO (mg/L)	DO Satn. (%)	ORP (mV)
5/3/11	9:32	Top	26.83	8.43	1,103	0.58	5.8	72	485
5/3/11	9:33	Middle	26.81	8.37	1,104	0.58	4.9	62	466
5/3/11	9:35	Bottom	26.71	8.32	1,105	0.58	4.2	52	445
5/10/11	8:39	Top	27.12	7.93	1,186	0.62	4.3	54	520
5/10/11	8:40	Middle	27.06	7.79	1,176	0.62	3.8	47	406
5/10/11	8:44	Bottom	26.96	7.69	1,174	0.62	3.2	40	367
5/17/11	10:17	Top	26.25	8.90	1,207	0.64	12.4	154	368
5/17/11	10:18	Middle	24.72	8.45	1,223	0.64	8.7	105	356
5/17/11	10:20	Bottom	24.61	8.43	1,226	0.65	7.9	94	360
5/24/11	8:49	Top	28.05	8.02	1,240	0.65	7.4	95	265
5/24/11	8:50	Middle	28.01	7.94	1,241	0.65	6.4	82	233
5/24/11	8:52	Bottom	27.98	7.90	1,249	0.66	6.1	78	214
6/2/11	8:07	Top	27.40	8.20	1,290	0.68	7.3	93	284
6/2/11	8:07	Middle	27.36	8.19	1,290	0.68	7.1	90	278
6/2/11	8:08	Bottom	27.33	8.15	1,288	0.68	6.5	83	245
6/7/11	9:15	Top	27.53	7.93	1,319	0.70	5.6	72	411
6/7/11	9:17	Middle	27.54	7.84	1,316	0.69	5.2	66	400
6/7/11	9:19	Bottom	27.49	7.77	1,313	0.69	4.9	62	384
6/17/11	9:20	Top	28.03	7.77	1,310	0.69	6.2	80	388
6/17/11	9:20	Middle	28.00	7.75	1,310	0.69	6.0	76	384
6/17/11	9:22	Bottom	27.91	7.71	1,311	0.69	5.3	67	372
6/22/11	9:05	Top	30.06	7.88	1,284	0.68	5.9	77	354
6/22/11	9:07	Middle	30.00	7.87	1,285	0.68	5.7	75	349
6/22/11	9:09	Bottom	29.83	7.79	1,287	0.68	5.4	72	309
6/28/11	9:48	Top	28.95	7.86	1,290	0.68	5.6	73	404
6/28/11	9:49	Middle	28.91	7.79	1,293	0.68	4.6	60	382
6/28/11	9:51	Bottom	28.81	7.71	1,293	0.68	4.2	54	272
7/7/11	9:12	Top	30.84	7.98	1,259	0.66	8.7	117	432
7/7/11	9:13	Middle	30.77	7.92	1,245	0.66	6.7	91	425
7/7/11	9:15	Bottom	30.71	7.87	1,237	0.65	5.4	72	341
7/11/11	8:11	Top	30.64	7.96	1,263	0.67	7.7	103	437
7/11/11	8:11	Middle	30.59	7.88	1,261	0.66	6.8	91	425
7/11/11	8:13	Bottom	30.49	7.79	1,258	0.66	5.5	73	318
7/18/11	8:36	Top	30.97	7.83	1,289	0.68	7.1	95	479
7/18/11	8:37	Middle	30.92	7.78	1,282	0.68	6.7	90	474
7/18/11	8:38	Bottom	30.81	7.66	1,277	0.67	5.0	67	459

Post Modification Field Measurements Collected in the PAFB Pond from May 2011 - April 2012

Date	Time	Depth (m)	Temp (°C)	pH (s.u.)	Cond (µmho/cm)	Salinity (ppt)	DO (mg/L)	DO Satn. (%)	ORP (mV)
7/26/11	9:25	Top	31.27	7.99	1,300	0.69	6.3	85	493
7/26/11	9:26	Middle	31.26	7.99	1,300	0.69	5.9	80	490
7/26/11	9:27	Bottom	31.24	7.99	1,301	0.69	5.6	76	477
8/2/11	9:27	Top	31.18	8.05	1,334	0.70	6.4	87	498
8/2/11	9:27	Middle	31.04	8.01	1,337	0.71	5.8	79	494
8/2/11	9:29	Bottom	30.94	7.94	1,338	0.71	5.2	71	441
8/8/11	8:51	Top	30.26	7.96	1,380	0.73	5.5	73	474
8/8/11	8:57	Middle	30.25	7.95	1,380	0.73	5.4	72	444
8/8/11	9:04	Bottom	30.21	7.88	1,383	0.73	5.1	68	284
8/16/11	8:54	Top	30.38	7.88	1,353	0.72	5.3	70	480
8/16/11	9:05	Middle	30.34	7.84	1,353	0.72	5.2	69	411
8/16/11	9:11	Bottom	30.33	7.79	1,359	0.72	5.0	66	227
8/23/11	8:29	Top	30.44	7.75	1,343	0.71	3.4	45	445
8/23/11	8:41	Middle	30.42	7.71	1,341	0.71	3.0	40	124
8/23/11	8:52	Bottom	30.42	7.69	1,327	0.70	3.1	41	129
9/1/11	8:36	Top	28.58	7.80	1,364	0.72	4.0	52	461
9/1/11	8:44	Middle	28.70	7.83	1,362	0.72	3.7	48	421
9/1/11	8:50	Bottom	28.46	7.81	1,364	0.72	3.4	44	103
9/8/11	8:31	Top	28.33	7.29	1,342	0.71	4.2	54	444
9/8/11	8:46	Middle	28.34	7.27	1,342	0.71	3.5	45	356
9/8/11	8:58	Bottom	28.26	7.27	1,345	0.71	3.5	44	321
9/15/11	8:52	Top	28.72	7.20	1,321	0.70	3.0	39	432
9/15/11	8:57	Middle	28.79	7.20	1,324	0.70	3.0	39	357
9/15/11	9:04	Bottom	28.74	7.18	1,322	0.70	2.6	34	335
9/22/11	8:31	Top	28.63	7.23	1,344	0.71	3.6	46	449
9/22/11	8:44	Middle	28.75	7.23	1,345	0.71	3.5	45	395
9/22/11	8:54	Bottom	28.57	7.21	1,349	0.71	3.0	39	385
9/30/11	8:42	Top	28.68	7.18	1,357	0.72	3.4	44	418
9/30/11	8:51	Middle	29.09	7.17	1,366	0.72	3.1	41	363
9/30/11	9:03	Bottom	28.51	7.17	1,342	0.71	3.1	40	339
10/7/11	9:01	Top	28.31	7.62	1,384	0.73	4.2	54	477
10/7/11	9:15	Middle	28.32	7.50	1,372	0.73	4.1	53	424
10/7/11	9:21	Bottom	28.26	7.48	1,373	0.73	3.8	49	404
10/13/11	8:31	Top	28.03	7.63	1,221	0.64	4.7	60	460
10/13/11	8:38	Middle	28.00	7.57	1,219	0.64	4.6	59	410
10/13/11	8:46	Bottom	28.01	7.51	1,223	0.64	3.8	48	373

Post Modification Field Measurements Collected in the PAFB Pond from May 2011 - April 2012

Date	Time	Depth (m)	Temp (°C)	pH (s.u.)	Cond (µmho/cm)	Salinity (ppt)	DO (mg/L)	DO Satn. (%)	ORP (mV)
10/20/11	8:26	Top	27.56	7.46	1,336	0.71	5.2	66	463
10/20/11	8:33	Middle	27.42	7.47	1,333	0.70	4.8	61	446
10/20/11	8:41	Bottom	27.36	7.42	1,331	0.70	4.1	52	342
10/27/11	8:40	Top	25.37	7.56	1,429	0.76	5.5	67	474
10/27/11	8:49	Middle	25.41	7.52	1,427	0.76	5.1	62	468
10/27/11	8:57	Bottom	25.44	7.54	1,428	0.76	4.8	58	432
11/3/11	8:44	Top	25.03	7.81	1,369	0.72	5.9	71	466
11/3/11	8:53	Middle	24.98	7.77	1,365	0.72	5.6	68	448
11/3/11	9:00	Bottom	25.01	7.71	1,367	0.72	5.2	63	433
11/8/11	8:39	Top	24.62	7.61	1,344	0.71	6.1	73	483
11/8/11	8:50	Middle	24.57	7.55	1,340	0.71	5.9	71	465
11/8/11	9:02	Bottom	24.51	7.48	1,337	0.71	5.3	63	425
11/16/11	8:36	Top	23.87	7.63	1,383	0.73	5.8	69	474
11/16/11	8:44	Middle	23.78	7.58	1,380	0.73	5.6	66	456
11/16/11	8:51	Bottom	23.77	7.52	1,382	0.73	4.8	57	431
11/22/11	8:17	Top	23.07	7.57	1,370	0.72	6.0	70	477
11/22/11	8:23	Middle	23.06	7.57	1,370	0.72	5.5	64	457
11/22/11	8:29	Bottom	23.06	7.50	1,369	0.72	4.8	55	443
11/29/11	8:23	Top	20.81	7.73	1,375	0.73	6.7	74	433
11/29/11	8:30	Middle	20.98	7.73	1,377	0.73	6.1	68	428
11/29/11	8:38	Bottom	21.01	7.75	1,377	0.73	6.0	67	427
12/6/11	9:21	Top	20.45	7.90	1,256	0.66	7.7	85	488
12/6/11	9:30	Middle	20.50	7.89	1,256	0.66	7.8	86	488
12/6/11	9:38	Bottom	20.44	6.90	1,249	0.66	6.9	76	86
12/13/11	8:32	Top	20.94	7.54	1,192	0.63	6.2	69	466
12/13/11	8:45	Middle	20.95	7.51	1,197	0.63	5.3	59	109
12/13/11	9:00	Bottom	20.94	7.50	1,286	0.68	4.0	45	62
12/20/11	8:20	Top	19.26	7.74	1,290	0.68	7.6	82	488
12/20/11	8:33	Middle	19.18	7.59	1,290	0.68	6.8	74	219
12/20/11	8:42	Bottom	19.14	7.60	1,291	0.68	6.8	73	128
12/27/11	8:41	Top	21.69	7.47	1,236	0.65	5.3	60	478
12/27/11	8:53	Middle	21.72	7.46	1,237	0.65	4.8	54	129
12/27/11	9:05	Bottom	21.69	7.48	1,290	0.68	4.8	54	108
1/3/12	8:32	Top	14.97	7.58	1,298	0.69	8.1	80	500
1/3/12	8:41	Middle	15.43	7.57	1,295	0.68	7.4	74	180
1/3/12	8:50	Bottom	15.39	7.59	1,299	0.69	7.3	73	105

Post Modification Field Measurements Collected in the PAFB Pond from May 2011 - April 2012

Date	Time	Depth (m)	Temp (°C)	pH (s.u.)	Cond (µmho/cm)	Salinity (ppt)	DO (mg/L)	DO Satn. (%)	ORP (mV)
1/10/12	8:36	Top	16.87	7.67	1,271	0.67	9.3	96	520
1/10/12	8:44	Middle	16.81	7.65	1,274	0.67	8.4	86	163
1/10/12	8:53	Bottom	16.77	7.67	1,308	0.69	8.3	85	163
1/17/12	8:36	Top	15.58	7.85	1,156	0.61	10.1	101	503
1/17/12	8:44	Middle	15.45	7.78	1,146	0.60	8.5	85	156
1/17/12	8:55	Bottom	15.36	7.82	1,291	0.68	8.5	85	142
1/25/12	8:36	Top	20.33	7.70	1,301	0.69	7.2	79	492
1/25/12	8:45	Middle	20.26	7.61	1,300	0.69	6.5	71	132
1/25/12	8:56	Bottom	20.25	7.63	1,301	0.69	5.9	65	131
1/31/12	8:44	Top	18.46	7.85	1,207	0.64	7.7	82	487
1/31/12	8:53	Middle	18.41	7.81	1,205	0.63	7.2	77	158
1/31/12	9:01	Bottom	18.41	7.78	1,304	0.69	6.8	72	101
2/7/12	8:34	Top	21.58	7.73	1,215	0.64	5.8	66	472
2/7/12	8:44	Middle	21.58	7.71	1,216	0.64	5.5	62	153
2/7/12	8:56	Bottom	21.58	7.62	1,301	0.69	5.0	56	65
2/14/12	8:31	Top	15.33	8.14	1,301	0.69	10.4	104	488
2/14/12	8:44	Middle	15.33	8.16	1,305	0.69	9.5	95	212
2/14/12	8:52	Bottom	15.32	8.16	1,307	0.69	9.3	92	180
2/21/12	8:22	Top	19.12	7.91	1,225	0.65	7.4	79	496
2/21/12	8:32	Middle	19.15	7.88	1,229	0.65	6.9	74	168
2/21/12	8:41	Bottom	19.19	7.81	1,231	0.65	6.4	69	103
2/28/12	8:16	Top	20.49	7.93	1,252	0.66	6.9	77	504
2/28/12	8:25	Middle	20.45	7.70	1,258	0.66	6.1	68	110
2/28/12	8:36	Bottom	20.45	7.85	1,259	0.66	6.1	67	99
3/6/12	8:16	Top	13.73	7.90	1,436	0.76	9.9	95	509
3/6/12	8:27	Middle	13.99	7.88	1,433	0.76	8.6	83	155
3/6/12	8:37	Bottom	14.22	7.88	1,421	0.75	8.0	78	121
3/13/12	8:23	Top	21.53	7.78	1,208	0.64	5.9	67	465
3/13/12	8:31	Middle	21.54	7.73	1,209	0.64	5.8	66	121
3/13/12	8:44	Bottom	21.49	7.76	1,211	0.64	5.6	63	111
3/20/12	8:41	Top	23.63	7.84	1,237	0.65	6.5	76	450
3/20/12	8:49	Middle	23.67	7.80	1,222	0.64	6.1	71	171
3/20/12	8:57	Bottom	23.63	7.85	1,222	0.64	6.0	70	119
3/27/12	9:17	Top	23.46	8.04	1,225	0.65	7.8	92	496
3/27/12	9:26	Middle	23.53	7.81	1,227	0.65	7.4	87	130
3/27/12	9:38	Bottom	23.48	8.01	1,233	0.65	7.4	87	136

Post Modification Field Measurements Collected in the PAFB Pond from May 2011 - April 2012

Date	Time	Depth (m)	Temp (°C)	pH (s.u.)	Cond (µmho/cm)	Salinity (ppt)	DO (mg/L)	DO Satn. (%)	ORP (mV)
4/3/12	8:36	Top	21.53	7.93	1,303	0.69	9.0	102	493
4/3/12	8:44	Middle	21.74	7.91	1,302	0.69	8.3	94	201
4/3/12	8:52	Bottom	21.72	7.89	1,301	0.69	7.7	88	190
4/10/12	8:34	Top	21.05	8.03	1,308	0.69	9.2	103	488
4/10/12	8:42	Middle	20.69	7.96	1,315	0.69	8.5	94	158
4/10/12	8:50	Bottom	20.88	7.98	1,306	0.69	8.2	91	157
4/17/12	8:25	Top	17.59	8.12	1,413	0.75	10.9	114	485
4/17/12	8:34	Middle	16.89	8.05	1,450	0.77	9.2	95	182
4/17/12	8:43	Bottom	16.65	7.97	1,449	0.77	8.4	87	135
4/23/12	8:29	Top	22.36	7.92	1,194	0.63	6.4	74	451
4/23/12	8:38	Middle	22.42	7.88	1,187	0.62	6.1	70	191
4/23/12	8:46	Bottom	22.37	7.88	1,186	0.62	6.0	68	170
4/30/12	8:41	Top	25.51	7.83	1,205	0.63	6.2	76	453
4/30/12	8:48	Middle	25.51	7.77	1,198	0.63	5.6	68	162
4/30/12	8:55	Bottom	25.43	7.62	1,244	0.66	5.0	61	50
Pre-Geometric Means		Top	19.74	8.23	1,161	0.61	8.4	92	462
		Middle	19.70	8.20	1,165	0.61	7.8	86	455
		Bottom	19.58	7.99	1,158	0.61	6.8	74	422
Post - Geometric Means		Top	24.03	7.81	1,289	0.68	6.3	76	455
		Middle	23.99	7.75	1,289	0.68	5.8	69	273
		Bottom	23.95	7.71	1,299	0.69	5.3	63	214

B.3 Groundwater Field Measurements

Groundwater Monitoring Well Field Measurements Collected from February 2011 - April 2012

Site	Date	Time		Temp (°C)	pH (s.u.)	Cond (µmho/cm)	Salinity (ppt)	DO (mg/L)	DO Satn. (%)	ORP (mV)
MW 1	2/3/11	9:53	›	18.09	6.92	2,625	1.41	0.9	9	231
MW 2	2/3/11	10:00	›	15.72	7.24	1,322	0.70	3.6	36	223
MW 3	2/3/11	10:11	›	17.16	7.06	1,455	0.77	4.1	43	148
MW 4	2/3/11	10:24	›	20.22	7.05	599	0.31	3.8	41	237
MW 1	2/15/11	10:21	›	18.06	6.96	2,503	1.35	1.0	11	325
MW 2	2/15/11	10:29	›	16.78	7.26	1,171	0.62	3.8	39	234
MW 3	2/15/11	10:37	›	16.69	7.16	1,199	0.63	4.1	42	157
MW 4	2/15/11	10:47	›	19.64	7.05	611	0.31	2.8	30	248
MW 1	3/17/11	8:13	›	19.98	6.97	2,115	1.13	0.7	8	245
MW 2	3/17/11	8:22	›	19.78	7.36	1,212	0.64	3.5	38	160
MW 3	3/17/11	8:36	›	20.44	7.21	1,231	0.65	3.8	42	101
MW 4	3/17/11	8:57	›	21.76	7.05	632	0.32	2.8	32	244
MW 1	4/15/11	8:53	›	23.15	7.13	2475	1.33	0.5	6	262
MW 2	4/15/11	9:03	›	21.06	7.33	1635	0.87	3.2	36	211
MW 3	4/15/11	9:14	›	22.37	7.41	1422	0.75	4.1	47	233
MW 4	4/15/11	9:22	›	23.54	7.18	710	0.37	2.5	30	253
MW1	5/17/11	10:30	›	25.00	7.09	2,143	1.15	3.5	43	-82
MW2	5/17/11	10:48	›	27.34	7.88	1,266	0.67	6.0	77	-106
MW3	5/17/11	10:57	›	26.87	7.48	1,268	0.67	7.3	92	-93
MW4	5/17/11	11:08	›	26.20	7.31	660	0.34	5.7	71	-59
MW1	6/17/11	9:47	›	26.21	7.18	1,854	0.99	1.1	14	311
MW2	6/17/11	9:57	›	26.48	7.46	1,497	0.79	3.3	41	319
MW3	6/17/11	10:10	›	26.39	7.29	1,530	0.81	2.9	36	251
MW4	6/17/11	10:19	›	26.12	7.15	644	0.33	3.1	38	264
MW1	7/18/11	8:21	›	27.31	7.31	1,554	0.82	2.5	32	307
MW2	7/18/11	8:29	›	28.22	7.49	1,821	0.97	3.3	42	307
MW3	7/18/11	8:37	›	27.49	7.44	1,852	0.99	2.0	25	266
MW4	7/18/11	8:48	›	27.35	7.31	1,154	0.61	1.8	23	264
MW 1	8/23/11	9:06	›	29.13	7.36	1,782	0.95	0.6	8	50
MW 2	8/16/11	8:11	›	29.44	7.44	1,656	0.88	0.9	12	63
MW 3	8/16/11	8:19	›	29.21	7.38	1,583	0.84	1.0	13	54
MW 4	8/16/11	8:24	›	29.16	7.29	1,476	0.78	0.8	10	40
MW1	9/15/11	9:22	›	28.52	6.99	2,023	1.08	1.1	14	71
MW2	9/15/11	8:28	›	28.49	7.31	1,851	0.99	1.0	13	95
MW3	9/15/11	8:36	›	28.41	7.08	2,237	1.20	1.1	14	74
MW4	9/15/11	8:43	›	28.27	7.15	1,183	0.62	0.8	10	87
MW1	10/20/11	9:02	›	26.23	7.30	1,463	0.78	1.0	12	73
MW2	10/20/11	9:11	›	26.08	7.78	1,618	0.86	0.8	10	109
MW3	10/20/11	9:20	›	26.11	7.36	1,597	0.85	0.8	10	69
MW4	10/20/11	9:28	›	25.97	7.45	1,423	0.75	0.7	9	126

Groundwater Monitoring Well Field Measurements Collected from February 2011 - April 2012

Site	Date	Time		Temp (°C)	pH (s.u.)	Cond (µmho/cm)	Salinity (ppt)	DO (mg/L)	DO Satn. (%)	ORP (mV)
MW1	11/16/11	9:11	✓	24.56	7.27	2,010	1.07	0.9	11	53
MW2	11/16/11	9:20	✓	24.39	7.34	1,560	0.83	0.9	10	73
MW3	11/16/11	9:28	✓	24.23	7.11	1,530	0.81	1.0	11	54
MW4	11/16/11	9:41	✓	24.55	7.06	2,170	1.16	1.0	12	125
MW1	12/13/11	9:32	✓	22.21	6.97	1,550	0.82	0.6	6	124
MW2	12/13/11	9:44	✓	22.26	7.35	1,279	0.67	0.4	5	87
MW3	12/13/11	9:52	✓	22.10	7.18	1,352	0.71	0.6	7	69
MW4	12/13/11	10:01	✓	23.09	7.13	2,200	1.18	0.5	5	116
MW1	1/17/12	9:26	✓	19.26	7.09	1,310	0.69	0.9	9	115
MW2	1/17/12	9:38	✓	18.36	7.36	1,346	0.71	0.9	9	83
MW3	1/17/12	9:46	✓	19.08	7.27	1,387	0.73	0.6	7	58
MW4	1/17/12	9:57	✓	20.28	7.25	1,630	0.87	1.2	13	160
MW1	2/14/12	9:16	✓	19.99	7.14	1,375	0.73	0.8	8	102
MW2	2/14/12	9:28	✓	18.99	7.31	1,359	0.72	1.5	16	91
MW3	2/14/12	9:40	✓	19.25	7.37	1,286	0.68	0.8	9	58
MW4	2/14/12	9:49	✓	20.79	7.29	1,570	0.83	1.5	17	160
MW1	3/13/12	9:10	✓	21.56	7.12	1,820	0.97	0.6	7	111
MW2	3/13/12	9:18	✓	21.02	7.35	2,090	1.12	0.5	5	80
MW3	3/13/12	9:27	✓	21.61	7.26	1,490	0.79	0.5	6	56
MW4	3/13/12	9:02	✓	22.19	7.34	1,362	0.72	0.8	9	137
MW1	4/17/12	9:35	✓	23.46	7.19	1,433	0.76	1.5	18	187
MW2	4/17/12	9:27	✓	17.57	7.32	1,550	0.82	1.1	11	149
MW3	4/17/12	9:20	✓	17.70	7.37	1,580	0.84	1.3	14	106
MW4	4/17/12	9:11	✓	17.85	7.38	1,324	0.70	1.2	13	190
				19.72	6.99	2,404	1.30	0.8	8	263
Pre Modification				18.21	7.30	1,233	0.70	3.5	37	205
Geometric Means				19.02	7.21	1,290	0.70	4.0	43	153
				21.24	7.08	614	0.33	2.9	33	245
				24.25	7.17	1,672	0.89	1.1	13	107
Post Modification				23.69	7.45	1,557	0.83	1.2	14	89
Geometric Means				23.72	7.30	1,539	0.82	1.2	14	64
				24.08	7.26	1,315	0.69	1.2	15	131

APPENDIX C

**MEASURED DAILY INFLOWS AND
OUTFLOWS TO THE PAFB POND**

C.1 Pre-Modification Period

C.2 Post-Modification Modification Period

C.1 Pre-Modification Period

EVAPORATION (ft³)

Day	Month			
	January	February	March	April
1	196	169	197	153
2	196	169	196	154
3	196	176	223	154
4	196	175	223	154
5	128	175	223	154
6	128	176	223	153
7	128	176	223	334
8	128	136	223	334
9	128	136	224	333
10	128	136	224	332
11	112	136	220	331
12	112	136	220	331
13	112	135	221	330
14	112	135	221	329
15	112	174	221	327
16	112	174	220	327
17	112	174	263	327
18	114	174	262	326
19	115	174	262	326
20	115	173	261	325
21	115	173	260	330
22	115	173	259	329
23	115	198	259	328
24	114	198	136	327
25	184	198	135	326
26	171	198	135	325
27	171	197	135	323
28	171	197	135	365
29	170		136	364
30	170		139	362
31	170		150	
Total	3,952	4,742	6,428	8,911

RAINFALL (ft³)

Day	Month		
	January	February	March
1		-	73
2		-	-
3	-	-	-
4	-	-	182
5	-	-	-
6	447	56	219
7	131	301	-
8	-	-	-
9	-	-	92
10	-	356	1,028
11	-	-	-
12	-	-	-
13	-	-	-
14	-	-	-
15	-	-	-
16	-	-	-
17	890	-	-
18	-	-	-
19	227	-	-
20	-	-	-
21	1,083	-	-
22	-	-	-
23	-	-	-
24	-	-	-
25	2,359	-	-
26	38	-	-
27	-	-	-
28	-	-	1,709
29	-	-	-
30	-	-	666
31	-	-	1,749
Total	5,175	714	5,717
			1,920

INFLOW (ft³)

Day	Month			
	January	February	March	April
1		7,302	-87	15,246
2		6,797	2	14,664
3	1,879	5,248	13	12,244
4	2,278	4,436	15	11,668
5	2,428	4,530	479	11,312
6	2,491	6,079	439	11,337
7	3,044	5,748	781	10,469
8	2,949	5,414	731	10,560
9	2,383	3,810	658	8,997
10	1,532	4,463	197	7,776
11	2,032	4,242	2,094	7,002
12	1,819	2,711	1,040	6,329
13	886	2,769	1,055	4,885
14	1,909	2,337	1,179	5,084
15	2,144	2,769	782	3,627
16	1,326	1,888	662	5,342
17	142	2,629	365	4,149
18	7,934	2,209	7	2,985
19	11,042	2,051	90	3,035
20	8,534	851	-107	2,418
21	9,913	952	-187	1,575
22	12,769	759	-108	1,068
23	8,125	677	151	358
24	7,629	355	-234	135
25	4,535	529	-234	-210
26	16,600	117	-263	-40
27	15,397	403	-71	-490
28	11,819	204	-1,873	-244
29	10,788		3,249	-559
30	9,918		3,654	-534
31	8,613		1,692	
Total	172,857	82,281	16,168	160,189

GROUNDWATER OUTFLOW (ft³)

Day	Month			
	January	February	March	April
1	566	1,004	314	1,115
2	575	959	276	1,248
3	583	889	243	1,218
4	588	831	222	1,182
5	618	796	225	1,221
6	642	848	239	1,203
7	640	866	262	1,161
8	674	848	280	1,120
9	653	790	298	1,045
10	615	791	351	983
11	610	765	481	914
12	605	695	501	862
13	581	667	506	797
14	575	647	515	781
15	586	644	494	748
16	560	617	471	772
17	623	627	435	750
18	933	615	383	700
19	1,061	592	331	680
20	1,027	535	281	652
21	1,145	507	232	611
22	1,220	490	190	559
23	1,102	475	170	503
24	1,032	447	138	447
25	1,009	426	96	360
26	1,392	388	61	295
27	1,376	386	34	223
28	1,267	357	62	166
29	1,186		265	121
30	1,118		447	61
31	1,055		604	
Total	25,075	18,502	9,406	22,495

OUTFLOW (ft³)

Day	Month			
	January	February	March	April
1	1,050	6,773	-	9,118
2	1,075	6,067	-	11,910
3	1,100	4,884	-	11,203
4	1,300	3,994	-	10,614
5	1,499	3,733	-	10,879
6	1,856	4,569	-	10,273
7	2,158	4,839	-	9,402
8	2,152	4,586	-	9,205
9	1,850	3,556	-	8,157
10	1,288	3,757	-	7,051
11	1,300	3,509	95	6,219
12	1,199	2,560	169	5,533
13	709	2,226	226	4,431
14	953	1,856	310	4,152
15	1,199	1,908	217	3,540
16	928	1,474	130	3,961
17	632	1,661	7	3,430
18	4,052	1,534	-	2,575
19	7,865	1,403	-	2,267
20	7,556	775	-	1,812
21	8,988	544	-	1,193
22	10,626	354	-	700
23	8,146	217	-	205
24	7,061	52	-	-
25	6,191	17	-	-
26	12,065	-	-	-
27	13,291	-	-	-
28	11,297	-	-	-
29	10,036		-	-
30	9,096		391	-
31	7,969		1,486	
Total	144,360	66,847	3,031	137,830

C.2 Post-Modification Modification Period

RAINFALL (ft³)

Day	2011							2012				
	May	June	July	August	September	October	November	December	January	February	March	April
1	-	-	628	-	494	-	-	-	-	-	-	-
2	-	-	-	147	-	-	-	-	-	-	-	-
3	-	-	-	-	-	-	-	-	-	-	-	-
4	-	-	-	-	189	-	-	-	-	-	151	19
5	-	-	-	-	-	-	-	38	-	37	-	19
6	-	-	-	-	38	150	39	-	-	-	-	19
7	-	-	528	491	884	600	-	-	-	-	-	133
8	-	-	76	-	492	15,860	77	-	-	-	38	-
9	-	-	207	1,359	2,074	2,531	-	-	-	-	189	-
10	-	-	-	457	1,061	237	-	2,039	19	238	94	-
11	-	-	-	1,030	-	394	-	591	-	129	4,371	-
12	-	-	-	-	-	122	-	4,033	-	-	-	207
13	-	-	1,054	19	-	40	-	40	-	-	-	319
14	421	684	-	2,111	-	-	115	-	-	-	-	-
15	53	207	375	701	-	-	537	-	-	-	-	-
16	-	-	-	228	-	-	-	-	-	-	-	-
17	-	-	-	-	-	731	-	-	-	-	-	-
18	-	2,565	354	-	-	458	-	-	-	-	-	-
19	-	-	-	-	-	118	57	-	-	684	-	373
20	-	-	-	-	647	-	-	19	-	-	57	543
21	-	-	-	-	-	-	152	-	-	-	-	-
22	-	-	912	-	190	-	38	-	-	1,114	-	1,286
23	-	-	-	56	-	-	-	-	-	-	-	-
24	-	1,001	-	150	-	-	-	19	-	-	610	-
25	-	556	-	131	152	-	-	-	-	-	38	-
26	-	-	243	94	95	-	-	304	-	-	-	-
27	-	-	-	131	-	-	-	592	-	842	-	-
28	-	19	-	-	-	233	152	-	-	-	-	-
29	-	1,954	-	619	-	3,551	-	-	-	-	-	-
30	35	379	-	1,219	57	-	-	-	-	-	-	-
31	-	-	-	2,039	-	1,567	-	-	-	-	1,336	-
Totals	508	7,365	4,376	10,983	6,372	26,592	1,167	7,675	19	3,044	6,886	2,918

INFLOW (ft³)

Day	2011												2012			
	May	June	July	August	September	October	November	December	January	February	March	April				
1	78	-345	11,388	478	11,163	6,583	32,763	7,263	10,856	1,042	8,160	17,017				
2	-18	219	10,714	26	9,482	4,689	25,903	6,866	11,078	936	7,846	14,048				
3	-140	548	9,747	266	7,932	4,668	24,891	6,616	9,658	748	7,643	14,278				
4	-81	328	8,323	9	7,237	5,231	23,893	6,369	9,141	426	7,404	12,775				
5	-228	355	7,409	-63	6,445	4,497	19,451	6,627	9,396	160	4,569	11,493				
6	-4	-107	6,203	-41	5,711	4,440	19,420	6,599	8,449	266	4,704	9,809				
7	-233	-224	6,879	-419	5,552	4,771	20,131	6,244	7,862	111	5,449	8,400				
8	22	799	8,008	112	9,261	73,025	18,990	5,891	7,772	261	7,705	7,543				
9	87	-137	6,020	-1,203	10,632	173,539	17,228	6,040	6,444	286	7,325	7,431				
10	-1	-393	7,931	2,081	20,776	116,313	16,501	6,389	6,384	377	7,557	7,339				
11	-225	-273	6,783	762	28,786	69,898	14,598	13,938	6,815	872	18,379	6,443				
12	-295	-281	6,203	3,535	26,905	54,433	13,774	35,799	7,035	85	54,987	5,027				
13	-801	-606	5,192	3,631	23,621	42,414	13,321	49,884	5,552	495	39,911	4,346				
14	-616	-1,130	5,185	2,106	18,708	35,844	13,240	29,546	5,199	911	30,911	4,248				
15	915	1,824	3,677	12,073	15,652	33,750	15,288	23,219	5,099	844	26,166	3,837				
16	49	540	3,926	10,817	14,062	34,589	17,608	20,638	4,394	834	21,199	3,469				
17	346	267	2,681	10,965	12,239	35,059	16,294	18,365	4,934	734	18,214	3,171				
18	-100	-2,693	2,058	10,223	11,386	42,221	12,879	15,684	5,697	464	16,602	2,921				
19	-35	8,581	2,356	9,594	10,007	27,944	12,195	13,960	5,033	844	15,020	2,951				
20	45	9,706	2,973	7,979	11,264	23,942	11,909	13,333	3,704	2,191	14,285	4,808				
21	-129	3,381	2,445	6,742	14,482	24,387	11,504	13,195	3,467	1,034	13,540	6,877				
22	-51	3,148	1,492	5,607	10,336	23,711	11,612	13,626	3,339	1,310	14,087	8,545				
23	-93	1,858	4,759	4,908	9,608	23,232	10,802	12,219	2,895	4,654	12,905	9,453				
24	-89	-146	5,406	5,265	8,862	23,711	11,024	11,840	2,967	5,519	11,762	9,026				
25	-25	766	4,056	4,712	8,701	23,168	9,610	11,205	2,399	5,143	13,444	8,192				
26	-376	2,925	2,707	5,164	9,305	23,923	9,752	10,862	2,399	3,559	12,999	7,239				
27	-267	3,284	2,001	4,751	7,777	24,115	9,353	12,895	1,940	3,346	13,535	6,442				
28	37	2,280	1,617	4,978	6,927	22,196	9,676	13,537	1,852	8,055	13,163	5,987				
29	-304	570	1,710	4,568	6,930	40,289	9,021	12,881	1,602	8,256	12,104	6,261				
30	-327	13,432	1,336	3,798	7,061	46,469	7,913	12,769	943		11,808	5,163				
31	-266		837	7,614		35,078		12,053	1,142		12,033					
Totals	-3,125	48,475	152,020	131,037	356,810	1,108,130	460,544	436,353	165,447	53,765	465,413	224,539				

OUTFLOW (ft³)

Day	2011								2012			
	May	June	July	August	September	October	November	December	January	February	March	April
1	-	-	9,734	130	8,858	5,598	31,639	6,402	9,901	458	6,773	14,038
2	-	-	9,435	-	8,314	4,363	25,790	5,925	9,779	376	6,675	12,874
3	-	-	8,708	-	7,151	3,903	23,517	5,607	8,847	259	6,528	12,667
4	-	-	7,587	-	6,470	4,052	22,230	5,350	8,220	88	6,402	11,626
5	-	-	6,655	-	5,626	3,676	18,824	5,432	8,188	-	4,560	10,500
6	-	-	5,626	-	4,901	3,580	17,917	5,478	7,577	-	3,961	9,064
7	-	-	6,057	-	5,061	4,019	18,122	5,277	7,011	-	4,186	7,792
8	-	-	6,626	-	7,151	62,133	17,459	4,999	6,773	-	5,654	6,763
9	-	-	5,644	-	9,768	145,384	16,030	4,990	5,868	-	6,095	6,354
10	-	-	6,354	-	16,758	116,173	15,145	6,392	5,515	-	6,335	6,171
11	-	-	5,756	-	23,726	75,528	13,613	10,752	5,644	-	15,978	5,570
12	-	-	5,205	809	24,342	55,610	12,618	29,538	5,821	-	42,002	4,621
13	-	-	5,043	1,805	22,186	42,528	12,029	42,328	4,981	-	38,030	3,961
14	-	-	4,363	2,596	18,245	35,211	11,874	30,721	4,474	-	30,672	3,469
15	-	-	3,469	8,062	15,145	32,068	13,477	23,561	4,236	-	25,590	3,052
16	-	-	3,067	9,064	13,230	31,903	15,145	20,000	3,741	-	20,854	2,682
17	-	-	2,233	9,348	11,520	32,732	14,760	17,496	3,871	-	17,591	2,412
18	-	-	1,786	8,977	10,420	37,943	12,365	14,991	4,363	-	15,599	2,179
19	-	-	1,564	8,463	9,216	28,609	11,250	13,156	4,152	178	13,975	2,308
20	-	1,711	1,780	7,272	10,081	23,531	10,683	12,269	3,328	723	13,039	3,485
21	-	2,152	1,606	6,124	12,041	22,553	10,341	11,898	2,887	532	12,232	4,875
22	-	2,145	1,510	5,061	10,047	21,822	10,216	12,065	2,632	1,053	12,365	7,201
23	-	1,486	2,704	4,312	8,869	21,300	9,623	11,180	2,301	2,468	11,626	7,803
24	-	751	3,612	4,295	8,042	21,502	9,579	10,649	2,199	3,660	11,052	7,648
25	-	636	3,212	3,912	7,731	21,170	8,665	10,047	1,824	3,945	11,578	7,081
26	-	1,300	2,454	3,912	8,031	21,604	8,463	9,823	1,668	3,143	11,437	6,315
27	-	1,837	1,661	3,684	7,081	21,996	8,146	11,262	1,369	3,189	11,767	5,579
28	-	1,606	1,155	3,660	6,219	20,940	8,357	11,696	1,188	5,442	11,626	5,061
29	-	1,576	979	3,781	5,934	35,759	7,906	11,426	1,000	6,470	10,890	5,052
30	-	8,157	728	3,733	5,906	41,496	7,081	11,285	614		10,489	4,484
31	-		402	6,441		35,776		10,798	536		11,379	
Totals	-	23,356	126,717	105,440	318,070	1,034,463	422,864	392,794	140,508	31,982	416,939	192,690

EVAPORATION (ft³)

Day	2011								2012			
	May	June	July	August	September	October	November	December	January	February	March	April
1	361	330	267	344	363	308	53	258	156	178	231	300
2	361	350	267	328	362	307	52	257	156	178	231	299
3	333	351	266	327	361	306	219	257	134	178	231	343
4	332	351	265	326	361	306	218	257	134	178	231	342
5	331	351	265	325	360	306	217	257	134	178	230	341
6	331	351	264	324	359	306	217	166	134	177	294	340
7	330	349	176	324	359	231	217	166	134	174	294	339
8	330	350	176	241	351	252	216	166	134	174	295	338
9	330	350	176	241	353	270	216	166	133	173	296	338
10	267	349	176	243	358	177	216	166	163	173	296	320
11	267	348	408	245	362	171	215	168	163	174	302	319
12	266	347	407	247	362	168	215	173	163	173	313	318
13	265	346	407	248	361	248	214	242	162	173	322	318
14	265	345	406	249	359	246	214	238	162	170	319	317
15	266	349	405	252	274	245	215	236	162	170	317	317
16	266	349	405	301	273	245	215	234	162	170	314	317
17	345	179	404	301	272	245	215	233	156	170	313	249
18	344	179	356	301	272	247	214	232	156	170	312	249
19	344	186	356	301	271	244	214	231	156	171	311	249
20	344	192	356	300	272	253	213	140	155	172	328	250
21	343	192	356	299	273	253	213	140	155	202	328	251
22	343	337	356	298	251	253	248	140	155	203	328	252
23	342	336	358	279	251	252	248	140	155	204	327	253
24	335	335	359	279	250	252	248	140	155	204	327	399
25	335	334	358	278	250	252	247	139	222	205	327	398
26	334	336	348	507	250	252	247	139	222	204	327	398
27	333	336	347	506	250	52	247	157	222	204	299	397
28	333	298	346	506	249	52	247	157	222	230	298	396
29	332	298	346	506	249	53	259	157	221	231	298	396
30	332	266	345	506	308	53	258	157	221		298	259
31	331		344	510		53		157	179		298	
Totals	9,972	9,369	10,071	10,242	9,247	6,860	6,447	5,866	5,137	5,363	9,233	9,603

GROUNDWATER OUTFLOW (ft³)

Day	2011												2012			
	May	June	July	August	September	October	November	December	January	February	March	April				
1	33	(241)	1,212	446	1,141	857	2,468	980	1,233	508	986	1,466				
2	5	(240)	1,161	399	1,085	773	2,132	956	1,203	495	995	1,396				
3	(18)	(239)	1,141	379	1,037	757	2,000	937	1,143	487	965	1,362				
4	(36)	(238)	1,056	345	972	775	1,932	915	1,111	480	993	1,306				
5	(59)	(237)	997	308	944	764	1,746	926	1,090	424	870	1,204				
6	(72)	(243)	902	277	923	769	1,693	927	1,062	413	835	1,131				
7	(86)	(247)	922	257	918	816	1,709	921	1,024	373	823	1,058				
8	(98)	(233)	959	201	1,044	3,259	1,664	895	996	347	889	998				
9	(104)	(236)	969	162	1,217	8,773	1,579	890	955	325	866	968				
10	(115)	(243)	992	300	1,525	6,948	1,517	1,041	932	331	883	951				
11	(129)	(247)	963	399	1,923	4,741	1,440	1,308	932	370	1,701	902				
12	(149)	(251)	918	555	1,970	4,312	1,389	2,386	948	342	3,143	870				
13	(177)	(253)	893	642	1,886	3,631	1,349	3,074	909	332	2,835	809				
14	(185)	(254)	839	736	1,654	2,759	1,338	2,400	877	359	2,389	792				
15	(154)	(244)	767	1,091	1,525	2,504	1,401	1,996	853	386	2,067	760				
16	(156)	(240)	735	1,163	1,400	2,498	1,514	1,774	816	392	1,816	740				
17	(151)	(232)	670	1,173	1,230	2,526	1,484	1,643	820	414	1,615	715				
18	(169)	(226)	635	1,132	1,216	2,746	1,366	1,515	857	401	1,525	677				
19	(180)	191	630	1,094	1,114	2,366	1,307	1,381	860	467	1,437	665				
20	(172)	613	648	1,035	1,128	2,010	1,283	1,346	773	540	1,393	754				
21	(178)	670	633	957	1,236	1,952	1,267	1,329	738	531	1,348	846				
22	(186)	672	624	873	1,174	1,918	1,246	1,344	741	583	1,334	1,031				
23	(197)	595	723	841	1,076	1,882	1,222	1,313	693	748	1,294	1,074				
24	(206)	504	791	852	998	1,878	1,219	1,324	694	798	1,263	1,061				
25	(208)	486	762	903	1,036	1,875	1,159	1,310	660	805	1,328	1,018				
26	(211)	590	703	840	959	1,899	1,147	1,314	644	758	1,301	952				
27	(218)	632	638	844	955	1,915	1,125	1,372	619	762	1,314	890				
28	(221)	593	584	828	939	1,851	1,114	1,479	614	927	1,305	839				
29	(225)	677	562	818	910	2,631	1,092	1,425	568	960	1,263	818				
30	(233)	1,122	536	811	920	3,044	1,017	1,393	537		1,214	772				
31	(237)		497	1,038		2,675		1,330	524		1,266					
Totals	(4,495)	2,999	25,060	21,699	36,055	78,104	43,919	43,146	26,426	15,057	43,255	28,825				

APPENDIX D

**CHEMICAL CHARACTERISTICS OF
COLLECTED PRE-MODIFICATION SAMPLES**

D.1 Inflow Samples

D.2 Outflow Samples

D.3 Groundwater Samples

D.4 Bulk Precipitation Samples

D.5 Pond Samples

D.1 Inflow Samples

D.2 Outflow Samples

D.3 Groundwater Samples

Chemical characteristics of Shallow Groundwater Samples Collected from January - April 2011

Sample Location	Collection Date	pH (s.u.)	Alkalinity (mg/l)	Conductivity (µmho/cm)	NH3-N (µg/l)	NOX-N (µg/l)	Diss. Org. N (µg/l)	Total N (µg/l)	SRP (µg/l)	Diss. Org. P (µg/l)	Total P (µg/l)	Color (Pt-Co)
MW 4	1/18/11	7.28	233	540	513	5	1220	1738	511	12	523	289
MW 4	1/26/11	7.38	228	584	573	2	1244	1819	490	43	533	288
MW 4	2/3/11	7.29	257	615	676	3	1011	1690	543	16	559	122
MW 4	2/15/11	7.35	254	614	545	2	588	1135	490	87	577	130
MW 4	3/17/11	7.25	263	512	477	3	1177	1657	475	67	542	126
MW 4	4/15/11	7.18	253	710	657	3	1188	1848	498	57	555	133
Minimum Value:		7.18	228	512	477	2	588	1135	475	12	523	122
Maximum Value:		7.38	263	710	676	5	1244	1848	543	87	577	289
Log-Normal Mean Value:		7.29	248	593	569	3	1039	1627	501	37	548	168

Number of Samples: 6

D.4 Bulk Precipitation Samples

D.5 Pond Samples

Measured Concentrations of Chlorophyll-a in the Western Pond

Sample Location	Date Collected	Chyl-a (mg/m ³)
Pond	1/18/11	4.6
Pond	1/26/11	7.0
Pond	2/3/11	6.3
Pond	2/8/11	7.3
Pond	2/15/11	25.1
Pond	2/23/11	11.1
Pond	3/3/11	4.0
Pond	3/11/11	16.8
Pond	3/17/11	13.7
Pond	3/24/11	21.9
Pond	4/7/11	218
Pond	4/15/11	247
Pond	4/21/11	277
Pond	4/28/11	156
Minimum Value:		4.0
Maximum Value:		277
Log-Normal Mean Value:		23.9
Number of Samples:		14

APPENDIX E

CALCULATED MONTHLY CONCENTRATIONS, MASS INPUTS, AND MASS LOSSES FOR THE PAFB POND UNDER PRE- AND POST-MODIFICATION CONDITIONS

Mean Monthly Concentrations of Measured Parameters at the PAFB Beemat Pond Under Pre and Post Modification Conditions

Month	Ammonia (µg/l)				NO _x (µg/l)				Diss. Organic N (µg/l)				Particulate N (µg/l)				Total N (µg/l)			
	Inflow	Rainfall	Outflow		Inflow	Rainfall	Outflow		Inflow	Rainfall	Outflow		Inflow	Rainfall	Outflow		Inflow	Rainfall	Outflow	
January	60	78	16		33	147	5		556	102	636		100	80	373		759	426	1061	
February	106	88	86		23	81	5		501	69	520		196	88	160		895	349	780	
March	94	98	8		23	45	3		779	47	817		105	97	371		1015	287	1209	
April	74	145	97		7	26	47		598	67	535		770	84	1020		1453	322	2048	
May		86				22				66				128				343		
June	27	51	15		16	18	27		691	65	907		62	195	260		911	365	1262	
July	31	126	29		3	5	2		674	118	677		138	385	431		947	634	1182	
August	82	349	128		3	48	2		610	69	371		138	222	354		891	688	995	
September	133	43	75		5	12	8		352	38	591		275	184	235		1045	290	948	
October	16	56	10		21	36	9		607	66	605		197	229	197		853	428	849	
November	18	233	13		13	5	12		552	29	573		210	246	218		836	521	840	
December	5	218	61		4	50	18		557	98	689		289	288	73		898	654	917	
January	26		13		16		7		394		461		58		55		518		570	
February	40	194	45		19	59	3		446	31	534		117	43	147		630	351	761	
March	23	196	23		8	55	10		373	14	416		160	16	173		580	281	663	
April	8	144	7		22	66	7		363	42	456		122	159	271		538	482	778	

Month	SRP (µg/l)			Diss. Organic P (µg/l)			Particulate P (µg/l)			Total P (µg/l)			TSS (mg/l)		
	Inflow	Rainfall	Outflow	Inflow	Rainfall	Outflow	Inflow	Rainfall	Outflow	Inflow	Rainfall	Outflow	Inflow	Rainfall	Outflow
January	158	10	28	19	9	20	17	33	63	210	106	112	2.2	3.2	7.6
February	170	18	82	25	7	12	20	68	36	291	138	134	3.7	3.0	5.1
March	235	33	4	37	6	25	14	141	62	290	180	92	1.9	2.8	8.0
April	175	47	12	25	31	12	146	234	148	349	312	207	5.6	13.6	15.5
May		21			32			166			229			7.7	
June	52	10	3	13	32	5	17	118	40	83	168	51	1.5	4.4	12.3
July	38	26	8	23	53	23	22	283	76	92	362	108	1.9	19.3	18.4
August	16	29	1	22	11	22	43	137	65	88	177	89	2.0	0.4	6.3
September	29	12	7	33	3	9	53	22	47	125	44	66	2.8	3.0	3.6
October	103	9	48	29	17	14	37	85	32	174	113	106	1.7	5.2	2.1
November	200	107	208	18	13	33	48	154	55	282	286	313	1.5	2.7	2.5
December	241	16	174	52	11	35	35	58	55	352	85	293	1.5	9.0	1.9
January	139		104	15		21	21		27	181		164	0.8		1.2
February	151	88	43	18	57	13	15	61	32	201	212	100	1.1	8.6	2.7
March	122	86	54	5	3	14	38	25	46	167	114	128	1.2	1.0	2.7
April	23	26	12	10	44	58	22	52	42	66	122	114	1.2	5.6	3.1

Mass Inputs and Losses of Ammonia from January 2011 - April 2012

Month	Pond Inputs (kg)			Pond Losses (kg)			Mass Removal (%)
	Inflow	Rainfall	Total Inputs	Outflow	GW	Total Losses	
January	0.27	0.01	0.28	0.06	0.01	0.07	75
February	0.23	0.00	0.23	0.15	0.04	0.19	16
March	0.04	0.02	0.06	0.00	0.00	0.00	95
April	0.29	0.01	0.29	0.32	0.06	0.38	-29
Totals:	0.83	0.04	0.86	0.52	0.12	0.64	25
May	0.12	0.02	0.13	0.09	0.02	0.11	18
June	0.04	0.01	0.05	0.01	0.00	0.01	78
July	0.12	0.02	0.13	0.09	0.02	0.11	18
August	0.27	0.11	0.38	0.33	0.08	0.41	-8
September	1.07	0.01	1.08	0.53	0.08	0.60	44
October	0.43	0.04	0.48	0.25	0.02	0.27	43
November	0.18	0.01	0.19	0.12	0.02	0.13	31
December	0.05	0.05	0.10	0.50	0.07	0.57	-475
January	0.11	0.00	0.11	0.04	0.01	0.05	49
February	0.06	0.02	0.07	0.04	0.02	0.06	26
March	0.22	0.04	0.26	0.19	0.03	0.22	17
April	0.04	0.01	0.06	0.03	0.01	0.04	30
Totals:	2.71	0.32	3.04	2.21	0.37	2.58	15

Jan-Apr	0.43	0.07	0.50	0.30	0.06	0.37	26
---------	------	------	------	------	------	------	----

Mass Inputs and Losses of SRP from January 2011 - April 2012

Month	Pond Inputs (kg)			Pond Losses (kg)			Mass Removal (%)
	Inflow	Rainfall	Total Inputs	Outflow	GW	Total Losses	
January	0.71	0.00	0.71	0.10	0.02	0.12	83
February	0.36	0.00	0.36	0.14	0.04	0.18	50
March	0.11	0.01	0.11	0.00	0.00	0.00	99
April	0.68	0.00	0.69	0.04	0.01	0.05	93
Totals:	1.86	0.01	1.87	0.28	0.07	0.35	81
May	0.00	0.00	0.00	0.00	0.00	0.00	100
June	0.07	0.00	0.07	0.00	0.00	0.00	97
July	0.14	0.00	0.15	0.02	0.01	0.03	81
August	0.05	0.01	0.06	0.00	0.00	0.00	93
September	0.23	0.00	0.23	0.05	0.01	0.06	74
October	2.83	0.01	2.84	1.22	0.11	1.32	53
November	1.98	0.00	1.99	1.84	0.26	2.09	-5
December	2.24	0.00	2.24	1.40	0.21	1.61	28
January	0.58	0.00	0.58	0.36	0.08	0.44	24
February	0.22	0.01	0.22	0.03	0.02	0.05	76
March	1.19	0.02	1.21	0.45	0.07	0.52	57
April	0.13	0.00	0.13	0.06	0.01	0.07	48
Totals:	9.65	0.06	9.71	5.44	0.76	6.20	36

Jan-Apr	2.11	0.03	2.14	0.90	0.17	1.08	50
---------	------	------	------	------	------	------	----

Mass Inputs and Losses of NO_x from January 2011 - April 2012

Month	Pond Inputs (kg)			Pond Losses (kg)			Mass Removal (%)
	Inflow	Rainfall	Total Inputs	Outflow	GW	Total Losses	
January	0.15	0.02	0.17	0.02	0.00	0.02	87
February	0.05	0.00	0.05	0.01	0.00	0.01	78
March	0.01	0.01	0.02	0.00	0.00	0.00	94
April	0.03	0.00	0.03	0.15	0.03	0.18	-504
Totals:	0.23	0.03	0.27	0.18	0.04	0.22	19
May	0.00	0.00	0.00	0.00	0.00	0.00	100
June	0.02	0.00	0.03	0.02	0.00	0.02	26
July	0.01	0.00	0.01	0.01	0.00	0.01	31
August	0.01	0.01	0.02	0.01	0.00	0.01	73
September	0.04	0.00	0.04	0.06	0.01	0.06	-53
October	0.58	0.03	0.61	0.23	0.02	0.25	59
November	0.13	0.00	0.13	0.11	0.02	0.13	1
December	0.04	0.01	0.05	0.15	0.02	0.17	-216
January	0.07	0.00	0.07	0.02	0.01	0.03	57
February	0.03	0.01	0.03	0.00	0.00	0.00	89
March	0.08	0.01	0.09	0.08	0.01	0.09	-2
April	0.12	0.01	0.12	0.03	0.01	0.04	71
Totals:	1.13	0.08	1.21	0.71	0.09	0.81	33

Jan-Apr	0.29	0.02	0.32	0.14	0.02	0.16	49
---------	------	------	------	------	------	------	----

Mass Inputs and Losses of Dissolved Organic P from January 2011 - April 2012

Month	Pond Inputs (kg)			Pond Losses (kg)			Mass Removal (%)
	Inflow	Rainfall	Total Inputs	Outflow	GW	Total Losses	
January	0.09	0.00	0.09	0.07	0.02	0.09	-1
February	0.05	0.00	0.05	0.02	0.01	0.03	52
March	0.02	0.00	0.02	0.00	0.01	0.01	50
April	0.10	0.00	0.10	0.04	0.01	0.05	51
Totals:	0.25	0.00	0.25	0.13	0.04	0.17	33
May	0.00	0.00	0.00	0.00	0.00	0.00	100
June	0.02	0.01	0.02	0.00	0.00	0.00	86
July	0.09	0.01	0.09	0.07	0.02	0.09	4
August	0.07	0.00	0.08	0.06	0.01	0.07	7
September	0.27	0.00	0.27	0.06	0.01	0.07	74
October	0.79	0.01	0.80	0.36	0.03	0.39	51
November	0.18	0.00	0.18	0.29	0.04	0.33	-88
December	0.49	0.00	0.49	0.28	0.04	0.33	33
January	0.06	0.00	0.06	0.07	0.02	0.09	-36
February	0.03	0.00	0.03	0.01	0.01	0.02	47
March	0.05	0.00	0.05	0.11	0.02	0.13	-163
April	0.06	0.00	0.06	0.26	0.05	0.31	-424
Totals:	2.09	0.04	2.13	1.58	0.24	1.82	14

Jan-Apr	0.19	0.01	0.20	0.46	0.08	0.54	-167
---------	------	------	------	------	------	------	------

Mass Inputs and Losses of Dissolved Organic Nitrogen from January 2011 - April 2012

Month	Pond Inputs (kg)			Pond Losses (kg)			Mass Removal (%)
	Inflow	Rainfall	Total Inputs	Outflow	GW	Total Losses	
January	2.50	0.02	2.52	2.32	0.49	2.81	-11
February	1.07	0.00	1.07	0.88	0.27	1.15	-8
March	0.36	0.01	0.36	0.07	0.22	0.29	20
April	2.33	0.00	2.33	1.74	0.34	2.08	11
Totals:	6.26	0.03	6.29	5.01	1.32	6.34	-1
May	0.00	0.00	0.00	0.00	0.00	0.00	100
June	0.90	0.01	0.92	0.54	0.08	0.62	32
July	2.59	0.01	2.60	2.12	0.48	2.60	0
August	2.01	0.02	2.03	0.95	0.23	1.18	42
September	2.84	0.01	2.85	4.13	0.61	4.73	-66
October	16.69	0.05	16.74	15.38	1.33	16.71	0
November	5.46	0.00	5.47	5.06	0.71	5.78	-6
December	5.18	0.02	5.20	5.56	0.84	6.40	-23
January	1.63	0.00	1.63	1.59	0.35	1.93	-18
February	0.64	0.00	0.64	0.43	0.23	0.66	-4
March	3.65	0.00	3.65	3.50	0.51	4.00	-10
April	1.99	0.00	1.99	2.08	0.37	2.45	-23
Totals:	43.6	0.14	43.7	41.3	5.74	47.1	-8

Jan-Apr	7.91	0.01	7.92	7.60	1.46	9.06	-14
---------	------	------	------	------	------	------	-----

Mass Inputs and Losses of Particulate P from January 2011 - April 2012

Month	Pond Inputs (kg)			Pond Losses (kg)			Mass Removal (%)
	Inflow	Rainfall	Total Inputs	Outflow	GW	Total Losses	
January	0.07	0.01	0.08	0.23	0.05	0.28	-245
February	0.04	0.00	0.05	0.06	0.02	0.08	-77
March	0.01	0.02	0.03	0.01	0.02	0.02	24
April	0.57	0.01	0.58	0.48	0.10	0.58	1
Totals:	0.70	0.04	0.74	0.78	0.18	0.96	-30
May	0.00	0.00	0.00	0.00	0.00	0.00	100
June	0.02	0.02	0.05	0.02	0.00	0.03	42
July	0.08	0.03	0.12	0.24	0.05	0.29	-143
August	0.14	0.04	0.18	0.17	0.04	0.21	-14
September	0.43	0.00	0.43	0.33	0.05	0.38	14
October	1.03	0.06	1.09	0.81	0.07	0.88	20
November	0.48	0.01	0.48	0.49	0.07	0.56	-15
December	0.33	0.01	0.34	0.45	0.07	0.51	-52
January	0.09	0.00	0.09	0.09	0.02	0.11	-32
February	0.02	0.01	0.03	0.03	0.01	0.04	-49
March	0.37	0.00	0.38	0.38	0.06	0.44	-17
April	0.12	0.00	0.13	0.19	0.03	0.22	-80
Totals:	3.11	0.20	3.31	3.19	0.48	3.66	-11

Jan-Apr	0.6	0.01	0.6	0.7	0.12	0.8	-33
---------	-----	------	-----	-----	------	-----	-----

Mass Inputs and Losses of Particulate Nitrogen from January 2011 - April 2012

Month	Pond Inputs (kg)			Pond Losses (kg)			Mass Removal (%)
	Inflow	Rainfall	Total Inputs	Outflow	GW	Total Losses	
January	0.45	0.01	0.46	1.36	0.29	1.65	-256
February	0.42	0.00	0.42	0.27	0.08	0.35	16
March	0.05	0.02	0.06	0.03	0.10	0.13	-107
April	3.00	0.00	3.01	3.32	0.65	3.98	-32
Totals:	3.92	0.03	3.95	4.99	1.12	6.11	-55
May	0.00	0.00	0.00	0.00	0.00	0.00	100
June	0.08	0.04	0.12	0.16	0.02	0.18	-46
July	0.53	0.05	0.58	1.35	0.31	1.66	-187
August	0.45	0.07	0.52	0.91	0.22	1.13	-116
September	2.22	0.03	2.26	1.64	0.24	1.88	17
October	5.43	0.17	5.60	5.00	0.43	5.43	3
November	2.08	0.01	2.09	1.92	0.27	2.20	-5
December	2.69	0.06	2.75	0.59	0.09	0.68	75
January	0.24	0.00	0.24	0.19	0.04	0.23	5
February	0.17	0.00	0.17	0.12	0.06	0.18	-7
March	1.57	0.00	1.57	1.46	0.21	1.67	-6
April	0.67	0.01	0.68	1.24	0.22	1.46	-114
Totals:	16.1	0.46	16.6	14.6	2.12	16.7	-1

Jan-Apr	2.64	0.02	2.66	3.00	0.54	3.54	-33
---------	------	------	------	------	------	------	-----

Mass Inputs and Losses of Total P from January 2011 - April 2012

Month	Pond Inputs (kg)			Pond Losses (kg)			Mass Removal (%)
	Inflow	Rainfall	Total Inputs	Outflow	GW	Total Losses	
January	0.94	0.02	0.96	0.41	0.09	0.49	49
February	0.62	0.00	0.62	0.23	0.07	0.30	52
March	0.13	0.03	0.16	0.01	0.03	0.03	80
April	1.36	0.02	1.37	0.67	0.13	0.81	41
Totals:	3.06	0.06	3.12	1.32	0.31	1.63	48
May	0.00	0.00	0.00	0.00	0.00	0.00	100
June	0.11	0.04	0.14	0.03	0.00	0.03	76
July	0.35	0.04	0.40	0.34	0.08	0.41	-4
August	0.29	0.05	0.34	0.23	0.05	0.28	18
September	1.01	0.01	1.02	0.46	0.07	0.53	48
October	4.79	0.09	4.88	2.71	0.24	2.94	40
November	2.80	0.01	2.81	2.77	0.39	3.16	-12
December	3.28	0.02	3.29	2.36	0.36	2.72	17
January	0.75	0.00	0.75	0.56	0.12	0.69	8
February	0.29	0.02	0.31	0.08	0.04	0.12	59
March	1.63	0.02	1.66	1.07	0.16	1.23	26
April	0.36	0.01	0.37	0.52	0.09	0.61	-64
Totals:	15.7	0.31	16.0	11.13	1.60	12.7	20

Jan-Apr	3.03	0.05	3.09	2.24	0.41	2.65	14
---------	------	------	------	------	------	------	----

Mass Inputs and Losses of Total Nitrogen from January 2011 - April 2012

Month	Pond Inputs (kg)			Pond Losses (kg)			Mass Removal (%)
	Inflow	Rainfall	Total Inputs	Outflow	GW	Total Losses	
January	3.42	0.07	3.49	3.87	0.81	4.68	-34
February	1.91	0.01	1.92	1.33	0.40	1.73	10
March	0.46	0.05	0.51	0.10	0.33	0.43	16
April	5.66	0.02	5.68	6.67	1.31	7.99	-41
Totals:	11.5	0.14	11.6	12.0	2.86	14.8	-28
May	0.00	0.00	0.00	0.00	0.00	0.00	100
June	1.19	0.08	1.27	0.75	0.11	0.86	32
July	3.63	0.08	3.71	3.69	0.85	4.54	-22
August	2.93	0.21	3.15	2.56	0.61	3.17	-1
September	8.45	0.05	8.50	6.62	0.97	7.59	11
October	23.47	0.32	23.79	21.60	1.88	23.48	1
November	8.27	0.02	8.29	7.43	1.05	8.48	-2
December	8.35	0.15	8.49	7.39	1.12	8.51	0
January	2.15	0.00	2.15	1.96	0.43	2.39	-11
February	0.90	0.03	0.93	0.62	0.33	0.95	-2
March	5.67	0.06	5.73	5.57	0.81	6.38	-11
April	2.95	0.04	2.99	3.56	0.63	4.19	-40
Totals:	68.0	1.04	69.0	61.8	8.78	70.5	-2

Jan-Apr	11.67	0.13	11.79	11.71	2.20	13.91	-18
---------	-------	------	-------	-------	------	-------	-----

Mass Inputs and Losses of TSS from January 2011 - April 2012

Month	Pond Inputs (kg)			Pond Losses (kg)			Mass Removal (%)
	Inflow	Rainfall	Total Inputs	Outflow	GW	Total Losses	
January	10.0	0.5	10.5	27.8	5.8	33.6	-221
February	7.9	0.1	7.9	8.6	2.6	11.2	-41
March	0.9	0.4	1.3	0.7	2.2	2.8	-117
April	22.0	0.7	22.7	50.6	10.0	60.6	-167
Totals:	40.7	1.7	42.4	87.7	20.6	108	-155
May	0.0	0.1	0.1	0.0	0.0	0.0	100
June	1.9	0.9	2.8	7.4	1.1	8.4	-197
July	7.3	2.4	9.7	57.6	13.2	70.8	-633
August	6.7	0.1	6.8	16.3	3.9	20.2	-196
September	22.8	0.5	23.4	25.3	3.7	29.0	-24
October	46.8	3.9	50.7	54.6	4.7	59.4	-17
November	15.0	0.1	15.1	22.3	3.1	25.4	-68
December	14.3	2.0	16.3	15.0	2.3	17.2	-6
January	3.4	0.0	3.4	4.0	0.9	4.8	-45
February	1.5	0.7	2.3	2.2	1.1	3.3	-46
March	11.8	0.2	12.0	22.4	3.3	25.6	-114
April	6.5	0.5	7.0	14.3	2.5	16.8	-142
Totals:	138	11.5	150	241	39.8	281	-88

Jan-Apr	23.2	1.43	24.6	42.8	7.82	50.6	-106
---------	------	------	------	------	------	------	------

APPENDIX F

**CHEMICAL CHARACTERISTICS OF
COLLECTED POST-MODIFICATION SAMPLES**

F.1 Inflow Samples

F.2 Outflow Samples

F.3 Groundwater Samples

F.4 Bulk Precipitation Samples

F.5 Pond Samples

F.1 Inflow Samples

Characteristics of Post Modification Inflow Samples Collected from May 2011 - April 2012

Sample Location	Date Collected	pH (s.u.)	Alkalinity (mg/l)	Sp. Cond. (µmho/cm)	NH ₃ (µg/l)	NO _x (µg/l)	Diss Org N (µg/l)	Part. N (µg/l)	Total N (µg/l)	SRP (µg/l)	Diss Org P (µg/l)	Part. P (µg/l)	Total P (µg/l)	Turbidity (NTU)	Color (Pt-Co)	TSS (mg/l)
Inflow	6/22/11	7.50	123	1145	30	88	770	14	902	45	15	19	79	0.9	25	0.9
Inflow	6/28/11	7.32	146	1143	25	3	620	272	920	61	11	16	88	0.9	30	2.4
Inflow	7/7/11	7.61	162	1241	10	5	727	21	763	72	28	7	107	1.3	28	1.4
Inflow	7/11/11	7.23	164	1232	97	3	504	305	909	48	21	28	97	1.1	26	2.2
Inflow	7/18/11	7.43	151	1282	95	3	688	409	1195	39	26	33	98	1.0	28	4.2
Inflow	7/26/11	7.08	152	1238	10	3	821	138	972	15	18	36	69	4.2	27	1.0
Inflow	8/2/11	7.33	163	1273	101	3	376	103	583	27	14	43	84	2.6	28	2.6
Inflow	8/8/11	7.50	146	1348	126	3	731	45	905	15	8	49	72	4.1	34	3.3
Inflow	8/16/11	7.52	149	1266	34	3	780	174	991	9	49	25	83	4.7	31	2.0
Inflow	8/23/11	7.24	158	1266	106	3	645	451	1205	17	41	62	120	2.3	31	1.0
Inflow	9/1/11	7.39	180	1365	696	3	142	368	1209	20	42	53	115	4.6	38	2.8
Inflow	9/8/11	7.41	180	1337	625	4	131	394	1154	8	52	68	128	2.5	33	2.6
Inflow	9/15/11	7.36	176	1279	25	27	627	370	1049	37	26	62	125	2.9	38	3.7
Inflow	9/22/11	7.19	200	1398	100	3	700	158	961	55	28	49	132	5.3	37	2.3
Inflow	9/30/11	7.48	185	1368	38	3	661	186	888	59	26	39	124	4.6	39	2.9
Inflow	10/7/11	7.39	148	1417	43	25	593	243	904	44	27	37	108	4.3	38	3.4
Inflow	10/13/11	7.46	154	1194	34	25	617	193	869	105	27	41	173	3.3	42	1.6
Inflow	10/20/11	7.72	207	1369	7	46	613	187	853	192	35	39	266	3.0	37	1.4
Inflow	10/27/11	7.78	222	1425	6	7	604	173	790	126	26	33	185	2.4	38	1.1
Inflow	11/3/11	7.65	207	1360	24	103	503	196	826	146	32	25	203	2.0	38	1.3
Inflow	11/8/11	7.88	214	1365	85	54	544	136	819	110	41	22	173	1.2	37	0.8
Inflow	11/16/11	7.64	220	1368	26	3	512	268	809	146	9	29	184	0.9	29	0.5
Inflow	11/22/11	7.54	213	1322	3	5	553	167	728	253	3	130	386	3.5	36	4.2
Inflow	11/29/11	7.61	262	1255	13	4	660	345	1022	543	50	128	721	16.1	50	3.7
Inflow	12/6/11	7.65	258	1064	3	15	713	240	971	342	160	81	583	8.5	37	6.4
Inflow	12/13/11	7.21	206	1255	33	3	494	377	907	138	17	22	177	0.8	31	0.8
Inflow	12/20/11	7.15	221	1148	3	3	504	569	1079	284	45	140	469	3.7	45	1.0
Inflow	12/27/11	7.53	202	1178	3	3	541	136	683	250	62	6	318	1.1	30	1.1
Inflow	1/3/12	7.75	202	1268	22	44	373	116	555	212	29	12	253	1.5	30	1.0
Inflow	1/10/12	7.91	200	1264	65	27	331	33	456	112	25	16	153	0.8	27	0.8
Inflow	1/17/12	7.72	201	1249	24	53	395	33	505	138	5	22	165	1.0	31	1.2
Inflow	1/25/12	7.69	195	1169	25	6	430	60	521	142	22	21	185	0.8	30	0.6
Inflow	1/31/12	7.67	187	1112	13	3	455	89	560	113	11	41	165	1.1	31	0.6
Inflow	2/7/12	7.69	184	1136	71	15	447	162	695	126	2	9	137	3.2	35	2.1
Inflow	2/14/12	7.76	186	1181	18	9	434	119	580	257	19	11	287	1.1	32	1.0
Inflow	2/21/12	7.63	182	1103	38	28	409	91	566	124	51	28	203	1.1	30	0.7
Inflow	2/28/12	7.69	174	1076	55	31	500	106	692	129	59	17	205	1.1	30	0.9

Characteristics of Post Modification Inflow Samples Collected from May 2011 - April 2012

Sample Location	Date Collected	pH (s.u.)	Alkalinity (mg/l)	Sp. Cond. (µmho/cm)	NH ₃ (µg/l)	NO _x (µg/l)	Diss Org N (µg/l)	Part. N (µg/l)	Total N (µg/l)	SRP (µg/l)	Diss Org P (µg/l)	Part. P (µg/l)	Total P (µg/l)	Turbidity (NTU)	Color (Pt-Co)	TSS (mg/l)
Inflow	3/6/12	7.56	175	1172	31	38	430	103	602	128	5	24	157	0.8	28	1.0
Inflow	3/13/12	7.28	174	1075	12	4	427	179	622	172	3	53	228	2.1	33	1.3
Inflow	3/20/12	7.64	182	1116	29	3	356	242	630	121	14	51	186	1.3	32	1.8
Inflow	3/27/12	7.63	185	1177	25	11	297	147	480	82	3	32	117	0.9	32	0.9
Inflow	4/3/12	7.52	196	1153	4	7	313	100	424	59	13	20	92	1.0	28	1.1
Inflow	4/10/12	7.45	109	1182	3	27	337	195	562	52	2	39	93	0.9	27	1.1
Inflow	4/17/12	7.51	173	1166	3	32	457	57	549	11	22	28	61	1.5	28	0.7
Inflow	4/23/12	7.55	171	1124	17	53	374	193	637	9	31	14	54	1.2	26	2.5
Inflow	4/30/12	7.53	175	1168	52	15	348	126	541	22	6	17	45	1.1	25	1.1
Minimum Value:		7.08	109	1064	3	3	131	14	424	8	2	6	45	0.8	25	0.5
Maximum Value:		7.91	262	1425	696	103	821	569	1209	543	160	140	721	16.1	50	6.4
Geometric Mean:		7.52	181	1231	25	9	480	148	753	72	19	30	148	1.9	32	1.5

F.2 Outflow Samples

Characteristics of Post Modification Outflow Samples Collected from May 2011 - April 2012

Sample Location	Date Collected	pH (s.u.)	Alkalinity (mg/l)	Sp. Cond. (umho/cm)	NH ₃ (ug/l)	NO _x (ug/l)	Diss Org N (ug/l)	Part. N (ug/l)	Total N (ug/l)	SRP (ug/l)	Diss Org P (ug/l)	Part. P (ug/l)	Total P (ug/l)	Turbidity (NTU)	Color (Pt-Co)	TSS (mg/l)
Outflow	6/22/11	7.40	108	1287	33	148	894	253	1328	2	11	35	48	18.0	22	26.2
Outflow	6/28/11	7.42	108	1276	7	5	920	267	1199	6	2	46	54	4.2	27	5.8
Outflow	7/7/11	7.55	119	1266	3	2	713	391	1109	8	33	76	117	24.4	24	23.5
Outflow	7/11/11	7.50	129	1265	82	2	652	269	1005	9	20	57	86	13.8	26	14.6
Outflow	7/18/11	7.29	123	1285	124	3	669	545	1341	4	21	69	94	33.4	24	19.8
Outflow	7/26/11	7.30	121	1233	22	3	677	603	1305	11	22	109	142	17.2	24	17.0
Outflow	8/2/11	7.16	112	1302	468	3	173	257	901	1	31	81	113	9.7	22	3.0
Outflow	8/16/11	7.57	122	1362	42	3	644	376	1065	1	20	54	75	6.5	36	11.0
Outflow	8/23/11	7.45	132	1324	107	1	460	460	1028	2	17	63	82	6.8	23	7.7
Outflow	9/1/11	7.58	145	1342	106	3	595	384	1088	5	22	60	87	11.4	27	8.8
Outflow	9/8/11	7.62	155	1263	156	4	575	295	1030	9	3	34	46	3.8	24	2.7
Outflow	9/15/11	7.50	166	1299	39	26	572	246	883	6	5	41	52	4.8	35	2.7
Outflow	9/22/11	7.53	167	1371	99	36	518	251	904	17	10	97	124	3.4	30	1.8
Outflow	9/30/11	7.67	184	1385	38	3	714	103	858	5	15	28	48	4.8	30	5.4
Outflow	10/7/11	7.55	182	1390	48	25	580	195	848	9	11	33	53	5.1	31	2.9
Outflow	10/13/11	7.48	173	1149	64	5	586	196	851	41	15	29	85	2.9	38	3.6
Outflow	10/20/11	7.76	203	1293	1	11	604	296	912	112	18	44	174	2.4	36	3.4
Outflow	10/27/11	7.62	214	1065	3	5	651	132	791	127	13	24	164	1.7	35	0.6
Outflow	11/3/11	7.74	213	1356	16	81	555	117	769	151	20	15	186	1.6	38	1.0
Outflow	11/8/11	7.46	229	1374	17	35	558	277	887	437	68	167	672	4.1	46	8.3
Outflow	11/16/11	7.60	282	1364	20	7	614	230	871	308	83	47	438	6.1	36	3.5
Outflow	11/22/11	7.64	228	1395	7	3	572	303	885	144	6	63	213	2.0	38	1.2
Outflow	11/29/11	7.72	223	1290	10	5	566	216	797	132	57	69	258	2.9	32	2.9
Outflow	12/6/11	7.73	221	1243	352	34	966	89	1441	177	142	30	349	3.0	42	5.3
Outflow	12/13/11	7.53	211	1210	136	6	534	129	805	192	16	34	242	2.4	40	3.3
Outflow	12/20/11	7.75	211	1222	11	57	580	99	747	142	32	147	321	1.9	40	1.7
Outflow	12/27/11	7.62	213	989	27	9	754	25	815	188	21	63	272	2.2	34	0.4
Outflow	1/3/12	7.70	214	1308	49	26	436	82	593	327	29	57	413	1.3	34	1.4
Outflow	1/10/12	7.83	209	1321	19	3	432	90	544	50	39	7	96	1.8	29	2.1
Outflow	1/17/12	7.81	197	1124	17	64	398	109	588	92	30	22	144	2.3	30	1.4
Outflow	1/25/12	7.63	206	1260	4	3	492	43	542	92	23	45	160	2.2	32	1.0
Outflow	1/31/12	7.72	194	924	6	1	565	14	586	90	5	35	130	1.4	32	0.5
Outflow	2/7/12	7.72	188	1029	74	4	570	114	762	46	36	14	96	2.1	35	2.2
Outflow	2/21/12	7.82	175	1218	63	5	533	86	687	40	22	37	99	3.6	31	3.9
Outflow	2/28/12	7.63	172	1185	19	1	500	322	842	42	3	61	106	2.1	29	2.2
Outflow	3/6/12	7.64	177	1221	16	3	496	147	662	59	10	28	97	2.5	29	2.0
Outflow	3/13/12	7.53	177	1164	23	12	489	91	615	112	3	51	166	3.6	31	1.5
Outflow	3/20/12	7.51	185	1204	31	3	406	319	759	61	35	56	152	5.6	32	4.2
Outflow	3/27/12	7.56	187	1222	23	87	304	212	626	21	32	55	108	3.4	35	4.0

Characteristics of Post Modification Outflow Samples Collected from May 2011 - April 2012

Sample Location	Date Collected	pH (s.u.)	Alkalinity (mg/l)	Sp. Cond. (umho/cm)	NH ₃ (ug/l)	NO _x (ug/l)	Diss Org N (ug/l)	Part. N (ug/l)	Total N (ug/l)	SRP (ug/l)	Diss Org P (ug/l)	Part. P (ug/l)	Total P (ug/l)	Turbidity (NTU)	Color (Pt-Co)	TSS (mg/l)
Outflow	4/3/12	7.67	183	1198	3	4	357	272	636	15	50	60	125	4.0	31	3.5
Outflow	4/10/12	7.97	177	1217	3	1	445	303	752	16	68	55	139	3.8	29	3.4
Outflow	4/17/12	7.60	159	1146	3	38	642	182	865	12	65	42	119	4.4	31	2.6
Outflow	4/23/12	7.64	149	1125	30	1	513	288	832	7	60	38	105	2.7	28	4.2
Outflow	4/30/12	7.61	147	1245	26	90	375	336	827	15	48	24	87	2.1	27	2.3

Minimum Value:

7.16

108

924

1

1

173

14

542

1

2

7

46

1.3

22

0.4

Maximum Value:

7.97

282

1395

468

148

966

603

1441

437

142

167

672

33.4

46

26.2

Geometric Mean:

7.60

173

1239

24

7

543

182

842

28

20

45

128

3.9

31

3.3

F.3 Groundwater Samples

Characteristics of Shallow Groundwater Samples collected from May 2011 - April 2012

Sample Location	Date Collected	pH (s.u.)	Alkalinity (mg/l)	Sp. Cond. (umho/cm)	NH ₃ (µg/l)	NO _x (µg/l)	Diss Org N (µg/l)	Total N (µg/l)	SRP (µg/l)	Diss Org P (µg/l)	Total P (µg/l)	Color (Pt-Co)
MW 1	5/17/11	6.99	304	2,202	386	3	1,192	1,581	487	84	571	96
MW 1	6/17/11	7.19	225	1,638	738	3	601	1,342	449	2	451	68
MW 1	7/18/11	7.40	208	1,554	690	3	1,166	1,859	410	2	412	55
MW 1	8/23/11	7.16	215	1,808	401	2	732	1,135	321	16	337	63
MW 1	9/15/11	7.06	254	2,137	223	26	1,019	1,268	320	17	337	90
MW 1	10/20/11	7.39	287	1,407	104	3	1,631	1,738	422	14	436	152
MW 1	11/16/11	7.23	244	2,067	137	3	1,476	1,616	296	41	337	131
MW 1	12/13/11	7.16	238	1,672	56	3	1,490	1,549	160	25	185	163
MW 1	1/17/12	7.39	216	1,481	116	3	1,340	1,459	375	22	397	147
MW 1	2/14/12	7.26	243	1,419	129	1	1,343	1,473	723	32	755	128
MW 1	3/13/12	7.30	240	2,047	81	2	985	1,068	291	4	295	113
MW 1	4/17/12	7.12	267	1,489	154	3	1,288	1,445	400	18	418	161
Minimum Value:		6.99	208	1,407	56	1	601	1,068	160	2	185	55
Maximum Value:		7.40	304	2,202	738	26	1,631	1,859	723	84	755	163
Geometric Mean:		7.22	244	1,721	193	3	1,145	1,444	366	14	389	107
MW 2	5/17/11	7.57	131	1,341	504	1	464	969	335	35	370	23
MW 2	6/17/11	7.57	163	1,553	364	3	314	681	343	9	352	27
MW 2	7/18/11	7.54	256	1,821	234	7	972	1,213	396	5	401	46
MW 2	8/16/11	7.43	165	1,676	94	1	483	578	313	4	317	30
MW 2	9/15/11	7.39	197	1,869	134	288	684	1,106	371	38	409	51
MW 2	10/20/11	7.69	196	1,591	78	3	1,047	1,128	783	10	793	101
MW 2	11/16/11	7.58	204	1,509	122	1	875	998	807	53	860	93
MW 2	12/13/11	7.63	205	1,290	103	1	538	642	656	18	674	68
MW 2	1/17/12	7.63	230	1,429	49	22	427	498	536	81	617	59
MW 2	2/14/12	7.39	191	1,339	1	1	380	382	640	152	792	59
MW 2	3/13/12	7.38	159	2,226	34	5	447	486	448	88	536	71
MW 2	4/17/12	7.31	205	1,382	19	3	395	417	432	70	502	61
Minimum Value:		7.31	131	1,290	1	1	314	382	313	4	317	23
Maximum Value:		7.69	256	2,226	504	288	1,047	1,213	807	152	860	101
Geometric Mean:		7.51	189	1,565	71	4	543	702	479	27	522	52

Characteristics of Shallow Groundwater Samples collected from May 2011 - April 2012

Sample Location	Date Collected	pH (s.u.)	Alkalinity (mg/l)	Sp. Cond. (umho/cm)	NH ₃ (µg/l)	NO _x (µg/l)	Diss Org N (µg/l)	Total N (µg/l)	SRP (µg/l)	Diss Org P (µg/l)	Total P (µg/l)	Color (Pt-Co)
MW 3	5/17/11	7.26	172	1,319	102	3	456	561	182	436	618	100
MW 3	6/17/11	7.35	188	1,527	246	3	293	542	330	257	587	127
MW 3	7/18/11	7.48	318	1,852	234	3	918	1,155	398	270	668	269
MW 3	8/16/11	7.25	194	1,605	121	3	419	543	286	267	553	132
MW 3	9/15/11	7.16	269	2,288	137	34	546	717	371	261	632	418
MW 3	10/20/11	7.29	237	1,568	126	3	1,137	1,266	818	169	987	291
MW 3	11/16/11	7.40	200	1,515	113	2	1,090	1,205	777	260	1,037	226
MW 3	12/13/11	7.44	196	1,343	232	3	723	958	600	168	768	186
MW 3	1/17/12	7.42	291	1,515	101	4	790	895	530	317	847	214
MW 3	2/14/12	7.45	184	1,345	15	1	365	381	210	335	545	220
MW 3	3/13/12	7.36	201	1,567	27	1	525	553	429	116	545	262
MW 3	4/17/12	7.27	298	1,400	55	1	378	434	502	144	646	306
Minimum Value:		7.16	172	1,319	15	1	293	381	182	116	545	100
Maximum Value:		7.48	318	2,288	246	34	1,137	1,266	818	436	1,037	418
Geometric Mean:		7.34	224	1,552	97	3	580	710	411	234	686	213
MW 4	5/17/11	7.17	261	671	756	4	1,137	1,897	489	61	550	143
MW 4	6/17/11	7.28	263	699	781	3	1,087	1,871	523	3	526	140
MW 4	7/18/11	7.26	240	1,154	579	3	1,613	2,195	484	8	492	133
MW 4	8/16/11	7.09	233	1,489	123	3	1,516	1,642	457	2	459	129
MW 4	9/15/11	7.18	219	1,203	526	26	1,176	1,728	427	21	448	128
MW 4	10/20/11	7.36	171	1,406	465	3	1,359	1,827	395	8	403	94
MW 4	11/16/11	7.52	188	2,054	202	3	1,281	1,486	411	23	434	112
MW 4	12/13/11	7.57	200	2,119	216	3	1,221	1,440	460	10	470	125
MW 4	1/17/12	7.53	250	1,770	135	1	1,261	1,397	533	35	568	147
MW 4	2/14/12	7.48	249	1,662	144	1	1,245	1,390	948	38	986	135
MW 4	3/13/12	7.72	261	1,403	153	1	1,311	1,465	547	55	602	208
MW 4	4/17/12	7.36	302	1,152	124	3	1,733	1,860	592	86	678	253
Minimum Value:		7.09	171	671	123	1	1,087	1,390	395	2	403	94
Maximum Value:		7.72	302	2,119	781	26	1,733	2,195	948	86	986	253
Geometric Mean:		7.37	234	1,321	272	3	1,316	1,666	508	17	535	141

F.4 Bulk Precipitation Samples

Characteristics of Bulk Precipitation Samples Collected at the Pond Site from May 2011 - April 2012

Sample Location	Date Collected	pH (s.u.)	Alkalinity (mg/l)	Sp. Cond. (umho/cm)	NH ₃ (ug/l)	NO _x (ug/l)	Diss Org N (ug/l)	Part. N (ug/l)	Total N (ug/l)	SRP (ug/l)	Diss Org P (ug/l)	Part. P (ug/l)	Total P (ug/l)	Turbidity (NTU)	Color (Pt-Co)	TSS (mg/l)
Bulk Precip.	6/17/11	5.65	10.6	22	88	40	55	122	305	1	23	106	130	0.3	20	5.6
Bulk Precip.	6/22/11	6.19	13.4	18	74	33	45	101	253	18	13	65	96	2.6	16	2.8
Bulk Precip.	6/28/11	6.04	12.0	62	51	12	78	517	658	18	76	198	292	4.3	41	4.2
Bulk Precip.	6/28/11	6.09	14.0	87	20	7	94	228	349	26	48	144	218	3.3	21	5.5
Bulk Precip.	7/7/11	5.85	6.5	48	126	5	118	385	634	26	53	283	362	7.7	36	19.3
Bulk Precip.	8/16/11	5.69	22.8	18	349	48	69	222	688	29	11	137	177	0.8	11	0.4
Bulk Precip.	9/1/11	6.66	32.4	43	112	6	83	258	459	84	1	35	120	2.2	13	3.4
Bulk Precip.	9/15/11	5.63	4.2	68	20	32	24	136	212	5	5	15	25	1.5	6	3.5
Bulk Precip.	9/30/11	6.73	33.6	41	35	10	28	178	251	4	4	20	28	2.1	31	2.2
Bulk Precip.	10/10/11	6.60	17.8	22	19	4	24	142	189	1	7	25	33	1.4	10	1.8
Bulk Precip.	10/13/11	6.40	10.2	2	213	91	115	544	963	45	35	182	262	6.7	11	10.6
Bulk Precip.	10/20/11	5.99	9.6	15	43	127	104	156	430	15	19	133	167	5.4	22	7.5
Bulk Precip.	11/3/11	5.49	17.4	14	180	3	48	186	417	62	16	155	233	7.0	21	2.0
Bulk Precip.	11/16/11	5.29	15.0	48	301	7	18	325	651	186	11	153	350	6.3	38	3.6
Bulk Precip.	12/13/11	6.26	13.7	16	218	50	98	288	654	16	11	58	85	2.5	10	9.0
Bulk Precip.	2/14/12	5.78	25.2	34	367	43	29	61	500	108	50	94	252	11.3	46	20.0
Bulk Precip.	2/28/12	6.35	25.8	17	103	80	34	30	247	72	66	40	178	2.2	17	3.7
Bulk Precip.	3/13/12	6.79	14.8	20	196	55	14	16	281	86	3	25	114	1.1	4	1.0
Bulk Precip.	4/3/12	6.22	21.6	21	359	151	16	229	755	53	74	103	230	4.8	13	7.6
Bulk Precip.	4/23/12	5.51	11.8	35	58	29	110	111	308	13	26	26	65	3.1	8	4.2
Minimum Value:		5.29	4.2	2	19	3	14	16	189	1	1	15	25	0.3	4	0.4
Maximum Value:		6.79	33.6	87	367	151	118	544	963	186	76	283	362	11.3	46	20.0
Geometric Mean:		6.04	14.8	26	98	23	48	160	413	22	16	73	134	2.8	16	4.1

F.5 Pond Samples

Concentrations of Chlorophyll-a Measured in the PAFB Pond Under Post Modification Conditions

Sample Location	Date Collected	Chl a (mg/m ³)
Pond	5/3/11	191.5
Pond	5/10/11	134.4
Pond	5/17/11	13.9
Pond	5/24/11	21.9
Pond	6/2/11	22.8
Pond	6/7/11	46.1
Pond	6/17/11	15.8
Pond	6/22/11	16.5
Pond	6/28/11	11.3
Pond	7/7/11	6.4
Pond	7/11/11	8.9
Pond	7/18/11	6.6
Pond	7/26/11	6.6
Pond	8/2/11	13.9
Pond Top	8/8/11	26.7
Pond Middle	8/8/11	30.2
Pond Bottom	8/8/11	14.0
Pond Top	8/16/11	13.5
Pond Middle	8/16/11	21.0
Pond Bottom	8/16/11	18.9
Pond Top	8/23/11	28.8
Pond Middle	8/23/11	15.2
Pond Bottom	8/23/11	11.3
Pond Top	9/1/11	14.7
Pond Middle	9/1/11	12.8
Pond Bottom	9/1/11	17.6
Pond Top	9/8/11	15.7
Pond Middle	9/8/11	24.0
Pond Bottom	9/8/11	15.8

Concentrations of Chlorophyll-a Measured in the PAFB Pond Under Post Modification Conditions

Sample Location	Date Collected	Chl a (mg/m ³)
Pond Top	9/15/11	6.7
Pond Middle	9/15/11	25.0
Pond Bottom	9/15/11	24.2
Pond Top	9/22/11	25.3
Pond Middle	9/22/11	22.6
Pond Bottom	9/22/11	19.0
Pond Top	9/30/11	15.9
Pond Middle	9/30/11	14.0
Pond Bottom	9/30/11	21.6
Pond Top	10/7/11	13.2
Pond Middle	10/7/11	13.7
Pond Bottom	10/7/11	12.4
Pond Top	10/13/11	6.3
Pond Middle	10/13/11	4.8
Pond Bottom	10/13/11	2.1
Pond Top	10/20/11	14.9
Pond Middle	10/20/11	40.3
Pond Bottom	10/20/11	29.0
Pond Top	10/27/11	11.4
Pond Middle	10/27/11	4.9
Pond Bottom	10/27/11	9.1
Pond Top	11/3/11	4.6
Pond Middle	11/3/11	5.0
Pond Bottom	11/3/11	11.1

Concentrations of Chlorophyll-a Measured in the PAFB Pond Under Post Modification Conditions

Sample Location	Date Collected	Chl a (mg/m³)
Pond Top	11/8/11	20.0
Pond Middle	11/8/11	22.1
Pond Bottom	11/8/11	23.0
Pond Top	11/16/11	11.5
Pond Middle	11/16/11	16.0
Pond Bottom	11/16/11	26.6
Pond Top	11/22/11	23.6
Pond Middle	11/22/11	7.8
Pond Bottom	11/22/11	7.4
Pond Top	11/29/11	29.2
Pond Middle	11/29/11	25.1
Pond Bottom	11/29/11	29.8
Pond Top	12/6/11	16.8
Pond Middle	12/6/11	12.1
Pond Bottom	12/6/11	19.4
Pond Top	12/13/11	10.2
Pond Middle	12/13/11	10.5
Pond Bottom	12/13/11	30.2
Pond Top	12/20/11	10.8
Pond Middle	12/20/11	23.5
Pond Bottom	12/20/11	7.8
Pond Top	12/27/11	6.6
Pond Middle	12/27/11	6.8
Pond Bottom	12/27/11	6.0

Concentrations of Chlorophyll-a Measured in the PAFB Pond Under Post Modification Conditions

Sample Location	Date Collected	Chl a (mg/m ³)
Pond Top	1/3/12	8.6
Pond Middle	1/3/12	7.1
Pond Bottom	1/3/12	4.7
Pond Top	1/10/12	6.4
Pond Middle	1/10/12	12.5
Pond Bottom	1/10/12	5.9
Pond Top	1/17/12	2.5
Pond Middle	1/17/12	5.5
Pond Bottom	1/17/12	3.2
Pond Top	1/25/12	6.5
Pond Middle	1/25/12	2.4
Pond Bottom	1/25/12	5.3
Pond Top	1/31/12	4.3
Pond Middle	1/31/12	5.6
Pond Bottom	1/31/12	5.3
Pond Top	2/7/12	5.4
Pond Middle	2/7/12	4.8
Pond Bottom	2/7/12	8.7
Pond Top	2/14/12	10.6
Pond Middle	2/14/12	12.1
Pond Bottom	2/14/12	10.2
Pond Top	2/21/12	8.6
Pond Middle	2/21/12	14.9
Pond Bottom	2/21/12	8.8

Concentrations of Chlorophyll-a Measured in the PAFB Pond Under Post Modification Conditions

Sample Location	Date Collected	Chl a (mg/m ³)
Pond Top	2/28/12	18.5
Pond Middle	2/28/12	23.2
Pond Bottom	2/28/12	20.5
Pond Top	3/6/12	13.4
Pond Middle	3/6/12	17.0
Pond Bottom	3/6/12	10.6
Pond Top	3/13/12	12.8
Pond Middle	3/13/12	13.6
Pond Bottom	3/13/12	12.6
Pond Top	3/20/12	8.2
Pond Middle	3/20/12	10.5
Pond Bottom	3/20/12	10.5
Pond Top	3/27/12	20.9
Pond Middle	3/27/12	37.0
Pond Bottom	3/27/12	29.3
Pond Top	4/3/12	30.9
Pond Middle	4/3/12	49.8
Pond Bottom	4/3/12	41.8
Pond Top	4/10/12	35.7
Pond Middle	4/10/12	42.6
Pond Bottom	4/10/12	44.4
Pond Top	4/17/12	24.7
Pond Middle	4/17/12	28.7
Pond Bottom	4/17/12	30.7

Concentrations of Chlorophyll-a Measured in the PAFB Pond Under Post Modification Conditions

Sample Location	Date Collected	Chl a (mg/m ³)
Pond Top	4/23/12	19.1
Pond Middle	4/23/12	25.6
Pond Bottom	4/23/12	38.3
Pond Top	4/30/12	14.0
Pond Middle	4/30/12	30.5
Pond Bottom	4/30/12	30.5
Pond Top:		12.5
Pond Middle:		14.3
Pond Bottom:		13.8