

*Agriculture is Life!*

**Field Demonstration of the Performance  
of an Electrocoagulation System  
to Reduce Phosphorus and Other Substances  
from Dairy Lagoon Effluent**

**Final Report  
July 2006**

**By:**

**S. Mukhtar, Texas AgriLife Research  
K. Wagner, Texas Water Resources Institute  
L. Gregory, Texas Water Resources Institute**

**Funded by the Texas State Soil and Water Conservation Board  
under CWA Section 319, EPA TSSWCB Project # 03-10**

**Partners: Texas AgriLife Extension Service (formerly Texas Cooperative Extension)  
Texas Water Resources Institute  
Ecoloclean Industries, Inc.**

**Texas Water Resources Institute Technical Report  
January 2009**

# Field Demonstration of the Performance of an Electrocoagulation System to Reduce Phosphorus and Other Substances from Dairy Lagoon Effluent



**Field Demonstration of the Performance  
of an Electrocoagulation System to  
Reduce Phosphorus and Other Substances  
from Dairy Lagoon Effluent**

**Final Report**

**July 2006**

Funded by the  
Texas State Soil and Water Conservation Board  
under CWA Section 319, EPA  
TSSWCB Project #03-10

Partners  
Texas Cooperative Extension  
Texas Water Resources Institute  
Ecoloclean Industries, Inc.

# Table of Contents

---

Executive Summary	1
Introduction	2
The Ecoloclean System	3
Sampling Methods	8
Results and Discussion	14
Total Solids	16
Total Volatile Solids	17
Total Fixed Solids	18
Total Suspended Solids	19
pH	20
Conductivity	21
Nitrate-Nitrite Nitrogen	22
Total Kjeldahl Nitrogen	24
Total Phosphorus	25
Soluble Phosphorus	26
Potassium	27
Calcium	28
Magnesium	29
Sodium	30
Manganese	31
Iron	32
Copper	33
Aluminum	34
Economics	35
Conclusion	35
References	36
Acknowledgements	36
Appendix I	37

# Executive Summary

---

Two upper North Bosque River segments were designated as impaired in 1998 due to point source and nonpoint source (NPS) pollution of phosphorus (P) to these segments in the watershed. As a result, two Total Maximum Daily Loads (TMDLs) were applied which called for the reduction of annual loading and annual average soluble reactive P (SRP) concentrations by an average of 50%. This demonstration was conducted to evaluate the efficacy of a prospective new technology, an Electrocoagulation (EC) system, to potentially aid the dairy farmers in meeting the goals set by the TMDLs.

This EC system used chemical pre-treatment to coagulate and separate solids in slurry pumped from the dairy lagoon, the liquid then flowed over charged iron electrodes giving off ions that cause coagulation and precipitation of P and other metals. The configuration of the system and its components varied from event to event. To accommodate these changes, the points at which samples were taken varied as well. At all sampling events, samples were taken from the lagoon effluent, the lagoon effluent after the addition of the chemical pre-treatments, the effluent from the EC system and the residual solids. Samples were also taken where the mixture exited the centrifuge after it was added to aid in removing solids. These samples were sent to the lab where they were analyzed for solids, nutrients, metals, pH, and conductivity.

In order for the EC unit to function properly, the technology provider removed large amounts of solids from the raw lagoon effluent even though its solid concentration was a low 0.6 mg/L. By the time the treated effluent reached the EC unit, concentrations of many analytes were so low it is hard to conclude whether or not it is an effective component for treating dairy lagoon effluent. Samples of effluent from the centrifuge indicated that it was the most efficient component in the system as it removed larger amounts of solids, as well as more of the nutrients and metals than any other component in the system. Overall, the performance of the system was sporadic from event to event, which may be attributed to the changes in the system that occurred. However, it was consistently effective in reducing total phosphorus (TP) and SRP, on average reducing these constituents by 96% and 99.6% respectively from the dairy lagoon effluent. Some uncertainty surrounds the efficacy of this system to reduce both TP and SRP so efficiently because both these and other nutrients are not stable and do change form.

Economic data shows that costs to treat dairy lagoon effluent were \$0.12 per gallon (\$120 per 1,000 gallons). This cost did not include removal of residual material from the farm and will vary depending on the number of cows and volume of process generated influent entering the lagoon. This price per gallon is considerably higher than traditional methods of sludge treatment that range from \$5 to \$32 per 1,000 gallons of treated effluent.

# Introduction

---

Water quality degradation due to phosphorus (P) contribution as a nonpoint source of pollution from effluent and manure applied to waste application fields (WAFs) is a major concern in the Bosque River watershed. Point sources of pollution have also been identified as contributors to the problem in the Bosque River. In 1998 two upper North Bosque River segments were designated as impaired segments on the Texas Clean Water Act, Section 303(d) list (TNRCC, 2001). This designation was the result of nutrient loading and aquatic plant growth in those segments. The changes in the status of the Bosque River segments prompted the Texas Commission on Environmental Quality (TCEQ) to apply TMDLs for P to the designated segments. In December 2002, the TCEQ approved the implementation plan of these two TMDLs, and they were approved by the Texas State Soil and Water Conservation Board (TSSWCB) in January 2003. These TMDLs call for a reduction of the annual loading and annual average SRP concentrations by an average of 50%.

The TCEQ has cited pollution from nonpoint source agricultural operations (by way of runoff) as the main source of contamination to water bodies. Reducing P from dairy effluent applied to WAFs is vital to protecting these water bodies.

Runoff from WAFs is not strictly regulated because it is regarded as a nonpoint source. Currently, a number of dairy operations in the watersheds are using best management practices (BMPs) to remove P and SRP from the wastewater. However, to meet the goals of these TMDLs, new, more effective and more efficient BMPs will need to be adopted by the dairies. One prospective BMP is the use of an EC system to remove pollutants from the effluent being stored and treated in dairy lagoons.

This report outlines the performance of an EC system that was introduced for evaluation by Ecoloclean Industries, Inc. This EC system used chemical pre-treatment to coagulate and separate solids in slurry pumped from the dairy lagoon, the liquid then flowed over charged iron electrodes giving off ions that cause coagulation and precipitation of P and other metals. The configuration of the system and its components varied from event to event. To accommodate these changes, the points at which samples were taken varied as well. At all sampling events, samples were taken from the lagoon effluent, the lagoon effluent after the addition of the chemical pre-treatments, the effluent from the EC system and the residual solids. Samples were also taken where the mixture exited the centrifuge after its addition to the system to aid in solids removal. The system was set-up to treat the effluent from a secondary lagoon of a 700-head lactating cow dairy in the Bosque River watershed. Manure from the two free-stall barns at this dairy was flushed into the primary lagoon. Effluent from the secondary lagoon was recycled for flushing the barns and irrigating hay and cropland at the dairy operation.

# The Electrocoagulation System

---

For the first sampling event on June 8, 2005 the system was configured as follows (Fig. 1):

- Effluent from the lagoon was pumped at about 40 gallons per minute into a large mixing tank (Fig. 3).
- Unknown quantities of Alum ( $AlSO_4$ ), lime ( $CaOH$ ), and a proprietary anionic emulsion polymer were pumped into the large mixing tank from separate smaller mixing tanks (Fig. 3).
- Unknown quantity of a proprietary “mud mixture” was mixed in the Tri-Flow tank (Fig. 4) and then pumped into the large mixing tank.
- The mixed slurry (lagoon effluent chemicals and the mud mix) was then pumped to a dissolved air flotation (DAF) unit (in the DAF, small air bubbles are introduced in to the liquid. Solid flocculants adhere to the surface of the bubbles as they float to the top of the DAF tank. These solids are then removed by scraping them off the top of the liquid).
- The liquid exiting the DAF (Fig. 5) was then sent to the EC unit (Fig. 6).
- The effluent from the EC was pumped into a series of sequential tanks:
  - Reaction tank with a mixer (provides a sufficient amount of time for the completion of chemical reactions and removal of gasses which result from the processes in the EC unit),
  - Poly feed tank with a mixer (here the polyelectrolyte flocculent is mixed with the solids precipitated by the EC unit. This is done to coagulate the solids so they will settle more readily),
  - Clarifier Tank A (in this tank the up-flow rate of the water is less than the settling rate of the coagulated solids to allow the solids settle out of the liquid.).
- From these tanks, the liquid drained to the final filter (the last component in the system) after which the resulting product (treated effluent) from the system was sampled (Fig. 6).

For the sampling event on June 27, 2005, the configuration was altered. The changes to Fig. 1 are as follows:

- The DAF was replaced by clarifier tank B.
- From the clarifying tank, the mixture was pumped into the EC unit.
- After treatment in the EC, the effluent was pumped into a defoaming tank with a mixer
- From the defoaming tank, the effluent was then pumped to clarifier tank C.
- The effluent then drained into the final filter it was sampled.

For the following weeks, refer to Fig. 2:

On the next sampling conducted July 7, 2005 the DAF was returned to its original location in the system's components configuration, and the reaction tank was removed. A centrifuge (Fig. 8) was placed after the large mixing tank. The liquid exiting the centrifuge tank then proceeded onto the collection/equalization tank and then to the EC unit.

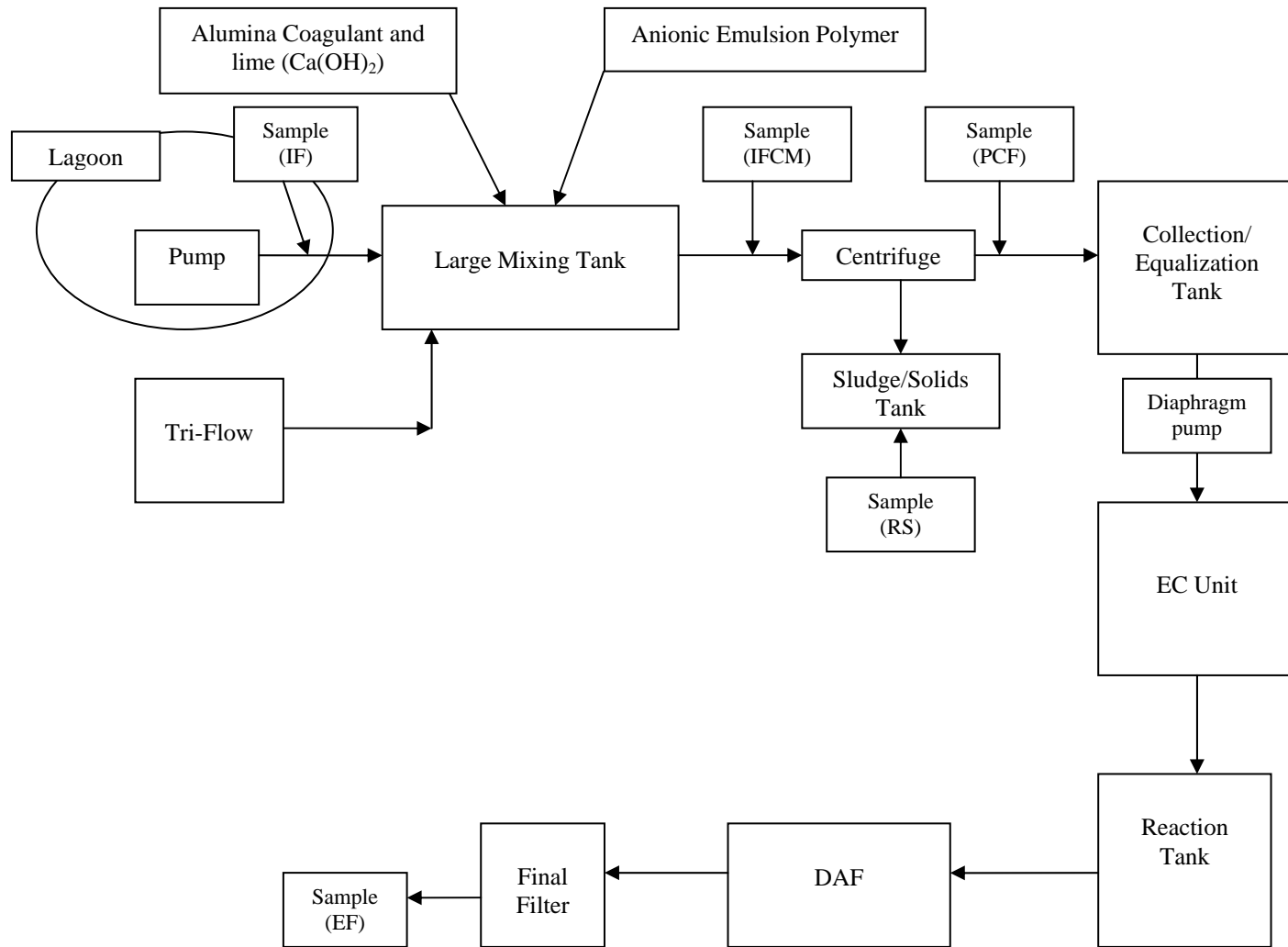
For sampling event on July 12, 2005, the same configuration was used from the previous sampling on July 7 with the removal of the DAF and the addition of a reaction/defoaming tank directly after the EC unit.

For the sampling event on July 19, 2005, the configuration was the same as the event on July 7, 2005. However, the defoaming tank was placed directly up-stream of the EC unit, and a different DAF was used.

For the next two sampling events on July 26, 2005 and August 8, 2005, the configuration remained the same as that for the July 7, 2005 sampling.







**Fig. 2: Schematic of EC System's Components Configuration for the Week of July 7, 2005 Through August 2, 2005**

**Table 1: Matrix of System Components and Their Order in the System per Sampling Event**

Component/Date	8-Jun	27-Jun	7-Jul	12-Jul	19-Jul	26-Jul	2-Aug
Small Mixing Tanks	1*a**	1a	1a	1a	1a	1a	1a
Tri-Flow	1b**	1b	1b	1b	1b	1b	1b
Large Mixing Tank	2	2	2	2	2	2	2
Centrifuge			3	3	3	3	3
Collection/Equilization Tank			5	4	5	5	5
Residual Solids Tank							
DAF A	3		4				
DAF B					4	4	4
EC Unit	4	4	6	5	7	7	7
Reaction Tank	5						
Poly-feed Tank	6						
Clarifier Tank A	7						
Clarifier Tank B		3					
Defoaming Tank		5		6	6	6	6
Clarifier Tank C		6					
Final Filter	8	7	7	7	8	8	8

- \* Numbers indicate the order in which the components were positioned in the system.  
A blank cell indicates that the component was not used for that sampling event.
- \*\* Letters denote that these components are placed parallel to one another in the system.  
The small mixing tanks and the Tri-Flow both feed into the large mixing tank, but do not interact with each other.

# Sampling Method

---

Ten sets of 15 (250 mL) grab samples were taken at each sampling event, with the exception of the first sampling event. As the system's components configuration changed, the locations at which samples were taken during each sampling event were as follows:

## Sampling event 1:

- Three sample sets were taken from the influent (IF) (lagoon effluent entering the system).
- One set of seven bottles were taken at the effluent outlet (EF). (Only seven bottles could be taken because the system could not be run for long enough to fill more than seven bottles.)
- Three samples of solids (RS) from the system were taken by fully filling a quart size freezer bag for each sample. (Solid samples were taken from the sludge tank.) (Fig. 1)

## Sampling event 2:

- Two sample sets were taken from the lagoon effluent entering the system (IF). (Fig. 1)
- Two sets were taken from the mixture exiting the large mixing tank (IFCM). (Fig. 1)
- Three sample sets were taken at the effluent outlet (EF). (Fig. 1)
- Three samples of solids (RS) from the system were taken. (Solid samples were taken from the sludge tank. Fig. 1)

## Sampling events 3 – 7:

- Two sample sets were taken from the lagoon effluent (IF) entering the system.
- Two sets were taken from the mixture exiting the large mixing tank (IFCM).
- Two sets were taken from the liquid exiting the centrifuge (PCF).
- Two samples of solids (RS) exiting the centrifuge were taken by fully filling a quart size freezer bag for each sample (Fig. 2).
- Two sets were taken at the effluent outlet (EF) (Fig. 2).

Samples were put on ice and transported to the laboratory within a few hours of each sampling event for analysis of the following analytes: Total Solids (TS), Total Volatile Solids (TVS), Total Fixed Solids (TFS), Total Suspended Solids (TSS), Total Dissolved Solids (TDS), Soluble Phosphorus (SRP), Total Phosphorus (TP), Nitrate/Nitrite-Nitrogen (NNN), Total Kjeldahl Nitrogen (TKN), Potassium (K), Aluminum (Al) Calcium (Ca), Magnesium (Mg), Sodium (Na), Manganese (Mn), Iron (Fe), and Copper (Cu). These analytes were analyzed according to the methods in Table 2.

---

**Table 2: Laboratory Analytical Methods\***

Parameter	Method	Equipment Used
Nitrite+Nitrate Nitrogen	EPA 351.2	Perstorp® or Lachat® QuickChem Autoanalyzer
Total Kjeldahl Nitrogen	EPA 353.2	Perstorp® or Lachat® QuickChem Autoanalyzer
Potassium	EPA 200.7	Spectro ® ICP
Calcium	EPA 200.7	Spectro ® ICP
Magnesium	EPA 200.7	Spectro ® ICP
Sodium	EPA 200.7	Spectro ® ICP
Manganese	EPA 200.7	Spectro ® ICP
Iron	EPA 200.7	Spectro ® ICP
Copper	EPA 200.7	Spectro ® ICP
Orthophosphate Phosphorus	EPA 365.2	Beckman® DU 640 Spectrophotometer
Total Phosphorus	EPA 365.2,4	Perstorp® or Lachat® QuickChem Autoanalyzer
Total Suspended Solids	EPA 160.2	Sartorius® AC210P or Mettler® AT261 analytical balance, oven
Total Solids	SM 2540C	Sartorius® AC210P or Mettler® AT261 analytical balance, oven
Volatile Solids	EPA 160.4	Sartorius® AC210P or Mettler® AT261 analytical balance, oven, muffle furnace
Potential Hydrogen	EPA 150.1	Accument® AB15 Plus pH meter
Conductivity	EPA 120.1	YSI® 3200 conductivity meter
Aluminum	EPA 200.7	Spectro ® ICP

\* Concentrations of Total Dissolved Solids were found by subtracting the concentrations of Total Suspended Solids from Total Solids.



**Fig. 3. Large Tank (Top) to Mix Added Alum, lime, and a Polymer (Bottom) for Chemical Pretreatment of Lagoon Effluent**



**Fig. 4. The Tri-Flow “Mud Mixer”**



**Fig. 5. The Dissolved Air Flotation (DAF) Unit**





**Fig. 6. The EC Unit with Iron Electrodes, Built on a Filter Press Frame**





**Fig. 7. The Final Filter and Port for Effluent Sampling**



**Fig. 8. Sample Being Taken from the Centrifuge**

## Results and Discussion

---

In the following section, results for each analyte are reported using the following abbreviations (Figs. 1 and 2 for locations where the samples were taken):

IF – Influent, the lagoon effluent pumped it to the treatment system  
IFCM – Influent (lagoon effluent) with chemical pretreatment  
PCF – Centrifuge effluent (liquid-solid separation of IFCM)  
EF – Effluent (Final treated lagoon effluent)  
RS – Residual Solids, separated solids by the centrifuge

Generally, concentrations of all physicochemical constituents analyzed from the lagoon effluent (influent pumped to the EC system) varied among sampling events. This may be attributed to the inlet location and depth in the lagoon that may have varied from week to week during these sampling events. Changing inlet locations are typical of dairy lagoons and were utilized to represent a field scenario for testing this technology. Pumps used to irrigate fields are situated on floating platforms that can move around in the lagoon; depth also changes quite often due to pumping, influent entering the lagoon, and rainfall events.

For all sampling events, analyses of the influent post chemical pretreatment (IFCM) showed increases in its conductivity and all solids, calcium, iron and aluminum concentrations. These increased concentrations resulted from alum, lime, polymer and the proprietary ‘mud mix’ added to the influent (IF) during the chemical pretreatment process.

Project limitations prohibited sample collection from occurring after each component in the system; however, this did not defeat the goal of measuring the overall effectiveness of the system to remove P from lagoon effluent. During the last five sampling events, the system setup (Fig. 1) allowed us to single out the large mixing tank (IF to IFCM) and the centrifuge (IFCM to PCF) and evaluate their individual effectiveness. During those weeks, those two components were responsible for removing the bulk of TP and SRP (see Table 11a and 12a). Other system components could not be individually sampled. Overall, the system removed at least 90% of TP and SRP in all sampling events.

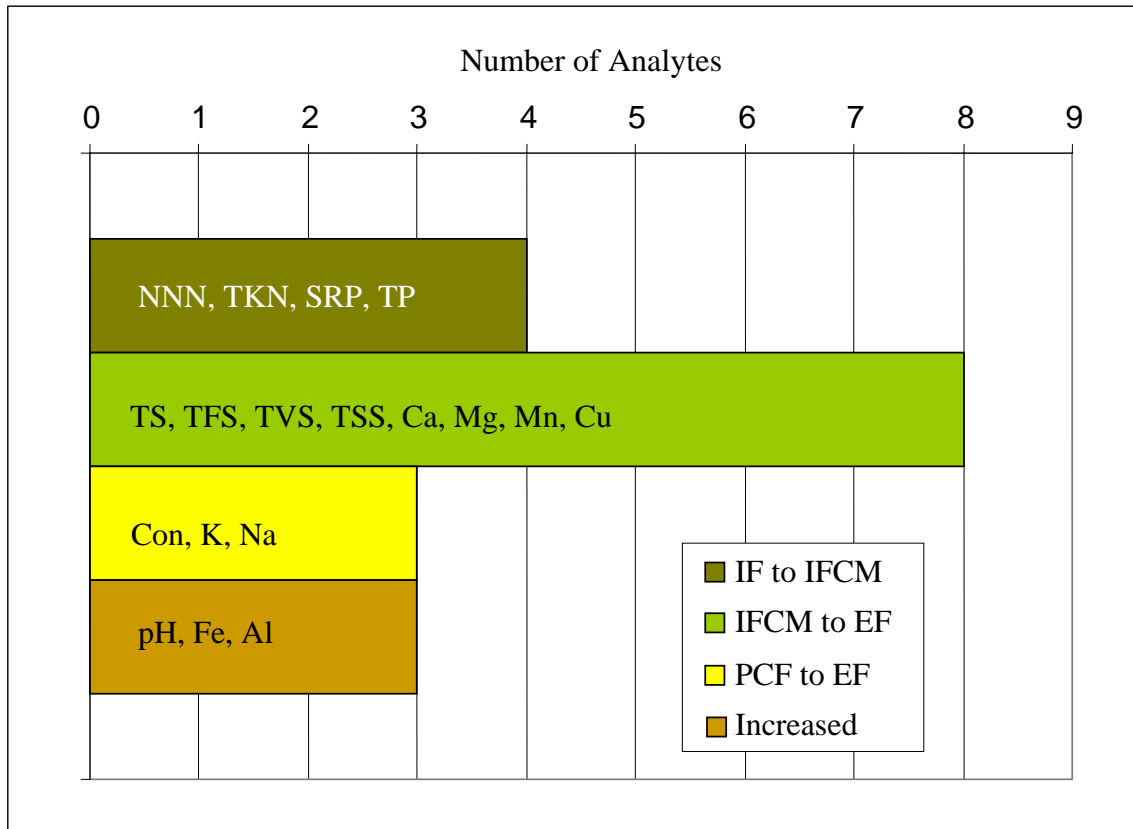
Effluent samples from the centrifuge (PCF) indicated that it was the most efficient component in the system as it removed larger amounts of solids, nutrients, and metals than any other component in the system. In Fig. 9, the analytes are grouped according to the stage in the system (i.e. IF to IFCM or PCF to EF) which was most effective in reducing its concentration. Fig. 9 shows that the centrifuge was by far the most efficient component for the most analytes and that chemical pre-treatment was the second most efficient within the system.

The main reductions in Na (although there was an overall increase in Na concentrations), K, and conductivity occurred between the sampling point after the centrifuge (PCF) and the final filter (EF). It is not clear why these reductions occurred. The EC unit may not

have caused these reductions since Na and K are positively charged metals and would not be affected by the positive iron ions being given off by the electrodes. These analytes are also highly soluble and would most likely not settle out in the series of tanks in between the two sampling points. In order for the EC unit to function properly, the technology provider removed large amounts of solids from the raw lagoon effluent even though its solid concentration was only about 0.6 mg/L. By the time the treated effluent reached the EC unit, concentrations of many analytes were so low it is hard to conclude whether or not it is an effective component for treating dairy lagoon effluent.

With the exception of Nitrate-Nitrite Nitrogen, there was no relationship between the concentration of any analyte and its overall percent reduction by the system from one sampling event to the other. For many of the analytes, either increase or reduction of their concentrations by different components in the system was variable among all sampling events. Concentrations of all analytes in residual solids (solids separated by the centrifuge) were substantially greater than those sampled from any other location in the system.

Because it was not possible to take a full set of samples on the June 8, 2005 event, and because of inconsistencies in the system's components configuration for this event, the data from this sampling was not used in the comparisons for this report



**Fig. 9. Analytes Grouped According to the Stage in the System which was the most Efficient in Reducing its Concentration**

## Total Solids (TS)

(Refer to Tables 3.a and 3.b)

There was a small but consistent drop in the concentration of influent TS over all six sampling events. The expected increase in concentration of TS from the influent to IFCM is apparent; however, the amount of increase varied from event to event. PCF values of TS were somewhat similar for most sampling events, but reduction of TS by the centrifuge (between IFCM and PCF) varied from event to event. Generally, the largest reduction of TS resulted in the liquid samples collected post centrifuge (IFCM) indicating the key mechanism for removing TS was the centrifuge. Conversely, a small reduction in TS concentrations from PCF to EF suggested that the EC unit was less effective in the removal of TS. The percent change from IF to EF of the lagoon effluent TS in the system was highly variable among all sampling events.

**Table 3.a. Average and Standard Deviations of TS Concentrations for each Sampling Point in the System\***

Date	27-Jun	7-Jul	12-Jul	19-Jul	26-Jul	2-Aug
<b>IF (s.d.)</b>	0.65 ± 0.001	0.61 ± 0.004	0.59 ± 0.03	0.58 ± 0.002	0.56 ± 0.008	0.55 ± 0.004
<b>IFCM (s.d.)</b>	0.7 ± 0.50	1.1 ± 0.11	1.0 ± 0.58	1.4 ± 0.11	1.3 ± 0.38	1.0 ± 0.30
<b>PCF (s.d.)</b>		0.47 ± 0.01	0.49 ± 0.11	0.39 ± 0.04	0.48 ± 0.14	0.42 ± 0.03
<b>EF (s.d.)</b>	0.24 ± 0.010	0.40 ± 0.002	0.35 ± 0.004	0.34 ± 0.032	0.39 ± 0.006	0.19 ± 0.011
<b>RS (s.d.)</b>	31 ± 2.2	27 ± 0.4	16 ± 2.4	19 ± 8.4	24 ± 1.7	24 ± 1.7

\*All values are on an as is basis. IF, IFCM, PCF and EF are in mg/L, RS is in mg/Kg.

**Table 3.b. Change in Concentration (mg/L) of TS between each Sampling Point in the System as well as the over all Percent Change of TS in the System (IF to EF)**

Date	27-Jun	7-Jul	12-Jul	19-Jul	26-Jul	2-Aug
<b>IF to IFCM</b>	0.07	0.50	0.45	0.78	0.73	0.50
<b>IFCM to EF</b>	-0.47					
<b>IFCM to PCF</b>		-0.64	-0.54	-0.96	-0.82	-0.63
<b>PCF to EF</b>		-0.08	-0.14	-0.05	-0.08	-0.23
<b>IF to EF</b>	-0.41	-0.21	-0.24	-0.24	-0.16	-0.36
<b>% Change (IF to EF)</b>	-63	-35	-40	-41	-29	-65

## Total Volatile Solids (TVS)

(Refer to Tables 4.a and 4.b)

The concentration of TVS in the influent was nearly 45% of TS over all six sampling events. Influent TVS concentrations after the chemical pretreatment varied somewhat and generally increased compared to those for the IF because of the addition of chemicals and other solids during pretreatment of IF. Both concentrations of TVS after the centrifuge (PCF) and effluent (EF) showed little variability among all sampling events. The largest reduction of TVS in the system occurred between IFCM and PCF, indicating the centrifuge was the predominant mechanism for removing TVS. The percent change from IF to EF of TVS was inconsistent from event to event.

**Table 4.a. Average and Standard Deviations of TVS Concentrations for each Sampling Point in the System\***

Date	27-Jun	7-Jul	12-Jul	19-Jul	26-Jul	2-Aug
IF (s.d.)	0.26 ± 0.002	0.27 ± 0.004	0.27 ± 0.004	0.25 ± 0.002	0.24 ± 0.004	0.23 ± 0.004
IFCM (s.d.)	0.20 ± 0.16	0.37 ± 0.04	0.30 ± 0.19	0.39 ± 0.02	0.34 ± 0.09	0.27 ± 0.07
PCF (s.d.)		0.13 ± 0.008	0.15 ± 0.016	0.11 ± 0.020	0.13 ± 0.042	0.12 ± 0.008
EF (s.d.)	0.05 ± 0.002	0.09 ± 0.002	0.10 ± 0.001	0.10 ± 0.003	0.10 ± 0.002	0.05 ± 0.009
RS (s.d.)	8 ± 0.25	7 ± 0.03	4 ± 0.35	5 ± 2.1	5 ± 0.15	4 ± 0.21

\*All values are on an as is basis. IF, IFCM, PCF and EF are in mg/L, RS is in mg/Kg.

**Table 4.b. Change in Concentration (mg/L) of TVS Between each Sampling Point in the System as well as the over all Percent Change of TVS in the System (IF to EF)**

Date	27-Jun	7-Jul	12-Jul	19-Jul	26-Jul	2-Aug
IF to IFCM	-0.07	0.10	0.03	0.13	0.10	0.04
IFCM to EF	-0.15					
IFCM to PCF		-0.24	-0.14	-0.28	-0.21	-0.15
PCF to EF		-0.04	-0.05	-0.01	-0.03	-0.07
IF to EF	-0.22	-0.17	-0.16	-0.16	-0.14	-0.18

% Change (IF to EF)	-83	-66	-61	-62	-59	-78
---------------------	-----	-----	-----	-----	-----	-----

## Total Fixed Solids (TFS)

(Refer to Tables 5.a and 5.b)

The TFS concentration in the influent was fairly consistent with small decreases on the second and third event. The concentration of TFS after the chemical pretreatment was highly variable. Concentrations of TFS after the centrifuge and in the effluent were fairly consistent for all six sampling events. The largest drop in TFS concentrations in the system was seen between the point where the chemical pretreatment was added (IFCM) and after it exited the centrifuge (PCF). This indicated that the key mechanism for removing TFS from lagoon effluent was the centrifuge. The percent change from IF to EF for TFS was highly variable for all six sampling events.

**Table 5.a. Average and Standard Deviations of TFS Concentrations for each Sampling Point in the System\***

Date	27-Jun	7-Jul	12-Jul	19-Jul	26-Jul	2-Aug
IF (s.d.)	0.39 ± 0.001	0.35 ± 0.0	0.32 ± 0.03	0.32 ± 0.004	0.32 ± 0.004	0.32 ± 0.008
IFCM (s.d.)	0.52 ± 0.33	0.75 ± 0.08	0.74 ± 0.39	0.97 ± 0.08	0.95 ± 0.30	0.78 ± 0.23
PCF (s.d.)		0.35 ± 0.02	0.34 ± 0.09	0.28 ± 0.02	0.34 ± 0.10	0.30 ± 0.03
EF (s.d.)	0.20 ± 0.008	0.31 ± 0.004	0.25 ± 0.003	0.25 ± 0.03	0.29 ± 0.004	0.14 ± 0.001
RS (s.d.)	24 ± 1.99	20 ± 0.44	13 ± 2.0	15 ± 6	19 ± 1.6	18 ± 0.60

\*All values are on an as is basis. IF, IFCM, PCF and EF are in mg/L, RS is in mg/Kg.

**Table 5.b. Change in Concentration (mg/L) of TFS Between each Sampling Point in the System as well as the over all Percent Change of TFS in the System (IF to EF)**

Date	27-Jun	7-Jul	12-Jul	19-Jul	26-Jul	2-Aug
IF to IFCM	0.13	0.40	0.42	0.64	0.64	0.46
IFCM to EF	-0.32					
IFCM to PCF		-0.40	-0.40	-0.69	-0.61	-0.48
PCF to EF		-0.04	-0.09	-0.03	-0.05	-0.16
IF to EF	-0.19	-0.04	-0.07	-0.08	-0.02	-0.18

% Change (IF to EF)	-49	-12	-23	-24	-7	-56
---------------------	-----	-----	-----	-----	----	-----

## Total Suspended Solids (TSS)

(Refer to Tables 6.a and 6.b)

The TSS concentration in the influent shows a small but consistent drop with each consecutive sampling event. TSS concentrations of IFCM are fairly inconsistent from event to event and, as expected, showed a marked increase from the TSS concentrations in the influent due to addition of chemicals and the proprietary ‘mud mix’. Concentrations of TSS after the centrifuge were similar from event to event with the exception of a much higher value on July 26. The centrifuge removed most TSS from the lagoon effluent being treated by the system. The percent change from IF to EF was highly variable ranging from a 46% increase to a 99% decrease over the six sampling events. In fact, on two of the six sampling events (July 7 and July 26), there was an overall increase in the TSS.

**Table 6.a. Average and Standard Deviations of TSS Concentrations for each Sampling Point in the System\***

Date	27-Jun	7-Jul	12-Jul	19-Jul	26-Jul	2-Aug
IF (s.d.)	0.09 ± 0.03	0.07 ± 0.07	0.05 ± 0.05	0.06 ± 0.06	0.06 ± 0.06	0.04 ± 0.04
IFCM (s.d.)			0.65 ± 0.65	1.06 ± 1.06	1.01 ± 1.01	0.84 ± 0.08
PCF (s.d.)		0.03 ± 0.03	0.02 ± 0.02	0.06 ± 0.06	0.27 ± 0.27	0.08 ± 0.08
EF (s.d.)	0.01 ± 0.004	0.09 ± 0.09	0.03 ± 0.03	0.04 ± 0.04	0.09 ± 0.09	0.02 ± 0.02

\*All values are on an as is basis. IF, IFCM, PCF and EF are in mg/L, RS is in mg/Kg.

**Table 6.b. Change in Concentration (mg/L) of TSS Between each Sampling Point in the System as well as the Over All Percent Change of TSS in the System (IF to EF)**

Date	27-Jun	7-Jul	12-Jul	19-Jul	26-Jul	2-Aug
IF to IFCM			0.60	1.00	0.96	0.80
IF to PCF		-0.05				
IFCM to PCF			-0.63	-1.00	-0.74	-0.76
PCF to EF		0.06	0.01	-0.02	-0.19	-0.06
IF to EF	-0.08	0.02	-0.01	-0.02	0.03	-0.01

% Change (IF to EF)	92	-18	31	32	-46	40
---------------------	----	-----	----	----	-----	----

## *pH*

---

(Refer to Tables 7.a and 7.b)

The pH of the influent had only slight variability in the samples for each event. The small increase in pH observed may have resulted from addition of lime in the pretreatment. There was also a consistent decrease in pH after the treated lagoon effluent passed through the centrifuge (with the exception of July 19 when there was an increase), and a consistent increase after the slurry passed through the EC unit. Overall, there was a small increase in pH with the exception of the sampling event on July 26.

**Table 7.a. Average and Standard Deviations of pH for each Sampling Point in the System\***

<b>Date</b>	<b>27-Jun</b>	<b>7-Jul</b>	<b>12-Jul</b>	<b>19-Jul</b>	<b>26-Jul</b>	<b>2-Aug</b>
<b>IF (s.d.)</b>	7.8 ± 0.01	7.8 ± 0.03	7.9 ± 0.03	7.8 ± 0.01	7.8 ± 0.03	7.9 ± 0.01
<b>IFCM (s.d.)</b>	8.8 ± 0.06	8.1 ± 0.01	8.2 ± 0.93	7.7 ± 0.00	7.9 ± 0.45	7.8 ± 0.08
<b>PCF (s.d.)</b>		7.6 ± 0.04	7.9 ± 0.42	8.2 ± 0.56	7.7 ± 0.10	7.7 ± 0.23
<b>EF (s.d.)</b>	8.3 ± 0.03	8.0 ± 0.03	8.1 ± 0.04	8.0 ± 0.02	7.8 ± 0.04	8.1 ± 0.01
<b>RS (s.d.)</b>	8.5 ± 0.11	8.0 ± 0.12	8.4 ± 0.36	8.1 ± 0.23	7.9 ± 0.007	8.1 ± 0.007

\*All values are on an as is basis.

**Table 7.b. Change in pH Between each Sampling Point in the System as Well as the Over All Percent Change of pH in the System (IF to EF)**

<b>Date</b>	<b>27-Jun</b>	<b>7-Jul</b>	<b>12-Jul</b>	<b>19-Jul</b>	<b>26-Jul</b>	<b>2-Aug</b>
<b>IF to IFCM</b>	1.0	0.2	0.3	-0.1	0.1	-0.1
<b>IFCM to EF</b>	-0.5					
<b>IFCM to PCF</b>		-0.5	-0.3	0.5	-0.2	-0.1
<b>PCF to EF</b>		0.5	0.2	-0.2	0.1	0.3
<b>IF to EF</b>	0.5	0.2	0.3	0.1	0.0	0.2
<b>% Change (IF to EF)</b>	7	2	3	2	0	2



## Conductivity (Cond)

(Refer to Tables 8.a and 8.b)

There was a small but steady drop in the influent conductivity over the six events that correspond to the pattern of declining concentration seen in the solids. There were slight increases and decreases in conductivity among sampling points in the system. These changes were not uniform from event to event. Percent change from IF to EF varied 35% over the six sampling events. These reductions were due to the removal of sodium and other conductive substances in the lagoon effluent treated by the system.

**Table 8.a. Average and Standard Deviations of Conductivity for each Sampling Point in the System\***

Date	27-Jun	7-Jul	12-Jul	19-Jul	26-Jul	2-Aug
IF (s.d.)	7605 ± 361	7200 ± 212	6685 ± 106	6810 ± 42	6610 ± 42	6630 ± 14
IFCM (s.d.)			5910 ± 467	6650 ± 42	5945 ± 403	6060 ± 14
PCF (s.d.)		7070 ± 14	6650 ± 382	6180 ± 580	6470 ± 127	6415 ± 247
EF (s.d.)	5173 ± 70	5715 ± 304	4830 ± 212	5195 ± 559	5675 ± 134	3380 ± 71

\*All values are on an as is basis. IF, IFCM, PCF and EF are in µS/cm

**Table 8.b. Change in Conductivity between Each Sampling Point in the System as well as the Over All Percent Change of Conductivity in the System (IF to EF)**

Date	27-Jun	7-Jul	12-Jul	19-Jul	26-Jul	2-Aug
IF to IFCM			-775	-160	-665	-570
IF to PCF		-130				
IFCM to PCF			740	-470	525	355
PCF to EF		-1355	-1820	-985	-795	-3035
IF to EF	-2431.7	-1485	-1855	-1615	-935	-3250
<b>% Change (IF to EF)</b>	32	21	28	24	14	49

## Nitrate-Nitrite Nitrogen (NNN)

(Refer to Tables 9.a and 9.b and Fig. 10)

The concentration of NNN in the influent varied among sampling events and was highly correlated (with an  $R^2$  value of 0.99) with the overall percent reduction (Figure 10); the higher the concentration of NNN in the influent the higher overall percent reduction. From these six sampling events, there did not appear to be any relationship between the concentration of NNN at a point in the system and the concentration of NNN in the residual (FS), which had a very wide range over the six sampling events. The largest drop in concentration of NNN was between IF and IFCM, indicating pretreatment of lagoon effluent with chemicals prior to solids removal with the centrifuge was the key mechanism for reducing NNN. The very small drop in concentration between PCF and EF indicated the EC unit did not effectively remove NNN during lagoon effluent treatment by this system. The percent change from IF to EF of NNN by the entire system was about 70 to 80% reduction.

**Table 9.a. Average and Standard Deviations of NNN Concentrations for each Sampling Point in the System\***

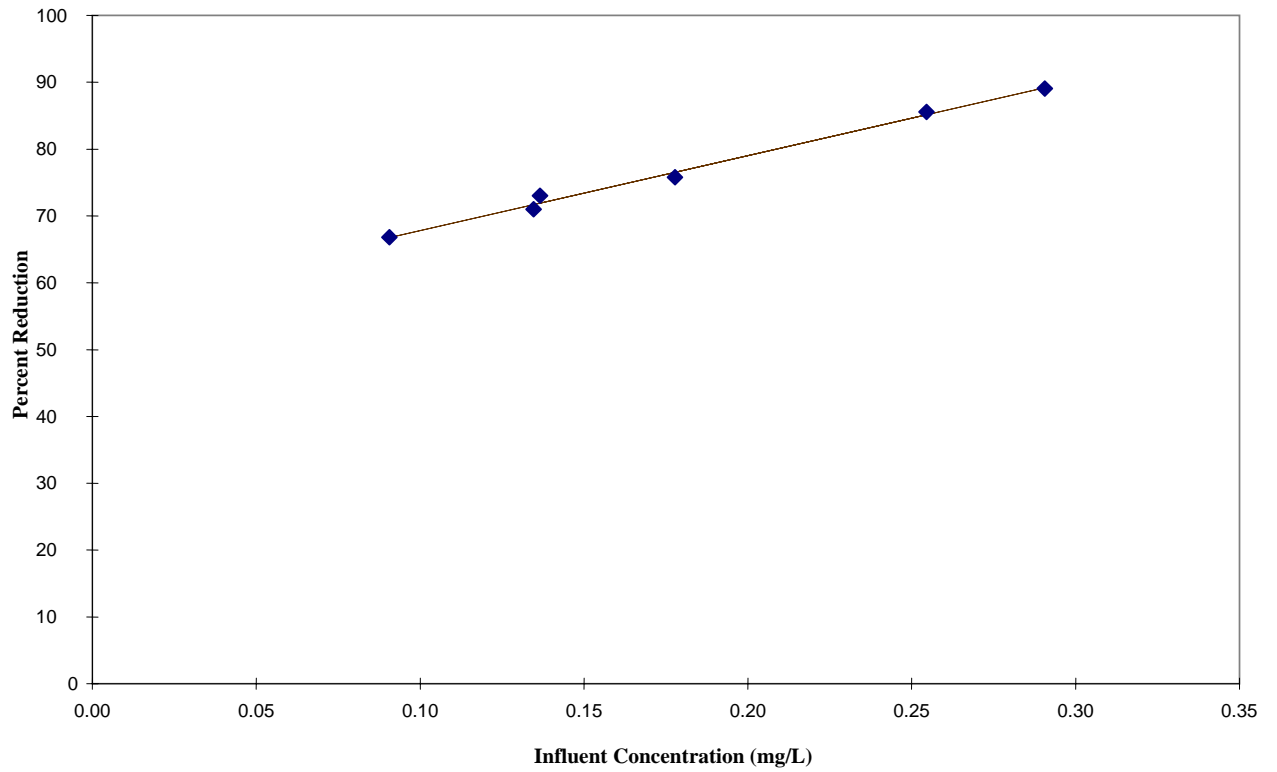
Date	27-Jun	7-Jul	12-Jul	19-Jul	26-Jul	2-Aug
<b>IF (s.d.)</b>	0.18 ± 0.038	0.29 ± 0.041	0.13 ± 0.009	0.09 ± 0.006	0.25 ± 0.005	0.14 ± 0.007
<b>IFCM (s.d.)</b>	0.14 ± 0.15	0.12 ± 0.01	0.04 ± 0.01	0.04 ± 0.009	0.13 ± 0.10	0.05 ± 0.03
<b>PCF (s.d.)</b>		0.03 ± 0.003	0.05 ± 0.014	0.09 ± 0.018	0.18 ± 0.096	0.04 ± 0.02
<b>EF (s.d.)</b>	0.04 ± 0.007	0.03 ± 0.020	0.04 ± 0.005	0.03 ± 0.002	0.04 ± 0.004	0.04 ± 0.007
<b>RS (s.d.)</b>	8.1 ± 3.6	3.4 ± 1.5	0.6 ± 0.02	0.1 ± 0.06	0.2 ± 0.14	0.1 ± 0.10

\*All values are on an as is basis. IF, IFCM, PCF and EF are in mg/L, RS is in mg/Kg.

**Table 9.b. Change in Concentration (mg/L) of NNN between each Sampling Point in the System as well as the Over All Percent Change of NNN in the System (IF to EF)**

Date	27-Jun	7-Jul	12-Jul	19-Jul	26-Jul	2-Aug
<b>IF to IFCM</b>	-0.04	-0.17	-0.10	-0.05	-0.13	-0.08
<b>IFCM to EF</b>	-0.10					
<b>IFCM to PCF</b>		-0.09	0.01	0.05	0.06	-0.01
<b>PCF to EF</b>		-0.0003	-0.01	-0.06	-0.15	-0.01
<b>IF to EF</b>	-0.13	-0.26	-0.10	-0.06	-0.22	-0.10
<b>% Change (IF to EF)</b>	-76	-89	-71	-67	-86	-73

**Regression Plot of NNN IF Concentration vs. Overall Percent Reduction**



**Fig. 10. Plot of NNN IF Concentration and Overall Percent Reduction along with the Line of Best Fit**

## Total Kjeldahl Nitrogen (TKN)

(Refer to Tables 10.a and 10.b)

The concentration of TKN in the influent was fairly consistent from event to event. The amount of TKN removed by the chemical pretreatment (IF to IFCM) was inconsistent as was the amount removed by the solids separation in the centrifuge and the amount removed by the EC unit. As a result of this inconsistency, it did not appear that any one mechanism in the system was key to removing TKN from lagoon effluent. The percent change from IF to EF of TKN by the entire system was variable and ranged from as low as nearly 37% to as high as 72%, over the six sampling events.

**Table 10.a. Average and Standard Deviations of TKN Concentrations for each Sampling Point in the System\***

Date	27-Jun	7-Jul	12-Jul	19-Jul	26-Jul	2-Aug
IF (s.d.)	631 ± 49	559 ± 50	587 ± 8	519 ± 13	562 ± 6	525 ± 5
IFCM (s.d.)	124 ± 38	556 ± 7	482 ± 71	444 ± 48	395 ± 64	426 ± 60
PCF (s.d.)		344 ± 130	395 ± 39	328 ± 13	379 ± 35	356 ± 20
EF (s.d.)	308 ± 80	355 ± 1.2	297 ± 28	280 ± 59	272 ± 17	149 ± 8
RS (s.d.)	6251 ± 133	5316 ± 102	2566 ± 304	3120 ± 1020	3693 ± 31	4322 ± 167

\*All values are on an as is basis. IF, IFCM, PCF and EF are in mg/L, RS is in mg/Kg.

**Table 10.b. Change in Concentration (mg/L) of TKN between each Sampling Point in the System as well as the Over All Percent Change of TKN in the System (IF to EF)**

Date	27-Jun	7-Jul	12-Jul	19-Jul	26-Jul	2-Aug
IF to IFCM	-507	-3	-105	-76	-167	-99
IFCM to EF	184					
IFCM to PCF		-212	-86	-116	-16	-70
PCF to EF		11	-99	-48	-106	-206
IF to EF	-323	-204	-290	-239	-289	-376
% Change (IF to EF)	-51	-37	-49	-46	-52	-72

## Total Phosphorus (TP)

(Refer to Tables 11.a and 11.b)

The concentration of TP in the influent was fairly consistent over most sampling events, with the exception of highly variable values on the first sampling event. Concentrations of TP after chemical pretreatment (IFCM) varied highly from week to week. There was also some variability in the TP concentrations in samples collected after the centrifuge (PCF) and in the final effluent. For some sampling events the largest reduction occurs between IF and IFCM and on other events it occurs between IFCM and PCF. On average, the system effectively removed more than 90% of TP from raw lagoon influent.

**Table 11.a. Average and Standard Deviations of TP Concentrations for each Sampling Point in the System\***

Date	27-Jun	7-Jul	12-Jul	19-Jul	26-Jul	2-Aug
IF (s.d.)	37 ± 35	52 ± 5.1	55 ± 0.6	55 ± 2.2	54 ± 0.1	54 ± 0.2
IFCM (s.d.)	10 ± 8	42 ± 0.8	2 ± 2	44 ± 9	21 ± 12	41 ± 13
PCF (s.d.)		1.1 ± 0.07	1.5 ± 0.64	4.1 ± 3.7	10 ± 9.8	7 ± 4.7
EF (s.d.)	0.74 ± 0.33	3.8 ± 0.93	0.82 ± 0.18	0.98 ± 0.24	4.2 ± 0.18	1.04 ± 0.85
RS (s.d.)	1712 ± 11	1500 ± 30	703 ± 89	1030 ± 433	1196 ± 21	1077 ± 48

\*All values are on an as is basis. IF, IFCM, PCF and EF are in mg/L, RS is in mg/Kg.

**Table 11.b. Change in Concentration (mg/L) of TP between each Sampling Point in the System as well as the Over All Percent Change of TP in the System (IF to EF)**

Date	27-Jun	7-Jul	12-Jul	19-Jul	26-Jul	2-Aug
IF to IFCM	-27	-10	-52	-10	-34	-13
IFCM to EF	-9					
IFCM to PCF		-41	-1	-40	-10	-35
PCF to EF		3	-0.6	-3	-6	-6
IF to EF	-36	-48	-54	-54	-50	-53
% Change (IF to EF)	-98	-93	-98	-98	-92	-98

## Soluble Phosphorus (SRP)

(Refer to Tables 12.a and 12.b)

The concentration of SRP in the influent varied slightly over all of the six sampling events. Table 3.a shows that the largest reduction in SRP concentration occurred between IF and IFCM. This indicates that the chemical pretreatment was the key mechanism for reducing SRP in this system. The percent change from IF to EF for the entire system was consistently higher than 99%; however, the increment in percent reduction from IFCM to EF was very small. This indicates the EC unit played a very small role in the removal of SRP from the lagoon effluent treated by the system.

**Table 12.a. Average and Standard Deviations of SRP Concentrations for each Sampling Point in the System\***

Date	27-Jun	7-Jul	12-Jul	19-Jul	26-Jul	2-Aug
<b>IF (s.d.)</b>	4.1 ± 0.13	4.6 ± 0.10	4.6 ± 0.11	5.7 ± 0.07	4.1 ± 0.02	5.3 ± 1.4
<b>IFCM (s.d.)</b>	0.50 ± 0.35	0.05 ± 0.009	0.05 ± 0.04	0.07 ± 0.002	0.12 ± 0.06	0.15 ± 0.11
<b>PCF (s.d.)</b>		0.05 ± 0.004	0.01 ± 0.002	0.11 ± 0.067	0.22 ± 0.012	0.11 ± 0.095
<b>EF (s.d.)</b>	0.064 ± 0.046	0.015 ± 0.007	0.006 ± 0.001	0.006 ± 0	0.010 ± 0.004	0.007 ± 0
<b>RS (s.d.)</b>	6.8 ± 1.4	0.25 ± 0.06	0.20 ± 0.12	1.7 ± 0.77	0.28 ± 0.03	2.4 ± 0.3

\*All values are on an as is basis. IF, IFCM, PCF and EF are in mg/L, RS is in mg/Kg.

**Table 12.b. Change in Concentration (mg/L) of SRP between each Sampling Point in the System as well as the Over All Percent Change of SRP in the System (IF to EF)**

Date	27-Jun	7-Jul	12-Jul	19-Jul	26-Jul	2-Aug
<b>IF to IFCM</b>	-3.6	-4.5	-4.6	-5.6	-4.0	-5.1
<b>IFCM to EF</b>	-0.4					
<b>IFCM to PCF</b>		-0.01	-0.04	0.04	0.09	-0.04
<b>PCF to EF</b>		-0.03	-0.01	-0.10	-0.21	-0.10
<b>IF to EF</b>	-4.0	-4.6	-4.6	-5.7	-4.1	-5.3
<b>% Change (IF to EF)</b>	-98	-99.7	-99.9	-99.9	-99.8	-99.9

## Potassium (K)

(Refer to Tables 13.a and 13.b)

The concentration of K in the influent decreased steadily for the first four sampling events then increased for the last two. This did not correspond to any pattern seen in the other analytes. The largest reductions of K occurred with the centrifuge but reductions in lagoon effluent K were generally small and inconsistent at different treatment points in the system on each sampling event. The percent change from IF to EF varied widely; ranging nearly 45% over the six sampling events.

**Table 13.a. Average and Standard Deviations of K Concentrations for each Sampling Point in the System\***

Date	27-Jun	7-Jul	12-Jul	19-Jul	26-Jul	2-Aug
<b>IF (s.d.)</b>	914 ± 10	861 ± 12	858 ± 10	736 ± 0.7	776 ± 23	780 ± 2
<b>IFCM (s.d.)</b>	768 ± 201	659 ± 115	795 ± 21	775 ± 0.7	716 ± 5	719 ± 6
<b>PCF (s.d.)</b>		750 ± 6	721 ± 10	655 ± 54	674 ± 4	649 ± 6
<b>EF (s.d.)</b>	565 ± 28	752 ± 12	569 ± 37	255 ± 293	624 ± 23	296 ± 8
<b>RS (s.d.)</b>	2189 ± 68	4071 ± 3195	1744 ± 1749	1165 ± 1229	1326 ± 26	1785 ± 21

\*All values are on an as is basis. IF, IFCM, PCF and EF are in mg/L, RS is in mg/Kg.

**Table 13.b. Change in Concentration (mg/L) of K between each Sampling Point in the System as well as the Over All Percent Change of K in the System (IF to EF)**

Date	27-Jun	7-Jul	12-Jul	19-Jul	26-Jul	2-Aug
<b>IF to IFCM</b>	-146	-201	-64	39	-61	-61
<b>IFCM to EF</b>	-203					
<b>IFCM to PCF</b>		90	-74	-120	-42	-70
<b>PCF to EF</b>		2	-153	-400	-51	-353
<b>IF to EF</b>	-349	-109	-290	-480	-153	-484
<b>% Change (IF to EF)</b>	-38	-13	-34	-65	-20	-62

## Calcium (Ca)

(Refer to Tables 14.a and 14.b)

As with the influent TS concentrations, there was a small but steady drop in the concentration of Ca in the influent over the six sampling events. The variations in the concentrations of the samples for each event were small as well. There was a large increase in the concentration from IF to IFCM due to the lime ( $\text{CaOH}_2$ ) added during the chemical pretreatment. The largest reduction of Ca from the lagoon effluent occurred between IFCM and PCF, indicating that the centrifuge was responsible for removing the majority of Ca. The amount of Ca removed by the EC unit was small in comparison to the reduction by the centrifuge. The percent change from IF to EF ranged nearly 72% over the six sampling events.

**Table 14.a. Average and Standard Deviations of Ca Concentrations for each Sampling Point in the System\***

Date	27-Jun	7-Jul	12-Jul	19-Jul	26-Jul	2-Aug
IF (s.d.)	296 ± 9	265 ± 3	256 ± 6	237 ± 0	228 ± 6	227 ± 4
IFCM (s.d.)	701 ± 712	1383 ± 220	2040 ± 283	1540 ± 382	1685 ± 530	937 ± 217
PCF (s.d.)		207 ± 18	175 ± 109	158 ± 18	235 ± 56	183 ± 18
EF (s.d.)	32 ± 3	153 ± 4	87 ± 10	106 ± 11	188 ± 30	77 ± 8
RS (s.d.)	46818 ± 3493	39002 ± 1761	19839 ± 4440	21888 ± 30019	20639 ± 1390	16868 ± 1296

\*All values are on an as is basis. IF, IFCM, PCF and EF are in mg/L, RS is in mg/Kg.

**Table 14.b. Change in Concentration (mg/L) of Ca between each Sampling Point in the System as well as the Over All Percent Change of Ca in the System (IF to EF)**

Date	27-Jun	7-Jul	12-Jul	19-Jul	26-Jul	2-Aug
IF to IFCM	405	1118	1784	1303	1458	710
IFCM to EF	-668					
IFCM to PCF		-1177	-1865	-1383	-1451	-754
PCF to EF		-54	-88	-51	-47	-106
IF to EF	-263	-112	-169	-131	-40	-150
% Change (IF to EF)	-89	-42	-66	-55	-17	-66



## Magnesium (Mg)

(Refer to Tables 15.a and 15.b)

Concentration of Mg in the influent consistently decreased a small amount over all sampling events. This trend was similar to TS concentrations in the influent. The change in concentration from IF to IFCM was inconsistent which may be due to the changes in chemical pretreatment from event to event. The reduction in Mg concentration between the different sampling points was inconsistent from event to event but the centrifuge removed the most Mg from the lagoon effluent treated by the system. The percent change from IF to EF varied slightly and ranged about 20% over the six sampling events.

**Table 15.a. Average and Standard Deviations of Mg Concentrations for each Sampling Point in the System\***

Date	27-Jun	7-Jul	12-Jul	19-Jul	26-Jul	2-Aug
IF (s.d.)	238 ± 6	219 ± 3	218 ± 4	185 ± 0.71	182 ± 6	184 ± 0.71
IFCM (s.d.)	148 ± 88	176 ± 28	172 ± 5	195 ± 23	218 ± 22	182 ± 8
PCF (s.d.)		119 ± 3	80 ± 17	107 ± 4	130 ± 1.4	128 ± 8
EF (s.d.)	97 ± 6	105 ± 1.4	74 ± 4	80 ± 9	105 ± 2	68 ± 3
RS (s.d.)	3552 ± 287	2671 ± 391	1446 ± 471	1489 ± 1712	1636 ± 84	1418 ± 89

\*All values are on an as is basis. IF, IFCM, PCF and EF are in mg/L, RS is in mg/Kg.

**Table 15.b. Change in Concentration (mg/L) of Mg between each Sampling Point in the System as well as the Over All Percent Change of Mg in the System (IF to EF)**

Date	27-Jun	7-Jul	12-Jul	19-Jul	26-Jul	2-Aug
IF to IFCM	-89	-43	-46	11	36	-2
IFCM to EF	-51					
IFCM to PCF		-57	-92	-89	-88	-54
PCF to EF		-14	-6	-27	-26	-59
IF to EF	-140	-114	-143	-105	-78	-115
% Change (IF to EF)	-59	-52	-66	-57	-43	-63

## Sodium (Na)

(Refer to Tables 16.a and 16.b)

Similar to TS and some other metals, the concentration of Na in the influent consistently decreased over all of the sampling events. The increases and decreases in Na concentration of the lagoon effluent being treated varied inconsistently from event to event making it unclear if there was any one mechanism contributing to the removal of Na. The percent change from IF to EF varied widely, ranging from a 7% increase to a 36% decrease.

**Table 16.a. Average and Standard Deviations of Na Concentrations for each Sampling Point in the System\***

Date	27-Jun	7-Jul	12-Jul	19-Jul	26-Jul	2-Aug
<b>IF (s.d.)</b>	324 ± 40	285 ± 7	268 ± 6	214 ± 0	212 ± 5	205 ± 2
<b>IFCM (s.d.)</b>	305 ± 54	204 ± 31	289 ± 16	268 ± 4	241 ± 30	247 ± 46
<b>PCF (s.d.)</b>		297 ± 21	265 ± 6	205 ± 7	205 ± 4	201 ± 6
<b>EF (s.d.)</b>	225 ± 13	304 ± 8	196 ± 9	179 ± 16	203 ± 5	131 ± 10
<b>RS (s.d.)</b>	755 ± 34	1545 ± 1343	713 ± 774	10361 ± 13618	441 ± 30	568 ± 19

\*All values are on an as is basis. IF, IFCM, PCF and EF are in mg/L, RS is in mg/Kg.

**Table 16.b. Change in Concentration (mg/L) of Na between each Sampling Point in the System as well as the Over All Percent Change of Na in the System (IF to EF)**

Date	27-Jun	7-Jul	12-Jul	19-Jul	26-Jul	2-Aug
<b>IF to IFCM</b>	-19	-81	21	54	29	43
<b>IFCM to EF</b>	-80					
<b>IFCM to PCF</b>		93	-24	-63	-36	-46
<b>PCF to EF</b>		7	-70	-26	-2	-71
<b>IF to EF</b>	-99	19	-73	-35	-9	-74
<b>% Change (IF to EF)</b>	-31	7	-27	-16	-4	-36

## Manganese (Mn)

(Refer to Tables 17.a and 17.b)

The concentration of Mn in the influent varied inconsistently from event to event; however, these variations were only a fraction of a mg/L for each event. There was a consistent decrease in Mn concentration between IFCM and PCF for all sampling events, showing that the centrifuge was effective in removing Mn from the lagoon effluent. From PCF to EF, there is a proportionally substantial increase in Mn concentration, ranging from a 5600% increase to a 170% increase over the five events employing the centrifuge. This many-fold increase may have been the addition of proprietary ‘mud mix,’ ahead of the centrifuge to the lagoon effluent. The percent change from IF to EF was highly variable, ranging from a 24% increase to an 80% decrease over the six sampling events.

**Table 17.a. Average and Standard Deviations of Mn Concentrations for each Sampling Point in the System\***

<b>Date</b>	<b>27-Jun</b>	<b>7-Jul</b>	<b>12-Jul</b>	<b>19-Jul</b>	<b>26-Jul</b>	<b>2-Aug</b>
<b>IF (s.d.)</b>	1.2 ± 0.02	1.1 ± 0.04	1.2 ± 0.02	0.8 ± 0.13	0.99 ± 0.01	1.1 ± 0.005
<b>IFCM (s.d.)</b>	0.8 ± 0.86	1.3 ± 0.22	1.1 ± 0.33	1.2 ± 0.41	1.9 ± 0.23	1.2 ± 0.19
<b>PCF (s.d.)</b>		0.04 ± 0.002	0.02 ± 0.02	0.06 ± 0.06	0.28 ± 0.23	0.16 ± 0.06
<b>EF (s.d.)</b>	0.2 ± 0.02	1.3 ± 0.02	1.2 ± 0.19	0.4 ± 0.63	1.2 ± 0.24	0.4 ± 0.08
<b>RS (s.d.)</b>	59 ± 1.9	37 ± 4.0	15 ± 4.1	23 ± 18	26 ± 1.9	27 ± 0.392

\*All values are on an as is basis. IF, IFCM, PCF and EF are in mg/L, RS is in mg/Kg.

**Table 17.b. Change in Concentration (mg/L) of Mn between each Sampling Point in the System as well as the Over All Percent Change of Mn in the System (IF to EF)**

<b>Date</b>	<b>27-Jun</b>	<b>7-Jul</b>	<b>12-Jul</b>	<b>19-Jul</b>	<b>26-Jul</b>	<b>2-Aug</b>
<b>IF to IFCM</b>	-0.4	0.2	-0.1	0.3	0.9	0.1
<b>IFCM to EF</b>	-0.6					
<b>IFCM to PCF</b>		-1.3	-1.0	-1.1	-1.6	-1.0
<b>PCF to EF</b>		1.3	1.1	0.4	0.9	0.3
<b>IF to EF</b>	-1.0	0.2	-0.04	-0.4	0.2	-0.6

<b>% Change (IF to EF)</b>	-83	20	-3	-45	24	-60
----------------------------	-----	----	----	-----	----	-----

## Iron (Fe)

(Refer to Tables 18.a and 18.b)

Influent Fe concentrations fluctuated slightly and generally decreased from event to event. There was a substantial increase in Fe concentration from IF to IFCM for all of the six sampling events. This increase was due to the chemical pretreatment of the lagoon effluent. The amount with which the Fe concentration increased was variable from event to event. A substantial decrease was seen from IFCM to PCF, indicating that the centrifuge was effective in reducing the concentration of Fe after the chemical pretreatment. Due to the ions given off by the iron electrodes in the EC unit, there was a very large increase in the effluent leaving the EC unit. Overall, there was a very large, but variable percent increase for all of the six sampling events ranging from a 28% increase to a 2600% increase.

**Table 18.a. Average and Standard Deviations of Fe Concentrations for each Sampling Point in the System\***

Date	27-Jun	7-Jul	12-Jul	19-Jul	26-Jul	2-Aug
IF (s.d.)	4.5 ± 0.25	3.8 ± 0.11	3.4 ± 0.08	3.7 ± 0.01	3.6 ± 0.09	3.3 ± 0.05
IFCM (s.d.)	9 ± 9.6	15 ± 3.3	9 ± 4.0	16 ± 5.3	28 ± 3.2	15 ± 0.1
PCF (s.d.)		0.03 ± 0.0	0.1 ± 0.1	0.7 ± 0.7	2.7 ± 2.9	1.3 ± 1.4
EF (s.d.)	6 ± 2	82 ± 3	94 ± 20	71 ± 14	86 ± 25	21 ± 3
RS (s.d.)	672 ± 29	451 ± 26	186 ± 67	697 ± 376	553 ± 97	567 ± 25

\*All values are on an as is basis. IF, IFCM, PCF and EF are in mg/L, RS is in mg/Kg.

**Table 18.b. Change in Concentration (mg/L) of Fe between each Sampling Point in the System as well as the Over All Percent Change of Fe in the System (IF to EF)**

Date	27-Jun	7-Jul	12-Jul	19-Jul	26-Jul	2-Aug
IF to IFCM	4.8	11	6	12	24	12
IFCM to EF	-3.6					
IFCM to PCF		-15	-9	-15	-25	-14
PCF to EF		82	94	70	83	20
IF to EF	1.2	78	90	67	82	18
% Change (IF to EF)	28	2052	2627	1798	2270	552

## Copper (Cu)

(Refer to Tables 19.a and 19.b)

Cu concentrations in the influent were fairly consistent, varying only slightly from event to event. The change in Cu concentration from IF to IFCM was inconsistent. For all sampling events regardless of the increase or decrease due to the chemical pretreatment, there was a considerable decrease in Cu concentration from IFCM to PCF. This indicated that the centrifuge was effective in removing Cu from the influent. The amount of the decrease from IFCM to PCF became smaller each event. The change in concentration was highly variable from PCF to EF ranging from a 700% increase to a 50% decrease. Therefore, it appeared that the EC unit does not effectively remove Cu from the lagoon effluent. With the exception of the event on July 19, there was a substantial percent change from IF to EF of Cu mainly due to the centrifuge effectively removing solids from the lagoon effluent being treated by the system.

**Table 19.a. Average and Standard Deviations of Cu Concentrations for each Sampling Point in the System\***

Date	27-Jun	7-Jul	12-Jul	19-Jul	26-Jul	2-Aug
IF (s.d.)	1.21 ± 0.04	1.16 ± 0.00	1.16 ± 0.04	0.93 ± 0.07	0.92 ± 0.03	1.1 ± 0.008
IFCM (s.d.)	0.7 ± 0.61	1.3 ± 0.29	0.8 ± 0.30	1.2 ± 0.36	1.5 ± 0.15	0.7 ± 0.20
PCF (s.d.)		0.08 ± 0.04	0.01 ± 0.006	0.13 ± 0.09	0.31 ± 0.3	0.31 ± 0.14
EF (s.d.)	0.09 ± 0.04	0.12 ± 0.01	0.05 ± 0	1.05 ± 1.4	0.15 ± 0.01	0.20 ± 0.007
RS (s.d.)	39 ± 1.4	33 ± 2.8	15 ± 3.7	29 ± 3.5	19 ± 0.4	19 ± 0.3

\*All values are on an as is basis. IF, IFCM, PCF and EF are in mg/L, RS is in mg/Kg.

**Table 19.b. Change in Concentration (mg/L) of Cu between each Sampling Point in the System as well as the Over All Percent Change of Cu in the System (IF to EF)**

Date	27-Jun	7-Jul	12-Jul	19-Jul	26-Jul	2-Aug
IF to IFCM	-0.51	0.19	-0.32	0.23	0.55	-0.35
IFCM to EF	-0.61					
IFCM to PCF		-1.27	-0.82	-1.03	-1.16	-0.41
PCF to EF		0.04	0.04	0.93	-0.16	-0.11
IF to EF	-1.12	-1.04	-1.11	0.13	-0.77	-0.87
% Change (IF to EF)	-92	-90	-96	14	-84	-81

## Aluminum (Al)

(Refer to Tables 20.a and 20.b)

Concentration of Al in the influent was fairly consistent, varying slightly from event to event. There was a many fold increase in Al concentration from IF to IFCM due to the addition of alum ( $Al_2SO_4$ ) in the pretreatment. The largest reduction of Al in the system occurred between IFCM and PCF, indicating that the centrifuge was the key mechanism for removing Al. There was a reduction of Al concentration by the EC unit, with the exception of the event on July 7 where there was a substantial increase between PCF and EF of 390%. The percent change from IF to EF ranged from an 1180% increase to a 4% decrease over the six sampling events.

**Table 20.a. Average and Standard Deviations of Al Concentrations for each Sampling Point in the System\***

Date	27-Jun	7-Jul	12-Jul	19-Jul	26-Jul	2-Aug
IF (s.d.)	2 ± 0.3	2 ± 0.1	2 ± 0.3	2 ± 0.0	2 ± 0.1	1 ± 0.1
IFCM (s.d.)	75 ± 67	300 ± 43	274 ± 172	242 ± 69	160 ± 1	115 ± 24
PCF (s.d.)		5 ± 0.3	8 ± 0.4	11 ± 6	32 ± 36	13 ± 15
EF (s.d.)	2 ± 1.3	23 ± 3.8	3 ± 0.8	10 ± 7.6	16 ± 0.1	2 ± 2.8
RS (s.d.)	4451 ± 353	7158 ± 2654	3537 ± 1939	9615 ± 4045	4732 ± 360	4064 ± 582

\*All values are on an as is basis. IF, IFCM, PCF and EF are in mg/L, RS is in mg/Kg.

**Table 20.b. Change in Concentration (mg/L) of Al between each Sampling Point in the System as well as the Over All Percent Change of Al in the System (IF to EF)**

Date	27-Jun	7-Jul	12-Jul	19-Jul	26-Jul	2-Aug
IF to IFCM	73	298	272	240	157	114
IFCM to EF	-73					
IFCM to PCF		-295	-266	-231	-127	-102
PCF to EF		18	-5	-1.3	-17	-11
IF to EF	-0.09	21	1.4	8	13	1.2
% Change (IF to EF)	-4	1185	84	456	538	89

## Economics

---

Economic information for the EC system was provided by Mr. Royis Ward from Ecoloclean Industries. Their estimate shows that the cost for the EC system to treat effluent from the dairy lagoon during this test was approximately \$0.12 per gallon (\$120 per 1,000 gallons) of treated effluent. This estimate does not include the costs to remove residual materials from the dairy. Costs will vary depending on the number of cows at each dairy and the volume of process generated influent entering the lagoon.

Compared to conventional methods; the EC system costs substantially more per 1,000 gallons of treated effluent. In 2000, the Environmental Review Commission of the North Carolina General Assembly estimated that using conventional technologies costs between \$5 and \$32 per 1,000 gallons of treated effluent depending on the type of treatment process employed.

## Conclusion

---

Due to the designation of the two upper North Bosque River segments as impaired from point source and nonpoint source pollution of P in the watershed, action must be taken towards the reduction of P from sources such as dairy lagoon effluent applied to the waste application fields. The best management practices currently in use are not sufficient to produce the needed reductions; therefore, many prospective new technologies are being researched.

The results for this EC system from six sampling events showed that the system removed TP and SRP on average by 96% and 99.6% respectively from the dairy lagoon effluent. The performance of the entire system with respect to removing metals was sporadic, only Mg was observed to have consistent reductions from each sampling event. The rest of the metals had a wide range of reductions and increases without any apparent trends from event to event. The inconsistencies in the performance of this system for both the metals and solids is very possibly linked to the changes made in the system's configuration and the changes in the chemical pre-treatment from event to event.

This system was effective in reducing both TP and SRP from lagoon effluent and exceeded the TMDL goal of 50% P removal. Costs for installing and operating this system could be an issue; but dairy producers will make the final decision whether or not to implement this technology. Findings from this study will be summarized in a fact sheet and distributed to dairymen, County Extension agents, the advisory committee, and other interested parties allowing them to make informed decisions about this technology.

## References

---

Texas Natural Resource Conservation Commission (TNRCC) (Now TCEQ). 2001. Two Total Maximum Daily Loads for Phosphorus in the North Bosque River. The Strategic Assessment Division, TNRCC.

## Acknowledgements

---

This demonstration was conducted with funds from a USEPA Clean Water Act §319 (h) NPS grant (Project No. 03-10) administered by the Texas State Soil and Water Conservation Board.

Thanks to Mr. Bert Velson, Owner, OSVE Dairy near Hico, TX for his cooperation and for providing facilities to conduct this demonstration.

Thanks to Mr. Don Smart, Chairman, Cross Timbers Soil and Water Conservation District for his assistance with selecting the cooperating dairy to conduct this demonstration in the Bosque River watershed.

Ecoclean Industries, Inc., Crystal City, Texas is acknowledged for their assistance and support with this demonstration.





## Appendix I

Raw Data: Concentrations of analytes for samples treated as liquid

**Table A.1. Concentrations of Nutrients (mg/L), Solids (mg/L) and pH for the 6/27/05 and the 7/7/05 Sampling Events**

site	Sample Date	Nitrate-Nitrite Nitrogen, dissolved EPA 353.2	Orthophosphate Phosphorus, dissolved EPA 365.2	Total Phosphorus EPA 365.4 mod	Total Kjeldahl Nitrogen EPA 351.2 mod	Total Suspended Solids EPA 160.2	Total Volatile Solids SM 2540 E	Total Fixed Solids SM 2540E	Total Dissolved Solids SM 2540C	Total Solids SM 2540B	pH EPA 150.1
IF1	6/27/2005	0.205	3.99	61.60	666	1060	2640	3850	5430	6490	7.77
IF2	6/27/2005	0.151	4.18	11.9	596	655	2610	3860	5820	6470	7.75
EF1	6/27/2005	0.035	0.117	1.12	388	112	478	2022	2390	2500	8.27
EF2	6/27/2005	0.050	0.048	0.574	228	53	448	1962	2360	2410	8.29
EF3	6/27/2005	0.044	0.028	0.519	308	41	430	1870	2260	2300	8.32
IF1	7/7/2005	0.319	4.51	55.8	595	560	2680	3480	5600	6160	7.82
IF2	7/7/2005	0.262	4.65	48.6	524	925	2620	3480	5170	6100	7.86
PCF1	7/7/2005	0.030	0.050	1.20	436	274	1220	3600	4550	4820	7.53
PCF2	7/7/2005	0.034	0.043	1.10	252	237	1330	3340	4430	4670	7.59
EF1	7/7/2005	0.018	0.020	4.46	356	970	900	3100	3030	4000	8.03
EF2	7/7/2005	0.046	0.010	3.15	354	785	922	3048	3180	3970	7.99

**Table A.2. Conductivity and Metals (mg/L) Concentrations for the 6/27/05 and the 7/7/05 Sampling Events**

site	Sample Date	Conductivity EPA 120.1	Potassium EPA 200.7	Calcium EPA 200.7	Magnesium EPA 200.7	Sodium EPA 200.7	Manganese EPA 200.7	Iron EPA 200.7	Copper EPA 200.7	Aluminum EPA 200.7
IF1	6/27/2005	7350	921	302	242	352	1.20	4.66	1.24	2.40
IF2	6/27/2005	7860	907	289	233	296	1.17	4.30	1.18	1.93
EF1	6/27/2005	5240	586	35.0	101	232	0.228	8.59	0.112	3.62
EF2	6/27/2005	5180	576	30.4	99.5	233	0.182	4.30	0.114	1.41
EF3	6/27/2005	5100	534	30.9	90.6	210	0.191	4.29	<0.05	1.20
IF1	7/7/2005	7350	869	267	221	280	1.08	3.90	1.16	1.89
IF2	7/7/2005	7050	852	263	217	290	1.14	3.74	1.16	1.71
PCF1	7/7/2005	7080	754	219	121	312	0.045	<0.03	0.103	4.94
PCF2	7/7/2005	7060	745	194	117	282	0.042	<0.03	<0.05	4.52
EF1	7/7/2005	5500	743	156	104	310	1.35	84.6	0.13	25.8
EF2	7/7/2005	5930	760	150	106	298	1.32	79.8	0.11	20.5

**Table A.3. Concentrations of Nutrients (mg/L), Solids (mg/L) and pH for the 7/12/05 and the 7/19/05 Sampling Events**

site	Sample Date	Nitrate-Nitrite Nitrogen, dissolved EPA 353.2	Orthophosphate Phosphorus, dissolved EPA 365.2	Total Phosphorus EPA 365.4 mod	Total Kjeldahl Nitrogen EPA 351.2 mod	Total Suspended Solids EPA 160.2	Total Volatile Solids SM 2540 E	Total Fixed Solids SM 2540E	Total Dissolved Solids SM 2540C	Total Solids SM 2540B	pH EPA 150.1
IF1	7/12/2005	0.128	4.70	54.9	593	507	2700	3020	5210	5720	7.85
IF2	7/12/2005	0.141	4.54	54.10	581	453	2670	3450	5660	6120	7.89
IFCM1	7/12/2005	0.050	0.079	1.08	432	3630	1600	4640	2610	6240	8.84
IFCM2	7/12/2005	0.029	0.021	3.76	532	9330	4330	10170	5230	14500	7.53
PCF1	7/12/2005	0.037	0.016	1.01	368	160	1430	2750	4020	4180	8.2
PCF2	7/12/2005	0.058	0.012	1.91	423	283	1660	4010	5390	5670	7.61
EF1	7/12/2005	0.042	0.006	0.949	277	367	1040	2520	3190	3560	8.11
EF2	7/12/2005	0.036	0.005	0.688	316	297	1030	2480	3220	3510	8.16
IF1	7/19/2005	0.086	5.76	56.4	528	707	2560	3210	5060	5770	7.82
IF2	7/19/2005	0.095	5.67	53.2	510	410	2530	3270	5390	5800	7.84
IFCM1	7/19/2005	0.049	0.073	37.8	410	11900	4040	10260	2460	14300	7.72
IFCM2	7/19/2005	0.036	0.069	50.9	477	9280	3720	9080	3550	12800	7.72
PCF1	7/19/2005	0.103	0.157	6.67	337	780	952	2688	2860	3640	8.57
PCF2	7/19/2005	0.077	0.062	1.46	319	360	1230	2940	3810	4170	7.78
EF1	7/19/2005	0.032	0.006	1.15	238	316	952	2258	2900	3210	7.96
EF2	7/19/2005	0.028	0.006	0.814	322	440	988	2672	3220	3660	7.99

**Table A.4. Conductivity and Metals (mg/L) Concentrations for the 7/12/05 and the 7/19/05 Sampling Events**

site	Sample Date	Conductivity EPA 120.1	Potassium EPA 200.7	Calcium EPA 200.7	Magnesium EPA 200.7	Sodium EPA 200.7	Manganese EPA 200.7	Iron EPA 200.7	Copper EPA 200.7	Aluminum EPA 200.7
IF1	7/12/2005	6760	851	252	215	272	1.18	3.38	1.13	1.41
IF2	7/12/2005	6610	865	260	220	264	1.21	3.50	1.18	1.90
IFCM1	7/12/2005	5580	809	1840	168	300	0.836	6.56	0.621	152
IFCM2	7/12/2005	6240	780	2240	175	278	1.30	12.2	1.04	396
PCF1	7/12/2005	6380	714	97.7	68.2	261	0.003	<0.03	0.015	8.48
PCF2	7/12/2005	6920	728	252	91.7	269	0.038	0.179	0.007	7.93
EF1	7/12/2005	4680	542	94.3	71.5	189	1.30	108	<0.05	3.59
EF2	7/12/2005	4980	595	79.5	76.8	202	1.02	79.6	<0.05	2.49
IF1	7/19/2005	6840	736	237	184	214	0.901	3.72	0.972	1.78
IF2	7/19/2005	6780	735	237	185	214	0.717	3.71	0.880	1.73
IFCM1	7/19/2005	6620	775	1270	179	265	0.86	12.3	0.901	193
IFCM2	7/19/2005	6680	774	1810	211	270	1.44	19.7	1.41	291
PCF1	7/19/2005	5770	693	145	104	209	0.101	1.25	0.189	15.5
PCF2	7/19/2005	6590	617	170	109	200	0.013	0.204	0.064	6.68
EF1	7/19/2005	4800	462	98.1	73.2	168	0.887	60.5	0.077	4.37
EF2	7/19/2005	5590	48.1	114	86	190	<0.001	80.5	2.03	15.1

**Table A.5. Concentrations of Nutrients (mg/L), Solids (mg/L) and pH for the 7/26/05 and the 8/2/05 Sampling Events**

site	Sample Date	Nitrate-Nitrite Nitrogen, dissolved EPA 353.2	Orthophosphate Phosphorus, dissolved EPA 365.2	Total Phosphorus EPA 365.4 mod	Total Kjeldahl Nitrogen EPA 351.2 mod	Total Suspended Solids EPA 160.2	Total Volatile Solids SM 2540 E	Total Fixed Solids SM 2540E	Total Dissolved Solids SM 2540C	Total Solids SM 2540B	pH EPA 150.1
IF1	7/26/2005	0.251	4.15	54.5	566	540	2380	3120	4960	5500	7.78
IF2	7/26/2005	0.258	4.13	54.4	557	630	2440	3180	4990	5620	7.82
IFCM1	7/26/2005	0.197	0.163	11.9	350	14000	3990	11610	1650	15600	8.2
IFCM2	7/26/2005	0.053	0.085	29.4	440	6290	2770	7430	3940	10200	7.57
PCF1	7/26/2005	0.250	0.208	17.2	403	5080	1600	4170	694	5770	7.78
PCF2	7/26/2005	0.114	0.225	3.31	354	390	1010	2720	3440	3730	7.64
EF1	7/26/2005	0.034	0.008	4.09	261	907	1010	2960	3060	3970	7.76
EF2	7/26/2005	0.040	0.013	4.35	284	807	984	2906	3080	3890	7.81
IF1	8/2/2005	0.132	4.26	54.5	522	385	2340	3150	5100	5490	7.85
IF2	8/2/2005	0.142	6.30	54.2	529	320	2280	3270	5230	5550	7.87
IFCM1	8/2/2005	0.073	0.225	32.1	384	6300	2200	6160	2060	8360	7.74
IFCM2	8/2/2005	0.036	0.069	50.9	469	10400	3220	9380	2230	12600	7.85
PCF1	8/2/2005	0.027	0.044	3.35	341	258	1150	2830	3700	3980	7.56
PCF2	8/2/2005	0.059	0.178	10.0	370	1330	1260	3200	4910	4460	7.88
EF1	8/2/2005	0.032	0.007	1.63	143	256	565	1435	1750	2000	8.04
EF2	8/2/2005	0.042	0.007	0.436	155	168	436	1414	1680	1850	8.06

**Table A.6. Conductivity and Metals (mg/L) Concentrations for the 7/26/05 and the 8/2/05 Sampling Events**

site	Sample Date	Conductivity EPA 120.1	Potassium EPA 200.7	Calcium EPA 200.7	Magnesium EPA 200.7	Sodium EPA 200.7	Manganese EPA 200.7	Iron EPA 200.7	Copper EPA 200.7	Aluminum EPA 200.7
IF1	7/26/2005	6580	760	223	178	209	0.979	3.56	0.900	2.40
IF2	7/26/2005	6640	792	232	186	215	1.00	3.69	0.937	2.58
IFCM1	7/26/2005	5660	719	2060	233	220	2.10	29.8	1.57	159
IFCM2	7/26/2005	6230	712	1310	202	262	1.76	25.3	1.36	161
PCF1	7/26/2005	6380	677	274	131	207	0.450	4.79	0.521	57.8
PCF2	7/26/2005	6560	671	195	129	202	0.119	0.646	0.097	7.11
EF1	7/26/2005	5580	607	209	103	200	1.40	103	0.158	15.9
EF2	7/26/2005	5770	640	167	106	207	1.06	68.4	0.142	15.8
IF1	8/2/2005	6640	781	224	184	206	1.08	3.23	1.08	1.39
IF2	8/2/2005	6620	778	230	183	203	1.09	3.30	1.07	1.19
IFCM1	8/2/2005	6050	723	783	176	280	1.07	15.6	0.584	98.4
IFCM2	8/2/2005	6070	714	1090	187	215	1.34	15.4	0.867	132
PCF1	8/2/2005	6590	644	196	133	206	0.119	0.296	0.213	2.61
PCF2	8/2/2005	6240	653	170	122	197	0.203	2.29	0.409	23.8
EF1	8/2/2005	3330	290	82.6	66.1	123	0.377	23.6	0.210	4.43
EF2	8/2/2005	3430	302	70.7	70.5	138	0.496	19.0	0.199	0.451

Raw Data: Concentrations of analytes for samples treated as solids

**Table A.7. Concentrations of Nutrients (mg/L), Solids (%) and pH for all of the Six Sampling Events**

Site ID	Date	Extractable Nitrate/Nitrite Nitrogen SSSA 38	Soluble Phosphorus SSSA 32	Total Phosphorus EPA 365.4 mod	Total Kjeldahl Nitrogen EPA 351.2 mod	% Total Volatile Solids SM2540G	% Total Fixed Solids SM2540G	% Total Solids SM2540G	pH EPA 150.1
IFCM1	6/27/2005	3.13	69.2	1443	9062	0.31	0.75	1.07	8.76
IFCM2	6/27/2005	68.8	69.8	1131	41927	0.08	0.28	0.36	8.84
RS1	6/27/2005	20.1	16.4	5377	19139	7.42	24.59	32.01	8.51
RS2	6/27/2005	42.1	26.5	5897	22167	7.32	21.51	28.83	8.36
RS3	6/27/2005	16.9	22.8	5195	18892	7.79	25.22	33.01	8.57
IFCM1	7/7/2005	11.0	5.01	3616	46300	0.39	0.8	1.19	8.06
IFCM2	7/7/2005	10.9	4.61	4063	54522	0.34	0.69	1.03	8.05
RS1	7/7/2005	8.86	0.79	5685	20136	6.93	19.82	26.76	8.04
RS2	7/7/2005	16.4	1.08	5414	19195	6.89	20.44	27.32	7.87
RS1	7/12/2005	3.71	1.58	4289	15571	3.9	13.96	17.86	8.62
RS2	7/12/2005	4.35	0.75	4420	16249	3.4	11.08	14.47	8.11
RS1	7/19/2005	8.77	1.36	5321	15299	6.05	19.06	25.11	7.9
RS2	7/19/2005	8.40	2.88	5440	18035	3.02	10.28	13.3	8.22
RS1	7/26/2005	0.32	1.20	4685	14569	4.84	20.36	25.2	7.92
RS2	7/26/2005	1.24	1.15	5321	16329	4.63	18.12	22.75	7.93
RS1	8/2/2005	0.23	2.66	4944	19921	4.02	17.08	21.1	8.1
RS2	8/2/2005	0.84	2.24	5000	19972	4.31	17.93	22.23	8.09

**Table A.8. Concentrations of Metals (mg/kg dry) for all of the Six Sampling Events**

Site ID	Date	Potassium EPA6010B	Calcium EPA6010B	Magnesium EPA6010B	Sodium EPA6010B	Manganese EPA6010B	Iron EPA6010B	Copper EPA6010B	Aluminum EPA6010B
IFCM1	6/27/2005	85100	112500	19660	32100	132.50	1501	106	11450
IFCM2	6/27/2005	174000	54842	23853	74000	57.26	698	75.2	7800
RS1	6/27/2005	6970	147600	11230	2342	183.50	2052	123	14860
RS2	6/27/2005	7320	149600	11260	2510	196.50	2265	132	14100
RS3	6/27/2005	6740	151700	11560	2399	183.20	2135	124	13730
IFCM1	7/7/2005	62200	129300	16430	18950	126.00	1422	131	27770
IFCM2	7/7/2005	56100	119200	15200	17650	115.60	1194	111	26120
RS1	7/7/2005	6770	150400	8950	2226	150.20	1752	129	33760
RS2	7/7/2005	23170	138200	10790	9130	126.40	1582	112	19330
RS1	7/12/2005	2841	93500	6230	926	68.40	777	69.4	12130
RS2	7/12/2005	20600	158800	12290	8710	124.90	1617	122	33920
RS1	7/19/2005	8100	171700	10750	2914	143.10	1715	124	26900
RS2	7/19/2005	2224	4972	2093	150300	82.00	7240	198	93800
RS1	7/26/2005	5190	85800	6730	1666	97.60	1923	73.5	17770
RS2	7/26/2005	5910	86400	6930	2032	119.70	2735	84.2	21920
RS1	8/2/2005	8390	75600	6420	2628	127.70	2604	90.6	17310
RS2	8/2/2005	8100	80000	6660	2616	123.70	2631	88.0	20130



