1-1-2003

The distribution of phosphorus in the nature preserve at the Clark County Wetlands Park in Las Vegas, Nevada

Rosangela Gomes Brazao
University of Nevada, Las Vegas

THE DISTRIBUTION OF PHOSPHORUS IN THE NATURE PRESERVE
AT THE CLARK COUNTY WETLANDS PARK IN LAS VEGAS, NV

by

Rosangela Gomes Brazão

Bachelor of Science in Industrial Chemistry
Universidade Técnico Educacional Souza Marques - Brazil
1987

Master of Science in Technology
Centro Educacional Celso Suckow da Fonseca - Brazil
1997

A thesis submitted in partial fulfillment
of the requirements for the

Master of Science Degree in Environmental Science
Department of Environmental Science
College of Urban Affairs

Graduate College
University of Nevada, Las Vegas
August 2003

UMI Number: 1416218

ProQuest Information and Learning Company
300 North Zeeb Road
P.O. Box 1346
Ann Arbor, MI 48106-1346

UNLV
UNIVERSITY OF NEVADA LAS VEGAS

Thesis Approval
The Graduate College
University of Nevada, Las Vegas

May 29th, 2003

The Thesis prepared by

Rosangela Gomes Brazao

Entitled

The Distribution of Phosphorus in the Nature Preserve at the Clark County Wetlands Park in Las Vegas, NV

is approved in partial fulfillment of the requirements for the degree of

Master of Sciences in Environmental Sciences

Examination Committee Co-Chair

Examination Committee Chair

Dean of the Graduate College

Examination Committee Member

Examination Committee Member

Graduate College Faculty Representative

1017-53

ABSTRACT

The Distribution of Phosphorus in the Nature Preserve at The Clark County Wetlands Park in Las Vegas, NV

by
Rosangela Gomes Brazão

Dr. Krystyna Stave, Examination Committee Co-Chair
Assistant Professor, Department of Environmental Science
University of Nevada, Las Vegas

Dr. Jacimaria Batista, Examination Committee Co-Chair
Assistant Professor, Department of Environmental and Civil Engineering
University of Nevada, Las Vegas

The main objective of this thesis was to investigate the distribution of phosphorus among three different compartments of the Upper Pond at the Nature Preserve at the Clark County Wetlands Park in Las Vegas, NV: influent and effluent water, sediments, and plants. Samples were collected from September 2002 to January of 2003 and analyzed for phosphorus content. Results showed that the Upper Pond removed 55% of the ortho phosphate (OP) and 39% of the total phosphorus (TP) loadings during the study period. Sediment results showed that the East Outflow concentrated the most P (644.85 ± 120.26 mg P Kg^{-1}), followed by the East Edge of the Island (576.00 ± 151.38 mg P Kg^{-1}) and the Inflow (468.55 ± 298.99 mg P Kg^{-1}). Results also showed that the sediment is accumulating mostly in the middle of the pond followed by the east edge of the island and the east outflow area. *Typha* and *Scirpus* plant species were analyzed for P content and results showed that *Typha* accumulated more P than *Scirpus* during this study. Only *Scirpus* showed significant difference in P content between above and belowground tissues. Belowground tissues had more P content.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ACRONYMS

BOD – Biochemical Oxygen Demand
CCCP – Clark County Comprehensive Planning
CCRFCD – Clark County Regional Flood Control District
CCP&R – Clark County Department of Parks and Recreation
CCWP – Clark County Wetlands Park
COD – Chemical Oxygen Demand
DIP – Dissolved Inorganic Phosphorus
DO – Dissolved Oxygen
EPA – Environmental Protection Agency
ESD – Environmental Studies Department
FWS – Free Water Surface
GPS – Global Position System
HFW – Horizontal Flow Wetlands
HRC – Harry Reid Center
HRT – Hydraulic Residence Time
LVV – Las Vegas Valley
LVW – Las Vegas Wash
LVWCC – Las Vegas Wash Coordination Committee
NPS – Non-point Source
OP – Ortho Phosphate
SFW – Subsurface-flow Wetlands
SNWA – Southern Nevada Water Authority
SRP – Soluble Reactive Phosphorus
SUP – Soluble unreactive Phosphorus
TDS – Total Dissolved Solids
TN – Total Nitrogen
TP – Total Phosphorus
TS – Total Solids
TSS – Total Suspended Solids
VFW – Vertical Flow Wetlands
WPNP – Clark County Wetlands Park Nature Preserve

ACKNOWLEDGEMENTS

I would first like to thank my advisors Dr. Stave and Dr. Batista for providing me with support, encouragement, and guidance in the writing of this thesis. My appreciation also goes to my other committee members Dr. Steinberg and Dr. James for sharing their knowledge with me.

For their financial support, I would like to thank the Bureau of Reclamation. Thanks also go to the Civil Engineering Department, especially Dr. Batista, for letting me use the environmental engineering lab for analyzing my samples. Thanks Dave Bettley for sharing the hydrology knowledge with me. To Jim Pollard, thank for your support during the two years of work together. I also would like to thank the crewmembers from the Environmental System Lab for their help in collecting my samples and also for the good moments during our work together. Thanks to my new friends from the Chemistry and the Engineering Departments for their friendly support, especially José, Daniela, and Renato.

Special thanks go to my parents, siblings, nieces and nephews who are always supporting me when I need them. Thanks Shirley, George and Phil, my closest family, for all your support since I came to Las Vegas. Finally, I would like to thank my fiancée for his love, patience, and understanding especially through this hard time. Thanks Douglas and Dayle for understanding my absence in many occasions.

CHAPTER 1

INTRODUCTION

1.1 Problem Statement

The purpose of this study is to investigate the distribution of phosphorus (P) in the Clark County Wetlands Park Nature Preserve (WPNP). The WPNP is a 130-acre Park with a five-acre wetlands system, constructed in Las Vegas in 2000. Water for the system is mostly supplied by non-point urban runoff and resurfacing groundwater. One of the reasons for the creation of the wetlands was to treat non-point source (NPS) pollution. Runoff that feeds the WPNP comes from the urban Las Vegas Valley (LVV), and transports with it fertilizer and pesticides from residential lawns, oil, grease, pathogens and other contaminants. Fertilizers contain nutrients (i.e. phosphorus and nitrogen) that need to be removed from runoff before it reaches Lake Mead. Lake Mead is a multi-purpose reservoir in the Colorado River that supplies the nearly 2 million inhabitants of Las Vegas with drinking water. Understanding the functions of the WPNP in relation to nutrients retention is important for the management of water quality in Lake Mead.

According to the National Water Quality Inventory, prepared under Section 305 (b) of the Clean Water Act, the leading pollutants and sources of pollutants reported by states and other jurisdictions are siltation, nutrients, bacteria, metals (primarily mercury),

and oxygen-depleting substances. Nutrients were found in 22% of the lakes and contributed to 50% of reported water quality problems in impaired lakes (USEPA, 2000). The same report described that the leading source of impairment is the pollution from urban and agricultural lands that is supplied by precipitation and NPS. The states reported that pollution from urban runoff and storm sewers degraded almost 1.4 million acres of lakes (8% of the evaluated lakes acres and 18% of the impaired lake acres) (USEPA, 2000). Over half of the degradation of water quality conditions in rivers and tributaries is due to NPS, such as runoff (Baker, 1992).

Many lakes have been overloaded with nutrients resulting in heavy algal blooms (Holtan *et al.*, 1988). P is known to be the most important cause of excessive and deleterious fertilization of lakes and rivers, causing eutrophication (Syers *et al.* 1973; Rhue and Harris, 1999; Correll, 1998). P has been found to be the limiting nutrient in the growth of algae under many conditions. Consequently, the trophic condition of a freshwater body usually reflects directly the concentration of available P in the water; high productivity increased with increasing depth of water – center of the lake, which is deeper, showed more P and N concentrations than the edges (Frink, 1969).

Numerous algal blooms have occurred in portions of Lake Mead and there is concern that the Lake is becoming increasingly eutrophic (LaBounty and Horn, 1997). Therefore, limiting the amount of nutrients that reach the Lake is desirable. The WPNP is expected to be a useful tool in purifying the runoff that passes through it.

Phosphorus is one of the most important elements in wetlands chemistry, especially if these wetlands receive NPS pollution or wastewater (Mitsch and Gosselink, 2000). Bolton and Greenway (1999) noted that phosphorus is lost from wetland along

three major nutrient exclusion pathways: loss to the atmosphere, drainage from the wetlands, and retention in the wetlands sinks.

1.2 Research Objectives and Hypothesis

This research investigates the distribution of P among three different compartments of the Upper Pond (also known as North Pond) at the WPNP wetlands: influent and effluent water, sediments, and plants. The determination of P in these compartments is important in order to establish the productivity and the efficiency of the wetlands in treating urban runoff. In addition, this research is a first step towards evaluating the effectiveness of P removal in different components of the wetlands. Therefore, it provides insight into the phosphorus concentrations leaving the wetlands towards Lake Mead.

The hypotheses tested in this research are that (a) P content in the water compartment will be greater in the influent than in the effluent because it is expected that the wetlands will remove P; (b) the P distribution in the sediment will be characterized by a difference in P concentrations between layers - it is expected that the upper sediment layer holds higher P concentrations; (c) P content in the plant compartment will vary between above and belowground portions – the roots would contain higher P concentration than aboveground tissue.

1.3 Support for Hypotheses in the Literature

1.3.1 Phosphorus Background

Phosphorus is one of the most abundant elements on earth (Holtan *et al.*, 1988). It can be transported to waterways in particulate and dissolved forms by runoff, as point source effluents from wastewater treatment plants, groundwater discharge, and atmospheric deposition. P occurs in nature almost exclusively as phosphate, in all known minerals more specifically as orthophosphates (PO_4^{3-}). The reaction mechanisms regulating P concentration in sediments are: adsorption, desorption, sorption, and precipitation. Precipitation can be a major source of nutrients for many lakes with highest levels of P found in industrial and agricultural areas and the highest rates measured in the summer (Holtan *et al.,* 1988). As defined in Holtan *et al.* (1988), a sorption reaction involves the removal of phosphate from solution by its concentration in a solid phase. P usually occurs in natural waters in the oxidized state, generally as ions of inorganic orthophosphates (HPO_4^{2-}, $H_2PO_4^-$, PO_4^{3-}). Because P has an attraction for calcium (Ca), iron (Fe), and aluminum (Al), it can form compounds, such as ferric phosphate or calcium phosphate. According to Holtan *et al.* (1988), natural P breaks down as follows:

Total Phosphorus (TP) ---
- -- Particulate Phosphorus (> 0.45 µm)
- -- Soluble Phosphorus --- (< 0.45 µm)
  - - Soluble Reactive Phosphorus (SRP)
  - - Soluble Unreactive Phosphorus (SUP)

Particulate P includes: exchangeable P, organic P, precipitates (fertilizer, reaction products with Ca, Fe, Al and other cations), crystalline minerals and amorphous P. The

"biologically available phosphorus" is defined as soluble reactive P, soluble unreactive P, and labile P (Holtan *et al.*, 1988). Phosphorus, in both organic and inorganic forms, occurs as soluble and insoluble complexes in wetland water and sediments.

1.3.2 Wetlands Background

According to Mitsch and Gossenlink (2000), definition of a wetland that satisfies all users has not been developed yet because the definition depends on the objectives and field of interest of the user. In this paper I use the definition that is used for ecology and inventories, which is the 1979 U.S. Fish and Wildlife Service definition. The definition was presented in a report entitled Classification of Wetlands and Deepwater Habitats of the United States:

> "Wetlands are lands transitional between terrestrial and an aquatic system where the water table is usually at or near the surface or the land is covered by shallow water... Wetlands must have one or more of the following three attributes: (1) at least periodically, the land supports predominantly hydrophytes, (2) the substrate is predominantly undrained hydric soil, and (3) the substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growing season of each year" (Cowardin *et al.*, 1979).

Wetlands are very dynamic ecosystems that offer not only rich and diverse habitat for plants and animals but also provide water quality improvement. These systems improve water quality by removing or retaining inorganic nutrients, from surface flows, processing organic wastes, and reducing suspended sediments before they reach open

water (USEPA, 2000). Wetlands are also important places for temporary nutrient storage: short-term compartments (plants) or long-term compartments (soil) (Emery & Perry, 1995; Verhoeven and Meuleman, 1999). In wetlands, nutrients are transformed and incorporated by the processes of sorption, precipitation, nitrification, denitrification and plant uptake; through these processes, wetlands can improve water quality (Emery & Perry, 1995).

Wetlands can also absorb large volumes of water during storm events and slowly discharge it to the adjacent surface. By absorbing water and diminishing the rate of flow, wetlands help to avoid damage to the surrounding environment, thereby reducing erosion (Kao and Wu, 2001). The complex nature of wetlands ecosystem and their interaction with hydrology, soil chemistry, and nutrient cycling have attracted the interest of a great variety of disciplines (Campbell and Ogden, 1999). Aquatic ecologists are recognizing and quantifying the fundamental importance of the land-water interface of aquatic ecosystems as a major source of organic matter and energy for the down-gradient water bodies. In particular, wetlands are being recognized as metabolically active ecosystem elements that influence the loading of nutrients (Moshiri, 1993).

In spite of the diversity of wetlands, they have many characteristics in common that support water quality improvement. Wetlands provide effective, free treatment for different types of polluted waters; removing pollutants from point sources and nonpoint sources, including organic matter, suspended solids, metals, and nutrients. High microbial activities in these systems have high capacity to decompose organic matter and other substances (Moshiri, 1993; Mitsch and Gosselink, 1993; Copper and Findlater, 1990).

Moshiri (1993) stated that both natural and constructed wetlands have been used as wastewater treatment systems and both act as efficient water purification systems and nutrient sinks. Because constructed wetlands can be built with a much greater degree of control, they allow the establishment of experimental treatment facilities with a well-defined composition of substrate, types of vegetation, and flow patterns. Constructed wetlands also offer additional advantages compared to natural wetlands, including site selection, flexibility in sizing, and most importantly, control over the hydraulic pathways and retention time. The pollutants in such systems are removed through a combination of physical, chemical, and biological processes including sedimentation, precipitation, adsorption to soil particles, assimilation by the plant tissue, and microbial transformation (Moshiri, 1993).

Two general variants of constructed wetlands have been used to treat wastewater: wetlands with a free water surface (FWS) and subsurface-flow wetlands (SFW). FWS wetlands look like natural wetlands since they have aquatic vegetation, which are rooted in a soil-layer on the bottom of a pond and the water flows through the leaves and steams of the plants at a relatively shallow depth (Dialynas *et al.*, 2002). SFW typically consist of emergent plants growing in a porous soil or gravel substratum through which the effluent flows (Cooper and Findlater, 1990).

1.3.3 Phosphorus in Wetlands

The principal inorganic P in wetland water is orthophosphates (Mitsch and Gosselink, 2000). At any given time, most of the P in wetlands is bound up in organic litter, peat, and in inorganic sediments, with the former dominating peatlands and the latter dominating mineral soil wetlands. P moves through the wetlands environment in a

sedimentary cycle (Mitsch and Gosselink, 1993). Storage of P in wetlands depends on the removal of DIP from the water by microbial and plant uptake, soil adsorption, and assimilation of organic phosphorus into soil peat. The initial removal of DIP under natural loading levels is attributable mainly to microbial uptake, and by Al and Fe minerals in the soil (Richardson, 1985).

Figure 1.1 represents the P cycle in wetlands. P flows into the wetland system in runoff, groundwater, and atmospheric deposition. Inflow brings dissolved P and particulate P in both organic and inorganic forms. Some particulate inorganic P goes directly to the sediment through adsorption or precipitation; some solved forms stays in the water column. Wetlands plants remove nutrients for biomass production through absorption and assimilation, sometimes directly from the water or indirectly from the sediment, taking up dissolved inorganic phosphorus (DIP) and converting it to organic phosphorus, as it becomes part of their tissues. Plants transform inorganic P to organic P that is then accumulated in organic peat, mineralized by microbial activity, or exported from the wetlands. As plants and animals excrete wastes or die, the organic phosphorus they contain sinks to the bottom, where bacterial decomposition converts it back to inorganic phosphorus, both dissolved and attached to particles. This inorganic P gets back into the water column when plants stir up the bottom, and the P cycle begins again. The sediment compartment contains particulate inorganic P, including inorganic compounds, such as Ca-P, Fe-P, and Al-P. These compounds increase the capacity of the system for aerobic bacterial decomposition of pollutants as well as its capacity for supporting a wide range of oxygen-using aquatic organisms, some of which directly or indirectly utilize additional pollutants. Table 1.1 shows the major types of phosphorus in natural waters.

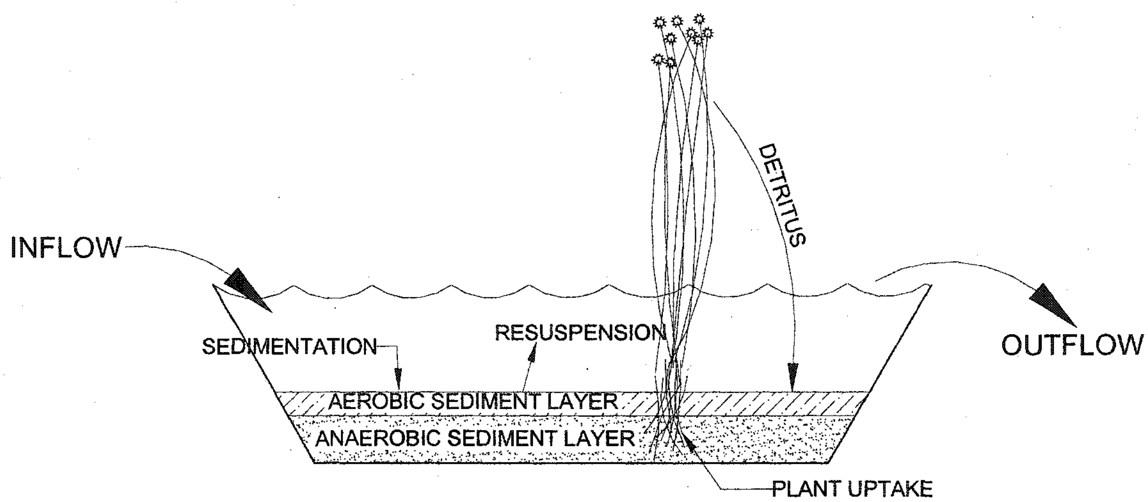


Figure 1.1 Phosphorus Cycle in Wetlands – Representation of the Main Compartments (Adapted from Misch *et al.*,1995)

Table 1.1 Major Types of Phosphorus in Natural Waters

Phosphorus	Soluble	Insoluble
Inorganic	Orthophosphates ($H_2O_4^-$; HO_4^{2-}; PO_4^{3-}) Polyphosphates Ferric Phosphate ($FeHPO_4^+$)	Clay-phosphate complexes Metal hydroxide phosphate, e.g. vivianite $Fe_3(PO_4)_2$, variscite $Al(OH)_2H_2PO_4$)
	Calcium Phosphate ($CaH_2PO_4^+$)	Minerals, e.g. apatite $[Ca_{10}(OH)_2(PO_4)_6]$
Organic	Dissolved organics, e.g. sugar phosphates, inusitol phosphates, phospholipids, phosphoproteins	Insoluble organic phosphorus bound in organic matter

Adapted from Mitsch & Gosselink, 2000.

Wetlands eliminate aquatic pollutants through a complex mixture of biological, physical, and chemical processes; these processes include adsorption, precipitation, sedimentation, and microbial transformation (Gersberg et al, 1986; Edwards, 1992; Emery & Perry, 1995). Wetlands retain wastewater P by adsorption and precipitation reactions with Aluminum (Al), Iron (Fe), and Calcium (Ca) content in the soil (Nichols, 1983). However, this process is not a limitless sink; with continuous application, the capacity of wetlands soils to retain P drops, as the soil becomes P saturated (Nichols, 1983).

Much research has been performed on the role of wetlands in treating runoff or wastewater by removing nutrients (e.g. Sundblad and Wittgren, 1997; Nichols, 1983; Reddy *et al.*, 1999; Cutbill, 1994; Lüderitz *et al.*, 2001; Gersberg et al, 1986; Edwards, 1992; Kadlec, 1994; Emery & Perry, 1995; Mitsch, 1995; Verhoeven and Meuleman, 1999; Godfrey *et al.*, 1985; Moshiri, 1993; Kao *et al.*, 2001; Dialynas *et al.*, 2002; Ceballos *et al.*, 2001; Lüderitz and Gerlach., 2002; Mitsch *et al.*, 1995; Kao and Wu, 2001).

All natural freshwater wetlands, especially those with peat soils were not very efficient in processing and storing P at high concentration (Richardson, 1985). In his study he concluded that wetlands used as wastewater filtration systems became P-saturated in a few years, exporting excessive quantities of phosphate, although wetlands with preponderance of mineral soils and high amorphous aluminum content are better P sinks than peatlands. A wetland system in New Zealand receiving sewage water with a high P flux (≈ 34 g P m^{-2} yr^{-1}) for over a decade was investigated and results showed that

particulate P deposition in sediment was the most important sink for P with 30 g P m^{-2} day^{-1} (Cooke, 1992).

Constructed wetlands can improve water quality of urban runoff, especially during spring and early summer (Cutbill, 1994). Cutbill's study demonstrated a 70% reduction in the levels of coliforms, nitrate, phosphorus and turbidity after the stormwater had moved across the wetlands. The efficacy of using constructed wetlands to treat NPS pollution was also confirmed by Kao *et al.* (2001), where more than 88% of N, 81% of chemical oxygen demand (COD), 85% of heavy metals, 70% of TP, and 60% of the total suspended solids (TSS) were removed by the wetlands system. Natural wetlands system removed 80% N; 91% TSS, 66% COD, and 59% TP from stormwater (Kao and Wu, 2001). Vertical flow (VFW) and horizontal flow (HFW) constructed wetlands removed more than 90% of organic load, TP and TN although HFW is better for long-term removal of phosphorus (Lüderitz *et al.*, 2001). Wetlands performed better to improve water quality when they were not isolated (Mitsch, 1995). Constructed wetlands in Holland showed removal rates of 99% bacterial pollution, 80-99% of COD and BOD, and 30-40% of N and P (Verhoeven and Meuleman, 1999). Dialynas *et al.* (2002) study on free water surface flow systems (FWS) wetlands as wastewater treatment in Greece found 95% reductions of BOD, COD and TSS and an approximately 50% reduction of TKN and TP. Ceballos et. al (2001) examined natural and constructed wetlands and found that removal rates for TP ranged between 10-53%.

Hydrologic conditions in a wetland affect the removal of wastewater nutrients (Nichols, 1983; Brix, 1994). At low flows, wetlands have the capability to remove much of the P applied; however, at high loading rates the efficiency of removal decreases

rapidly. Nichols' study0 demonstrated that the removal efficiency of P and N in wetlands fell off rapidly as loadings were increased (Nichols, 1983). His results showed that on average, it was necessary 1 ha of wetland to remove 50 % of the P and N from wastewater produced by 60 people (Nichols, 1983).

The Iron Bridge wetland, which receives water with less than 1.0 mg/L of TP and 49,000 m^3/day of treated municipal wastewater, presented an uptake rate coefficient (k) of 10.0 m/yr. The second wetlands analyzed was OCESA, which was permitted to treat 13,000 m^3/day of wastewater from treatment plants in Orange County; this system had k = 6.4 m/yr. Boney Marsh wetland hydraulic load averaged 3.1 cm/day with an average incoming TP of 50 ± 11 μg/L, and the average outflow of 21 ± 11 μg/L. The uptake P rate coefficient for this wetland was 13 ± 3 m/yr. The WCA2A wetlands removal rate coefficient was 10.2 m/yr as the best fit. The author concluded that the removal of P to new soils is comparative to P concentration in the surface waters (Kadlec, 1994).

Sakadevan and Bavor (1999) studied the ability of five constructed wetlands systems in Australia to treat secondary sewage effluent. This system was constructed with free water surface, 30 m X 5 m of size, 400 mm subsoil clay layer, and a topsoil layer of 300 mm. Four effects were evaluated: hydraulic loading rate (high x low), phosphorus concentration (high x low), retention time (long x short), and water column depth (high x low) for P and N transformations within soil-plant-water systems. Their findings summarized that the influent water TP concentration for high P concentrations systems ranged from 6.6 to 13.9 mg P L^{-1} and for low P concentrations systems ranged from 0.17 to 5.26 mg P L^{-1}. The average TP concentrations of effluent water of all sites were lower than TP of inflow. The effluent water for high P systems ranged from 6.4 to

7.3 mg P L^{-1} and mean TP concentration was 1.8 mg P L^{-1} for low P systems. Percentage of P removal in high P systems ranged from 11% to 22.7% for high P and 47.0% to 48.9% for low P systems. The results showed that all systems receiving high P concentration presented lower P removal, which confirmed the conclusions of previous studies: P removal is directly affected by the P concentration in influent water. Higher water depth, high hydraulic loading, and low retention time resulted in a decrease of P removal (Sakadevan and Bavor, 1999). They concluded that low hydraulic loading combined with greater retention times increased the removal of P and N from wastewater in constructed wetlands.

Addition of iron fillings to the filter material is more effective in assuring a high removal capacity than the use of Ca-rich soils. Horizontal flow wetlands (HFW) with an iron-rich soil filter at pH values between 4.6 and 4.9 removed 97% of P while the vertical flow wetlands (VFW) presented a lot lower removal rate (27%) at pH values between 5.8 and 6.4. (Lüderitz and Gerlach, 2002).

Wetlands have a threshold for P that, if exceeded, might result in downstream elevated P concentrations (Richardson, 1999). His study suggested that to store P for the long term and to avoid downstream movement of high P concentrations background P loadings in wetlands must be close to or lower than 1.0 $gm^{-2}yr^{-1}$, which he called the "one-gram rule" (Richardson, 1999). This theory was criticized as being an over-simplication of the P process in wetlands. The "one-gram rule" should not be applied as a general rule because the transition from TP suppression happens at different P loadings for different wetlands (Kadlec, 1999).

Constructed freshwater wetlands can effectively remove P from river water even in comparatively low P concentrations. Mitsch *et al.* (1995) study showed that high-flow wetlands were as efficient as the low-flow wetlands in removing P; high-flow removed 1.4 – 2.9 g $Pm^{-2}yr^{-1}$ and low-flow wetlands removed 0.4 – 1.71 g $Pm^{-2}yr^{-1}$. Average P concentrations decreased by 64-92% in low-flow wetlands (to 11 - 40 μg P/L) and by 53 - 90% (to 12 – 57 μg P/L) in high-flow wetlands (Mitsch *et al.*, 1995).

1.3.6 Phosphorus in Sediments

Wetland sediment is both the medium in which a myriad chemical transformations occur and the primary storage reservoir of available chemicals for most macrophytes (Mitsch and Gosselink, 1993). Brigham *et al.*, (2001) stated that geochemical and biological phenomena are responsible for controlling P movement in sediments and the dominant mechanism of P storage in wetlands is adsorption to soils. Nutrient addition and storage are important in controlling wetlands productivity, species diversity and water quality (Craft & Casey, 2000). Sediments play an important function in the overall phosphorus metabolism of aquatic environments. It controls the levels of availability of resources causing an effect on the composition, growth, and assortment of aboveground macrophytes, and sediment micro flora and fauna. Sediment can be both source and sink of phosphorus (Chambers *et al.*, 1994; Barko & Smart, 1980; Boström *et al.*, 1988). For instance, if the aquatic environment has high trophic levels, P release may exceed P accumulation (Boström *et al.*, 1988). There is strong evidence that sorption and release of P in some lake sediments is intimately connected with redox-dependent variations in microbial physiology (Rhue and Harris, 1999). Created wetlands soils make

substrate available for aquatic environment to establish and to prosper, and consequently, re-establish the ecosystem's integrity (Nair *et al.*, 2001).

Many researchers have studied the interactions between wetlands sediments and nutrients (e.g. Bridgham *et al.*, 2001; Gilliam *et al.*, 1999; Nair *et al.*, 2001; Qiu and McComb, 2000; Craft & Casey, 2000; Newman and Robinson, 1999; Reddy *et al.*, 1999; Sakadevan and Bavor, 1999). Many other studies have been performed on the phosphorus contents of sediments, the fractionation and the association of phosphorus to the different soil components (Bray and Kurtz, 1945; Chang and Jackson, 1957; Chapman and Pratt, 1961; Williams *et al.*, 1967; Sommers *et al.*, 1970; Williams *et al.*, 1971; Sommers and Nelson, 1972; Aspila *et al.*, 1976; Hieltjes and Lijklema, 1980; Hedley *et al.*, 1982; Pettersson *et al.*, 1988; Oluyedun *et al.*, 1991; Graetz and Nair, 1995; Christensen *et al.*, 1996; Graetz and Nair, 1999; Wetzel, R.G., 1999).

Bray and Kurtz (1945) summarized the methods and procedures of analysis for the determination of P content in soils. Chang and Jackson (1957) classified inorganic phosphate for the first time into four main groups: calcium phosphate, aluminum phosphate, iron phosphate, and the reductant soluble phosphate. Their method was the first detailed fractionation method for P in soils. Results from Sommers *et al.* (1970) study on total organic P in lake sediments ranged from 23 to 147 mg P/100 g oven-dried sediments and from 8% to 63% of the TP. Aspila *et al.*, described a semi-automated method for determining inorganic, organic, and TP in lake and river sediments (Aspila *et al.*, 1976). Results from fractionation of inorganic phosphates in calcareous sediments in Lake Brielle, a shallow eutrophic hard water lake southwest of Rotterdan, showed $CaCO_3$

content ranged from 8.5 to 18% by weight and the TP content was in the range of 0.75 to 4.0 mg per g dry weight (Hieltjes and Lijklema, 1980).

Graetz and Nair (1999) studied Florida's aquatic systems and demonstrated that the majority of P in wetlands sediments was related with inorganic iron and aluminum. According to the authors, this kind of P is stable and difficult to remove, except under extended saturated water conditions. The amounts of this P ranged from 17% (TP = 987 mg P kg^{-1}) to 37% (TP = 294 mg P kg^{-1}). Most of the sediments studied had low levels of Ca- and Mn, and TP content was greater than in the indigenous upland areas. For the authors, the TP content in wetlands sediments and soils is insufficient information to determine the behavior of phosphorus in the environment; they suggest a P fractionation analysis, offers a means of acquiring significant information on the P chemistry of sediments.

Analysis of sediment in seven Western Australia wetlands sediments results showed that labile P usually accounted for less than 10% of TP; organic P accounted for up to 73% of sediment TP; high proportions of HCl-P, accounting for 33-48% of sediment TP, and NaOH-P explained 30-88% of TP in those wetlands. Evidence also showed that TP was associated with organic and water content of sediments, suggesting the importance of the surfacial, organic-rich deposition as P reservoir. Humic material was also important in sediment P allocation, which accounted for 5-73% TP (Qiu and McComb, 2000).

Craft & Casey's study of a floodplain and a depressional freshwater wetlands showed that both wetlands had comparable amounts of sediment, organic C and N, while P accumulation was 1.5 to 3 times greater in floodplain wetlands sediments. P retention

was affected by surface area and connectivity to sources of fine textured (clay) sediments as evidenced by higher P accumulation in floodplain wetlands (Craft & Casey, 2000).

Constructed and native wetlands in Florida had comparable concentrations of available nutrients, although sporadically some of the values were slightly higher in the surface sediments of the native wetlands. Organic matter accretion and nutrient status of sediment showed that available P ranged from 350 to 450 mg P Kg^{-1} in surface sediment and from 370 to 1020 mg P Kg^{-1}at lower depths, pH was close to neutral (6.0 - 7.4) to slightly alkaline (7.5 - 8.0) (Nair *et al.*, 2001).

Boström *et al.* (1998) found that the sediment-water interface exchange in lakes water demonstrated that even between lakes of comparable trophic levels, fractional composition of sedimentary P varied significantly. Moreover, lake morphometry was also fundamental for P mobilization and transport processes; in this system N also influenced P processes (Boström *et al.*, 1988).

Sediment P concentration was not influenced by the P loading, retention time or water column depth in a constructed wetlands in Australia. In all five systems tested sediment present increased in P content after the first year but there was no correlation with an increase in P inlet water (Sakadevan and Bavor's, 1999).

After examining P sorption dynamics in two riverine wetlands, in northern Minnesota and Wisconsin, Bridgham *et al.* (2001) found that amorphous iron (Fe) and Aluminum (Al), sulfide, soil pH, soil size fractions, percentage organic matter, bulk density, and water depth have important effects on P cycle. A strong seasonal component was also found in the surface-water soluble reactive phosphorus (SRP), extractable soil P (pore water SRP was predicted better in the summer than it was in the spring). Frequent

hydrologic flushing might prevent establishment of stability conditions between soil and surface-water (Bridgham *et al.*, 2001). The results eight months after wetlands creation in West Virginia confirmed that extractable P decreased rather than increased under flooded conditions (e.g. Created wetland soil P mean value before was equal to 3.9 mg Kg^{-1}, and after it was 3.0 mg Kg^{-1}) (Gilliam *et al.*, 1999).

1.3.7 Phosphorus in Plants

In wetlands, macrophytes affect the physical, chemical, and the biological environments, thus playing an important role in purifying and treating the water (Nichols, 1983; Guntenspergen *et al.*, 1989; Carpenter & Lodge, 1996). In these systems, the wastewater spreads out and passes through the plants, which slows the water , and permits sediments and pollutants to settle. Macrophytes behave like a filter, settling inorganic and organic particulate matter, and removing some of the urban pollutants, such as nutrients diminishing the amount released to the watercourse (Nichols, 1983). In addition, macrophytes in wetlands also help to stabilize the surface of the beds, to provide optimum conditions for physical filtration of solids, and to prevent vertical flow systems from clogging (Brix, 1994). The rate of uptake of nutrients by aquatic vegetation from the wetlands water depends on the importance of root versus shoot absorption (Howard-Williams, 1985). Emergent macrophytes, such as *Thypha sp.* (cattail), *Phragmites sp.* (reed), and *Scirpus sp* (bulrush) have high annual productivity.

Many studies have been performed on the role and importance of macrophytes in purifying wastewater or runoff in wetlands (Klopatek, J.M., 1978; Nichols, 1983; Gersberg *et al.*, 1986; Howard-Williams, 1985; Reddy and DeBusk, 1987; Guntenspergen *et al.*, 1989; Edwards, 1992; Brix, 1994; Ansola *et al.*, 1995; Emery &

Perry, 1995; Newman *et al.*, 1996; Soto *et al.*, 1999; Svengsouk & Mitsch, 2001; DeBusk *et al.*, 2001; Tanner, 2001). Other studies focused on macrophyte nutrients' content and uptake (Mason & Bryant, 1975; Barko & Smart, 1980; Carignan & Kalff, 1980; Smith, 1978; Chen & Barko, 1988; Carpenter & Lodge, 1986; Gersberg *et al.*, 1986; Gaudet, 1977; Smith & Adams, 1986; Granéli & Solander, 1988; Boyd & Hess, 1970; Güsewell & Hoerselman, 2002; Horppila & Nurminen, 2001; Boyd, 1969; Boyd, C.E., 1978; Reddy *et al.*, 1987; Shardendu, 1991; Pomogyi et al, 1984; Wigand *et al.*, 1997).

Most aquatic macrophytes are rooted and represent a living link between sediments and the overlaying water (Carpenter & Lodge, 1986). Rooted macrophytes rely mainly on sediment as a source of phosphorus, using their roots as the major paths for P entry (Smith, 1978; Barko & Smart, 1980; Granéli & Solander, 1988; Chen & Barko, 1988; Carignan & Kalff, 1980; Brix, 1994). However, Shardendu (1991) stated that they can also rely on the water as their source of P. *Vallisneria Americana Michx* species relied on either sediment or overlaying water for their phosphorus resource (Wigand *et al.*, 1997).

Vegetation is considered a storage compartment for nutrients in wetlands systems and uptake is associated with growth and production (Guntenspergen *et al.*, 1989). During the growing season plants absorb nutrients, especially P (Emery and Perry, 1995; Carpenter & Lodge, 1986). Later on, phosphorus is transported to shoots, where it possibly will enter the pond water by release from living or decaying shoots (Carpenter & Lodge, 1996; Emery & Perry, 1995). It is known that the release of P by living shoots is minor and the P uptake by roots exceeds the uptake by shoots (Smith, 1978; Barko &

Smart, 1980; Carignan & Kalff, 1980). Pomogyi *et al.*, (1984) showed that P loss from dead plants is predominantly high and percolates faster.

Recent studies claim that the uptake of pollutants by wetlands plants cannot itself be responsible for the high pollutant removal efficiencies often observed at high loading rates at wetlands (Gersberg *et al.*, 1986; Nichols, 1983). Vegetation uptake of nutrients is only quantitatively significant if it is in low-loaded surface flow systems (Brix, 1994). Although several studies showed that wetlands plants can take up large quantities of N and P (according to Brix, 1994, emergent macrophyte uptake is approximately in the range 50 to 150 kg P ha^{-1} $year^{-1}$) during growing season, much of it is released back to the water when plants die (Nichols, 1983; Guntenspergen *et al.*, 1989; Verhoeven and Meuleman, 1999). Macrophytes serve as nutrient source in aquatic systems throughout the year (growing and decay season), which would be important in P-limited systems (Pomogyi et al, 1984). Macrophytes can be short-term sink for phosphorus if the biomass is harvested (Richardson, 1985).

Gersberg *et al.* (1986) agreed that artificial wetland planted with macrophytes is a good methodology to incorporate in secondary and advanced (N removal) treatment of municipal wastewater (Gersberg *et al.*, 1986). The importance of plants in constructed wetlands sewage purification was demonstrated in Lüderitz and Gerlach's (2002) research, where the removal of plants from the sediment filter resulted in a decrease of 50% in the P removal rate. Macrophyte uptake accounted for 12 to 73% of TP removal, showing the emergent plants having the potential for fast nutrient uptake at the same time as providing a greater extent of nutrient storage (Reddy and DeBusk, 1987). *Scirpus* and *Typha* are the most suitable plants in the removal of organic matter (about 70%). For

phosphorus removal, *Scirpus Lacustris* was slightly more competent (47 to 61%), while *Typha Angustifolia* normally averaged removal efficiencies somewhat lower, maximum of 59% for a flow rate of 150 L/day in a hydraulic loading of 11.8 cm/day (Ansola et al, 1995). Another study on *Scirpus sp.* demonstrated a removal of 20% TP and 39% of phosphate from wastewater (Soto *et al.*, 1999). Aquatic macrophytes substantially reduced concentrations of N and P in sediments (Chen & Barko, 1988). Shardendu (1991) concluded that there is a seasonal variation of nutrient concentrations of submerged plants (N and P were higher during the summer). P concentration followed predicted trend over macrophytes growing season and regression analyses exposed significant correlations between nutrient uptake by the aquatic plants and available total sediment N and P content (Klopatek's 1978).

Typha species average P concentration ranged from 1.29 to 2.55 g $P{\cdot}m^{-2}$ (Emery & Perry, 1995). In Kirkojarvi basin *Typha Angustifolia* retained 3-5% of the annual external P loading (Horppila & Nurminen, 2001). *Typha Angustifolia* living shoots contents was found to be in a range of 0.071 to 3.21 g m^{-2}, with individual peaks in early September (Mason & Bryant, 1975). In a water pond environment of mean concentration of 0.008 ppm of PO_4–P *Typha Latifolia* P content was 0.14 ± 0.02 % dry weight (DW) and *Sirpus Americanus* P content was 0.18 ± 0.01 % DW (Boyd, 1970). Svengsouk & Mitsch concluded that *Typha Latifolia* responded with increased growth when higher P and N conditions were present (Svengsouk & Mitsch, 2001).

CHAPTER 2

DESCRIPTION OF THE RESEARCH SITE

2.1 Research Site Location

The Las Vegas Wash (LVW) is a natural channel that crosses the East side of the Las Vegas Valley from North Las Vegas to the Lake Mead National Recreation Area (Figure 2.1). This Wash receives the drainage of the entire Las Vegas Valley (LVV), which represents an area of 1,600 square miles. The lower, southeastern portion of the Wash supports an extensive marsh that is primarily fed by treated wastewater effluent and perennial springs from the LVV.

Since 1972, the wetlands have been drained, resulting in degradation of its biological richness, and more than half of the wetlands have diminished in consequence of larger flows of water that eroded the channel. Seven hundred acres of wetlands have vanished in the upper part of the Wash (SWS, 1995a; SWS, 1995b). The loss of wetlands led to a loss of wetland plants on the effluent, which had a negative impact on the filtering effect of the wetlands on storm water and the effluent that go to Lake Mead.

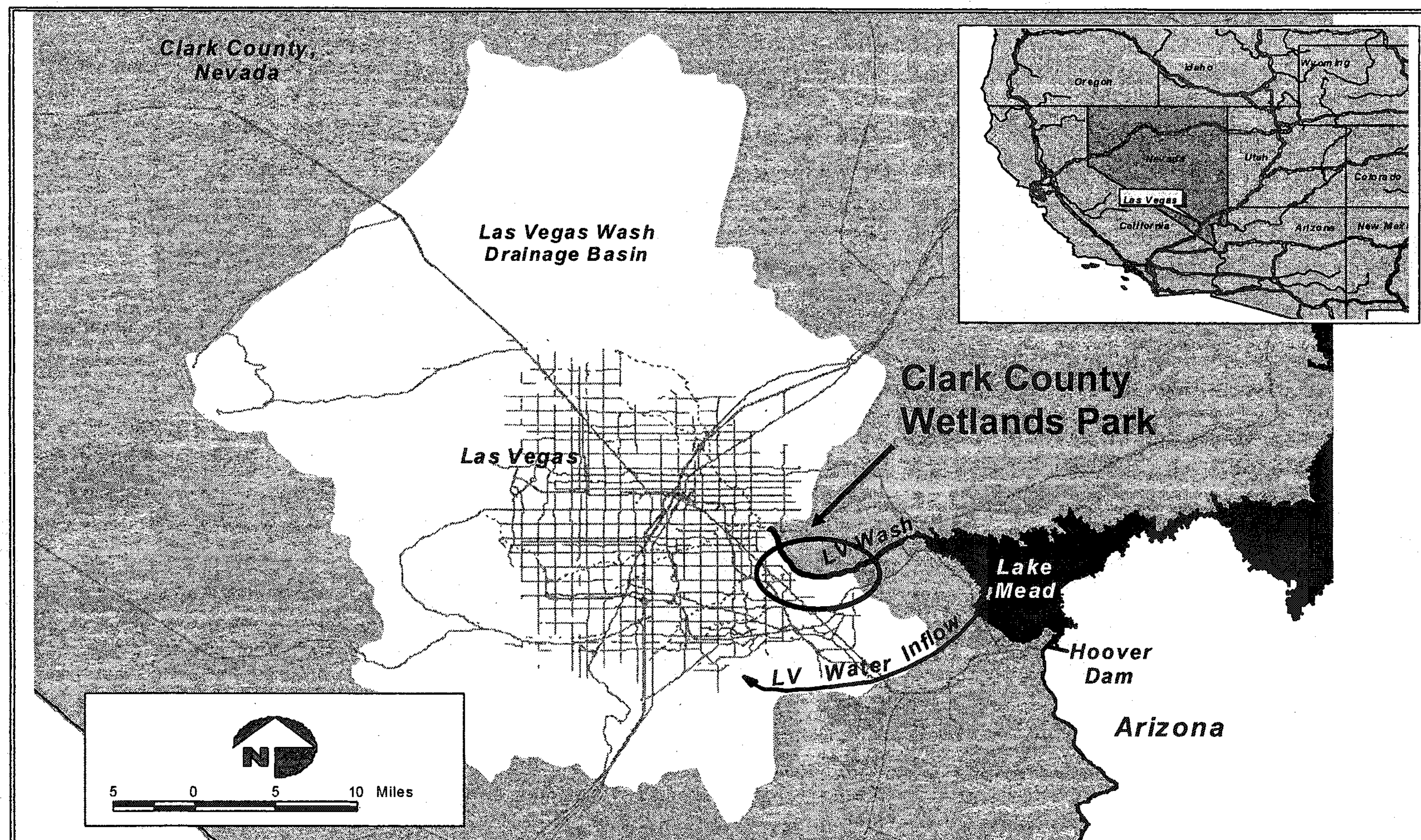


Figure 2.1 Clark County Wetlands Park Situation Map
(Source: Stave, 2001)

From 1980-82, Clark County Departments of Parks and Recreation (CCP&R) and Clark County Comprehensive Planning (CCCP), with the assistance of Southwest Wetlands Consortium (SWS) prepared a wetland master plan and environmental assessment for the area. Between 1987 and 1989, the CCCP started an integrated and comprehensive plan to control the degradation of the Wash. This plan is named the Clark County Wetlands Park Master Plan (CCWP), which covers a study area of approximately 5,200 acres, including wetland and riparian environments along seven miles of the Wash. In 1991 Nevada voters approved a $13.3 million bond issue for erosion control structures and for the creation of the CCWP (SWC, 1995a). In December 1993, the CCP&R, the CCCP, and the SWC started putting together a planning process for the CCWP, which was published in July 1995 (SWC, 1995a). The CCWP is located in the southeastern portion of Las Vegas Valley, along the Las Vegas Wash. Figure 2.2 shows the boundaries and details of the Clark County Wetlands Park area (SWC, 1995a).

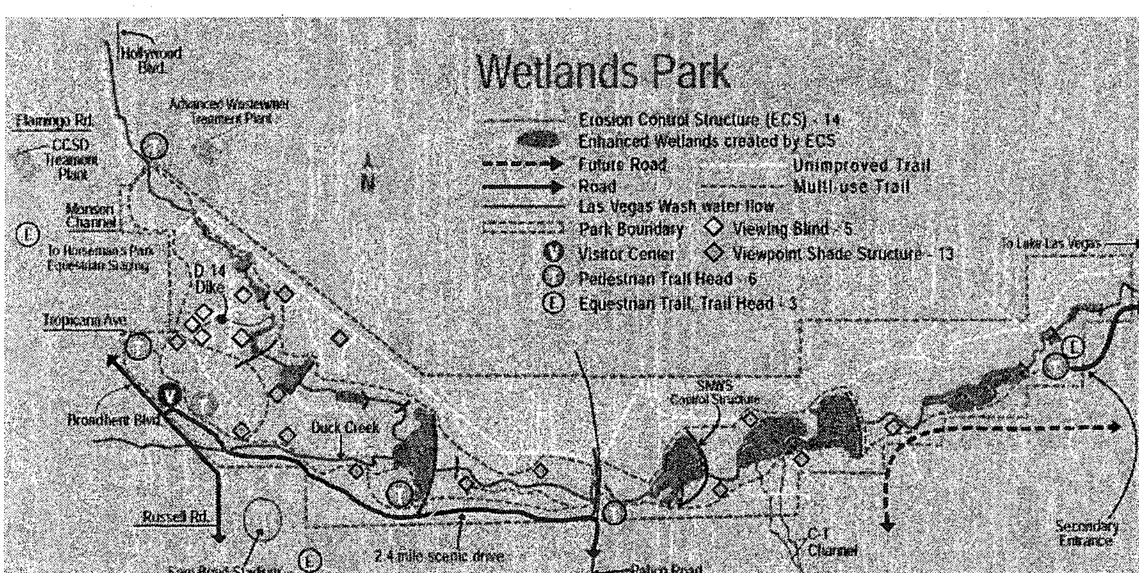


Figure 2.2 Clark County Wetlands Park Project Boundaries
(Source:http://www.co.clark.nv.us/parks/Wetlands/Wetlands_Nature_Preserve.htm)

2.2 Description of the Research Site

The CCWP plan included the construction of the Clark County Wetlands Park Nature Preserve (WPNP), an area that would incorporate an open water habitat. The first step to establish the Nature Preserve was to study the area and its opportunities and limitations, which included water quality, mosquitoes' habitats, hydrology, and geologic information (Montgomery Watson, 1998).

The Nature Preserve was created in the northeastern portion of the Wetlands Park (eastern end of Tropicana Ave.), in an area previously known as D-14 Dike (Figure 2.3). The WPNP covers an area of approximately 130 acres, in which five acres of ponds and streams were constructed; this area includes an improved wetlands community, emergent vegetation, series of trails, wildlife observation blinds, reclamation areas, visitors' center, research facilities, parking, and picnic areas (BOR, 1999).

The 5 ponds of the system are connected to each other and have been designated as: Upper Pond or North Pond (NP-2), Middle Ponds (NP-3, NP-4, NP-5), and Lower Pond (NP-8); these nomenclatures were assigned by the CCP&R and Harry Reid Center (HRC) staff in response to comments on site conventions by Southern Nevada Water Authority (SNWA). Figure 2.4 shows a schematic view of the five interconnected ponds at the Nature Preserve Wetland System. This system has served as a study area for many UNLV students. Table 2.1 illustrates the physical characteristics of the five ponds, including surface area, depth of the ponds, water volume, and average hydraulic residence time (HRT). The focus of my research is the Upper Pond of this Wetland System. This pond was chosen for the study because it was the only pond that has maintained its water source characteristics since the construction of the WPNP. The other

ponds, in dry seasons, received pumped water from the LVW to maintain desired water levels for wildlife.

Table 2.1 Physical Characteristics of Nature Preserve Ponds

Characteristics	Site ID				
	NP-2	NP-3	NP-4	NP-5	NP-8
Surface Area (ac)	1.26	0.22	0.28	0.26	2.28
(m^2)	5,099.22	890.34	1,133.16	1,052.22	9,227.16
Depth (ft)	5	5	5	5	4
(m)	1.52	1.52	1.52	1.52	1.22
Volume of Storage (ac-ft)*	3.72	0.92	0.90	0.90	6.05
(m^3)	4,588.58	1,134.81	1,110.14	1,110.14	7,462.61
Theoretical HRT (days)*	2.13	0.37	0.58	0.63	4.12
Calculated HRT (days)*	1.2	1.3 days (pond 3 through pond 5)			1.6 days
Estimated Depth of Sediments (ft) **	1	-	-	-	-
(m)	0.30	-	-	-	-
Ponding Depth (ft)*	4.12	3.66	4.21	4.77	3.88
(m)	1.26	1.12	1.28	1.45	1.18

* Information obtained from Dave Betley's dye study and hydrology model study (Betley, 2003).
** Information obtained from cross section measurements done in 2001 by Betley and myself.

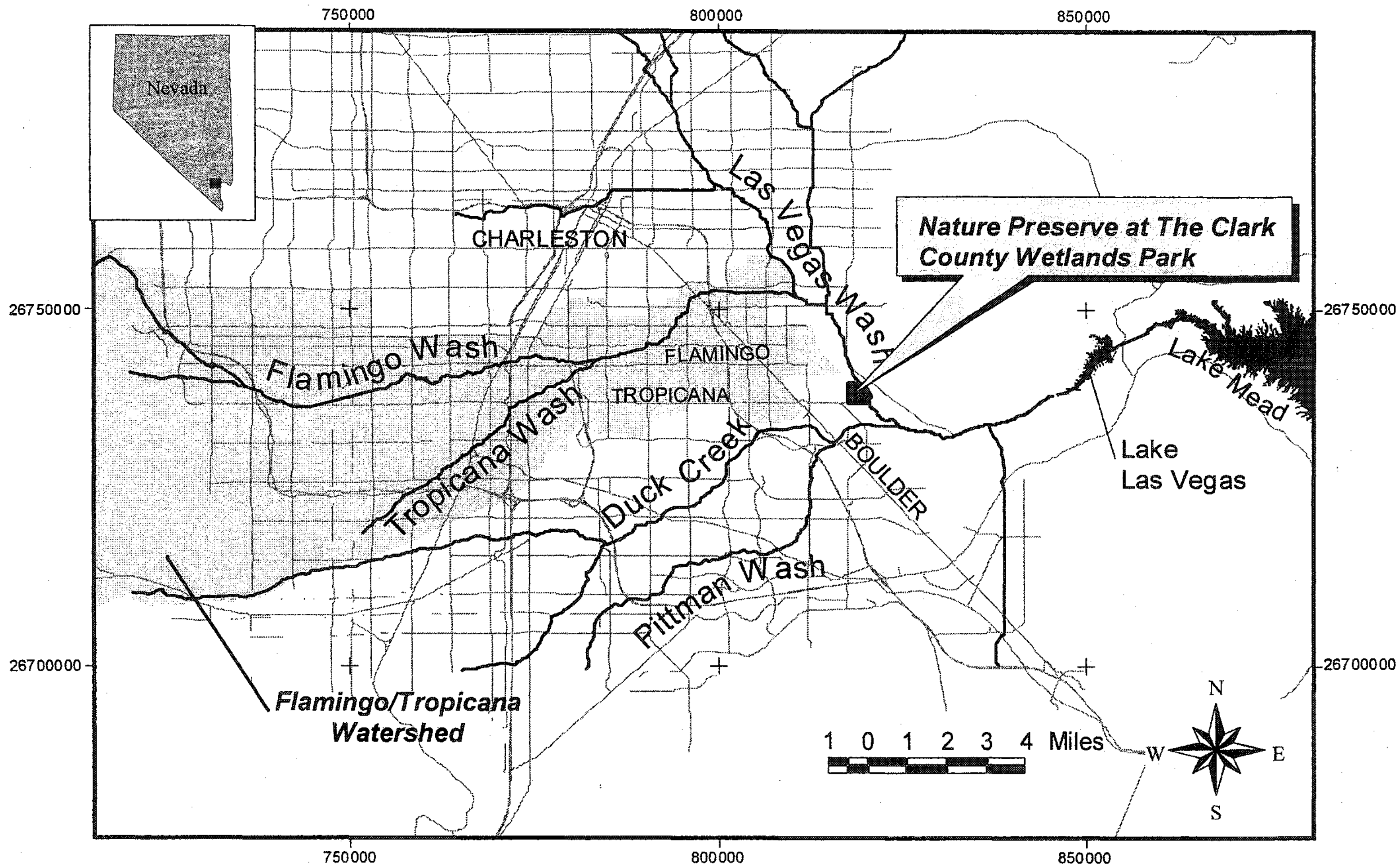


Figure 2.3 Nature Preserve Situation Map

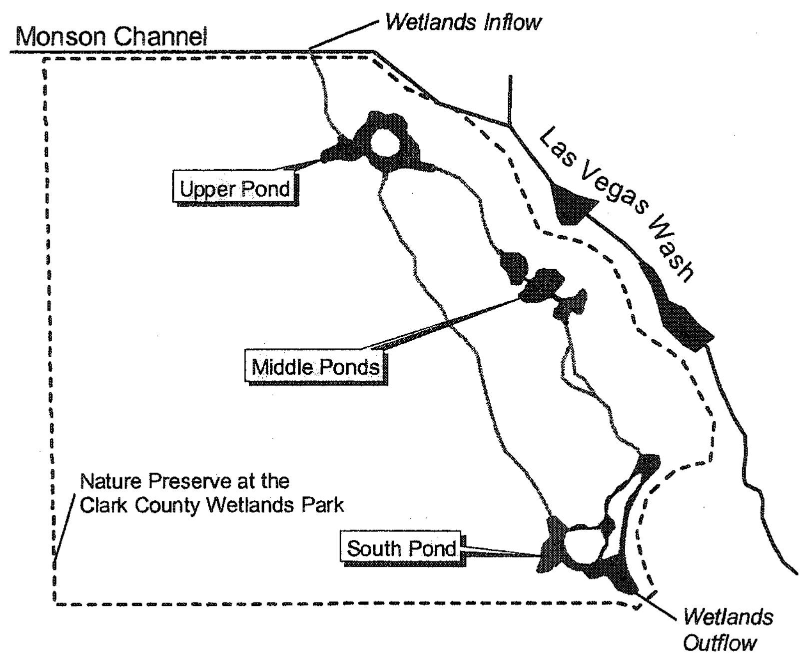


Figure 2.4 Five Ponds at the Wetlands System Nature Preserve

2.3 History of the Construction and Objectives

2.3.1 History of the Construction

In May of 2000, the CCP&R started to manage the construction of the WPNP and in April of 2001, this construction was finished (Pollard et al, 2002). Figure 2.5 shows the Upper Pond at the WPNP approximately six months after the excavation. Table 2.2 summarizes the activities at the Nature Preserve in chronological order.

In October of 2000, a Monitoring Plan for the WPNP was written. This monitoring plan was designed to provide baseline water quality monitoring, long-term monitoring, selenium monitoring, and wetland treatment efficiency evaluation for the WPNP. In January of 2001 baseline monitoring started once a month at WPNP.

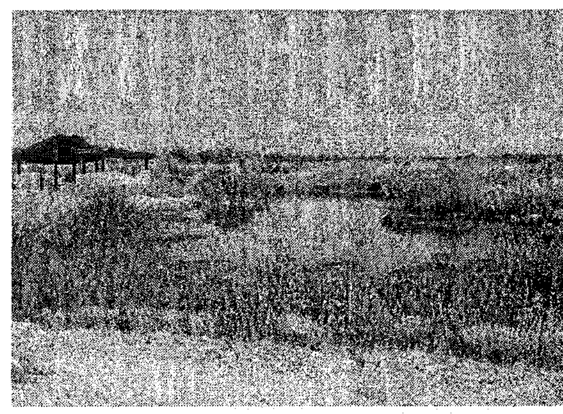
Figure 2.5 WPNP Upper Pond in Nov 2000 (J. Pollard)

Table 2.2 Chronological Activities at the WPNP

	Date						
Activities	May 2000	Jan 2001	Feb 2001	April 2001	Aug 2001	Oct, Nov, Dec 2001 Mar 2002	Aug 2002
Construction of the WPNP	X						
8,000 aquatic plants were planted on and around the ponds			X				
Storm input to the WPNP			X		X		
Spill from CCSDTP						X	
Pump LVW water into Middle Ponds							X
WPNP Completed				X			

Figure 2.6 shows the Upper Pond and the evolution of the vegetation around it. Figure a) shows a picture taken right after the planting day in February of 2001; it shows the view from East Outflow. Figure b) shows the evolution of the vegetation after six months. Figure c) was taken from the East side when a dye study was performed. Figure d) was taken from the Inflow in November of 2002.

a) Upper Pond View from NP-2 East Outflow in February 2001 (J. Pollard)



b) Upper Pond View Near to West Outflow in August 2001 (J. Pollard)

c) Upper Pond view from the east side in May 2002 (R. Brazão)

d) Overview of the Upper Pond from the inflow in November 2002 (R. Brazão)

Figure 2.6 Upper Pond Views and Vegetation Evolution

Figure 2.7 shows aerial photos taken every six months. In Spring 2000, it shows that the area has been excavated for the construction of the pond. In Fall 2000, the pond was already completed and filled with water but there was no vegetation around the pond. In Spring 2001 some of the vegetation that had been planted in February had started growing on the edges of the pond. In Fall 2001 the photo shows that the edges of the pond were completely vegetated. In Spring 2002 the water was completely green due to algae growth from March storms. By Fall 2002 vegetation was denser than the year before.

2.3.2 Goals and Objectives of the CCWP and the WPNP

According to the Planning process and the Master Plan documents (SWC, 1995a; SWC, 1995b), the CCWP has 5 distinctive goals and objectives:

> (1) Develop recreational and tourism opportunities, based on public needs, that are compatible with the conservation/restoration of the Wash; (2) Create social benefits for the Valley by providing opportunities for area residents to gain a sense of community pride and ownership of this park; (3) Create educational opportunities to convey the importance and significance of the Wash through various media; (4) Conserve and restore natural resources by protecting and enhancing of the Las Vegas Wash; (5) Complete a master plan that will guide the design and development of the Park's recreational facilities and support infrastructure.

The objectives of the WPNP, in compliance with the CCWP objectives, are to provide recreation and educational opportunities at the wetlands for the Las Vegas community, to re-establish and to protect the wetlands, to preserve the wetlands habitat and enhance wildlife

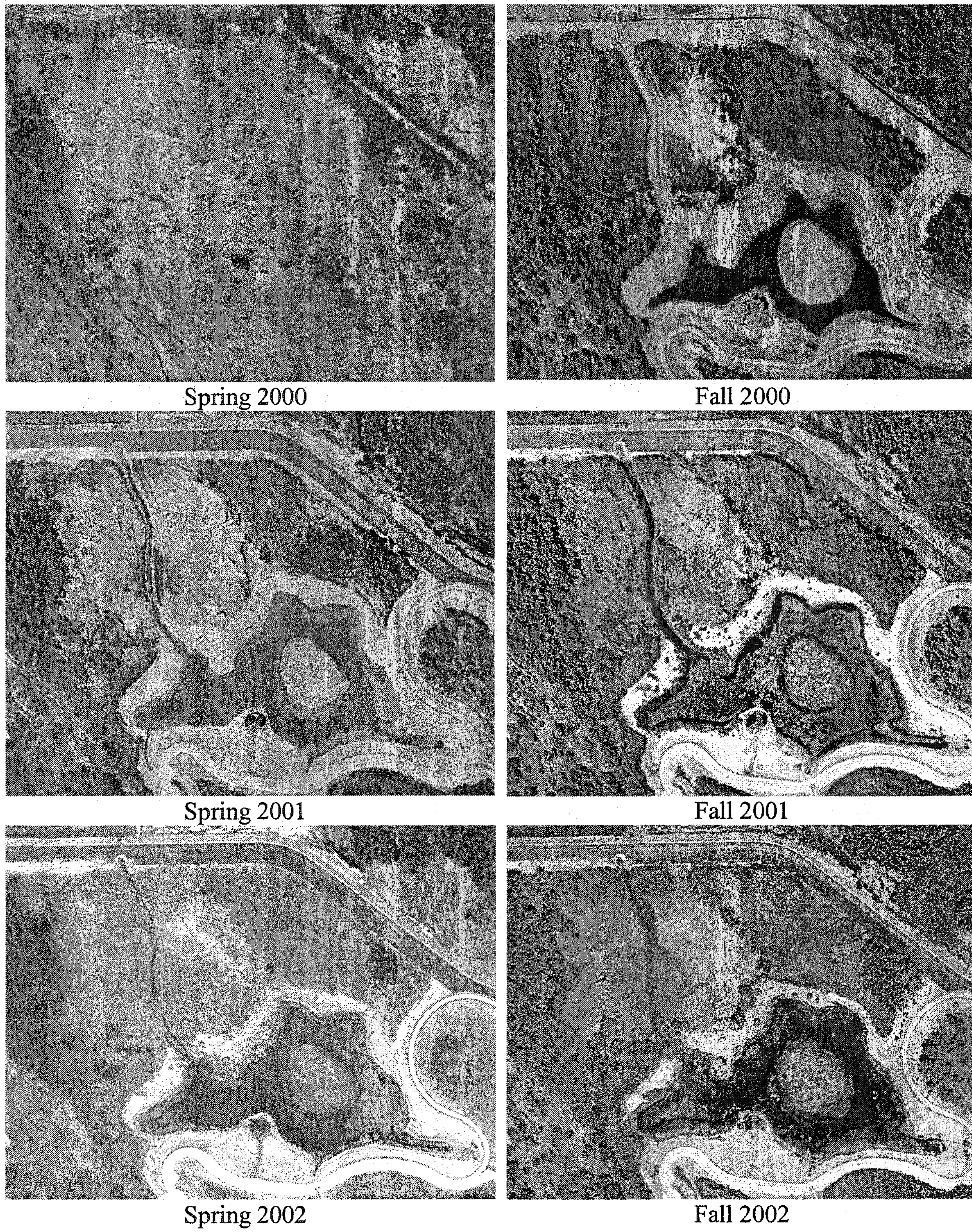


Figure 2.7 Clark County Wetlands Nature Preserve Aerial Photos

habitat, to improve the quality of urban runoff water that discharges into Lake Mead, while increasing environmental awareness for the Las Vegas community (BOR, 1999).

To accomplish these goals, the University of Nevada, Las Vegas (UNLV) Harry Reid Center (HRC) and the Environmental Studies Department (ESD) staff and students, started monitoring the WPNP environment. Between May and December of 2000, baseline data from pre-construction and during construction of the WPNP water, sediment and biota were collected and analyzed. The results of these analyses were presented in the Monitoring Plan (HRC-E-3-4-3) and in the Monitoring Report HRC-C-1-3-1 (Kinney et al, 2000; Pollard et al., 2002). From January 2001 through December 2002, a monthly environmental monitoring of the WPNP water samples from the Nature Preserve ponds was conducted.

2.4 Nature Preserve Water Sources

The primary source of water entering the WPNP is at the northern end of the site from the Monson Channel, which consists mainly of resurfacing water from streets runoff, surface flow, and resurfacing groundwater. Figure 2.8 shows the Monson drainage area that collects water for the WPNP inflow. This channel collects drainage from the urban Flamingo Wash watershed and from the watershed between Boulder Highway and Las Vegas Wash (BOR, 1999).

A study of the pre-construction in-stream water parameters for the Monson channel and Tropicana Road Channel was carried out in 2000 and these results were published in HRC reports (Kinney et al, 2002 and Pollard et al, 2002). Only midway through the 2001-2002 permit year, the Monson Channel at Stephanie Street (MC_1) was included, as a monitoring site, in the Clark County Regional Flood Control District wet weather program – CCRFCD/NPDES

(Montgomery Watson, 2002). The Las Vegas Wash Coordination Committee is currently measuring the flow rates in Monson Channel. Table 2.3 depicts flow rates measured in the Monson Channel at MC_1 site.

Table 2.3 Monson Channel Flow Rates

Tributary	Site ID	Date	Flow Rate (cfs)	Flow Rate (MGD)
Monson Channel	MC_1	4/25/01*	0.778	0.503
		5/25/01*	0.636	0.411
		6/27/01*	0.603	0.390
		7/30/01*	0.683	0.441
		8/24/01*	0.787	0.509
		9/21/01*	0.514	0.332
		11/30/01*	0.579	0.374
		1/23/02*	0.871	0.563
		2/25/02**	0.959	0.620
		3/25/02**	1.174	0.759
		5/22/02**	1.165	0.753
		6/24/02**	0.855	0.553
		7/24/02**	0.885	0.572
		8/27/02**	0.965	0.624
		11/18/02**	1.0959	0.384
		Mean	0.837	0.519

*Montgomery Watson Report, 2002.
**Personnal Communication with Xiaoping Zhou – LVWCC.

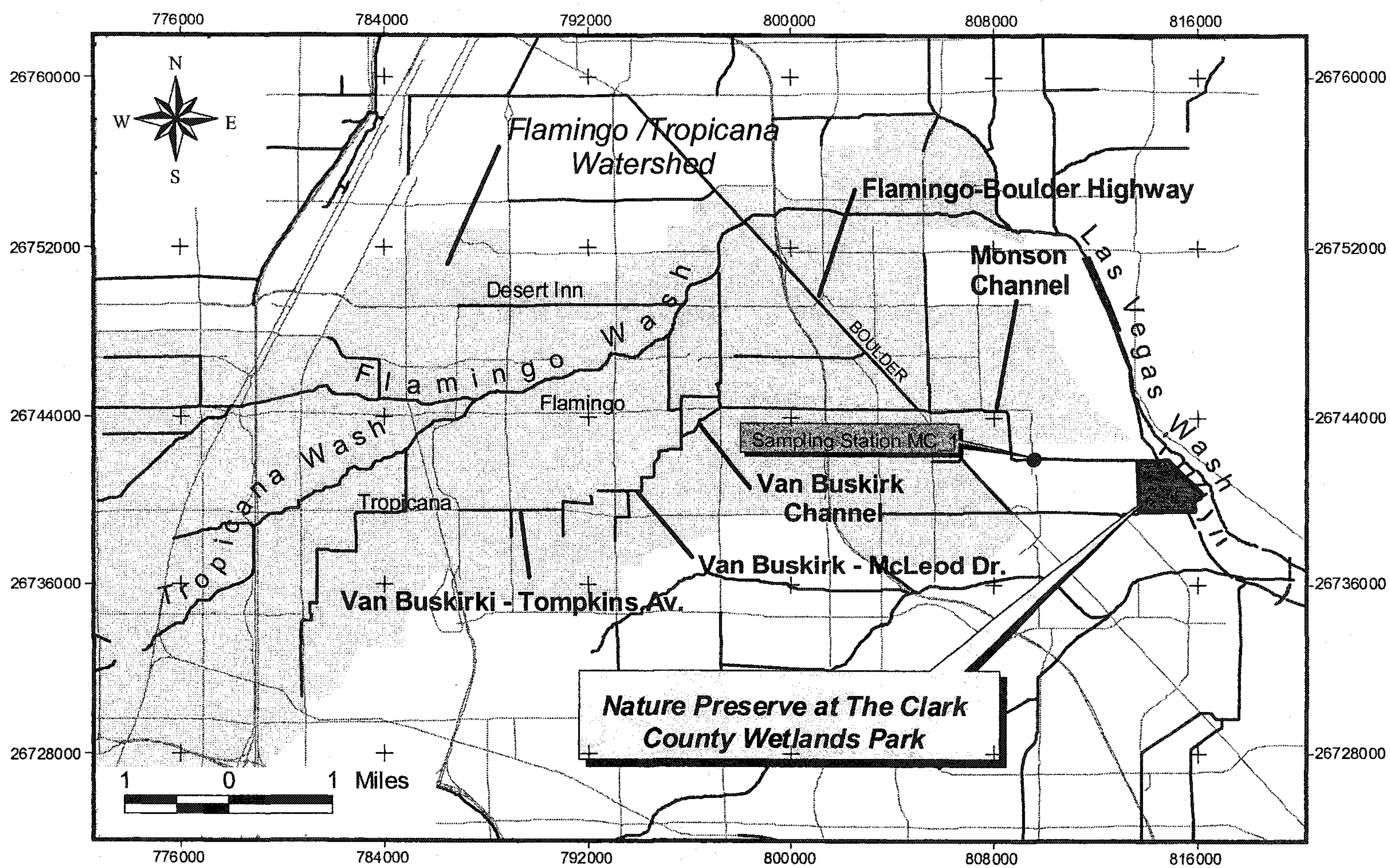


Figure 2.8 Water Sources for the Nature Preserve Wetlands

The secondary source of water for the Nature Preserve is the Tropicana Road Channel, from which water enters the southwest corner of the Nature Preserve and flows into the outflow pond (NP-8). The amount of water available from this source is small, but is it unquantified at present, because it is difficult to measure extremely low flows and also because the channel has been often dry. This source does not influence the present study site because it feeds only the lower pond, which is the outflow for the WPNP system.

Another potential source for the WPNP is the effluent from Clark County Sanitation District Treatment Plant, which is discharged into the WPNP in case of accidental spill or in case of the necessity during the dry season. A fourth potential source of water to the WPNP is the water from the LVW in case of storm overflow (the structure at the Monson channel was constructed to support a 10 years storm – Mr. Bruce Sillitoe, personal communication - CCP&R , January 12, 2003).

Two other water sources for the WPNP ponds are direct precipitation and the groundwater infiltration. Direct precipitation does not generally contribute much to the flow to the ponds because it only rains 4 inches per year, on average. It did not rain significantly during the study period (see rainfall precipitation Table 2.4). Groundwater infiltration is not easy to measure or estimate. The WPNP ponds are unlined (Personal communications Bruce Sillitoe – CCP&R; Dr. Stave – UNLV; and Jim Pollard – HRC), and groundwater could potentially infiltrate into the ponds because the groundwater table in this area is below the bottom of the pond.

2.5 Clark County Wetlands Nature Preserve Water Parameters

Wetzel (1999) noted that P availability in aquatic ecosystems depends largely on the amount contributed by the entry from the drainage basin. The amount of P in Upper Pond therefore, needs to be examined. Background information from this system is summarized herein.

Table 2.4 Average Rainfall at the Nature Preserve Vicinity*

	Official Rainfall (NWS) (inches)	
Gauge ID - Name*	Total Rainfall in 2001	Total Rainfall in 2002
4089 - LV Wash at Vegas Valley	3.32	0.63
4379 - VanBuskirk DB	3.83	0.71
4544 – LV Wash at Pabco Rd	2.68	0.51
4749 - Pittman Wash at Stephanie	3.75	0.63
Total Rainfall Average for the Area (inches)	3.40	0.62
Total Annual LV Valley Rainfall (NWS) (inches)	3.97	1.44

*Adapted from Clark Count Regional Flood Control District (htpp://www.ccrfcd.org/03-2001.htm)

2.5.1 Flow

From November of 2001 to April 2002, Dave Betley and I conducted a flow study for the WPNP ponds. The recorded data from this study was used by Betley to develop a

hydrologic model for the CCWN ponds (Betley, 2003). Table 2.5 shows the average flows rates for the WPNP sites during the flow study.

Table 2.5 Average Flow Rates from Nov 2001 to April 2002 at the WPNP

WPNP Site	Average Flow Rate (cfs)
NP-1	1.28
NP-2E	0.88
NP-3	0.83
NP-4	0.78
NP-5	0.72
NP-8	0.74

Source: (Bettley, 2003)

2.5.2 Water Chemistry Parameters in the WPNP First Two Years

Since the beginning of January 2001, the water chemistry has been monitored monthly in six sites of the WPNP (NP-1, NP-2, NP-4, NP-6, NP-8, and NP-11). During this period, field measurements were performed and water samples were collected for laboratory analyses (Table 2.6).

In this section the data collected from the inflow (NP-1) and the final outflow (NP-8) of the WPNP will be evaluated. The characteristics of these two sites are important in order to understand the behavior of the entire WPNP system in the first two years of activity. Tables 2.7 and 2.8 summarize the annual averages and the standard deviation numbers for all the chemical analysis for the NP-1 and NP-8 sites for 2001 and 2002, respectively.

Table 2.6 Water Quality Parameters at the WPNP

Laboratory Analyses	Field Parameters
Turbidity	pH
TDS and TSS	DO
E. Coli and Coliforms	Conductivity
Phosphate and Nitrate	Temperature
Hardness, Alkanility,	
Chlorides, Sulphates	
Selenium, Arsenic, Cadmium,	
Nickel, Zinc, and Manganese	

Appendix A contains the raw water quality data from the two major sites NP-1 (inflow of the WPNP), and NP-8 (outflow of the WPNP) both shown in Figure 2.4. These data were collected during the first two years of the system activities from Jan 2001 to Dec 2002. Appendix B contains the descriptive statistical analysis for these data. Temporal variation graphs for all the parameters analyzed in the NP-1 and NP-8 sites for both years are shown in the Appendix C.

2.5.2.1 Variation in NP-1 and NP-8 Water Quality

In order to understand the chemical characteristics of the WPNP wetlands system, an analysis of the first two years water quality data was performed. The data were compiled by site, and clustered columns graphs representing the two-years data averages for both sites were created for various parameters. Statistics tests were performed for significance (Confidence Level - 95%) and results are demonstrated in the Appendix D.

Table 2.7 WPNP 2001 Annual Averages and Standard Deviations for the Chemical Analysis Data

Parameter	Site	n	Annual Average	Min.	Max.	Std. Deviation
Dissolved Oxygen (mg/L)	NP-1	12	9.15	6.06	11.78	2.06
	NP-8	12	9.49	5.81	15.86	2.54
pH (SU)	NP-1	11	7.45	6.39	7.94	0.44
	NP-8	12	7.76	6.80	8.34	0.46
Temperature (°C)	NP-1	12	18.8	13.2	23.7	2.7
	NP-8	12	19.31	7.20	27.70	7.1
Spec.Conductance (μmhos/cm)	NP-1	12	5494	4800	5800	303
	NP-8	12	5434	3160	6160	777
Turbidity (FTU)	NP-1	11	14	8	18	3.41
	NP-8	11	19	11	40	9
TDS (mg/L)	NP-1	9	5293	4800	5520	232
	NP-8	7	5257	4450	5680	411
TSS (mg/L)	NP-1	5	13	4	12	8.89
	NP-8	6	9	4	23	7
Nitrate (mg/L)	NP-1	12	8.64	0.90	13.70	4.34
	NP-8	12	6.13	0.70	11.60	4.18
Phosphate (mg/L)	NP-1	12	0.10	0.03	0.31	0.08
	NP-8	12	0.09	0.01	0.18	0.05
Hardness (mg/L)	NP-1	12	2602	2200	2920	224
	NP-8	11	2413	1280	2760	404
Alkalinity (mg/L)	NP-1	12	241	200	268	21.22
	NP-8	12	192	124	240	37
Sulphate (mg/L)	NP-1	11	2318	1850	2850	347
	NP-8	11	2205	1100	2900	498
Chlorides (mg/L)	NP-1	12	740	560	960	98.72
	NP-8	12	765	480	920	117
Selenium (mg/L)	NP-1	10	0.021	0.013	0.041	0.008
	NP-8	10	0.023	0.011	0.077	0.02
Arsenic (mg/L)	NP-1	10	0.035	0.019	0.055	0.012
	NP-8	10	0.032	0.016	0.056	0.011
Cadmium (mg/L)	NP-1	7	0.002	0.000	0.008	0.003
	NP-8	8	0.002	0.000	0.008	0.002
Nickel (mg/L)	NP-1	10	0.004	0.002	0.009	0.002
	NP-8	10	0.005	0.002	0.007	0.001
Zinc (mg/L)	NP-1	09	0.022	0.001	0.139	0.044
	NP-8	10	0.025	0.004	0.155	0.045
Copper (mg/L)	NP-1	9	0.002	0.000	0.008	0.002
	NP-8	8	0.002	0.001	0.003	0.001
Manganese (mg/L)	NP-1	10	0.024	0.001	0.060	0.018
	NP-8	10	0.015	0.001	0.041	0.015
E. Coli (CFU/100mL)	NP-1	8	794	120	3000	1003
	NP-8	8	60	0	170	60
Coliforms (CFU/100mL)	NP-1	7	843	10	3050	1227
	NP-8	8	97	0	265	99

Table 2.8 WPNP 2002 Annual Averages and Standard Deviations for the Chemical Analysis Data

Parameter	Site	n	Annual Average	Min.	Max.	Std. Deviation
Dissolved Oxygen (mg/L)	NP-1	12	7.18	5.01	9.32	1.56
	NP-8	12	8.63	2.58	12.01	3.01
pH (SU)	NP-1	12	7.63	6.92	8	0.27
	NP-8	12	7.81	6.61	8.27	0.57
Temperature (°C)	NP-1	12	15.91	9.10	23.20	4.73
	NP-8	12	16.36	5.50	25.60	6.59
Spec.Conductance (μmhos/cm)	NP-1	12	5231	4870	5800	267
	NP-8	12	4897	2490	5670	1114
Turbidity (FTU)	NP-1	12	11	5	18.50	3.88
	NP-8	12	15	9	21	3
TDS (mg/L)	NP-1	12	5204	4670	5710	336
	NP-8	12	4863	1970	6230	1359
TSS (mg/L)	NP-1	12	7	3	15	3.62
	NP-8	11	10	1	36	10
Nitrate (mg/L)	NP-1	12	6.77	3.30	12	2.64
	NP-8	12	5.33	2.20	12.70	3.2
Phosphate (mg/L)	NP-1	12	0.59	0.01	2.79	0.85
	NP-8	12	0.23	0.01	0.88	0.29
Hardness (mg/L)	NP-1	12	2448	2120	2680	164
	NP-8	12	2240	880	2680	623.42
Alkalinity (mg/L)	NP-1	12	209	160	260	28.1
	NP-8	12	178	104	244	51.05
Sulphate (mg/L)	NP-1	12	2606	2250	3100	275
	NP-8	12	2367	550	3250	865
Chlorides (mg/L)	NP-1	12	637	560	760	55
	NP-8	12	630	400	800	107
Selenium (mg/L)	NP-1	12	0.019	0.009	0.026	0.005
	NP-8	12	0.016	0.005	0.025	0.006
Arsenic (mg/L)	NP-1	12	0.019	0.004	0.032	0.009
	NP-8	12	0.014	0.003	0.026	0.007
Cadmium (mg/L)	NP-1	10	0.002	0.000	0.004	0.002
	NP-8	11	0.001	0.000	0.004	0.002
Nickel (mg/L)	NP-1	12	0.003	0.001	0.005	0.001
	NP-8	12	0.004	0.000	0.007	0.002
Zinc (mg/L)	NP-1	10	0.007	0.001	0.030	0.009
	NP-8	10	0.023	0.006	0.046	0.015
Copper (mg/L)	NP-1	9	0.001	0.000	0.004	0.001
	NP-8	8	0.001	0.001	0.004	0.001
Manganese (mg/L)	NP-1	12	0.020	0.004	0.081	0.021
	NP-8	12	0.007	0.001	0.030	0.008
E. Coli (CFU/100mL)	NP-1	12	611.7	93	2930	871
	NP-8	12	259.5	1	1213	385
Coliforms (CFU/100mL)	NP-1	12	1347	113.3	6500	1870
	NP-8	12	350	1	1617	569

Figure 2.9 depicts the two-years data average values for dissolved oxygen (NP-1 = 8.17 mg/L; NP-8 = 9.06 mg/L), temperature (NP-1 = 17.35 °C; NP-8 = 17.83 °C), pH NP-1 = 7.54; NP-8 = 7.78), turbidity (NP-1 = 12 FTU; NP-8 = 17 FTU), and TSS (NP-1 = 9.05 mg/L; NP-8 = 9.83 mg/L) for both inflow and outflow of the WPNP system. Statistical significance evaluation using t-test demonstrated that there is no significant difference between the inflow and outflow average values for DO, temperature, pH, TSS. Significant difference was found for turbidity ($p = 0.006$), with higher average turbidity in the outflow water. It is thought that the increased turbidity is caused by the result of falling plant seeds and flowers more present in the outflow pond.

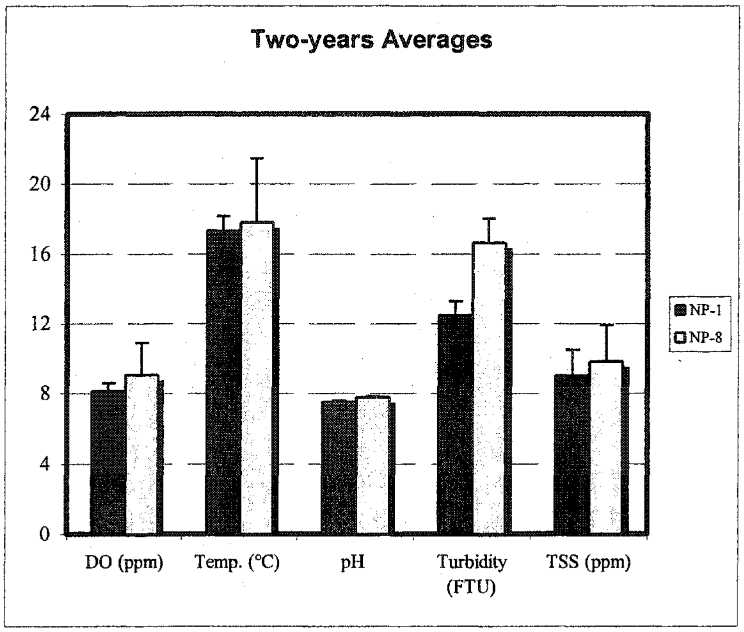


Figure 2.9 Two-years Data Averages of DO, Temperature, pH, Turbidity, and TSS

Figure 2.10 presents the two-years data average results for specific conductance (NP-1 = 5363 μmhos/cm; NP-8 = 5166 μmhos/cm), TDS (NP-1 = 5202 mg/L; NP-8 = 4954 mg/L), hardness (NP-1 = 2525 mg/L; NP-8 = 2323 mg/L), and alkalinity (NP-1 = 225 mg/L; NP-8 = 185 mg/L) for both inflow and outflow sites. T-test found no significant difference between the inflow and outflow average values for TDS, specific conductance, and hardness. Significant difference was found for alkalinity ($p = 0.001$), which is higher in the inflow water.

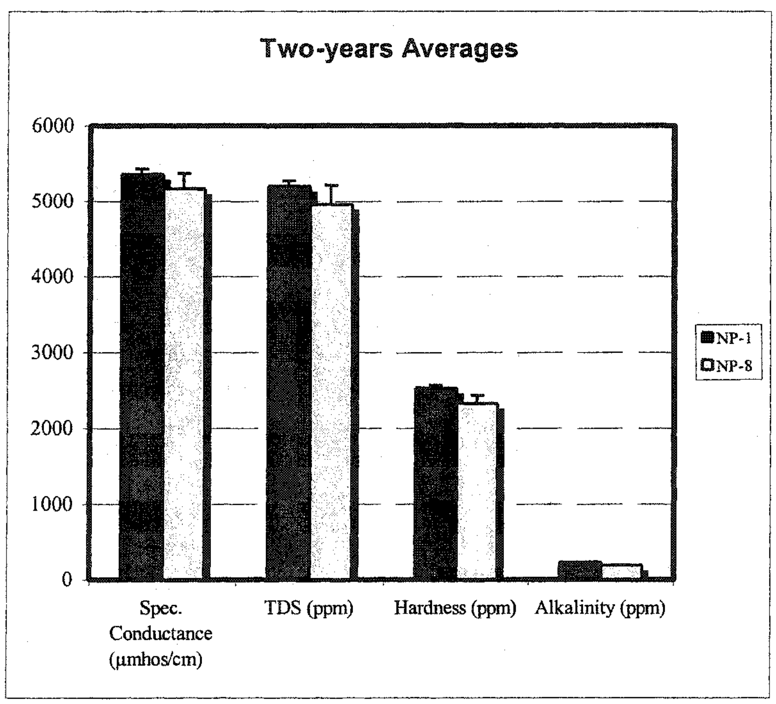


Figure 2.10 Two-years Data Averages of Specific Conductance, TDS, Hardness, and Alkalinity

In the inflow and outflow of the wetlands in 2001 conductivity remained practically stable. However, in the second year the outflow water presented much lower conductivity during the summer months (Appendix A). The lower conductivity values

found in September of 2002 are the result of addition of LVW water to the NP-8 pond during the dry season. Average TDS in the inflow water was slightly higher than the outflow. TDS average concentration was 5202 ppm for inflow and 4954 ppm for the outflow water. TDS trend in this system followed the same trend as the specific conductance (Figure 2.11). Pearson correlation test was performed and showed positive correlation between TDS and conductivity in inflow (r = 0.71) and in outflow (r = 0.96) (Appendix D).

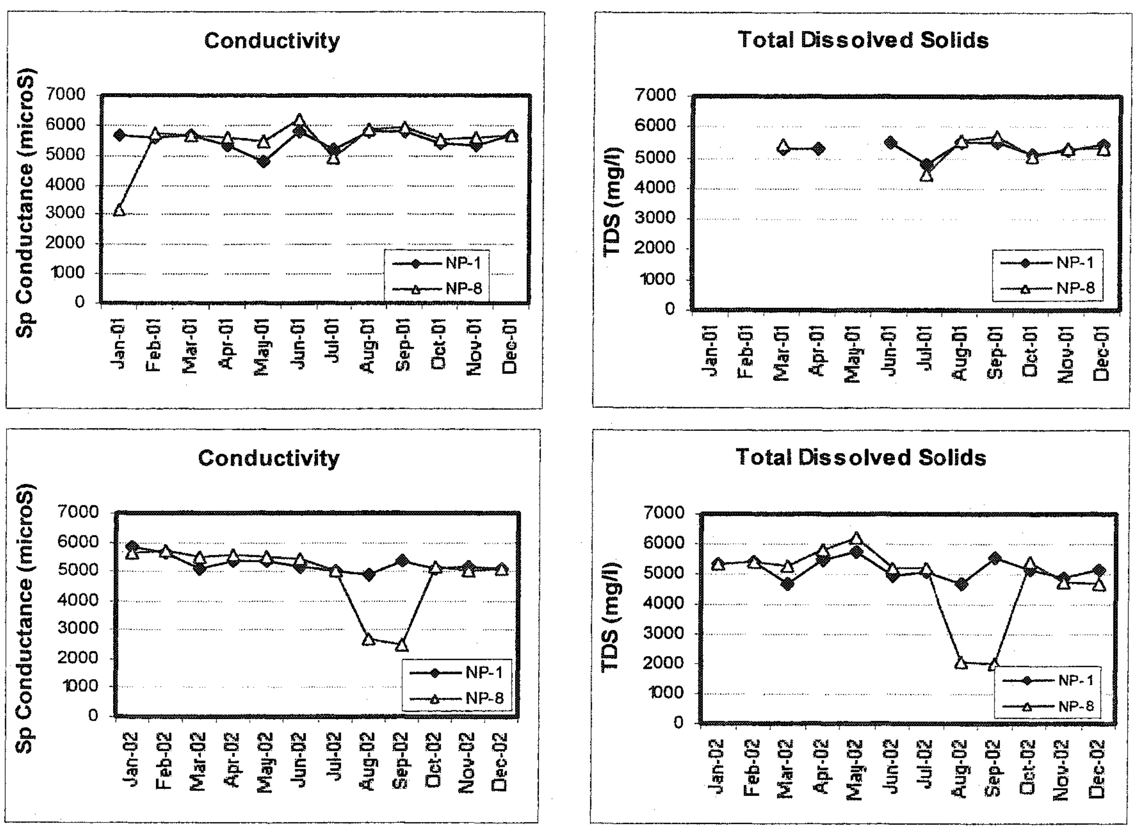


Figure 2.11 Temporal Variation for Specific Conductance and Total Dissolved Solids in 2001 and 2002

Figure 2.12 demonstrates the two-years data average results for sulphates (NP-1 = 2468 mg/L; NP-8 = 2289 mg/L) and chlorides (NP-1 = 688 mg/L; NP-8 = 698 mg/L) in

inflow and outflow water. T-tests showed no significant difference in sulphate or in chlorides concentration in neither sites.

Figures 2.13a and 2.13b depict the two-years data concentrations for the nutrients in the inflow and in the outflow of the WPNP. Phosphate concentration in the Inflow averaged 0.34 ppm and the outflow water was 0.16 ppm. Nitrate average in inflow water was 7.70 ppm and outflow average was 5.73 ppm. T-test demonstrated no significant difference between inflow and outflow for phosphate concentrations, but a significant difference between sites was noticed for nitrate (p = 1.679).

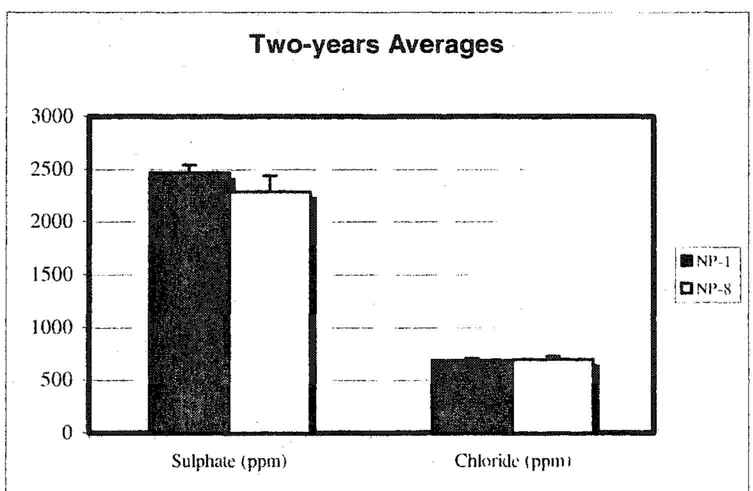


Figure 2.12 Two-years Data Averages of Sulphate and Chloride

The average concentration of phosphate in the inflow water in 2002 was higher compared to the 2001 (Tables 2.7, 2.8, and Figures 2.13a and 2.13b). However, flow rates were not measured at all times and the total loading for 2001 and 2002 cannot be evaluated. In contrast, the average nitrate concentration to the system was lower in 2002 (Table 2.7, 2.8, and Figures 2.13a and 2.13b). Analysis of temporal variation for the 2002

data showed better efficiency of the WPNP system in removing phosphate in the second year of activity (Figure 2.14). On the other hand, the system already showed efficiency in removing nitrate from the water during the first year, and this behavior continued in the second year.

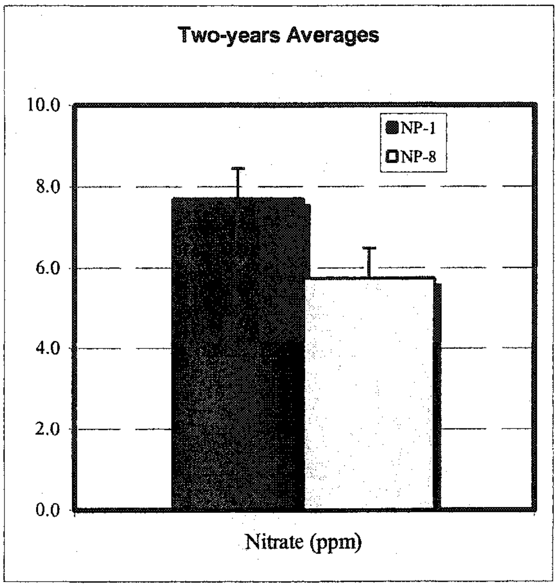


Figure 2.13a Two-years Data Averages of Nitrate

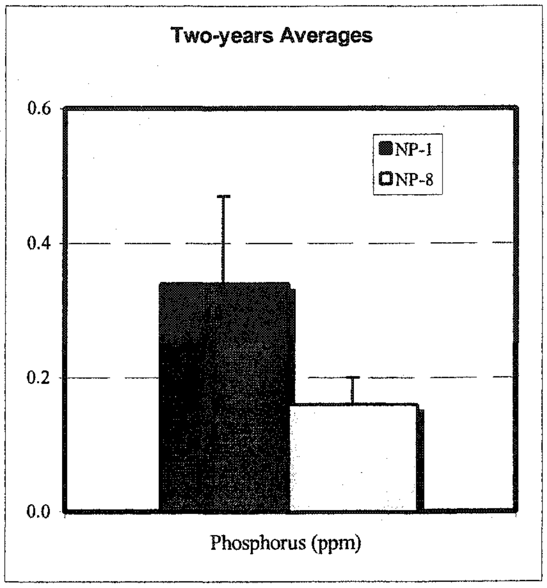


Figure 2.13b Two-years Data Averages of Phosphorus

The water from WPNP ponds was also analyzed for metals concentrations and the two-years data average results are illustrated in Figure 2.15. T-tests showed no significant differences between inflow and outflow metal concentrations, except for manganese ($p = 0.031$), which was higher at the inflow water (Appendix D).

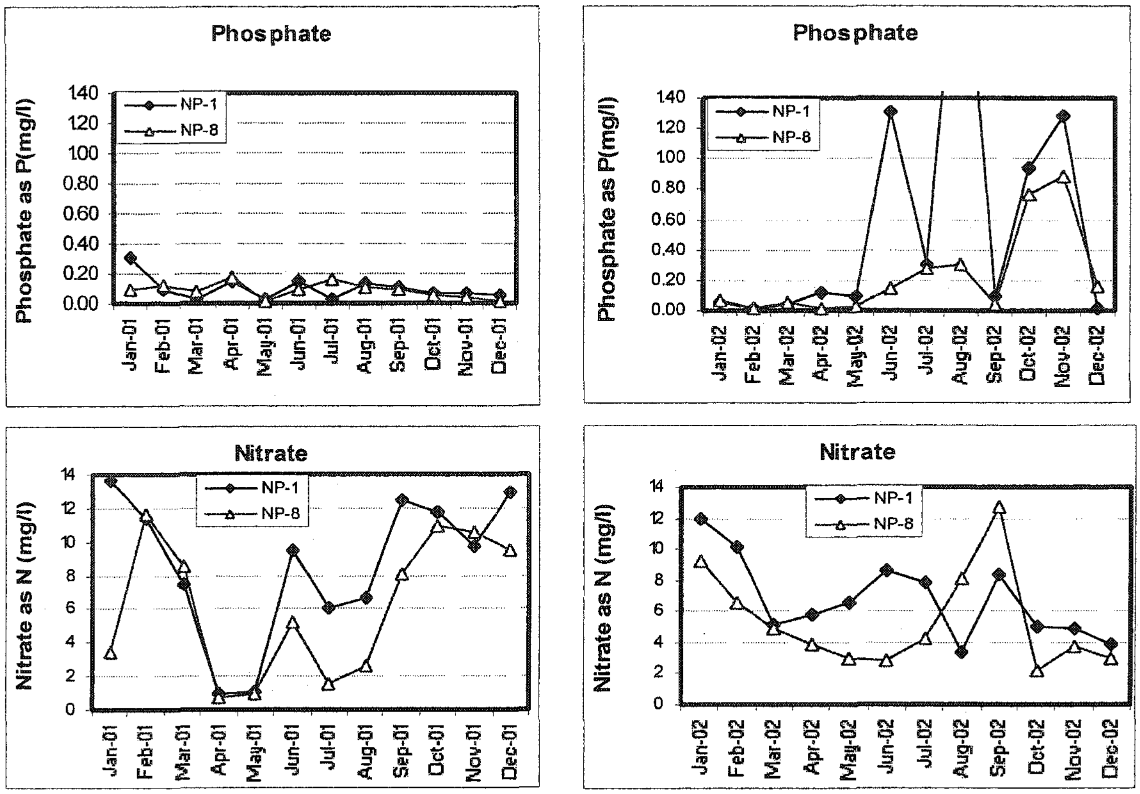


Figure 2.14 Temporal Variation for Phosphate and Nitrate Concentrations in 2001 and 2002

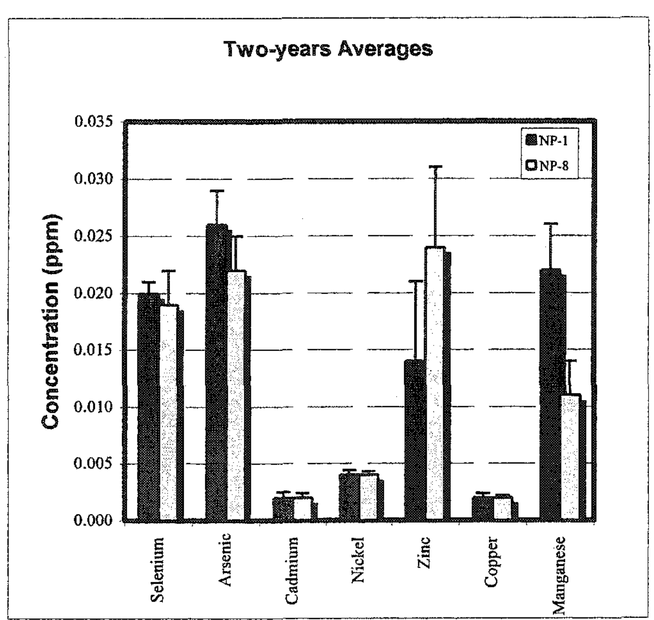


Figure 2.15 The two-years Data Averages of Metals Concentrations

The two-years data average values of E. Coli and coliforms in the inflow water were 685 (CFU/100 mL) and 1160 (CFU/100 mL), respectively (Figure 2.16). In the outflow the E. Coli and coliforms counts dropped considerably:180 (CFU/100 mL) for E. coli, and 257 (CFU/100 mL) for coliforms. T-tests demonstrated significant differences for both bacteria, with inflow content higher than outflow. This demonstrates that the system is able to remove significant amount of bacteria.

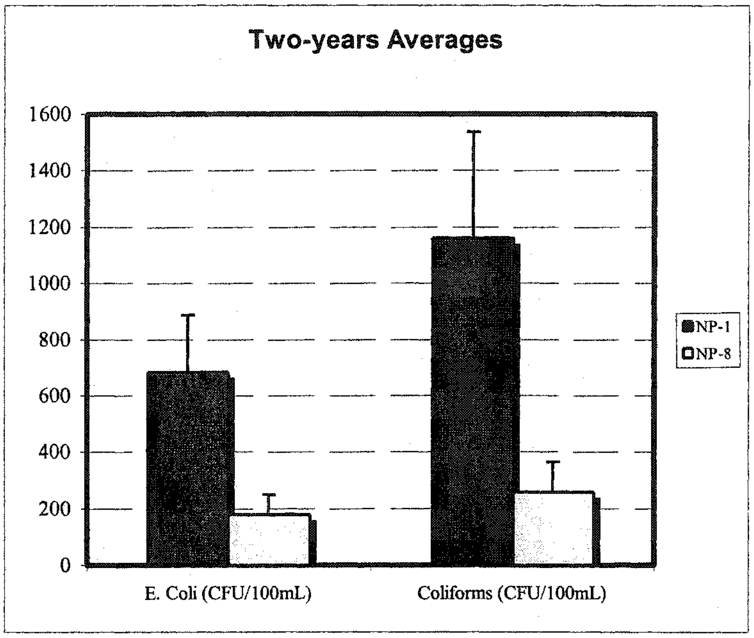


Figure 2.16 Bacteria Two-years Data Averages Concentrations

2.5.2.2 Seasonal Variation Analysis for the 2001 and 2002 Data

The characteristic climate of Nevada leads to extreme changes in temperature throughout the year; this fact can cause changes in the performance of the Wetlands. In addition, the difference in 2001 and 2002 precipitation in the Valley varied considerably (see Table 2.4). In order to verify if there were seasonal changes caused by climatical

variation, average summer (April-Sep; temperature higher than 19°C) and winter (Oct-March; temperature lower than 19°C) parameters were computed from the two-years data in each season and comparison of inflow and outflow concentrations were made (Table 2.9).

Table 2.9 Average Seasonal Water Quality Parameters for WPNP

Parameter	n	Site	Two-years Data Average	
			Summer	Winter
pH (SU)	11	NP-1	7.52 ± 0.38	7.57 ± 0.51
	11	NP-8	7.62 ± 0.56	7.93 ± 0.39
Dissolved Oxygen (mg/L)	12	NP-1	7.59 ± 2.12	11.49 ± 10.45
	12	NP-8	7.56 ± 2.69	10.44 ± 1.98
Temperature (°C)	12	NP-1	20.33 ± 1.98	14.38 ± 3.33
	12	NP-8	23.42 ± 3.06	12.25 ± 4.61
Phosphate (ppm)	12	NP-1	0.44 ± 0.82	0.25 ± 0.42
	12	NP-8	0.12 ± 0.10	0.19 ± 0.30
Nitrate(ppm)	12	NP-1	6.42 ± 3.38	8.99 ± 3.55
	12	NP-8	4.46 ± 3.56	7.00 ± 3.44

Summer (April-Sep) and winter (Oct-March).

Statistical significance tests for seasonal variation for DO, pH, temperature, phosphate and nitrate were performed. The first test analyzed if there was a significant difference between sites. T-test demonstrated that there is no significant difference between the inflow and outflow average values, except for temperature ($p = 0.008$), which was higher in the outflow water. The second test performed was to check the behavior of each site during different seasons. T-test showed no significant difference for

pH, phosphate, and nitrate in either sites. However significant differences were found for temperature ($p < 0.0001$) and DO ($p = 0.218$). Temperature was higher in the inflow and outflow water during the summer. DO had significant difference only in the outflow water, which was higher in the winter.

CHAPTER 3

PROCEDURES

In this study, the phosphorus content of water, sediment, and aquatic vegetation in the Upper Pond of the WPNP was evaluated weekly from mid-September 2002 to mid-January 2003. Water samples were analyzed for total phosphorus (TP), soluble reactive phosphorus (SRP), total solids (TS), total suspended solids (TSS), and total dissolved solids (TDS). Plant and sediments samples were analyzed for TP content. This chapter describes the experimental methods used in this research. It includes procedures for sample collection, preservation, and analyses.

3.1 Phosphorus in Water

3.1.1 Water Sample Collection, Preservation, and Composite

Water samples were collected from the inflow (NP-1) and the two outflows of the Upper Pond (East Outflow - NP-2E and West Outflow - NP-2W). Figure 3.1 depicts the sites of collection in the three different points. A Global Positioning System (GPS), Magellan™, Model Map, 330 was used to identify the exact location of the sampling points (Table 3.1).

Two automated samplers (ISCO™ 3700) with 24 X 500 mL polyethylene containers were used to collect the sample and were installed, at the inflow (Figure 3.2)

and at the East Outflow (Figure 3.3). Grab samples were collected from the West Outflow.

Table 3.1 GPS Location for Water Sampling

Sampling Site	GPS Position	Location Description
NP-1	36° 06' 464 N 115° 01' 481 W	Inflow to NP-2
NP-2E	36° 06' 376 N 115° 01' 362 W	East Outflow (feeds the lower ponds)
NP-2W	36° 06' 372 N 115° 01' 411 W	West Outflow

All the sample bottles and glassware used in this analysis were pre-washed by soaking in Micro-90™ solution for at least 24 hours, and rinsing thoroughly with DI water.

The two automated samplers were programmed to collect individual 400-mL water samples, in individually pre-labeled polyethylene bottles, with 3-h intervals between samples, for a period of eighteen hours. A total of 7 samples were collected in the 18 hours period. Sampling in the ISCO™ samplers started at 3 p.m. on Tuesdays and ended at 9 a.m. on Wednesdays. The grab sample from NP-2W was collected at 9 a.m. on Wednesdays; at the same time and day of the automated sampler's last collection. All samples were preserved on ice for transport to the laboratory.

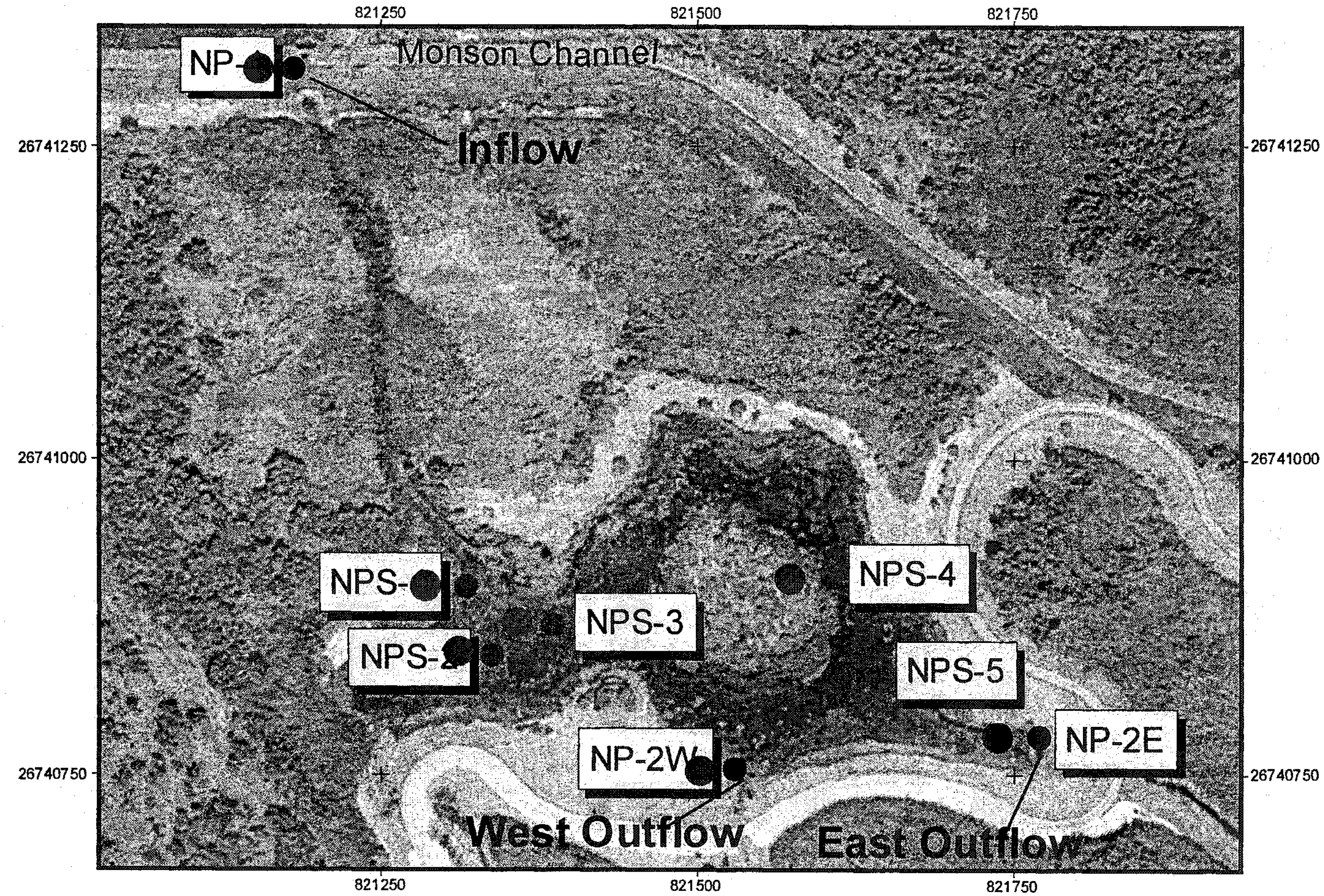


Figure 3.1 Upper Pond - Illustration of the Sampling Points

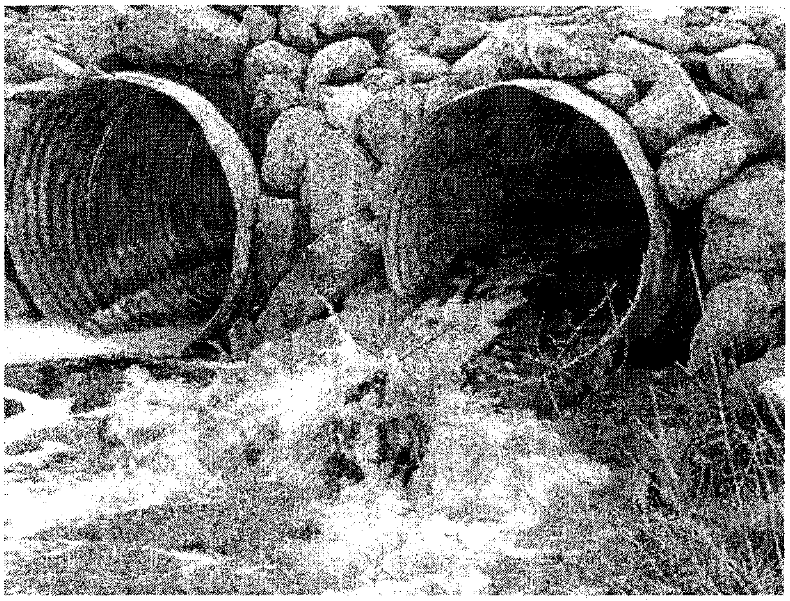


Figure 3.2 View of the Inflow to the Upper Pond on a Storm Day

Figure 3.3 Weir Structure at the East Outflow and Automated Sampler Installation

3.1.2 Field Parameters and Flow Measurements

3.1.2.1 Field Parameters

Field measurements of pH, dissolved oxygen (DO), conductivity and temperature of each site were taken on Wednesdays before the last automated sample was collected. To measure conductivity and temperature a Cole Parmer® 410 portable meter was used. An OAKTON® 310 portable meter was used to measure DO and a Cole Parmer® 310 portable meter was used for pH measurements. Instruments used in field measurements were calibrated every day before measurements and QCCS were done after last site was checked.

3.1.2.2 Flow Measurements

The flow rate at the inflow, and each of the outflows of the study site were measured each time the field measurements were made. The flow structure installed at the Inflow site is a circular corrugated steel culvert, with 2.42 ft diameter (D) (Figure 3.2). To calculate the flow at this site, the water height and the water velocity were measured. A Swoffer™ 3000 flow meter was used to measure water velocity and the water height was measured by using a steel MAYES™ yardstick with 1/8" inch marks (Figure 3.4a). To calculate the flow rates, the recorded numbers were applied to the equation (Brater & King, 1976):

$$\mathbf{Q = V*A}, \text{ where}$$

Q is the flow rate (cfs), **V** is velocity (ft/s), and **A** is cross sectional area (ft^2) (Figure 3.4b). **A** was calculated based on water depth and diameter of the culvert using the following equation:

$$A = (D^2/4) * [\theta - (\sin (2* \theta)/2)], \text{ where}$$

θ is equal to $\cos^{-1}(2z/D)$, **D** = diameter of the tub; **Z** is equal to $(r - y)$; **r** is equal to D/2.

Figure 3.4a Measuring Water Velocity at the Inflow

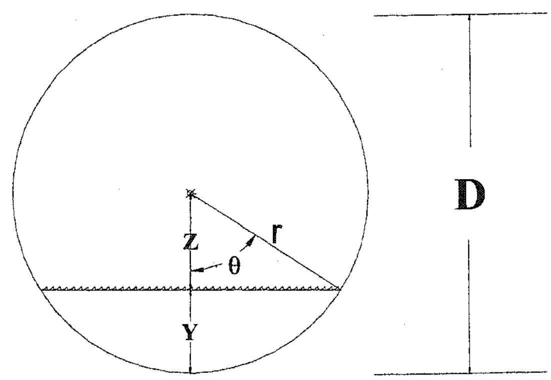


Figure 3.4b Cross Sectional Area

Flow measurements at this site were initially taken by measuring the average water velocity and water height at the middle point of the flow section. After discussing my methodology with one of my committee members, Dr. David James, he suggested that I make additional flow measurements, using the averaged flow measurements of the whole section, instead of a point measurement. We decided to perform an uncertainty

study on the field flow measurements. I have collected some more flow velocity and water height data, at three different points in the cross section: at the left, center and right positions (Figure 3.5). The data obtained was used to calculate the volumetric flows rates in the three sections. Next, I used this information to calculate the total flow rate in the entire cross section using the product of the flow rate in each subsection and the cross sectional area of each subsection. The calculations for the flows for both collection periods are presented in Appendix E. The slope of Figure 3.6 shows corrected results using weighted average flows, with depth measured at the propeller location are about 33% higher than flows calculated using a center point flow rate and depth measurement at the front of the culvert.

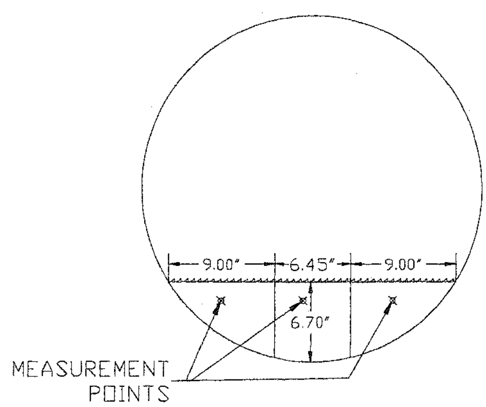


Figure 3.5 Points of Flow Measurements at the Inflow Structure

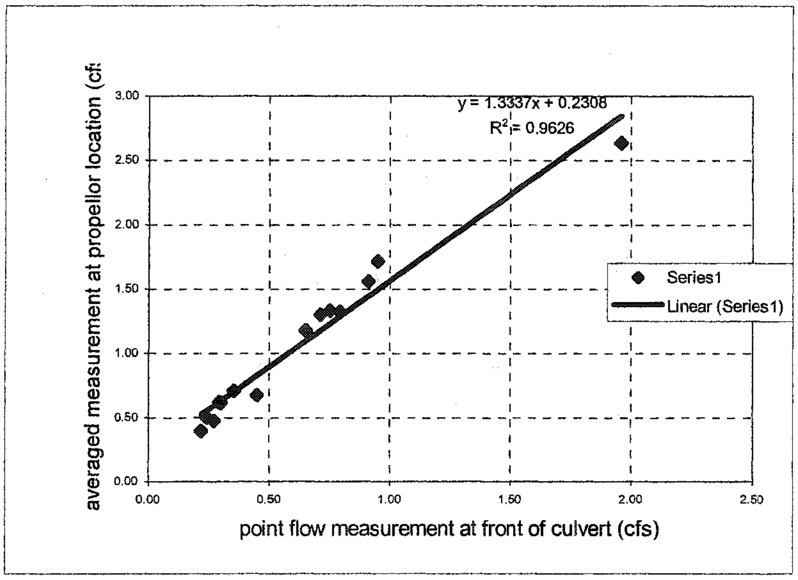


Figure 3.6 Correlation Averaged Flows to Point Flow

Figure 3.7 shows the horizontal crested weirs that control the two outflows from the Upper Pond. Flow measurements at both outflows sites were taken by measuring the water height passing through the weirs (Figure 3.8). To calculate the flow rates at these sites the following equation was used (Brater & King, 1976 and U.S.D.I. – BOR, 1997):

$$\mathbf{Q = C_w * L * h^{3/2}}, \text{ where}$$

$\mathbf{C_w}$ is the width of the weir, **L** is the length of the weir, and **h** is height of the water above the crest of weir. Calculations of the flows for both outflows are presented in Appendix E.

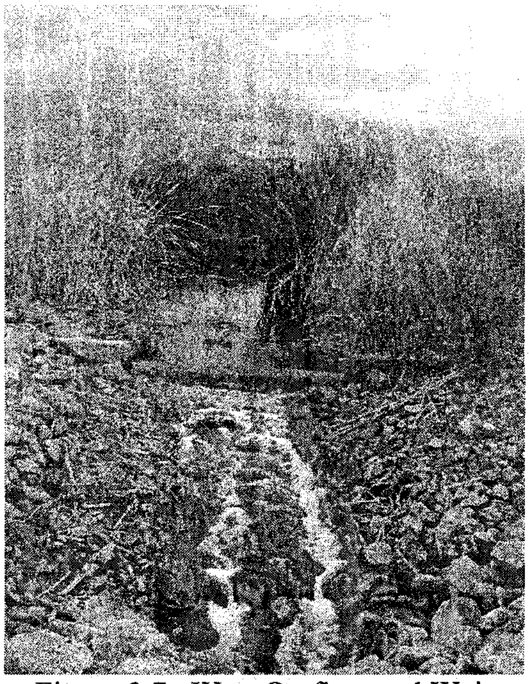


Figure 3.7 West Outflow and Weir Structure View on a Storm Day

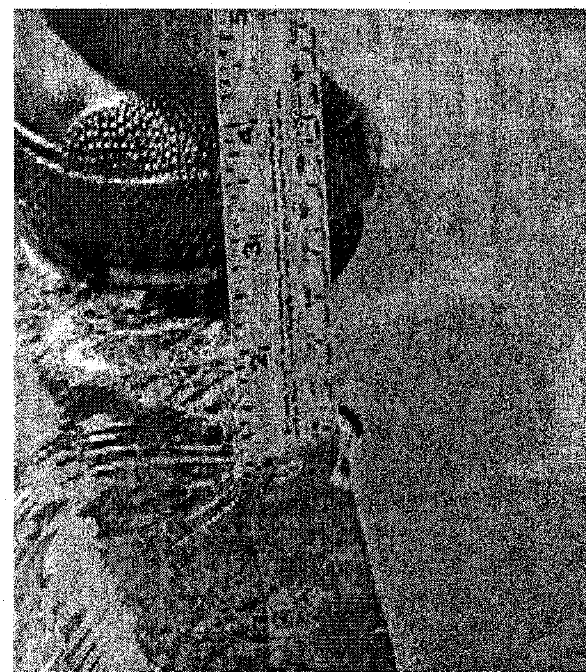


Figure 3.8 Measuring Water Height at Outflow

3.1.3 Phosphorus Analysis in Water

In the laboratory, 300-mL of each of the 7 samples collected at each site by the auto samplers were mixed in order to obtain a total composite sample of 2,100 mL for each site. The composite sample and the grab sample were then analyzed for phosphorus using the methods indicated in Table 3.2.

Table 3.2 Methods for Phosphorus Species Analysis in Water Samples

Volume of Sample (mL)	Filtration	Phosphorus Species*	Standard Method APHA, 1998	Method Number APHA, 1998
200	Yes	SRP	Colorimetric - Ascorbic Acid	4500-P E
200	No	TP	Digestion - Persulphate & Colorimetric – Ascorbic Acid	4500-P B5 & 4500-P E

*APHA, 1998

All phosphorus analyses were performed within 6 hours after collection. A Spectrophotometer, Spectronic® model 20D, equipped with an infrared phototube for use at 880 nm with a light path of 2.5 cm, was used to detect the phosphorus content in water samples. For the SRP analysis, the composite sample was immediately filtered through a 0.45-μm membrane. Twenty-five milliliters of the sample were placed in a one-inch test tube and analyzed for phosphorus, using the ascorbic acid method (APHA, 1998). For total phosphorus analysis, fifty milliliters of the composite sample was digested by the persulphate method (APHA, 1998). Two hundred-mL Pyrex® Erlenmeyer flasks were used as digestion flasks. An autoclave was used, instead of a heating plate, for better digestion. Digestion was performed on a Market Forge STERILMATIC™ autoclave at 121°C for 30 minutes. After the digestion, samples were analyzed for total phosphorus by the ascorbic acid method (APHA, 1998). Analytical procedures for phosphorus analysis are described in Appendix F.

For each batch of samples analyzed, a series of five standards, within the phosphate concentration range of 2.5 – 100 ppb for SRP and 10 – 100 ppb for TP were run. DI water was used as a blank, and duplicates were performed for all samples. Calibration curves were built for each batch of sample by plotting absorbance versus standard phosphate concentration, to give a straight line passing through the origin. An example of calibration curve is shown in Figure 3.9. An R^2 of 0.997 or better was considered satisfactory.

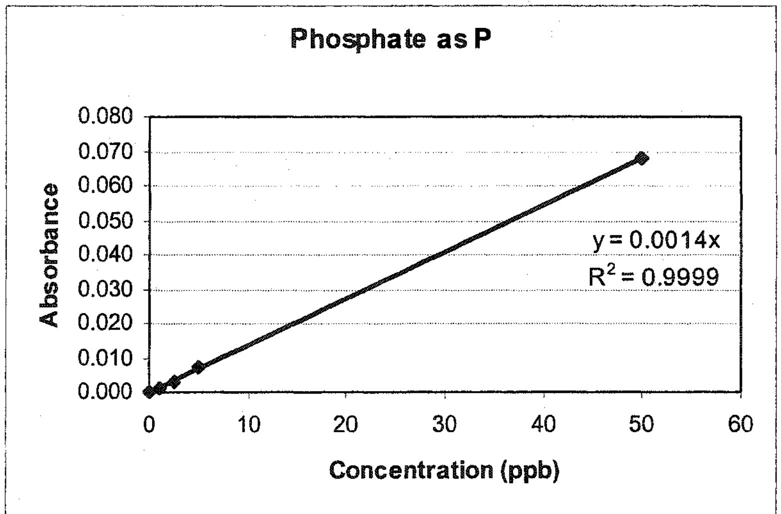


Figure 3.9 Example of calibration curve obtained in the SRP analysis

3.1.4 Solids Analysis

Sub-samples from collected water were analyzed for Total Solids (TS), Total Dissolved Solids (TDS), and Total Suspended Solids (TSS). Total suspended solids and total dissolved solids were determined gravimetrically after filtration and drying to a constant weight at 103-105 °C, according to Standard Methods 2540 (APHA, 1998). Total Solids were determined without filtration, using the same method. Duplicate runs were performed for all samples.

3.2 Phosphorus in Sediment

3.2.1 Sediment Sample Collection and Preservation

Sediment samples from the Upper Pond were collected in five different points: Inflow (NPS-1), Edge West (NPS-2), Middle Pond (NPS-3), East Edge of the Island (NPS-4), and East Outflow (NPS-5). Figure 3.1 shows the exact locations of the sites where the sediment cores were collected. A Global Position System (GPS), Magellan™

Model Map 330 was used to identify the exact location of the sediment sampling sites (Table 3.3).

All the sample bottles and glassware used in this analysis were pre-washed by soaking in Micro-90™ solution for at least 24 hours, and rinsing thoroughly with DI water.

Table 3.3 GPS Location for Sediment Sampling

Sampling Site	GPS Position	Location Description
Inflow (NPS-1)	36° 06' 396 N 115° 01' 454 W	Close to Pond Inflow
Edge West (NPS-2)	36° 06' 387 N 115° 01' 450 W	Left West Side, Close to the Edge of the Pond
Middle Pond (NPS-3)	36° 06' 391 N 115° 01' 440 W	West Middle of the Pond
East Edge of the Island (NPS-4)	36° 06' 397 N 115° 01' 395 W	East Edge of the Island
East Outflow (NPS-5)	36° 06' 384 N 115° 01' 388 W	Close to East Outflow

Sediment cores were collected once per week. Sampling was done by leaning over the side of a boat, using a stainless soil corer. The end of the metal corer was fitted with a plastic liner, ¾ X 12 inches, to avoid cross-contamination of the soil cores. Figure 3.10 shows a sample being collected using the soil corer. After collection, the plastic liner with the soil core was removed from the corer and labeled with site name, date, and

collection time (Figure 3.11). Immediately after collection, the plastic liners containing the cores were preserved on ice for transport to the laboratory.

Figure 3.10 Collecting Sediment Sample

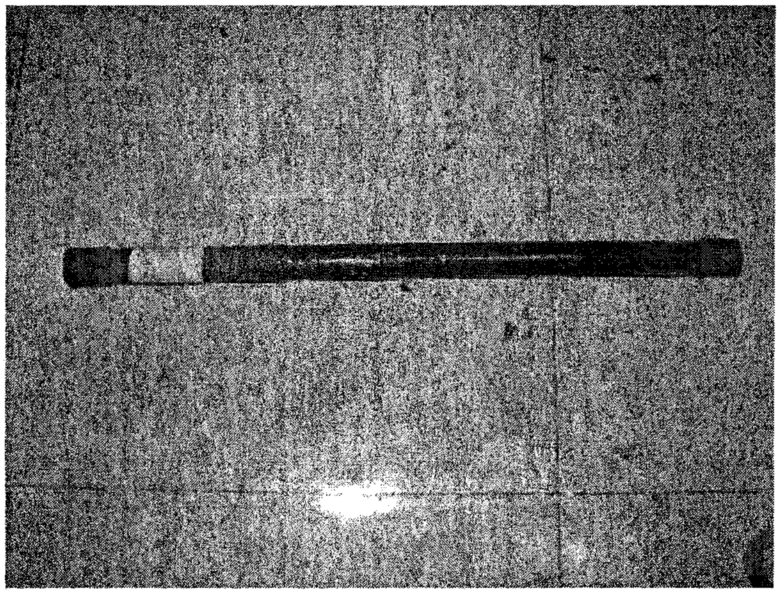


Figure 3.11 Plastic Liner with Sediment Sample

3.2.2 pH and Phosphorus Analysis in Sediment

Sediment samples were analyzed for pH and phosphorus content. pH analyses were performed on fresh sub-samples, immediately after collection by the EPA 9045 Method (USEPA, 1986). The persulphate digestion method was used to extract TP from sediment sample (APHA, 1998). After digestion, total phosphorus concentration was analyzed by the ascorbic acid method (APHA, 1998).

In general, each collected soil core was divided into two parts, based on observed color differences. When color differences were not present, cores were divided into upper and lower portions; the upper portion was considered the first 6 centimeters. Sub-samples of each portion were mixed into 50 mL of DI water (1:10, weight:volume), and the pH was measured using the EPA Method and a calibrated ACCUMET® AR pH meter (USEPA, 1986).

Each sediment layer was well mixed and weighed, using a calibrated Sargent Welch® model TLA 100 scale. Weight was recorded to determine bulk density. Samples were placed in a dehydrator at 40°C until constant weight was reached. After 48 hours, each sample was weighed and the weight was checked every 48 hours, until constant weight was obtained. Dried samples were pulverized (Figure 3.12), placed in tightly pre-cleaned glass vials, and stored for later analysis.

A sub-sample of 0.5 g dried sediment was accurately weighted, using a calibrated Sargent Welch® model TLA 100 scale. Then, samples were well mixed in 50 mL of DI water inside two hundred-mL Pyrex® Erlenmeyer flasks, which were used as digestion flasks. An autoclave was used, instead of a heating plate, for better digestion. Digestion was performed on a Market Forge STERILMATIC™ autoclave at 121°C for 30 minutes.

Later on, 25-mL of the digested samples were placed in one-inch test tubes and analyzed for total phosphorus. Analytical procedures for phosphorus analysis are described in Appendix F.

For each batch of soil samples analyzed, a series of five standards, within the phosphate concentration range of 10 – 250 ppb were run. DI water was used as a blank, and duplicates were performed for all samples. Calibration curves were built for each batch of sample by plotting absorbance versus standard phosphate concentration, to give a straight line passing through the origin. An R^2 of 0.997 or better was considered satisfactory.

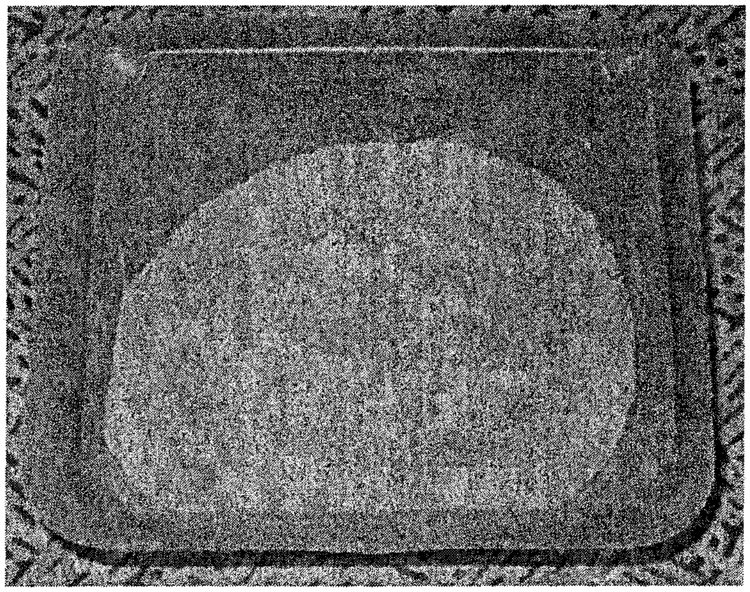


Figure 3.12 Ground Soil Sample

3.3 Phosphorus in Plant

3.3.1 Plant Sample Identification, Collection, and Preservation

Consultation with Dr. Wesley Niles (UNLV, associate professor) on a field trip to the Nature Preserve in May of 2002 (Figure 3.13) showed that the Upper Pond is

dominated by emergent vegetation, such as *Typha Species (Dominguensis and Angustifolia)* and *Scirpus Species (Acutus and Maritimus)*. Some other common species were found, but in smaller quantities, such as *Eleocharis* and *Phragmmites Australis* (Dr.W. Niles, personal communication, May 22, 2002).

All the sample bottles and glassware used in this analysis were pre-washed by soaking in Micro-90™ solution for at least 24 hours, and rinsing thoroughly with DI water.

Figure 3.13 Dr. Wesley Niles Identifying the Vegetation Species at the Upper Pond

Samples from two plant species (*Typha* and *Scirpus*) were collected weekly at two random locations along the Upper Pond's edges (Figure 3.14). Samples were collected randomly depending on the availability of the species. *Typha* and *Scirpus* species were chosen for this research because they were the predominant species on that pond. Plant samples were carefully dug out from the soil, with the roots, using a shovel. The roots

were then rinsed with pond water to remove mud and all foreign materials. To prevent leaching, excessive washing was avoided. Plants were placed in plastic bags, which were labeled with plant species' name and date of collection. Then, the plastic bags were placed into a cooler with ice and transported to the laboratory.

Figure 3.14 Plant Samples Being Collected in October, 2002

3.3.2 Phosphorus Analysis in Plants

The Gravimetric Quinolinium Molybdophosphate Method was used to extract total phosphorus (TP) from plant samples (AOAC, 1990). This method was chosen because it uses a saturated solution of magnesium nitrate, which prevents phosphorus volatilization from sample plants (Shardendu, 1991). A hot plate was used instead of a Fisher burner to ignite the plant samples. After TP extraction, plant samples were

analyzed for total phosphorus by the colorimetric ascorbic acid Standard Method 4500-P E (APHA, 1998).

In the laboratory, fresh plants were separated in above and belowground portions. Each portion was cut into small pieces. This procedure was performed as rapidly as possible to avoid decomposition or weight loss by respiration. The plant samples were then frozen using liquid nitrogen to facilitate grinding. Frozen samples were ground using a WARING COMMERCIAL® laboratory blender model 31BL40. Ground sub-samples were well mixed and weighed, using a calibrated Sargent Welch® model TLA 100 scale. The wet weight was recorded for use in dry weight and biomass calculation. Samples were placed in a dehydrator and dried at 40°C (Figure 3.15). Weight of the samples was checked after the first 48 hours and re-weighted every day until constant weight.

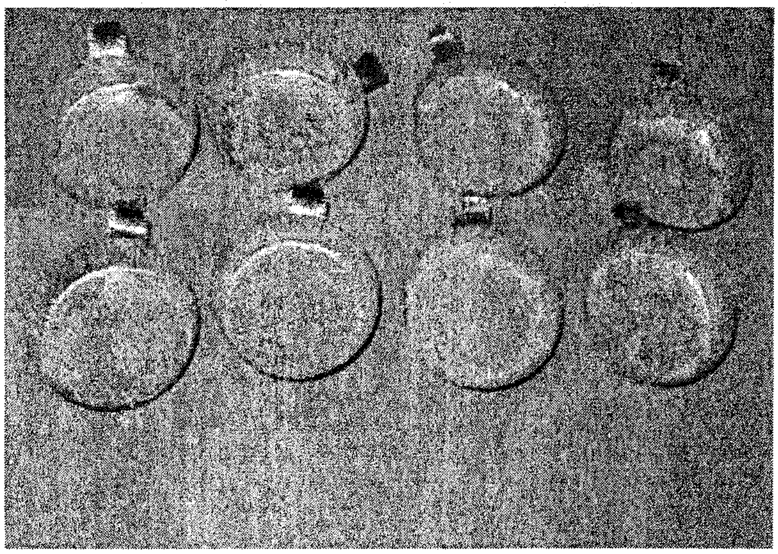


Figure 3.15. Ground Plant Tissue

Total phosphorus extractions were performed on 0.5 g dried plant sample. Samples were weighed, using a calibrated Sargent Welch® model TLA 100 scale. After

extraction, 25-mL of the sample were placed in one-inch test tube and analyzed for total phosphorus content (Figure 3.16). Analytical procedures for phosphorus analysis are described in Appendix F.

For each batch of samples analyzed, a series of five standards, within the phosphate concentration range of 10 – 250 ppb were run. DI was used for blank, and duplicates were performed for all samples. Calibration curves were built for each batch of sample by plotting absorbance versus standard phosphate concentration, to give a straight line passing through the origin. An R^2 of 0.997 or better was considered satisfactory.

To validate my method two runs of a NIST Standard of tomato leaves with known % P (0.20-0.22%P) was performed during this study.

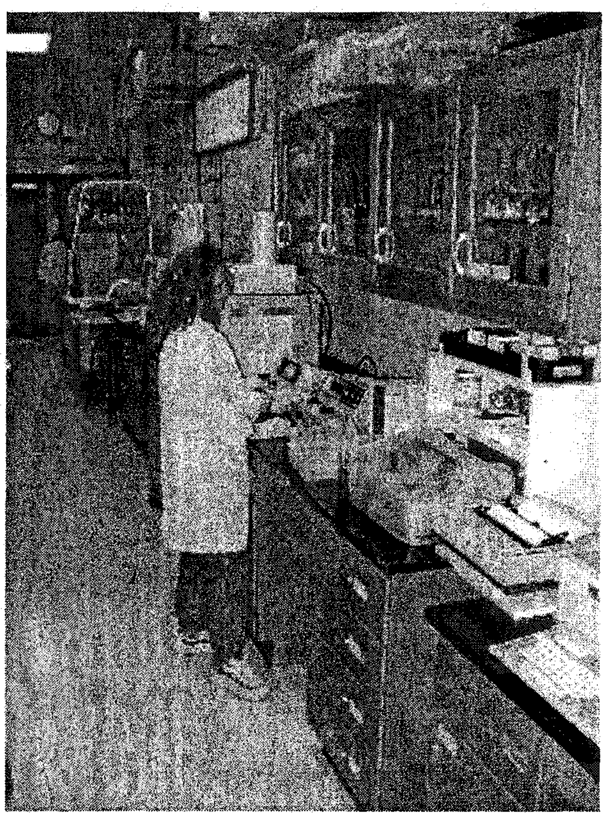


Figure 3.16 Reading Samples Using the Spectronic 20D

CHAPTER 4

RESULTS

This chapter presents results for flow measurements, TP and OP concentrations and loadings, solids concentrations, and field parameters for the WPNP during the study period. It also shows results for the phosphorus distribution in sediment and plant compartments.

4.1 Water Compartment

4.1.1 Flow Measurements

The raw flow rates data for both inflows and outflows, collected during the study period, are presented in Appendix E. The flow rates in cubic feet per second (cfs) are summarized in Table 4.1. On average, the total inflow to the Upper Pond during this study was 1.34 cfs and the total outflow was 1.01 cfs. This difference can likely be attributed to evapotranspiration and infiltration. The flowrate at the East Outflow (0.66 cfs) is almost twice that of the West Outflow (0.35 cfs). The West inflow structure was open only from 9/18/02 to 10/09/02. Most of the time, the inflow rates were higher than the outflow rates except in 10/30/02, 11/06/02, and 11/13/02 when the inflow was, on average, 55% lower than the total outflow. During the week of 10/30/02 the CCP&R staff harvested the vegetation around the West Outflow and at the East Outflow some of the vegetation was dormant. This explains the increase in the flow rate of the outflows on

these dates because the plants increased the hydraulic profile of the pond, resulting in larger flow.

Table 4.1 Flow Rates Measurements for the Upper Pond of the WPNP

Date	Flow at the East Inflow Culvert (cfs)	Flow at the West Inflow Culvert (cfs)	Total Inflow (cfs)	Flow at East Outflow (cfs)	Flow at West Outflow (cfs)	Total Outflow (cfs)
9/18/02	0.50	1.04	1.54	0.19	0.27	0.46
9/25/02	0.61	1.06	1.67	0.64	0.02	0.66
10/02/02	0.62	0.99	1.61	0.54	0.35	0.89
10/09/02	0.71	0.90	1.60	0.64	0.64	1.28
10/16/02	1.33	No Flow	1.33	0.54	0.19	0.73
10/30/02	0.68	No Flow	0.68	0.75	0.54	1.29
11/06/02	0.40	No Flow	0.40	0.64	0.54	1.18
11/13/02	0.48	No Flow	0.48	0.75	0.27	1.02
11/27/02	1.30	No Flow	1.30	0.54	0.27	0.81
12/04/02	1.56	No Flow	1.56	0.64	0.27	0.91
12/11/02	1.17	No Flow	1.17	0.64	0.27	0.91
12/18/02	1.42	No Flow	1.42	0.75	0.35	1.10
1/8/03	1.32	No Flow	1.32	0.64	0.19	0.83
1/15/03	2.64	No Flow	2.64	1.38	0.75	2.13
Mean	1.05	0.29	1.34	0.66	0.35	1.01

4.1.2 Phosphorus Concentration

Raw data for TP and OP concentrations for each day of water sampling from the inflow and both outflows are contained in Appendix G. Table 4.2 shows the average TP and OP concentrations for the influent, and both effluents (East and West) during the

study period. Average TP in the inflow and outflow was 44.81 ppb and 41.71 ppb, respectively (Figures 4.1a). The average OP concentrations were 15.41 ppb at the inflow and 8.64 ppb at the outflows (Figures 4.1c). Higher OP removal in the pond water is explained by the fact that plants and algae rapidly use OP since it is the dissolved reactive form of phosphorus easily available. On the other hand, TP removal is lower because TP resulting from plants, algae, and microorganisms' biomass growing in the Upper Pond contribute to addition of TP concentration in the outflow. TP includes phosphate that is combined in the particulate or colloidal forms and is released by the digestion process.

Table 4.2 Average Phosphorus Concentrations in the Water Column

	TP (ppb)			OP-P (ppb)			TP/OP	TP/OP	TP/OP
	Inflow	East Outflow	West Outflow	Inflow	East Outflow	West Outflow	Inflow	East Outflow	West Outflow
Means	44.81	42.69	40.73	15.41	6.52	10.76	4.87	8.69	5.57
S.D.	27.79	16.38	14.90	19.96	3.66	8.61	4.14	5.89	3.53
S.E.	7.43	4.38	3.98	5.33	0.98	2.30	1.11	1.57	0.94

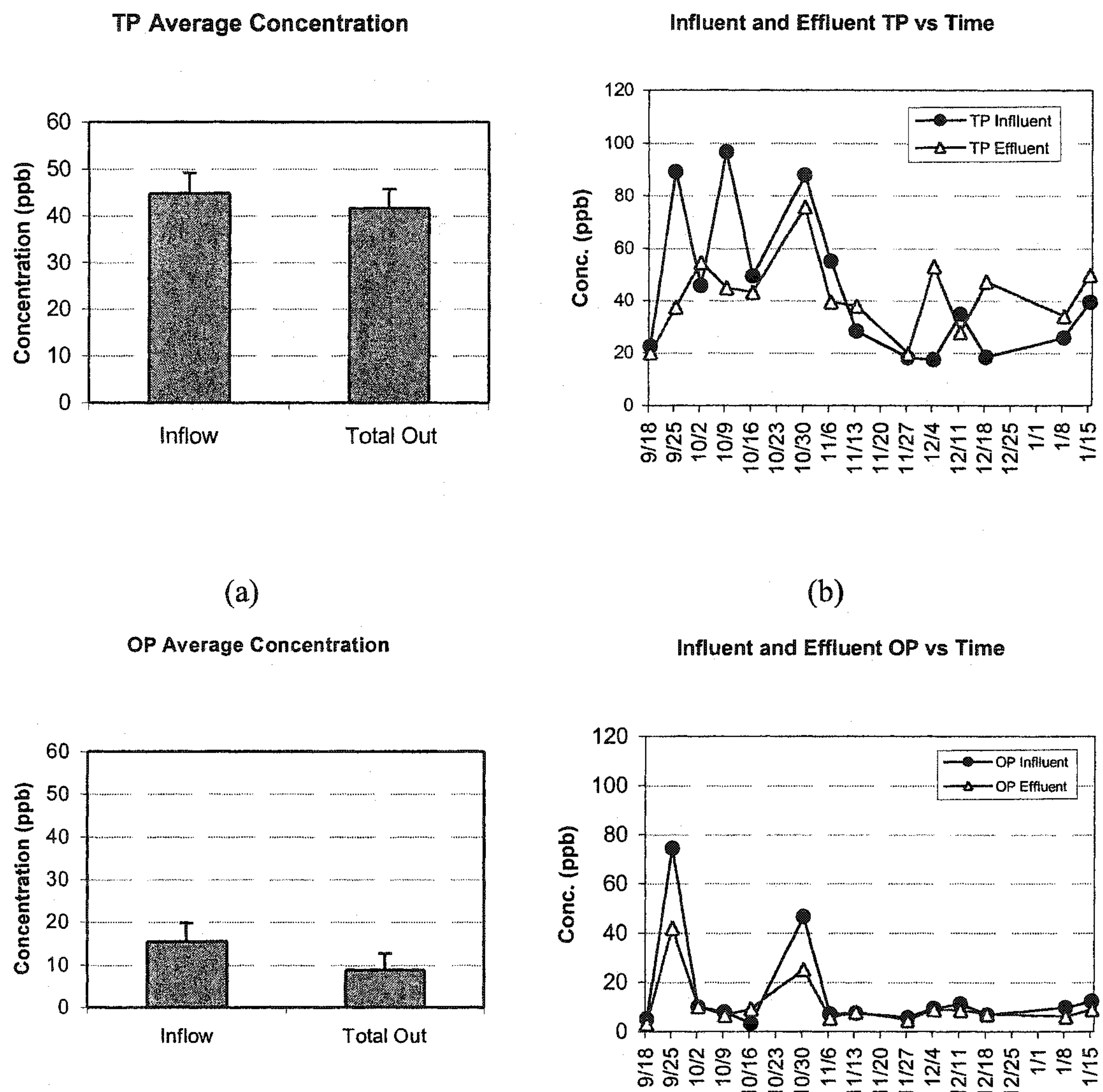
Figures 4.1b and 4.1d depict behavior over time of TP and OP concentrations at the inflow and at outflows, respectively. Statistical analyses were performed to check for significance in TP and OP concentrations among inflow and each of the outflows. An F-test revealed no significant differences among means either for TP ($F = 0.138$; $p = 0.871$) or for OP ($F = 1.711$; $p = 0.194$) concentrations (Appendix H). T-tests for significance in TP and OP concentrations between the two outflows resulted in no significant differences

between the two outflows neither for TP concentration (p = 0.743) nor for OP concentrations (p = 0.102).

At the inflow and outflow TP and OP concentrations had similar trend (Figures 4.1b and 4.1d). The behavior of TP and OP in the Upper Pond will be described in more detail in the next section when P loadings, instead of P are evaluated.

During the study period, the inflow TP/OP ratio was on average 4.87. At the East Outflow this ratio was 8.69 and at the West Outflow it was 5.57. The lower average TP/OP ratio was found in the inflow, which was expected since the P content of the outflow is affected by bioactivity within the pond. The West Outflow has higher OP concentration than the East Outflow. Although during the study period only the retention time to the East Outflow was measured, the shorter distance from the inflow to the West Outflow suggests that the retention time to this outflow is less than that to the East Outflow. This probably explains why the OP in the West Outflow is higher than that of the East Outflow. Also, it could be explained by the presence of larger amount of vegetation in the East site leading to larger bioactivity (periphyton activity around the plants).

Error analysis of the slope of TP and OP calibrations curves revealed that the error of the slope was in the order of four significant digits (Appendix H). A conservative approach was used in this thesis, and only two digits were used to express the TP and OP concentrations results.



(c) (d)

Figure 4.1 TP and OP Concentration in Water

4.1.3 Phosphorus Loading

Concentrations by themselves do not explain the phosphorus behavior at the Upper Pond; therefore, loading calculations were performed. TP and OP load in influent and effluent water were calculated for each sampling date as both grams of P per day (g

P/day) and grams of P per square meter of wetlands per year (g $m^{-2}yr^{-1}$). The two unit expressions were chosen because published data in the literature are often reported in both units (Table 4.3). Phosphorus loadings were based on the flow rates measured weekly, TP and OP concentrations, and the area of the pond (5099.22 m^2).

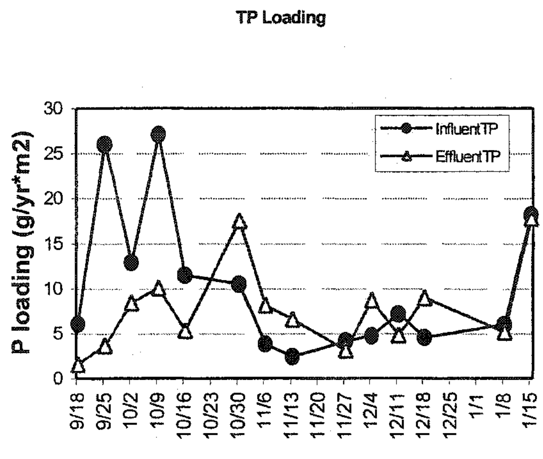
The average flow into the Upper Pond during this study was 3,272 m^3/day. Average TP and OP Inflow loadings for the same period were 10.34 g $m^{-2}yr^{-1}$ (144.50 g P/day) and 3.65 g $m^{-2}yr^{-1}$ (51 g P/day), respectively.

Statistical analysis Tukey's t-tests were performed and revealed significant differences between TP and OP loadings at the inflow ($p = 0.016$), and also at the outflow ($p = 0.00004$) (Appendix H). TP was higher than OP at both sites. On 10/30 TP outflow was higher than the inflow probably caused by the remaining of storm water from 10/27 (Figures 4.2a). Statistical t-tests also revealed significant difference for TP loadings when comparing inflow with outflow ($p = 0.17$) and also for OP loadings ($p = 0.08$). The TP loading leaving the Upper Pond was 39% less than the inflow loading. OP percent removal was higher: outflow water had 55% less OP than the inflow water (Figure 4.2b).

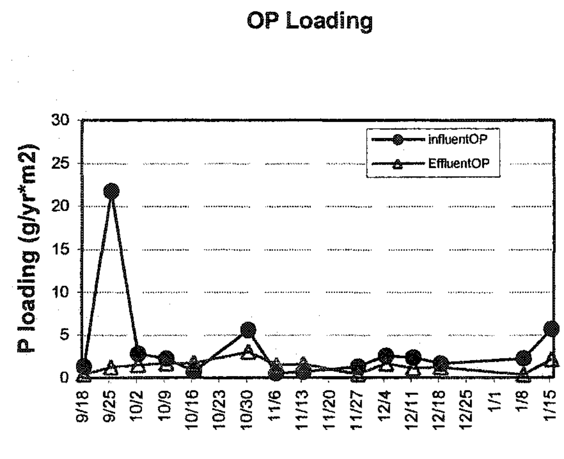
Assuming errors in flow readings ranging from ± 5% - ± 20% (Appendix H) the corresponding loading calculations, still show significant difference between inflow and outflow P loadings.

Table 4.3 Phosphorus Loading at the Upper Pond of the WPNP

Date	Inflow Flow Rate (m3/day)	Inflow TP Load (g/day)	Inflow OP-P Load (g/day)	Inflow TP Loading (g $m^{-2}yr^{-1}$)	Inflow OP-P Loading (g $m^{-2}yr^{-1}$)	Total Outflow Flow Rate (m3/day)	Total Outflow TP Load (g/day)	Total Outflow OP-P Load (g/day)	Total Outflow TP Loading (g $m^{-2}yr^{-1}$)	Total Outflow OP-P Loading (g $m^{-2}yr^{-1}$)
9/18/02	3,768	84.78	18.84	6.07	1.35	1,126	22.52	5.20	1.61	0.37
9/25/02	4,086	363.92	303.57	26.05	21.73	1,615	60.31	33.45	4.32	2.39
10/02/02	3,939	179.76	39.39	12.87	2.82	2,178	118.75	19.84	8.50	1.42
10/09/02	3,914	377.95	30.77	27.05	2.20	3,132	140.33	22.94	10.04	1.64
10/16/02	3,254	160.21	10.48	11.47	0.75	1,786	76.94	21.37	5.51	1.53
10/30/02	1,663	145.90	77.25	10.44	5.53	3,156	238.56	48.47	17.08	3.47
11/06/02	978	53.83	6.99	3.85	0.50	2,887	113.95	21.65	8.16	1.55
11/13/02	1,174	33.14	8.57	2.37	0.61	2,496	94.49	23.04	6.76	1.65
11/27/02	3,180	57.51	18.16	4.12	1.30	1,982	39.26	5.30	2.81	0.38
12/04/02	3,817	66.07	35.46	4.73	2.54	2,227	117.76	24.65	8.43	1.76
12/11/02	2,862	99.31	31.69	7.11	2.27	2,227	61.93	16.30	4.43	1.17
12/18/02	4,208	63.72	23.18	4.56	1.66	2,692	126.96	15.72	9.09	1.13
1/8/03	3,229	83.07	31.17	5.95	2.23	2,031	68.91	5.08	4.93	0.36
1/15/03	6,459	253.80	78.42	18.17	5.61	5,212	258.74	29.81	18.52	2.13
Means	3,272	144.50	51.00	10.34	3.65	2,482	109.96	20.92	7.87	1.50



(a)



(b)

Figure 4.2 Influent and Effluent TP and OP Loadings

Table 4.4 shows published data for flow (m^3/day), phosphorus concentration (ppb) and loadings (g-P $m^{-2}yr^{-1}$) for several wetlands. TP (2.37 – 27.05 g-P $m^{-2}yr^{-1}$) and OP (0.50 – 21.73 g-P $m^{-2}yr^{-1}$) inflow loadings to the Upper Pond wetlands are higher when compared to the ones with similar water source (runoff) from the literature (Table 4.5). Mitsch *et al.* (1995); Cronk & Mitsch (1994) and Kadlec (1994) studied wetlands that received runoff water (Table 4.4).

The Upper pond removal rates were in the range of 17 – 83% for TP and 25 - 89% for OP. TP Loadings removal rates in the literature were higher 56 – 95% (Table 4.5). TP and OP input in Sakadevan & Bavor's (1999) study was higher (TP 16.79 – 298.57 g-P*$m^{-2}yr^{-1}$ and OP 8.76 – 266.45 g-P*$m^{-2}yr^{-1}$) than the ones in the WPNP wetlands because their study site received wastewater. The Upper Pond TP and OP removal were lower when compared to wetlands receiving runoff water but higher when compared to

wetlands fed by wastewater. This is expected because, in general, the higher the input loadings, the lower the removal rates.

Table 4.4 Findings in the Literature for Flow, TP and OP Concentrations and Loadings

Flow (m^3/day)		Phosphorus Concentrations (ppb)				Loading (g-P $m^{-2}yr^{-1}$)				Reference
IN	OUT	OP IN	OP OUT	TP IN	TP OUT	OP IN	OP OUT	TP IN	TP OUT	
144				14760	745					Dialynas *et al.*, 2002
327.6	301	40	4	111	40	0.20	0.02	0.57	0.19	Mitsch *et al.*, 1995*
793.51	202	40	3	111	25	0.34	0.01	0.93	0.05	
1,258	1,282	40	5	111	38	0.79	0.10	2.19	0.76	
940	906	40	3	111	42	0.73	0.05	2.04	0.74	
247.37	177.17	62	8	132	11	0.24	0.02	0.51	0.03	
448.51	138.00	62	9	132	12	0.29	0.01	0.63	0.02	
1,265	1,158	62	16	132	27	1.23	0.29	2.62	0.49	
1,007	630.47	62	15	132	13	1.22	0.18	2.59	0.16	
457.98	314.23	54	11	22	16	0.39	0.05	0.87	0.08	
3,232	3,066	54	14	22	57	2.73	0.67	6.18	2.74	
916	676	54	14	22	27	0.97	0.18	2.18	0.36	
No Data								0.4 - 4		Mitsch, 1995
1,350		57		164		1.22		3.51		Cronk & Mitsch, 1994*
299		55		151		0.26		0.71		
204		60		153		0.20		0.49		
1,116		56		154		1.20		3.30		
432		61		147		0.28		0.68		
No Data				60-1460						Mason and Bryant, 1975
No Data				240-310						Brown, 1988
0.15				19				0.95		Ansola *et al.*, 1995*
44,021				50	21			0.57	0.24	Kadlec, 1994*
15				8180	7300			298.57	266.45	Sakadevan & Bavor, 1999*
6				8210	7100			119.87	103.66	
6				3580	1800			52.27	26.28	
2				3450	1800			16.79	8.76	
2				8260	6400			40.20	31.15	
3,272	2,482	15.41	17.28	44.81	83.42	3.65	1.50	10.34	7.87	This Study

* My calculation based on the information provided in the authors' article.

Table 4.4a Findings in the Literature for Flow, TP and OP Concentrations and Loadings

Loadings (g-P m^{-2}yr^{-1})				% Removal		Source	Reference
TP IN	TP OUT	OP IN	OP OUT	TP	OP		
0.5-6.18	0.02-2.74	0.20-2.73	0.01-0.67	56-95	75-97	Runoff	Mitsch *et al.*, 1995
0.49-3.51		0.20-1.22		-	-	Runoff	Cronk & Mitsch, 1994
0.57	0.24			58	-	Runoff	Kadlec, 1994
16.79 - 298.57	8.76 - 266.45			11-98	-	Wastewater	Sakadevan & Bavor, 1999
2.37-27.05	1.61-18.52	0.50-21.73	0.36-3.47	17-83	25-89	Runoff	This study

4.1.4 Field Parameters

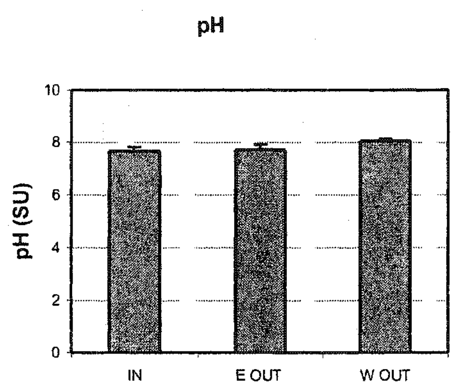
Table 4.5 shows the average values for pH, DO, conductivity, and temperature in the inflow and both outflows of the Upper Pond, during the study period. Statistical evaluations of all field parameters revealed no significant difference between the inflow and the two outflows value for any of the parameters checked (Appendix H). This implies that, on average, the parameters analyzed were not affected by the wetlands' behavior.

Figure 4.3a shows the mean pH with standard errors and Figure 4.3b depicts pH behavior over time for all three sites during the study period. The pH of the water entering and leaving the Upper Pond was slightly alkaline, as observed on the long-term data presented in Chapter 2. However, on Sep 25 the pH dropped to 5.56 in the East

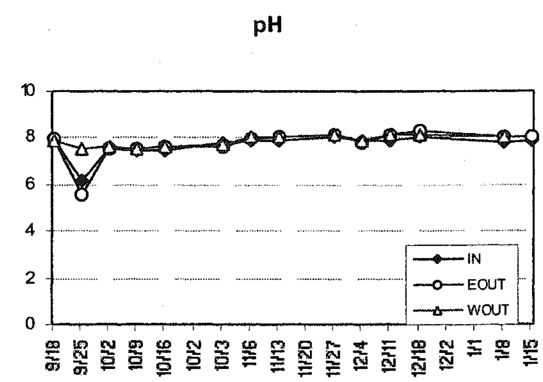
Table 4.5 Field Parameters Averages

Parameter	Inflow (NP-1)	East Outflow (NP-2E)	West Outflow (NP-2W)
pH (SU)	7.68	7.73	8.05
DO (mg/L)	7.70	8.14	9.18
Temp. (°C)	13.73	13.84	10.32
Spec. Conduct. (μmhos/cm)	5110	5059	5022

Outflow and 6.14 in the inflow water. We cannot explain these low pH values on that day.



(a)



(b)

Figure 4.3 pH Averages and Behavior During P Study

Although as a whole there was no significant difference between DO in the inflow and the outflows (Figure 4.4a), sporadically lower (10/30, 12/04), and higher (01/08) DO levels were observed in the outlets (Figure 4.4b). The influent DO on those days was about the same as observed previously. The lower DO values can be attributed to rainfall events that occurred prior to the collection dates due to the presence of BOD in the

runoff. It is possible that oxygen demanding components (i.e. Biological Oxygen Demand - BOD) contained in the runoff contributed to the lower DO value observed in the outflows. Bacteria present in the pond consume oxygen as they utilize BOD as a carbon source for growth. During the winter months, the DO in the effluent is higher than in the influent. There are several competing factors that could contribute to this behavior: during the winter the activity of algae and plants is reduced resulting in less DO release to the water; on the other hand, the solubility of DO in the water increases at lower temperatures and the use of DO by bacteria in the pond decreases. The net DO levels will depend on the magnitude of the factors mentioned above; in the case of the Upper Pond the factors that contribute to higher DO levels prevailed. Figure 4.4c shows the mean water temperature with standard errors and Figure 4.4d depicts temporal behavior of temperature for all three sites. A great difference in the water temperature was noticed in the Upper Pond during the study period (Figure 4.4d). At the beginning, from 9/18 to 10/30, the average temperature was 18.2°C and it dropped to an average of 10.5°C in the last part of the study period. A T-test revealed significant temperature difference between the first part and the second part of the study period ($p < 0.00001$) (Appendix H).

A Pearson statistical test ($r = -0.85$) resulted in strong significance correlation between DO and temperature for inflow and outflows. Linear regression explained 65% of the data (Figure 4.5).

Mean conductivity with standard errors is depicted in Figure 4.6a and temporal behavior for all three sites are shown in Figure 4.6b. The conductivity in the inflow and both outflows of the Upper Pond is usually stable approximately 5000-5300 μmhos/cm. Lower values (i.e. 4280; 4460 μmhos/cm) were observed on 10/30. The lower

conductivity values could be attributed to rainfall events that occurred prior to the collection dates (10/27/02 and 12/01/02). The presence of storm water in the pond could explain the drop in conductivity values.

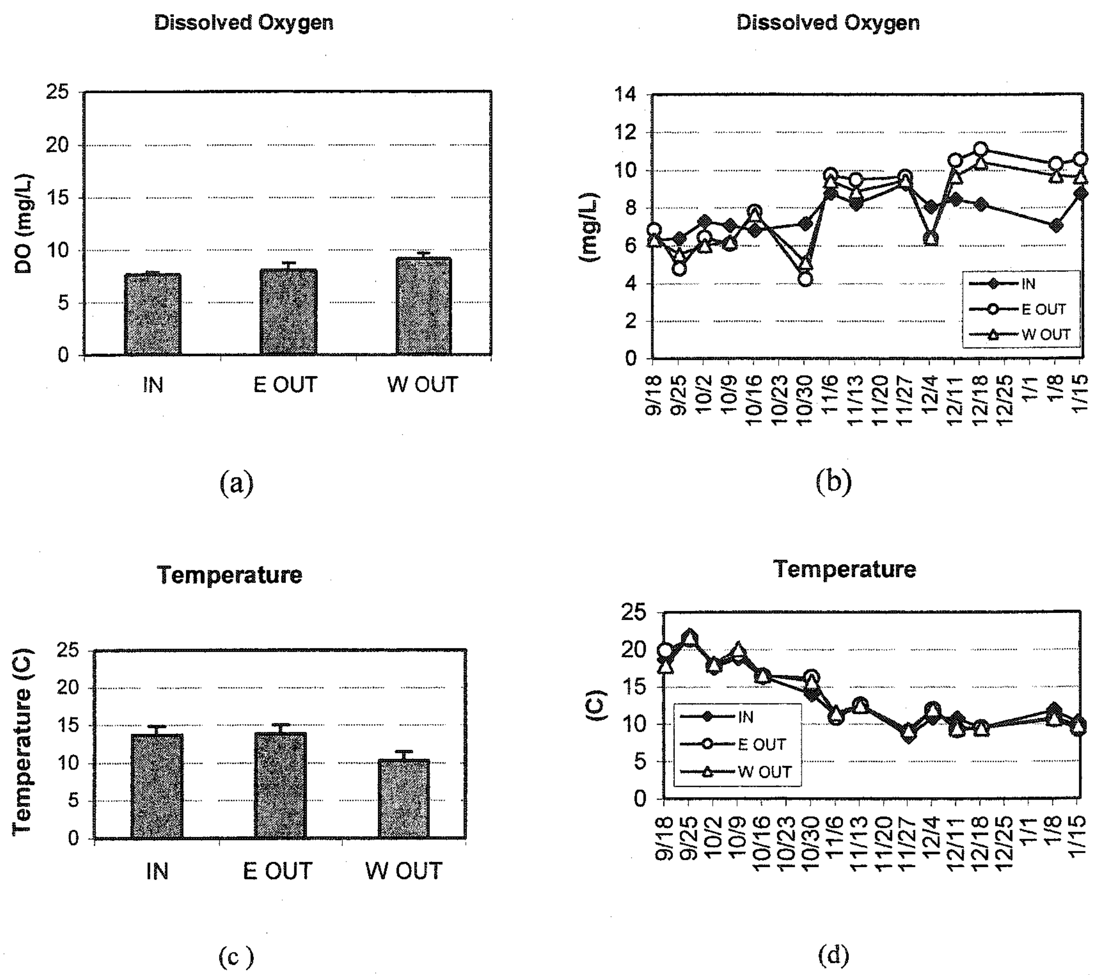


Figure 4.4 Dissolved Oxygen and Temperature Averages and Behavior During P Study

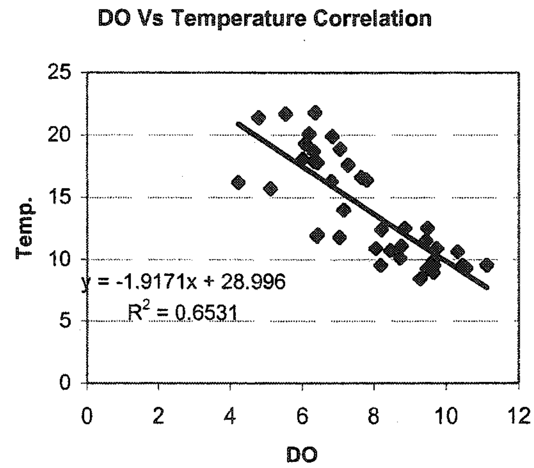
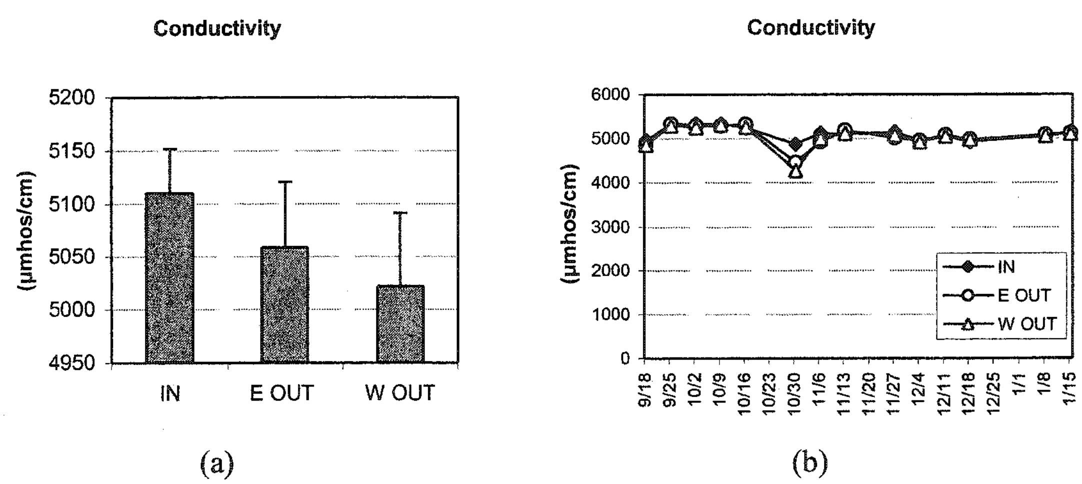


Figure 4.5 DO and Temperature Correlation



(a) (b)

Figure 4.6 Conductivity Averages and Behavior During Phosphorus Study

4.1.5 Solids Concentration in Water Column

Raw data for solids analysis are reported in Appendix G. During the study period, Upper Pond influent water averaged 4904 mg/L TS, 4941 mg/L TDS, and 6 mg/L TSS. The East effluent water averages were 4921 mg/L, 4905 mg/L, and 15 mg/L for TS, TDS,

and TSS respectively. At the West Outflow water TS concentration was 4929 mg/L, TDS average was 4936 mg/L, and 21 mg/L for TSS (Table 4.6).

Table 4.6 Solids in Water Average Concentrations

Site	Inflow			East Outflow			West Outflow		
Solids (mg/L)	TS	TDS	TSS	TS	TDS	TSS	TS	TDS	TSS
Means	4904	4941	6	4921	4905	15	4929	4936	21
Stand Dev	279.38	124.71	4.56	336.05	308.16	5.88	267.27	210.79	27.54
Stand Error	75	44	2	90	109	2	71	75	10

Figure 4.7a shows TS concentrations at the three sites. On some days TS inflow was a little lower than in both outflows. However, an F-test revealed no significant difference in TS between sites ($F = 0.026$, $p = 0.974$) (Appendix H). The results demonstrate that the majority of the solids in the Upper Pond are TDS. TDS average was slightly higher than TS in the inflow and West Outflow. This is the result of the closeness between the TS and TDS values. The TDS concentration practically equals the total solids concentration and differentiating between them within the margins of experimental error is difficult. TSS content in the Upper Pond was much lower than TS and TDS in all three sites (Figure 4.7b, 4.7c, and 4.7d).

In inflow water TS and TDS had the same trend. From 10/21 to 12/18 TSS had opposite behavior than the TS and TDS but from 1/8 it had the same trend as the other solids (Figure 4.7b). In the East and West Outflows TS and TDS also had the same trend

(Figure 4.7c and 4.7d). TSS behavior in both outflows was not as stable as it was in the inflow, it varied significantly. This can be attributed to plant matter presence in both outflows. TSS at East Outflow was in the range of 7 – 25 ppm. Figure 4.7d shows 88 ppm for TSS concentration on 11/13. At this site grab samples were collected not a composite sample. Some days during the study period an accumulation of organic material appeared in the surface of the water, which appeared to be seeds and/or plant flowers. This could contribute to the increase of TSS concentrations in the outflows.

Figure 4.8 shows averages TSS concentrations for inflow and total outflow. A t-test revealed significant higher TSS in total outflow ($p = 0.019$) than at the inflow (Appendix H). Outflow TSS concentration was higher. TSS concentration in this pond is not high comparing to number found in literature (mean = 104 mg/L in Cronk & Mitsch, 1994).

A Pearson correlation test was performed and showed a positive correlation between TDS and conductivity in the Upper Pond ($r = 0.68$, $p = 0.003$). Linear regression explained 46% of the data (Figure 4.9a). Another Pearson test was performed to check for correlation between TP and OP and TSS content in each site. The test resulted in strong correlation ($r = 0.80$) between TSS and OP concentration only at the East Outflow (Appendix H). Linear regression explained 63% of the data (Figure 4.9b).

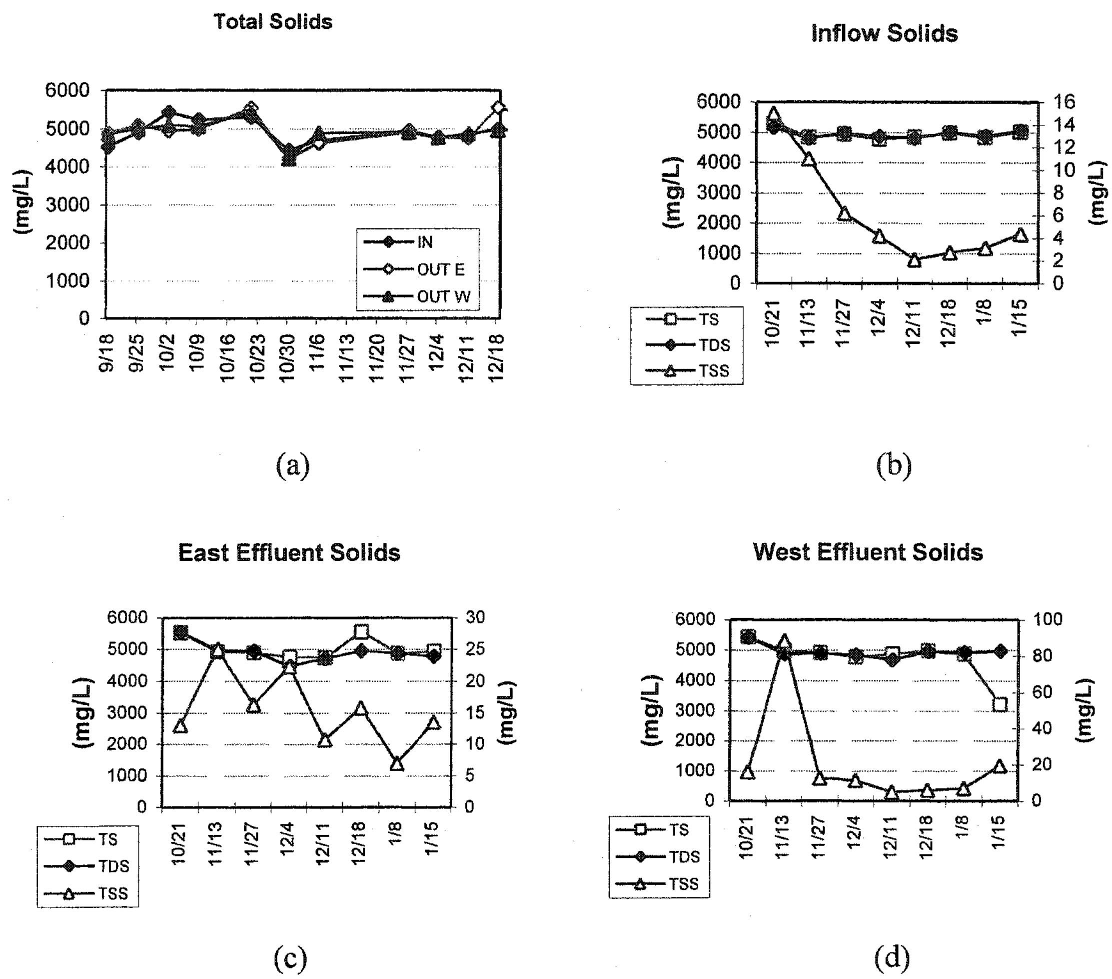


Figure 4.7 Solids Temporal Variation

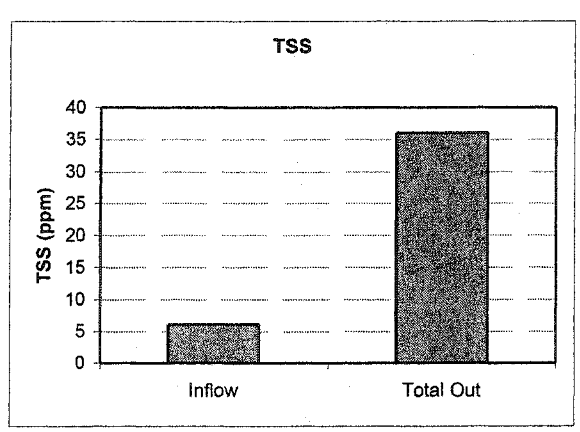
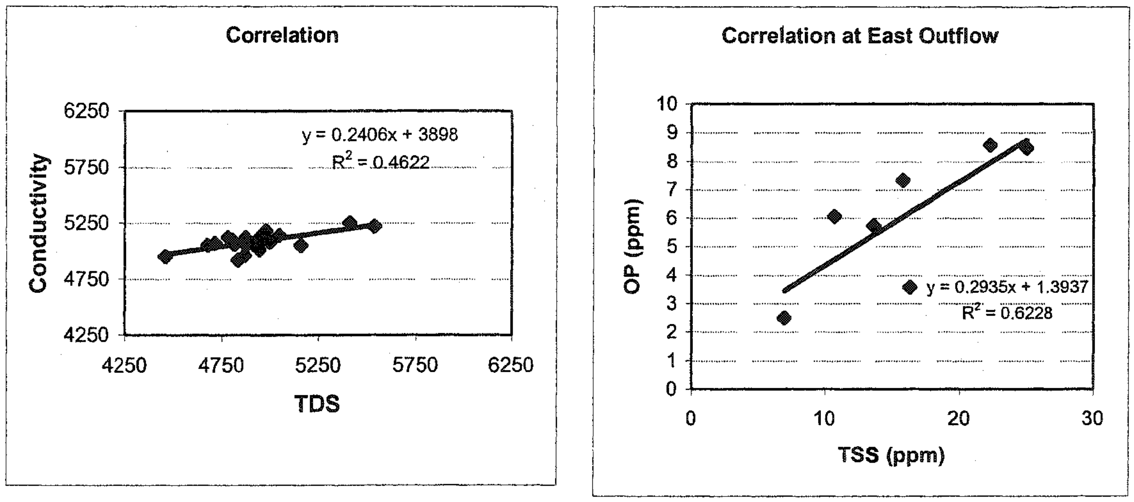


Figure 4.8 Average TSS Inflow and Total Outflow



(a) (b)

Figure 4.9 Correlation

4.2 Sediment Compartment

Sediment samples from the Upper Pond of the WPNP were analyzed for pH and phosphorus content.

4.2.1 pH and Phosphorus Concentration

Raw data for pH and TP concentrations in the sediments for each sampling date for the inflow, West Edge of the Pond, Middle of the Pond, east edge of island, and East Outflow are contained in Appendix G. Average pH and TP results are shown in Table 4.7. The sediment at the Upper Pond is alkaline at all sites, pH averages ranged from 8.46 – 8.86.

Sediment TP concentration ranged from 76 to 1285 mg P kg^{-1} among all sites. The total average TP content at the upper layer was 565.86 mg P kg^{-1} and 422.72 mg P kg^{-1} at the lower layer. Statistical test revealed a significant difference between layers ($F = 15.252$; $p = 0.0002$) with the upper layer averages higher in TP content than the lower layers (Appendix H). However, some sporadic data points showed higher results for

lower layers (Table 4.7). In addition, some measurements in the Upper Pond layers (Inflow - 9/28/02) and in the lower layers (East Edge of the Island - 10/26/02) showed values significantly different from the site average. Duplicate runs of the samples showed similar results.

Statistical test also revealed significant difference in TP content among sites ($F = 7.709$; $p = 0.00002$). In order to know which site has accumulated most phosphorus, a multiple comparison Tukey's test was conducted and significant differences were found. The East Outflow had the most P content, followed by the East Edge of the Island, the Inflow, the middle of the pond, and the West Edge of the Pond. The East Outflow had higher TP than the Inflow ($p = 0.025$). That site was also higher in TP than the West Edge of the Pond ($p = 0.0001$) and the middle of the pond ($p = 0.001$). The Tukey's test also revealed that the East Edge of the Island had higher TP concentration than at the West Edge of the Pond ($p = 0.007$). Also, at the East Edge of the Island TP concentration was higher than the TP concentration in Middle of the Pond ($p = 0.034$).

Table 4.7 pH and Average TP Concentration in Sediment (mg P Kg^{-1})

Collection Date	Site									
	Inflow		EdgeWest		Middle Pond		E.Edge Island		East Outflow	
	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower	Upper	Lower
9/14/02	No data	No data	710	335	705	245	780	570	800	435
9/21/02	370	165	720	245	565	730	540	325	620	700
9/28/02	1285	685	500	280	571	360	750	570	710	650
10/05/02	283	335	260	150	246	121	430	325	345	345
10/12/02	200	690	190	170	495	151	730	630	675	680
10/26/02	525	290	331	76	575	225	440	535	605	630
11/02/02	No data	No data	545	547	671	275	815	800	705	645
11/10/02	820	248	720	720	420	270	720	370	710	800
11/23/02	930	240	625	615	605	275	645	470	710	745
12/1/02	685	210	380	375	555	315	735	510	690	810
12/08/02	440	275	280	275	635	170	725	535	600	565
12/15/02	515	180	305	305	455	380	810	725	617	690
Means	605±331	332±194	431±197	321±203	512±115	300±174	652±135	499±131	628±109	661±134
Average pH	8.69	8.78	8.76	8.86	8.73	8.76	8.73	8.46	8.52	8.71

Figure 4.10 shows mean TP concentration in mg P Kg^{-1} and compares upper and lower layer averages in each collection site. The smallest difference between layers was at the East Outflow site (5%). The greatest difference between layers was noted in the Inflow site at which upper layer TP content was 82% higher than the lower layer

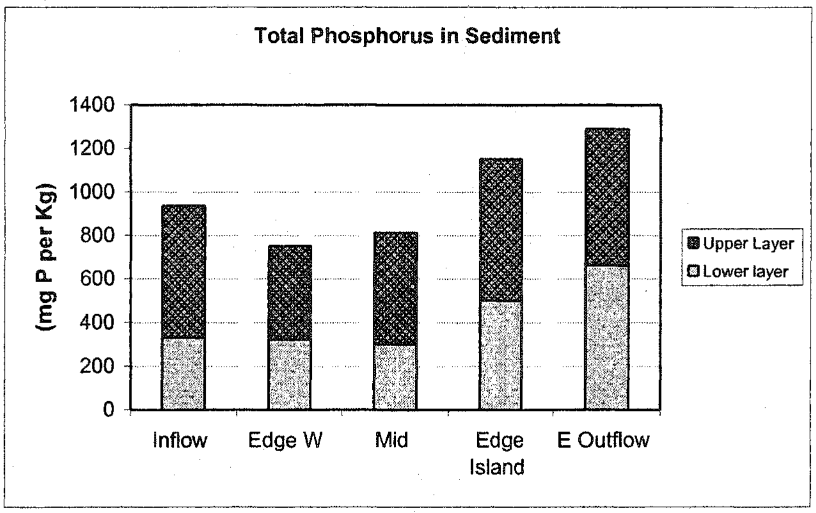


Figure 4.10 Average TP in Sediment Samples

Figure 4.11 shows the average distribution of phosphorus in sediments in the Upper Pond. The highest TP concentrations are found in the East Outflow site, followed by the East Edge of the Island and the Inflow.

In this study upper layer sediment ranged from 200 to 1285 mg P Kg^{-1} and the lower layer ranged from 76 to 800 mg P Kg^{-1}. On average, the sediment TP concentrations found in the Upper Pond of the WPNP were comparable to those of some studies reported in the literature (Table 4.8). Graetz & Nair (1999), Sakadevan & Bavor (1999), Kadlec & Walker (1999), Nair *et al.* (2001), and Reddy *et al.* (1999) reported results in the range of (180-1020 mg P Kg^{-1}).

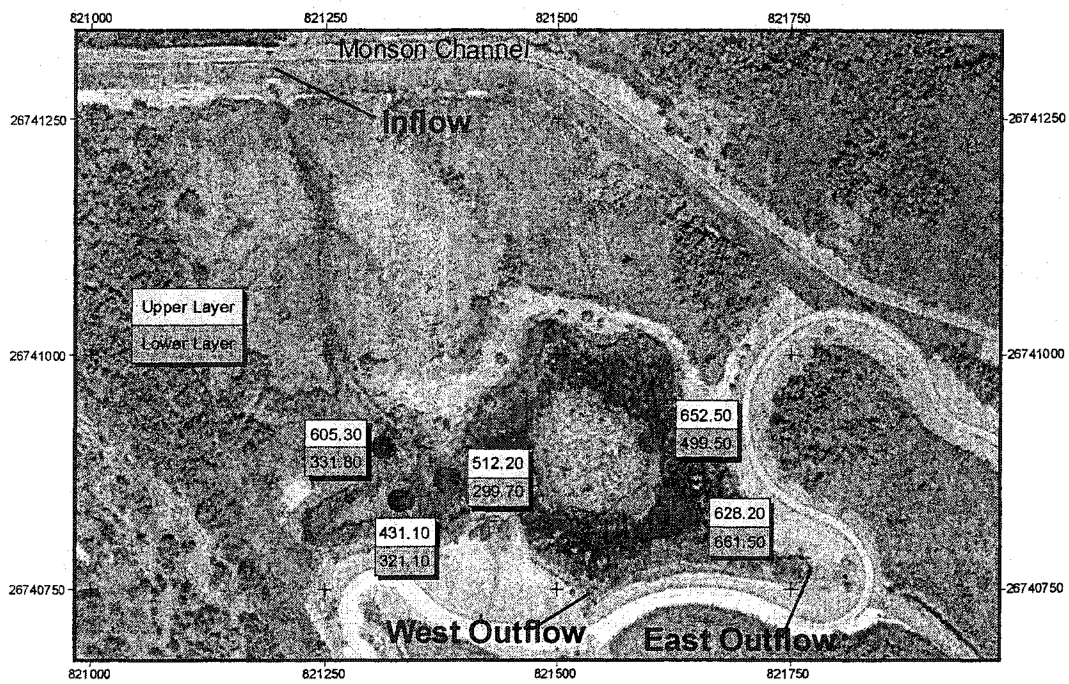


Figure 4.11 Sediment – Phosphorus Distribution

On the other hand, Bolton & Greenway (1999) and Gilliam *et al.* (1999) found very low TP content (1.9 – 3.9 mg P Kg^{-1}). These small P contents were found in recent created wetlands soil (eight months). Some other studies reported higher values for TP (1170-1670 mg P Kg^{-1}) Horpilla & Nurminen (2001) and (750-4000 mg P Kg^{-1}) Hieltjes & Lijklema (1980). Newman *et al.* (1996) and Sakadevan & Bavor, (1999) reported that upper layers sediments contained more phosphorus than lower layers, similar to what was found in this study. On the other hand, Nair *et al.* (2001) found higher concentrations at lower depths.

Table 4.8 Sediment Findings

Phosphorus Concentration in Sediments (mg P Kg^{-1})	Reference
350 – 450 in upper layer 370 – 1020 at lower layer (pH 6.0 – 8.0)	Nair *et al.*, 2001
1170 – 1670	Horpilla & Nurminen, 2001
270 – 2050	Y. Pan *et al.*, 2000
294 - 987	Graetz and Nair, 1999
1.9 – 2.3	Bolton & Greenway, 1999
3.0 – 3.9	Gilliam *et al.*, 1999
380 in upper layer 180 at lower layer (pH 6.2 – 7.2)	Sakadevan & Bavor, 1999
540 – 720 (20 cm of core)	Kadlec & Walker, 1999
486 – 1608 (0-15 cm of core)	Reddy *et al.,* 1999
619	Newman *et al.*, 1996
750 – 4000	Hieltjes & Lijklema, 1980
565.86 ± 205.24 in upper layer 422.72 ± 214.99 at lower layer (pH 8.5 – 8.9)	This Study

The lengths of the sediment cores from all sites were measured to determine where sediment is being accumulated in the Upper Pond (Figure 4.12). Inflow and West Edge of the pond had similar lengths: 24 cm; the Middle of the Pond had the highest length: 30 cm, and East Edge of the Island and East Outflow had similar lengths: 28 cm and 27 cm, respectively. The results show that the sediment is accumulating mostly in the middle of the pond followed by the East Edge of the Island and East Outflow areas. The

accumulation of the sediment does not reflect the accumulation of P. While the thickest sediments are found in the Middle of the Pond, most phosphorus is found in the East Outflow.

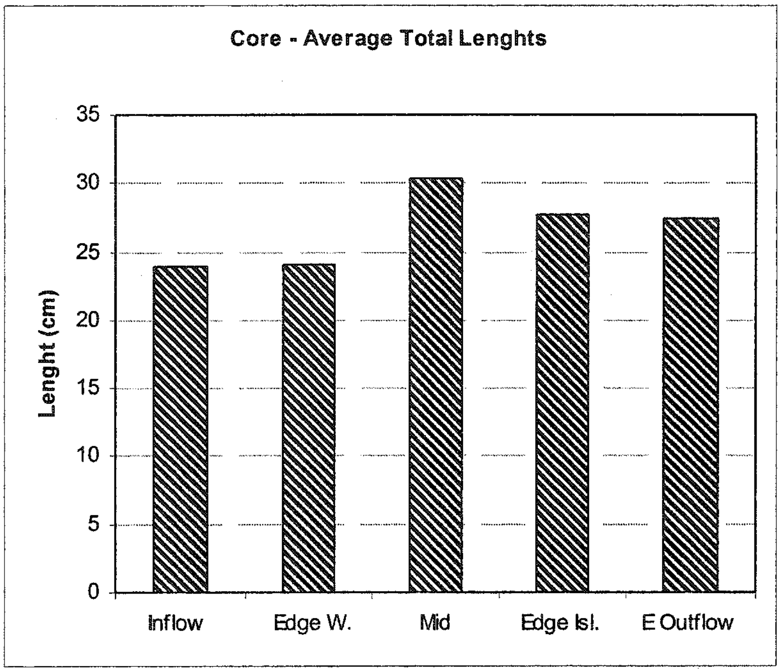


Figure 4.12 Average Length of Sediment Cores

4.3 Plant Compartment

Raw data for P content in plant tissue for each sampling date are presented in Appendix G. Average percent P per dry weight for *Typha* and *Scirpus* species in both above and belowground tissues were calculated and are summarized in Table 4.9 and represented in Figure 4.13. P measurements in NIST Standard tomato leaves resulted in 0.19% and 0.18% P, which is within the range expected (Chapter 3).

Table 4.9 Average Phosphorus Concentration in Plant Species (% P DW)

Collection Date	Plant Species and P Concentration			
	Typha		Scirpus	
	Aboveground	Belowground	Aboveground	Belowground
9/14/02	0.19	0.20	0.07	0.13
9/21/02	0.17	0.13	0.12	0.20
9/28/02	0.05	0.06	0.06	0.07
10/05/02	0.13	0.11	0.02	0.03
10/12/02	0.13	0.13	0.08	0.10
10/26/02	0.12	0.12	0.14	0.12
11/02/02	0.12	0.12	0.07	0.12
11/10/02	0.09	0.19	0.13	0.14
11/23/02	0.15	0.14	0.09	0.15
12/1/02	0.14	0.16	0.13	0.13
12/08/02	0.12	0.20	0.11	0.14
12/15/02	0.07	0.10	0.12	0.14
Means	0.13	0.14	0.09	0.12
Std Dev.	0.04	0.04	0.04	0.05
Std Error	0.01	0.01	0.01	0.01

Some studies assert that uptake rate of nutrients by aquatic vegetation in wetlands water depends on the importance of belowground versus aboveground absorption (Howard-Williams, 1985). In this study, *Scirpus* P content in aboveground averaged 0.09 ± 0.04%, and TP belowground averaged 0.12 ± 0.05%. *Typha* aboveground TP averaged 0.13 ± 0.04% and belowground averaged 0.14 ± 0.04%. To determine the relationship between above and belowground tissues t-tests were performed for each species. T-test

revealed significant difference for S*cirpus* species, with high P content in aboveground (p = 0.34), but no significant difference was found for *Typha* species (p = 0.35). To determine which species accumulated more TP content, a t-test was performed and revealed that *Typha* accumulated more TP than S*cirpus* (p = 0.006) (Appendix H).

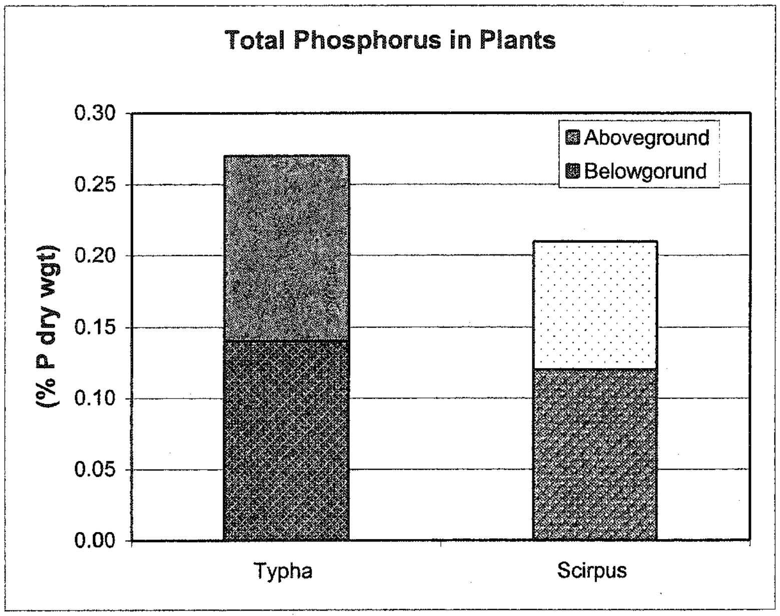
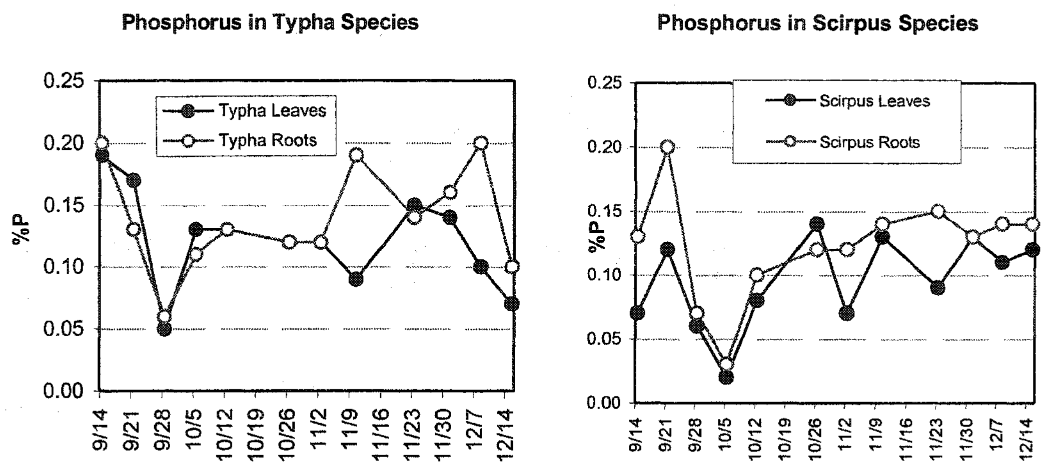


Figure 4.13 Average TP in Plant Species

Figures 4.14a and 4.14b shows the temporal variation for *Typha* and *Scirpus* species during the study period. *Typha* belowground and aboveground tissues showed very close P content except for 11/10 and 12/08 when belowground had higher P content. *Scirpus* belowground P content was higher than the aboveground most of the time except for 9/28 and 10/05 when both tissues had closer P content.



(a) (b)

Figure 4.14 Plant Species Temporal Variation

Plant P contents in this study (0.10 – 0.14%) were similar to those reported in the literature (DeBusk & Dierberg (1999); McJannet *et al.* (1995); Harper & Daniel (1934); Boyd (1970); Richardson (1991); Miao and Reddy (1992). Some other studies found higher range of P content (Auclair, 1979; Richardson, 1991; Carpenter, 1980), these studies were performed in different seasons compared to those from this study. Although Boyd (1970) reported similar results for P content, his study showed that *Scirpus* (0.18%) had higher P content than *Typha* (0.14%) (Table 4.10). Boyd's site (1970) had different water chemistry characteristics: low alkalinity, sulfate, and nitrate concentrations. Concentrations of these water parameters are much higher in the WPNP wetlands (Chapter 2). Maybe that could account for the difference in plant behavior in different locations or perhaps it was just the timeframe or season in which the study was performed since the percentage of P range is so close. Kock and Reddy (1992) reported that *Typha r*oots (0.08%) had lower P content than *Typha s*hoots (0.23%), which is the

opposite of my findings. Some results had higher percentage of P than the results from this study because of the season when the plants were analyzed.

Table 4.10 Plant Findings

Phosphorus Content	Reference
3-5% of the annual loading *Typha*	Horpilla & Nurminen, 2001
1.29 – 2.55 g P m^{-2} *Typha**	Emery & Perry, 1995
0.071 – 3.21 g m^{-2} *Typha aboveground**	Mason & Bryant, 1975
0.1 % *Typha*	Kadlec & Walker, 1999**
0.10 – 0.68%	DeBusk & Dierberg, 1999
0.2 - 0.4%	Carpenter, 1980
0.13% - 1.07% (miscellaneous)	McJannet *et al.,* 1995
0.13% - 0.30% *Typha*	Harper & Daniel, 1934
0.19% and 0.24% *Scirpus* 0.21% *Typha*	Auclair, 1979**
0.14 ± 0.02% *Typha* 0.18 ± 0.01% *Scirpus*	Boyd, 1970
0.13% – 0.32% *Typha* aboveground 0.13% – 0.32% *Typha* belowground	Richardson, 1991**
0.23% *Typha* Shoots 0.08% *Typha* Roots	Kock and Reddy, 1992**
0.12% *Typha* aboveground and belowground	Miao and Sklar,1998**
0.09 ± 0.04% *Scirpus* aboveground 0.12 ± 0.05% *Scirpus* belowground 0.13 ± 0.04% *Typha* aboveground 0.14 ± 0.04% *Typha* belowground	This Study

*express for biomass.
**my calculations from article information

CHAPTER 5

DISCUSSION AND RECOMMENDATIONS

5.1 Discussion

The purpose of this study was to investigate the distribution of P among different compartments of the Upper Pond at the Wetlands Park Nature Preserve: influent and effluent water, sediments, and plants.

The first hypothesis was that the Upper Pond influent water would have higher P concentrations than the effluent. Average flow into the Upper Pond during the study period averaged 3,272 m^3/day and the total outflow was 2,471 m^3/day. The flow rate at the East Outflow is twice that of the West Outflow. Average TP in the inflow and outflows was 44.81 ppb and 15.41 ppb, respectively. The average OP concentrations were 15.41 ppb at the inflow and 8.6 ppb at the outflows. The East Outflow had the highest TP/OP ratio (8.69). The West Outflow had higher OP concentrations than the East Outflow. The retention time to the West Outflow is less than that of the East Outflow (Table 2.1). This probably explains why the OP in the West Outflow is higher than that of the East Outflow. Also, could be explained by the presence of larger amount of vegetation in the East site leading to larger bioactivity (periphyton activity around the plants). Average TP and OP inflow loadings for the study period were 144.50 grams per day (10.34 g $m^{-2}yr^{-1}$) and 51 grams per day (3.65 g $m^{-2}yr^{-1}$), respectively. The TP loading leaving the Upper Pond was 39% less than the inflow loading. OP percent removal was

higher: outflow water had 55% less OP than the inflow water, which confirms my hypothesis that the outflow would have lower P than the inflow. The TP and OP loadings to the Upper Pond wetlands are higher when compared to the ones with similar water source (runoff) from the literature (Table 4.5). Mitsch *et al.* (1995); Cronk & Mitsch (1994) and Kadlec (1994) studied wetlands that received runoff water. The Upper pond removal rates were in the range of 17 – 83% for TP and 25 - 89 % for OP. TP Loadings removal rates in the literature were higher 56 – 95% (Table 4.5). TP and OP input in Sakadevan & Bavor's (1999) study was higher (TP 16.79 – 298.57 g $m^{-2}yr^{-1}$ and OP 8.76 – 266.45 g $m^{-2}yr^{-1}$) than the ones in the WPNP wetlands because their study site received wastewater. The Upper Pond TP and OP removal were lower when compared to wetlands receiving runoff water but higher when compared to wetlands fed by wastewater. This is expected because, in general, the higher the input loadings, the lower the percent phosphorus removal.

I expected to find that the distribution of P in the sediment would be characterized by a difference in P concentrations between layers. It was hypothesized, based on the literature review, that the upper sediment layer would hold higher P concentrations.

I found that the total average TP content at the upper layer was 565.86 ± 205.24 mg P Kg^{-1} and 422.72 ± 214.99 mg P Kg^{-1} at lower layers. On average, the sediment TP concentrations found in the Upper Pond were comparable to those of some studies reported in the literature (180-1020 mg P Kg^{-1}) (Table 4.8). Statistical analyses showed that the upper layer had higher P content when compared to the lower layer, which confirmed my hypothesis that the upper layer of the sediment would have higher P content. Newman *et al.* (1996) and Sakadevan & Bavor (1999) also found more

phosphorus content in upper layer (Table 4.8). TP concentration in the sediment ranged from 76 – 1285 mg P Kg^{-1} among all sites and the pH of the sediments were alkaline (8.46 – 8.86). Statistical analyses also revealed that the sediment at East Outflow site had the most P content, followed by the East Edge of Island, the Inflow, the Middle of the Pond, and the West Edge of the Pond.

The fine sediment particles carried by the flow of the water towards the East Outflow explain the concentration of P in this area. The East Edge of the Island's P content accumulation was also expected since it is an area of slow flow; therefore, the movement of sediment does not occur quite often. As to the Middle Pond area, it is possibly that the reason for the lower concentration in this area is the result of pond depth. The fact that the water volume is higher could prevent accumulation of fine sediment particles.

Based on the literature review, the third hypothesis was that the P content in plants would vary between above and belowground tissues. It was also hypothesized that belowground tissue would have the higher P content Although *Typha* accumulated more P content than *Scirpus*, only *Scirpus* species revealed a significant difference between above and belowground tissues P content. *Scirpus* P content in aboveground (0.09 ± 0.04%) was lower than belowground tissue (0.12 ± 0.05%). *Typha* P content in aboveground (0.13 ± 0.04%) did not show significant difference in P content compared to belowground (0.14 ± 0.04%).

Plant P contents in this study (0.10 – 0.14 %) were similar to those reported in the literature (DeBusk & Dierberg (1999); McJannet *et al.* (1995); Harper & Daniel (1934); Boyd (1970); Richardson (1991); Miao and Reddy (1992). Some other studies found

higher range of P content (Auclair, 1979; Richardson, 1991; Carpenter, 1980). Although Boyd (1970) reported similar results for P content, his study showed that *Scirpus* (0.18%) had higher P content than *Typha* (0.14%) (Table 4.10). Boyd's site (1970) had different water chemistry characteristics: alkalinity, sulfate, and nitrate. Concentrations of these parameters are much higher in WPNP wetlands. Maybe these environmental differences could account for the difference in P content in plants from different locations or perhaps it was influenced by the growing season. Kock and Reddy (1992) reported that *Typha* roots (0.08%) had lower P than *Typha* shoots (0.23%), which is the opposite of my findings.

5.2 Other Findings

The majority of the solids in the Upper Pond are total dissolved solids with low TSS concentrations. The water is slightly alkaline (pH 7.68 – 8.05) and the conductivity of the water was 5000 – 5300 μmhos/cm. Strong correlation was found between DO and temperature ($r = -0.85$); between TDS and conductivity ($r = 0.68$), and between TSS and OP but only in the East Outflow ($r = 0.80$).

The lengths of the sediment cores were measured and results showed that the sediment is accumulating most in the Middle of the Pond followed by the East Edge of the Island and East Outflow areas. The accumulation of the sediment does not reflect the accumulation of P. While the thickest sediments are found in the Middle of the Pond, most of the phosphorus is found in the East Outflow followed by the East Edge of the Island and the Inflow.

5.3 Phosphorus Mass Balance

Through the literature review presented in Chapter 1, we recall that a wetland ecosystem consists of interacting biological and physical components that modify fluxes of materials, including nutrients (i.e. P and N). In order to understand how effective wetlands system is in reducing phosphorus concentrations in wastewater, mass balance of phosphorus is needed. To calculate the mass balance of phosphorus in wetlands one needs to know how much phosphorus is contained in each of the following compartments: water, plants, sediment, and algae/microorganisms. Figure 5.1 represents general P mass balance in wetlands, detailing P forms in each compartment (Table 5.1). The mass balance of P can be expressed by the following equation:

$$\textbf{Total } \mathbf{P_{in}} = \textbf{Total } \mathbf{P_{out}} + \mathbf{\Delta} \textbf{ of } \mathbf{P_{Pond}}$$

$$\mathbf{\Delta} \textbf{ of } \mathbf{P_{Pond}} = \mathbf{\Delta} \textbf{ of } \mathbf{P_{Sed}} + \mathbf{\Delta} \textbf{ of } \mathbf{P_{Plant\,s}} + \mathbf{\Delta} \textbf{ of } \mathbf{P_{water\ column}} + \mathbf{\Delta} \textbf{ of } \mathbf{P_{algae/microorganisms}} \text{ ,where}$$

Total P_{in} = total amount of P input to the wetlands at a particular time;

Total P_{out} = total amount of P output to the wetlands at a particular time;

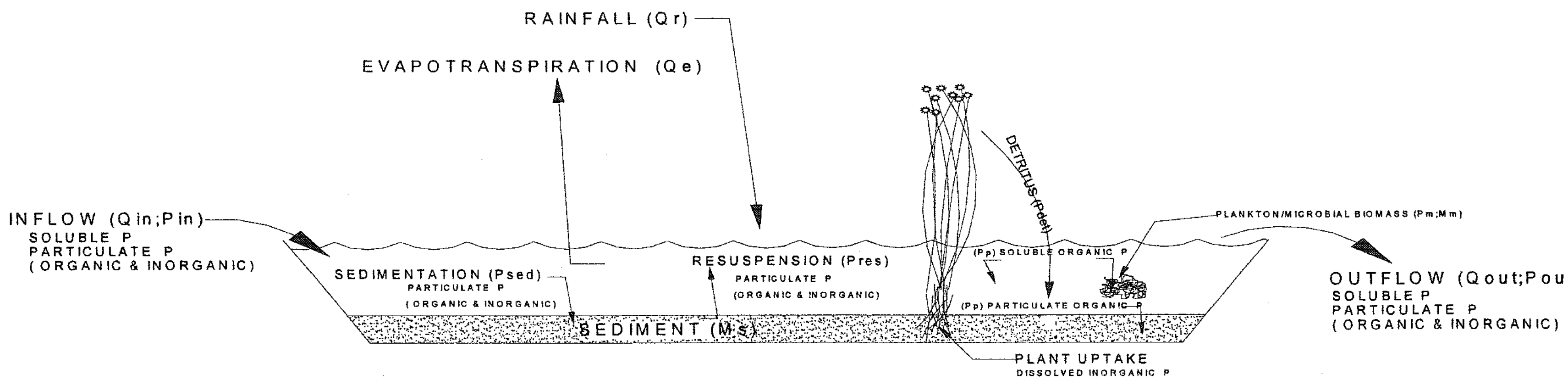
Δ of P_{Pond} = variation of P amount in each compartment of the Pond at a particular time (amount of P in the water + amount of P in the sediment + amount of P in the plant + amount of P in the microorganisms)

Each compartment of the wetlands is considered a standing stock for P at a particular time (since nutrient cycling in wetlands is extremely dynamic), which can be calculated as:

$$\textbf{Standing Compartment = Concentration X Mass}$$

In the present research, P content was calculated in some of the compartments involved in the P mass balance model, as follows:

1. Water compartment: P concentrations of the water at the inflow and at the outflows were calculated and volume of the water was assumed to be constant.
2. Plant compartment: aboveground and belowground P concentrations were calculated. To estimate the total mass of P accumulated in the plants, one needs to know the total mass of plant present in the Pond. In this study, survey of the total mass of vegetation in the Pond was not performed.
3. Sediment compartment: the average concentration of P in sediments was calculated. Mass of sediment was estimated to be about one foot of sediment at the Upper Pond. However, the background P concentration in the wetlands area was not known, which can be a point for further research.
4. Algae/microorganisms compartment: this compartment was not included in this study. This can be a point for further research.



Compartment	Variable	Compartment	Variable
Water Inflow	Q_{in} = inflow P_{in} = P concentration at the inflow	Sediment	P_{sed} = P sedimentation P_{rs} = P resuspension M_s = Mass of sediment
Water Outflow	Q_{out} = outflow P_{out} = P concentration at the outflow	Plankton/microbial biomass	P_m = P concentration in microorganisms M_m = Mass of microorganisms
Plant	P_p = P concentration in one plant P_{det} = P concentration in plant detritus		

Figure 5.1 Phosphorus Mass Balance in Wetlands
(Adapted from Misch *et al.*,1995 and Mitsch & Gosselink, 2000)

5.4 Recommendations for Further Studies

To better understand the distribution of phosphorus in the Upper Pond of Clark County Wetlands Park Nature Preserve, further research is suggested:

1. Based on the sediment results, I would recommend the Outflow and the Inflow areas as the target for future studies in controlling and managing the TP accumulations in the Upper Pond, which could also be used as the basis for the same study at the other ponds of the WPNP.
2. A more detailed study on the sediment compartment in order to characterize the existing pools of P using sequential extraction schemes would be recommended. The distribution and the forms of each species of P by fractionation analysis, among other things, would give information of P binding to other elements. That can help to determine the removing processes, to decide the productivity of the wetlands, and to provide more information on the chemistry of P in sediments. In addition, it would be also interesting to study the sediment particles size, and mineralogy.
3. It would be interesting to conduct another study on the plant species to check for seasonal variation or at least to analyze the plants during the growing season. Literature mentions that the plants uptake more nutrients (P & N) during the summer (Shardendu, 1991; Emery and Perry, 1995; Carpenter & Lodge, 1986; Mason & Bryant, 1975). Consequently, it is possible that the results from this research did not account for the maximum of TP content in the plants since the study was not performed in the growing season.

4. Some literature mentions that when plant die 35% to 75% of the P content is released back to the wetlands (Richardson, 1985). Based on these results I would recommend that if P control is desired in this wetlands plants should be harvested periodically and *Typha* would be the species of special concern because they uptake more P.
5. A study of the microbial pool and organic matter in this wetland's sediments would be interesting information since it is an important factor on the release of nutrients, especially N and P that are the elements responsible for eutrophication.
6. A study on the TN:TP ratio content in this system would also be of relevance. This ratio is often mentioned in the literature to be used in understanding which of these two major nutrients limits the production of plant biomass in aquatic systems.
7. During some periods of the year, suspended organic matter has been observed in the surface of the water of the WPNP ponds. The exact composition of this matter is unknown; however, physically it is a mixture of seeds from the wetlands plants and resuspended vegetation from the bottom of the pond. I analyzed one sample and found that it contained high level of phosphorus. Therefore, it would be surely important to the nutrients mass balance to identify the origin and composition of this matter.

8. Algae, periphyton, and phytoplankton compartments also need to be studied in order to complete the P cycle, since they influence the P assimilation capacity of wetlands.

APPENDIX A

WATER QUALITY PARAMETERS OF THE CLARK COUNTY WETLANDS PARK NATURE PRESERVE INFLOW AND OUTFLOW - RAW DATA FROM JAN 2001 TO DEC 2002

Water Quality Parameters at the CCWPNP Inflow and Outflow for 2001 (Based on HRC Data)

Sampling Site	Sampling Date	pH (SU)	Tempe (°C)	DO (mg/l)	Spec.Conduct. (µmhos/Cm)	Turbidity (FTU)	Ortho P (mg/l)	NO3-N (mg/l)	Sulfates (mg/l)	Chlorides (mg/l)	Alkalinity (mg/l)	Hardness (mg/l)	Selenium (mg/l)	Arsenic (mg/l)
NP-1	1/16/2001	7.4	16.1	11.21	5630		0.31	13.7	2250	680	268	2800		
NP-1	2/13/2001	7.5	17.4	11.76	5610	18	0.09	11.4	2000	560	252	2640	0.0132	0.0299
NP-1	3/16/2001		18.4	11.38	5640	18	0.03	7.5	2400	760	252	2240	0.0410	0.0460
NP-1	4/18/2001	7.62	19.3	9.61	5310	16	0.15	0.9	2150	760	200	2200	0.0230	0.0550
NP-1	5/15/2001	7.63	20.2	8.29	4800	17	0.03	1.1	2850	960	224	2600	0.0179	0.0482
NP-1	6/18/2001	7.46	21.3	9.6	5800	8	0.14	9.5		760	228	2760	0.0194	0.0436
NP_1	7/16/2001	6.39	23.7	11.78	5170	17	0.03	6.0	2800	760	224	2820	0.0229	0.0193
NP_1	8/20/2001	7.7	21.5	6.06	5800	12	0.13	6.7	2350	840	268	2920	0.0160	0.0276
NP_1	9/17/2001	7.71	18.7	7	5770	12	0.11	12.5	2250	760	264	2640	0.0172	0.0294
NP_1	10/8/2001	7.68	17.9	6.91	5380	11	0.07	11.8	1850	680	244	2400	0.0203	0.0218
NP_1	11/5/2001	6.9	17.9	7.32	5340	14	0.07	9.7	1900	680	224	2560	0.0210	0.0302
NP_1	12/3/2001	7.94	13.2	8.89	5680	11	0.05	12.9	2700	680	240	2640		
NP-8	1/16/2001	8.2	7.2	15.86	3160		0.1	3.5	1100	480	124	1280		
NP-8	2/13/2001	8	11.8	11.3	5730	22	0.12	11.6	1750	800	240		0.0126	0.0306
NP-8	3/16/2001	7.8	17.6	11.25	5650	18	0.08	8.5	2200	880	228	2560	0.0770	0.0160
NP-8	4/18/2001	7.83	20.8	9.84	5610	25	0.18	0.7	2350	820	220	2600	0.0143	0.0365
NP-8	5/15/2001	7.82	24.5	8.37	5480	23	0.02	0.9	2900	920	212	2520	0.0234	0.0559
NP-8	6/18/2001	7.14	25.9	7.9	6160	16	0.1	5.2		800	148	2720	0.0190	0.0384
NP_8	7/16/2001	7.93	27.7	5.81	4890	40	0.16	1.5	2750	720	160	2520	0.0112	0.0337
NP_8	8/20/2001	8.34	27.4	7.62	5840	16	0.11	2.6	2450	840	160	2760	0.0207	0.0262
NP_8	9/17/2001	8	23.3	7.99	5920	11	0.09	8.1	2350	800	188	2560	0.0116	0.0259
NP_8	10/8/2001	8.04	20.7	8.61	5530	11	0.06	10.9	1950	760	192	2240	0.0194	0.0259
NP_8	11/5/2001	7.27	16.1	9.67	5610	13	0.04	10.6	2450	720	200	2340	0.0184	0.0347
NP_8	12/3/2001	6.8	8.7	9.7	5630	12	0.01	9.5	2000	640	228	2440		
Average=	**NP-1**	7.45	18.8	9.15	5494	14	0.10	8.64	2318	740	241	2602	0.021	0.035
	NP-8	7.764	19.3	9.49	5434	19	0.09	6.13	2205	765	192	2413	0.023	0.032
Std Deviation=	**NP-1**	0.44	2.73	2.06	303	3.41	0.08	4.34	347	99	21	224	0.008	0.012
	NP-8	0.46	7.10	2.54	777	9	0.05	4.18	498	117	37	404	0.020	0.011

Water Quality Parameters at the CCWPNP Inflow and Outflow for 2001 (Based on HRC Data) Cont.

Sampling Site	Sampling Date	Cadmium (mg/l)	Copper (mg/l)	Manganese (mg/l)	Nickel (mg/l)	Zinc (mg/l)	TDS (mg/l)	TSS (mg/l)	E. Coli (CFU/100 ml)	Coliforms (CFU/100 ml)
NP-1	1/16/2001								420	130.0
NP-1	2/13/2001	0.0012	0.0020	0.0119	0.0039	0.0079			180	277.0
NP-1	3/16/2001	0.0001	0.0020	0.0600	0.0060	0.0160	5300			
NP-1	4/18/2001	0.0005	0.0022	0.0175	0.0093	0.0086	5300		235	135.0
NP-1	5/15/2001	0.0013	0.0007	0.0010	0.0029	0.0024			350	160.0
NP-1	6/18/2001	0.0013	0.0009	0.0079	0.0028	0.0030	5500		120	10.0
NP_1	7/16/2001		0.0008	0.0115	0.0016	0.0032	4800		3000	3050.0
NP_1	8/20/2001	0.0076	0.0077	0.0341	0.0062	0.1387	5520	4	1565	
NP_1	9/17/2001	0.0004	0.0008	0.0395	0.0052	0.0009	5480	24	480	2140.0
NP_1	10/8/2001			0.0326	0.0038	0.0150	5100	20		
NP_1	11/5/2001		0.0004	0.0283	0.0025	below det	5220	12		
NP_1	12/3/2001						5420	5		
NP-8	1/16/2001								60	265
NP-8	2/13/2001	0.0013	0.0009	0.0258	0.0039	0.0061			100	90
NP-8	3/16/2001	0.0001	0.0030	0.0360	0.0040	0.0120	5450			
NP-8	4/18/2001	0.0014	0.0015	0.0211	0.0044	0.1548			170	55.0
NP-8	5/15/2001	0.0014	0.0018	0.0122	0.0067	0.0074			0	10.0
NP-8	6/18/2001	0.0014	0.0018	0.0054	0.0044	0.0117			30	0.0
NP_8	7/16/2001		0.0028	0.0407	0.0067	0.0113	4450	23	100	200.0
NP_8	8/20/2001	0.0075	0.0013	0.0066	0.0053	0.0134	5580	8	10	
NP_8	9/17/2001	0.0004	0.0006	0.0016	0.0043	0.0130	5680	8	10	60.0
NP_8	10/8/2001			0.0013	0.0020	0.0036	5060	4		
NP_8	11/5/2001	0.0010		0.0013	0.0035	0.0177	5300	4		
NP_8	12/3/2001						5280	5		
Average=	**NP-1**	0.002	0.002	0.024	0.004	0.022	5293	13	794	843
	NP-8	0.002	0.002	0.015	0.005	0.025	5257	9	60	97
Std Deviation=	**NP-1**	0.003	0.002	0.018	0.002	0.044	232	9	1003	1228
	NP-8	0.002	0.001	0.015	0.001	0.046	411	7	60	99

Water Quality Parameters at the CCWPNP Inflow and Outflow for 2002 (Based on HRC Data)

Sampling Site	Sampling Date	pH (SU)	Temperature (°C)	DO (mg/l)	Spec.Conduct. (µmhos/Cm)	Turbidity (FTU)	Ortho P (mg/l)	NO3-N (mg/l)	Sulfates (mg/l)	Chlorides (mg/l)	Alkalinity (mg/l)	Hardness (mg/l)	Selenium (mg/l)	Arsenic (mg/l)
NP-1	1/23/2002	6.92	9.1	8.54	5800	10	0.05	12.00	2350	680	260	2600	0.0206	0.0293
NP-1	2/25/2002	7.8	12.6	8.37	5600	14	0.01	10.10	2325	680	228	2400	0.0086	0.0126
NP-1	3/25/2002	7.65	12.3	5.98	5070	16	0.04	5.10	2350	600	224	2120	0.0156	0.0112
NP-1	4/29/2002	7.65	17.6	6.97	5375	18.5	0.12	5.80	2850	680	192	2480	0.0210	0.0035
NP-1	5/20/2002	7.63	17.2	9.32	5325	12	0.09	6.50	2850	640	200	2600	0.0202	0.0320
NP-1	6/24/2002	7.73	20.4	6.63	5155	5	1.31	8.60	2850	600	208	2440	0.0140	0.0140
NP_1	7/22/2002	7.6	23.2	5.01	5000	12	0.31	7.80	3100	760	172	2360	0.0138	0.0139
NP_1	8/27/2002	7.61	20.7	5.21	4870	7	2.79	3.30	2500	560	160	2280	0.0253	0.0163
NP_1	9/23/2002	7.48	20.2	5.58	5330	12	0.09	8.30	2800	640	208	2680	0.0176	0.0247
NP_1	10/21/2002	7.54	16.2	6.83	5050	8	0.94	5.00	2450	600	192	2340	0.0184	0.0287
NP_1	11/18/2002	8	9.7	9.28	5120	10	1.28	4.90	2250	600	236	2640	0.0245	0.0192
NP_1	12/16/2002	7.91	11.7	8.45	5080	8	0.01	3.80	2600	600	228	2440	0.0260	0.0199
NP-8	1/23/2002	8.2	5.5	10.61	5660	9	0.06	9.2	2700	800	236	2560	0.0112	0.0145
NP-8	2/25/2002	8.27	12.5	10.66	5670	18	0.01	6.5	2100	680	224	2680	0.0099	0.0118
NP-8	3/25/2002	8.18	13.9	9.05	5520	21	0.05	4.9	2500	720	184	2400	0.0215	0.0165
NP-8	4/29/2002	7.89	18.8	8.89	5575	14	0.01	3.8	3150	680	180	2480	0.0204	0.0034
NP-8	5/20/2002	8.16	19.9	10.11	5495	11	0.03	2.9	2600	640	200	2640	0.0179	0.0223
NP-8	6/24/2002	6.9	25.2	12.01	5435	12	0.15	2.8	3250	680	104	2520	0.0182	0.0146
NP_8	7/22/2002	7.21	25.6	2.58	4990	15	0.28	4.2	2850	680	120	2440	0.0182	0.0140
NP_8	8/27/2002	6.61	21.6	4.18	2650	12	0.3	8.1	750	480	120	960	0.0064	0.0064
NP_8	9/23/2002	8.01	20.3	5.16	2490	18	0.04	12.7	550	400	120	880	0.0053	0.0047
NP_8	10/21/2002	7.81	15.2	8.68	5140	14	0.76	2.2	3000	600	172	2480	0.0200	0.0186
NP_8	11/18/2002	8.27	9.7	11.03	5040	16	0.88	3.7	2450	600	230	2480	0.0247	0.0160
NP_8	12/16/2002	8.15	8.1	10.54	5100	16	0.16	2.9	2500	600	244	2360	0.0227	0.0264
Average=	**NP-1**	7.63	15.91	7.18	5231	11	0.59	6.77	2606	637	209	2448	0.019	0.019
	NP-8	7.81	16.36	8.63	4897	15	0.23	5.33	2367	630	178	2240	0.016	0.014
Std Deviation=	**NP-1**	0.27	4.73	1.56	267	3.88	0.85	2.64	275	55	28	164	0.005	0.009
	NP-8	0.57	6.59	3.01	1114	3.39	0.29	3.20	865	107	51	623	0.006	0.007

Water Quality Parameters at the CCWPNP Inflow and Outflow for 2002 (Based on HRC Data) Cont.

Sampling Site	Sampling Date	Cadmium (mg/l)	Copper (mg/l)	Manganese (mg/l)	Nickel (mg/l)	Zinc (mg/l)	TDS (mg/l)	TSS (mg/l)	E. Coli (CFU/100 ml)	Coliforms (CFU/100 ml)	NH3-N (mg/L-N)
NP-1	1/23/2002	0.0001	0.0002	0.0265	0.0046	below det.	5332	10	150	250.0	na
NP-1	2/25/2002	0.0044		0.0127	0.0014	below det.	5420	9	150	500.0	na
NP-1	3/25/2002	0.0039	0.0001	0.0811	0.0027	0.0090	4680	12	2930	6500.0	na
NP-1	4/29/2002	0.0025	0.0017	0.0255	0.0041	0.0051	5490	6	250	496.7	na
NP-1	5/20/2002	0.0024	0.0015	0.0175	0.0043	0.0144	5710	5	93	223.3	below det.
NP-1	6/24/2002	0.0026	0.0008	0.0181	0.0032	0.0033	4920	8	413	533.3	below det.
NP_1	7/22/2002	0.0000	0.0010	0.0083	0.0022	0.0025	5070	8	583	2740.0	0.25
NP_1	8/27/2002	0.0001	0.0006	0.0035	0.0011	0.0035	4670	4	680	933.3	0.21
NP_1	9/23/2002	0.0002	0.0043	0.0068	0.0045	0.0042	5540	4	1767	2833.3	0.15
NP_1	10/21/2002	0.0001	0.0024	0.0086	0.0025	0.0295	5160	15	103	756.7	0.06
NP_1	11/18/2002	ND	ND	0.0088	0.0016	0.0011	4860	5	133.3	266.6	
NP_1	12/16/2002	ND	ND	0.0172	0.0043	0.0011	5140	3	87	113.3	0.12
NP-8	1/23/2002	0.0001	below det.	0.0046	0.0004	below det.	5348	11	150	1	na
NP-8	2/25/2002	0.0043	below det.	0.0050	0.0021	below det.	5420	10	1	1	na
NP-8	3/25/2002	0.0041	0.0006	0.0297	0.0034	0.0057	5290	4	803	1410.0	na
NP-8	4/29/2002	0.0026	0.0014	0.0107	0.0053	0.0113	5810	7	6.66	3.3	na
NP-8	5/20/2002	0.0021	0.0008	0.0072	0.0037	0.0085	6230	4	103.33	40.0	below det.
NP-8	6/24/2002	0.0025	0.0008	0.0025	0.0033	0.0207	5200	36	18.66	44.0	below det.
NP_8	7/22/2002	0.0001	0.0007	0.0029	0.0032	0.0387	5220		13.3	16.6	0.14
NP_8	8/27/2002	0.0002	0.0027	0.0024	0.0027	0.0448	2090	10	1213.3	1616.7	0.29
NP_8	9/23/2002	0.0002	0.0012	0.0025	0.0038	0.0201	1970	1	480	523.3	0.27
NP_8	10/21/2002	0.0001	0.0036	0.0011	0.0056	0.0459	5390	5	110	320.0	0.24
NP_8	11/18/2002	0.0003	ND	0.0051	0.0067	0.0201	4710	9	3.33	6.7	
NP_8	12/16/2002	ND	ND	0.0161	0.0031	0.0188	4640	18	211.66	220.0	0.28
Average=	**NP-1**	0.002	0.001	0.020	0.003	0.007	5166	7	611.7	1345.5	0.16
	NP-8	0.001	0.001	0.007	0.004	0.023	4777	10	259.5	350.2	0.24
Std Deviation=	**NP-1**	0.002	0.001	0.021	0.001	0.009	341	4	870.9	1870.4	0.07
	NP-8	0.002	0.001	0.008	0.002	0.015	1350	10	384.9	568.8	0.06

APPENDIX B

WATER QUALITY PARAMETERS OF THE CLARK COUNTY WETLANDS PARK NATURE PRESERVE INFLOW AND OUTFLOW - DESCRIPTIVE STATISTICS ANALYSIS - 2001 AND 2002 DATA

NP-1 2001 Data

Phosphorus (mg/L)		*PH (SU)*	
Mean	0.10	Mean	7.45
Standard Error	0.02	Standard Error	0.13
Median	0.08	Median	7.62
Mode	0.03	Mode	
Standard Deviation	0.08	Standard Deviation	0.44
Sample Variance	0.01	Sample Variance	0.19
Kurtosis	4.17	Kurtosis	2.91
Skewness	1.81	Skewness	-1.71
Range	0.28	Range	1.55
Minimum	0.03	Minimum	6.39
Maximum	0.31	Maximum	7.94
Sum	1.21	Sum	81.93
Count	12.00	Count	11.00
Confidence Level(95.0%)	0.05	Confidence Level(95.0%)	0.29

Temperature (°C)		*DO (mg/L)*	
Mean	18.8	Mean	9.15
Standard Error	0.8	Standard Error	0.59
Median	18.6	Median	9.25
Mode	17.9	Mode	#N/A
Standard Deviation	2.7	Standard Deviation	2.06
Sample Variance	7.5	Sample Variance	4.25
Kurtosis	0.8	Kurtosis	-1.53
Skewness	-0.2	Skewness	-0.02
Range	10.5	Range	5.72
Minimum	13.2	Minimum	6.06
Maximum	23.7	Maximum	11.78
Sum	225.6	Sum	109.81
Count	12.0	Count	12.00
Confidence Level(95.0%)	1.7	Confidence Level(95.0%)	1.31

NP-1 2001 Data

Spec. Conductance (µmhos/cm)		*Turbidity (FTU)*	
Mean	5494	Mean	14
Standard Error	87	Standard Error	1.03
Median	5620	Median	14.00
Mode	5800	Mode	18.00
Standard Deviation	303	Standard Deviation	3.41
Sample Variance	91681	Sample Variance	11.60
Kurtosis	1	Kurtosis	-1.20
Skewness	-1	Skewness	-0.30
Range	1000	Range	10.00
Minimum	4800	Minimum	8.00
Maximum	5800	Maximum	18.00
Sum	65930	Sum	154.00
Count	12	Count	11.00
Confidence Level(95.0%)	192	Confidence Level(95.0%)	2.29

Nitrate (mg/L)		*Sulfates (mg/L)*	
Mean	8.64	Mean	2318
Standard Error	1.25	Standard Error	105
Median	9.60	Median	2250
Mode	#N/A	Mode	2250
Standard Deviation	4.34	Standard Deviation	347
Sample Variance	18.81	Sample Variance	120136
Kurtosis	-0.36	Kurtosis	-1
Skewness	-0.80	Skewness	0
Range	12.80	Range	1000
Minimum	0.90	Minimum	1850
Maximum	13.70	Maximum	2850
Sum	103.70	Sum	25500
Count	12.00	Count	11
Confidence Level(95.0%)	2.76	Confidence Level(95.0%)	233

NP-1 2001 Data

Chlorides (mg/L)		*Alkalinity (mg/L)*	
Mean	740	Mean	240.67
Standard Error	28.50	Standard Error	6.13
Median	760.00	Median	242.00
Mode	760.00	Mode	224.00
Standard Deviation	98.72	Standard Deviation	21.22
Sample Variance	9745.45	Sample Variance	450.42
Kurtosis	1.85	Kurtosis	-0.59
Skewness	0.57	Skewness	-0.30
Range	400.00	Range	68.00
Minimum	560.00	Minimum	200.00
Maximum	960.00	Maximum	268.00
Sum	8880.00	Sum	2888.00
Count	12.00	Count	12.00
Confidence Level(95.0%)	62.72	Confidence Level(95.0%)	13.48

Hardness (mg/L)		*Selenium (mg/L)*	
Mean	2602	Mean	0.021
Standard Error	65	Standard Error	0.002
Median	2640	Median	0.02
Mode	2640	Mode	#N/A
Standard Deviation	224	Standard Deviation	0.008
Sample Variance	50215	Sample Variance	0.0001
Kurtosis	0	Kurtosis	6.06
Skewness	-1	Skewness	2.22
Range	720	Range	0.03
Minimum	2200	Minimum	0.013
Maximum	2920	Maximum	0.041
Sum	31220	Sum	0.21
Count	12	Count	10.00
Confidence Level(95.0%)	142	Confidence Level(95.0%)	0.01

NP-1 2001 Data

Arsenic (mg/L)		*Cadmium (mg/L)*	
Mean	0.035	Mean	0.002
Standard Error	0.004	Standard Error	0.001
Median	0.030	Median	0.001
Mode	#N/A	Mode	0.001
Standard Deviation	0.012	Standard Deviation	0.003
Sample Variance	0.000	Sample Variance	0.000
Kurtosis	-1.271	Kurtosis	6.256
Skewness	0.379	Skewness	2.457
Range	0.036	Range	0.008
Minimum	0.019	Minimum	0.000
Maximum	0.055	Maximum	0.008
Sum	0.351	Sum	0.012
Count	10.000	Count	7.000
Confidence Level(95.0%)	0.009	Confidence Level(95.0%)	0.002

Copper (mg/L)		*Manganese (mg/L)*	
Mean	0.002	Mean	0.024
Standard Error	0.001	Standard Error	0.006
Median	0.001	Median	0.023
Mode	0.002	Mode	#N/A
Standard Deviation	0.002	Standard Deviation	0.018
Sample Variance	0.000	Sample Variance	0.000
Kurtosis	6.837	Kurtosis	0.186
Skewness	2.521	Skewness	0.688
Range	0.007	Range	0.059
Minimum	0.000	Minimum	0.001
Maximum	0.008	Maximum	0.060
Sum	0.018	Sum	0.244
Count	9.000	Count	10.000
Confidence Level(95.0%)	0.002	Confidence Level(95.0%)	0.013

NP-1 2001 Data

Nickel (mg/L)		*Zinc (mg/L)*	
Mean	0.004	Mean	0.022
Standard Error	0.001	Standard Error	0.015
Median	0.004	Median	0.008
Mode	#N/A	Mode	#N/A
Standard Deviation	0.002	Standard Deviation	0.044
Sample Variance	0.000	Sample Variance	0.002
Kurtosis	0.975	Kurtosis	8.611
Skewness	1.021	Skewness	2.914
Range	0.008	Range	0.138
Minimum	0.002	Minimum	0.001
Maximum	0.009	Maximum	0.139
Sum	0.044	Sum	0.196
Count	10.000	Count	9.000
Confidence Level(95.0%)	0.002	Confidence Level(95.0%)	0.034

TDS (mg/L)		*TSS (mg/L)*	
Mean	5293	Mean	13
Standard Error	77	Standard Error	3.97
Median	5300	Median	12.00
Mode	5300	Mode	#N/A
Standard Deviation	232	Standard Deviation	8.89
Sample Variance	53900	Sample Variance	79.00
Kurtosis	2	Kurtosis	-2.45
Skewness	-1	Skewness	0.26
Range	720	Range	20.00
Minimum	4800	Minimum	4.00
Maximum	5520	Maximum	24.00
Sum	47640	Sum	65.00
Count	9	Count	5.00
Confidence Level(95.0%)	178	Confidence Level(95.0%)	11.04

NP-1 2001 Data

E. Coli (cfu/ 100 mL)		*Coliforms (cfu/ 100 mL)*	
Mean	794	Mean	843.14
Standard Error	355	Standard Error	464.03
Median	385	Median	160.00
Mode	#N/A	Mode	#N/A
Standard Deviation	1003	Standard Deviation	1227.70
Sample Variance	1005748	Sample Variance	1507237.48
Kurtosis	3	Kurtosis	0.32
Skewness	2	Skewness	1.40
Range	2880	Range	3040.00
Minimum	120	Minimum	10.00
Maximum	3000	Maximum	3050.00
Sum	6350	Sum	5902.00
Count	8	Count	7.00
Confidence Level(95.0%)	838	Confidence Level(95.0%)	1135.43

NP-8 2001 Data

PH (SU)		*Temperature (°C)*	
Mean	7.76	Mean	19.31
Standard Error	0.13	Standard Error	2.05
Median	7.88	Median	20.75
Mode	8.00	Mode	#N/A
Standard Deviation	0.46	Standard Deviation	7.10
Sample Variance	0.21	Sample Variance	50.47
Kurtosis	0.38	Kurtosis	-0.97
Skewness	-1.06	Skewness	-0.55
Range	1.54	Range	20.50
Minimum	6.80	Minimum	7.20
Maximum	8.34	Maximum	27.70
Sum	93.17	Sum	231.70
Count	12.00	Count	12.00
Confidence Level(95.0%)	0.29	Confidence Level(95.0%)	4.51

NP-8 2001 Data

DO (mg/L)		*Turbidity (FTU)*	
Mean	9.49	Mean	19
Standard Error	0.73	Standard Error	3
Median	9.14	Median	16
Mode	#N/A	Mode	16
Standard Deviation	2.54	Standard Deviation	9
Sample Variance	6.45	Sample Variance	73
Kurtosis	3.05	Kurtosis	3
Skewness	1.35	Skewness	2
Range	10.05	Range	29
Minimum	5.81	Minimum	11
Maximum	15.86	Maximum	40
Sum	113.92	Sum	207
Count	12.00	Count	11
Confidence Level(95.0%)	1.61	Confidence Level(95.0%)	6

Spec. Conductance (µmhos/cm)		*Phosphorus (mg/L)*	
Mean	5434	Mean	0.09
Standard Error	224	Standard Error	0.01
Median	5620	Median	0.10
Mode	5610	Mode	0.10
Standard Deviation	777	Standard Deviation	0.05
Sample Variance	603736	Sample Variance	0.00
Kurtosis	8	Kurtosis	-0.41
Skewness	-3	Skewness	0.14
Range	3000	Range	0.17
Minimum	3160	Minimum	0.01
Maximum	6160	Maximum	0.18
Sum	65210	Sum	1.07
Count	12	Count	12.00
Confidence Level(95.0%)	494	Confidence Level(95.0%)	0.03

NP-8 2001 Data

Nitrate (mg/L)		*Sulfate (mg/L)*	
Mean	6.13	Mean	2205
Standard Error	1.21	Standard Error	150
Median	6.65	Median	2350
Mode	#N/A	Mode	2350
Standard Deviation	4.18	Standard Deviation	498
Sample Variance	17.46	Sample Variance	247727
Kurtosis	-1.83	Kurtosis	1
Skewness	-0.07	Skewness	-1
Range	10.90	Range	1800
Minimum	0.70	Minimum	1100
Maximum	11.60	Maximum	2900
Sum	73.60	Sum	24250
Count	12.00	Count	11
Confidence Level(95.0%)	2.65	Confidence Level(95.0%)	334

Choride (mg/L)		*Alkanility (mg/L)*	
Mean	765	Mean	192
Standard Error	34	Standard Error	11
Median	800	Median	196
Mode	800	Mode	228
Standard Deviation	117	Standard Deviation	37
Sample Variance	13682	Sample Variance	1342
Kurtosis	2	Kurtosis	-1
Skewness	-1	Skewness	0
Range	440	Range	116
Minimum	480	Minimum	124
Maximum	920	Maximum	240
Sum	9180	Sum	2300
Count	12	Count	12
Confidence Level(95.0%)	74	Confidence Level(95.0%)	23

NP-8 2001 Data

Hardness (mg/L)		*Cadmium (mg/L)*	
Mean	2413	Mean	0.002
Standard Error	122	Standard Error	0.001
Median	2520	Median	0.001
Mode	2560	Mode	0.001
Standard Deviation	404	Standard Deviation	0.002
Sample Variance	163542	Sample Variance	0.000
Kurtosis	7	Kurtosis	6.980
Skewness	-3	Skewness	2.567
Range	1480	Range	0.007
Minimum	1280	Minimum	0.000
Maximum	2760	Maximum	0.008
Sum	26540	Sum	0.015
Count	11	Count	8.000
Confidence Level(95.0%)	272	Confidence Level(95.0%)	0.002

Selenium (mg/L)		*Arsenic (mg/L)*	
Mean	0.023	Mean	0.032
Standard Error	0.006	Standard Error	0.003
Median	0.019	Median	0.032
Mode	#N/A	Mode	0.026
Standard Deviation	0.020	Standard Deviation	0.011
Sample Variance	0.000	Sample Variance	0.000
Kurtosis	8.787	Kurtosis	2.364
Skewness	2.897	Skewness	0.954
Range	0.066	Range	0.040
Minimum	0.011	Minimum	0.016
Maximum	0.077	Maximum	0.056
Sum	0.228	Sum	0.324
Count	10.000	Count	10.000
Confidence Level(95.0%)	0.014	Confidence Level(95.0%)	0.008

NP-8 2001 Data

Copper (mg/L)		*Manganese (mg/L)*	
Mean	0.002	Mean	0.015
Standard Error	0.000	Standard Error	0.005
Median	0.002	Median	0.009
Mode	0.002	Mode	0.001
Standard Deviation	0.001	Standard Deviation	0.015
Sample Variance	0.000	Sample Variance	0.000
Kurtosis	-0.718	Kurtosis	-0.970
Skewness	0.455	Skewness	0.744
Range	0.002	Range	0.039
Minimum	0.001	Minimum	0.001
Maximum	0.003	Maximum	0.041
Sum	0.014	Sum	0.152
Count	8.000	Count	10.000
Confidence Level(95.0%)	0.001	Confidence Level(95.0%)	0.011

Nickel (mg/L)		*Zinc (mg/L)*	
Mean	0.005	Mean	0.025
Standard Error	0.000	Standard Error	0.014
Median	0.004	Median	0.012
Mode	0.004	Mode	#N/A
Standard Deviation	0.001	Standard Deviation	0.046
Sample Variance	0.000	Sample Variance	0.002
Kurtosis	0.295	Kurtosis	9.787
Skewness	0.180	Skewness	3.116
Range	0.005	Range	0.151
Minimum	0.002	Minimum	0.004
Maximum	0.007	Maximum	0.155
Sum	0.045	Sum	0.251
Count	10.000	Count	10.000
Confidence Level(95.0%)	0.001	Confidence Level(95.0%)	0.033

NP-8 2001 Data

TDS (mg/L)		*TSS (mg/L)*	
Mean	5257	Mean	9
Standard Error	155	Standard Error	3
Median	5300	Median	7
Mode	#N/A	Mode	8
Standard Deviation	411	Standard Deviation	7
Sample Variance	168824	Sample Variance	53
Kurtosis	2	Kurtosis	5
Skewness	-1	Skewness	2
Range	1230	Range	19
Minimum	4450	Minimum	4
Maximum	5680	Maximum	23
Sum	36800	Sum	52
Count	7	Count	6
Confidence Level(95.0%)	380	Confidence Level(95.0%)	8

E. Coli (cfu/ 100 mL)		*Coliforms (cfu/ 100 mL)*	
Mean	60	Mean	97
Standard Error	21	Standard Error	37
Median	45	Median	60
Mode	100	Mode	#N/A
Standard Deviation	60	Standard Deviation	99
Sample Variance	3543	Sample Variance	9832
Kurtosis	0	Kurtosis	0
Skewness	1	Skewness	1
Range	170	Range	265
Minimum	0	Minimum	0
Maximum	170	Maximum	265
Sum	480	Sum	680
Count	8	Count	7
Confidence Level(95.0%)	50	Confidence Level(95.0%)	92

NP-1 2002 Data

PH (SU)		*Temperature (°C)*	
Mean	7.63	Mean	15.91
Standard Error	0.08	Standard Error	1.36
Median	7.64	Median	16.70
Mode	7.65	Mode	#N/A
Standard Deviation	0.27	Standard Deviation	4.73
Sample Variance	0.07	Sample Variance	22.36
Kurtosis	4.40	Kurtosis	-1.40
Skewness	-1.56	Skewness	-0.04
Range	1.08	Range	14.10
Minimum	6.92	Minimum	9.10
Maximum	8.00	Maximum	23.20
Sum	91.52	Sum	190.90
Count	12.00	Count	12.00
Confidence Level(95.0%)	0.17	Confidence Level(95.0%)	3.00

DO (mg/L)		*Spec. Conductance (µmhos/cm)*	
Mean	7.18	Mean	5231
Standard Error	0.45	Standard Error	77
Median	6.90	Median	5138
Mode	#N/A	Mode	#N/A
Standard Deviation	1.56	Standard Deviation	267
Sample Variance	2.45	Sample Variance	71141
Kurtosis	-1.55	Kurtosis	1
Skewness	0.04	Skewness	1
Range	4.31	Range	930
Minimum	5.01	Minimum	4870
Maximum	9.32	Maximum	5800
Sum	86.17	Sum	62775
Count	12.00	Count	12
Confidence Level(95.0%)	0.99	Confidence Level(95.0%)	169

NP-1 2002 Data

Turbidity (FTU)		*Phosphorus (mg/L)*	
Mean	11	Mean	0.59
Standard Error	1.12	Standard Error	0.25
Median	11.00	Median	0.11
Mode	12.00	Mode	0.01
Standard Deviation	3.88	Standard Deviation	0.85
Sample Variance	15.02	Sample Variance	0.73
Kurtosis	-0.16	Kurtosis	3.27
Skewness	0.41	Skewness	1.82
Range	13.50	Range	2.78
Minimum	5.00	Minimum	0.01
Maximum	18.50	Maximum	2.79
Sum	132.50	Sum	7.04
Count	12.00	Count	12.00
Confidence Level(95.0%)	2.46	Confidence Level(95.0%)	0.54

Nitrate (mg/L)		*Sulfate (mg/L)*	
Mean	6.77	Mean	2606
Standard Error	0.76	Standard Error	79
Median	6.15	Median	2550
Mode	#N/A	Mode	2850
Standard Deviation	2.64	Standard Deviation	275
Sample Variance	6.95	Sample Variance	75696
Kurtosis	-0.31	Kurtosis	-1
Skewness	0.63	Skewness	0
Range	8.70	Range	850
Minimum	3.30	Minimum	2250
Maximum	12.00	Maximum	3100
Sum	81.20	Sum	31275
Count	12.00	Count	12
Confidence Level(95.0%)	1.68	Confidence Level(95.0%)	175

NP-1 2002 Data

Chloride (mg/L)		*Alkalinity (mg/L)*	
Mean	637	Mean	209
Standard Error	16	Standard Error	8.1
Median	620	Median	208.0
Mode	600	Mode	228.0
Standard Deviation	55	Standard Deviation	28.1
Sample Variance	3042	Sample Variance	791.6
Kurtosis	1	Kurtosis	-0.2
Skewness	1	Skewness	0.0
Range	200	Range	100.0
Minimum	560	Minimum	160.0
Maximum	760	Maximum	260.0
Sum	7640	Sum	2508.0
Count	12	Count	12.0
Confidence Level(95.0%)	35	Confidence Level(95.0%)	17.87679165

Hardness (mg/L)		*Selenium (mg/L)*	
Mean	2448	Mean	0.019
Standard Error	47	Standard Error	0.002
Median	2440	Median	0.019
Mode	2600	Mode	#N/A
Standard Deviation	164	Standard Deviation	0.005
Sample Variance	26870	Sample Variance	0.000
Kurtosis	0	Kurtosis	-0.309
Skewness	0	Skewness	-0.363
Range	560	Range	0.017
Minimum	2120	Minimum	0.009
Maximum	2680	Maximum	0.026
Sum	29380	Sum	0.226
Count	12	Count	12.000
Confidence Level(95.0%)	104	Confidence Level(95.0%)	0.003

NP-1 2002 Data

Arsenic (mg/L)		*Cadmium (mg/L)*	
Mean	0.019	Mean	0.002
Standard Error	0.002	Standard Error	0.001
Median	0.018	Median	0.001
Mode	#N/A	Mode	#N/A
Standard Deviation	0.009	Standard Deviation	0.002
Sample Variance	0.000	Sample Variance	0.000
Kurtosis	-0.656	Kurtosis	-1.518
Skewness	0.035	Skewness	0.461
Range	0.029	Range	0.004
Minimum	0.004	Minimum	0.000
Maximum	0.032	Maximum	0.004
Sum	0.225	Sum	0.016
Count	12.000	Count	10.000
Confidence Level(95.0%)	0.005	Confidence Level(95.0%)	0.001

Copper (mg/L)		*Manganese (mg/L)*	
Mean	0.001	Mean	0.020
Standard Error	0.000	Standard Error	0.006
Median	0.001	Median	0.015
Mode	#N/A	Mode	#N/A
Standard Deviation	0.001	Standard Deviation	0.021
Sample Variance	0.000	Sample Variance	0.000
Kurtosis	2.436	Kurtosis	8.404
Skewness	1.479	Skewness	2.745
Range	0.004	Range	0.078
Minimum	0.000	Minimum	0.004
Maximum	0.004	Maximum	0.081
Sum	0.013	Sum	0.235
Count	9.000	Count	12.000
Confidence Level(95.0%)	0.001	Confidence Level(95.0%)	0.013

NP-1 2002 Data

Nickel (mg/L)		*Zinc (mg/L)*	
Mean	0.003	Mean	0.007
Standard Error	0.000	Standard Error	0.003
Median	0.003	Median	0.004
Mode	#N/A	Mode	#N/A
Standard Deviation	0.001	Standard Deviation	0.009
Sample Variance	0.000	Sample Variance	0.000
Kurtosis	-1.610	Kurtosis	4.788
Skewness	-0.190	Skewness	2.149
Range	0.003	Range	0.028
Minimum	0.001	Minimum	0.001
Maximum	0.005	Maximum	0.030
Sum	0.037	Sum	0.074
Count	12.000	Count	10.000
Confidence Level(95.0%)	0.001	Confidence Level(95.0%)	0.006

TDS (mg/L)		*TSS (mg/L)*	
Mean	5166	Mean	7
Standard Error	98.14	Standard Error	1.05
Median	5140	Median	7.00
Mode	#N/A	Mode	5.00
Standard Deviation	341.01	Standard Deviation	3.62
Sample Variance	116287	Sample Variance	13.13
Kurtosis	-1	Kurtosis	0.11
Skewness	0	Skewness	0.82
Range	1040	Range	12.00
Minimum	4670	Minimum	3.00
Maximum	5710	Maximum	15.00
Sum	61992	Sum	88.90
Count	12	Count	12.00
Confidence Level(95.0%)	216.67	Confidence Level(95.0%)	2.30

NP-1 2002 Data

E. Coli (cfu/100 mL)		*Coliforms (cfu/100 mL)*	
Mean	611.66	Mean	1345.55
Standard Error	251.39	Standard Error	539.42
Median	200	Median	516.67
Mode	150	Mode	#N/A
Standard Deviation	870.85	Standard Deviation	1870.3
Sample Variance	758382	Sample Variance	3498198
Kurtosis	4.47	Kurtosis	5.3
Skewness	2.18	Skewness	2.3
Range	2843.34	Range	6586.7
Minimum	86.66	Minimum	113.3
Maximum	2930	Maximum	6500
Sum	7239.45	Sum	16146
Count	12	Count	12
Confidence Level(95.0%)	553.31	Confidence Level(95.0%)	1188.3

Ammonia (mg/L-N)	
Mean	0.158
Standard Error	0.033
Median	0.150
Mode	#N/A
Standard Deviation	0.075
Sample Variance	0.006
Kurtosis	-1.019
Skewness	-0.077
Range	0.190
Minimum	0.060
Maximum	0.250
Sum	0.790
Count	5.000
Confidence Level(95.0%)	0.093

NP-8 2002 Data

pH (SU)		Temperature (°C)	
Mean	7.81	Mean	16.36
Standard Error	0.17	Standard Error	1.90
Median	8.08	Median	17.00
Mode	8.27	Mode	#N/A
Standard Deviation	0.57	Standard Deviation	6.59
Sample Variance	0.33	Sample Variance	43.44
Kurtosis	0.33	Kurtosis	-1.08
Skewness	-1.30	Skewness	-0.18
Range	1.66	Range	20.10
Minimum	6.61	Minimum	5.50
Maximum	8.27	Maximum	25.60
Sum	93.66	Sum	196.30
Count	12.00	Count	12.00
Confidence Level(95.0%)	0.36	Confidence Level(95.0%)	4.19

DO (mg/L)		*Spec. Conductance (μmhos/cm)*	
Mean	8.63	Mean	4897
Standard Error	0.87	Standard Error	322
Median	9.58	Median	5288
Mode	#N/A	Mode	#N/A
Standard Deviation	3.01	Standard Deviation	1114
Sample Variance	9.07	Sample Variance	1240598
Kurtosis	-0.04	Kurtosis	2
Skewness	-1.08	Skewness	-2
Range	9.43	Range	3180
Minimum	2.58	Minimum	2490
Maximum	12.01	Maximum	5670
Sum	103.50	Sum	58765
Count	12.00	Count	12
Confidence Level(95.0%)	1.91	Confidence Level(95.0%)	708

NP-8 2002 Data

Turbidity (FTU)		*Phosphorus (mg/L)*	
Mean	15	Mean	0.23
Standard Error	1	Standard Error	0.09
Median	15	Median	0.11
Mode	18	Mode	0.01
Standard Deviation	3	Standard Deviation	0.29
Sample Variance	12	Sample Variance	0.09
Kurtosis	0	Kurtosis	1.61
Skewness	0	Skewness	1.63
Range	12	Range	0.87
Minimum	9	Minimum	0.01
Maximum	21	Maximum	0.88
Sum	176	Sum	2.73
Count	12	Count	12.00
Confidence Level(95.0%)	2	Confidence Level(95.0%)	0.19

Nitrate (mg/L)		*Sulfate (mg/L)*	
Mean	5.33	Mean	2367
Standard Error	0.92	Standard Error	250
Median	4.00	Median	2550
Mode	2.90	Mode	2500
Standard Deviation	3.20	Standard Deviation	865
Sample Variance	10.25	Sample Variance	747424
Kurtosis	1.16	Kurtosis	1
Skewness	1.32	Skewness	-1
Range	10.50	Range	2700
Minimum	2.20	Minimum	550
Maximum	12.70	Maximum	3250
Sum	63.90	Sum	28400
Count	12.00	Count	12
Confidence Level(95.0%)	2.03	Confidence Level(95.0%)	549

NP-8 2002 Data

Chloride (mg/L)		*Alkalinity (mg/L)*	
Mean	630	Mean	178
Standard Error	31	Standard Error	15
Median	660	Median	182
Mode	680	Mode	120
Standard Deviation	107	Standard Deviation	51
Sample Variance	11382	Sample Variance	2606
Kurtosis	1	Kurtosis	-2
Skewness	-1	Skewness	0
Range	400	Range	140
Minimum	400	Minimum	104
Maximum	800	Maximum	244
Sum	7560	Sum	2134
Count	12	Count	12
Confidence Level(95.0%)	68	Confidence Level(95.0%)	32

Hardness (mg/L)		*Selenium (mg/L)*	
Mean	2240	Mean	0.016
Standard Error	180	Standard Error	0.002
Median	2480	Median	0.018
Mode	2480	Mode	#N/A
Standard Deviation	623	Standard Deviation	0.006
Sample Variance	388655	Sample Variance	0.000
Kurtosis	2	Kurtosis	-0.940
Skewness	-2	Skewness	-0.663
Range	1800	Range	0.019
Minimum	880	Minimum	0.005
Maximum	2680	Maximum	0.025
Sum	26880	Sum	0.196
Count	12	Count	12.000
Confidence Level(95.0%)	396	Confidence Level(95.0%)	0.004

NP-8 2002 Data

Arsenic (mg/L)		*Copper (mg/L)*	
Mean	0.014	Mean	0.001
Standard Error	0.002	Standard Error	0.000
Median	0.015	Median	0.001
Mode	#N/A	Mode	0.001
Standard Deviation	0.007	Standard Deviation	0.001
Sample Variance	0.000	Sample Variance	0.000
Kurtosis	-0.287	Kurtosis	0.876
Skewness	-0.001	Skewness	1.403
Range	0.023	Range	0.003
Minimum	0.003	Minimum	0.001
Maximum	0.026	Maximum	0.004
Sum	0.169	Sum	0.012
Count	12.000	Count	8.000
Confidence Level(95.0%)	0.004	Confidence Level(95.0%)	0.001

Cadmium (mg/L)		*Zinc (mg/L)*	
Mean	0.001	Mean	0.023
Standard Error	0.001	Standard Error	0.005
Median	0.000	Median	0.020
Mode	#N/A	Mode	#N/A
Standard Deviation	0.002	Standard Deviation	0.015
Sample Variance	0.000	Sample Variance	0.000
Kurtosis	-0.793	Kurtosis	-1.076
Skewness	0.779	Skewness	0.602
Range	0.004	Range	0.040
Minimum	0.000	Minimum	0.006
Maximum	0.004	Maximum	0.046
Sum	0.012	Sum	0.235
Count	9.000	Count	10.000
Confidence Level(95.0%)	0.001	Confidence Level(95.0%)	0.010

NP-8 2002 Data

Manganese (mg/L)		*Nickel (mg/L)*	
Mean	0.007	Mean	0.004
Standard Error	0.002	Standard Error	0.000
Median	0.005	Median	0.003
Mode	#N/A	Mode	#N/A
Standard Deviation	0.008	Standard Deviation	0.002
Sample Variance	0.000	Sample Variance	0.000
Kurtosis	4.888	Kurtosis	0.654
Skewness	2.164	Skewness	0.137
Range	0.029	Range	0.006
Minimum	0.001	Minimum	0.000
Maximum	0.030	Maximum	0.007
Sum	0.090	Sum	0.043
Count	12.000	Count	12.000
Confidence Level(95.0%)	0.005	Confidence Level(95.0%)	0.001

E. Coli (cfu/100 mL)		*Coliforms (cfu/100 mL)*	
Mean	259.5	Mean	350.2
Standard Error	111.1	Standard Error	164.19
Median	106.7	Median	42
Mode	#N/A	Mode	1
Standard Deviation	384.9	Standard Deviation	568.77
Sample Variance	148160	Sample Variance	323502
Kurtosis	2.7	Kurtosis	1.87
Skewness	1.8	Skewness	1.76
Range	1213.3	Range	1615.70
Minimum	1	Minimum	1
Maximum	1213	Maximum	1616.70
Sum	3114.2	Sum	4202.59
Count	12	Count	12
Confidence Level(95.0%)	244.6	Confidence Level(95.0%)	361.38

NP-8 2002 Data

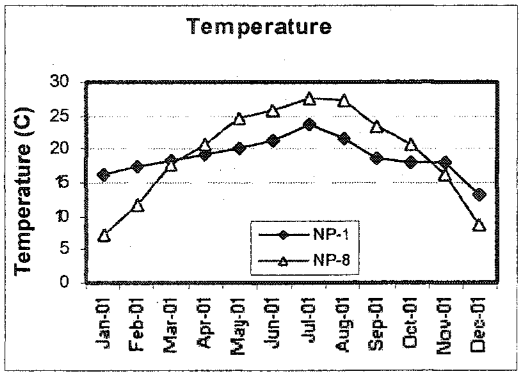
TDS (mg/L)		*TSS (mg/L)*	
Mean	4777	Mean	10
Standard Error	389.78	Standard Error	3
Median	5255	Median	9
Mode	#N/A	Mode	10
Standard Deviation	1350.23	Standard Deviation	10
Sample Variance	1846684	Sample Variance	93
Kurtosis	1.67	Kurtosis	5
Skewness	-1.61	Skewness	2
Range	4260	Range	35
Minimum	1970	Minimum	1
Maximum	6230	Maximum	36
Sum	57318	Sum	115
Count	12	Count	11
Confidence Level(95.0%)	857.90	Confidence Level(95.0%)	6

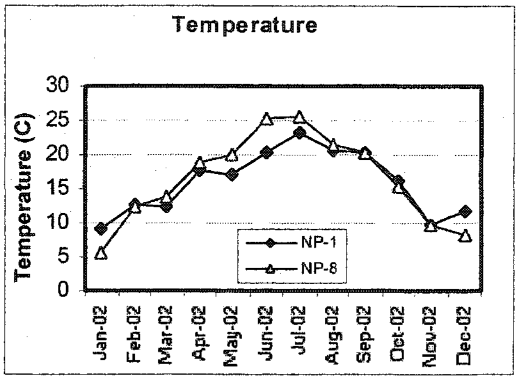
Ammonia (mg/L-N)	
Mean	0.24
Standard Error	0.03
Median	0.27
Mode	#N/A
Standard Deviation	0.06
Sample Variance	0.00
Kurtosis	3.10
Skewness	-1.76
Range	0.15
Minimum	0.14
Maximum	0.29
Sum	1.22
Count	5.00
Confidence Level(95.0%)	0.08

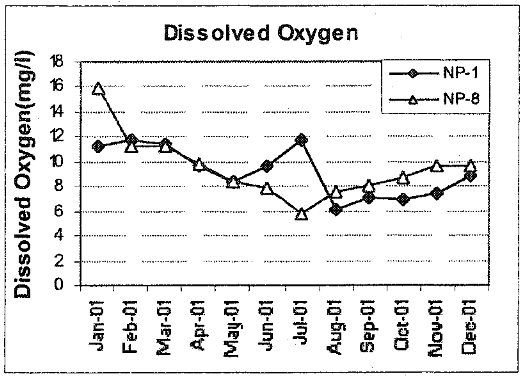
APPENDIX C

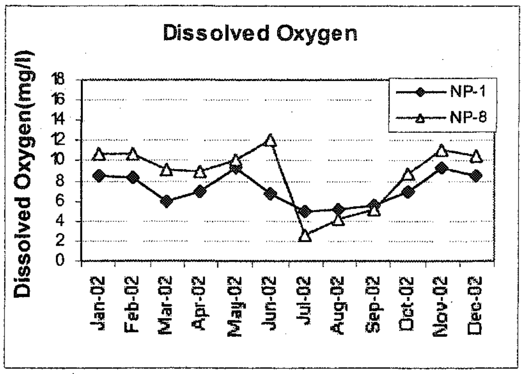
THE CLARK COUNTY WETLANDS PARK NATURE PRESERVE 2001 AND 2002

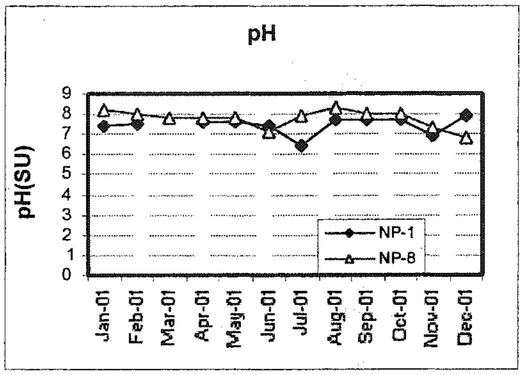
WATER QUALITY DATA – TEMPORAL VARIATON GRAPHS

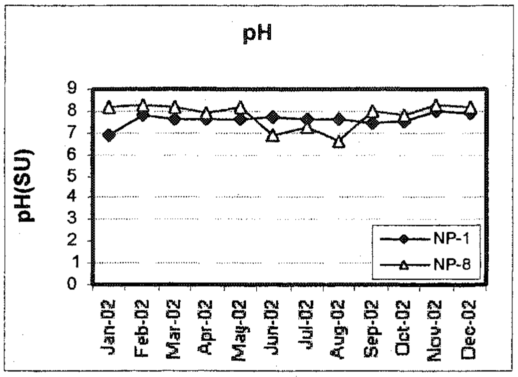

Temperature
Temperature (C)
NP-1
NP-8
Jan-01 Feb-01 Mar-01 Apr-01 May-01 Jun-01 Jul-01 Aug-01 Sep-01 Oct-01 Nov-01 Dec-01

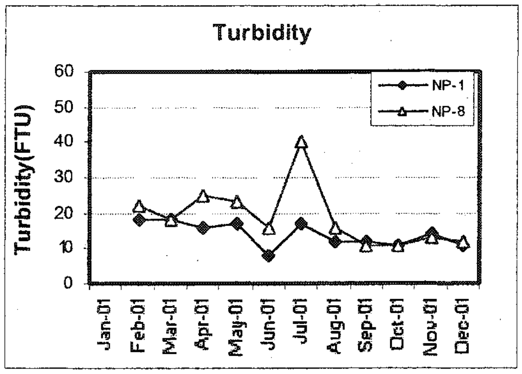

Temperature
Temperature (C)
NP-1
NP-8
Jan-02 Feb-02 Mar-02 Apr-02 May-02 Jun-02 Jul-02 Aug-02 Sep-02 Oct-02 Nov-02 Dec-02

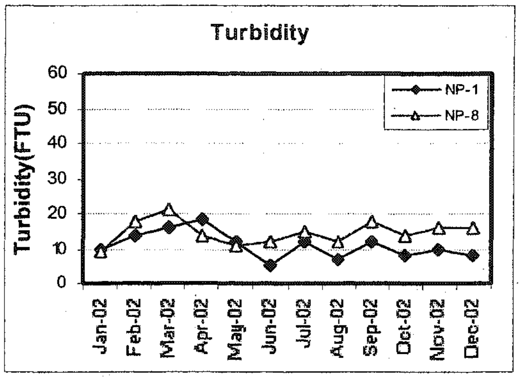

Dissolved Oxygen
Dissolved Oxygen(mg/l)
NP-1
NP-8
Jan-01 Feb-01 Mar-01 Apr-01 May-01 Jun-01 Jul-01 Aug-01 Sep-01 Oct-01 Nov-01 Dec-01

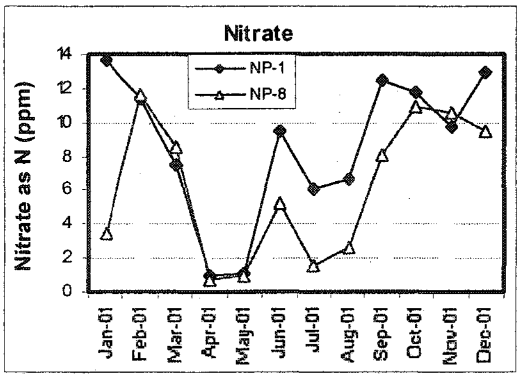

Dissolved Oxygen
Dissolved Oxygen(mg/l)
NP-1
NP-8
Jan-02 Feb-02 Mar-02 Apr-02 May-02 Jun-02 Jul-02 Aug-02 Sep-02 Oct-02 Nov-02 Dec-02

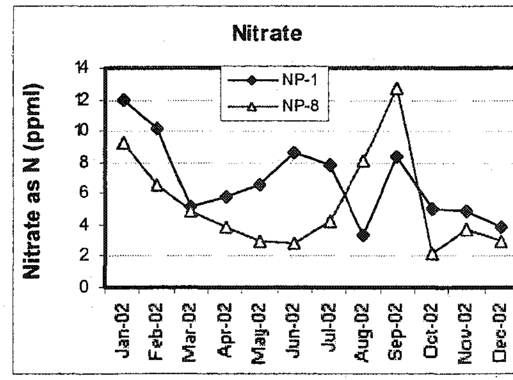

pH
pH(SU)
NP-1
NP-8
Jan-01 Feb-01 Mar-01 Apr-01 May-01 Jun-01 Jul-01 Aug-01 Sep-01 Oct-01 Nov-01 Dec-01

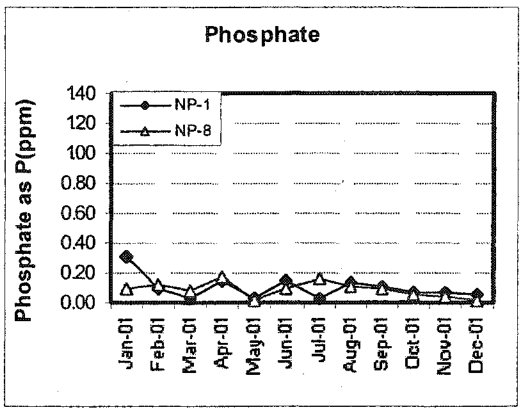

pH
pH(SU)
NP-1
NP-8
Jan-02 Feb-02 Mar-02 Apr-02 May-02 Jun-02 Jul-02 Aug-02 Sep-02 Oct-02 Nov-02 Dec-02

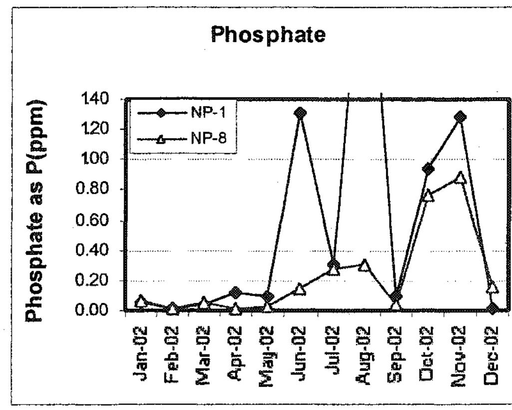

Turbidity
Turbidity(FTU)
NP-1
NP-8
Jan-01 Feb-01 Mar-01 Apr-01 May-01 Jun-01 Jul-01 Aug-01 Sep-01 Oct-01 Nov-01 Dec-01

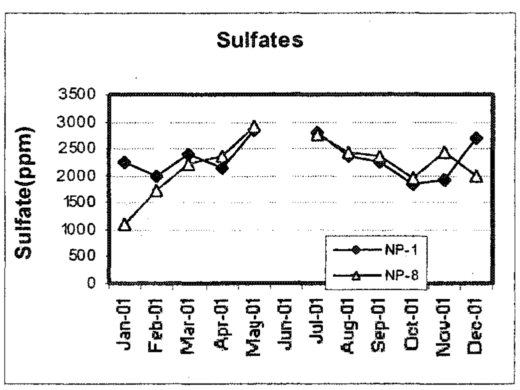

Turbidity
Turbidity(FTU)
NP-1
NP-8
Jan-02 Feb-02 Mar-02 Apr-02 May-02 Jun-02 Jul-02 Aug-02 Sep-02 Oct-02 Nov-02 Dec-02

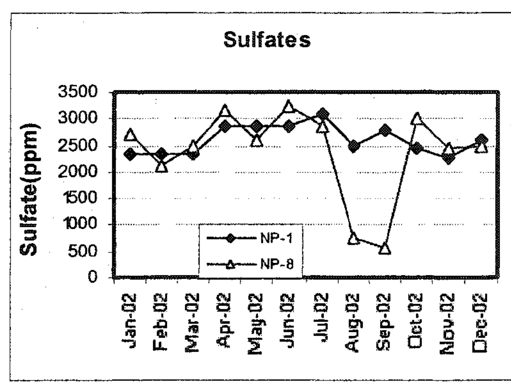

Nitrate
Nitrate as N (ppm)
NP-1
NP-8
Jan-01 Feb-01 Mar-01 Apr-01 May-01 Jun-01 Jul-01 Aug-01 Sep-01 Oct-01 Nov-01 Dec-01

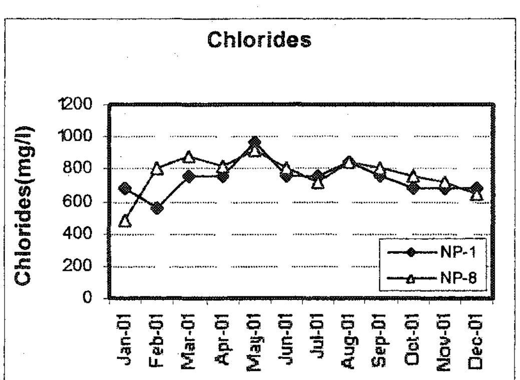

Nitrate
Nitrate as N (ppml)
NP-1
NP-8
Jan-02 Feb-02 Mar-02 Apr-02 May-02 Jun-02 Jul-02 Aug-02 Sep-02 Oct-02 Nov-02 Dec-02

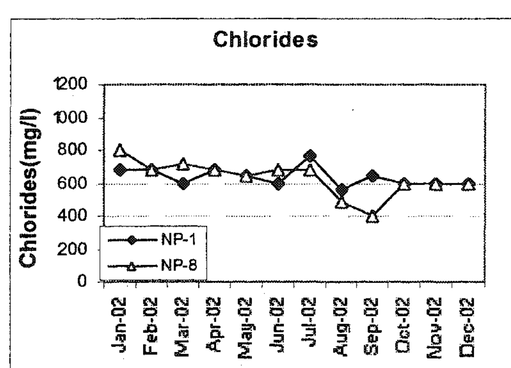

Phosphate
Phosphate as P(ppm)
NP-1
NP-8
Jan-01 Feb-01 Mar-01 Apr-01 May-01 Jun-01 Jul-01 Aug-01 Sep-01 Oct-01 Nov-01 Dec-01

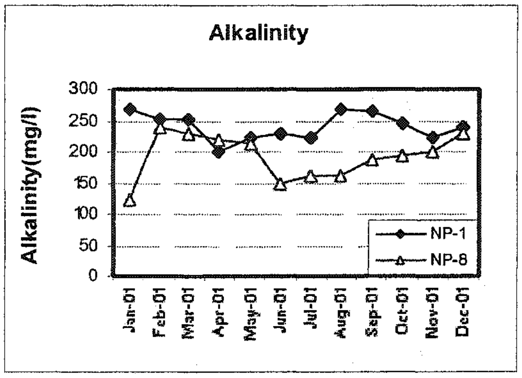

Phosphate
Phosphate as P(ppm)
NP-1
NP-8
Jan-02 Feb-02 Mar-02 Apr-02 May-02 Jun-02 Jul-02 Aug-02 Sep-02 Oct-02 Nov-02 Dec-02

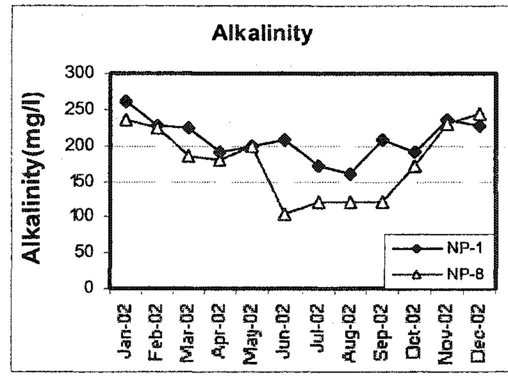

Sulfates
Sulfate(ppm)
NP-1
NP-8
Jan-01 Feb-01 Mar-01 Apr-01 May-01 Jun-01 Jul-01 Aug-01 Sep-01 Oct-01 Nov-01 Dec-01

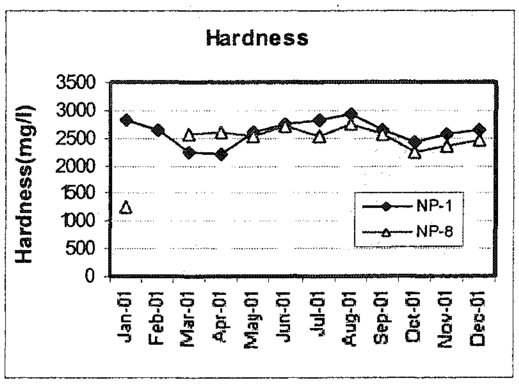

Sulfates
Sulfate(ppm)
NP-1
NP-8
Jan-02 Feb-02 Mar-02 Apr-02 May-02 Jun-02 Jul-02 Aug-02 Sep-02 Oct-02 Nov-02 Dec-02

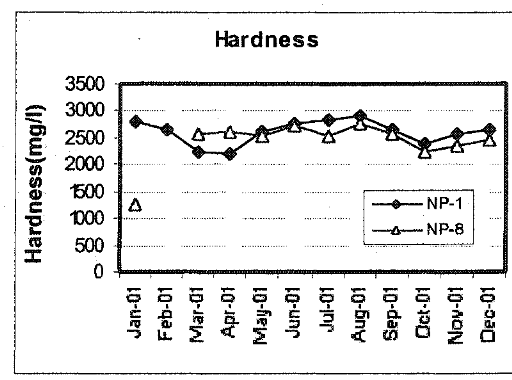

Chlorides
Chlorides(mg/l)
NP-1
NP-8
Jan-01 Feb-01 Mar-01 Apr-01 May-01 Jun-01 Jul-01 Aug-01 Sep-01 Oct-01 Nov-01 Dec-01

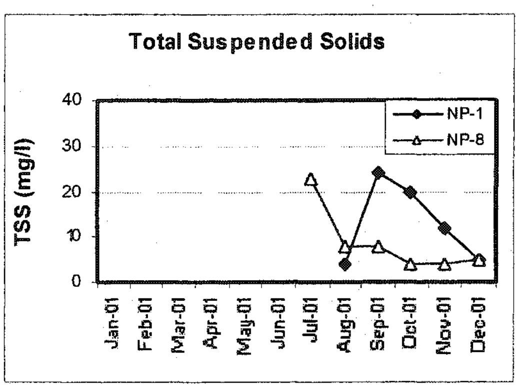

Chlorides
Chlorides(mg/l)
NP-1
NP-8
Jan-02 Feb-02 Mar-02 Apr-02 May-02 Jun-02 Jul-02 Aug-02 Sep-02 Oct-02 Nov-02 Dec-02

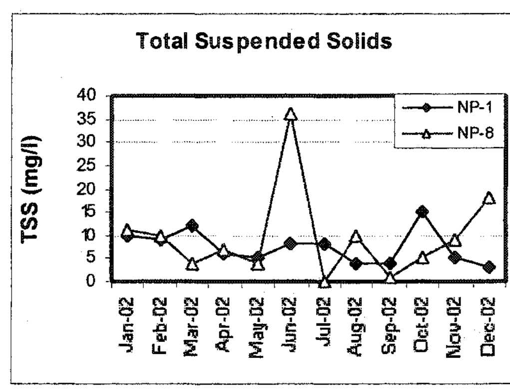

Alkalinity
Alkalinity(mg/l)
300
250
200
150
100
50
0
NP-1
NP-8
Jan-01
Feb-01
Mar-01
Apr-01
May-01
Jun-01
Jul-01
Aug-01
Sep-01
Oct-01
Nov-01
Dec-01

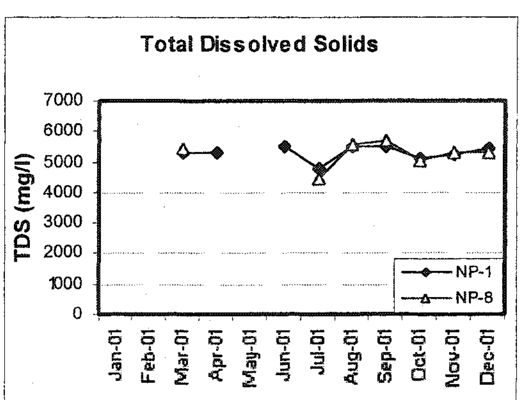

Alkalinity
Alkalinity(mg/l)
300
250
200
150
100
50
0
NP-1
NP-8
Jan-02
Feb-02
Mar-02
Apr-02
May-02
Jun-02
Jul-02
Aug-02
Sep-02
Oct-02
Nov-02
Dec-02

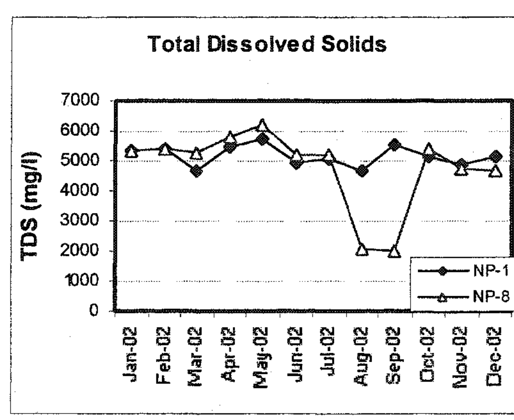

Hardness
Hardness(mg/l)
3500
3000
2500
2000
1500
1000
500
0
NP-1
NP-8
Jan-01
Feb-01
Mar-01
Apr-01
May-01
Jun-01
Jul-01
Aug-01
Sep-01
Oct-01
Nov-01
Dec-01

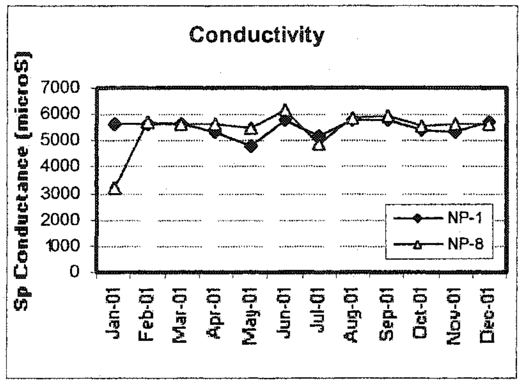

Hardness
Hardness(mg/l)
3500
3000
2500
2000
1500
1000
500
0
NP-1
NP-8
Jan-01
Feb-01
Mar-01
Apr-01
May-01
Jun-01
Jul-01
Aug-01
Sep-01
Oct-01
Nov-01
Dec-01

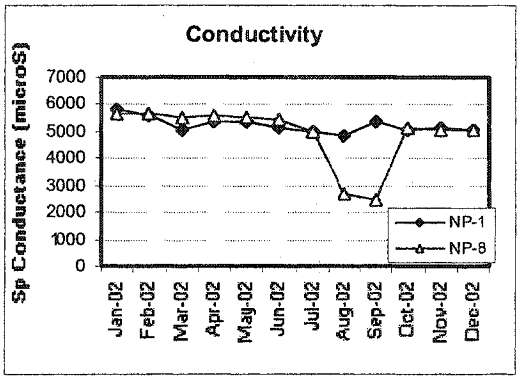

Total Suspended Solids
TSS (mg/l)
40
30
20
10
0
NP-1
NP-8
Jan-01
Feb-01
Mar-01
Apr-01
May-01
Jun-01
Jul-01
Aug-01
Sep-01
Oct-01
Nov-01
Dec-01

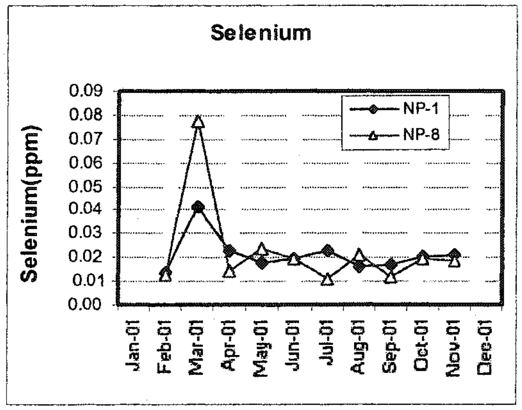

Total Suspended Solids
TSS (mg/l)
40
35
30
25
20
15
10
5
0
NP-1
NP-8
Jan-02
Feb-02
Mar-02
Apr-02
May-02
Jun-02
Jul-02
Aug-02
Sep-02
Oct-02
Nov-02
Dec-02

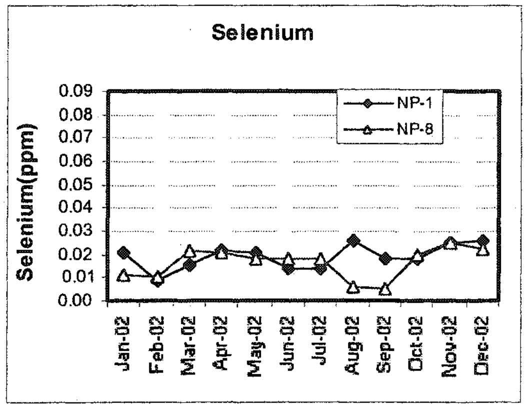

Total Dissolved Solids
TDS (mg/l)
7000
6000
5000
4000
3000
2000
1000
0
NP-1
NP-8
Jan-01
Feb-01
Mar-01
Apr-01
May-01
Jun-01
Jul-01
Aug-01
Sep-01
Oct-01
Nov-01
Dec-01

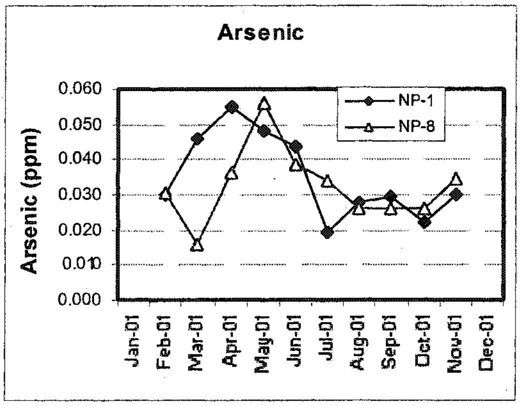

Total Dissolved Solids
TDS (mg/l)
7000
6000
5000
4000
3000
2000
1000
0
NP-1
NP-8
Jan-02
Feb-02
Mar-02
Apr-02
May-02
Jun-02
Jul-02
Aug-02
Sep-02
Oct-02
Nov-02
Dec-02

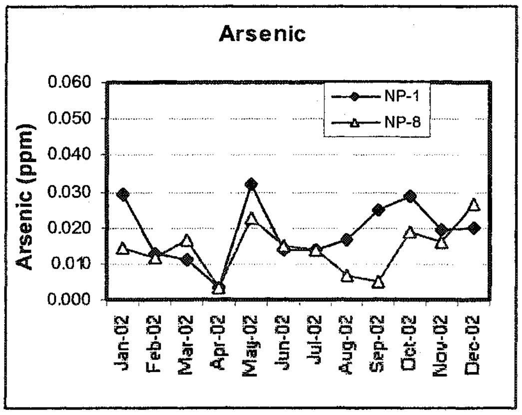

Conductivity
Sp Conductance [microS]
NP-1
NP-8

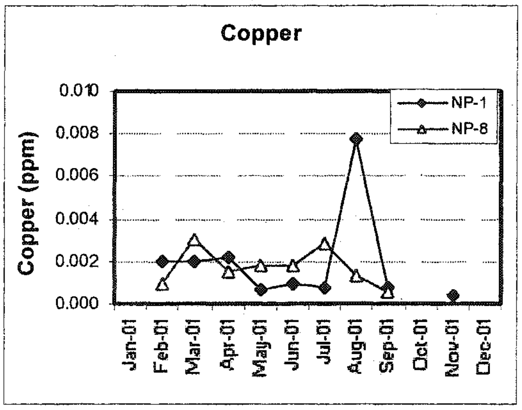

Conductivity
Sp Conductance [microS]
NP-1
NP-8

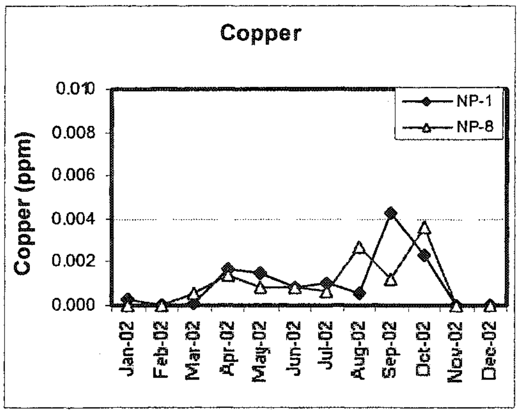

Selenium
Selenium(ppm)
NP-1
NP-8

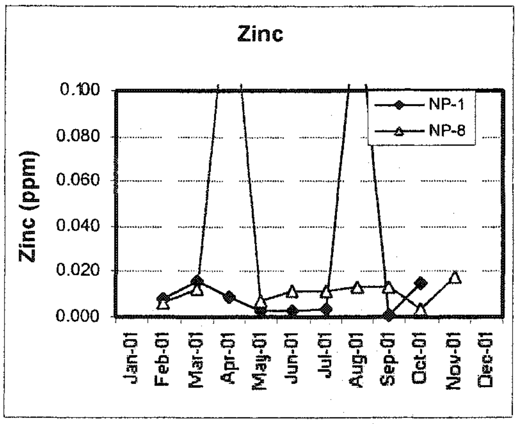

Selenium
Selenium(ppm)
NP-1
NP-8

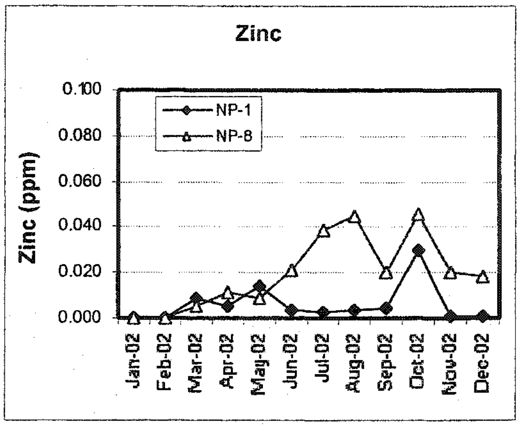

Arsenic
Arsenic (ppm)
NP-1
NP-8

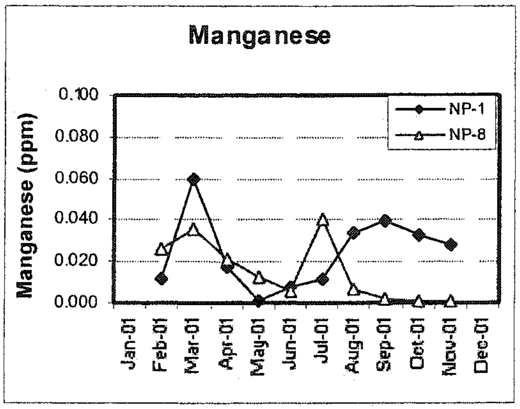

Arsenic
Arsenic (ppm)
NP-1
NP-8

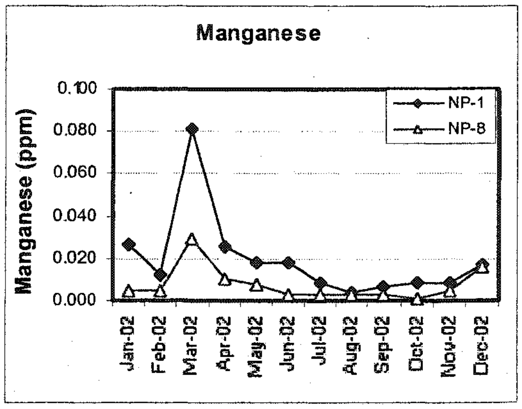

Copper
Copper (ppm)
NP-1
NP-8

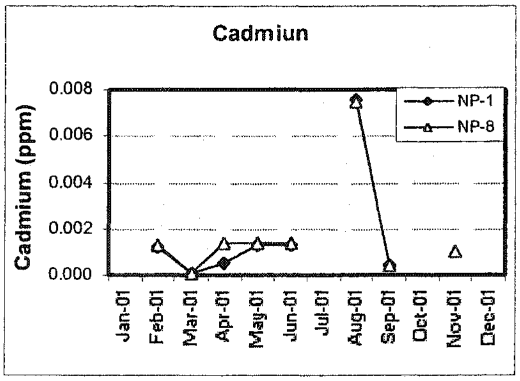

Copper
Copper (ppm)
NP-1
NP-8

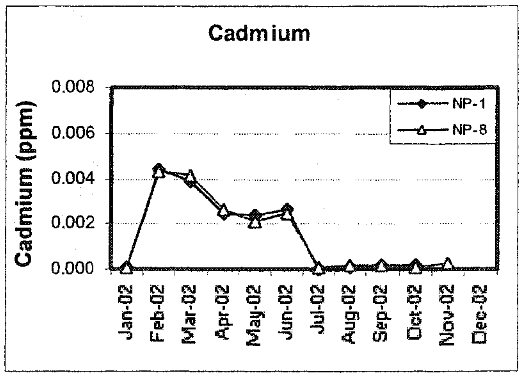

Zinc
Zinc (ppm)
NP-1
NP-8
Jan-01 Feb-01 Mar-01 Apr-01 May-01 Jun-01 Jul-01 Aug-01 Sep-01 Oct-01 Nov-01 Dec-01

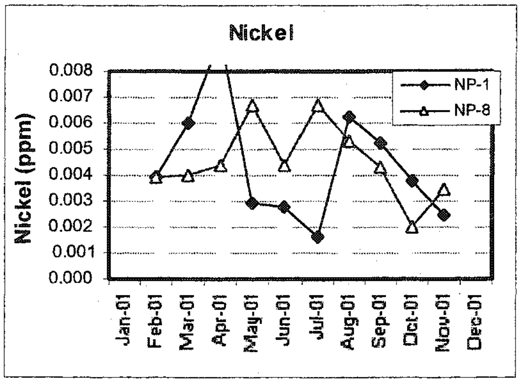

Zinc
Zinc (ppm)
NP-1
NP-8
Jan-02 Feb-02 Mar-02 Apr-02 May-02 Jun-02 Jul-02 Aug-02 Sep-02 Oct-02 Nov-02 Dec-02

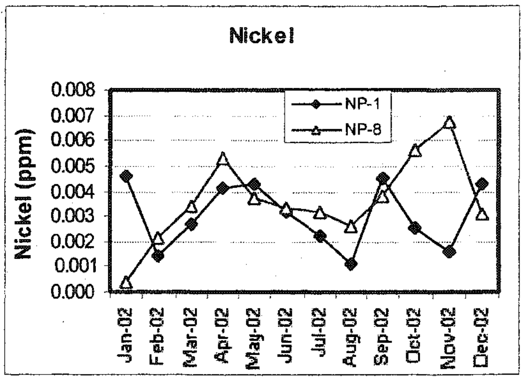

Manganese
Manganese (ppm)
NP-1
NP-8
Jan-01 Feb-01 Mar-01 Apr-01 May-01 Jun-01 Jul-01 Aug-01 Sep-01 Oct-01 Nov-01 Dec-01

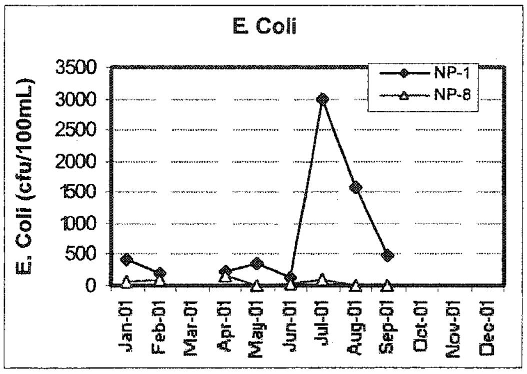

Manganese
Manganese (ppm)
NP-1
NP-8
Jan-02 Feb-02 Mar-02 Apr-02 May-02 Jun-02 Jul-02 Aug-02 Sep-02 Oct-02 Nov-02 Dec-02

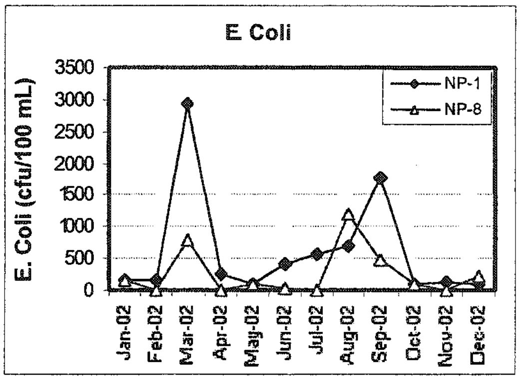

Cadmiun
Cadmium (ppm)
NP-1
NP-8
Jan-01 Feb-01 Mar-01 Apr-01 May-01 Jun-01 Jul-01 Aug-01 Sep-01 Oct-01 Nov-01 Dec-01

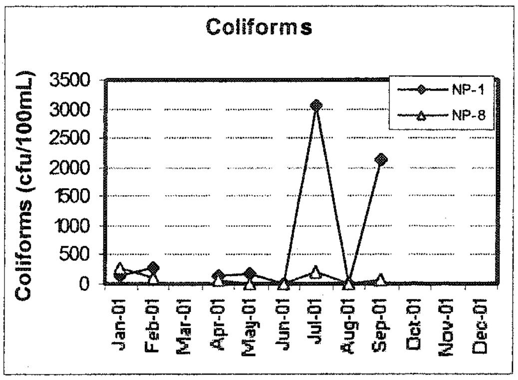

Cadmium
Cadmium (ppm)
NP-1
NP-8
Jan-02 Feb-02 Mar-02 Apr-02 May-02 Jun-02 Jul-02 Aug-02 Sep-02 Oct-02 Nov-02 Dec-02

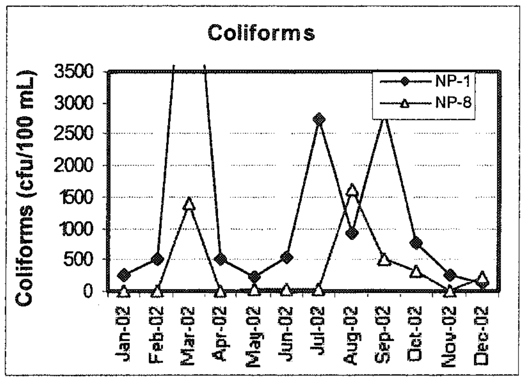

Nickel
Nickel (ppm)
NP-1
NP-8
Jan-01 Feb-01 Mar-01 Apr-01 May-01 Jun-01 Jul-01 Aug-01 Sep-01 Oct-01 Nov-01 Dec-01

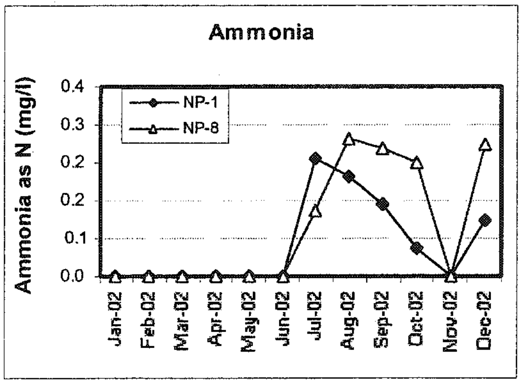

Nickel
Nickel (ppm)
NP-1
NP-8
Jan-02 Feb-02 Mar-02 Apr-02 May-02 Jun-02 Jul-02 Aug-02 Sep-02 Oct-02 Nov-02 Dec-02


E Coli
E. Coli (cfu/100mL)
NP-1
NP-8
3500
3000
2500
2000
1500
1000
500
0
Jan-01
Feb-01
Mar-01
Apr-01
May-01
Jun-01
Jul-01
Aug-01
Sep-01
Oct-01
Nov-01
Dec-01


E Coli
E. Coli (cfu/100 mL)
NP-1
NP-8
3500
3000
2500
2000
1500
1000
500
0
Jan-02
Feb-02
Mar-02
Apr-02
May-02
Jun-02
Jul-02
Aug-02
Sep-02
Oct-02
Nov-02
Dec-02


Coliforms
Coliforms (cfu/100mL)
NP-1
NP-8
3500
3000
2500
2000
1500
1000
500
0
Jan-01
Feb-01
Mar-01
Apr-01
May-01
Jun-01
Jul-01
Aug-01
Sep-01
Oct-01
Nov-01
Dec-01


Coliforms
Coliforms (cfu/100 mL)
NP-1
NP-8
3500
3000
2500
2000
1500
1000
500
0
Jan-02
Feb-02
Mar-02
Apr-02
May-02
Jun-02
Jul-02
Aug-02
Sep-02
Oct-02
Nov-02
Dec-02


Ammonia
Ammonia as N (mg/l)
NP-1
NP-8
0.4
0.3
0.2
0.2
0.1
0.0
Jan-02
Feb-02
Mar-02
Apr-02
May-02
Jun-02
Jul-02
Aug-02
Sep-02
Oct-02
Nov-02
Dec-02

APPENDIX D

THE CLARK COUNTY WETLANDS PARK NATURE PRESERVE - 2001 AND 2002

WATER QUALITY DATA – T-TESTS

T-tests For 2001 and 2002 HRC Data Comparing Inflow (NP_1) with Outflow (NP_8)

t-Test: Two-Sample Assuming Equal Variances		
pH		
	Inflow	*Outflow*
Mean	7.54	7.78
Variance	0.13	0.27
Observations	23	23
Pooled Variance	0.200727	
Hypothesized Mean Difference	0	
df	44	
t Stat	-1.836	
P(T<=t) one-tail	0.037	
t Critical one-tail	1.680	
P(T<=t) two-tail	**0.073**	
t Critical two-tail	**2.015**	

t-Test: Two-Sample Assuming Equal Variances		
Temperature		
	Inflow	*Outflow*
Mean	17.35	17.83
Variance	16.45	47.18
Observations	24	24
Pooled Variance	31.813	
Hypothesized Mean Difference	0	
df	46	
t Stat	-0.294	
P(T<=t) one-tail	**0.385**	
t Critical one-tail	**1.679**	
P(T<=t) two-tail	0.770	
t Critical two-tail	2.013	

t-Test: Two-Sample Assuming Equal Variances		
TSS		
	Inflow	*Outflow*
Mean	9.12	9.01
Variance	37.97	67.89
Observations	16	16
Pooled Variance	52.933	
Hypothesized Mean Difference	0	
df	30	
t Stat	0.044	
P(T<=t) one-tail	**0.483**	
t Critical one-tail	**1.697**	
P(T<=t) two-tail	0.965	
t Critical two-tail	2.042	

t-Test: Two-Sample Assuming Equal Variances		
TDS		
	Inflow	*Outflow*
Mean	5201.68	4953.58
Variance	94587	1227148
Observations	19	19
Pooled Variance	660868	
Hypothesized Mean Difference	0	
df	36	
t Stat	0.941	
P(T<=t) one-tail	**0.177**	
t Critical one-tail	**1.688**	
P(T<=t) two-tail	0.353	
t Critical two-tail	2.028	

T-tests For 2001 and 2002 HRC Data Comparing Inflow (NP_1) with Outflow (NP_8) (Cont.)

t-Test: Two-Sample Assuming Equal Variances		
Nitrate		
	Inflow	*Outflow*
Mean	7.70	5.73
Variance	13.24	13.42
Observations	24	24
Pooled Variance	13.331	
Hypothesized Mean Difference	0	
df	46	
t Stat	1.874	
P(T<=t) one-tail	**0.034**	
t Critical one-tail	**1.679**	
P(T<=t) two-tail	0.067	
t Critical two-tail	2.013	

t-Test: Two-Sample Assuming Equal Variances		
phosphate		
	Inflow	*Outflow*
Mean	0.34	0.16
Variance	0.41	0.05
Observations	24	24
Pooled Variance	0.2306	
Hypothesized Mean Difference	0	
df	46	
t Stat	1.338	
P(T<=t) one-tail	**0.094**	
t Critical one-tail	**1.679**	
P(T<=t) two-tail	0.188	
t Critical two-tail	2.013	

t-Test: Two-Sample Assuming Equal Variances		
Chlorides		
	Inflow	*Outflow*
Mean	688.33	697.50
Variance	8901.45	16741.30
Observations	24	24
Pooled Variance	12821.38	
Hypothesized Mean Difference	0	
df	46	
t Stat	-0.280	
P(T<=t) one-tail	0.390	
t Critical one-tail	1.679	
P(T<=t) two-tail	**0.780**	
t Critical two-tail	**2.013**	

t-Test: Two-Sample Assuming Equal Variances		
Sulphates		
	Inflow	*Outflow*
Mean	2468.48	2289.13
Variance	114103	493172
Observations	23	23
Pooled Variance	303638	
Hypothesized Mean Difference	0	
df	44	
t Stat	1.104	
P(T<=t) one-tail	**0.138**	
t Critical one-tail	**1.680**	
P(T<=t) two-tail	0.276	
t Critical two-tail	2.015	

T-tests For 2001 and 2002 HRC Data Comparing Inflow (NP_1) with Outflow (NP_8) (Cont.)

t-Test: Two-Sample Assuming Equal Variances		
Hardness		
	Inflow	*Outflow*
Mean	2520.00	2322.61
Variance	44327	276447
Observations	23	23
Pooled Variance	160387	
Hypothesized Mean Difference	0	
df	44	
t Stat	1.671	
P(T<=t) one-tail	**0.051**	
t Critical one-tail	**1.680**	
P(T<=t) two-tail	0.102	
t Critical two-tail	2.015	

t-Test: Two-Sample Assuming Equal Variances		
Alkalinity		
	Inflow	*Outflow*
Mean	224.83	184.75
Variance	855.62	1938.37
Observations	24	24
Pooled Variance	1397.00	
Hypothesized Mean Difference	0	
df	46	
t Stat	3.715	
P(T<=t) one-tail	0.000	
t Critical one-tail	1.679	
P(T<=t) two-tail	**0.001**	
t Critical two-tail	**2.013**	

t-Test: Two-Sample Assuming Equal Variances		
Dissolved Oxygen		
	Inflow	*Outflow*
Mean	8.17	9.06
Variance	4.21	7.62
Observations	24	24
Pooled Variance	5.917	
Hypothesized Mean Difference	0	
df	46	
t Stat	-1.272	
P(T<=t) one-tail	**0.105**	
t Critical one-tail	**1.679**	
P(T<=t) two-tail	0.210	
t Critical two-tail	2.013	

t-Test: Two-Sample Assuming Equal Variances		
Turbidity		
	Inflow	*Outflow*
Mean	12.46	16.65
Variance	15.07	43.60
Observations	23	23
Pooled Variance	29.33	
Hypothesized Mean Difference	0	
df	44	
t Stat	-2.627	
P(T<=t) one-tail	**0.006**	
t Critical one-tail	**1.680**	
P(T<=t) two-tail	0.012	
t Critical two-tail	2.015	

T-tests For 2001 and 2002 HRC Data Comparing Inflow (NP_1) with Outflow (NP_8) (Cont.)

t-Test: Two-Sample Assuming Equal Variances		
E. Coli		
	Inflow	*Outflow*
Mean	684.5	179.7
Variance	817978.5	97138.8
Observations	20	20
Pooled Variance	457558.62	
Hypothesized Mean Difference	0	
df	38	
t Stat	2.360	
P(T<=t) one-tail	**0.012**	
t Critical one-tail	**1.686**	
P(T<=t) two-tail	0.024	
t Critical two-tail	2.024	

t-Test: Two-Sample Assuming Equal Variances		
Coliforms		
	Inflow	*Outflow*
Mean	1160.5	257.0
Variance	2702203	216703
Observations	19	19
Pooled Variance	1459453	
Hypothesized Mean Difference	0	
df	36	
t Stat	2.305	
P(T<=t) one-tail	**0.014**	
t Critical one-tail	**1.688**	
P(T<=t) two-tail	0.027	
t Critical two-tail	2.028	

t-Test: Two-Sample Assuming Equal Variances		
Cadmium		
	Inflow	*Outflow*
Mean	0.0017	0.0017
Variance	0.000004	0.000004
Observations	17	17
Pooled Variance	4.15E-06	
Hypothesized Mean Difference	0	
df	32	
t Stat	-0.083	
P(T<=t) one-tail	0.467	
t Critical one-tail	1.694	
P(T<=t) two-tail	**0.935**	
t Critical two-tail	**2.037**	

t-Test: Two-Sample Assuming Equal Variances		
Copper		
	Inflow	*Outflow*
Mean	0.0018	0.0016
Variance	0.00000	0.00000
Observations	16	16
Pooled Variance	2.18E-06	
Hypothesized Mean Difference	0	
df	30	
t Stat	0.467	
P(T<=t) one-tail	0.322	
t Critical one-tail	1.697	
P(T<=t) two-tail	**0.644**	
t Critical two-tail	**2.042**	

T-tests For 2001 and 2002 HRC Data Comparing Inflow (NP_1) with Outflow (NP_8) (Cont.)

t-Test: Two-Sample Assuming Equal Variances		
Selenium		
	Inflow	*Outflow*
Mean	0.0199	0.0193
Variance	0.00004	0.0002
Observations	22	22
Pooled Variance	0.000118	
Hypothesized Mean Difference	0	
df	42	
t Stat	0.188	
P(T<=t) one-tail	0.426	
t Critical one-tail	1.682	
P(T<=t) two-tail	**0.852**	
t Critical two-tail	**2.018**	

t-Test: Two-Sample Assuming Equal Variances		
Arsenic		
	Inflow	*Outflow*
Mean	0.0262	0.0224
Variance	0.0002	0.0002
Observations	22	22
Pooled Variance	0.000165	
Hypothesized Mean Difference	0	
df	42	
t Stat	0.978	
P(T<=t) one-tail	0.167	
t Critical one-tail	1.682	
P(T<=t) two-tail	**0.333**	
t Critical two-tail	**2.018**	

t-Test: Two-Sample Assuming Equal Variances		
Nickel		
	Inflow	*Outflow*
Mean	0.004	0.004
Variance	0.000004	0.000003
Observations	22	22
Pooled Variance	3.09E-06	
Hypothesized Mean Difference	0	
df	42	
t Stat	-0.663	
P(T<=t) one-tail	0.255	
t Critical one-tail	1.682	
P(T<=t) two-tail	**0.511**	
t Critical two-tail	**2.018**	

t-Test: Two-Sample Assuming Equal Variances		
Zinc		
	Inflow	*Outflow*
Mean	0.0142	0.0246
Variance	0.0010	0.0012
Observations	19	19
Pooled Variance	0.001057	
Hypothesized Mean Difference	0	
df	36	
t Stat	-0.991	
P(T<=t) one-tail	0.164	
t Critical one-tail	1.688	
P(T<=t) two-tail	**0.328**	
t Critical two-tail	**2.028**	

T-tests For 2001 and 2002 HRC Data Comparing Inflow (NP_1) with Outflow (NP_8) (Cont.)

t-Test: Two-Sample Assuming Equal Variances		
Manganese		
	Inflow	*Outflow*
Mean	0.0218	0.0110
Variance	0.0004	0.0001
Observations	22	22
Pooled Variance	0.00026	
Hypothesized Mean Difference	0	
df	42	
t Stat	2.234	
P(T<=t) one-tail	0.015	
t Critical one-tail	1.682	
P(T<=t) two-tail	**0.031**	
t Critical two-tail	**2.018**	

T-tests For 2001 and 2002 HRC Data Seasonal Variation

t-Test: Two-Sample Assuming Equal Variances		
pH Winter Variation		
	In	***Out***
Mean	7.57	7.93
Variance	0.14	0.22
Observations	11	11
Pooled Variance	0.182	
Hypothesized Mean Difference	0.000	
df	20	
t Stat	1.972	
P(T<=t) one-tail	0.031	
t Critical one-tail	1.725	
P(T<=t) two-tail	**0.063**	
t Critical two-tail	**2.086**	

t-Test: Two-Sample Assuming Equal Variances		
pH Summer Variation		
	In	***Out***
Mean	7.52	7.65
Variance	0.13	0.30
Observations	12	12
Pooled Variance	0.216	
Hypothesized Mean Difference	0.000	
df	22	
t Stat	0.717	
P(T<=t) one-tail	0.241	
t Critical one-tail	1.717	
P(T<=t) two-tail	**0.481**	
t Critical two-tail	**2.074**	

t-Test: Two-Sample Assuming Equal Variances		
DO Summer Variation		
	In	***Out***
Mean	7.59	7.56
Variance	4.50	7.26
Observations	12	12
Pooled Variance	5.881	
Hypothesized Mean Difference	0	
df	22	
t Stat	0.025	
P(T<=t) one-tail	0.490	
t Critical one-tail	1.717	
P(T<=t) two-tail	**0.980**	
t Critical two-tail	**2.074**	

t-Test: Two-Sample Assuming Equal Variances		
DO Winter Variation		
	In	***Out***
Mean	11.49	10.44
Variance	109.13	3.92
Observations	12	12
Pooled Variance	56.526	
Hypothesized Mean Difference	0	
df	22	
t Stat	0.342	
P(T<=t) one-tail	0.368	
t Critical one-tail	1.717	
P(T<=t) two-tail	**0.735**	
t Critical two-tail	**2.074**	

T-tests For 2001 and 2002 HRC Data Seasonal Variation (Cont.)

t-Test: Two-Sample Assuming Equal Variances		
Temperature Summer Variation		
	In	***Out***
Mean	20.33	23.42
Variance	3.91	9.37
Observations	12	12
Pooled Variance	6.641	
Hypothesized Mean Difference	0	
df	22	
t Stat	2.931	
P(T<=t) one-tail	0.004	
t Critical one-tail	1.717	
P(T<=t) two-tail	**0.008**	
t Critical two-tail	**2.074**	

t-Test: Two-Sample Assuming Equal Variances		
Temperature Winter Variation		
	In	***Out***
Mean	14.38	12.25
Variance	11.11	21.27
Observations	12	12
Pooled Variance	16.187	
Hypothesized Mean Difference	0	
df	22	
t Stat	1.294	
P(T<=t) one-tail	0.105	
t Critical one-tail	1.717	
P(T<=t) two-tail	**0.209**	
t Critical two-tail	**2.074**	

t-Test: Two-Sample Assuming Equal Variances		
Phosphate Summer Variation		
	In	***Out***
Mean	0.442	0.123
Variance	0.669	0.009
Observations	12	12
Pooled Variance	0.3391	
Hypothesized Mean Difference	0	
df	22	
t Stat	1.342	
P(T<=t) one-tail	0.097	
t Critical one-tail	1.717	
P(T<=t) two-tail	**0.193**	
t Critical two-tail	**2.074**	

t-Test: Two-Sample Assuming Equal Variances		
Phosphate Winter Variation		
	In	***Out***
Mean	0.25	0.19
Variance	0.17	0.09
Observations	12	12
Pooled Variance	0.1312	
Hypothesized Mean Difference	0	
df	22	
t Stat	0.349	
P(T<=t) one-tail	0.365	
t Critical one-tail	1.717	
P(T<=t) two-tail	**0.730**	
t Critical two-tail	**2.074**	

T-tests For 2001 and 2002 HRC Data Seasonal Variation (Cont.)

t-Test: Two-Sample Assuming Equal Variances		
Nitrate Summer Variation		
	In	***Out***
Mean	6.42	4.46
Variance	11.44	12.70
Observations	12	12
Pooled Variance	12.067	
Hypothesized Mean Difference	0.000	
df	22	
t Stat	1.381	
P(T<=t) one-tail	0.091	
t Critical one-tail	1.717	
P(T<=t) two-tail	**0.181**	
t Critical two-tail	**2.074**	

t-Test: Two-Sample Assuming Equal Variances		
Nitrate Winter Variation		
	In	***Out***
Mean	8.99	7.00
Variance	12.63	11.85
Observations	12	12
Pooled Variance	12.238	
Hypothesized Mean Difference	0.000	
df	22	
t Stat	1.395	
P(T<=t) one-tail	0.089	
t Critical one-tail	1.717	
P(T<=t) two-tail	**0.177**	
t Critical two-tail	**2.074**	

t-Test: Two-Sample Assuming Equal Variances		
pH		
	In Summer	***In Winter***
Mean	7.52	7.57
Variance	0.15	0.14
Observations	11	11
Pooled Variance	0.1437	
Hypothesized Mean Difference	0	
df	20	
t Stat	-0.287	
P(T<=t) one-tail	0.389	
t Critical one-tail	1.725	
P(T<=t) two-tail	**0.777**	
t Critical two-tail	**2.086**	

t-Test: Two-Sample Assuming Equal Variances		
pH		
	Out Summer	***Out Winter***
Mean	7.62	7.93
Variance	0.31	0.22
Observations	11	11
Pooled Variance	0.2688	
Hypothesized Mean Difference	0	
df	20	
t Stat	-1.382	
P(T<=t) one-tail	0.091	
t Critical one-tail	1.725	
P(T<=t) two-tail	**0.182**	
t Critical two-tail	**2.086**	

T-tests For 2001 and 2002 HRC Data Seasonal Variation (Cont.)

t-Test: Two-Sample Assuming Equal Variances		
DO		
	In Summer	***In Winter***
Mean	7.59	11.49
Variance	4.50	109.13
Observations	12	12
Pooled Variance	56.816	
Hypothesized Mean Difference	0	
df	22	
t Stat	-1.269	
P(T<=t) one-tail	0.109	
t Critical one-tail	1.717	
P(T<=t) two-tail	**0.218**	
t Critical two-tail	**2.074**	

t-Test: Two-Sample Assuming Equal Variances		
DO		
	Out Summer	***Out Winter***
Mean	7.56	10.44
Variance	7.26	3.92
Observations	12	12
Pooled Variance	5.590	
Hypothesized Mean Difference	0	
df	22	
t Stat	-2.983	
P(T<=t) one-tail	0.003	
t Critical one-tail	1.717	
P(T<=t) two-tail	**0.007**	
t Critical two-tail	**2.074**	

t-Test: Two-Sample Assuming Equal Variances		
Temperature		
	In Summer	*In Winter*
Mean	20.33	14.38
Variance	3.91	11.11
Observations	12	12
Pooled Variance	7.510	
Hypothesized Mean Difference	0	
df	22	
t Stat	5.326	
P(T<=t) one-tail	0.000	
t Critical one-tail	1.717	
P(T<=t) two-tail	**0.000**	
t Critical two-tail	**2.074**	

t-Test: Two-Sample Assuming Equal Variances		
Temperature		
	Out Summer	*Out Winter*
Mean	23.417	12.250
Variance	9.369	21.266
Observations	12	12
Pooled Variance	15.318	
Hypothesized Mean Difference	0	
df	22	
t Stat	6.989	
P(T<=t) one-tail	0.000	
t Critical one-tail	1.717	
P(T<=t) two-tail	**0.000**	
t Critical two-tail	**2.074**	

T-tests For 2001 and 2002 HRC Data Seasonal Variation (Cont.)

t-Test: Two-Sample Assuming Equal Variances		
Nitrate		
	In Summer	*In winter*
Mean	6.42	8.99
Variance	11.44	12.63
Observations	12	12
Pooled Variance	12.03208 3	
Hypothesized Mean Difference	0	
df	22	
t Stat	-1.818	
P(T<=t) one-tail	0.041	
t Critical one-tail	1.717	
P(T<=t) two-tail	**0.083**	
t Critical two-tail	**2.074**	

t-Test: Two-Sample Assuming Equal Variances		
Nitrate		
	Out Summer	*Out Winter*
Mean	4.46	7.00
Variance	12.70	11.85
Observations	12	12
Pooled Variance	12.2722	
Hypothesized Mean Difference	0	
df	22	
t Stat	-1.777	
P(T<=t) one-tail	0.045	
t Critical one-tail	1.717	
P(T<=t) two-tail	**0.089**	
t Critical two-tail	**2.074**	

t-Test: Two-Sample Assuming Equal Variances		
Phosphate		
	In Summer	*In Winter*
Mean	0.44	0.25
Variance	0.67	0.17
Observations	12	12
Pooled Variance	0.4217	
Hypothesized Mean Difference	0	
df	22	
t Stat	0.739	
P(T<=t) one-tail	0.234	
t Critical one-tail	1.717	
P(T<=t) two-tail	**0.468**	
t Critical two-tail	**2.074**	

t-Test: Two-Sample Assuming Equal Variances		
Phosphate		
	Out Summer	*Out Winter*
Mean	0.12	0.19
Variance	0.01	0.09
Observations	12	12
Pooled Variance	0.049	
Hypothesized Mean Difference	0	
df	22	
t Stat	-0.796	
P(T<=t) one-tail	0.217	
t Critical one-tail	1.717	
P(T<=t) two-tail	**0.434**	
t Critical two-tail	**2.074**	

APPENDIX E

THE CLARK COUNTY WETLANDS PARK NATURE PRESERVE UPPER POND PHOSPHORUS STUDY DATA – FLOW RATES CALCULATIONS FROM SEP 2002 TO JAN 2003

Flow Data Calculations Considering Center Point Measurements

9/18/2002	**NP-1**	**(Inlet Culvert, East)**				**NP-1**	**(Inlet Culvert, West)**		
*the two culvert were open					*the two culvert were open				
	y(depth of water)=		2.625	inches		y(depth of water)=		3.25	inches
	D(diameter of tub)=		2.42	feet		D(diameter of tub)=		2.42	feet
	z(D/2-y)=		0.99125			z(D/2-y)=		0.939167	
theta	O=cos^-1(2z/D)		0.610756		theta	O=cos^-1(2z/D)		0.682226	
area:	A(D^2/4(O-sin2O/2))=		0.20636	(ft^2)	area:	A(D^2/4(O-sin2O/2))=		0.282327	(ft^2)
wetted	P=D*O		1.478029	(ft)	wetted	P=D*O		1.650988	(ft)
perimeter					perimeter				
	v(velocity)=		1.168	(ft/s)		v(velocity)=		1.937	(ft/s)
flow rate	Q=v*A		**0.24**	(cfs)	flow rate	Q=v*A		**0.55**	(cfs)
	NP-2E			**NP-2W**					
	Weir			**Weir**					
	Q=Cw*L*h^(3/2)			Q=Cw*L*h^(3/2)					
	Cw=	2.8		Cw=	2.8				
	L=	8		L=	8				
	h=	0.5		h=	0.625				
	Q=	**0.19**		Q=	**0.27**				

Flow Data Calculations Considering Center Point Measurements (Cont.)

		9/25/2002							
	NP-1	**(Inlet Culvert, East)**				**NP-1**	**(Inlet Culvert, West)**		
*the two culvert were open					*the two culvert were open				
	y(depth of water)=		2.75	inches		y(depth of water)=		3	inches
	D(diameter of tub)=		2.42	feet		D(diameter of tub)=		2.42	feet
	z(D/2-y)=		0.980833			z(D/2-y)=		0.96	
theta	O=cos^-1(2z/D)		0.62561		theta	O=cos^-1(2z/D)		0.654441	
area:	A(D^2/4(O-sin2O/2))=		0.22097	(ft^2)	area:	A(D^2/4(O-sin2O/2))=		0.251083	(ft^2)
wetted	P=D*O		1.513976	(ft)	wetted	P=D*O		1.583747	(ft)
perimeter					perimeter				
	v(velocity)=		1.36	(ft/s)		v(velocity)=		2.136	(ft/s)
flow rate	Q=v*A		**0.30**	(cfs)	flow rate	Q=v*A		**0.54**	(cfs)
	NP-2E			**NP-2W**					
	Weir			**Weir**					
	Q=Cw*L*h^(3/2)			Q=Cw*L*h^(3/2)					
	Cw=	2.8		Cw=	2.8				
	L=	8		L=	8				
	h=	1.125		h=	0.125				
	Q=	**0.64**		Q=	**0.02**				

Flow Data Calculations Considering Center Point Measurements (Cont.)

		10/2/2002							
	NP-1	**(Inlet Culvert, East)**				**NP-1**	**(Inlet Culvert, West)**		
*the two culvert were open					*the two culvert were open				
	y(depth of water)=		2.5	inches		y(depth of water)=		3.25	inches
	D(diameter of tub)=		2.42	feet		D(diameter of tub)=		2.42	feet
	z(D/2-y)=		1.001667			z(D/2-y)=		0.939167	
theta	O=cos^-1(2z/D)		0.595579		theta	O=cos^-1(2z/D)		0.682226	
area:	A(D^2/4(O-sin2O/2))=		0.19206	(ft^2)	area:	A(D^2/4(O-sin2O/2))=		0.282327	(ft^2)
wetted	P=D*O		1.441302	(ft)	wetted	P=D*O		1.650988	(ft)
perimeter					perimeter				
	v(velocity)=		1.525	(ft/s)		v(velocity)=		1.846	(ft/s)
flow rate	Q=v*A		**0.29**	(cfs)	flow rate	Q=v*A		**0.52**	(cfs)
	NP-2E				**NP-2W**				
	Weir				**Weir**				
	Q=Cw*L*h^(3/2)				Q=Cw*L*h^(3/2)				
	Cw=	2.8			Cw=	2.8			
	L=	8			L=	8			
	h=	1			h=	2.25			
	Q=	**0.54**			Q=	**1.82**			

Flow Data Calculations Considering Center Point Measurements (Cont.)

		10/9/2002							
	NP-1	**(Inlet Culvert, East)**				**NP-1**	**(Inlet Culvert, West)**		
*the two culvert were open					*the two culvert were open				
	y(depth of water)=		2.875	inches		y(depth of water)=		3	inches
	D(diameter of tub)=		2.42	feet		D(diameter of tub)=		2.42	feet
	z(D/2-y)=		0.970417			z(D/2-y)=		0.96	
theta	O=cos^-1(2z/D)		0.640165		theta	O=cos^-1(2z/D)		0.654441	
area:	A(D^2/4(O-sin2O/2))=		0.235881	(ft^2)	area:	A(D^2/4(O-sin2O/2))=		0.251083	(ft^2)
wetted	P=D*O		1.549199	(ft)	wetted	P=D*O		1.583747	(ft)
perimeter					perimeter				
	v(velocity)=		1.49	(ft/s)		v(velocity)=		1.808	(ft/s)
flow rate	Q=v*A		**0.35**	(cfs)	flow rate	Q=v*A		**0.45**	(cfs)
	NP-2E				**NP-2W**				
	Weir				**Weir**				
	Q=Cw*L*h^(3/2)				Q=Cw*L*h^(3/2)				
	Cw=	2.8			Cw=	2.8			
	L=	8			L=	8			
	h=	1.125			h=	2.25			
	Q=	**0.64**			Q=	**1.82**			

Flow Data Calculations Considering Center Point Measurements (Cont.)

		10/16/2002							
	NP-1	**(Inlet Culvert, East)**				**NP-1**	**(Inlet Culvert, West)**		
						Closed			
	y(depth of water)=		3.75	inches		y(depth of water)=			inches
	D(diameter of tub)=		2.42	feet		D(diameter of tub)=		2.42	feet
	z(D/2-y)=		0.8975			z(D/2-y)=		1.21	
theta	O=cos^-1(2z/D)		0.735142		theta	O=cos^-1(2z/D)		0	
area:	A(D^2/4(O-sin2O/2))=		0.347966	(ft^2)	area:	A(D^2/4(O-sin2O/2))=		0	(ft^2)
wetted	P=D*O		1.779044	(ft)	wetted	P=D*O		0	(ft)
perimeter					perimeter				
	v(velocity)=		2.155	(ft/s)		v(velocity)=			(ft/s)
flow rate	Q=v*A		**0.75**	(cfs)	flow rate	Q=v*A		**0.00**	(cfs)
	NP-2E			**NP-2W**					
	Weir			**Weir**					
	Q=Cw*L*h^(3/2)			Q=Cw*L*h^(3/2)					
	Cw=	2.8		Cw=	2.8				
	L=	8		L=	8				
	h=	1		h=	0.5				
	Q=	**0.54**		Q=	**0.19**				

Flow Data Calculations Considering Center Point Measurements (Cont.)

	10/30/2002								
	NP-1	**(Inlet Culvert, East)**				**NP-1**	**(Inlet Culvert, West)**		
						Closed			
	y(depth of water)=		4.75	inches		y(depth of water)=			inches
	D(diameter of tub)=		2.42	feet		D(diameter of tub)=		2.42	feet
	z(D/2-y)=		0.814167			z(D/2-y)=		1.21	
theta	O=cos^-1(2z/D)		0.832721		theta	O=cos^-1(2z/D)		0	
area:	A(D^2/4(O-sin2O/2))=		0.490414	(ft^2)	area:	A(D^2/4(O-sin2O/2))=		0	(ft^2)
wetted	P=D*O		2.015186	(ft)	wetted	P=D*O		0	(ft)
perimeter					perimeter				
	v(velocity)=		0.911	(ft/s)		v(velocity)=			(ft/s)
flow rate	Q=v*A		**0.45**	(cfs)	flow rate	Q=v*A		**0.00**	(cfs)
	NP-2E			**NP-2W**					
	Weir			**Weir**					
	Q=Cw*L*h^(3/2)			Q=Cw*L*h^(3/2)					
	Cw=	2.8		Cw=	2.8				
	L=	8		L=	8				
	h=	1.25		h=	1				
	Q=	**0.75**		Q=	**0.54**				

Flow Data Calculations Considering Center Point Measurements (Cont.)

	11/6/2002								
	NP-1	**(Inlet Culvert, East)**				**NP-1**	**(Inlet Culvert, West)**		
						Closed			
	y(depth of water)=		3.75	inches		y(depth of water)=			inches
	D(diameter of tub)=		2.42	feet		D(diameter of tub)=		2.42	feet
	z(D/2-y)=		0.8975			z(D/2-y)=		1.21	
theta	O=cos^-1(2z/D)		0.735142		theta	O=cos^-1(2z/D)		0	
area:	A(D^2/4(O-sin2O/2))=		0.347966	(ft^2)	area:	A(D^2/4(O-sin2O/2))=		0	(ft^2)
wetted	P=D*O		1.779044	(ft)	wetted	P=D*O		0	(ft)
perimeter					perimeter				
	v(velocity)=		0.643	(ft/s)		v(velocity)=			(ft/s)
flow rate	Q=v*A		**0.22**	(cfs)	flow rate	Q=v*A		**0.00**	(cfs)
	NP-2E			**NP-2W**					
	Weir			**Weir**					
	Q=Cw*L*h^(3/2)			Q=Cw*L*h^(3/2)					
	Cw=	2.8		Cw=	2.8				
	L=	8		L=	8				
	h=	1.125		h=	1				
	Q=	**0.64**		Q=	**0.54**				

Flow Data Calculations Considering Center Point Measurements (Cont.)

	11/13/2002								
	NP-1	**(Inlet Culvert, East)**				**NP-1**	**(Inlet Culvert, West)**		
						Closed			
	y(depth of water)=		3.875	inches		y(depth of water)=			inches
	D(diameter of tub)=		2.42	feet		D(diameter of tub)=		2.42	feet
	z(D/2-y)=		0.887083			z(D/2-y)=		1.21	
theta	O=cos^-1(2z/D)		0.747888		theta	O=cos^-1(2z/D)		0	
area:	A(D^2/4(O-sin2O/2))=		0.364992	(ft^2)	area:	A(D^2/4(O-sin2O/2))=		0	(ft^2)
wetted	P=D*O		1.809889	(ft)	wetted	P=D*O		0	(ft)
perimeter					perimeter				
	v(velocity)=		0.749	(ft/s)		v(velocity)=			(ft/s)
flow rate	Q=v*A		**0.27**	(cfs)	flow rate	Q=v*A		**0.00**	(cfs)
	NP-2E			**NP-2W**					
	Weir			**Weir**					
	Q=Cw*L*h^(3/2)			Q=Cw*L*h^(3/2)					
	Cw=	2.8		Cw=	2.8				
	L=	8		L=	8				
	h=	1.25		h=	0.625				
	Q=	**0.75**		Q=	**0.27**				

Flow Data Calculations Considering Center Point Measurements (Cont.)

	11/27/2002								
	NP-1	**(Inlet Culvert, East)**				**NP-1**	**(Inlet Culvert, West)**		
						Closed			
	y(depth of water)=		3.5	inches		y(depth of water)=			inches
	D(diameter of tub)=		2.42	feet		D(diameter of tub)=		2.42	feet
	z(D/2-y)=		0.918333			z(D/2-y)=		1.21	
theta	O=cos^-1(2z/D)		0.709092		theta	O=cos^-1(2z/D)		0	
area:	A(D^2/4(O-sin2O/2))=		0.31464	(ft^2)	area:	A(D^2/4(O-sin2O/2))=		0	(ft^2)
wetted	P=D*O		1.716004	(ft)	wetted	P=D*O		0	(ft)
perimeter					perimeter				
	v(velocity)=		2.253	(ft/s)		v(velocity)=			(ft/s)
flow rate	Q=v*A		**0.71**	(cfs)	flow rate	Q=v*A		**0.00**	(cfs)
	NP-2E			**NP-2W**					
	Weir			**Weir**					
	Q=Cw*L*h^(3/2)			Q=Cw*L*h^(3/2)					
	Cw=	2.8		Cw=	2.8				
	L=	8		L=	8				
	h=	1		h=	0.625				
	Q=	**0.54**		Q=	**0.27**				

Flow Data Calculations Considering Center Point Measurements (Cont.)

	12/4/2002								
	NP-1	**(Inlet Culvert, East)**				**NP-1**	**(Inlet Culvert, West)**		
						Closed			
	y(depth of water)=		4	inches		y(depth of water)=			inches
	D(diameter of tub)=		2.42	feet		D(diameter of tub)=		2.42	feet
	z(D/2-y)=		0.876667			z(D/2-y)=		1.21	
theta	O=cos^-1(2z/D)		0.760462		theta	O=cos^-1(2z/D)		0	
area:	A(D^2/4(O-sin2O/2))=		0.382252	(ft^2)	area:	A(D^2/4(O-sin2O/2))=		0	(ft^2)
wetted	P=D*O		1.840317	(ft)	wetted	P=D*O		0	(ft)
perimeter					perimeter				
	v(velocity)=		2.386	(ft/s)		v(velocity)=			(ft/s)
flow rate	Q=v*A		**0.91**	(cfs)	flow rate	Q=v*A		**0.00**	(cfs)
	NP-2E			**NP-2W**					
	Weir			**Weir**					
	Q=Cw*L*h^(3/2)			Q=Cw*L*h^(3/2)					
	Cw=	2.8		Cw=	2.8				
	L=	8		L=	8				
	h=	1.125		h=	0.625				
	Q=	**0.64**		Q=	**0.27**				

Flow Data Calculations Considering Center Point Measurements (Cont.)

	12/11/2002								
	NP-1	**(Inlet Culvert, East)**				**NP-1**	**(Inlet Culvert, West)**		
						Closed			
	y(depth of water)=		3.625	inches		y(depth of water)=			inches
	D(diameter of tub)=		2.42	feet		D(diameter of tub)=		2.42	feet
	z(D/2-y)=		0.907917			z(D/2-y)=		1.21	
theta	O=cos^-1(2z/D)		0.722213		theta	O=cos^-1(2z/D)		0	
area:	A(D^2/4(O-sin2O/2))=		0.33118	(ft^2)	area:	A(D^2/4(O-sin2O/2))=		0	(ft^2)
wetted	P=D*O		1.747757	(ft)	wetted	P=D*O		0	(ft)
perimeter					perimeter				
	v(velocity)=		1.964	(ft/s)		v(velocity)=			(ft/s)
flow rate	Q=v*A		**0.65**	(cfs)	flow rate	Q=v*A		**0.00**	(cfs)
	NP-2E			**NP-2W**					
	Weir			**Weir**					
	Q=Cw*L*h^(3/2)			Q=Cw*L*h^(3/2)					
	Cw=	2.8		Cw=	2.8				
	L=	8		L=	8				
	h=	1.125		h=	0.625				
	Q=	**0.64**		Q=	**0.27**				

Flow Data Calculations Considering Center Point Measurements (Cont.)

	12/18/2002								
	NP-1	**(Inlet Culvert, East)**				**NP-1**	**(Inlet Culvert, West)**		
						Closed			
	y(depth of water)=		3.625	inches		y(depth of water)=			inches
	D(diameter of tub)=		2.42	feet		D(diameter of tub)=		2.42	feet
	z(D/2-y)=		0.907917			z(D/2-y)=		1.21	
theta	O=cos^-1(2z/D)		0.722213		theta	O=cos^-1(2z/D)		0	
area:	A(D^2/4(O-sin2O/2))=		0.33118	(ft^2)	area:	A(D^2/4(O-sin2O/2))=		0	(ft^2)
wetted	P=D*O		1.747757	(ft)	wetted	P=D*O		0	(ft)
perimeter					perimeter				
	v(velocity)=		2.871	(ft/s)		v(velocity)=			(ft/s)
flow rate	Q=v*A		**0.95**	(cfs)	flow rate	Q=v*A		**0.00**	(cfs)
	NP-2E			**NP-2W**					
	Weir			**Weir**					
	Q=Cw*L*h^(3/2)			Q=Cw*L*h^(3/2)					
	Cw=	2.8		Cw=	2.8				
	L=	8		L=	8				
	h=	1.25		h=	0.75				
	Q=	**0.75**		Q=	**0.35**				

Flow Data Calculations Considering Center Point Measurements (Cont.)

	1/8/2003								
	NP-1	**(Inlet Culvert, East)**				**NP-1**	**(Inlet Culvert, West)**		
						Closed			
	y(depth of water)=		4.125	inches		y(depth of water)=			inches
	D(diameter of tub)=		2.42	feet		D(diameter of tub)=		2.42	feet
	z(D/2-y)=		0.86625			z(D/2-y)=		1.21	
theta	O=cos^-1(2z/D)		0.772871		theta	O=cos^-1(2z/D)		0	
area:	A(D^2/4(O-sin2O/2))=		0.39974	(ft^2)	area:	A(D^2/4(O-sin2O/2))=		0	(ft^2)
wetted	P=D*O		1.870348	(ft)	wetted	P=D*O		0	(ft)
perimeter					perimeter				
	v(velocity)=		1.971	(ft/s)		v(velocity)=			(ft/s)
flow rate	Q=v*A		**0.79**	(cfs)	flow rate	Q=v*A		**0.00**	(cfs)
	NP-2E			**NP-2W**					
	Weir			**Weir**					
	Q=Cw*L*h^(3/2)			Q=Cw*L*h^(3/2)					
	Cw=	2.8		Cw=	2.8				
	L=	8		L=	8				
	h=	1.125		h=	0.5				
	Q=	**0.64**		Q=	**0.19**				

Flow Data Calculations Considering Center Point Measurements (Cont.)

	1/15/2003								
	NP-1	**(Inlet Culvert, East)**				**NP-1**	**(Inlet Culvert, West)**		
						Closed			
	y(depth of water)=		5.5	inches		y(depth of water)=			inches
	D(diameter of tub)=		2.42	feet		D(diameter of tub)=		2.42	feet
	z(D/2-y)=		0.751667			z(D/2-y)=		1.21	
theta	O=cos^-1(2z/D)		0.900508		theta	O=cos^-1(2z/D)		0	
area:	A(D^2/4(O-sin2O/2))=		0.605698	(ft^2)	area:	A(D^2/4(O-sin2O/2))=		0	(ft^2)
wetted	P=D*O		2.179229	(ft)	wetted	P=D*O		0	(ft)
perimeter					perimeter				
	v(velocity)=		3.241	(ft/s)		v(velocity)=			(ft/s)
flow rate	Q=v*A		**1.96**	(cfs)	flow rate	Q=v*A		**0.00**	(cfs)
	NP-2E			**NP-2W**					
	Weir			**Weir**					
	Q=Cw*L*h^(3/2)			Q=Cw*L*h^(3/2)					
	Cw=	2.8		Cw=	2.8				
	L=	8		L=	8				
	h=	1.875		h=	1.25				
	Q=	**1.38**		Q=	**0.75**				

Correction of Flow Data Calculations Considering the Whole Section of the Culvert at the Inflow WPNP

		9/18/2002							
	NP-1	**(Inlet Culvert, East)**				**NP-1**	**(Inlet Culvert, West)**		
*the two culvert were open					*the two culvert were open				
	y(depth of water)=		4.102	Inches		y(depth of water)=		4.797	inches
	D(diameter of tub)=		2.42	Feet		D(diameter of tub)=		2.42	feet
	z(D/2-y)=		0.868			z(D/2-y)=		0.810	
theta	O=cos^-1(2z/D)		0.771		theta	O=cos^-1(2z/D)		0.837	
area:	A(D^2/4(O-sin2O/2))=		0.396	(ft^2)	area:	A(D^2/4(O-sin2O/2))=		0.497	(ft^2)
wetted	P=D*O		1.865	(ft)	wetted	P=D*O		2.026	(ft)
perimeter					perimeter				
	v(velocity)=		1.168	(ft/s)		v(velocity)=		1.937	(ft/s)
flow rate	Q=v*A		**0.46**	(cfs)	flow rate	Q=v*A		**0.96**	(cfs)
		9/25/2002							
	NP-1	**(Inlet Culvert, East)**				**NP-1**	**(Inlet Culvert, West)**		
*the two culvert were open					*the two culvert were open				
	y(depth of water)=		4.250	inches		y(depth of water)=		4.532	inches
	D(diameter of tub)=		2.42	feet		D(diameter of tub)=		2.42	feet
	z(D/2-y)=		0.856			z(D/2-y)=		0.832	
theta	O=cos^-1(2z/D)		0.785		theta	O=cos^-1(2z/D)		0.812	
area:	A(D^2/4(O-sin2O/2))=		0.417	(ft^2)	area:	A(D^2/4(O-sin2O/2))=		0.458	(ft^2)
wetted	P=D*O		1.900	(ft)	wetted	P=D*O		1.966	(ft)
perimeter					perimeter				
	v(velocity)=		1.36	(ft/s)		v(velocity)=		2.136	(ft/s)
flow rate	Q=v*A		**0.57**	(cfs)	flow rate	Q=v*A		**0.98**	(cfs)

Correction of Flow Data Calculations Considering the Whole Section of the Culvert at the Inflow WPNP (Cont.)

		10/2/2002		
	NP-1	**(Inlet Culvert, East)**		
*the two culvert were open				
	y(depth of water)=		3.950	inches
	D(diameter of tub)=		2.42	feet
	z(D/2-y)=		0.881	
theta	O=cos^-1(2z/D)		0.755	
area:	A(D^2/4(O-sin2O/2))=		0.375	(ft^2)
wetted	P=D*O		1.828	(ft)
perimeter				
	v(velocity)=		1.525	(ft/s)
flow rate	Q=v*A		**0.57**	(cfs)

	NP-1	**(Inlet Culvert, West)**		
*the two culvert were open				
	y(depth of water)=		4.797	inches
	D(diameter of tub)=		2.42	feet
	z(D/2-y)=		0.810	
theta	O=cos^-1(2z/D)		0.837	
area:	A(D^2/4(O-sin2O/2))=		0.497	(ft^2)
wetted	P=D*O		2.026	(ft)
perimeter				
	v(velocity)=		1.846	(ft/s)
flow rate	Q=v*A		**0.92**	(cfs)

		10/9/2002		
	NP-1	**(Inlet Culvert, East)**		
*the two culvert were open				
	y(depth of water)=		4.393	inches
	D(diameter of tub)=		2.42	feet
	z(D/2-y)=		0.844	
theta	O=cos^-1(2z/D)		0.799	
area:	A(D^2/4(O-sin2O/2))=		0.438	(ft^2)
Wetted	P=D*O		1.933	(ft)
Perimeter				
	v(velocity)=		1.49	(ft/s)
flow rate	Q=v*A		**0.65**	(cfs)

	NP-1	**(Inlet Culvert, West)**		
*the two culvert were open				
	y(depth of water)=		4.532	inches
	D(diameter of tub)=		2.42	feet
	z(D/2-y)=		0.832	
theta	O=cos^-1(2z/D)		0.812	
area:	A(D^2/4(O-sin2O/2))=		0.458	(ft^2)
wetted	P=D*O		1.966	(ft)
perimeter				
	v(velocity)=		1.808	(ft/s)
flow rate	Q=v*A		**0.83**	(cfs)

Correction of Flow Data Calculations Considering the Whole Section of the Culvert at the Inflow WPNP (Cont.)

		10/16/2002							
	NP-1	**(Inlet Culvert, East)**			**10/30/2002**	**NP-1**	**(Inlet Culvert, East)**		
						y(depth of water)=		6.022	inches
	y(depth of water)=		5.275	inches		D(diameter of tub)=		2.42	feet
	D(diameter of tub)=		2.42	feet		z(D/2-y)=		0.708	
	z(D/2-y)=		0.770		theta	O=cos^-1(2z/D)		0.946	
Theta	O=cos^-1(2z/D)		0.881		area:	A(D^2/4(O-sin2O/2))=		0.690	(ft^2)
area:	A(D^2/4(O-sin2O/2))=		0.570	(ft^2)	wetted	P=D*O		2.288	(ft)
Wetted	P=D*O		2.131	(ft)	perimeter				
Perimeter						v(velocity)=		0.911	(ft/s)
	v(velocity)=		2.155	(ft/s)	flow rate	Q=v*A		**0.63**	(cfs)
flow rate	Q=v*A		**1.23**	(cfs)					
11/6/2002	**NP-1**	**(Inlet Culvert, East)**			**11/13/2002**	**NP-1**	**(Inlet Culvert, East)**		
	y(depth of water)=		5.275	inches		y(depth of water)=		5.383	inches
	D(diameter of tub)=		2.42	feet		D(diameter of tub)=		2.42	feet
	z(D/2-y)=		0.770			z(D/2-y)=		0.761	
Theta	O=cos^-1(2z/D)		0.881		theta	O=cos^-1(2z/D)		0.890	
area:	A(D^2/4(O-sin2O/2))=		0.570	(ft^2)	area:	A(D^2/4(O-sin2O/2))=		0.587	(ft^2)
Wetted	P=D*O		2.131	(ft)	wetted	P=D*O		2.154	(ft)
Perimeter					perimeter				
	v(velocity)=		0.643	(ft/s)		v(velocity)=		0.749	(ft/s)
flow rate	Q=v*A		**0.37**	(cfs)	flow rate	Q=v*A		**0.44**	(cfs)

Correction of Flow Data Calculations Considering the Whole Section of the Culvert at the Inflow WPNP (Cont.)

11/27/2002	**NP-1**	**(Inlet Culvert, East)**		**12/4/2002**	**NP-1**	**(Inlet Culvert, East)**	
	y(depth of water)=	5.044	inches		y(depth of water)=	5.488	inches
	D(diameter of tub)=	2.42	feet		D(diameter of tub)=	2.42	feet
	z(D/2-y)=	0.7896			z(D/2-y)=	0.753	
theta	O=cos^-1(2z/D)	0.8598		theta	O=cos^-1(2z/D)	0.899	
area:	A(D^2/4(O-sin2O/2))=	0.5349	(ft^2)	area:	A(D^2/4(O-sin2O/2))=	0.604	(ft^2)
wetted	P=D*O	2.0807	(ft)	wetted	P=D*O	2.177	(ft)
perimeter				perimeter			
	v(velocity)=	2.253	(ft/s)		v(velocity)=	2.386	(ft/s)
flow rate	Q=v*A	**1.21**	(cfs)	flow rate	Q=v*A	**1.44**	(cfs)
12/11/2002	**NP-1**	**(Inlet Culvert, East)**		**12/18/2002**	**NP-1**	**(Inlet Culvert, East)**	
	y(depth of water)=	5.162	inches		y(depth of water)=	5.162	inches
	D(diameter of tub)=	2.42	feet		D(diameter of tub)=	2.42	feet
	z(D/2-y)=	0.7799			z(D/2-y)=	0.7799	
theta	O=cos^-1(2z/D)	0.8704		theta	O=cos^-1(2z/D)	0.8704	
area:	A(D^2/4(O-sin2O/2))=	0.5529	(ft^2)	area:	A(D^2/4(O-sin2O/2))=	0.5529	(ft^2)
wetted	P=D*O	2.1064	(ft)	wetted	P=D*O	2.1064	(ft)
perimeter				perimeter			
	v(velocity)=	1.964	(ft/s)		v(velocity)=	2.871	(ft/s)
flow rate	Q=v*A	**1.09**	(cfs)	flow rate	Q=v*A	**1.59**	(cfs)

Correction of Flow Data Calculations Considering the Whole Section of the Culvert at the Inflow WPNP (Cont.)

1/8/2003	**NP-1**	**(Inlet Culvert, East)**		**1/15/2003**	**NP-1**	**(Inlet Culvert, East)**	
	y(depth of water)=	5.588	inches		y(depth of water)=	6.401	inches
	D(diameter of tub)=	2.42	feet		D(diameter of tub)=	2.42	feet
	z(D/2-y)=	0.744			z(D/2-y)=	0.677	
theta	O=cos^-1(2z/D)	0.908		theta	O=cos^-1(2z/D)	0.977	
area:	A(D^2/4(O-sin2O/2))=	0.620	(ft^2)	area:	A(D^2/4(O-sin2O/2))=	0.752	(ft^2)
wetted	P=D*O	2.198	(ft)	wetted	P=D*O	2.365	(ft)
perimeter				perimeter			
	v(velocity)=	1.971	(ft/s)		v(velocity)=	3.241	(ft/s)
flow rate	Q=v*A	**1.22**	(cfs)	flow rate	Q=v*A	**2.44**	(cfs)

Flow Measurements						
	Flows at Inflow East Culvert (cfs)		Flows at Inflow West Culvert (cfs)		Flows at Outflow East (cfs)	Flows at Outflow West (cfs)
Date	Flows Measured at Center Front	Adjusted Flows After Correction	Flows Measured at Center Front	Adjusted Flows After Correction		
9/18/02	0.24	0.50	0.79	1.04	0.19	0.27
9/25/02	0.30	0.61	0.84	1.06	0.64	0.02
10/02/02	0.29	0.62	0.81	0.99	0.54	0.35
10/09/02	0.35	0.71	0.81	0.90	0.64	0.64
10/16/02	0.75	1.33	No Flow	No Flow	0.54	0.19
10/30/02	0.45	0.68	No Flow	No Flow	0.75	0.54
11/06/02	0.22	0.40	No Flow	No Flow	0.64	0.54
11/13/02	0.27	0.48	No Flow	No Flow	0.75	0.27
11/27/02	0.71	1.30	No Flow	No Flow	0.54	0.27
12/04/02	0.91	1.56	No Flow	No Flow	0.64	0.27
12/11/02	0.65	1.17	No Flow	No Flow	0.64	0.27
12/18/02	0.95	1.72	No Flow	No Flow	0.75	0.35
1/8/02	0.79	1.32	No Flow	No Flow	0.64	0.19
1/15/02	1.96	2.64	No Flow	No Flow	1.38	0.75

APPENDIX F

ANALYTICAL PROCEDURES FOR PHOSPHORUS ANALYSIS

Sample Analysis

The ascorbic acid method will be used for the analysis of both orthophosphate and total phosphorus in water, for total phosphorus in sediment and total phosphorus in plant. The persulphate method will be used to extract the total phosphorus from the water and from sediment samples. Gravimetric Quinolium Molybdophosphate Method will be used to extract TP from plant samples. Duplicate runs will be performed for all samples.

Ascorbic Acid and Persulphate Methods

Reagents

- Sulfuric Acid (H_2SO_4), 5N
- Sulfuric Acid Solution, 30% (Carefully add 300 mL conc. H_2SO_4 to approximately 600 mL distilled water and dilute to 1 L with distilled water).
- Antimony Potassium Tartrate ($K(SbO)C_4H_4O_6*1/2H_2O$)
- Ammonium Molybdate $(NH_4)_6Mo_7O_{24}*4H_2O$
- Ascorbic Acid, 0.1M
- Anhydrous Potassium Phosphate Monobasic (KH_2PO_4)
- Phenolphthalein indicator
- Potassium Persulfate ($K_2S_2O_8$)
- Sodium Hydroxide, 1N (NaOH)

Ascorbic Acid Method (Stand. Method 4500-P E)

Preparing the Phosphate Standards

1. **Sulfuric Acid (H_2SO_4), 5N**: Dilute 70 mL of conc. H_2SO_4 to 500 mL with distilled water.
2. **Potassium Antimonyl Tartrate Solution**: Dissolve 1.3715 g $K(SbO)C_4H_4O_6*1/2H_2O$ in 400 mL distilled water in a 500 mL volumetric flask and dilute to volume. Store in a glass-stoppered bottle.
3. **Ammonium Molybdate Solution**: Dissolve 20 g $(NH_4)_6Mo_7O_{24}*4H_2O$ in 500 mL with DI water. Store in a glass-stoppered bottle.
4. **Ascorbic Acid, 0.1M**: Dissolve 1.76 g ascorbic acid in 100 mL distilled water. The solution is stable for about one week at 4 °C.
5. **Combined Reagent**: Mix the above reagents in the following proportions for 100 mL of the combined reagent: 50 mL 5N H_2SO_4, 5 mL of potassium antimonyl tartrate solution, 15 mL ammonium molybdate solution, and 30 mL ascorbic acid solution. ***Mix after addition of each reagent***. Let all reagents reach room temperature before they are mixed and mix in the order given. If turbidity forms in the combined reagent, shake and let stand for a few minutes until turbidity disappears before proceeding. The reagent is stable for 4 h.
6. **Stock phosphate solution**: Dissolve in distilled water 0.2195 g anhydrous Potassium Phosphate Monobasic (KH_2PO_4) and dilute to 1000 mL = 50.0 µg PO_4^{-3}-P. (µg/ml = 50 ppm).

7. **Standard phosphate solution**: Dillute 50.0 mL of stock phosphate solution to 1000 mL with distilled water; 1.00 mL = 2.50 μg P (2.50 ppm).

Preparation of Calibration Curve

1. Turn on spectrophotometer and allow it to warm up for at least 15 minutes.
2. Prepare individual phosphorus calibration standards. Prepare blank using 25 mL of distilled water and 4 mL of the combined reagent to make photometric readings for the calibration to give a straight line passing through the origin.
3. Pipet 25 mL of standard into a clean, dry test tube (1"diam). Add 0.05 mL (1 drop) of phenolphthalein indicator solution. If a red color develops, add 5N H_2SO_4 solution dropwise to just discharge the color.
4. Add 4.0 mL of combined reagent in each tube and mix thoroughly.
5. After at least 10 min but no more than 30 min, measure absorbance of each sample at 880 nm, using reagent blank as the reference solution.
6. Prepare a calibration curve using the absorbance readings obtained in step 5. An R^2 of at least 0.997 will be required for the calibration curve of the standards.
7. For each five samples run, one QC sample, consisting of a standard will be run.
8. For analysis of the samples, the same procedure is followed except that 25 mL of sample is used in place of the standard.

Correction for turbidity or interfering color

1. If sample water is highly colored or turbid, prepare a new combined reagent by adding all reagents except ascorbic acid and potassium antimony tartrate to the sample. Use this as a blank to check absorbance of each sample.

Persulphate Digestion Method (Stand. Method 4500-P B5.)

Prepare individual phosphorus calibration standards. Prepare blank using 50 mL of distilled water to make photometric readings for the calibration to give a straight line passing through the origin. Run the calibration standard through the persulphate method as follow:

1. Take 50 mL of thoroughly mixed sample into a clean 250 mL erlenmeyer flask.
2. Add 0.05 mL (1 drop) of phenolphthalein indicator solution. If a red color develops, add drop by drop of 30 % H_2SO_4 till the color changes to colorless.
3. Add 1 mL of 30 % H_2SO_4 solution to each sample and add 0.5 g of potassium persulphate ($K_2S_2O_8$) to each sample, mix and cover each flask
4. Heat samples in autoclave for 30 minutes at 121 °C (250 °F). (This process takes about 1:20 h).
5. Let the samples cool to room temperature. Add 0.05 mL (1 drop) of phenolphthalein indicator solution.
6. Add drop by drop of NaOH to neutralize till color changes to a faint pink color.
7. Add drop by drop of 30% H_2SO_4 till the color changes to colorless.

8. After 10 to 15 minutes, determine total phosphorus by Ascorbic Acid Method, for which a separate calibration curve has been constructed by carrying standards through the persulfate digestion procedure.

Gravimetric Quinolium Molybdophosphate Method (AOAC Method 966.01)

For TP Extraction in Plant Samples

Reagents

- P-free magnesium nitrate - $Mg(NO_3)_2$
- HCl (2:1 and 1:9 dilutions)

Solution Preparation

Take 950 g P-free $Mg(NO_3)_2.6H_2O$ dissolve in DI water and dilute to 1L.

Analysis

1. Accurately weigh 0.5 g of dried plant sample in a aluminum dish, and add 7.5 mL of $Mg(NO_3)_2$ solution .
2. Dry in oven for 2 h at 105-110°C (or until dry).
3. Ignite carefully over a hot plate, inside the hood, until bubbling and smoking cease.
4. Complete ashing in furnace for 2h at 550-600°C.
5. Dissolve ash in few (3-10mL) HCl (2+1) and evaporate to dryness on steam bath.

6. Take up residue in 10-15 mL of HCl (1+9) and filter thru coarse paper (whatman 41 - 20-25 μm) into 100mL volumetric flask.
7. Wash paper thoroly with distilled water and let filtrate cool to room temperature. Dilute to volume with distilled water.

TP Determination

Pipet 0.25 mL portion of the sample into a clean, dry test tube (1" diam.) and add 24.75 mL of DI water. Proceed with TP analysis by Ascorbic Acid Method (Stand. Method 4500-P E).

APPENDIX G

THE CLARK COUNTY WETLANDS PARK NATURE PRESERVE UPPER POND PHOSPHORUS STUDY - RAW DATA

Water Data

	NP-1(Inflow)						NP-2E (Outflow East)						NP-2W (outflow West)					
Date	pH (SU)	DO (mg/L)	Temp (°C)	Spec. Conduct. (µmhos/cm)	TP (ppb)	OP (ppb)	pH SU)	DO (mg/L)	Temp (°C)	Spec. Conduct. (µmhos/cm)	TP (ppb)	OP (ppb)	pH (SU)	DO (mg/L)	Temp (°C)	Spec. Conduct. (µmhos/cm)	TP (ppb)	OP (ppb)
18/02	7.91	6.32	18.7	4950	22.50	5.00	7.93	6.84	19.9	4840	21.25	1.54	7.89	6.32	17.9	4860	18.75	7.69
25/02	6.14	6.36	21.8	5330	89.06	74.29	5.56	4.78	21.4	5330	30.94	9.64	7.49	5.54	21.7	5290	43.75	31.79
.02/02	7.48	7.28	17.6	5330	45.63	10.00	7.54	6.43	17.8	5280	51.56	10.36	7.64	6.01	18.1	5250	57.50	7.86
.09/02	7.45	7.06	18.9	5330	96.54	7.86	7.50	6.08	19.3	5280	47.69	5.36	7.48	6.19	20.1	5320	41.92	9.29
.16/02	7.40	6.81	16.3	5240	49.23	3.22	7.62	7.8	16.4	5320	40.00	15.00	7.6	7.65	16.6	5260	46.15	8.93
.30/02	7.81	7.16	14.0	4870	87.69	46.43	7.63	4.22	16.2	4460	88.85	3.57	7.65	5.11	15.7	4280	62.31	27.14
.06/02	7.89	8.78	11.1	5120	55.00	7.14	7.99	9.75	10.9	4920	38.57	3.57	8.04	9.45	11.5	5000	40.36	11.43
.13/02	7.90	8.21	12.4	5100	28.22	7.30	8.05	9.49	12.5	5180	35.00	8.46	8.07	8.87	12.5	5120	40.72	10.00
.27/02	8.05	9.29	8.4	5140	18.08	5.71	8.10	9.66	8.90	5010	27.69	3.57	8.14	9.47	9.2	5080	11.93	1.78
.04/02	7.88	8.06	10.9	4960	17.31	9.29	7.82	6.4	11.9	4950	57.31	8.57	7.88	6.43	12	4920	48.46	13.57
.11/02	7.89	8.46	10.7	5060	34.69	11.07	8.13	10.53	9.2	5070	33.44	6.07	8.11	9.68	9.5	5050	22.19	8.57
.18/02	8.03	8.2	9.5	4924	18.34	6.67	8.33	11.12	9.5	4980	45.67	7.34	8.10	10.45	9.5	4978	48.67	4.34
.8/03	7.78	7.04	11.8	5050	25.42	9.65	8.00	10.31	10.6	5080	36.43	2.50	8.00	9.7	10.8	5060	31.43	2.50
15/03	7.87	8.74	10.1	5140	39.29	12.14	8.05	10.54	9.3	5120	43.22	5.72	8.15	9.64	9.8	5100	56.07	5.72
eans	**7.68**	**7.70**	**13.73**	**5110**	**44.81**	**15.41**	**7.73**	**8.14**	**13.84**	**5059**	**42.69**	**6.52**	**8.05**	**9.18**	**10.32**	**5022**	**40.73**	**10.76**
. Dev	**0.49**	**0.95**	**4.18**	**154.55**	**27.79**	**19.96**	**0.67**	**2.33**	**4.49**	**232.84**	**16.38**	**3.66**	**0.25**	**1.89**	**4.31**	**259.5**	**14.90**	**8.61**
Error	**0.13**	**0.25**	**1.12**	**41.30**	**7.43**	**5.33**	**0.18**	**0.62**	**1.20**	**62.23**	**4.38**	**0.98**	**0.07**	**0.50**	**1.15**	**69.35**	**3.98**	**2.30**

Solids in Water – Raw Data

	NP-1(Inflow)			NP-2E (East Outflow)			NP-2W (West Outflow)		
Date	TS(ppm)	TDS(ppm)	TSS(ppm)	TS(ppm)	TDS(ppm)	TSS(ppm)	TS(ppm)	TDS(ppm)	TSS(ppm)
9/18/02	4513	NA	NA	4878	NA	NA	4850	NA	NA
9/25/02	4895	NA	NA	5080	NA	NA	4985	NA	NA
10/02/02	5423	NA	NA	4938	NA	NA	5093	NA	NA
10/09/02	5228	NA	NA	4983	NA	NA	5058	NA	NA
10/21/02	5300	5160	15	5525	5540	13	5420	5410	16
10/30/02	4425	NA	11	4200	NA	NA	4205	NA	NA
11/06/02	4683	NA	6	4618	NA	NA	4883	NA	NA
11/13/02	4828	4800	4	4920	4978	25	4968	4873	88
11/27/02	4935	4965	2	4890	4943	16	4905	4885	13
12/04/02	4765	4867	3	4752	4458	22	4767	4832	12
12/11/02	4839	4814	3	4741	4715	11	4858	4675	5
12/18/02	4984	4999	4	5550	4953	16	4965	4944	6
1/08/03	4835	4875	3	4876	4876	7	4864	4914	7
1/15/03	5009	5047	4	4943	4781	14	5193	4953	20
Means	**4904**	**4941**	**6**	**4921**	**4905**	**15**	**4929**	**4936**	**21**

Inflow Total Phosphorus and Ortho Phosphorus Loading

Date	Inflow (cfs)	Inflow (L/day)	Inflow (m3/day)	OP Conc (ppb)	OP Conc (ppm)	OP Loading Inflow x Conc (microg/day)	OP Loading Inflow x Conc (mg/day)	OP Loading Inflow x Conc (g/day)	OP Loading Inflow x Conc (g/yr*m2)	TP Conc (ppb)	TP Conc (ppm)	TP Loading Inflow x Conc (microg/day)	TP Loading Inflow x Conc (mg/day)	TP Loading Inflow x Conc (g/day)	TP Loading Inflow x Conc (g/yr*m2)
9/18/2002	1.54	3,768,146	3,768	5.00	0.0050	18,840,730	18,841	18.84	1.35	22.50	0.0225	84,783,283	84,783	84.78	6.07
9/25/2002	1.67	4,086,236	4,086	74.29	0.0743	303,566,484	303,566	303.57	21.73	89.06	0.0891	363,920,192	363,920	363.92	26.05
10/2/2002	1.61	3,939,425	3,939	10.00	0.0100	39,394,253	39,394	39.39	2.82	45.63	0.0456	179,755,976	179,756	179.76	12.87
10/9/2002	1.60	3,914,957	3,915	7.86	0.0079	30,771,560	30,772	30.77	2.20	96.54	0.0965	377,949,929	377,950	377.95	27.05
10/16/2002	1.33	3,254,308	3,254	3.22	0.0032	10,478,871	10,479	10.48	0.75	49.23	0.0492	160,209,575	160,210	160.21	11.47
10/30/2002	0.68	1,663,857	1,664	46.43	0.0464	77,252,864	77,253	77.25	5.53	87.69	0.0877	145,903,589	145,904	145.90	10.44
11/6/2002	0.40	978,739	979	7.14	0.0071	6,988,198	6,988	6.99	0.50	55.00	0.0550	53,830,656	53,831	53.83	3.85
11/13/2002	0.48	1,174,487	1,174	7.30	0.0073	8,573,755	8,574	8.57	0.61	28.22	0.0282	33,144,024	33,144	33.14	2.37
11/27/2002	1.30	3,180,902	3,181	5.71	0.0057	18,162,953	18,163	18.16	1.30	18.08	0.018	57,510,715	57,511	57.51	4.12
12/4/2002	1.56	3,817,083	3,817	9.29	0.0093	35,460,700	35,461	35.46	2.54	17.31	0.017	66,073,705	66,074	66.07	4.73
12/11/2002	1.17	2,862,812	2,863	11.07	0.0111	31,691,331	31,691	31.69	2.27	34.69	0.035	99,310,954	99,311	99.31	7.11
12/18/2002	1.42	3,474,524	3,475	6.67	0.0067	23,175,076	23,175	23.18	1.66	18.34	0.018	63,722,773	63,723	63.72	4.56
1/8/2003	1.32	3,229,839	3,230	9.65	0.0097	31,167,950	31,168	31.17	2.23	25.72	0.026	83,071,468	83,071	83.07	5.95
1/15/2003	2.64	6,459,679	6,460	12.14	0.0121	78,420,500	78,420	78.42	5.61	39.29	0.039	253,800,777	253,801	253.80	18.17
means	**1.34**	**3,271,785**	**3,272**	**15.41**	**0.02**	**50,996,087**	**50996.1**	**51.00**	**3.65**	**44.81**	**0.04**	**144,499,115**	**144499.12**	**144.50**	**10.34**

Total Outflow Total Phosphorus and Ortho Phosphorus Loading

Date	totalOut (cfs)	Total Outflow (L/day)	Total Outflow (m3/day)	OP Conc (ppb)	OP Conc (ppm)	OP Loading Outfl x Conc (microg/day)	OP Loading Outfl x Conc (mg/day)	OP Loading Outfl x Conc (g/day)	OP Loading Outfl x Conc (g/yr*m2)	TP Conc (ppb)	TP Conc (ppm)	TP Loading Outflow x Conc (microg/day)	TP Loading Outflow x Conc (mg/day)	TP Loading Outflow x Conc (g/day)	TP Loading Outflow x Conc (g/yr*m2)
9/18/2002	0.46	1,126,000	1,126	4.62	0.005	5,196,490	5,196	5.20	0.37	20.00	0.0200	22,520,000	22,520	**22.52**	1.61
9/25/2002	0.66	1,614,920	1,615	20.72	0.021	33,453,061	33,453	33.45	2.39	37.35	0.0373	60,309,175	60,309	**60.31**	4.32
10/2/2002	0.89	2,177,695	2,178	9.11	0.009	19,838,799	19,839	19.84	1.42	54.53	0.0545	118,749,693	118,750	**118.75**	8.50
10/9/2002	1.28	3,131,965	3,132	7.33	0.007	22,941,647	22,942	22.94	1.64	44.81	0.0448	140,327,712	140,328	**140.33**	10.04
10/16/2002	0.73	1,786,199	1,786	11.97	0.012	21,371,872	21,372	21.37	1.53	43.08	0.0431	76,940,524	76,941	**76.94**	5.51
10/30/2002	1.29	3,156,434	3,156	15.36	0.015	48,467,043	48,467	48.47	3.47	75.58	0.0756	238,563,276	238,563	**238.56**	17.08
11/6/2002	1.18	2,887,281	2,887	7.50	0.008	21,654,605	21,655	21.65	1.55	39.47	0.0395	113,946,530	113,947	**113.95**	8.16
11/13/2002	1.02	2,495,785	2,496	9.23	0.009	23,036,095	23,036	23.04	1.65	37.86	0.0379	94,490,419	94,490	**94.49**	6.76
11/27/2002	0.81	1,981,947	1,982	2.68	0.003	5,301,708	5,302	5.30	0.38	19.81	0.0198	39,262,368	39,262	**39.26**	2.81
12/4/2002	0.91	2,226,632	2,227	11.07	0.011	24,648,813	24,649	24.65	1.76	52.89	0.0529	117,755,416	117,755	**117.76**	8.43
12/11/2002	0.91	2,226,632	2,227	7.32	0.007	16,298,944	16,299	16.30	1.17	27.82	0.0278	61,933,760	61,934	**61.93**	4.43
12/18/2002	1.1	2,691,533	2,692	5.84	0.006	15,718,552	15,719	15.72	1.13	47.17	0.0472	126,959,602	126,960	**126.96**	9.09
1/8/2003	0.83	2,030,884	2,031	2.50	0.003	5,077,210	5,077	5.08	0.36	33.93	0.0339	68,907,889	68,908	**68.91**	4.93
1/15/2003	2.13	5,211,786	5,212	5.72	0.006	29,811,417	29,811	29.81	2.13	49.65	0.0496	258,739,128	258,739	**258.74**	18.52
Means	**1.01**	**2,481,835**	**2,482**	**8.64**	**0.01**	**20,915,447**	**20,915**	**20.92**	**1.50**	**41.71**	**0.04**	**109,957,535**	**109,958**	**109.96**	**7.87**

Sediment Raw Data

pH Data

pH measurements on Sediments Samples

Sample ID	9/14/2002	9/21/2002	9/28/2002	10/5/2002	10/12/2002	10/26/2002	11/2/2002	11/10/2002	11/23/2002	12/1/2002	12/8/2002	12/15/2002	Average pH
Outflow E below	8.03	8.9	8.83	8.49	8.44	8.57	8.74	8.61	9.32	8.8	8.84	8.94	8.71
OutflowE top	8.34	8.39	8.51	7.77	8.84	8.48	8.48	8.44	8.97	8.65	8.65	8.76	8.52
E Edge Island top	8.65	8.49	8.71	8.98	8.69	8.74	8.59	8.44	8.69	8.84	8.7	9.24	8.73
E Edge Island below	8.09	8.14	8.36	8.45	8.550	8.45	8.41	8.40	8.50	8.55	8.46	9.11	8.46
Middle of pond top	8.13	8.51	8.68	8.97	8.834	8.8	8.81	8.53	8.61	9.04	8.77	9.02	8.73
Middle of pond below	8.21	8.32	8.66	8.77	8.899	8.75	8.85	8.76	8.5	9.11	9.18	9.17	8.76
Inflow top		8.42	8.67	8.75	8.479	8.55		8.55	9.15	8.68	8.68	8.93	8.69
Inflow below		8.25	8.73	9.26	8.856	8.71	8.7		8.52	8.96	8.92	8.93	8.78
Edge W.below	8.29	8.54	8.86	8.95	9.026	8.83	8.32	8.83	9.37	8.98	9.03	9.29	8.86
Edge W.top	8.04	8.66	8.8	9	8.979	8.72	8.47	8.44	8.86	8.98	9.01	9.22	8.76

Total Phosphorus in Sediment – Raw Data

Site	Collection Date	Conc. P (ppb)	mg of P per Kg of soil sample	Average mg of P per Kg of soil sample
E outflow lower	9/14/2002	5214.29	482	436
E outflow lowerR	9/14/2002	4000.00	390	
E outflow lower	9/21/2002	7500.00	719	702
E outflow lowerR	9/21/2002	7142.86	685	
E outflow lower	9/28/2002	6214.29	600	650
E outflow lowerR	9/28/2002	7214.29	700	
E outflow lower	10/5/2002	3571.43	350	345
E outflow lowerR	10/5/2002	3428.57	340	
E outflow lower	10/12/2002	7214.29	676	676
E outflow lowerR	10/12/2002	7142.86	676	
E outflow lower	10/26/2002	6642.86	640	630
E outflow lowerR	10/26/2002	6285.71	620	
E outflow lower	11/2/2002	5857.14	590	645
E outflow lowerR	11/2/2002	7071.43	700	
E outflow lower	11/10/2002	8285.71	800	800
E outflow lowerR	11/10/2002	8928.57	800	
E outflow lower	11/23/2002	8071.43	760	745
E outflow lowerR	11/23/2002	7785.71	730	
E outflow lower	12/1/2002	8285.71	810	810
E outflow lowerR	12/1/2002	8214.29	810	
E outflow lower	12/8/2002	6500.00	560	565
E outflow lowerR	12/8/2002	5928.57	570	
E outflow lower	12/15/2002	7071.43	700	690
E outflow lowerR	12/15/2002	6857.14	680	
E outflow upper	9/14/2002	6214.29	580	800
E outflow upperR	9/14/2002	5285.71	490	
E outflow upper	9/21/2002	7000.00	620	620
E outflow upperR	9/21/2002	6428.57	620	
E outflow upper	9/28/2002	7071.43	690	710
E outflow upperR	9/28/2002	7500.00	730	
E outflow upper	10/5/2002	3428.57	340	345
E outflow upperR	10/5/2002	3571.43	350	
E outflow upper	10/12/2002	6785.71	660	675
E outflow upperR	10/12/2002	6928.57	690	
E outflow upper	10/26/2002	5857.14	564	607
E outflow upperR	10/26/2002	7071.43	649	
E outflow upper	11/2/2002	7285.71	720	705
E outflow upperR	11/2/2002	6928.57	690	
E outflow upper	11/10/2002	7285.71	720	710
E outflow upperR	11/10/2002	7071.43	700	
E outflow upper	11/23/2002	7000.00	690	710
E outflow upperR	11/23/2002	7714.29	730	
E outflow upper	12/1/2002	7214.29	700	690
E outflow upperR	12/1/2002	6857.14	680	

Total Phosphorus in Sediment – Raw Data (Cont.)

Site	Collection Date	Conc. P (ppb)	mg of P per Kg of soil sample	Average mg of P per Kg of soil sample
E outflow upper	12/8/2002	6142.86	600	600
E outflow upperR	12/8/2002	6142.86	600	
E outflow upper	12/15/2002	6071.43	585	617
E outflow upperR	12/15/2002	6642.86	648	
E Edge of Island upper	9/14/2002	8928.57	870	780
E Edge of Island upperR	9/14/2002	7142.86	690	
E Edge of Island upper	9/21/2002	5357.14	520	540
E Edge of Island upperR	9/21/2002	5785.71	560	
E Edge of Island upper	9/28/2002	7714.29	770	750
E Edge of Island upperR	9/28/2002	7357.14	730	
E Edge of Island upper	10/5/2002	4285.71	420	430
E Edge of Island upperR	10/5/2002	4357.14	440	
E Edge of Island upper	10/12/2002	7357.14	720	730
E Edge of Island upperR	10/12/2002	7500.00	740	
E Edge of Island upper	10/26/2002	5142.86	480	440
E Edge of Island upperR	10/26/2002	4285.71	400	
E Edge of Island upper	11/2/2002	8357.14	830	815
E Edge of Island upperR	11/2/2002	8071.43	800	
E Edge of Island upper	11/10/2002	7214.29	700	720
E Edge of Island upperR	11/10/2002	7428.57	740	
E Edge of Island upper	11/23/2002	6642.86	650	645
E Edge of Island upperR	11/23/2002	6571.43	640	
E Edge of Island upper	12/1/2002	7928.57	770	735
E Edge of Island upperR	12/1/2002	7142.86	700	
E Edge of Island upper	12/8/2002	7500.00	750	725
E Edge of Island upperR	12/8/2002	7000.00	700	
E Edge of Island upper	12/15/2002	7785.71	780	810
E Edge of Island upperR	12/15/2002	8642.86	840	
E Edge of Island lower	9/14/2002	6000.00	510	570
E Edge of Island lowerR	9/14/2002	6571.43	630	
E Edge of Island lower	9/21/2002	4142.86	380	325
E Edge of Island lowerR	9/21/2002	2714.29	270	
E Edge of Island lower	9/28/2002	6214.29	580	570
E Edge of Island lowerR	9/28/2002	6071.43	560	
E Edge of Island lower	10/5/2002	2857.14	310	325
E Edge of Island lowerR	10/5/2002	5714.29	340	
E Edge of Island lower	10/12/2002	6357.14	630	630
E Edge of Island lowerR	10/12/2002	6428.57	630	
E Edge of Island lower	10/26/2002	5857.14	540	535
E Edge of Island lowerR	10/26/2002	5571.43	530	
E Edge of Island lower	11/2/2002	7642.86	760	800
E Edge of Island lowerR	11/2/2002	8500.00	840	
E Edge of Island lower	11/10/2002	4357.14	370	370
E Edge of Island lowerR	11/10/2002	4000.00	370	

Total Phosphorus in Sediment – Raw Data (Cont.)

Site	Collection Date	Conc. P (ppb)	mg of P per Kg of soil sample	Average mg of P per Kg of soil sample
E Edge of Island lower	11/23/2002	4857.14	460	470
E Edge of Island lowerR	11/23/2002	4857.14	480	
E Edge of Island lower	12/1/2002	5214.29	520	510
E Edge of Island lowerR	12/1/2002	5357.14	500	
E Edge of Island lower	12/8/2002	5714.29	530	535
E Edge of Island lowerR	12/8/2002	5642.86	540	
E Edge of Island lower	12/15/2002	7357.14	720	725
E Edge of Island lowerR	12/15/2002	7571.43	730	
Inflow upper	9/14/2002	no data	0	
Inflow upper	9/21/2002	4071.43	390	370
Inflow upperR	9/21/2002	3857.14	350	
Inflow upper	9/28/2002	13071.43	1270	1285
Inflow upperR	9/28/2002	13071.43	1300	
Inflow upper	10/5/2002	2857.14	285	285
Inflow upperR	10/5/2002	2857.14	284	
Inflow upper	10/12/2002	2000.00	200	200
Inflow upperR	10/12/2002	2000.00	200	
Inflow upper	10/26/2002	5928.57	550	525
Inflow upperR	10/26/2002	5142.86	500	
Inflow upper	11/2/2002	no data	0	
Inflow upper	11/10/2002	7857.14	770	820
Inflow upperR	11/10/2002	8928.57	870	
Inflow upper	11/23/2002	9714.29	950	930
Inflow upperR	11/23/2002	9285.71	910	
Inflow upper	12/1/2002	6500.00	640	685
Inflow upperR	12/1/2002	7357.14	730	
Inflow upper	12/8/2002	4642.86	450	440
Inflow upperR	12/8/2002	4428.57	430	
Inflow upper	12/15/2002	5714.29	520	515
Inflow upperR	12/15/2002	5428.57	510	
Inflow lower	9/14/2002	no data	0	
Inflow lower	9/21/2002	1857.14	160	165
Inflow lowerR	9/21/2002	1928.57	170	
Inflow lower	9/28/2002	7285.71	710	685
Inflow lowerR	9/28/2002	6857.14	660	
Inflow lower	10/5/2002	3571.43	350	335
Inflow lowerR	10/5/2002	3500.00	320	
Inflow lower	10/12/2002	9714.29	860	690
Inflow lowerR	10/12/2002	5285.71	520	
Inflow lower	10/26/2002	3071.43	300	290
Inflow lowerR	10/26/2002	2928.57	280	

Total Phosphorus in Sediment – Raw Data (Cont.)

Site	Collection Date	Conc. P (ppb)	mg of P per Kg of soil sample	Average mg of P per Kg of soil sample
Inflow lower	11/2/2002	2357.14	236	248
Inflow lowerR	11/2/2002	2714.29	260	
Inflow lower	11/10/2002	no data	0	
Inflow lower	11/23/2002	2642.86	230	240
Inflow lowerR	11/23/2002	2928.57	250	
Inflow lower	12/1/2002	2285.71	210	210
Inflow lowerR	12/1/2002	2357.14	210	
Inflow lower	12/8/2002	3285.71	290	275
Inflow lowerR	12/8/2002	2714.29	260	
Inflow lower	12/15/2002	2142.86	190	180
Inflow lowerR	12/15/2002	1785.71	170	
edge W.upper	9/14/2002	7357.14	700	710
edge W.upperR	9/14/2002	7357.14	720	
edge W.upper	9/21/2002	7428.57	720	720
edge W.upperR	9/21/2002	6428.57	720	
edge W.upper	9/28/2002	5214.29	510	500
edge W.upperR	9/28/2002	5214.29	490	
edge W.upper	10/5/2002	2500.00	250	260
edge W.upperR	10/5/2002	2857.14	270	
edge W.upper	10/12/2002	1928.57	180	190
edge W.upperR	10/12/2002	2000.00	200	
edge W.upper	10/26/2002	3214.29	321	331
edge W.upperR	10/26/2002	3642.86	340	
edge W.upper	11/2/2002	6142.86	600	545
edge W.upperR	11/2/2002	5000.00	490	
edge W.upper	11/10/2002	7571.43	710	720
edge W.upperR	11/10/2002	7428.57	730	
edge W.upper	11/23/2002	7000.00	650	625
edge W.upperR	11/23/2002	6357.14	600	
edge W.upper	12/1/2002	4071.43	400	380
edge W.upperR	12/1/2002	3714.29	360	
edge W.upper	12/8/2002	3071.43	280	280
edge W.upperR	12/8/2002	2857.14	280	
edge W.upper	12/15/2002	3142.86	290	305
edge W.upperR	12/15/2002	3285.71	320	
edge W.lower	9/14/2002	3642.86	350	335
edge W.lowerR	9/14/2002	3357.14	320	
edge W.lower	9/21/2002	2714.29	240	245
edge W.lowerR	9/21/2002	2642.86	250	
edge W.lower	9/28/2002	3000.00	280	280
edge W.lowerR	9/28/2002	3071.43	280	
edge W.lower	10/5/2002	1785.71	160	150
edge W.lowerR	10/5/2002	1428.57	140	
edge W.lower	10/12/2002	1928.57	180	170
edge W.lowerR	10/12/2002	1642.86	160	

Total Phosphorus in Sediment – Raw Data (Cont.)

Site	Collection Date	Conc. P (ppb)	mg of P per Kg of soil sample	Average mg of P per Kg of soil sample
edge W.lower	10/26/2002	714.29	71	76
edge W.lowerR	10/26/2002	857.14	80	
edge W.lower	11/2/2002	6142.86	614	547
edge W.lowerR	11/2/2002	5000.00	480	
edge W.lower	11/10/2002	7571.43	710	720
edge W.lowerR	11/10/2002	7428.57	730	
edge W.lower	11/23/2002	7000.00	640	615
edge W.lowerR	11/23/2002	6357.14	590	
edge W.lower	12/1/2002	4071.43	390	375
edge W.lowerR	12/1/2002	3714.29	360	
edge W.lower	12/8/2002	3071.43	270	275
edge W.lowerR	12/8/2002	2857.14	280	
edge W.lower	12/15/2002	3142.86	300	305
edge W.lowerR	12/15/2002	3285.71	310	
Middle of pond upper	9/14/2002	7071.43	700	705
Middle of pond upperR	9/14/2002	7214.29	710	
Middle of pond upper	9/21/2002	6714.29	593	566
Middle of pond upperR	9/21/2002	5500.00	538	
Middle of pond upper	9/28/2002	5928.57	587	567
Middle of pond upperR	9/28/2002	5571.43	546	
Middle of pond upper	10/5/2002	2142.86	214	245
Middle of pond upperR	10/5/2002	2785.71	275	
Middle of pond upper	10/12/2002	4928.57	480	495
Middle of pond upperR	10/12/2002	5214.29	510	
Middle of pond upper	10/26/2002	6214.29	600	575
Middle of pond upperR	10/26/2002	6000.00	550	
Middle of pond upper	11/2/2002	7071.43	700	671
Middle of pond upperR	11/2/2002	6428.57	643	
Middle of pond upper	11/10/2002	4142.86	400	420
Middle of pond upperR	11/10/2002	4714.29	440	
Middle of pond upper	11/23/2002	5857.14	580	605
Middle of pond upperR	11/23/2002	6571.43	630	
Middle of pond upper	12/1/2002	5357.14	530	555
Middle of pond upperR	12/1/2002	6142.86	580	
Middle of pond upper	12/8/2002	6571.43	650	635
Middle of pond upperR	12/8/2002	6428.57	620	
Middle of pond upper	12/15/2002	4857.14	470	455
Middle of pond upperR	12/15/2002	4428.57	440	
Middle of pond lower	9/14/2002	3428.57	290	245
Middle of pond lowerR	9/14/2002	2142.86	200	
Middle of pond lower	9/21/2002	12857.14	1170	730
Middle of pond lowerR	9/21/2002	3000.00	290	
Middle of pond lower	9/28/2002	4000.00	370	360
Middle of pond lowerR	9/28/2002	3642.86	350	
Middle of pond lower	10/5/2002	1071.43	100	121
Middle of pond lowerR	10/5/2002	1428.57	143	

Total Phosphorus in Sediment – Raw Data (Cont.)

Site	Collection Date	Conc. P (ppb)	mg of P per Kg of soil sample	Average mg of P per Kg of soil sample
Middle of pond upper	10/12/2002	4928.57	480	495
Middle of pond upperR	10/12/2002	5214.29	510	
Middle of pond upper	10/26/2002	6214.29	600	575
Middle of pond upperR	10/26/2002	6000.00	550	
Middle of pond upper	11/2/2002	7071.43	700	671
Middle of pond upperR	11/2/2002	6428.57	643	
Middle of pond upper	11/10/2002	4142.86	400	420
Middle of pond upperR	11/10/2002	4714.29	440	
Middle of pond upper	11/23/2002	5857.14	580	605
Middle of pond upperR	11/23/2002	6571.43	630	
Middle of pond upper	12/1/2002	5357.14	530	555
Middle of pond upperR	12/1/2002	6142.86	580	
Middle of pond upper	12/8/2002	6571.43	650	635
Middle of pond upperR	12/8/2002	6428.57	620	
Middle of pond upper	12/15/2002	4857.14	470	455
Middle of pond upperR	12/15/2002	4428.57	440	
Middle of pond lower	9/14/2002	3428.57	290	245
Middle of pond lowerR	9/14/2002	2142.86	200	
Middle of pond lower	9/21/2002	12857.14	1170	730
Middle of pond lowerR	9/21/2002	3000.00	290	
Middle of pond lower	9/28/2002	4000.00	370	360
Middle of pond lowerR	9/28/2002	3642.86	350	
Middle of pond lower	10/5/2002	1071.43	100	121
Middle of pond lowerR	10/5/2002	1428.57	143	
Middle of pond lower	10/12/2002	1785.71	160	151
Middle of pond lowerR	10/12/2002	1428.57	143	
Middle of pond lower	10/26/2002	2571.43	250	225
Middle of pond lowerR	10/26/2002	2214.29	200	
Middle of pond lower	11/2/2002	3071.43	290	275
Middle of pond lowerR	11/2/2002	2714.29	260	
Middle of pond lower	11/10/2002	3000.00	290	270
Middle of pond lowerR	11/10/2002	2571.43	250	
Middle of pond lower	11/23/2002	2928.57	270	275
Middle of pond lowerR	11/23/2002	3071.43	280	
Middle of pond lower	12/1/2002	3642.86	320	315
Middle of pond lowerR	12/1/2002	3214.29	310	
Middle of pond lower	12/8/2002	1785.71	180	170
Middle of pond lowerR	12/8/2002	1571.43	160	
Middle of pond lower	12/15/2002	3928.57	380	380
Middle of pond lowerR	12/15/2002	3857.14	380	

Average Total Phosphorus in Sediment

Date	Site Location									
	E Outflow Lower	E Outflow Upper	E.Edge Island Lower	E.Edge Island Upper	Inflow Lower	Inflow Upper	EdgeWest Lower	EdgeWest Upper	Middle Lower	Middle Upper
9/14/02	435	800	570	780	No data	No data	335	710	245	705
9/21/02	700	620	325	540	165	370	245	720	730	565
9/28/02	650	710	570	750	685	1285	280	500	360	571
10/05/02	345	345	325	430	335	283	150	260	121	246
10/12/02	680	675	630	730	690	200	170	190	151	495
10/26/02	630	605	535	440	290	525	76	331	225	575
11/02/02	645	705	800	815	No data	No data	547	545	275	671
11/10/02	800	710	370	720	248	820	720	720	270	420
11/23/02	745	710	470	645	240	930	615	625	275	605
12/1/02	810	690	510	735	210	685	375	380	315	555
12/08/02	565	600	535	725	275	440	275	280	170	635
12/15/02	690	617	725	810	180	515	305	305	380	455
Means	**641.25**	**648.92**	**530.42**	**676.67**	**530.42**	**676.67**	**331.80**	**605.30**	**341.08**	**463.83**
Std. Dev.	**137.55**	**112.04**	**147.04**	**134.83**	**194.13**	**330.88**	**194.67**	**196.78**	**158.54**	**124.58**
Std. Error	**39.71**	**32.34**	**42.45**	**38.92**	**61.39**	**104.63**	**56.20**	**56.81**	**45.77**	**35.96**

Total Phosphorus in Plant – Raw Data

Scirpus Species Scirpus Leaves	Collection Date	% P in DW	% P Average
SCL I	9/14/2002	0.05	0.06
SCL IR	9/14/2002	0.07	
SCL II	9/14/2002	0.07	0.08
SCL IIR	9/14/2002	0.08	
SCL I	09/21/02	0.09	0.09
SCL IR	09/21/02	0.08	
SCL II	09/21/02	0.16	0.16
SCL IIR	09/21/02	0.15	
SCL I	09/28/02	0.04	0.05
SCL IR	09/28/02	0.05	
SCL II	09/28/02	0.08	0.08
SCL IIR	09/28/02	0.07	
SCL I	10/05/02	0.02	0.03
SCL IR	10/05/02	0.03	
SCL II	10/05/02	0.02	0.02
SCL IIR	10/05/02	0.02	
SCL I	10/12/2002	0.06	0.06
SCL IR	10/12/2002	0.06	
SCL II	10/12/2002	0.08	0.09
SCL IIR	10/12/2002	0.10	
SCL I	10/26/2002	0.14	0.15
SCL IR	10/26/2002	0.15	
SCL II	10/26/2002	0.12	0.13
SCL IIR	10/26/2002	0.13	
SCL I	11/2/2002	0.05	0.05
SCL IR	11/2/2002	0.04	
SCL II	11/2/2002	0.08	0.10
SCL IIR	11/2/2002	0.11	
SCL I	11/10/2002	0.13	0.14
SCL IR	11/10/2002	0.14	
SCL II	11/10/2002	0.11	0.12
SCL IIR	11/10/2002	0.12	
SCL I	11/23/2002	0.06	0.06
SCL IR	11/23/2002	0.06	
SCL II	11/23/2002	0.11	0.12
SCL IIR	11/23/2002	0.12	
SCL I	12/1/2002	0.15	0.15
SCL IR	12/1/2002	0.14	
SCL II	12/1/2002	0.10	0.11
SCL IIR	12/1/2002	0.12	
SCL I	12/8/2002	0.13	0.13
SCL IR	12/8/2002	0.13	
SCL II	12/8/2002	0.08	0.08
SCL IIR	12/8/2002	0.08	
SCL I	12/15/2002	0.11	0.11
SCL IR	12/15/2002	0.11	
SCL II	12/15/2002	0.13	0.13
SCL IIR	12/15/2002	0.12	

Total Phosphorus in Plant – Raw Data (Cont.)

Scirpus Species Scirpus Roots	Collection Date	% P in DW	% P Average
SCR I	9/14/2002	0.12	0.13
SCR IR	9/14/2002	0.14	
SCR IIR	9/14/2002	0.12	0.12
SCR I	09/21/02	0.1	0.10
SCR IR	09/21/02	0.1	
SCR II	09/21/02	0.29	0.30
SCR IIR	09/21/02	0.30	
SCR I	09/28/02	0.03	0.03
SCR IR	09/28/02	0.03	
SCR II	09/28/02	0.11	0.11
SCR IIR	09/28/02	0.10	
SCR I	10/05/02	0.04	0.04
SCR IR	10/05/02	0.03	
SCR I	10/05/02	0.03	0.03
SCR IIR	10/05/02	0.03	
SCR I	10/12/2002	0.09	0.1
SCR IR	10/12/2002	0.11	
SCR II	10/12/2002	0.1	0.11
SCR IIR	10/12/2002	0.11	
SCR I	10/26/2002	0.11	0.12
SCR IR	10/26/2002	0.12	
SCR II	10/26/2002	0.11	0.12
SCR IIR	10/26/2002	0.12	
SCR I	11/2/2002	0.12	0.13
SCR IR	11/2/2002	0.13	
SCR II	11/2/2002	0.12	0.12
SCR IIR	11/2/2002	0.12	
SCR I	11/10/2002	0.15	0.15
SCR IR	11/10/2002	0.15	
SCR II	11/10/2002	0.13	0.14
SCR IIR	11/10/2002	0.14	
SCR I	11/23/2002	0.11	0.11
SCR IR	11/23/2002	0.11	
SCR II	11/23/2002	0.18	0.18
SCR IIR	11/23/2002	0.18	
SCR I	12/1/2002	0.13	0.14
SCR IR	12/1/2002	0.15	
SCR II	12/1/2002	0.11	0.12
SCR IIR	12/1/2002	0.12	
SCR I	12/8/2002	0.15	0.14
SCR IR	12/8/2002	0.15	
SCR II	12/8/2002	0.14	0.15
SCR IIR	12/8/2002	0.12	
SCR I	12/15/2002	0.15	0.14
SCR IR	12/15/2002	0.16	
SCR II	12/15/2002	0.13	0.15
SCR IIR	12/15/2002	0.13	

Total Phosphorus in Plant – Raw Data (Cont.)

Typha Species Typha Leaves	Collection Date	% P in DW	% P Average
TL I	9/14/2002	0.20	0.20
TL IR	9/14/2002	0.19	
TL II	9/14/2002	0.16	0.18
TL IIR	9/14/2002	0.19	
TL I	09/21/02	0.19	0.20
TL IR	09/21/02	0.21	
TL II	09/21/02	0.14	0.14
TL IIR	09/21/02	0.14	
TL I	09/28/02	0.06	0.07
TL IR	09/28/02	0.07	
TL II	09/28/02	0.04	0.04
TL IIR	09/28/02	0.04	
TL I	10/05/02	0.13	0.13
TL IR	10/05/02	0.13	
TL II	10/05/02	0.14	0.13
TL IIR	10/05/02	0.12	
TL I	10/12/2002	0.15	0.16
TL IR	10/12/2002	0.16	
TL II	10/12/2002	0.11	0.11
TL IIR	10/12/2002	0.11	
TL I	10/26/2002	0.10	0.12
TL IR	10/26/2002	0.13	
TL II	10/26/2002	0.12	0.13
TL IIR	10/26/2002	0.14	
TL I	11/2/2002	0.1	0.10
TL IR	11/2/2002	0.1	
TL II	11/2/2002	0.13	0.13
TL IIR	11/2/2002	0.13	
TL I	11/10/2002	0.07	0.07
TL IR	11/10/2002	0.06	
TL II	11/10/2002	0.11	0.11
TL IIR	11/10/2002	0.10	
TL I	11/23/2002	0.14	0.15
TL IR	11/23/2002	0.16	
TL II	11/23/2002	0.13	0.14
TL IIR	11/23/2002	0.15	
TL I	12/1/2002	0.15	0.14
TL IR	12/1/2002	0.12	
TL II	12/1/2002	0.15	0.11
TL IIR	12/1/2002	0.15	
TL I	12/8/2002	0.09	0.14
TL IR	12/8/2002	0.11	
TL I	12/8/2002	0.11	0.09
TL IR	12/8/2002	0.10	
TL II	12/15/2002	0.07	0.13
TL IIR	12/15/2002	0.07	
TL II	12/15/2002	0.08	0.15
TL IIR	12/15/2002	0.07	

Total Phosphorus in Plant – Raw Data (Cont.)

Typha Species Typha Roots	Collection Date	% P in DW	% P Average
TR I	9/14/2002	0.19	0.20
TR IR	9/14/2002	0.20	
TR IIR	9/14/2002	0.21	0.21
TR I	09/21/02	0.13	0.13
TR IR	09/21/02	0.12	
TR II	09/21/02	0.14	0.13
TR IIR	09/21/02	0.12	
TR I	09/28/02	0.05	0.05
TR IR	09/28/02	0.05	
TR II	09/28/02	0.07	0.07
TR IIR	09/28/02	0.07	
TR I	10/05/02	0.12	0.12
TR IR	10/05/02	0.11	
TR II	10/05/02	0.11	0.11
TR IIR	10/05/02	0.11	
TR I	10/12/2002	0.13	0.13
TR IR	10/12/2002	0.13	
TR II	10/12/2002	0.12	0.13
TR IIR	10/12/2002	0.13	
TR I	10/26/2002	0.11	0.11
TR IR	10/26/2002	0.1	
TR II	10/26/2002	0.13	0.14
TR IIR	10/26/2002	0.15	
TR I	11/2/2002	0.1	0.10
TR IR	11/2/2002	0.1	
TR II	11/2/2002	0.14	0.14
TR IIR	11/2/2002	0.14	
TR I	11/10/2002	0.19	0.20
TR IR	11/10/2002	0.2	
TR II	11/10/2002	0.19	0.19
TR IIR	11/10/2002	0.19	
TR I	11/23/2002	0.15	0.15
TR IR	11/23/2002	0.14	
TR II	11/23/2002	0.14	0.14
TR IIR	11/23/2002	0.14	
TR I	12/1/2002	0.16	0.16
TR IR	12/1/2002	0.15	
TR II	12/1/2002	0.16	0.16
TR IIR	12/1/2002	0.15	
TR I	12/8/2002	0.18	0.19
TR IR	12/8/2002	0.19	
TR II	12/8/2002	0.20	0.21
TR IIR	12/8/2002	0.21	
TR I	12/15/2002	0.10	0.10
TR IR	12/15/2002	0.10	
TR II	12/15/2002	0.10	0.10
TR IIR	12/15/2002	0.10	

APPENDIX H

THE CLARK COUNTY WETLANDS PARK NATURE PRESERVE UPPER POND

PHOSPHORUS STUDY - STATISTICAL ANALYSIS

Water Analysis

Regression Analysis of the Calibration Curves – Water Samples

Date	Water	Slope	Stand. Error of the Slope
09/18/02	TP	0.00157	0.00001
	OP	0.00134	0.00002
09/25/02	TP	0.00149	0.00017
	OP	0.00141	0.00002
10/02/02	TP	0.00153	0.00009
	OP	0.00141	0.00001
10/09/02	TP	0.00122	0.00006
	OP	0.00136	0.00001
10/16/02	TP	0.00132	0.00004
	OP	0.00143	0.00003
10/30/02	TP	0.00133	0.00002
	OP	0.00136	0.00003
11/06/02	TP	0.00134	0.00002
	OP	0.00145	0.00002
11/13/02	TP	0.00138	0.00001
	OP	0.00130	0.00006
11/27/02	TP	0.00134	0.00002
	OP	0.00138	0.00005
12/04/02	TP	0.00141	0.00016
	OP	0.00136	0.00004
12/11/02	TP	0.00154	0.00015
	OP	0.00145	0.00003
12/18/02	TP	0.00149	0.00004
	OP	0.00146	0.00002
01/08/03	TP	0.00140	0.00002
	OP	0.00139	0.00002
01/15/03	TP	0.00136	0.00004
	OP	0.00138	0.00005

T-test for TP water Comparing Two Outflows

Group Statistics

	group	N	Mean	Std. Deviation	Std. Error Mean
TP	outEast	14	42.6871	16.38048	4.37787
	outWest	14	40.7293	14.90450	3.98339

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means				
		F	Sig.	t	df	p-value	Mean Difference	Std. Error Difference
TP	Equal variances assumed	.001	.977	.331	26	.743	1.9579	5.91888
	Equal variances not assumed			.331	25.772	.743	1.9579	5.91888

T-test for OP water Comparing Two Outflows

Group Statistics

	group	N	Mean	Std. Deviation	Std. Error Mean
OP	outEast	14	6.5193	3.66150	.97858
	outWest	14	10.7579	8.60731	2.30040

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means				
		F	Sig.	t	df	p-value	Mean Difference	Std. Error Difference
OP	Equal variances assumed	2.919	.099	-1.696	26	.102	-4.2386	2.49989
	Equal variances not assumed			-1.696	17.556	.108	-4.2386	2.49989

Oneway Anova for TP in Water Differences Among Three Sites

Descriptives
CONC

	N	Mean	Std. Deviation	Std. Error
inflow	14	44.8071	27.78831	7.42674
outfloweast	14	42.6871	16.38048	4.37787
outflowwest	14	40.7293	14.90450	3.98339
Total	42	42.7412	20.07970	3.09837

ANOVA
CONC

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	116.464	2	58.232	.138	.871
Within Groups	16414.510	39	420.885		
Total	16530.973	41			

Oneway Anova for OP in Water Differences Among Three Sites

Descriptives
CONC

	N	Mean	Std. Deviation	Std. Error
inflow	14	15.4121	19.95598	5.33346
outfloweast	14	6.5193	3.66150	.97858
outflowwest	14	10.7579	8.60731	2.30040
Total	42	10.8964	12.94314	1.99717

ANOVA
CONC

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	553.984	2	276.992	1.711	.194
Within Groups	6314.533	39	161.911		
Total	6868.516	41			

T-test for Total Phosphorus and Ortho Phosphorus Loadings

T-Test TP Inflow Loading Vs OP Inflow Loading

Group Statistics

	group	N	Mean	Std. Deviation	Std. Error Mean
TPVSOPIN	TPIN	14	10.34	7.80	1.84617
	OPIN	14	3.65	5.24	1.24014

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means				
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
TPVSOPIN	Equal variances assumed	3.311	.080	2.566	26	**.016**	5.7071	2.22403
	Equal variances not assumed			2.566	22.747	.017	5.7071	2.22403

T-Test TP load out Vs OP load out

Group Statistics

	group	N	Mean	Std. Deviation	Std. Error Mean
TPVSOPOUT	TPOUT	14	7.84	4.12849	1.10339
	OPOUT	14	1.38	.60916	.16281

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means				
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
TPVSOPOUT	Equal variances assumed	12.538	.002	4.943	26	**.00004**	5.5136	1.11533
	Equal variances not assumed			4.943	13.566	.0002	5.5136	1.11533

T-test for Total Phosphorus and Ortho Phosphorus Loadings

t-Test: Two-Sample Assuming Equal Variances
TP Loadings Calculations

	TPIN	*TPOUT*
Mean	10.34	7.87
Variance	65.55	23.83
Observations	14.00	14.00
Pooled Variance	44.69	
Hypothesized Mean Difference	0.00	
df	26.00	
t Stat	**0.98**	
P(T<=t) one-tail	**0.17**	
t Critical one-tail	**1.71**	
P(T<=t) two-tail	0.34	
t Critical two-tail	2.06	

t-Test: Two-Sample Assuming Equal Variances
OP Loadings Calculations

	OPIN	*OPOUT*
Mean	3.65	1.50
Variance	29.58	0.71
Observations	14.00	14.00
Pooled Variance	15.15	
Hypothesized Mean Difference	0.00	
df	26.00	
t Stat	**1.46**	
P(T<=t) one-tail	**0.08**	
t Critical one-tail	**1.71**	
P(T<=t) two-tail	0.16	
t Critical two-tail	2.06	

Inflow Calculations – Error Analysis

Date	(m3/day)	plus 5%	minus 5%	plus 10%	minus 10%	plus 15%	minus 15%	plus 20%	minus 20%
9/18/2002	3,768	3,957	3,580	4,145	3,391	4,333	3,203	4,522	3,015
9/25/2002	4,086	4,291	3,882	4,495	3,678	4,699	3,473	4,903	3,269
10/2/2002	3,939	4,136	3,742	4,333	3,545	4,530	3,349	4,727	3,152
10/9/2002	3,915	4,111	3,719	4,306	3,523	4,502	3,328	4,698	3,132
10/16/2002	3,254	3,417	3,092	3,580	2,929	3,742	2,766	3,905	2,603
10/30/2002	1,664	1,747	1,581	1,830	1,497	1,913	1,414	1,997	1,331
11/6/2002	979	1,028	930	1,077	881	1,126	832	1,174	783
11/13/2002	1,174	1,233	1,116	1,292	1,057	1,351	998	1,409	940
11/27/2002	3,181	3,340	3,022	3,499	2,863	3,658	2,704	3,817	2,545
12/4/2002	3,817	4,008	3,626	4,199	3,435	4,390	3,245	4,580	3,054
12/11/2002	2,863	3,006	2,720	3,149	2,577	3,292	2,433	3,435	2,290
12/18/2002	3,475	3,648	3,301	3,822	3,127	3,996	2,953	4,169	2,780
1/8/2003	3,230	3,391	3,068	3,553	2,907	3,714	2,745	3,876	2,584
1/15/2003	6,460	6,783	6,137	7,106	5,814	7,429	5,491	7,752	5,168
Means	3,272	**3,435**	**3,108**	**3,599**	**2,945**	**3,763**	**2,781**	**3,926**	**2,617**

Outflow Calculations – Error Analysis

Date	(m3/day)	plus 5%	minus 5%	plus 10%	minus 10%	plus 15%	minus 15%	plus 20%	minus 20%
9/18/2002	1,126	1,182	1,069	1,238	1,013	1,294	957	1,351	900
9/25/2002	1,615	1,696	1,534	1,776	1,453	1,857	1,373	1,938	1,292
10/2/2002	2,178	2,287	2,069	2,395	1,960	2,504	1,851	2,613	1,742
10/9/2002	3,132	3,289	2,975	3,445	2,819	3,602	2,662	3,758	2,506
10/16/2002	1,786	1,876	1,697	1,965	1,608	2,054	1,518	2,143	1,429
10/30/2002	3,156	3,314	2,999	3,472	2,841	3,630	2,683	3,788	2,525
11/6/2002	2,887	3,032	2,743	3,176	2,599	3,320	2,454	3,465	2,310
11/13/2002	2,496	2,621	2,371	2,745	2,246	2,870	2,121	2,995	1,997
11/27/2002	1,982	2,081	1,883	2,180	1,784	2,279	1,685	2,378	1,586
12/4/2002	2,227	2,338	2,115	2,449	2,004	2,561	1,893	2,672	1,781
12/11/2002	2,227	2,338	2,115	2,449	2,004	2,561	1,893	2,672	1,781
12/18/2002	2,692	2,826	2,557	2,961	2,422	3,095	2,288	3,230	2,153
1/8/2003	2,031	2,132	1,929	2,234	1,828	2,336	1,726	2,437	1,625
1/15/2003	5,212	5,472	4,951	5,733	4,691	5,994	4,430	6,254	4,169
Means	**2,482**	**2,606**	**2,358**	**2,730**	**2,234**	**2,854**	**2,110**	**2,978**	**1,985**

T-tests For TP Loadings – Using Flows from Error Analysis

t-Test: Two-Sample Assuming Equal Variances
Primary Calculations

	TPIN	*TPOUT*
Mean	10.34	7.87
Variance	65.55	23.83
Observations	14.00	14.00
Pooled Variance	44.69	
Hypothesized Mean Difference	0.00	
df	26.00	
t Stat	**0.98**	
P(T<=t) one-tail	**0.17**	
t Critical one-tail	**1.71**	
P(T<=t) two-tail	0.34	
t Critical two-tail	2.06	

t-Test: Two-Sample Assuming Equal Variances
Plus5%Error

	TPIN	*TPOUT*
Mean	10.86	8.26
Variance	72.27	26.28
Observations	14.00	14.00
Pooled Variance	49.27	
Hypothesized Mean Difference	0.00	
df	26.00	
t Stat	**0.98**	
P(T<=t) one-tail	**0.17**	
t Critical one-tail	**1.71**	
P(T<=t) two-tail	0.34	
t Critical two-tail	2.06	

T-Tests For TP Loadings – Using Flows from Error Analysis

t-Test: Two-Sample Assuming Equal Variances
Minus5%Error

	TPIN	*TPOUT*
Mean	9.83	7.48
Variance	59.16	21.51
Observations	14.00	14.00
Pooled Variance	40.34	
Hypothesized Mean Difference	0.00	
df	26.00	
t Stat	**0.98**	
P(T<=t) one-tail	**0.17**	
t Critical one-tail	**1.71**	
P(T<=t) two-tail	0.34	
t Critical two-tail	2.06	

t-Test: Two-Sample Assuming Equal Variances
Plus10%Error

	TPIN	*TPOUT*
Mean	11.38	8.66
Variance	79.32	28.84
Observations	14.00	14.00
Pooled Variance	54.08	
Hypothesized Mean Difference	0.00	
df	26.00	
t Stat	**0.98**	
P(T<=t) one-tail	**0.17**	
t Critical one-tail	**1.71**	
P(T<=t) two-tail	0.34	
t Critical two-tail	2.06	

t-Test: Two-Sample Assuming Equal Variances
Minus10%Error

	TPIN	*TPOUT*
Mean	9.31	7.08
Variance	53.10	19.30
Observations	14.00	14.00
Pooled Variance	36.20	
Hypothesized Mean Difference	0.00	
df	26.00	
t Stat	**0.98**	
P(T<=t) one-tail	**0.17**	
t Critical one-tail	**1.71**	
P(T<=t) two-tail	0.34	
t Critical two-tail	2.06	

t-Test: Two-Sample Assuming Equal Variances
Plus15%Error

	TPIN	*TPOUT*
Mean	11.89	9.05
Variance	86.70	31.52
Observations	14.00	14.00
Pooled Variance	59.11	
Hypothesized Mean Difference	0.00	
df	26.00	
t Stat	**0.98**	
P(T<=t) one-tail	**0.17**	
t Critical one-tail	**1.71**	
P(T<=t) two-tail	0.34	
t Critical two-tail	2.06	

T-Tests For TP Loadings – Using Flows from Error Analysis

t-Test: Two-Sample Assuming Equal Variances
Minus15%Error

	TPIN	*TPOUT*
Mean	8.79	6.69
Variance	47.36	17.22
Observations	14.00	14.00
Pooled Variance	32.29	
Hypothesized Mean Difference	0.00	
df	26.00	
t Stat	**0.98**	
P(T<=t) one-tail	**0.17**	
t Critical one-tail	**1.71**	
P(T<=t) two-tail	0.34	
t Critical two-tail	2.06	

t-Test: Two-Sample Assuming Equal Variances
Plus20%Error

	TPIN	*TPOUT*
Mean	12.41	9.44
Variance	94.40	34.32
Observations	14.00	14.00
Pooled Variance	64.36	
Hypothesized Mean Difference	0.00	
df	26.00	
t Stat	**0.98**	
P(T<=t) one-tail	**0.17**	
t Critical one-tail	**1.71**	
P(T<=t) two-tail	0.34	
t Critical two-tail	2.06	

t-Test: Two-Sample Assuming Equal Variances
Minus20%Error

	TPIN	*TPOUT*
Mean	8.27	6.30
Variance	41.95	15.25
Observations	14.00	14.00
Pooled Variance	28.60	
Hypothesized Mean Difference	0.00	
df	26.00	
t Stat	**0.98**	
P(T<=t) one-tail	**0.17**	
t Critical one-tail	**1.71**	
P(T<=t) two-tail	0.34	
t Critical two-tail	2.06	

T-Tests For OP Loadings – Using Flows from Error Analysis

t-Test: Two-Sample Assuming Equal Variances
Primary Calculations

	OPIN	*OPOUT*
Mean	3.65	1.50
Variance	29.58	0.71
Observations	14.00	14.00
Pooled Variance	15.15	
Hypothesized Mean Difference	0.00	
df	26.00	
t Stat	**1.46**	
P(T<=t) one-tail	**0.08**	
t Critical one-tail	**1.71**	
P(T<=t) two-tail	0.16	
t Critical two-tail	2.06	

t-Test: Two-Sample Assuming Equal Variances
Plus5%Error

	OPIN	*OPOUT*
Mean	3.83	1.57
Variance	32.61	0.79
Observations	14.00	14.00
Pooled Variance	16.70	
Hypothesized Mean Difference	0.00	
df	26.00	
t Stat	**1.46**	
P(T<=t) one-tail	**0.08**	
t Critical one-tail	**1.71**	
P(T<=t) two-tail	0.16	
t Critical two-tail	2.06	

t-Test: Two-Sample Assuming Equal Variances
Minus5%Error

	OPIN	*OPOUT*
Mean	3.47	1.42
Variance	26.69	0.64
Observations	14.00	14.00
Pooled Variance	13.67	
Hypothesized Mean Difference	0.00	
df	26.00	
t Stat	**1.46**	
P(T<=t) one-tail	**0.08**	
t Critical one-tail	**1.71**	
P(T<=t) two-tail	0.16	
t Critical two-tail	2.06	

t-Test: Two-Sample Assuming Equal Variances
Plus10%Error

	OPIN	*OPOUT*
Mean	4.02	1.65
Variance	35.79	0.86
Observations	14.00	14.00
Pooled Variance	18.33	
Hypothesized Mean Difference	0.00	
df	26.00	
t Stat	**1.46**	
P(T<=t) one-tail	**0.08**	
t Critical one-tail	**1.71**	
P(T<=t) two-tail	0.16	
t Critical two-tail	2.06	

T-Tests For OP Loadings – Using Flows from Error Analysis

t-Test: Two-Sample Assuming Equal Variances
Minus10%Error

	OPIN	*OPOUT*
Mean	3.29	1.35
Variance	23.96	0.58
Observations	14.00	14.00
Pooled Variance	12.27	
Hypothesized Mean Difference	0.00	
df	26.00	
t Stat	**1.46**	
P(T<=t) one-tail	**0.08**	
t Critical one-tail	**1.71**	
P(T<=t) two-tail	0.16	
t Critical two-tail	2.06	

t-Test: Two-Sample Assuming Equal Variances
Plus15%Error

	OPIN	*OPOUT*
Mean	4.20	1.72
Variance	39.12	0.94
Observations	14.00	14.00
Pooled Variance	20.03	
Hypothesized Mean Difference	0.00	
df	26.00	
t Stat	**1.46**	
P(T<=t) one-tail	**0.08**	
t Critical one-tail	**1.71**	
P(T<=t) two-tail	0.16	
t Critical two-tail	2.06	

t-Test: Two-Sample Assuming Equal Variances
Minus15%Error

	OPIN	*OPOUT*
Mean	3.10	1.27
Variance	21.37	0.52
Observations	14.00	14.00
Pooled Variance	10.94	
Hypothesized Mean Difference	0.00	
df	26.00	
t Stat	**1.46**	
P(T<=t) one-tail	**0.08**	
t Critical one-tail	**1.71**	
P(T<=t) two-tail	0.16	
t Critical two-tail	2.06	

t-Test: Two-Sample Assuming Equal Variances
Plus20%Error

	OPIN	*OPOUT*
Mean	4.38	1.80
Variance	42.59	1.03
Observations	14.00	14.00
Pooled Variance	21.81	
Hypothesized Mean Difference	0.00	
df	26.00	
t Stat	**1.46**	
P(T<=t) one-tail	**0.08**	
t Critical one-tail	**1.71**	
P(T<=t) two-tail	0.16	
t Critical two-tail	2.06	

T-Tests For OP Loadings – Using Flows from Error Analysis

t-Test: Two-Sample Assuming Equal Variances
Minus20%Error

	OPIN	*OPOUT*
Mean	2.92	1.20
Variance	18.93	0.46
Observations	14.00	14.00
Pooled Variance	9.69	
Hypothesized Mean Difference	0.00	
df	26.00	
t Stat	**1.46**	
P(T<=t) one-tail	**0.08**	
t Critical one-tail	**1.71**	
P(T<=t) two-tail	0.16	
t Critical two-tail	2.06	

Correlation Tests Between DO and Temperature

Inflow Site

Correlation

Descriptive Statistics

	Mean	Std. Deviation	N
dissolved oxygen	7.6979	.95267	14
temperature	13.729	4.1814	14

Correlations

		dissolved oxygen	temperature
dissolved oxygen	Pearson Correlation	1	-.868
	Sig. (1-tailed)	.	.000
	N	14	14
temperature	Pearson Correlation	-.868	1
	Sig. (1-tailed)	.000	.
	N	14	14

** Correlation is significant at the 0.01 level (1-tailed).

Regression

Variables Entered/Removed

Model	Variables Entered	Variables Removed	Method
1	dissolved oxygen	.	Enter

a All requested variables entered.
b Dependent Variable: temperature

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.868	.754	.734	2.1579

a Predictors: (Constant), dissolved oxygen
b Dependent Variable: temperature

Correlation Tests Between DO and Temperature (Cont.)

ANOVA

Model		Sum of Squares	df	Mean Square	F	P-VALUE
1	Regression	171.410	1	171.410	36.810	.0001
	Residual	55.879	12	4.657		
	Total	227.289	13			

a Predictors: (Constant), dissolved oxygen
b Dependent Variable: temperature

Coefficients

		Unstandardized Coefficients		Standardized Coefficients	t	P-VALUE
Model		B	Std. Error	Beta		
1	(Constant)	43.069	4.870		8.843	.000001
	dissolved oxygen	-3.812	.628	-.868	-6.067	.000056

a Dependent Variable: temperature

Residuals Statistics

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	7.660	18.980	13.729	3.6312	14
Residual	-4.436	2.972	.000	2.0732	14
Std. Predicted Value	-1.671	1.446	.000	1.000	14
Std. Residual	-2.056	1.377	.000	.961	14

a Dependent Variable: temperature

Correlation Between DO and Temperature (Cont.)

Outflow East Site

Correlation

Descriptive Statistics

	Mean	Std. Deviation	N
dissolved oxygen	8.1393	2.32781	14
temperature	13.843	4.4857	14

Correlations

		dissolved oxygen	temperature
dissolved oxygen	Pearson Correlation	1	-.840
	Sig. (1-tailed)	.	.000
	N	14	14
temperature	Pearson Correlation	-.840	1
	Sig. (1-tailed)	.000	.
	N	14	14

** Correlation is significant at the 0.01 level (1-tailed).

Variables Entered/Removed

Model	Variables Entered	Variables Removed	Method
1	dissolved oxygen	.	Enter

a All requested variables entered.
b Dependent Variable: temperature

Regression

Variables Entered/Removed

Model	Variables Entered	Variables Removed	Method
1	dissolved oxygen	.	Enter

a All requested variables entered.
b Dependent Variable: temperature

Correlation Between DO and Temperature (Cont.)

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.840	.706	.681	2.5321

a Predictors: (Constant), dissolved oxygen
b Dependent Variable: temperature

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	184.636	1	184.636	28.798	.0002
	Residual	76.938	12	6.411		
	Total	261.574	13			

a Predictors: (Constant), dissolved oxygen
b Dependent Variable: temperature

Coefficients

		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
Model		B	Std. Error	Beta		
1	(Constant)	27.020	2.547		10.608	.0000002
	dissolved oxygen	-1.619	.302	-.840	-5.366	.0002

a Dependent Variable: temperature

Residuals Statistics

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	9.017	20.188	13.843	3.7687	14
Residual	-4.759	3.954	.000	2.4328	14
Std. Predicted Value	-1.280	1.684	.000	1.000	14
Std. Residual	-1.879	1.561	.000	.961	14

a Dependent Variable: temperature

Correlation Between DO and Temperature (Cont.)

Outflow West Site

Correlation

Descriptive Statistics

	Mean	Std. Deviation	N
dissolved oxygen	7.8936	1.88753	14
temperature	13.921	4.3146	14

		dissolved oxygen	temperature
dissolved oxygen	Pearson Correlation	1	-.854
	Sig. (1-tailed)	.	.000
	N	14	14
temperature	Pearson Correlation	-.854	1
	Sig. (1-tailed)	.000	.
	N	14	14

** Correlation is significant at the 0.01 level (1-tailed).

Regression

Variables Entered/Removed

Model	Variables Entered	Variables Removed	Method
1	dissolved oxygen	.	Enter

a All requested variables entered.
b Dependent Variable: temperature

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.854	.729	.706	2.3379

a Predictors: (Constant), dissolved oxygen
b Dependent Variable: temperature

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	176.417	1	176.417	32.278	.000
	Residual	65.587	12	5.466		
	Total	242.004	13			

a Predictors: (Constant), dissolved oxygen
b Dependent Variable: temperature

Correlation Between DO and Temperature (Cont.)

Coefficients

		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
Model		B	Std. Error	Beta		
1	(Constant)	29.327	2.783		10.539	.000
	Dissolved oxygen	-1.952	.344	-.854	-5.681	.000

a Dependent Variable: temperature

Residuals Statistics

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	8.932	19.354	13.921	3.6838	14
Residual	-4.778	3.185	.000	2.2461	14
Std. Predicted Value	-1.354	1.475	.000	1.000	14
Std. Residual	-2.044	1.362	.000	.961	14

a Dependent Variable: temperature

Correlation Between TDS and Conductivity

Correlations Using All Sites TDS vs Conductivity

Descriptive Statistics

	Mean	Std. Deviation	N
TDS	4927.29	217.762	24
Conductivity	5083.33	77.047	24

Correlations

		TDS	Conductivity
Pearson Correlation	TDS	1.000	.680
	Conductivity	.680	1.000
Sig. (1-tailed)	TDS	.	.000
	Conductivity	.000	.
N	TDS	24	24
	Conductivity	24	24

Correlation Between TDS and Conductivity (Cont.)

Regression

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.680	.462	.438	163.265

a Predictors: (Constant), Conductivity

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	504248.751	1	504248.751	18.917	.0003
	Residual	586420.207	22	26655.464		
	Total	1090668.958	23			

a Predictors: (Constant), Conductivity
b Dependent Variable: TDS

Coefficients

		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
Model		B	Std. Error	Beta		
1	(Constant)	-4841.743	2246.312		-2.155	.042
	Conductivity	1.922	.442	.680	4.349	.000

a Dependent Variable: TDS

Correlations Between TSS Vs OP at East Outflow

Correlations

		TSS	OP
TSS	Pearson Correlation	1	.805
	Sig. (2-tailed)	.	.029
	N	7	7
OP	Pearson Correlation	.805	1
	Sig. (2-tailed)	.029	.
	N	7	7

* Correlation is significant at the 0.05 level (2-tailed).

Correlations Between TSS Vs OP at East Outflow (Cont.)

Correlations

		TSS	OP
TSS	Pearson Correlation	1	.805
	Sig. (2-tailed)	.	.029
	N	7	7
OP	Pearson Correlation	.805	1
	Sig. (2-tailed)	.029	.
	N	7	7

* Correlation is significant at the 0.05 level (2-tailed).

Descriptive Statistics

	Mean	Std. Deviation	N
OP	6.0329	2.33391	7
TSS	15.86	6.149	7

Correlations

		OP	TSS
Pearson Correlation	OP	1.000	.805
	TSS	.805	1.000
Sig. (1-tailed)	OP	.	.014
	TSS	.014	.
N	OP	7	7
	TSS	7	7

Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.805	.648	.577	1.51732

a Predictors: (Constant), TSS
b Dependent Variable: OP

ANOVA

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	21.171	1	21.171	9.196	.029
	Residual	11.511	5	2.302		
	Total	32.683	6			

a Predictors: (Constant), TSS
b Dependent Variable: OP

Correlations Between TSS Vs OP at East Outflow (Cont.)

Coefficients

		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
Model		B	Std. Error	Beta		
1	(Constant)	1.189	1.697		.700	.515
	TSS	.305	.101	.805	3.032	.029

a Dependent Variable: OP

Residuals Statistics

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	3.3271	8.8259	6.0329	1.87845	7
Residual	-2.5065	1.5210	.0000	1.38512	7
Std. Predicted Value	-1.440	1.487	.000	1.000	7
Std. Residual	-1.652	1.002	.000	.913	7

a Dependent Variable: OP

Oneway Anova for Field Parameters - Water Differences Among Three Sites

Conductivity

Descriptives

	N	Mean	Std. Deviation	Std. Error
inflow	14	5110.29	154.545	41.304
outfloweast	14	5058.57	232.837	62.228
outflowwest	14	5040.57	259.488	69.351
Total	42	5069.81	216.810	33.455

ANOVA
Conductivity

	Sum of Squares	df	Mean Square	F	p-value
Between Groups	36672.762	2	18336.381	.378	.688
Within Groups	1890605.714	39	48477.070		
Total	1927278.476	41			

Oneway Anova for Field Parameters - Water Differences Among Three Sites (Cont.)

Post Hoc Tests

Multiple Comparisons
Dependent Variable: Conductivity
Tukey HSD

		Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
(I) SITES	(J) SITES				Lower Bound	Upper Bound
inflow	outfloweast	51.71	83.218	.809	-151.03	254.46
	outflowwest	69.71	83.218	.682	-133.03	272.46
outfloweast	inflow	-51.71	83.218	.809	-254.46	151.03
	outflowwest	18.00	83.218	.975	-184.75	220.75
outflowwest	inflow	-69.71	83.218	.682	-272.46	133.03
	outfloweast	-18.00	83.218	.975	-220.75	184.75

pH

Descriptives

	N	Mean	Std. Deviation	Std. Error
inflow	14	7.6771	.48791	.13040
outfloweast	14	7.7321	.67198	.17959
outflowwest	14	7.8764	.25257	.06750
Total	42	7.7619	.49610	.07655

ANOVA
PH

	Sum of Squares	df	Mean Square	F	P-value
Between Groups	.297	2	.148	.591	.559
Within Groups	9.794	39	.251		
Total	10.091	41			

Oneway Anova for Field Parameters - Water Differences Among Three Sites (Cont.)

Post Hoc Tests

Multiple Comparisons
Dependent Variable: PH
Tukey HSD

		Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
(I) SITES	(J) SITES				Lower Bound	Upper Bound
inflow	outfloweast	-.0550	.18941	.955	-.5165	.4065
	outflowwest	-.1993	.18941	.549	-.6607	.2622
outfloweast	inflow	.0550	.18941	.955	-.4065	.5165
	outflowwest	-.1443	.18941	.728	-.6057	.3172
outflowwest	inflow	.1993	.18941	.549	-.2622	.6607
	outfloweast	.1443	.18941	.728	-.3172	.6057

Temperature

Descriptives

	N	Mean	Std. Deviation	Std. Error
inflow	14	13.7286	4.18136	1.11751
outfloweast	14	13.8429	4.48565	1.19884
outflowwest	14	13.9214	4.31459	1.15312
Total	42	13.8310	4.22285	.65160

ANOVA
temperature

	Sum of Squares	df	Mean Square	F	P-value
Between Groups	.263	2	.132	.007	.993
Within Groups	730.866	39	18.740		
Total	731.130	41			

Oneway Anova for Field Parameters - Water Differences Among Three Sites (Cont)

Post Hoc Tests

Multiple Comparisons
Dependent Variable: temperature
Tukey HSD

		Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
(I) SITES	(J) SITES				Lower Bound	Upper Bound
inflow	outfloweast	-.1143	1.63620	.997	-4.1006	3.8720
	outflowwest	-.1929	1.63620	.992	-4.1792	3.7934
outfloweast	inflow	.1143	1.63620	.997	-3.8720	4.1006
	outflowwest	-.0786	1.63620	.999	-4.0649	3.9077
outflowwest	inflow	.1929	1.63620	.992	-3.7934	4.1792
	outfloweast	.0786	1.63620	.999	-3.9077	4.0649

Dissolved oxygen

Descriptives

	N	Mean	Std. Deviation	Std. Error
inflow	14	7.6979	.95267	.25461
outfloweast	14	8.1393	2.32781	.62213
outflowwest	14	7.8936	1.88753	.50446
Total	42	7.9102	1.78016	.27468

ANOVA
dissolved oxygen

	Sum of Squares	df	Mean Square	F	p-value
Between Groups	1.370	2	.685	.208	.813
Within Groups	128.558	39	3.296		
Total	129.928	41			

Oneway Anova for Field Parameters - Water Differences Among Three Sites (Cont)

Post Hoc Tests

Multiple Comparisons
Dependent Variable: dissolved oxygen
Tukey HSD

		Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
(I) SITES	(J) SITES				Lower Bound	Upper Bound
inflow	outfloweast	-.4414	.68623	.797	-2.1133	1.2304
	outflowwest	-.1957	.68623	.956	-1.8676	1.4761
outfloweast	inflow	.4414	.68623	.797	-1.2304	2.1133
	outflowwest	.2457	.68623	.932	-1.4261	1.9176
outflowwest	inflow	.1957	.68623	.956	-1.4761	1.8676
	outfloweast	-.2457	.68623	.932	-1.9176	1.4261

Oneway for Total Solids Comparing Sites

Descriptives
CONC

	N	Mean	Std. Deviation	Std. Error
inflow	14	4904.43	279.404	74.674
outfloweast	14	4921.00	336.018	89.804
outflowwest	14	4929.57	267.306	71.440
Total	42	4918.33	288.652	44.540

ANOVA
CONC

	Sum of Squares	df	Mean Square	F	p-value
Between Groups	4574.476	2	2287.238	.026	.974
Within Groups	3411546.857	39	87475.560		
Total	3416121.333	41			

Oneway for Total Solids Comparing Sites (Cont.)

Post Hoc Tests

Multiple Comparisons
Dependent Variable: CONC
Tukey HSD

		Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
(I) SITES	(J) SITES				Lower Bound	Upper Bound
inflow	outfloweast	-16.57	111.788	.988	-288.92	255.78
	outflowwest	-25.14	111.788	.973	-297.49	247.21
outfloweast	inflow	16.57	111.788	.988	-255.78	288.92
	outflowwest	-8.57	111.788	.997	-280.92	263.78
outflowwest	inflow	25.14	111.788	.973	-247.21	297.49
	outfloweast	8.57	111.788	.997	-263.78	280.92

T-Test TSS Comparing In with Total Out

Group Statistics

	group	N	Mean	Std. Deviation	Std. Error Mean
TSS	TSSIN	8	6.00	4.598	1.626
	TSSOUT	8	36.25	31.892	11.275

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means				
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
TSS	Equal variances assumed	3.262	.092	-2.655	14	.019	-30.25	11.392
	Equal variances not assumed			-2.655	7.291	.032	-30.25	11.392

Univariate Analysis of Variance Factorial 3 X 3 for TDS,TS,TSS among the 3 Sites

Between-Subjects Factors

		Value Label	N
SOLIDS	1	TS	24
	2	TDS	24
	3	TSS	24
SITE	1	inflow	24
	2	out east	24
	3	out west	24

Descriptive Statistics
Dependent Variable: CONC

SOLIDS	SITE	Mean	Std. Deviation	N
TS	inflow	4936.875	169.3006	8
	out east	5024.750	324.8489	8
	out west	4742.500	656.3342	8
	Total	4901.375	431.8077	24
TDS	inflow	4940.875	124.7734	8
	out east	4905.500	308.0876	8
	out west	4935.750	210.7875	8
	Total	4927.375	217.7226	24
TSS	inflow	6.113	4.5517	8
	out east	15.463	5.8841	8
	out west	20.737	27.7696	8
	Total	14.104	17.0206	24
Total	inflow	3294.621	2378.1731	24
	out east	3315.237	2396.7589	24
	out west	3232.996	2352.6531	24
	Total	3280.951	2342.4919	72

Tests of Between-Subjects Effects
Dependent Variable: CONC

Source	Type III Sum of Squares	df	Mean Square	F	p-value
SOLIDS	384210579.840	2	192105289.920	2398.956	.0000000
SITE	87891.034	2	43945.517	.549	.580
SOLIDS * SITE	252617.169	4	63154.292	.789	.537
Error	5044958.196	63	80078.702		
Corrected Total	389596046.240	71			

a Computed using alpha = .05
b R Squared = .987 (Adjusted R Squared = .985)

Univariate Analysis of Variance Factorial 3 X 3 for TDS,TS,TSS among the 3 Sites (Cont.)

Estimated Marginal Means

SOLIDS * SITE
Dependent Variable: CONC

		Mean	Std. Error	95% Confidence Interval	
SOLIDS	SITE			Lower Bound	Upper Bound
TS	inflow	4936.875	100.049	4736.943	5136.807
	out east	5024.750	100.049	4824.818	5224.682
	out west	4742.500	100.049	4542.568	4942.432
TDS	inflow	4940.875	100.049	4740.943	5140.807
	out east	4905.500	100.049	4705.568	5105.432
	out west	4935.750	100.049	4735.818	5135.682
TSS	inflow	6.112	100.049	-193.820	206.045
	out east	15.463	100.049	-184.470	215.395
	out west	20.737	100.049	-179.195	220.670

Post Hoc Tests
SITE

Multiple Comparisons
Dependent Variable: CONC
Tukey HSD

		Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
(I) SITE	(J) SITE				Lower Bound	Upper Bound
inflow	out east	-20.617	81.6898	.966	-216.699	175.465
	out west	61.625	81.6898	.732	-134.457	257.707
out east	inflow	20.617	81.6898	.966	-175.465	216.699
	out west	82.242	81.6898	.575	-113.840	278.324
out west	inflow	-61.625	81.6898	.732	-257.707	134.457
	out east	-82.242	81.6898	.575	-278.324	113.840

Based on observed means.

Univariate Analysis of Variance Factorial 3 X 3 for TDS,TS,TSS among the 3 Sites (Cont.)

Multiple Comparisons
Dependent Variable: CONC
Tukey HSD

		Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
(I) SITE	(J) SITE				Lower Bound	Upper Bound
inflow	out east	-20.617	81.6898	.966	-216.699	175.465
	out west	61.625	81.6898	.732	-134.457	257.707
out east	inflow	20.617	81.6898	.966	-175.465	216.699
	out west	82.242	81.6898	.575	-113.840	278.324
out west	inflow	-61.625	81.6898	.732	-257.707	134.457
	out east	-82.242	81.6898	.575	-278.324	113.840

Based on observed means.

Multiple Comparisons
Dependent Variable: CONC
Tukey HSD

		Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
(I) SOLIDS	(J) SOLIDS				Lower Bound	Upper Bound
TS	TDS	-26.000	81.6898	.946	-222.082	170.082
	TSS	4887.271	81.6898	.000	4691.189	5083.353
TDS	TS	26.000	81.6898	.946	-170.082	222.082
	TSS	4913.271	81.6898	.000	4717.189	5109.353
TSS	TS	-4887.271	81.6898	.000	-5083.353	-4691.189
	TDS	-4913.271	81.6898	.000	-5109.353	-4717.189

Based on observed means.
* The mean difference is significant at the .05 level.

Sediment Analysis

Regression Analysis of the Calibration Curves – Sediment Samples

Date	Sediment	Slope	Stand. Error of the Slope
09/14/02	TP	0.00138	0.00001
09/21/02	TP	0.00138	0.00003
09/28/02	TP	0.00141	0.00001
10/05/02	TP	0.00142	0.00002
10/12/02	TP	0.00139	0.00001
10/26/02	TP	0.00138	0.00001
11/02/02	TP	0.00140	0.00007
11/10/02	TP	0.00142	0.00002
11/23/02	TP	0.00139	0.00002
12/01/02	TP	0.00134	0.00004
12/08/02	TP	0.00138	0.00001
12/15/02	TP	0.00138	0.00001

Sediment Univariate Analysis of Variance

Between-Subjects Factors

		Value Label	N
LAYER	1	upper	50
	2	lower	50
SITE	1	outEast	20
	2	EdgeIsland	20
	3	Inflow	20
	4	EdgeWest	20
	5	Middle	20

*S*ediment Univariate Analysis of Variance

Descriptive Statistics
Dependent Variable: CONC

LAYER	SITE	Mean	Std. Deviation	N
upper	outEast	628.200	109.4489	10
	EdgeIsland	652.500	135.1183	10
	Inflow	605.300	330.8756	10
	EdgeWest	431.100	196.6494	10
	Middle	512.200	114.8156	10
	Total	565.860	205.2372	50
lower	outEast	661.500	133.9372	10
	EdgeIsland	499.500	130.8190	10
	Inflow	331.800	194.1339	10
	EdgeWest	321.100	202.8817	10
	Middle	299.700	174.2974	10
	Total	422.720	214.9946	50
Total	outEast	644.850	120.2647	20
	EdgeIsland	576.000	151.3761	20
	Inflow	468.550	298.9905	20
	EdgeWest	376.100	202.4830	20
	Middle	405.950	180.3273	20
	Total	494.290	221.1342	100

Sediment Univariate Analysis of Variance (Cont)

Tests of Between-Subjects Effects
Dependent Variable: CONC

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Noncent. Parameter	Observed Power
		1					
LAYER	512226.490	1	512226.490	15.252	.0002	15.252	.972
SITE	1035604.340	4	258901.085	7.709	.00002	30.835	.996
LAYER * SITE	270655.460	4	67663.865	2.015	.099	8.059	.583
Error	3022646.300	90	33584.959				
Corrected Total	4841132.590	99					

a Computed using alpha = .05
b R Squared = .376 (Adjusted R Squared = .313)

Estimated Marginal Means

1. LAYER
Dependent Variable: CONC

	Mean	Std. Error	95% Confidence Interval	
LAYER			Lower Bound	Upper Bound
upper	565.860	25.917	514.371	617.349
lower	422.720	25.917	371.231	474.209

2. SITE
Dependent Variable: CONC

	Mean	Std. Error	95% Confidence Interval	
SITE			Lower Bound	Upper Bound
outEast	644.850	40.979	563.439	726.261
EdgeIsland	576.000	40.979	494.589	657.411
Inflow	468.550	40.979	387.139	549.961
EdgeWest	376.100	40.979	294.689	457.511
Middle	405.950	40.979	324.539	487.361

Sediment Univariate Analysis of Variance (Cont)

3. LAYER * SITE
Dependent Variable: CONC

		Mean	Std. Error	95% Confidence Interval	
LAYER	SITE			Lower Bound	Upper Bound
upper	outEast	628.200	57.953	513.067	743.333
	EdgeIsland	652.500	57.953	537.367	767.633
	Inflow	605.300	57.953	490.167	720.433
	EdgeWest	431.100	57.953	315.967	546.233
	Middle	512.200	57.953	397.067	627.333
lower	outEast	661.500	57.953	546.367	776.633
	EdgeIsland	499.500	57.953	384.367	614.633
	Inflow	331.800	57.953	216.667	446.933
	EdgeWest	321.100	57.953	205.967	436.233
	Middle	299.700	57.953	184.567	414.833

Post Hoc Tests
Site

Multiple Comparisons
Dependent Variable: CONC
Tukey HSD

		Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
(I) SITE	(J) SITE				Lower Bound	Upper Bound
outEast	EdgeIsland	68.850	57.9525	.758	-92.481	230.181
	Inflow	176.300	57.9525	.025	14.969	337.631
	EdgeWest	268.750	57.9525	.0001	107.419	430.081
	Middle	238.900	57.9525	.001	77.569	400.231
EdgeIsland	outEast	-68.850	57.9525	.758	-230.181	92.481
	Inflow	107.450	57.9525	.350	-53.881	268.781
	EdgeWest	199.900	57.9525	.007	38.569	361.231
	Middle	170.050	57.9525	.034	8.719	331.381
Inflow	outEast	-176.300	57.9525	.025	-337.631	-14.969
	EdgeIsland	-107.450	57.9525	.350	-268.781	53.881
	EdgeWest	92.450	57.9525	.504	-68.881	253.781
	Middle	62.600	57.9525	.816	-98.731	223.931
EdgeWest	outEast	-268.750	57.9525	.0001	-430.081	-107.419
	EdgeIsland	-199.900	57.9525	.007	-361.231	-38.569
	Inflow	-92.450	57.9525	.504	-253.781	68.881
	Middle	-29.850	57.9525	.986	-191.181	131.481
Middle	outEast	-238.900	57.9525	.001	-400.231	-77.569
	EdgeIsland	-170.050	57.9525	.034	-331.381	-8.719
	Inflow	-62.600	57.9525	.816	-223.931	98.731
	EdgeWest	29.850	57.9525	.986	-131.481	191.181

Based on observed means.
* The mean difference is significant at the .05 level.

Plant Analysis

Regression Analysis of the Calibration Curves – Plant Samples

Date	Plant	Slope	Stand. Error of the Slope
09/14/02	TP	0.00135	0.00001
09/21/02	TP	0.00133	0.00003
09/28/02	TP	0.00137	0.00005
10/05/02	TP	0.00138	0.00001
10/12/02	TP	0.00137	0.00001
10/26/02	TP	0.00135	0.00001
11/02/02	TP	0.00140	0.00001
11/10/02	TP	0.00138	0.00001
11/23/02	TP	0.00139	0.00001
12/01/02	TP	0.00110	0.00003
12/08/02	TP	0.00141	0.00001
12/15/02	TP	0.00136	0.00001

T-Test for Typha Comparing Above with Below Parts

Group Statistics

	plant part	N	Mean	Std. Deviation	Std. Error Mean
TP	above	24	.1279	.03811	.00778
	below	24	.1388	.04132	.00843

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means				
		F	Sig.	t	df	p-value	Mean Difference	Std. Error Difference
TP	Equal variances assumed	.373	.544	-.944	46	.350	-.0108	.01147
	Equal variances not assumed			-.944	45.702	.350	-.0108	.01147

T-Test for Scirpus Comparing Above with Below Parts

Group Statistics

	plant part	N	Mean	Std. Deviation	Std. Error Mean
TP	above	24	.0938	.04322	.00882
	below	24	.1242	.05266	.01075

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means				
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
TP	Equal variances assumed	.123	.728	-2.187	46	.034	-.0304	.01391
	Equal variances not assumed			-2.187	44.314	.034	-.0304	.01391

T-Test Between Species Above Parts

Group Statistics

	species	N	Mean	Std. Deviation	Std. Error Mean
TP	typha	24	.1279	.03811	.00778
	scirpus	24	.0938	.04322	.00882

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means				
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
TP	Equal variances assumed	1.205	.278	2.905	46	.006	.0342	.01176
	Equal variances not assumed			2.905	45.289	.006	.0342	.01176

T-Test Comparing Species Below Parts

Group Statistics

	species	N	Mean	Std. Deviation	Std. Error Mean
TP	typha	24	.1388	.04132	.00843
	scirpus	24	.1242	.05266	.01075

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means				
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference
TP	Equal variances assumed	.000	.994	1.067	46	.291	.0146	.01366
	Equal variances not assumed			1.067	43.535	.292	.0146	.01366

REFERENCE

Ansola G., Fernandez, C., de Luis, E., 1995. *Removal of Organic Matter and Nutrients from Urban Wastewater by Using an Experimental Emergent Aquatic Macrophyte System,* Ecological Engineering. Vol. 5, pp 13-19.

APHA, 1998. *Standard Methods for the Examination of Water and Wastewater.* 20th Edition. Clesceri, L. S., Greenberg, A. E. Eaton, A. D., editors. American Public Health Association, American Water Works Association and Water Environment Federation, Washington, D.C.

Aspila, K.L.; Agemina, H.; Chau, S. Y., 1976. *A Semi-automated Method for the Determination of Inorganic, Organic, and Total Phosphorus in Sediments,* Analyst. Vol. 101, pp 187-197.

Association of Official Analytical Chemists (AOAC), *Official Methods of Analysis of the Association of Official Analytical Chemists,* 15th Ed. Washington, DC, USA.

Auclair, A.N.D., 1979. *Factors Affecting Tissue Nutrient Concentrations in a Scirpus-Equisetum Wetland*, Ecology. Vol. 60, pp 337-348.

Baker, L.A., 1992. *Introduction to Nonpoint Source Pollution in the United States and Prospects for Wetlands Use,* Ecological Engineering. Vol. 1, pp 1-26.

Barko, J. W. and Smart, R. M., 1980. *Mobilization of Sediment Phosphorus by Submersed Freshwater Macrophytes,* Freshwater Biology. Vol. 10, pp 229-238.

Betley, D., 2003. *Development of the Hydraulic Residence Time for Las Vegas Wetlands* Park. Unpublished master's thesis, University of Nevada, Reno, Nevada, USA.

Bolton, K.G.E. and Greenway, M., 1999. *Nutrient Sinks in a Constructed Melaleuca Wetland Receiving Secondary Treated Effluent*, Water Science and Technology. Vol. 40, No.3, pp. 341-347.

Boström, B.; Andersen, J.M.; Fleischer, S. and Jansson, M., 1988. *Exchange of Phosphorus Across the Sediment-water Interface*, Hydrobiologia. Vol. 170, pp 229-244.

Boyd, C.E., 1969. *Production, Mineral Nutrient Absorption, and Biochemical Assimilation by Justicia Americana and Alternanthera Philoxeroides*, Arch. Hydrobiol. Vol. 66, pp 139-160.

Boyd, C.E., 1970. *Chemical Analyses of Some Vascular Aquatic Plants*, Arch. Hydrobiol. Vol. 67, pp 78-85.

Boyd, C.E., 1978. *Chemical Composition of Wetlands Plants.* In: Freshwater Wetlands Ecological Processes and Management Potential. Ralph E. Good; Dennis F. Whigham; Robert L. Simpson (Ed.). New York: Academic Press.

Brater, E.F. & King, H. W., 1976. Handbook of Hydraulics: For the Solution of Hydraulic Engineering Problems (6^{th} Ed.). New York: McGraw-Hill.

Bray, R.H. and Kurtz, L.T., 1945. *Determination of Total, Organic and Available Forms of Phosphorus in Soils*, Soil Science. Vol. 59, pp 39-45.

Bridgham, S.D. ; Johnston, C.A. ; Schubauer-Berigan, J.P. and Weishamped, P., 2001. *Phosphorus Sorption Dynamics in Soils and Coupling with Surface and Pore Water in Riverine Wetlands*, Soil Science Society of America Journal. Vol. 65, pp 577-588.

Brix, H., 1994. *Functions of Macrophytes in Constructed Wetlands*, Water Science and Technology. Vol. 29, No. 4, pp 71-78.

Brown, T.B., 1998. *A Simulation Model of Hydrology and Nutrients Dynamics in Wetlands*, Comput. Environ. and Urban Systems. Vol. 12, pp. 221-237.

Bureau of Reclamation (BOR), 1999. *Final Environmental Assessment for the Nature Center at the Clark County Wetlands Park,* Prepared by Harry Reid Center for Environmental Studies, University of Nevada, Las Vegas, NV.

Campbell, C. S. and Ogden, M. H., 1999. *Constructed Wetlands in the Sustainable Landscape.* John Wiley & Sons Inc., New York, 270 pp.

Carignan, R. and Kalff, J., 1980. *Phosphorus Sources for Aquatic Weeds: Water or Sediments?* Science. Vol. 207, pp 987-989.

Carpenter, S. R. and Lodge, D. M., 1986. *Effects of Submerged Macrophytes on Ecosystem Processes*, Aquatic Botany. Vol. 26, pp. 341-370.

Carpenter, S.R., 1980. *Enrichment of Lake Wingra, Wisconsin, by Submersed Macrophyte Decay*, Ecology. Vol 61. Issue 5, pp. 1145-1155.

Ceballos, B. O.; Oliveira, H.; Meira, C.M.B.S.; Konig, A.; Guimarães, A.O. and Souza, J.T., 2001. *River Water Quality Improvement by Natural and Constructed Wetland Systems in the Tropical semi-arid region of Northeastern Brazil*, Water Science and Technology. Vol. 44 No. 11-12, pp. 599-605.

Chambers, J. C.; Brown, R.W. and Williams, B.D., 1994. *An Evaluation of Reclamation success on Idaho's phosphate mines*, Restoration Ecology. Vol. 2, pp 4-16.

Chang, S.C. and Jackson, M.L., 1957. *Fractionation of Soil Phosphorus*, Soil Science. Vol. 84, pp 133-144.

Chen, R. L. and Barko, J. W., 1988. *Effects of Freshwater Macrophytes on Sediment Chemistry,* J. of Freshwater Ecology. Vol. 4, No. 3, pp 279-289.

Christensen, K.K.; Andersen, F.O. and Jensen, H.S., 1996. *Comparison of Iron, Manganese, and Phosphorus Retention in Freshwater Littoral Sediment with Growth of Litorella Uniflora and Benthic Microalgae*, Biogeochemistry. Vol. 38, pp. 149-171.

Clark County Regional Flood Control District, 2003. http://www.ccrfcd.org/03-2001.htm, NV, Las Vegas.

Cooke, J.G., 1992. P*hosphorus Removal Processes in a Wetland After a Decade of Receiving a Sewage Effluent*, J. Environ. Qual. Vol. 21, pp. 733-739.

Cooper, P.F., and Findlater, B.C., 1990. *Constructed Wetlands in Water Pollution Control.* Pergamon Press, Oxford, UK. 605 pp.

Correll, D.L., 1998. *Phosphorus: A Rate Limiting Nutrient in Surface Waters,* Poultry Science. Vol. 78, pp. 674-682.

Cowardin, L. M., V. Carter, F. C. Golet, and E. T. LaRoe, 1979. *Classification of Wetlands and Deepwater Habitats of the United States,* U.S. Fish & Wildlife Service Pub. FWS/OBS-79/31. Washington, D.C.

Craft, C. B. and Casey, W.P., 2000. *Sediment and Nutrient Accumulation in Floodplain and Depressional Freshwater Wetlands of Georgia, U.S.A.* Wetlands. Vol. 20 No. 2, pp. 323-332

Cronk, J.K. and Mitsch, W.J., 1994. *Aquatic Metabolism in Four Newly Constructed Freshwater Wetlands with Different Hydrologic Inputs*, Ecological Engineering. Vol. 3, pp. 449-468.

Cutbill, L.B., 1994. The Potential for Urban Stormwater Treatment by Constructed Wetlands. *4 Th International Conference on* Wetland Systems for Water Pollution Control.

DeBusk, T.A. and Dierberg, F.E., 1999. *Techniques for Optimizing Phosphorus Removal in Treatment Wetlands.* In: Phosphorus Biogeochemistry in Subtropical Ecosystems edited by Reddy, K.R.; O'Connor's G.A and Schelske, C.L. Boca Raton, Florida: Lewis Publishers, 707 pp.

DeBusk, T.A.; Dierberg, F.E. and Reddy, K.R., 2001. *The Use of Macrophyte-based Systems for Phosphorus Removal: an Overview of 25 years of Research and Operational results in Florida*, Water Science and Technology. Vol. 44, No. 11-12, pp. 39-46.

Dialynas, N.; Kefalakis, N.; Dialynas, M.; Angelakis, A., 2002. *Performance of an Innovative FWS constructed Wetland in Crete, Greece,* Water Science and Technology. Vol. 46, No. 4-5, pp. 355-360.

Edwards, C. S., 1992. *Root Distribution of Soft-stem Bulrush (Scirpus Validus) in a Constructed Wetland*, Ecological Engineering. Vol. 1, pp 239-243.

Emery, S.L. and Perry, J.A., 1995. *Aboveground Biomass and Phosphorus Concentrations of Lythrum Salicaria (Purple Loosestrife) and Typha spp. (Cattail) in 12 Minnesota Wetlands*, Am. Midl. Nat. Vol. 134, pp 394-399.

Frink, C. R., 1969. *Chemical and Mineralogical Characteristics of Eutrophic Lake Sediments*, Soil Sci. Soc. of Am. Vol. 33, pp 369-372.

Gaulet, J. J., 1977. *Uptake, Accumulation, and Loss of Nutrients by Papyrus in Tropical Swamps,* Ecology. Vol. 58, Issue 2, pp 415-422.

Gersberg, R. M., Elkins, S. R., Lyon, S. R. and Goldman, C. R., 1986. *Role of Aquatic Plants in Wastewater Treatment by Artificial Wetlands*, Wat. Res. Vol. 20, No. 3, pp 363-368.

Gilliam, F.S.; May, J.D.; Fisher, M..A. and Evans, D.K., 1999. *Short-term Changes in Soil Nutrients During Wetland Creation*, Wetlands Ecology and Management. Vol. 6, pp 203-208.

Godfrey, P.F.; Kaynor, E.R.; Pelczarski, S. and Benforado, J., 1985. *Ecological Considerations in Wetlands Treatment of Municipal Wastewater.* New York, Savant Nostrand Reinhold Company Inc.

Graetz, D..A. and Nair, V.D., 1995. *Fate of Phosphorus in Florida Spodosols Contaminated with Cattle Manure*, Ecological Engineering. Vol. 5, pp 163-181.

Graetz, D.A. and Nair, V.D., 1999. *Inorganic Forms of Phosphorus in Soils and Sediments* In: Phosphorus Biogeochemistry in Subtropical Ecosystems edited by Reddy, K.R.; O'Connors G.A and Schelske, C.L. Boca Raton, Florida: Lewis Publishers, 707 pp.

Granéli, W. and Solander, D., 1988. *Influence of Aquatic Macrophytes on Phosphorus Cycling in Lakes*, Hydrobiologia. Vol. 170, pp 245-266.

Guntenspergen, G.R.; Stearns, F. and Kadlec, J.A., 1989. W*etlands Vegetation* In: Hammer, D.A. (Ed), Cognition: Constructed Wetlands for Wastewater Treatment (pp. 73-88). Lewis Publishers, Inc.

Güsewell, S. and Koerselman, W., 2002. *Variation in Nitrogen and Phosphorus Concentrations of Wetland Plants*, Perspectives in Plant Ecology, Evolution and Systematics. Vol. 5, No. 1, pp 37-61.

Harper, H.J. and Daniel, H.A., 1934. *Chemical Composition of Certain Aquatic Plants*, Botanical Gazette. Vol. 96, Issue 1, pp. 186-189.

Hedley, M.J.; Stewart, W.B. and Chauhan, B.S., 1982. *Changes in Inorganic Organic Soil Phosphorus Fractions Induced by Cultivation Practices and by Laboratory Incubations*, Soil Sci. Soc. Am. J. Vol. 46, pp 970-976.

Hieltjes, A.H.M. and Lijklema, L., 1980. *Fractionation of Inorganic Phosphates in Calcareous Sediments*, J. Environ. Qual. Vol. 9. No. 3, pp 405-407.

Holtan, H.; Kamp-Nielsen, L. and Stuanes, A.O., 1988. *Phosphorus in soil, water and Sediment: an Overview*, Hydrobiologia. Vol, 170, pp. 19-34.

Horppila, J. and Nurminen, L., 2001. *The effect of an emergent Macrophyte (Typha Angustifolia) on Sediment Resuspension in a Shallow North Temperate Lake*, Freshwater Biology. Vol. 46, pp 1447-1455.

Howard-Williams, C., 1985. *Cycling and Retention of Nitrogen and Phosphorus in Wetlands: aTheoretical and Applied Perspective*, Freshwater Biology. Vol. 15, pp. 391-431.

Kadlec, R. H., 1994. *Phosphorus Uptake in Florida Marshes*, Water Science and Technology. Vol. 30, No. 8, pp. 225-234.

Kadlec, R. H., 1999. *The Limits of Phosphorus Removal in Wetlands,* Wetlands Ecology and Management. Vol. 7, pp. 165-175.

Kadlec, R.H. and Hey, D.L., 1994. *Constructed Wetlands for River Water Quality Improvement*, Wat. Sci. Tech. Vol 29. No. 4, pp. 159-168.

Kadlec, R.H. and Walker, W.W., 1999. *Management Models to Evaluate Phosphorus Impacts on Wetlands*. In: Phosphorus Biogeochemistry in Subtropical Ecosystems edited by Reddy, K.R.; O'Connor's G.A and Schelske, C.L. Boca Raton, Florida: Lewis Publishers, 707 pp.

Kao, C.M and Wu, M.J., 2001. *Control of Non-point Source Pollution by a Natural Wetland*, Water Science and Technology. Vol. 43, No.5, pp.169-174.

Kao, C.M.; Wang, J.Y.; Lee, H.Y. and Wen, C.K., 2001. *Application of a Constructed Wetlands for non-point Source Pollution Control*, Water Science and Technology. Vol. 44, No. 11-12, pp 585-590.

Kinney, W. L.; Pollard, J. E. and Stave, K., 2000. *Monitoring Plan for the Nature Center at the Clark County Wetlands Park* - HRC-E-3-4-3. Harry Reid Center for Environmental Studies, University of Nevada, Las Vegas.

Klopatek J.M., 1978. *Nutrient Dynamics of Freshwater Riverine Marshes and the Role of Emergent Macrophytes.* In: Freshwater Wetlands Ecological Processes and Management Potential. Ralph E. Good; Dennis F. Whigham; Robert L. Simpson (Eds). New York: Academic Press.

Kock, M.S. and Reddy, K.R., 1992. *Distribution of Soil and Plant Nutrients Along a Trophic Gradient in the Florida Everglades,* Soil Sci. Soc. Am. J. Vol. 56, pp. 1492-1499.

LaBounty, J.F. and Horn, J.M., 1997. *The Influence of Drainage of the Las Vegas Valley on the Limnology of Boulder Basin, Lake Mead, Arizona-Nevada,* Journal of Lake and Reservoir Management. Vol. 13, pp. 95-108.

Lüderitz, V. and Gerlach, F., 2002. *Phosphorus in Different Constructed Wetlands*, Acta Biotechnol. Vol. 22, pp. 91-99.

Lüderitz, V.; Eckert, E.; Lange-Weber, M.; Lange, A. and Gersberg, R.M., 2001. *Nutrient Removal Efficiency and Resource Economics of Vertical Flow and Horizontal Flow Constructed Wetlands*, Ecological Engineering. Vol. 18, pp 157-171.

Mason, C.F., Bryant, R. J., 1975. *Production, Nutrient Content and Decomposition of Prhagmites communis Trin. and Typha Aungustifolia L., Journal of Ecology. Vol. 63, Issue, pp 71-95.*

McJannet, C.L.; Keddy, P.A. and Pick, F.R., 1995. *Nitrogen and Phosphorus Tissue Concentrations in 41 Wetland Plants: A Comparison* Across *Habitats and Functional Groups*, Functional Ecology. Vol 9, Issue 2, pp.231-238.

Miao, S.L. and Sklar, F.H., 1998. *Biomass and Nutrient Allocation of Sawgrass and Cattail Along a Nutrient Gradient in Florida Everglades*, Wetland Ecosystem and Management (in Press).

Mitsch, W.J. and Gosselink, J.G., 1993. W*etlands.* 2nd Ed. New York, USA:Van Nostrand Reinhold.

Mitsch, W.J. and Gosselink, J.G., 2000. *Wetlands*. John Wiley & Sons Inc., New York, 920 pp.

Mitsch, W.J., 1995. *Restoration of Our Lakes and Rivers with Wetlands – An Important Application of Ecological Engineering*, Water Science and Technology. Vol. 31, No. 8, pp 167-177.

Mitsch, W.J.; Cronk, J.K.; Wu, X.; Nair, R.W. and Hey, D.L., 1995. *Phosphorus Retention in Constructed Freshwater Riparian Marsches*, Ecological Applications. Vol. 5, Issue.3, pp. 830-845.

Montgomery Watson Harza (MWH), 1998. *D-14 Dike Opportunities and Constraints Summary.* Memorandum to Clark County Parks and Recreation. Las Vegas, Nevada.

Montgomery Watson Harza (MWH), 2002. *2001-2002 Annual Report Las Vegas Valley NPDES Municipal Stormwater Discharge Permit.* Las Vegas, Nevada.

Moshiri, G.A., 1993. *Constructed Wetlands for Water Quality Improvement.* Boca Raton, Florida: Lewis Publishers.

Nair, V. D.; Graetz, D.A.; Reddy, K. R. and Olila, O. G., 2001. *Soil Development in Phosphate-Mined Created Wetlands of Florida, USA*, Wetlands. Vol. 21, No. 2, pp 232-239.

Newman, S. and Robinson, J.S., 1999. *Forms of Phosphorus in Water, Soils, and Sediments. In: Phosphorus Biogeochemistry in Subtropical Ecosystems* edited by Reddy, K.R.; O'Connor's G.A and Schelske, C.L. Boca Raton, Florida: Lewis Publishers.

Newman, S.; Grace, J.B.; Koebel, J. W., 1996. *Effects of Nutrients and Hydroperiod on Typha, Cladium, and Eleocharis Implications for Everglades Restoratio*, Ecological Applications. Vol. 6, Issue 3, pp 774-783.

Nichols, D. S., 1983. *Capacity of Natural Wetlands to Remove Nutrients from Wastewater,* J. Wat. Pollut. Control Fed. Vol. 55, pp 495-505.

Oluyedun, O.A.; Ajayi, S.O. and van Loon, G.W., 1991. *Methods for fractionation of Organic Phosphorus in Sediments*, The Science of the Total Environment. Vol. 106, pp 243-252.

Pan, Y., Stevenson, R.J., Vaithiyanathan, P., Slate, J. and Richardson, C.J., 2000. *Changes in Algal Assemblages Along Observed and Experimental Phosphorus Gradients in a Subtropical Wetland, U.S.A.*, Freshwater Biology. Vol. 44, pp. 339-353.

Pettersson, K.; Boström, B. and Jacobsen, O., 1988. *Phosphorus in Sediments – Speciation and Analysis,* Hydrobiologia. Vol. 170, pp 91-101.

Pollard, J. E., Kinney, W. L., Stave, K., 2002. *Monitoring Report for the Nature Preserve at the Clark County Wetlands Park – Baseline Data from the Pre-Construction and During Construction Periods Final Draft* - HRC-C-1-3-1 Harry Reid Center for Environmental Studies, University of Nevada, Las Vegas.

Pomogyi, P., Best, E. P.H., Dassen, J.H.A. and Boon, J.J., 1984. *On the Relation Between Age, Plant Composition and Nutrient Release From Living and Killed Ceratophyllum Plant,* Aquatic Botany. Vol. 19, pp 243-250.

Qiu, S. and McComb, A., 2000. *Properties of Sediment Phosphorus in Seven Wetlands of the Swan Coastal Plain, South-Western Australia*, Wetlands. Vol 20, No. 2, pp 267-279.

Reddy K.R. and Debusk, W.F., 1987. *Nutrient Storage Capabilities of Aquatic and Wetland Plants* In: Aquatic Plants for Water Treatment and Resource Recovery. K.R. Reddy and W.H. Smith (Eds.), Magnolia Publishing Inc, Orlando, Florida.

Reddy, K.R.; Tucker, J. C., and DeBusk, W.F., 1987. *The Role of Egerian Removing Nitrogen and Phosphorus from Nutrient Enriched Waters*, J. Aquat. Plant Managem. Vol. 25, pp 14-19.

Reddy, K.R.; White, J.R.; Wright, A. and Chua, T., 1999. *Influence of Phosphorus Loading on Microbial Processes in the Soli and Water Column of Wetlands.* In: Phosphorus Biogeochemistry in Subtropical Ecosystems edited by Reddy, K.R.; O'Connors G.A and Schelske, C.L. Boca Raton, Florida: Lewis Publishers, 707 pp.

Rhue, R.D. and Harris W. G., 1999. *Phosphorus Sorption/Desorption Reactions in Soils and Sediments.* In: Phosphorus Biogeochemistry in Subtropical Ecosystems edited by Reddy, K.R.; O'Connors G.A and Schelske, C.L. Boca Raton, Florida: Lewis Publishers, 707 pp.

Richardson, C.J., 1985. *Mechanisms Controlling Phosphorus Retention Capacity in Freshwater Wetlands*, Science. Vol. 228, Issue 4706, pp 1424-1427.

Richardson, C.J., 1991. *Effects of Nutrients Loadings and Hydroperiod Alteration on Control of Cattail Expansion, Community Structure and Nutrient Retention in the Water Conservation Areas of South Florida*, Unpublished Report Submitted to Agricultural Area Environmental Protection District.

Richardson, R. G., 1999. *The Role of Wetlands in Storage, Release and Cycling of Phosphorus on the Landscape: A 25-Year Retrospective.* In: Phosphorus Biogeochemistry in Subtropical Ecosystems edited by Reddy, K.R.; O'Connor's G.A and Schelske, Boca Raton, Florida: Lewis Publishers.

Sakadevan, K. and Bavor, H. J., 1999. *Nutrient Removal Mechanisms in Constructed Wetlands and Sustainable Water Management*, Water Sci. Tech. Vol. 40, No. 2, pp. 121-128.

Shardendu, R.S.A., 1991. *Relationship of Nutrients in Water with Biomass and Nutrient Accumulation of Submerged Macrophytes of a Tropical Wetland,* New Phytologist, Vol.117, Issue 3, pp 493-500.

Smith, C. S., 1978. *Phosphorus Uptake by Roots and Shoots of Myriophyllum Spicatum* L.Ph.D. Thesis, University of Wisconsin, Madison, 113 pp.

Smith, C.S. and Adams, M. S., 1986. *Phosphorus Transfer From Sediments by Myriophyllum Spicatum*, Limnol. Oceanogr. Vol. 31, pp 1312-1321.

Sommers, L.E. and Nelson, D.W., 1972. *Determination of Total Phosphorus in Soils: A Rapid Perchloric Acid Digestion Procedure,* Soil Sci. Soc. Am. J. Vol. 36, pp 902-904.

Sommers, L.E.; Harris, R.F.; Williams, J.D.H.; Armstrong, D.E.; Syers, J.K., 1970. *Determination of Total Organic Phosphorus in Lake Sediments*, Limnology and Oceonography. Vol. 15, pp 301-304.

Soto, F.; Garcia, M. de Luis, E. and Becares, E., 1999. *Role of Scirpus Lacustris in Bacterial and Nutrient Removal from Wastewater*, Water Science and Technology. Vol. 40, No.3, pp. 241-147.

Southwest Wetlands Consortium (SWS), 1995a. *Clark County Wetlands Park Planning Process*, Prepared by the Southwest Wetlands Consortium for the Clark County Departments of Parks and Recreation and the Clark County Comprehensive Planning, Las Vegas, NV.

Southwest Wetlands Consortium (SWS), 1995b. *Clark County Wetlands Park Master Plan*, Prepared by the Southwest Wetlands Consortium for the Clark County Departments of Parks and Recreation and the Clark County Comprehensive Planning, Las Vegas, NV.

Stave, K.A., 2001. *Dynamics of Wetland Development and Resource Management in Las Vegas Wash, Nevada*, J. of American Water Resources Association. Vol. 37, No.5, pp. 1369-1379.

Sundblad, K. and Wittgren, H., 1997. *Wastewater Nutrient Removal and Recovery in an Infiltration wetland*, In Ecological Engineering for Wastewater Treatment. 2nd Ed .Etnier Carl and Bjorn Guterstam (Eds.), Boca Raton, USA: Lewis Publishers.

Svengsouk, L.J.and Mitsch, W.J., 2001. *Dynamics of Mixtures of Typha Latifolia and Schoenoplectus Tabernaemontani in Nutrient-enrichment Wetland Experiments*, Am. Midl. Nat. Vol. 145, pp 309-324.

Syers, J.K.; Harris, R.F.; Armstrong, D.E.; 1973. *Phosphate Chemistry in Lake Sediments*, J. Environ. Quality. Vol. 2, No. 2, pp 1-14.

Tanner, C.C., 2001. *Plants as Ecosystems engineers in Subface-flow Treatment Wetlands*, Water Science and Technology. Vol. 44, No. 11-12, pp. 9-17.

U.S. Department of Interior – Bureau of Reclamation (U.S. D.I - BOR), 1997. *Water Measurement Manual: A Water Resources Technical Publication* (3rd ed.). Washington DC.

USEPA, 1986. *Method 9045 – Soil pH*, September 1986.

USEPA, 2000. *National Water Quality Inventory 2000 Report*. http://www.epa.gov.

Verhoeven, J.T.A. and Meuleman, A.F.M., 1999. *Wetlands for Wastewater Treatment: Opportunities and Limitations*, Ecological Engineering. Vol.12, pp 5-12.

Wetzel, R. G., 1999. *Organic Phosphorus Mineralization in Soils and Sediments*. In: Phosphorus Biogeochemistry in Subtropical Ecosystems edited by Reddy, K.R.; O'Connors G.A and Schelske, Boca Raton, Florida: Lewis Publishers, 707 pp.

Wigand, C.; Stevenson, J.C. and Cornwell, J.C., 1997. *Effects of different Submersed Macrophytes on Sediment Biogeochemistry*, Aquatic Botany. Vol. 56, pp 233-244.

Williams, J.D.H.; Syers, R.F.; Harris, R.F. and Armstrong, 1971a. *Fractionation of Inorganic Phosphate in Calcareous Lake Sediments*, Proceedings Soil Sci. Soc. Am. J. Vol. 35, pp 250-255.

Williams, J.D.H.; Syers, R.F.; Walker, T.W., 1967. *Fractionation of Soil Inorganic Phosphate by a Modification of Chang and Jackson's Procedure*, Proceedings Soil Sci. Soc. Am. J. Vol. 31, pp 736-739.

VITA

Graduate College
University of Nevada, Las Vegas

Rosangela Gomes Brazão

Local Address:
2269 Moresca Avenue
Las Vegas, Nevada 89052

Degrees:
Bachelor of Science, Industrial Chemistry, 1987
Universidade Técnico Educacional Souza Marques, Brazil

Master of Science, Technology, 1997
Centro Educacional Celso Suckow da Fonseca, Brazil

Thesis Title: The Distribution of Phosphorus in the Nature Preserve at the Clark County Wetlands Park in Las Vegas, NV.

Thesis Examination Committee:
Co-Chairperson, Dr. Krystyna Stave, Ph. D.
Co-Chairperson, Dr. Jacimaria R. Batista, Ph. D.
Committee Member, Dr. Spencer M. Steinberg, Ph. D.
Graduate Faculty Representative, Dr. David James, Ph. D.