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Final Report on Experiment #2: Seasonal Water Quality Changes in Flooded Peat Soil Environments Due to Peat Soil, Water Depth, and Water Exchange Rate

Marvin Jung and Associates, Inc.

Study conducted and funded by the
Municipal Water Quality Investigations Program
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Marvin Jung[1] and Lori Weisser[2]

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Lori Weisser is a Water Resources Engineering Associate at the Municipal Water Quality Investigations Program of the California Department of Water Resources. She serves as the Site Manager for the **SMARTS** facility, where her primary duties include maintaining and operating the experiments and serving as a co-investigator. She has co-authored previous annual and technical reports for the MWQI studies. Since 1986, she has participated in field sampling, monitoring program planning and design, coordination with laboratory services, contract bidding and management, database management and analysis, and the reporting of water quality data. Ms. Weisser has an AA degree in Business Administration.

Acknowledgments

got smarts? we do.

We gratefully acknowledge the Division of Flood Management's Sacramento Maintenance Facility staff for the construction of the SMARTS (Special Multipurpose Applied Research Technology Station) facility and their assistance in conducting our first trial experiment in 1998 and our second experiment in 1999. Very special thanks to Gerald Snow, Dennis Storasli, Wendy Underhill, and Bill Carey. Dennis spent many months welding, assembling, and painting SMARTS and in the loading of peat into the tanks. Wendy took our sketches and drafted the platform design and Bill did the heavy concrete foundation work.

The second experiment at SMARTS began on January 13, 1999 and ended January 20, 2000. We thank the participating agencies of the Municipal Water Quality Investigations Program for sponsoring our study. SMARTS is serving as an important platform for conducting the experiments needed on the effects of flooded peat soil environments on drinking water quality.

Phil Wendt and Rich Breuer helped promote and approve the project under the MWQI Program. David Gonzalez and Chris Huitt of the Field Support Unit of the Water Quality Assessment Branch helped us with repairs, gave advice, and shared their facility and equipment. Murage Ngatia assisted with the chlorophyll work and Jim Hockenberry performed multiple wavelength UV absorbance scans. Bill Nickels and his staff at the DWR Bryte Chemical Laboratory promptly processed our samples.

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Marvin Jung Lori Weisser

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Executive Summary

The Municipal Water Quality Investigations (MWQI) Program of the California Department of Water Resources (DWR) conducted two experiments on the potential impacts of flooding peat soil on surface water quality. There are concerns that conversion of existing Delta islands to wetlands or water storage facilities could result in higher organic carbon and mineral salt loads in Delta drinking water supplies. Earlier MWQI studies have documented high total and dissolved organic carbon (TOC/DOC) loads, as well as salts, from drained fields in the Delta. The Delta was once a vast tule marsh prior to being reclaimed as farmland in the mid-1800s. Natural organic matter in the peat soil, which originated from decaying wetland plants, is the major source of the organic carbon.

New USEPA drinking water regulations impose stringent treatment requirements on the amounts of TOC that must be removed prior to disinfection. These laws were developed to reduce the exposure levels of disinfection by-products at the consumer's tap. During the disinfection process, organic matter chemically reacts with disinfectants, such as chlorine, to form trihalomethanes (THM) and other carcinogenic compounds. Higher TOC in the raw water supply will increase the costs of treatment. Currently, the Delta is the primary source of drinking water for two-thirds of the State's population.

A new outdoor testing facility named SMARTS (Special Multipurpose Applied Research Technology Station) was designed and constructed by DWR for the experiments. Eight large tanks--with different combinations of peat soil depth (1.5 or 4 ft.), water depth (2 or 7 ft.), and water exchange rates (none or 1.5 times per week)-- were monitored in a three-month study (Expt. 1, 7/15/98 – 10/7/98) and, later, in a one-year study (Expt. 2, 1/13/99 – 1/21/00).

Experiment Design Matrix

Tank number	**Depth of Peat Soil**	**Water Depth**	**Water Flow Rate Exchanges/week**	**Total Soil and Water Height**
1	Low @ 1.5 ft.	Low @ 2 ft.	none	3.5 ft.
2 flow-thru	Low @ 1.5 ft.	Low @ 2 ft.	high @ 1.5/wk	3.5 ft.
3	high @ 4 ft.	Low @ 2 ft	none	6 ft.
4 flow-thru	high @ 4 ft.	low @ 2 ft	high @ 1.5/wk	6 ft.
5	high @ 4 ft.	high @ 7 ft.	none	11 ft.
6 flow-thru	Low @ 1.5 ft	high @ 7 ft.	high @ 1.5/wk	8.5 ft.
7	Low @ 1.5 ft	high @ 7 ft	none	8.5 ft
8 flow-thru	high @ 4 ft.	high @ 7 ft	high @ 1.5/wk	11 ft.
9 control	none	11 ft	none	11 ft.

DWR MWQI SMARTS Facility at Sacramento Maintenance Yard in Bryte

The studies showed:

1. Peat soil is a rich source of organic carbon and nutrients. When flooded and contained (no water exchange), the flood water concentrations of organic carbon, trihalomethane formation potential, EC, and nutrients can increase to high concentrations.

2. There were seasonal patterns in TOC/DOC concentrations in the simulated flooded peat soil environment. The trend appears to be related to seasonal temperature effects on microbial activities in the flooded peat soil and water. Microbes (e.g., bacteria, fungi) breakdown the organic matter and the rate roughly doubles or quadruples for every ten degree rise in temperature. TOC/DOC production and buildup was slowest in the cold winter and then rapidly increased in the warm spring and hot summer. The TOC/DOC concentrations remained steady through the fall as temperatures began declining.

3. The poorest water quality occurred under conditions of shallow water depth (2 ft.) and no surface water exchange. Those tanks that continuously received an exchange of new water at the rate of 1 to 1.5 surface water volumes per week had water quality similar to the incoming water supply due to constant dilution and flushing.

4. Shallow peat soil layers (1.5 and 4 feet deep) that had been submerged (2 and 7 feet) and had continuous surface water exchanged for a year continued to release DOC five months after the second experiment ended. Samples taken five months (6/21/00) after the one-year study ended (1/21/00) strongly suggest that the seasonal cycle would repeat itself and that organic carbon was still available from the peat soil.

5. Predicting the water quality impact or organic carbon loading from flooding soil cannot be determined by soil organic carbon (SOC) analyses alone. Soil organic carbon consists of weakly bound and strongly bound fractions. Peat soils of similar SOC concentrations can have significantly different proportions of these two fractions. It is the weakly bound or weakly adsorbed colloidal organic carbon fraction that becomes the dissolved organic carbon when in contact with water. The studies also showed that the DOC from submerged peat soil was humic and contained THM precursors. The strongly bound organic fraction eventually degraded and became a source of DOC during the study.

6. New or other soil test methods that involve filtration or centrifuging wet soil sample extracts for DOC and other constituents (e.g., iron, manganese) are needed to supplement SOC analyses to assess the "DOC formation potential" of a submerged soil. Mass loading estimates based on SOC data alone can depart widely from actual if an assumed SOC to DOC relationship is made. Two soil batches of similar SOC concentration in Experiment #2 were significantly different in their contribution of DOC to water.

7. Water quality impacts from flooded peat soils that had been leached and drained of soluble organic carbon prior to flooding, such as by heavy rainfall or by ponding, will produce a lesser impact than from soils that had not.

8. The peat soil was a source of increasing surface water EC and bromide. It is not known what proportion of salts are from peat (partially decomposed plant matter) or from evaporative deposits of irrigation water.

9. The experiments showed that for the protection of drinking water quality, the manipulation or selection of criteria for designing and operating confined wetlands or shallow water storage reservoirs should evaluate peat soil characteristics and flooding depths, water exchange rates, timing and duration of storage and released, and applied water quality.

10. Other significantly important contributing factors that were not studied include organic carbon generation and cycling of aquatic plants and algae. Plant and algae production may surpass peat soil as a major carbon source as a wetland develops and matures.

11. Six proposed actions were developed for incorporation in a wetlands restoration plan that could reduce impacts on drinking water quality from flooding agricultural fields. The combined actions could help reduce soil organic carbon and DOC availability in the fields prior to flooding and enhance the dilution and dispersion of organic carbon and nutrients released from the inundated soils. They are:

    1. Selecting proposed wetland sites with a low potential to release organic carbon;
    2. Reducing crop residues in the fields prior to initial flooding;
    3. Plowing the proposed flooded wetland areas during the warm months prior to initial flooding (Note: Land on or adjacent to the levees, however, should not be plowed as this would increase subsidence and erosion of the levees.);
    4. Flooding and draining fields prior to long-term flooding;
    5. Allowing water exchanges and movement across the wetlands; and
    6. Minimizing repeated wet and dry periods on the wetlands.

    The effectiveness of each action and in combination with each other are expected to vary with different field conditions and how the actions are conducted. Further studies can provide specific guidance on the best operating procedure for each action.

12. Future work should include collection of soil data from proposed flooded areas in the Delta. Data on the physical and chemical characteristics of soil and pore water constituents are extremely limited to a few islands. Temporal and spatial variability are expected features that will be found across the 738,000 acres of the Delta. This information is needed to assess the potential levels of leachable constituents (e.g., DOC, nutrients) from the soil.

Introduction

Wetlands restoration and water storage on Sacramento-San Joaquin Delta islands are under consideration as major subcomponents to the CALFED Delta alternatives. It is unclear as to whether these actions could cause water quality impacts that could impair the ability of municipal water treatment plants in meeting new EPA regulations for the control of disinfection byproducts.

As part of the DWR Municipal Water Quality Investigations Program (MWQI), studies are underway and planned to assess these concerns. Computer model simulations will be used to compare the relative predicted water quality changes from different hypothetical scenarios of wetlands and island water storage facilities in the Delta. Details of this work and simulations of water quality changes from treating island drainage prior to discharge to reduce organic carbon loads are described in the MWQI Modeling Delta Alternatives To Improve Drinking Water Quality Work Plan. This work is important in assessing the water quality benefits of the CALFED Delta alternatives.

The California Urban Water Agencies (CUWA) and MWQI Program cosponsored our first experiment. The study was conducted from July 15 to October 7, 1998. The results were published in the report titled, "A Trial Experiment On Studying Short-Term Water Quality Changes In Flooded Peat Soil Environments." (Jung and Weisser, 1999).

The objectives of that trial experiment were met successfully. The objectives were to:

1. Design and test a new approach to gather information on the long-term changes in water quality in both surface and waterlogged peat soil water under different conditions of peat soil depth, flood water depth, and water exchange rate;
2. Obtain direction and guidance for planning the next iteration of experiments based on the technical challenges faced with a new study facility, equipment, and experimental protocol;
3. Observe short-term water quality changes during the early stages of flooded peat soil environments during the summer months under shallow flooded conditions (2 and 7 ft. deep); and
4. Serve as the first small step in planning future studies for the design, construction, and operation of shallow flooded wetlands that will have minimal impact on Delta water quality.

The second experiment had the primary objective of examining seasonal water quality changes. Experiment #2 was an improved version of the first trial experiment. All of the technical challenges (e.g., flow control) and confounding effects (e.g., algal blooms) that were encountered in the trial experiment were under control in the second experiment. The overall goal of these studies was to provide results that would lead to the development of the best practices to minimize organic carbon levels in waters overlying peat soils during the construction and operation of submerged Delta islands and wetlands.

This is the final report for Experiment #2. The one-year study was conducted from January 13, 1999 through January 21, 2000. While the observations and findings are informative and insightful, any use of the results and conclusions of this report and of the first trial experiment should be made within the context of the stated objectives, test conditions, and duration of the experiments. The results of future experiments and of Experiments #1 and #2 will provide a more complete picture on the potential monthly mass loads of organic carbon from newly developed shallow wetland habitats in the Delta. Other important long-term factors that contribute or affect organic carbon loads, such as wetland plants and increased microbial activity, need to be studied.

Experimental Design

Three major factors that might affect the quality of water from flooding Delta peat soils were studied for a year in a mesocosm experiment. The factors are: (1) peat soil depth, (2) water depth, and (3) water exchange rate. Each factor was tested under a high and low condition.

These three factors were chosen because similar factors are controlled to protect water quality in receiving waters from wastewater discharges. Wastewater discharge permits include: (1) limits on mass loads being discharged; (2) a minimum discharge depth, and; (3) a minimum dilution ratio or water exchange. It is not known if these same factors could also affect the water quality of flooded peat soil environments and, if so, could controlling any of them result in lower organic carbon loads.

The important relationship between wetland plant communities and hydrology are, however, known.

> "Water depth, flow patterns, and duration and frequency of flooding, which are the result of all of the hydrologic inputs and outputs, influence the biochemistry of the soils and are the major factors in the ultimate selection of the biota of wetlands. …Hydrology is probably the single most important determinant of the establishment and maintenance of specific types of wetlands and wetland processes." (Mitsch and Gosselink, 1993)

Since field-type experiments are difficult to control and regulate and are extremely expensive, a controllable mesocosm-type of experimental approach and facility were designed. A 2^3 full-factorial design was used to study the resulting water quality changes from different conditions of flooding. Full-factorial designed experiments are more efficient than single-factor experiments as fewer runs are necessary. The method can identify the main effects and interactive synergistic and antagonistic effects of the three factors. The design matrix for the experiment included eight runs (three factors each with two conditions) in eight tanks. A materials control test tank was added to assess leaching of organic carbon from the plastic PVC pipes and fiberglass tanks that were used.

The experimental design consisted of using nine large fiberglass tanks (four 810-gallon and five 1500-gallon capacities) filled with different combinations of peat soil and water depths under two different water exchange rates. A new testing facility was required and its construction was completed in late June of 1998. The facility was named **SMARTS** (Special Multipurpose Applied Research Technology Station) and is located at the Department of Water Resources Sacramento Maintenance Facility in West Sacramento (Bryte), which also houses the agency's Chemical Laboratory and MWQI Field Unit.

The tanks (6 and 11 feet high) were plumbed with an outlet pipe and valve mounted 0.5 feet from the bottom to sample peat soil water. A standpipe outlet was also plumbed to the inside of each tank to maintain constant water levels (depth) in the tanks. The water flowing into the standpipes were collected into a trough for disposal to a nearby storm drain. Above each tank, fresh tap water was supplied to fill and maintain water exchange in the tanks.

Peat soil was collected from a Twitchell Island farm field to serve as the soil test material. Dry peat soil was collected in November 1998 to fill the first four tanks. Dirt was scraped from the top two feet of soil and loaded onto a dump truck by a front loader for delivery at the SMARTS facility. Large clumps of root mass and plants were removed by hand. The remaining soil was then mixed by a backhoe tractor and then loaded into the six-foot high tanks. Staff entered the tanks to tamp down and spread the soil evenly across the specified peat soil heights.

Due to the limited capacity of a small dump truck, a second load of peat was collected from the same Twitchell Island field of the first load to fill the remaining four eleven-foot high tanks in December 1998. However, the consistency of the peat soil was water saturated due to December rainstorms. The peat was in large, heavy, mud-like clumps. One fiberglass tank was damaged during loading when the peat was dropped into the tall, eleven-foot high tank, and was subsequently repaired.

All tanks were filled with the peat and water combinations on January 13, 1999. Water from a fire hydrant nearby to SMARTS was used to quickly fill the tanks. The tanks were later topped off on January 15.

The SMARTS water supply was tapped into a nearby water main in the Bryte Yard. The City of West Sacramento tap water was used as the water supply because of its fairly consistent chemical composition that was needed during the experiment. Natural water taken from the Sacramento River at Bryte varies chemically and would confound the planned experiment, especially when water quality constituents, such as TOC, DOC, and TTHMFP concentrations, are affected by upstream dam releases, farm drainage, runoff, and weather changes during the year.

Water exchange rates for each tank were adjusted with flow meters or in combination with adjustable screw-type valves for plastic tubing. Flows to designated tanks began on January 21. Small submersible electric water fountain pumps provided circulation (120 gph or 2880 gpd) in each tank to ensure complete mixing. The pumps and the first sampling event were also started on January 21 in the nine tanks.

The test conditions for each tank are described in the following design matrix table (Table 1). Peat soil depth did not exceed four feet to reduce the potential for structural failure of the fiberglass tanks. Peat soil samples were taken initially for soil organic carbon, percent organic matter, total Kjeldahl organic nitrogen, total phosphorus, and bromide analyses. This information was needed to check for homogeneity of the peat soil placed into each tank prior to the start of the experiment and to account for differences that may be due to variations in the starting organic and nutrient content of the peat soil in each tank. BSK Laboratories, laboratory contractor for DWR, performed the soil analyses.

Table 1. Design Matrix

Nominal depths, rates, and heights

Tank number	**Depth of Peat Soil**	**Water Depth**	**Water Flow Rate Exchanges/week**	**Total Soil and Water Height**
1	Low @ 1.5 ft.	low @ 2 ft.	none	3.5 ft.
2f	Low @ 1.5 ft.	low @ 2 ft.	high @ 1.5/wk	3.5 ft.
3	high @ 4 ft.	low @ 2 ft	none	6 ft.
4f	high @ 4 ft.	low @ 2 ft	high @ 1.5/wk	6 ft.
5	high @ 4 ft.	high @ 7 ft.	none	11 ft.
6f	Low @ 1.5 ft	high @ 7 ft.	high @ 1.5/wk	8.5 ft.
7	Low @ 1.5 ft	high @ 7 ft	none	8.5 ft
8f	high @ 4 ft.	high @ 7 ft	high @ 1.5/wk	11 ft.
9	none	11 ft	none	11 ft.

All samples were collected following procedures in the Municipal Water Quality Investigations Program Field Manual, August 1995, except where deviations were needed to meet this specific project. Water samples were collected every two weeks from the surface water (1-3 ft. below surface) of each tank and the water supply line. The small submersible pumps (2880 gpd) circulated surface water at the rate of 2.8 times per day in the tanks with 7 feet of water and 9.8 times per day in the tanks with 2 feet of water. Peat soil water samples were taken monthly from the bottom outlets of the tanks from January to July 1999. Thereafter, samples were taken quarterly as the previous monthly data showed minor changes in water quality. A duplicate sample was taken at each sampling event for QA/QC purposes.

A glass jar (500 ml.) that was suspended by a nylon cord was used to collect water samples from the tanks. Depending on the scheduled laboratory analyses about 2 or 3 liters of water were collected. The samples were, therefore, composites of smaller volume samples collected from the glass jar. A stainless steel bucket was used to collect from the water supply line. Water samples were transferred into one-gallon amber bottles that had been prerinsed with demineralized water and permanently labeled and assigned to each sample source (tank surface and bottom) to prevent cross-contamination and carry-over during the course of the experiment. Samples were preserved (Table 2) and transferred to the adjacent DWR Bryte Chemical Lab within four hours after collection. The Bryte Laboratory processed the samples to meet holding times.

Field measurements included water temperature, specific conductance (EC), pH, dissolved oxygen (DO), and turbidity. All instruments were calibrated prior to taking the first sample of the day following the respective manufacturer's instructions.

Table 2. Water Quality Laboratory Analyses

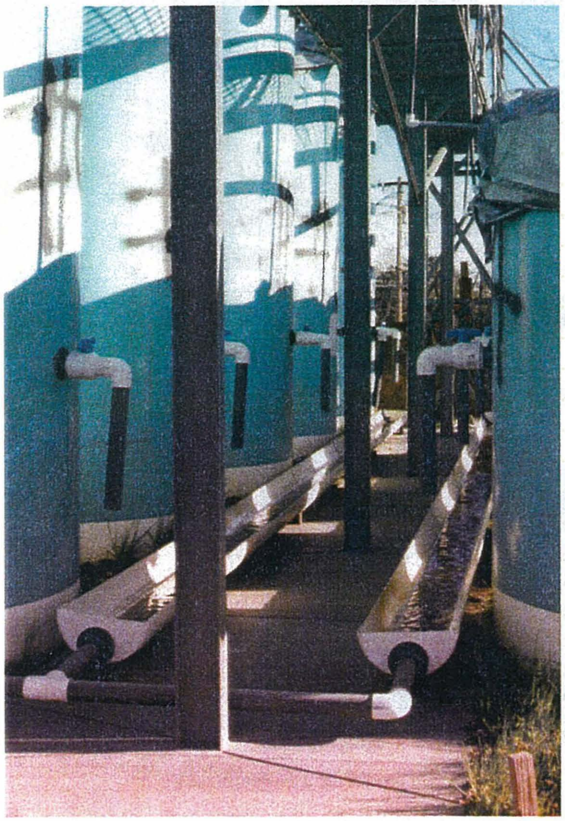
PARAMETER	CONTAINER	VOLUME	PRESERVATION	HOLDING TIME
Total Organic Carbon	Clear glass vial w/Teflon-silicone septa & screw cap	40 ml	H_3PO_4, pH<2, 4°C	28 days
Dissolved Organic Carbon	Clear glass vial w/Teflon-silicone septa & screw cap	40 ml	0.45_u filtered, H_3PO_4, pH<2, 4°C	28 days
Trihalomethane Formation Potential (THMFP) reactivity-based	Amber glass vial w/Teflon-silicone septa & screw cap	3 - 40 ml	0.45_u filtered, 4°C	14 days after quenching
UVA 254_{nm}	poly	50 ml	0.45_u filtered, 4°C	48 hours
Bromide	poly	50 ml	none required	28 days
Total Alkalinity	poly	100ml	4°C	28 days
Standard Nutrients (Code 2)	8 oz. poly 8 oz. poly	100 ml 100 ml	4°C unfiltered freeze unfiltered	48 hours 3 months
Ammonia	poly	400 ml	Cool to 4°C H_2SO_4 to pH<2	28 days
Total Organic Nitrogen and Total Phosphorus	poly	100 ml	H_2SO_4 to pH<2, 4°C	28 days
Chlorophyll *a*	0.45 micron glass fiber filter	500 ml	Freeze	28 days

Water misters, placed along the SMARTS platform railing above the tanks, were operated by a clock timer and began operating in April. The misters provided cooling for workers and the tanks during warm days. The tanks were covered in Experiment #2 to prevent water gain from rainfall, water loss from evaporation, and algae growth.

A set of four sampling wells for collecting peat soil water at 1, 2, 3, and 4 feet below the peat soil-water surface were installed into tanks 5 and 8. The wells were constructed of one-inch diameter, electrical PVC conduit pipe with pre-drilled holes located three inches along the soil end. Fiberglass window screening material was wrapped around the section (3 inch) with the holes and secured with plastic wire ties and an end cap. A peristaltic pump pulled the peat soil water samples from the pipe into an air-tight, flow-through glass jar that had pH and redox potential electrodes inserted through a large rubber stopper. EC was measured on the water exiting the glass chamber. Redox potential values were recorded when the water EC became steady. This assumed that a steady EC reading indicated that the well was purged of carry-over water and that in-situ water was now being pumped up into the chamber.

The peat soil was mixed by a backhoe prior to loading into the tanks.

The SMARTS facility began operating in mid-July 1998. This photo was taken when the second experiment began in January 1999. Plastic tarps were placed to prevent rainfall from entering the tanks and to limit evaporative losses and algae growth during the experiment.



Troughs collected water drained from the standpipes in the tanks that had continuous water exchange.

Trial Experiment # 1 Results

The results of the three-month (7/15/98 – 10/7/98) trial experiment showed that all three factors tested (peat soil depth, water depth, and water exchange rate) had significant effects on water quality and that their effects were additive. Each of the eight test tank conditions simulated different combinations of the three factors during a short period of inundation. All tanks with continuous water exchange had better water quality than those tanks with no continuous water exchange. Water quality was considered best in this study as a condition with low concentrations of TOC, DOC, TTHMFP, mineral salts, nutrients, and algae. The results were published in the report titled, "A Trial Experiment On Studying Short-Term Water Quality Changes In Flooded Peat Soil Environments." (Jung and Weisser, 1999).

Peat soil depth was a major factor and the water quality of the peat soil water showed that peat is a large reservoir of organic carbon with a high TTHMFP and high mineral (EC) and nutrient content. The concentrations were significantly greater than in the surface water. The concentrations were higher than those typically found in the subsurface of drained and ponded fields. The difference is attributed to the absence of a drainage mechanism in the SMARTS tanks, which resulted in an anaerobic waterlogged environment. Concentrations are expected to decrease if the peat soil water is continuously or partially drained over time.

Peat soil was a high source of nutrients that helped stimulate algal growth in all the tanks. Mats of algae and gas ebullition from photosynthesis and respiration were seen. In some tanks, the algae mats floated and covered the entire surface and later sank to the bottom or became suspended as the algae colonies died or became dense and sank. This affected turbidity and probably some of the duplicate sample RPDs (relative percent differences) of the chlorophyll-*a* and nutrient analyses.

The most severe algal blooms were in the shallow flooded tanks with no continuous water exchange. Tank 3 surface water had the highest nutrient levels and chlorophyll-*a*. This tank contained four feet of peat under two feet of water with no continuous water exchange. Based on the surface water chlorophyll-*a* data, the Trophic State Index was 52 (Carlson, 1977). At this index, the conditions are described as the lower boundary of classical eutrophy for a lake, which is characterized by decreased transparency, anoxic hypolimnia during the summer, possible macrophyte problems, and iron and manganese and taste and odor problems if the water is used for drinking water (American Water Works Association Research Foundation, 1989). Others consider the conditions as hypereutrophic (Vollenweider and Kerekes, 1980).

The computed TOC from algae based on a standard chlorophyll-*a* to TOC conversion formula did not show algae to be the dominant source of organic carbon. Peat soil appeared to be the primary organic carbon source. However, the true contribution cannot be determined from the estimated biomass based on chlorophyll values. Future work needs to measure primary productivity, the rate at which inorganic carbon is converted to organic carbon.

The importance of dilution or high water depth in reducing high organic carbon and salt concentrations was seen. Tank 3 also had the poorest water quality. TOC reached 166 mg/l at the end of ten weeks of submergence. The EC was 532 µS/cm, TTHMFP at 11,300 µg/l, and DOC at 108 mg/l. A massive algal mat grew in the tank and chlorophyll-*a* was up to 200 µg/l (equivalent to 13.4 mg/l TOC). These values far exceeded those reported for Delta island drain water samples except for a few collected during or after winter leaching of adjacent fields that were ponded to leach out salts (CDWR, 1994).

The best water quality of a water storage condition was in tank 7, which held 1.5 ft. of peat under 7 ft. of water with no continuous water exchange. By the tenth week of submergence, the impounded water had 17.7 mg/l TOC, 16.5 mg/l DOC, 1430 µg/l TTHMFP, and EC at 174 µS/cm. Surface water in tank 5, which contained 4 ft. of peat under 7 ft. of water under no continuous water exchange, had 33.3 mg/l TOC, 26 mg/l DOC, 225 µS/cm EC, and 2,190 µg/l TTHMFP. In both cases, these concentrations, except for EC, are higher than those typically seen in the Delta channels and water export intakes.

Water exchange was another major factor that benefited water quality. The best conditions were seen in tanks 8f (4 ft. of peat) and 6f (1.5 ft. of peat), each with 7 ft. of water and a continuous water exchange of 1.5 surface water volume exchanges per week. The water quality was similar to conditions seen in the Delta channels.

Water quality in the tanks did not appear to stabilize until as early as the tenth week of the twelve-week experiment. For some tanks, in particular those with no water exchange and flooded to a two-foot depth, water quality continued to degrade. The trends showed that future experiments should be longer than three months.

Water quality could have been worse as release mechanisms at the soil-water surface, such as bioturbation, wave action, and pore water circulation, were not studied or simulated. An in-depth study of the contribution of organic carbon from the seasonal production and decomposition of vegetation, macrophytes, algae, and phytoplankton, also needs to be studied. Future experiments have been planned to examine these sources.

The increases in TOC, DOC, UVA_{254nm}, nutrients, and THMFP over time in hydric soils were in agreement with known biogeochemical processes of wetlands. The results were similar to those reported in other studies of drainage and wetlands performed by the MWQI Program, the USGS, and researchers in Florida (Moore et. al., 1998; Vaithiyanathan and Richardson, 1998).

The results were compared against field studies conducted by others. There was good agreement between our simulated experiment and field studies. Minor differences could be attributed to containment of the subsurface water in our tanks. The studies of open fields and ponds had seepage and subsurface water movement (drainage) occurring.

The study provided information on which factors should continue to be studied to predict the possible water quality conditions that might be seen from the immediate flooding and storage of water on a Delta peat soil wetland or island. Water quality changes were studied during the summer over a twelve-week period. Complete stabilization of some water quality parameters was uncertain and it indicated the need for longer experiments to observe seasonal changes (e.g., overturn of organic matter) and to compute seasonal mass loads of organic carbon and other constituents. It is possible that other factors or some of the tested factors will become less important over time. For example, plant or algal production might surpass peat soil as a major controlling factor of organic carbon as a wetland matures.

The potential impact for impairing the drinking water quality of Delta water supplies is real but could be minimized. The study showed that: (1) the design, construction, and operation of a flooded peat environment in the Delta must at least consider the three factors that were studied, (2) long-term studies must be conducted, and (3) more intensive studies are needed to quantitatively predict water quality changes from different types of wetlands and management schemes.

Other factors to be studied should include plant biomass contributions of organic carbon. Factorial experiments follow an iterative process to identify the best conditions of main factors to produce desired results. In our case, the desired results are good water quality. Future experiments might include examining water quality changes from: (1) a deep flooded condition (30 – 45 ft. inundation), (2) sediment or liner capping of peat soil, (3) wetland plant decay, (4) cycles of wet and dry periods in flooded wetlands, and (5) iterations of the past experiment to refine design and operational criteria for a wetland or shallow water storage basin in the Delta.

Experiment #2 Results

The operation of Experiment #2 differed from the previous trial experiment. In Experiment #2, the tanks were covered to eliminate the confounding effects of water loss (e.g., evapotranspiration) and gain (e.g., rainfall) and algae blooms from occurring in the tanks. The tanks were uncovered in the trial experiment. The sampling frequency was also reduced because of the longer duration of the study and to reduce sampling and laboratory costs. Sampling wells were installed in tanks 5 and 8 for collecting peat soil water samples for EC, pH, and redox potential measurements at four depths below the peat soil-water surface. The major differences between the trial experiment and current second experiment are summarized below:

Table 3. Differences in Trial and Experiment #2 Operations

Operation/Event	Trial Experiment	Experiment #2
Duration	12 weeks (7/15-10/7/98)	54 weeks (1/13/99-1/21/00)
Sampling surface water	Weekly	Every two weeks
Peat soil from Twitchell Island field	Mixed one dry batch and loaded into tanks	Two separate batches from the same field had to be collected to fill all tanks. The first batch for tanks 1 – 4 was fairly dry. Due to rainfall, the second batch (less mixed) for tanks 5- 8 was wet and clumped.
Peat soil water measurements	Limited to sampling port located at 0.5 ft. from bottom of each tank. Monthly sampling.	Added sampling wells for redox potential, EC, and pH measurements in tanks 5 and 8 at 1, 2, 3, and 4 foot soil depths. Monthly sampling then quarterly after 7/21/99
Tank covers	No covers. Full sun exposure	Covered tightly with tarps; later with fiberglass lids
Controlling algal blooms	Blooms allowed to occur.	No blooms. Tanks covered.
Controlling water loss (evapotranspiration or evaporation)	No control. Water added to some tanks during experiment to maintain water level.	Negligible water loss due to tank covers
Water exchange rate control at 1 –1.5 surface water volume exchanges/week	Some interruptions and unsteady flows until better flow regulators found.	Near constant at 1.5 surface water volume exchanges/week
Continuous water circulation inside tanks	Pumps at 70 gph	Installed new pumps at 120 gph

Peat Soil Characteristics

The characteristics of peat soil in the Delta vary spatially and with depth below land surface and with time. As with many other soil types, variation and heterogeneity is the rule not the exception (James and Dow, 1972; Reed and Rigney, 1947). Soil is not a homogenous mass but rather a heterogeneous body of material (Petersen and Calvin, 1986). A DWR-USGS cooperative study found soil organic carbon concentrations at a Twitchell Island agricultural field to range from 18.3 to 27.7 percent for near-surface soils (0.5 to 1.5 ft. below land surface). Organic carbon taken from 4.5 to 6 feet of soil ranged from 25.2 to 36.9 percent (Fujii et al., 1998). The amounts of soil organic matter and other constituents (e.g., EC, minerals, moisture, nutrients) also change with the seasons as the fields are farmed (e.g., irrigated, flooded).

Peat soil samples were collected into glass jars from each tank for laboratory analyses performed by BSK Laboratories. Each glass jar was filled with a composite soil sample, consisting of 4 small grab samples taken in a random pattern from the peat soil surface layer of each tank.

Two batches of peat soil from the same field on Twitchell Island were collected for the study because a large dump truck was unavailable for our schedule. The first batch was collected in November 1998 before a storm event occurred in early December. Tanks 1 through 4 were filled with soil from the first batch. The second batch filled tanks 5 through 8 and was collected in December 1998. The latter batch was clumpy, muddy, and wet due to the storm. The rainstorm also resulted in significant differences between the two batches in the chemistry of the peat soil (Table 4). The soils data showed that the second soil batch had much of the soluble organic matter and nutrients washed away by the heavy rains prior to collection. The average concentration of DOC in the peat soil pore water after a week of flooding in tanks 1 - 4 were four-and-a half times than in tanks 5 –8. The soil batch differences resulted in changing the experiment to include a comparison of water quality changes resulting from flooding a dry peat soil layer against a soil layer recently leached by heavy rains. In terms of comparing the paired tanks (i.e., tanks with same peat soil and water depths but different water exchange rates) the data was not affected by the different soil batches. Tank pair 1 and 2 and tank pair 3 and 4 used the first soil batch while tank pair 5 and 8 and pair 6 and 7 had the second soil batch.

Dissolved organic carbon is colloidal and organic carbon is adsorbed onto mineral particles such as iron oxide. The rains had removed much of the iron, phosphate, sulfate, and nitrogen in the second soil batch. The average DOC concentration in the pore water after the first week of flooding was 89.55 mg/l for the first batch tanks (#1 – 4) and 20.2 mg/l in the second batch tanks (#5 – 8). This indicates that the first batch had about four-and-a-half times more weakly bound organic carbon than the second soil batch. This assumes that the equilibrium DOC concentrations had been reached by the first week of flooding in the tanks. Laboratory studies confirm that the kinetics of DOC sorption/desorption are fast and within minutes (Thoma, et. al., 1991)

Table 4. Peat Soil Raw Data

Analyses	Tank 1	Tank 2	Tank 3	Tank 4	Tank 5	Tank 6	Tank 7	Tank 8	Average	Std.Dev.
Soil Organic Carbon (mg/Kg)	*70000	46000	39000	48000	41000	39000	49000	40000	43143	4375
Soil Organic Carbon (%)	*7	4.6	3.9	4.8	4.1	3.9	4.9	4	4.2	0.4
% Organic Matter (Gravimetric)	14.5 18	13	13	14	12	22	14	9.8	14.5 14	4
% Ash Content 12%	61 56	62	63	63	14	19	21	28	26.5 41	22
% Moisture	26	24	24	23	74	59	65	62	45	22
Nitrate (mg/Kg)	16	16	12	12	1.3	1.3	1.3	2.6	7.8	6.8
Total Nitrogen (mg/Kg)	3900	3400	3300	3000	1800	1500	1800	1700	2550	946
Total Kjeldahl Nitrogen (mg/Kg)	3900	3400	3300	3000	1800	1500	1800	1700	2550	946
Total Phosphorus (mg/Kg)	839	751	613	700	148	211	500	186	494	277
Bromide (mg/Kg)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5		
Sulfate (mg/Kg)	440	290	390	380	68	150	120	230	259	138
Total Iron (mg/Kg)	15000	17000	17000	14000	2900	4000	7200	5700	10350	5985
Week 1 Pore water DOC (mg/l)	82.1	96	85.5	94.6	14.1	11.3	27.5	27.9		
Week 1 Surface water DOC (mg/l)	10.7	16.8	8.6	11.3	1.9	1.8	2.2	2.8		

35% OM

*Determined to be extraneous value by Dixon method (SSSA, 1986).
Laboratory analyses by BSK Laboratories, Fresno, CA. Methods used are listed below.
Soil organic carbon (mg/kg) and soil organic carbon (%) by Walkley-Black method (SSSA, 1996). BSK lab results reported the Walkley-Black Method for determining soil organic carbon as soil organic matter. Technically, the use of these two terms interchangeably is incorrect. Soil organic carbon is a component of soil organic matter (SSSA, 1979). Soil organic matter estimates are roughly twice the Walkley-Black Method soil organic carbon values (SSSA, 1996).
% organic matter (gravimetric) by ASTM D2974-87 (reapproved 1995) computed by equation % organic matter = 100% - (% ash + % moisture).
% ash content by Standard Method 2540-B. % moisture by ASTM D2974 method C.
Nitrate (NO3-N) , bromide, and sulfate by EPA 300.0. Total Nitrogen and Total Kjeldahl Nitrogen by Standard Methods 4500. Total iron by EPA 6010.

Statistical approaches (Keogh and Mapels, 1967; Sabbe and Marx, 1987) were reviewed to describe and handle the expected variation in soil characteristics. The raw data of the soil analyses from the eight tanks in Experiment #2 were checked for extraneous values following the recommended methods of the American Society of Agronomy and Soil Science Society of America (Dixon, 1986). The soil organic carbon (SOC) result (70,000 mg/kg) in tank 1 was determined to be an extraneous value and not used in computing the 95% confidence interval for the mean value of the remaining 7 analyses. The mean confidence interval SOC was about 43,140 ± 3,330 mg/kg. If the extraneous value was included, the 95% mean confidence interval SOC would be about 46,500 ± 8,900 mg/kg. The former mean value can be used in estimating the peat soil organic carbon mass load of each tank. The mean SOC and percent organic carbon values for tanks with the first soil batch (tanks 1-4) and second batch (5-8) were about the same (Table 5).

The soil organic carbon measurement using either the Walkley-Black method or ASTM D2974-87 showed that it alone could not be a reliable or quantitative measure of the weakly bound organic carbon in soil that will be removed by water (DOC). Soil organic carbon is composed of a strongly bound fraction, that repeated washing will not remove, and a weakly bound fraction that is measured as DOC when the soil is immersed (Thoma, et. al., 1991). However, portions of the strongly bound fraction can become removable by microbial degradation, soil enzymes, and changes in pH and other environmental factors. A leachate or saturated paste extraction type of test may be more useful in assessing the potential availability of DOC from water saturated soil. The difficulty in assessing potential DOC from SOC is analogous to measuring TOC alone in water to estimate DOC (fraction $< 0.45\mu$) and POC (particulate organic carbon, $>0.45\mu$) fractions, which vary with time and source.

Soil organic matter is defined as the organic fraction of soil that includes plant, animal, and microbial residues, fresh and at all stages of decomposition, and the relatively resistant soil humus (SSSA, 1979). The organic matter content influences many soil properties such as water retention, extractable bases, the supply of N, P, and micronutrients, soil aggregation, and soil aeration. Soil organic matter is normally restricted to only those organic materials that accompany soil particles through a 2-mm sieve. The organic matter of a soil may be estimated by multiplying the organic C content by a constant factor based on the percentage of C in organic matter. Published organic C-organic matter conversion factors for surface soils have ranged from 1.724 to 2.0. The factor of 1.724 is based on the assumption that organic matter contains 58% organic C when actually this proportion varies with soil type and depth. Surface soils rarely have a factor less than 1.8 and the subsurface factor may average about 2.5. Because both direct determinations of organic matter and the calculation of organic matter content from conversion factors is not completely accurate, it is recommended that these values serve as an index of the organic matter content in a soil (Nelson and Sommers, 1996). For comparison, the percentage of soil organic matter was computed by subtracting the percent moisture and percent ash from 100 (ASTM, 1995). This method yielded higher values than those that could be computed from the conversion factors (e.g., 1.74 – 2.2) applied to the organic carbon values. The discrepancy may be attributed to dehydroxylation and decomposition of inorganic constituents, chiefly the hydrated aluminosilicates, which lose structural water and carbonate minerals and some hydrated salts during the ignition of the soil samples to 440 °C under the ASTM method (loss-on-ignition). The heating results in weight losses considerably in excess of actual organic matter content. This problem is particularly pronounced in subsoils with high clay and low organic matter (Christensen and Malmros, 1982; Howard and Howard, 1990).

Table 5. Experiment #2 Peat Soil Data Summary

Mean and 95% lower (LCL) and upper confidence limits (UCL) shown

Soil Character	Batch #1 Tanks 1 - 4			Batch #2 Tanks 5 – 8		
	95% LCL	Mean value	95% UCL	95% LCL	Mean value	95% UCL
Soil organic carbon (mg/kg)	32594	44333 × .757 33560	56073	34972	42250 × .35 14788	49527
% organic carbon	3.3	4.4	5:6	3.5	4.2	4.9
% organic matter (ASTM)	10.7	14.5	18.3	6	14.5	23
% ash content	55.6	61	66.4	11.3	20.5	29.7
% moisture	22.3	24.3	26.2	54.7	65	75.3
Nitrate (mg/kg)	10.3	14	17.7	.6	1.6	2.7
TKN or TN (mg/kg)	2805	3400	3995	1475	1700	1925
Total P (mg/kg)	575	726	876	4.7	261	517.9
Sulfate (mg/kg)	276	375	474	34	142	250
Total Fe (mg/kg)	13363	15750	18137	1941	4950	7959

Note: Tank 1 soil organic carbon value of 70000 mg/kg (7%) was deleted from statistical analysis as it was determined to be an extraneous value by the Dixon method (SSSA, 1986). The SOC mean value for tanks 2 – 7 was 43143 mg/l with a 95% LCL of 39096 mg/kg and 95% UCL of 47189 mg/kg.

Phosphorus in soil has both solid (> 99%) and solution phases. The solid phase consists of organic P, Fe, Al, and Ca phosphates, and P sorbed onto the surfaces of Fe and Al oxides. The solution phase is mostly orthophosphate ($H_2PO_4^-$ or PO_4^{-3}) and small amounts of dissolved organic P and P bound to colloidal organic matter and iron oxide. A portion of the solid phase (< 25%) is labile (i.e., bioavailable) and readily transferred into the solution phase. When anaerobic conditions occur such as when soils are flooded, iron and manganese mineral oxides are reduced and become more soluble. Phosphorus sorbed onto these minerals will then be released into the water. The lower total P concentrations in the second batch soils correlated with the lower total Fe concentrations, thereby, indicating dissolution, desorption, and oxidation-reduction processes had occurred to release P and Fe.

Water Supply and Materials Control Tank Water Quality

The water quality of the city water supply is shown in Table 6. The water quality was similar to that observed in the first trial experiment conducted during the summer of 1989. During the year the DOC ranged from 0.8 to 1.7 mg/l with the higher values in November 2000. Overall, the DOC concentrations were mostly between 0.8 and 1.2 mg/l. Total alkalinity ranged from 31 to 62 mg/l as $CaCO_3$. The electrical conductivities varied but with a few exceptions were between 150 to 200 µS/cm during the year. Bromide levels were below the 0.01 mg/l reporting limit. The TTHMFP test was not performed but based on current drinking water standards for tap water (0.1 mg/l or 100 µg/l) and the initial sample taken from the materials control tank (84 µg/l), the TTHMFP was under 100 µg/l. Residual chlorine was probably 2 mg/l, typical of water distribution systems.

Relative to some water quality constituents that have been observed in the Delta channels, the city tap water supply is much lower in organic carbon, TTHMFP, and EC. The low residual chlorine dose in tap water is not enough to form THMs. MWQI studies have shown that about 120 mg/l of chlorine is needed to maintain at least a 2 mg/l chlorine residual in the TTHMFP test for agricultural drain water collected from peat soil islands in the Delta (CDWR, 1990). If the residual is not met, the formation of THMs is an incomplete reaction. It, therefore, was unlikely that the tap water supply contributed significantly to the observed TTHMFP, TOC, and DOC in the experiment.

Water quality in tank #9, the materials control tank, showed that leaching of organic carbon from the fiberglass tanks and PVC pipes were insignificant to affect the experimental results (Table 7). No additional water was added after this tank was filled at the beginning of the experiment. The DOC ranged from 1.0 to 1.3 mg/l. EC increased from 170 to about 190 µS/cm during the year, probably due to some minor evaporation through the tarp covering the tank. There were a few instances (3/31/00) of low EC readings that could have been due to rainwater falling into the tank when the cover was removed for sampling or flapping during the strong winds during the storms.

Table 6. Water Supply Water Quality

Sampling date	DOC (mg/L)	UVA cm-1	Specific Absorbance	Alkalinity (mg/L as CaCO3)	Bromide (mg/L)	Total Iron (mg/L)	Dissolved Sulfate (mg/L)	Field EC (uS/cm)	Field DO	Field pH
1/21/99	1.3	0.22	1.69	31	<0.01	0.489	22	116		8.3
2/3/99	1.1	0.018	1.64	42	<0.01	0.352	20	154	10.2	7.11
2/18/99	1.0	0.016	1.6	39	<0.01	0.506	18	141	10.2	6.72
3/4/99	0.9	0.017	1.89	41	<0.01	0.358	22	142	9.5	6.46
3/17/99	0.8	0.014	1.75	45	<0.01	0.83	21	152	10.7	6.42
3/31/99	1.0	0.016	1.6	47	<0.01	0.161	25	170	9.29	7.15
4/13/99	0.8	0.013	1.63		<0.01	0.084	20	151	9.37	7.06
4/28/99	0.8	0.012	1.5	45	<0.01	0.054	17	122	8.4	6.83
5/12/99	0.9	0.011	1.22	40	<0.01	0.014	19	147	8.96	7.01
5/26/99	0.8	0.013	1.63	44	<0.01	0.129	20	161	7.67	6.86
6/9/99	1.0	0.015	1.5	51	<0.01	0.076	23	176	8.85	7.04
6/23/99	1.1	0.015	1.36	49	<0.01	0.054	17	165	8.61	6.79
7/7/99	1.1	0.017	1.55	47	<0.01	0.338	16	149	6.45	
7/21/99	0.9	0.015	1.67	41	<0.01	0.142	22	149	8.55	7.05
8/4/99	0.8	0.014	1.75	39	<0.01	0.225	20	159	8.54	6.95
8/19/99	1.2	0.021	1.75	58	<0.01	0.081	18	194	8.05	7.03
9/1/99	1.2	0.023	1.92	55	<0.01	0.155	22	187	7.54	6.9
9/15/99	1.4	0.023	1.64	64	<0.01	0.254	26	214	7.9	7.04
9/29/99	1.0	0.018	1.8	54	<0.01	0.376	16	160	8.48	6.78
10/13/99	0.8	0.016	2	44	<0.01	0.705	12	141	7.96	6.96
10/27/99	1.1	0.019	1.73	50	<0.01	2.63	16	155		
11/9/99	1.5	0.025	1.67	62	<0.01	0.806	18	182		
11/23/99	1.7	0.033	1.94	60	<0.01	0.486	26	215		
12/8/99	1.4	0.022	1.57	55	<0.01	0.645	19	189		7.24
12/21/99	1.2	0.018	1.5	57	<0.01	0.427	14	184		
1/5/00	0.9	0.018	2	58	<0.01	0.472	20	182		
1/19/00	1.2	0.021	1.75	38	<0.01	1.35	25	163		

Table 7. Materials Control Tank Water Quality

Date	TOC (mg/L)	DOC (mg/L)	UVA (cm-1)	Spec. Abs.	Alkalinity (mg/L as CaCO3)	Ammonia (mg/L)	Bromide (mg/L)	TKN (mg/L)	Total Phosphorus (mg/L)	Bromodichloromethane (ug/L)	Bromoform (ug/L)	Chloroform (ug/L)	Dibromochloromethane (ug/L)	Total THMFP (ug/L)	Field EC (uS/cm)	Field DO (mg/L)	Field pH	Field Turbidity (ntu)
1/21/99	1.9	1.12	0.015	1.34	46.9	0.05	<0.01	0.3	0.18	11	<10	73	<10	84	170	11.0	7.2	2.1
2/3/99	1.5	1.3	0.016	1.23		0.09				11	<10	65	<10	76	173	10.4	7.3	1.4
2/18/99	1.2	1.3	0.017	1.31		0.12				10	<10	71	<10	81	172	10.7	6.75	1.12
3/4/99	1.2	1.1	0.017	1.55		0.12				10	<10	60	<10	70	171	9.97	7.05	2.91
3/17/99	1.2	1.1	0.018	1.64	51	0.15	<0.01	0.2	0.11	10	<10	56	<10	66	170	10.05	7.11	0.85
3/31/99	1.1	1.1	0.02	1.82		0.15				10	<10	58	<10	68	129	9.47	7.62	1.31
4/13/99	1.2	1.0	0.018	1.8		0.13				11	<10	57	10	78	133	9.76	7.75	0.61
4/28/99	1.5	1.0	0.021	2.1		<0.01				11	<10	52	<10	63	143	8.11	7.24	0.96
5/12/99	1.0	1.2	0.019	1.58	51	<0.01	<0.01	0.1	0.1	<10	<10	50	<10	50	175	8.22	7.43	0.55
5/26/99	1.1	1.1	0.022	2.0		<0.01				<10	<10	56	<10	56	180	8.47	7.13	
6/9/99	1.1	1.0	0.019	1.9	49	<0.01	<0.01	<0.1	0.1	<10	<10	57	<10	57	182	8.65	7.56	0.62
6/23/99	1.1	1.2	0.019	1.58		0.02				<10	<10	58	<10	58	185	8.5	7.27	0.44
7/7/99	1.2	1.1	0.02	1.87	53	<0.01	0.01	0.1	0.07	<10	<10	48	<10	48	183	7.3	7.24	
7/21/99	1.2	1.3	0.02	1.54		<0.01				11	<10	58	<10	69	185	8.97	7.62	0.72
8/4/99	1.2	1.1	0.02	1.82	58	<0.01	<0.01	0.3	0.02	11	<10	57	<10	68	190	9.43	7.43	0.39
8/19/99	1.1	1.1	0.02	1.82		<0.01				11	<10	52	<10	63	187	9.27	8.37	0.65
9/1/99	1.4	1.1	0.02	1.82	54	<0.01	<0.01	0.1	0.01	<10	<10	57	<10	57	186	7.85	8.18	0.45
9/15/99	1.6	1.2	0.019	1.58		0.01				<10	<10	50	<10	50	186	7.97	8.53	0.49
9/29/99	1.2	1.1	0.019	1.73	59	<0.01	0.01	<0.1	0.01	<10	<10	52	<10	52	188	8.0	8.35	0.38
10/13/99	1.2	1.1	0.02	1.82		<0.01				8	<1	53	2	63	189	8.36	8.55	0.59
10/27/99	1.3	1.2	0.02	1.67	58	<0.01	<0.01	0.1	<0.01	9	<1	54	2	65	188	8.96	8.44	0.76
11/9/99	1.4	1.1	0.019	1.73		<0.01				8	<1	50	2	60	188	10.5	8.53	1
11/23/99	1.3	1.1	0.022	2.0	57	<0.01	0.01	<0.1	0.01	8	<1	57	1	66	193	10.73	8.3	0.7
12/8/99	1.2	1.0	0.019	1.9		<0.01				8	<1	47	<1	55	193	10.67	8.32	0.83
12/21/99	1.3	1.2	0.02	1.67	54	<0.01	<0.01	0.1	<0.01	7	<1	48	1	56	194	11.88	7.92	0.5
1/5/00	1.1	1.0	0.022	2.2		<0.01				8	<1	46	1	55	124	12.1	6.94	3.05
1/19/00	1.2	1.1	0.02	1.82	52	<0.01	<0.01	<0.1	<0.01	8	<1	51	2	61	189	12.8	7.86	0.45

Flooded Soil and Soil Water Quality

When soil is flooded, oxygen levels in the soil column rapidly decrease to negligible concentrations as aerobic microorganisms consume oxygen and normal gaseous exchange is restricted as water blocks the entry of gases. This results in decreasing the thickness of the aerobic zone and increasing the anaerobic soil zone. Associated with these changes are a decrease in the aerobic microbial population and an increase in facultative and obligate anaerobes.

To meet their metabolic requirements, the microflora oxidize organic carbon (biological oxidation). In this process, inorganic and organic compounds are used as an energy source, serve as electron donors, and become oxidized. Since each oxidation reaction must be accompanied by a reduction reaction, there must be electron acceptors present to receive the electrons released during the oxidation of a substrate. The microbial processes that occur in flooded soil are: (1) those that use inorganic substances (O_2, manganic compounds, ferric oxyhydroxide compounds, and nitrogen oxides such as nitrate, nitrite, NO, N_2O, sulfate, carbon dioxide, and H_2) and (2) fermentation in which organic compounds are used as electron acceptors. Depending on the redox condition, these two types of microbial metabolism can occur simultaneously in different zones of the same soil.

The anaerobic conditions can be monitored by measuring the oxidation-reduction or redox potential (E_h). This is a measure of electron availability and it characterizes the intensity of reduction and the likely forms of redox couples (i.e., specific chemical reactions). Aerobic bacteria respire at high E_h (>300 mV), facultative anaerobic bacteria at intermediate E_h (>0 mV and <300 mV), and obligate anaerobes at low or negative E_h values (>-100 mV-Reddy et. al. 1986). Organic matter turnover and nutrient cycling are strongly correlated with electron acceptor availability and redox conditions in wetland soils (McLatchey and Reddy, 1998).

Redox potential values (E_h) at the 1, 2, 3, and 4-foot peat soil depths in tanks 5 and 8 were mostly within the –100 to –200 millivolt (mV) range (Appendix A). At this E_h range, sulfate is reduced to sulfide. Hydrogen sulfide odors emanating from the collected peat water samples confirm this occurrence. Tanks 5 and 8 each had 4 feet of peat flooded to a water depth of 7 feet. Tank 8 had a surface water volume exchange rate of 1.5 times per week while tank 5 had no water exchange.

Under flooded conditions, obligate anaerobic bacteria reduce SO_4 to S^{2-} by using sulfate as an electron acceptor. Sulfide formation occurs after all the NO_3^-, which inhibits sulfate reduction, is lost from the system. Connell and Patrick (1968) reported S^{2-} formation in anaerobic soil with E_h of less than -150 mV. In a later study, sulfate reduction was found to begin at an E_h of <-100 mV and was followed by CO_2 reduction (methane formation – Reddy et al. 1986). The optimum pH for sulfide formation was between 6.5 and 8.5. Ammonia-nitrogen levels in the peat soil water in the Experiment #2 tanks increased over time (Figure 1) while nitrate levels decreased due to reduction

(Figure 2). This further supports the conclusion that sulfide formation was occurring in the flooded soil.

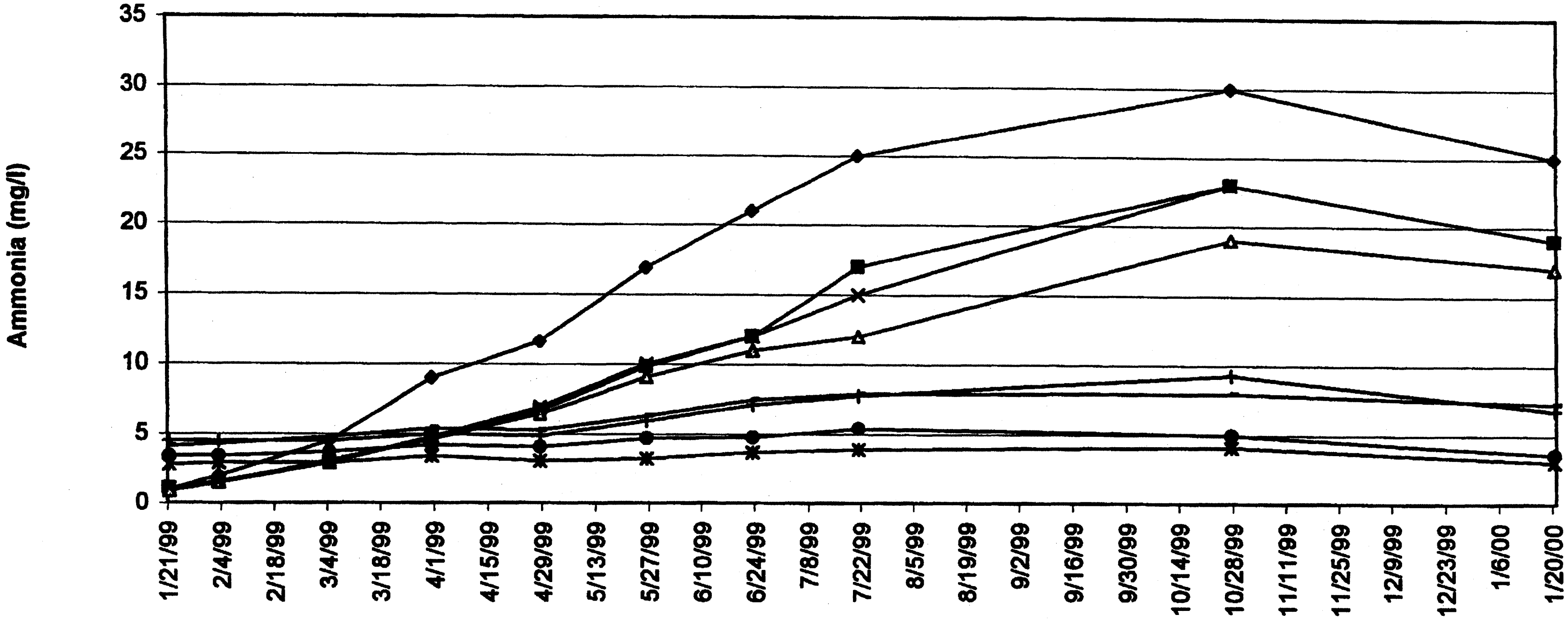
The E_h values in the two tanks showed that if an aerobic soil layer existed, it was less than a foot thick at the soil-water interface. The thickness of the aerobic zone has been found to vary from a few millimeters to 1 to 2 cm (Patrick and DeLaune, 1972; Patrick and Mikkelsen, 1971; Mitsch and Gosselink, 1993). The thickness of the aerobic layer is determined by the O_2 concentration of the floodwater (Howeler and Bouldin, 1971), the oxygen consumption rate of the underlying soil (Engler and Patrick, 1974), and the water percolation rate through the soil profile. Oxygen consumption rates of organic soils are expected to be higher than for mineral soils because of the higher organic matter in the former.

In addition to the redox potential (E_h) being affected by flooding, the ionic strength or salt concentration and pH in the soil column are also impacted. Flooding an organic soil increases the ion concentration in the soil solution. The most common cations that accumulate are ammonium (NH_4^+), Ca, Fe, Mg, and Mn, which occupy the majority of the exchange complex. The cations formed during the reduction process (e.g., NH_4^+, Fe, and Mn) displace other cations from the cation exchange complex into the soil solution, thereby increasing the ion concentration (Reddy, 1987). The EC and bromide concentrations over time are shown in Figures 3 and 4, respectively.

The concentrations and forms of nutrients such as nitrogen and phosphorus compounds are also controlled by redox conditions in flooded soils. Flooding organic soils can increase P release into drainage effluent by 4-8 times, compared with drained conditions (Reddy, 1983). The reduced forms of Fe and Mn minerals are more soluble than their oxidized counterparts such that P release from sediments is typically greater under anaerobic conditions than aerobic. Large fluxes of P from sediment could occur in shallow impoundments under low oxygen conditions due to the reduction and solubilization of ferric phosphate minerals in surficial sediments (Moore and Reddy, 1994). Diffusive and resuspension flux from bottom sediments can potentially support eutrophic levels in shallow lakes until P becomes a limiting factor (Reddy et al., 1996). Seasonal water-table fluctuations in wetlands can result in flooded and drained conditions in the surface soil, which could result in significant P release. Phosphorus flux in soils drained for 6 weeks was 10-fold higher (334 mg P $m^{-2}day^{-1}$) than in soils drained for 3 weeks (Olila, et. al., 1997). Orthophosphate concentrations in peat soil water in Experiment #2 tanks are shown in Figure 5).

Microbial decomposition of organic matter results in the release of nitrogen in the ammonium form (NH_4^+) through the process called ammonification. This is a mineralization process where there is microbial conversion of organic nitrogen into inorganic forms. Heterotrophic microorganisms utilize the organic matter as an energy source and only release inorganic nitrogen when the organic matter contains more nitrogen than the microorganisms need for their metabolism. This occurs when the carbon to nitrogen ratio in the organic matter is below 25:1 (Patrick and Mikkelsen, 1971). In the anaerobic soil layer, ammonium concentrations will increase as it is more

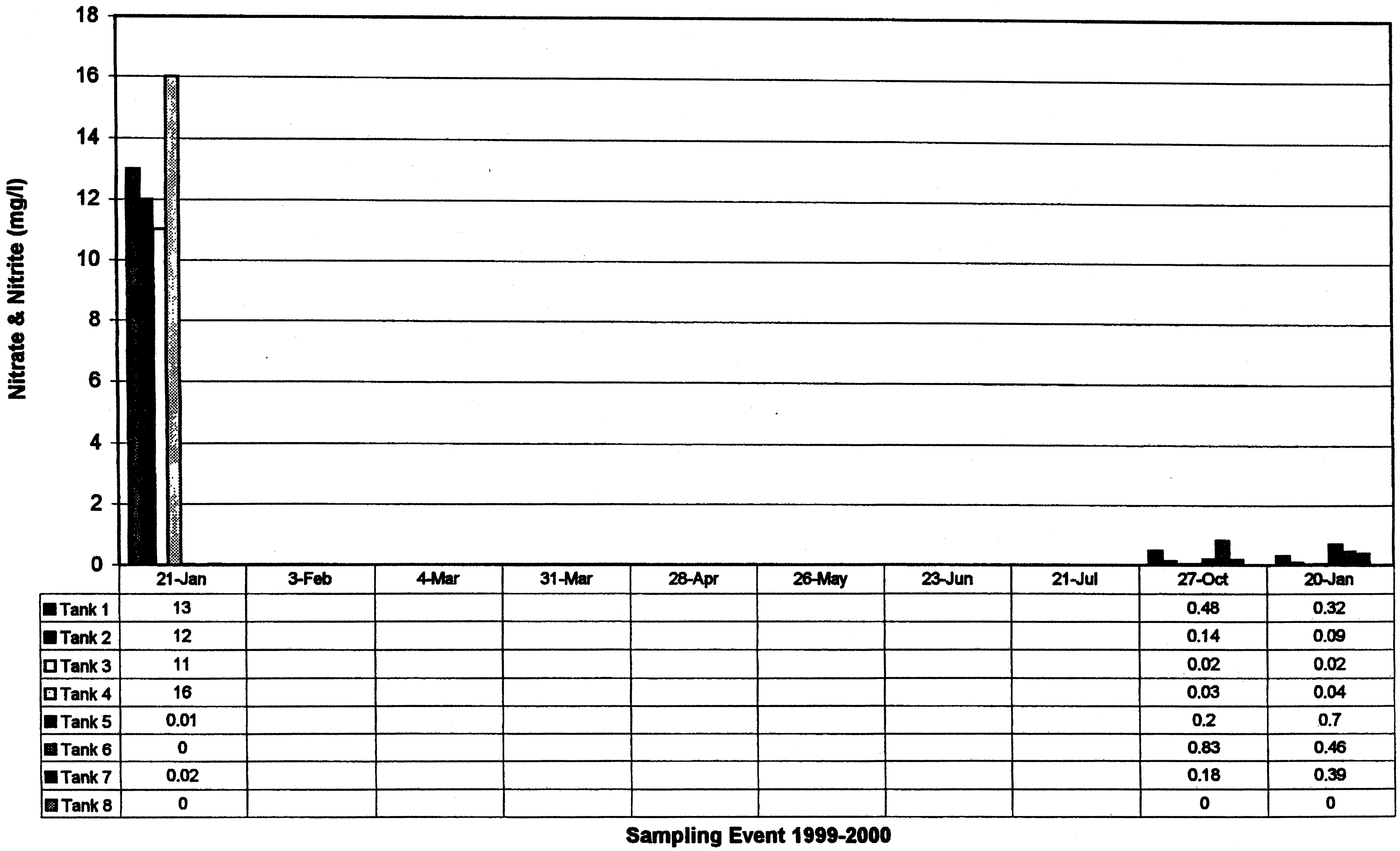
Figure 1. Peat Soil Water Ammonia



	21-Jan	3-Feb	4-Mar	31-Mar	28-Apr	26-May	23-Jun	21-Jul	27-Oct	20-Jan
◆ Tank 1	0.98	2	4.5	9	11.61	16.9	21	25	30	25
■ Tank 2	1.1	1.5	2.9	4.7	6.72	9.84	12	17	23	19
△ Tank 3	0.87	1.5	3.1	4.6	6.45	9.07	11	12	19	17
× Tank 4	1.1	1.6	3	4.8	6.93	10.02	12	15	23	19
✱ Tank 5	2.8	2.9	2.9	3.4	3.07	3.23	3.7	3.9	4.1	3.1
● Tank 6	3.4	3.4	3.7	4.2	4.06	4.69	4.8	5.4	5	3.6
+ Tank 7	4.5	4.5	4.5	5	4.86	5.97	7.1	7.8	9.3	6.8
— Tank 8	4.1	4.3	4.8	5.4	5.27	6.31	7.5	7.9	8	7.3

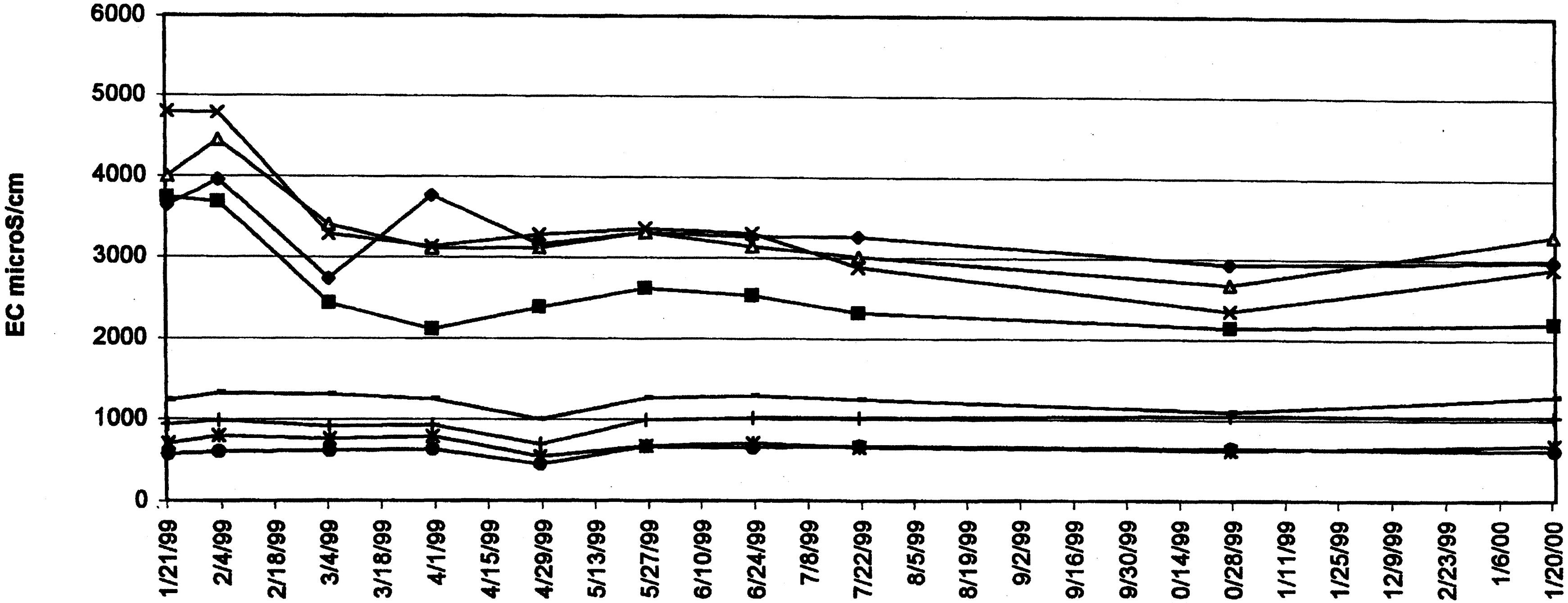
Sampling Event 1999-2000

Figure 2. Peat Soil Water Nitrate & Nitrite



	21-Jan	3-Feb	4-Mar	31-Mar	28-Apr	26-May	23-Jun	21-Jul	27-Oct	20-Jan
■ Tank 1	13								0.48	0.32
■ Tank 2	12								0.14	0.09
□ Tank 3	11								0.02	0.02
▨ Tank 4	16								0.03	0.04
■ Tank 5	0.01								0.2	0.7
▨ Tank 6	0								0.83	0.46
■ Tank 7	0.02								0.18	0.39
▨ Tank 8	0								0	0

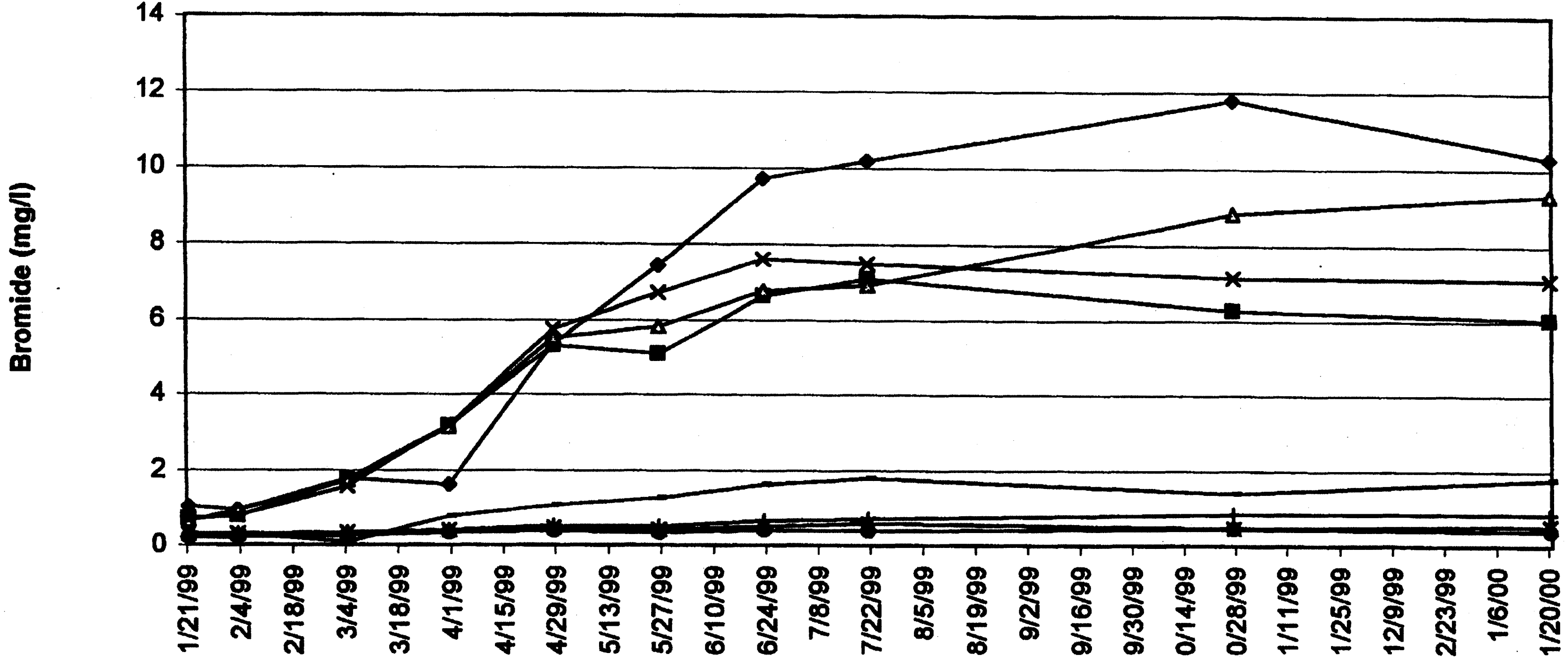
Figure 3. Peat Soil Water EC



	21-Jan	3-Feb	4-Mar	31-Mar	28-Apr	26-May	23-Jun	21-Jul	27-Oct	20-Jan
—◆— Tank 1	3640	3960	2730	3770	3159	3310	3260	3260	2925	2974
—■— Tank 2	3740	3680	2430	2110	2383	2620	2530	2320	2138	2198
—△— Tank 3	4000	4450	3400	3100	3115	3310	3140	3010	2672	3292
—×— Tank 4	4800	4790	3290	3130	3280	3360	3300	2880	2344	2881
—✱— Tank 5	708	797	761	790	550	676	714	663	631	689
—●— Tank 6	578	604	619	635	455	673	656	675	648	620
—+— Tank 7	936	985	915	924	702	990	1021	1021	1046	1036
—— Tank 8	1232	1321	1308	1250	998	1265	1291	1249	1096	1294

Sampling Event 1999-2000

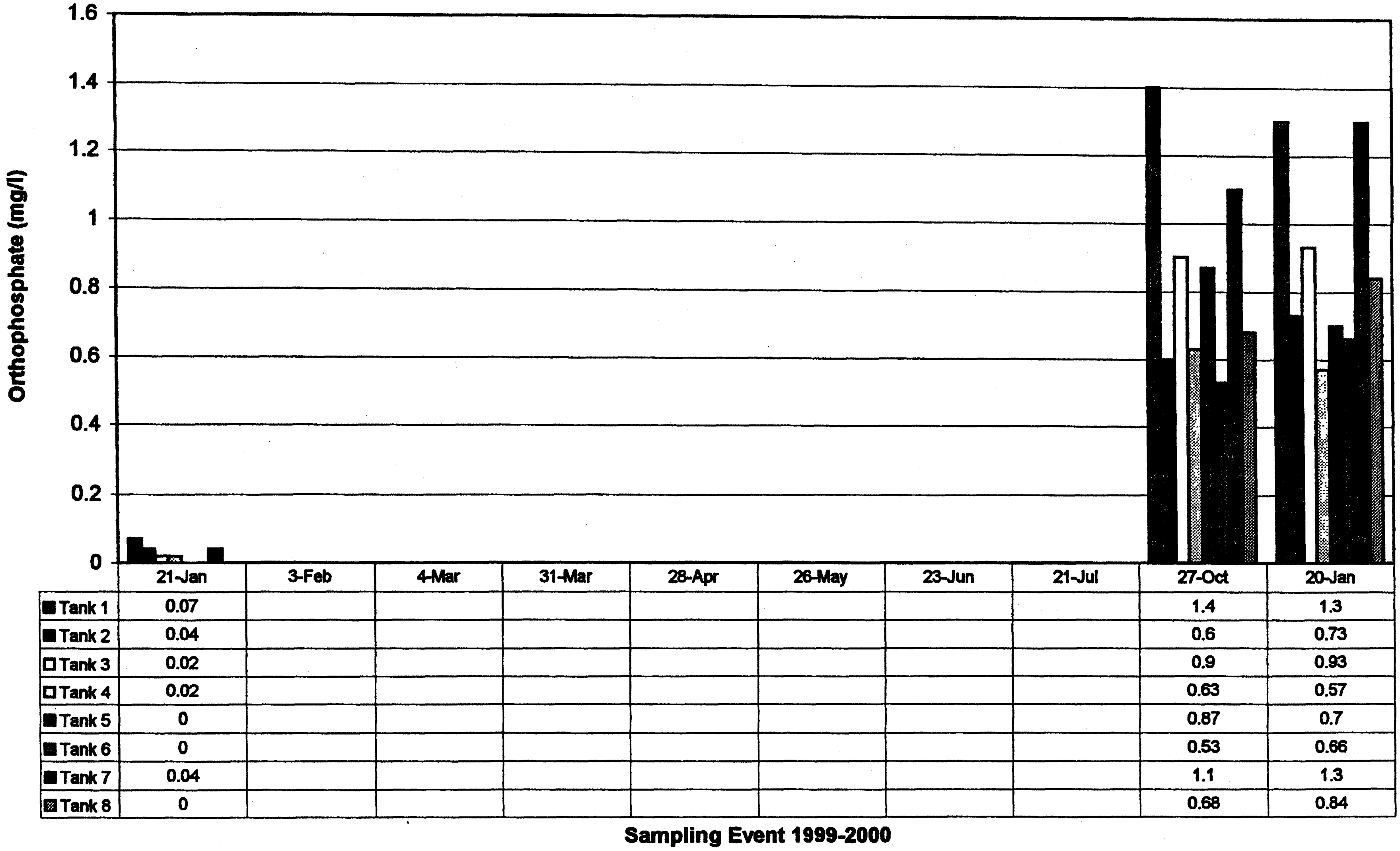
Figure 4. Peat Soil Water Bromide



	21-Jan	3-Feb	4-Mar	31-Mar	28-Apr	26-May	23-Jun	21-Jul	27-Oct	20-Jan
◆ Tank 1	1.04	0.96	1.77	1.62	5.36	7.45	9.71	10.2	11.8	10.3
■ Tank 2	0.72	0.77	1.76	3.18	5.31	5.09	6.64	7.09	6.28	6.06
△ Tank 3	0.64	0.94	1.73	3.13	5.53	5.83	6.78	6.92	8.82	9.33
✕ Tank 4	0.68	0.79	1.58	3.18	5.76	6.72	7.61	7.49	7.14	7.1
✱ Tank 5	0.31	0.3	0.33	0.41	0.47	0.42	0.51	0.59	0.47	0.53
● Tank 6	0.2	0.21	0.25	0.33	0.38	0.34	0.4	0.38	0.45	0.4
+ Tank 7	0.24	0.25	0.33	0.41	0.52	0.5	0.66	0.71	0.84	0.83
— Tank 8	0.28	0.32	0.09	0.77	1.08	1.28	1.63	1.8	1.41	1.78

Sampling Event 1999-2000

Figure 5. Peat Soil Water Orthophosphate



	21-Jan	3-Feb	4-Mar	31-Mar	28-Apr	26-May	23-Jun	21-Jul	27-Oct	20-Jan
■ Tank 1	0.07								1.4	1.3
■ Tank 2	0.04								0.6	0.73
□ Tank 3	0.02								0.9	0.93
□ Tank 4	0.02								0.63	0.57
■ Tank 5	0								0.87	0.7
■ Tank 6	0								0.53	0.66
■ Tank 7	0.04								1.1	1.3
▨ Tank 8	0								0.68	0.84

Sampling Event 1999-2000

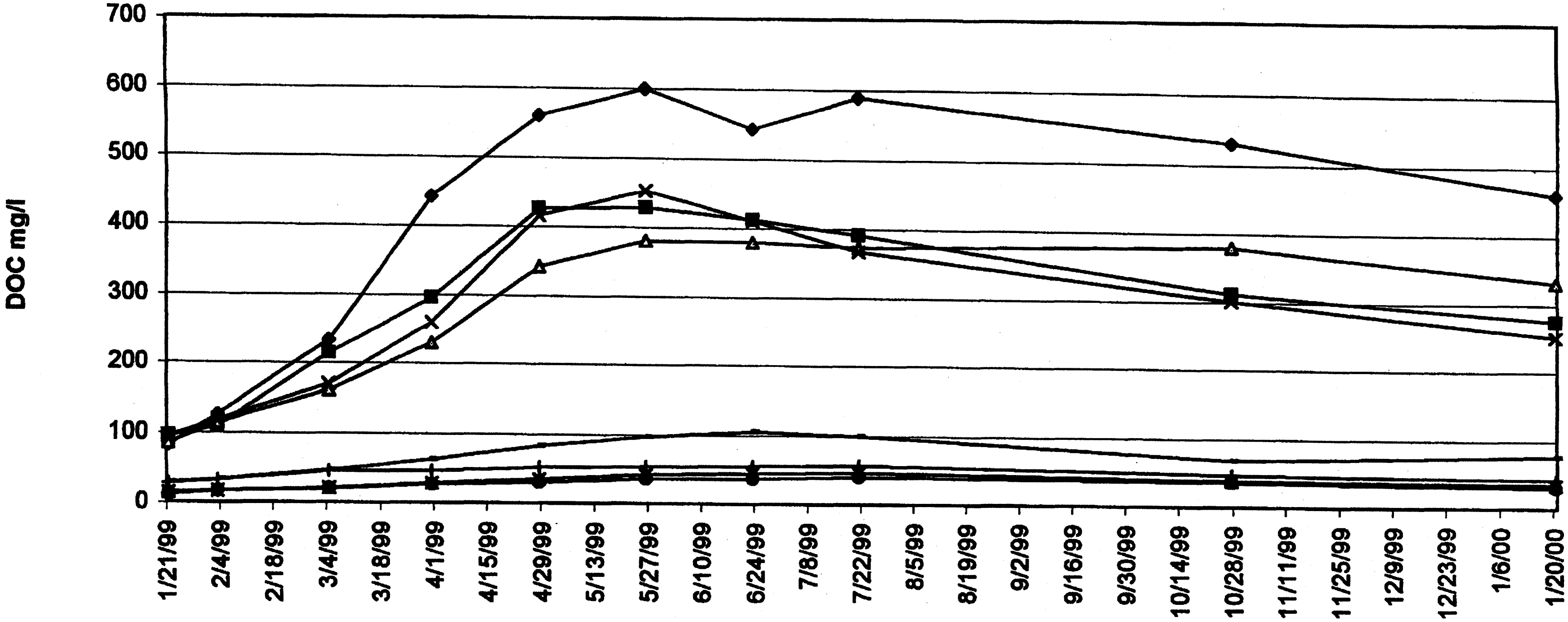
stable under oxygen-deficit conditions than in aerobic conditions. Peat soil water ammonia concentrations followed this trend in both Experiments 1 and 2.

DOC is effectively retained in many subsoils and it is generally attributed to the sorption by Al and Fe oxides and clay (McDowell and Wood, 1984; Guggenberger and Zech, 1993; Kaiser and Zech, 1998). A recent study (Hagedorn et al., 2000) found that DOC coprecipitated with iron when a soil solution from a reduced mineral soil became aerobic. These sorption reactions are commonly seen in the use of alum and ferric chloride coagulants in water and wastewater treatment to remove DOC. However, both field and laboratory experiments indicate that under reducing conditions, the retention of dissolved organic matter (DOM) is small (McLaughlin et al., 1994). The explanation is the reductive dissolution of iron and manganese oxides.

Organic matter decomposition in flooded soils is related to its nature and the supply of electron acceptors. The rate of C decomposition has been described as first-order kinetics in two or three phases. Gilmour et al. (1977) indicated that the rapid phase involves amino acids and simple sugars followed by an intermediate phase involving cellulose and hemicellulose breakdown. The slow phase involves lipid and lignin fractions of organic matter. Reddy et al. (1980) indicated that the easily decomposable organic fraction was correlated with the C/N ratio of the substrate. Over 90 percent of the variability in aerobic C mineralization rates in peat and plant litter was attributed to by substrate P concentration and lignocellulose composition. Anaerobic C mineralization rates were about one-third of aerobic rates (DeBusk and Reddy, 1998).

The rate of organic matter decomposition under flooded soil conditions will depend on bacterial efficiency and the supply of electron acceptors (e.g., O_2, NO_3^-, Mn_4^+, Fe_3^+, SO_4^{2-}, and CO_2). Temperature changes can also affect the microbial activity of each season. Microbial activity is negligible below 5 °C and microbially mediated reduction-oxidation reactions that consume O_2 and reduce Fe and Mn compounds become inhibited (Megonigal et al., 1996). The monthly DOC concentrations and UVA_{254nm} are shown in Figures 6 and 7, respectively. Both DOC and UVA_{254nm} increased through the warm summer and began to decline in the late summer as water temperatures fell. Tanks #1- 4 had the higher DOC and UVA_{254nm} values due to the soil batch, which had the higher amount of weakly absorbed organic carbon and iron content. Tanks #5 - 8 had the lower values due to the soil batch, which had the lesser amount of weakly absorbed organic carbon and total iron. A literature search showed that the decomposition rate of organic carbon was reported to increase by 2 to 4 times for each 10°C rise in temperature (Reddy et. al., 1980). The peat soil water temperatures are shown in Figure 8. The monthly pattern in DOC, UVA254nm, specific absorbance (Figure 9), and TTHMFP (Figure 10) in the peat soil water corresponded well with the water temperatures. The data further showed that the DOC released from the peat soil in tanks #1 – 4 had a high THM formation potential and were humic in nature as shown by the high specific absorbance values. The lower DOC and THMFP concentrations in tanks #5 – 8 showed that most of the humic material had been removed from the second soil batch prior to flooding.

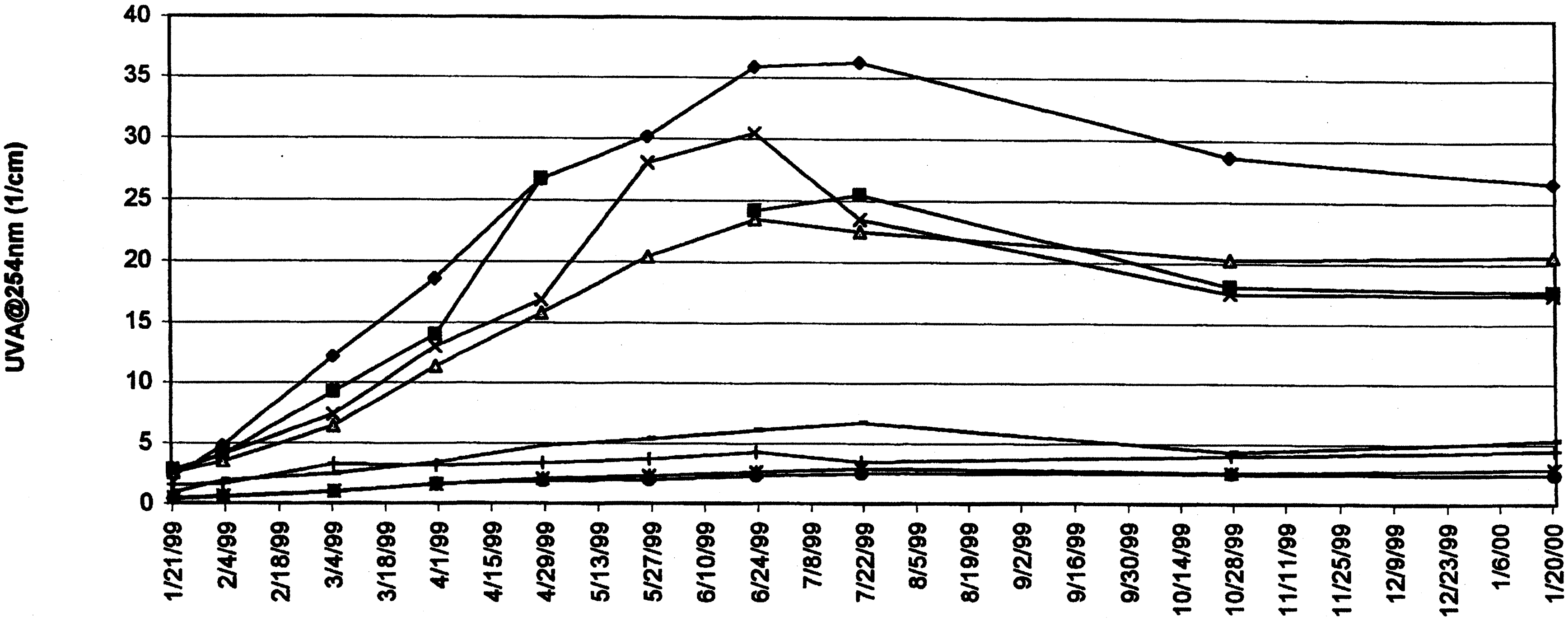
Figure 6. Peat Soil Water DOC



	21-Jan	3-Feb	4-Mar	31-Mar	28-Apr	26-May	23-Jun	21-Jul	27-Oct	20-Jan
◆ Tank 1	82.1	126	233	441.7	561	600	544	590	532	460
■ Tank 2	96	109	214	295.6	426	429	413	392	312	275
△ Tank 3	85.5	114	161	229.5	342	381	380	374	380	332
× Tank 4	94.6	118	170	259.8	416	453	411	368	301	251
✱ Tank 5	14.1	16.7	21.1	28.2	35.1	42.2	45.3	46.8	37.9	35
● Tank 6	11.3	16.7	20	26.6	29.7	35.6	36.4	40.1	35.9	30.6
+ Tank 7	27.5	32.4	45.6	47	52.8	54.2	55.8	57.8	47.4	42.2
— Tank 8	27.9	33.6	47.1	63	83.5	97.4	106	99.5	68.9	77.5

Sampling Event 1999-2000

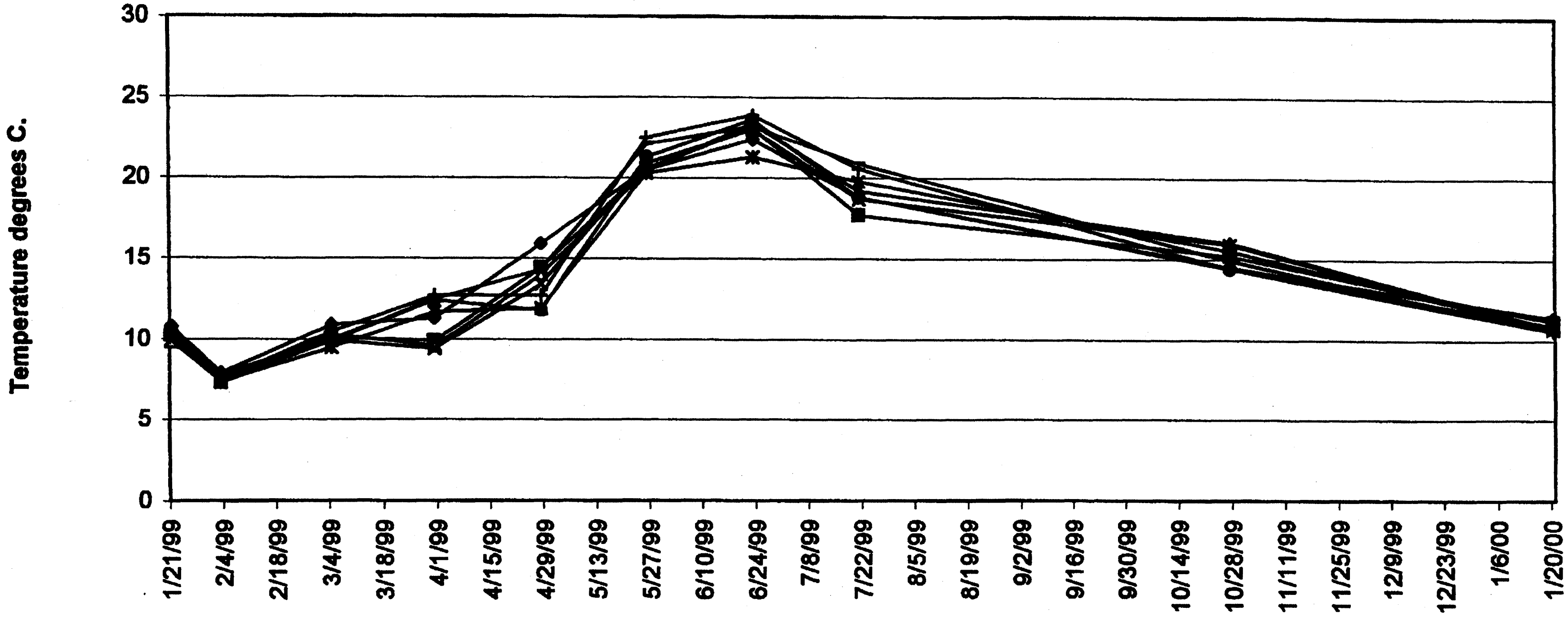
Figure 7. Peat Soil Water UVA 254nm



	21-Jan	3-Feb	4-Mar	31-Mar	28-Apr	26-May	23-Jun	21-Jul	27-Oct	20-Jan
◆ Tank 1	2.23	4.8	12.14	18.6	26.8	30.2	35.9	36.3	28.66	26.6
■ Tank 2	2.82	4.09	9.22	14	26.8		24.2	25.5	18.08	17.7
△ Tank 3	2.52	3.54	6.39	11.3	15.8	20.4	23.5	22.5	20.24	20.6
× Tank 4	2.56	4.09	7.34	13	16.9	28.1	30.5	23.5	17.52	17.4
✱ Tank 5	0.467	0.6	1.02	1.55	2.05	2.27	2.63	2.92	2.58	2.88
● Tank 6	0.389	0.589	0.974	1.61	1.84	1.93	2.29	2.49	2.46	2.36
+ Tank 7	1.53	1.63	3.29	3.12	3.4	3.7	4.28	3.46	3.99	4.47
— Tank 8	0.892	1.88	2.49	3.41	4.8	5.36	6.05	6.64	4.32	5.32

Sampling Event 1999-2000

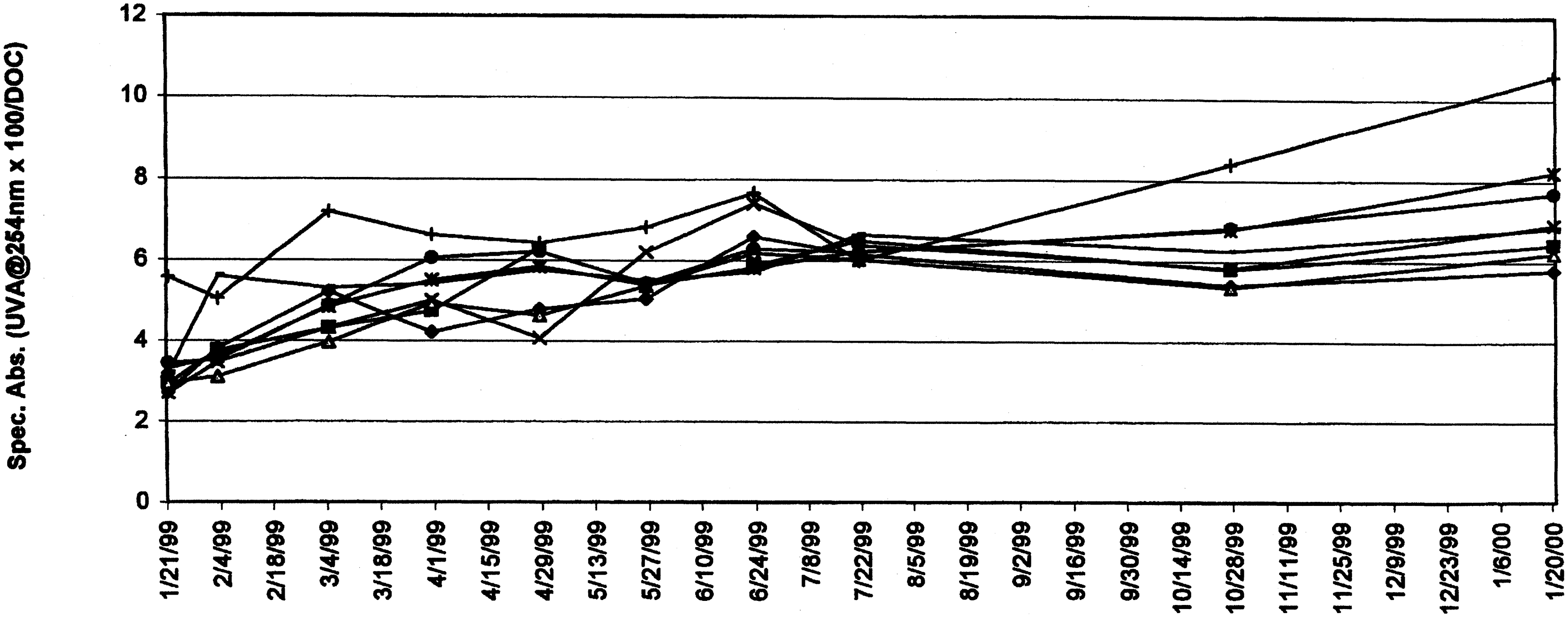
Figure 8. Peat Soil Water Temperature



	21-Jan	3-Feb	4-Mar	31-Mar	28-Apr	26-May	23-Jun	21-Jul	27-Oct	20-Jan
—◆—Tank 1	10.8	7.9	10.9	11.3	15.9	20.5	22.4	18.8	14.5	11.4
—■—Tank 2	10.2	7.3	10.1	9.9	14.4	20.6	23.1	17.7	15.2	11.2
—△—Tank 3	9.8	7.6	10.3	9.6	14.0	20.4	23.4	19.2	16	10.8
—×—Tank 4	9.9	7.3	9.9	9.4	13.4	20.9	23.0	18.7	15.9	10.7
—✱—Tank 5	10.4	7.3	9.5	11.7	11.9	20.3	21.3	19.8	15.5	10.8
—●—Tank 6	10.3	7.4	9.9	12.4	11.8	21.3	23.6	18.8	14.4	10.9
—+—Tank 7	10.3	7.5	10.5	12.7	12.7	22.5	23.9	20.6	14.4	10.6
—-—Tank 8	10.4	7.8	10.0	12.5	14.3	22.1	23.2	20.9	14.9	10.6

Sampling Event 1999-2000

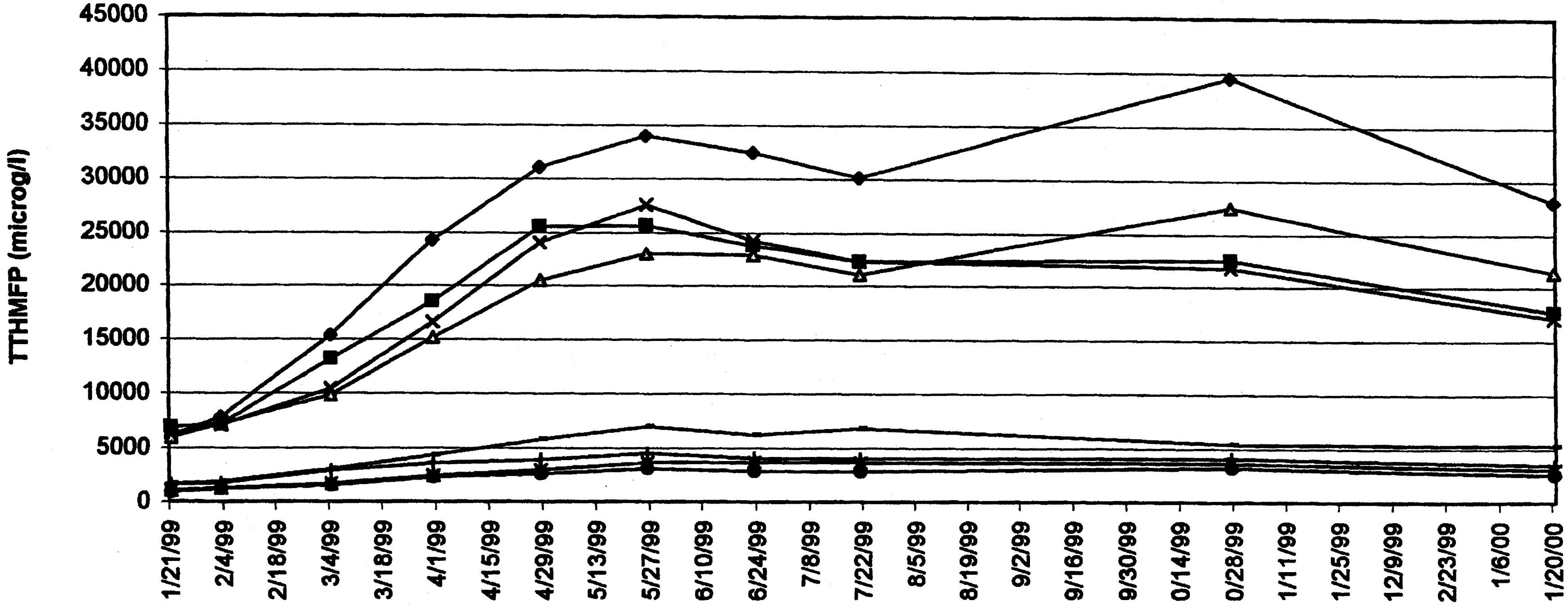
Figure 9. Peat Soil Water Specific Absorbance



	21-Jan	3-Feb	4-Mar	31-Mar	28-Apr	26-May	23-Jun	21-Jul	27-Oct	20-Jan
—◆—Tank 1	2.72	3.81	5.21	4.21	4.78	5.03	6.6	6.15	5.39	5.78
—■—Tank 2	2.94	3.75	4.31	4.74	6.29		5.86	6.51	5.79	6.44
—△—Tank 3	2.95	3.11	3.97	4.92	4.62	5.35	6.18	6.02	5.33	6.2
—×—Tank 4	2.71	3.47	4.32	5	4.06	6.2	7.42	6.39	5.82	6.93
—✱—Tank 5	3.31	3.59	4.83	5.5	5.84	5.38	5.81	6.24	6.81	8.23
—●—Tank 6	3.44	3.53	4.87	6.05	6.2	5.42	6.29	6.21	6.85	7.71
—+—Tank 7	5.56	5.03	7.21	6.64	6.44	6.83	7.67	5.99	8.42	10.59
—Tank 8	3.2	5.6	5.29	5.41	5.75	5.5	5.71	6.67	6.27	6.86

Sampling Event 1999-2000

Figure 10. Peat Soil Water TTHMFP



	21-Jan	3-Feb	4-Mar	31-Mar	28-Apr	26-May	23-Jun	21-Jul	27-Oct	20-Jan
◆ Tank 1	6080	7820	15340	24300	31100	34000	32500	30200	39600	28100
■ Tank 2	6890	7170	13150	18500	25600	25700	23800	22300	22500	17700
△ Tank 3	5950	7150	9850	15120	20500	23000	22900	21100	27500	21400
× Tank 4	6330	7050	10420	16600	24100	27600	24300	22300	21800	17100
✳ Tank 5	1056	1209	1640	2386	2940	3630	3700	3660	3560	3050
● Tank 6	927	1181	1510	2234	2580	3070	2840	2800	3140	2580
+ Tank 7	1600	1720	2890	3570	3890	4500	4090	3990	4040	3470
— Tank 8	1634	1880	3070	4360	5780	6940	6220	6770	5420	5300

Sampling Event 1999-2000

Depending on the intensity of reduction, the anaerobic metabolism of soil organic matter results in the formation of complex residual humic materials, low molecular weight organic acids, carbon dioxide, methane, hydrogen, ammonia, amines, mercaptans, and hydrogen sulfide. Anoxic decomposition occurs through a series of intermediate steps that can be mediated by one or more microbial populations working with each other (Billen et al., 1988). Aerobic metabolism results in mostly the formation of carbon dioxide, sulphate, nitrate, and residual humic materials. It is believed that the humic materials formed and transformed under anaerobic conditions may tend to have large molecular weight and be structurally more complex (Gambrell et at. 1991).

Organic matter decomposition occurs at a slower rate in an anaerobic soil layer than in the thin aerobic soil layer. As a result, there is an accumulation of soluble organic carbon. Reddy (1982) showed that soluble organic carbon concentrations in flooded organic soils were more than double that found under drained conditions. This was seen in the peat soil water samples of the two experiments. Ammonia concentrations also accumulated because of the low N requirements of anaerobic bacteria (Moore et al., 1992). Extensive groundwater studies have dispelled the commonly held belief that groundwater is low in microbial activity because of low numbers of organisms. In fact, the numbers of organisms are only about one to two logs lower than in surface soil (e.g., 10^6/g vs. 10^8/g; Ward and Elliott, 1995).

Other data from Experiment #2, including peat soil water alkalinity, TKN, TP, and pH are presented in the Appendix. These data also agreed with known biogeochemical processes of flooded agricultural soils under anaerobic conditions.

The Thin Aerobic Soil Layer

While a flooded soil condition will restrict the oxygen resupply rate and there is a continued consumption of oxygen or of other electron acceptors, it does not necessarily cause the formation of a uniformly reduced soil profile (Patrick and DeLaune, 1977). The top few millimeters or centimeters may remain aerobic because of oxygen diffusion for a short distance into the flooded soil from the overlying atmosphere and surface water. In this thin aerobic layer, the oxygen resupply rate exceeds the oxygen demand rate. However, if floodwaters are deep and stratified, an anaerobic layer can extend into the overlying water. This condition occurs when bottom waters are anoxic due to stratification.

The aerobic layer could be thicker in a large wetland or flooded area subject to large wind fetch or tidal pumping such as in an estuary. Such conditions can result in pore water circulation that brings organic matter and oxygen to the interior sediment and increases the flux of pore water constituents across the sediment-water interface (Shum and Sundby, 1996).

Important transformations of nitrogen occur in the aerobic soil layer. The ammonium that accumulates in the thick anaerobic layer diffuses up to the aerobic layer and is oxidized by chemoautotrophic bacteria to nitrite then nitrate. The formed nitrate can diffuse down to the anaerobic layer due to the concentration gradient where denitrification converts it to molecular dinitrogen gas (Patrick and Reddy, 1976). Ammonia concentrations in Experiment #2 surface water samples (avg. <0.2 mg/L) were significantly less than in the anaerobic peat soil water (3-25 mg/L), thereby indicating nitrification of ammonium in the thin aerobic soil layer and overlying oxygenated surface water. The nitrification rate is dependent upon the thickness of the aerobic soil layer, ammonium concentration, pH, alkalinity, temperature, and number of nitrifying bacteria. The E_h is >300 mV when nitrification occurs. Denitrification below the aerobic zone occurs when the E_h is <300 mV and the rate depends on the nitrate levels, available carbon, temperature, and microflora.

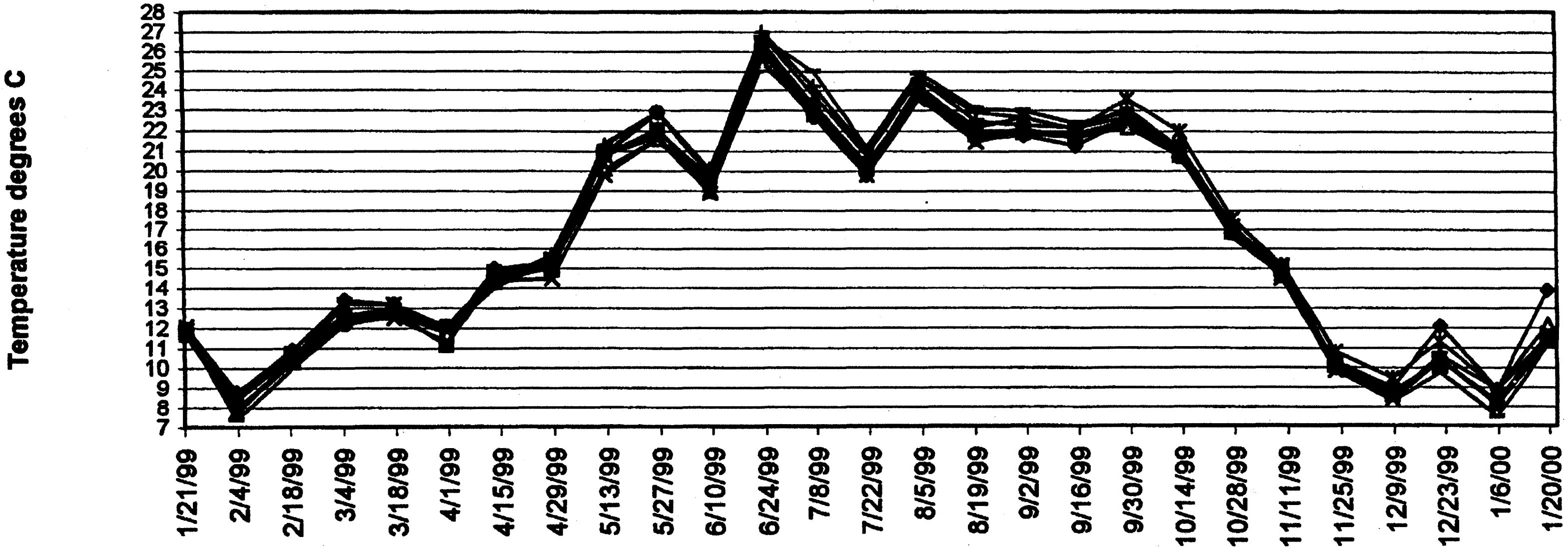
Surface Water Quality

Strong concentration gradients for the water quality parameters existed between the peat soil and overlying surface water. As a result, upward diffusion through the porous peat resulted in a progressive increase in organic carbon, THMFP, SUVA, and some other constituents (e.g., turbidity, color) in the surface water of both experiments. Initial changes in Experiment #2 were slow and attributed to the colder winter temperatures that would inhibit molecular diffusion, increase water viscosity and density, and is a period of low microbial activity and organic decomposition.

Gas ebullition in the tanks was very high in the beginning after the tanks were flooded and water filled the air spaces in the porous peat soil. Gas formation or bubbling continued during the experiments as surface water continued to move down the soil column and as gases (e.g., N_2, N_2O, NH_3, CO_2, H_2S, CH_4) evolved from redox reactions and organic soil degradation occurred. Water depths in the tanks became shallower over time in the covered tanks with no water exchange and were attributed to water movement into the peat soil voids created by evolving gases moving out of the peat soil. Advection such as from gas ebullition may have been an important transport mechanism (D'Angelo and Reddy, 1994).

July to October 1998 surface water temperatures in Experiment #1 were between 15° and 28°C (average 22.7°C) with the lowest temperatures in the fall. Experiment #2 surface water temperatures started at about 7°C in January 1999 and reached 27°C by July before decreasing steadily in October and to below 10°C by December (Figure 11). In tanks 1 and 3, the monthly trends (increasing) of some water quality parameters (e.g., peat soil water ammonia and organic carbon, surface water TOC, DOC, THMFP) followed the water temperature changes. EC, bromide, TOC, DOC, UVA_{254nm}, TTHMFP, specific absorbance, TP, orthophosphate, and TKN reached their highest values in October and stabilized or declined when water temperatures progressively decreased (Figures 12 – 21). Other noticeable changes included higher dissolved oxygen levels in the surface water in the fall. These changes were attributed to decreased microbial activity (e.g., respiration and degradation) in the fall as water temperature fell, increased oxygen saturation in water, and lower oxygen demands in the water column (Figure 22)

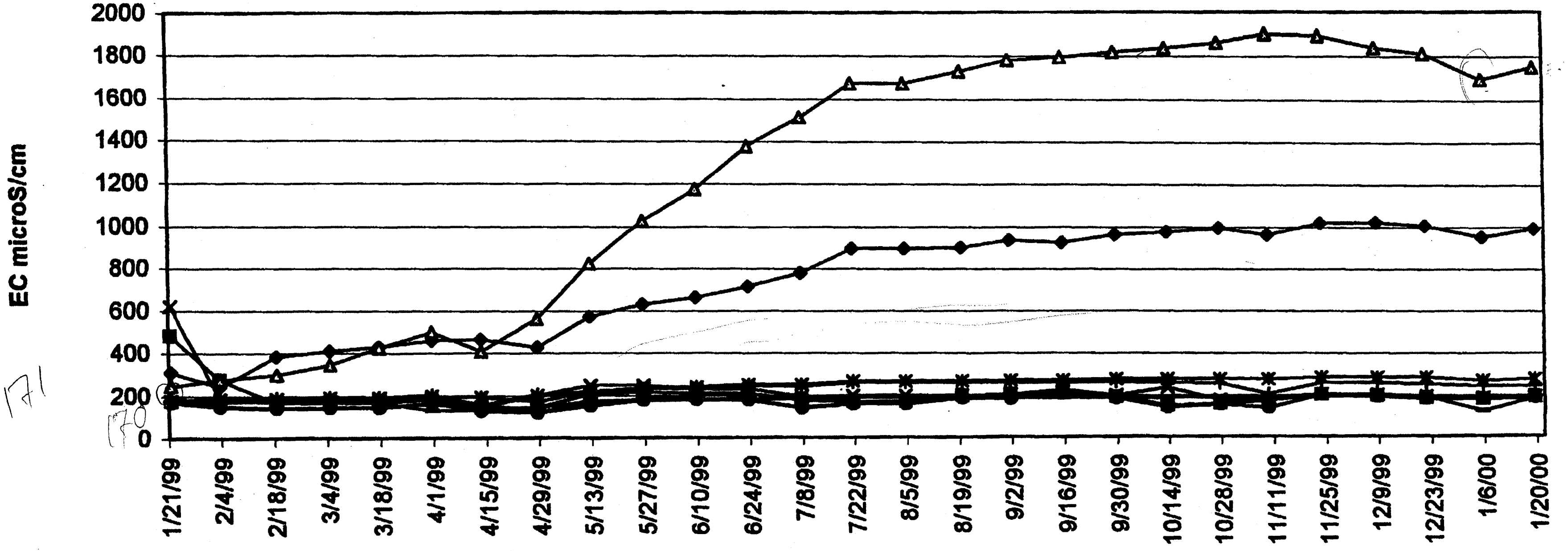
Figure 11. Surface Water Temperature



	21-Jan	3-Feb	4-Mar	17-Mar	31-Mar	13-Apr	12-May	26-May	9-Jun	7-Jul	21-Jul	4-Aug	19-Aug	15-Sep	29-Sep	13-Oct	9-Nov	23-Nov	8-Dec	21-Dec	19-Jan
◆ Tank 1	12	8.8	13.4	13.2	11.7	15	20.8	21.7	19.2	22.7	19.8	23.8	21.6	21.3	22.6	21.3	14.6	10.3	9	12.1	13.9
■ Tank 2	11.8	8.4	12.5	12.8	11.1	14.8	20.8	22	19.7	23.2	20.1	24.1	21.8	21.7	22.4	20.9	15.1	10.1	8.7	10.4	11.7
△ Tank 3	11.7	7.8	12.7	12.8	11.7	14.3	20.1	21.6	19.0	22.9	20.2	24.2	22	21.7	22.2	20.8	14.7	10.2	8.6	10.6	12.2
× Tank 4	12.1	7.7	12.4	12.5	11.3	14.4	19.8	21.6	18.9	22.8	19.8	23.6	21.5	21.9	22.5	21.3	14.5	9.9	8.4	10.4	11.7
✱ Tank 5	11.9	8.7	13.2	13.2	12.1	14.6	20.8	22.1	19.3	23.1	20.2	24	22.2	22.1	23.6	22	15.2	10.8	9.5	11.3	11.5
● Tank 6	11.9	8	12.2	12.9	12.1	14.5	20.9	22.9	19.8	23.3	20.4	23.9	21.8	21.7	22.6	20.7	14.7	10.1	8.8	10.4	11.3
+ Tank 7	11.9	7.9	12.6	13	12.1	14.4	21.3	22.9	20.1	24.2	21	24.6	22.9	22.1	23.1	21.2	14.9	10	8.7	10.4	11.4
— Tank 8	11.6	7.9	12.4	12.8	11.9	14.8	21.4	22.9	19.9	23.8	20.8	24.6	22.5	22.2	22.7	21.1	14.8	10.1	8.8	10.4	11.3
— Tank 9	11.9	7.4	12.2	12.6	11.9	14	20.8	22.9	20.0	25	21.2	24.9	23.1	22.4	22.9	20.9	14.7	9.9	8.3	9.8	11.1

Sampling Event 1999-2000

Figure 12. Surface Water EC



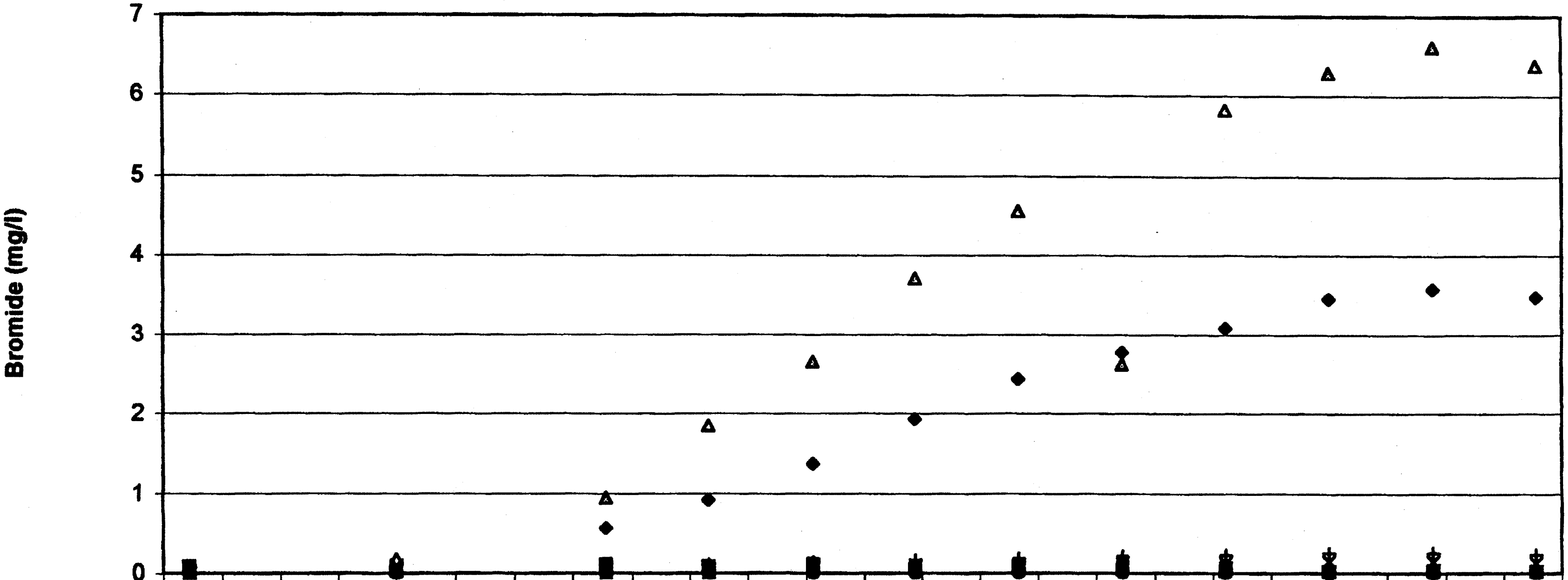
171

170

	21-Jan	3-Feb	18-Feb	4-Mar	31-Mar	13-Apr	28-Apr	12-May	26-May	9-Jun	23-Jun	7-Jul	4-Aug	19-Aug	1-Sep	15-Sep	29-Sep	13-Oct	27-Oct	9-Nov	8-Dec	21-Dec	5-Jan	19-Jan
◆ Tank 1	312	244	386	411	461	465	428	574	632	664	717	780	896	903	938	926	964	976	995	964	1024	1006	953	992
■ Tank 2	483	276	166	166	186	142	145	206	219	211	209	177	169	198	205	218	190	152	160	175	197	187	181	193
△ Tank 3	248	276	302	348	500	410	563	825	1029	1177	1378	1513	1675	1731	1781	1796	1819	1839	1864	1904	1840	1815	1698	1755
× Tank 4	621	187	172	175	198	149	203	249	251	232	234	195	199	198	204	227	198	237	179	185	202	194	187	193
✱ Tank 5	177	182	186	191	199	195	171	222	236	243	253	254	268	270	273	271	277	278	277	277	284	284	270	277
● Tank 6	170	148	139	142	163	127	119	152	179	181	177	139	158	187	184	213	186	144	155	139	193	183	180	189
+ Tank 7	184	188	191	193	204	157	206	222	234	238	246	246	261	261	265	262	265	260	256	207	258	254	243	246
— Tank 8	194	152	142	145	166	161	124	159	187	185	180	144	162	188	185	213	188	149	157	174	193	183	180	190
— Tank 9	170	173	172	171	129	133	143	175	180	182	185	183	190	187	186	186	186	189	188	188	193	194	124	189

Sampling Event 1999-2000

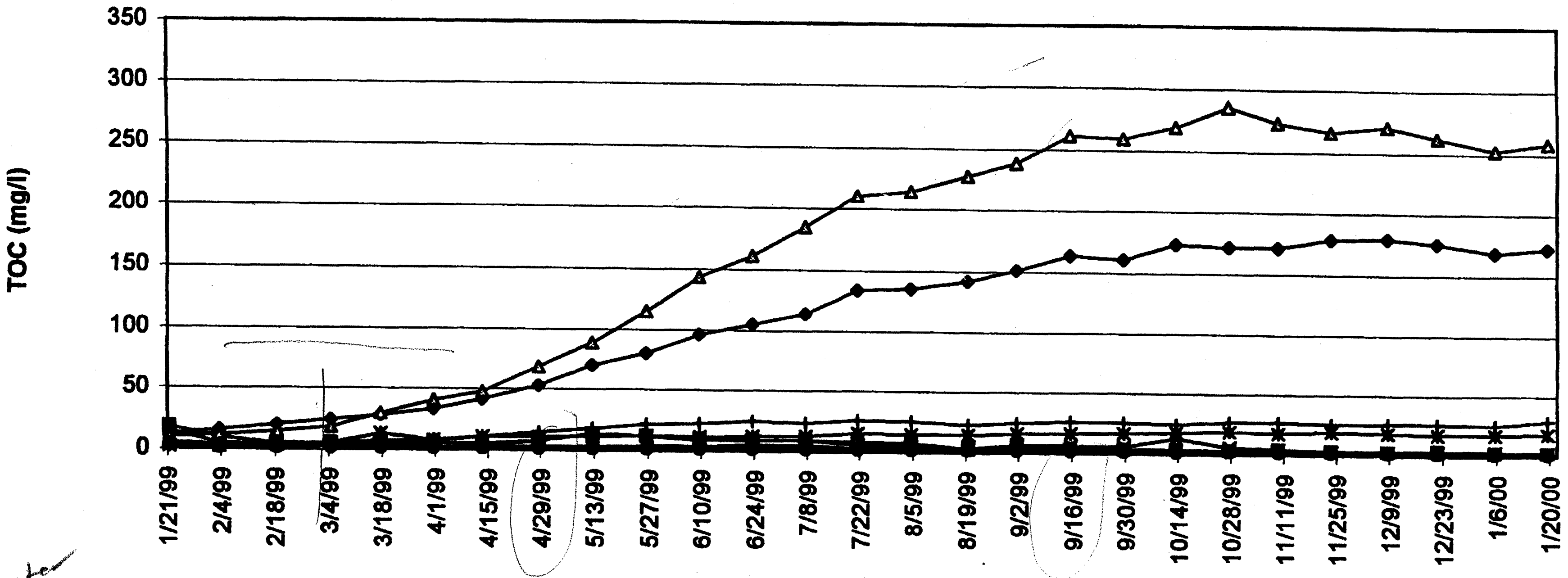
Figure 13. Surface Water Bromide



	21-Jan	3-Feb	18-Feb	4-Mar	31-Mar	13-Apr	28-Apr	12-May	26-May	9-Jun	23-Jun	7-Jul	4-Aug	19-Aug	1-Sep	15-Sep	29-Sep	13-Oct	27-Oct	9-Nov	8-Dec	21-Dec	5-Jan	19-Jan
—◆— Tank 1	0.02							0.56		0.92		1.38	1.93		2.44		2.78		3.09			3.58		3.48
—■— Tank 2	0.08							0.1		0.08		0.11	0.05		0.07		0.04		0.03			0.03		0.02
—△— Tank 3	0.01							0.95		1.85		2.66	3.71		4.56		2.63		5.82			6.61		6.38
—✕— Tank 4	0.01							0		0.01		0.11	0.1		0.07		0.08		0.07			0.04		0.03
—✱— Tank 5	0							0.04		0.05		0.09	0.09		0.11		0.12		0.13			0.15		0.13
—●— Tank 6	0.01							0		0		0	0		0.01		0		0			0		0
—+— Tank 7	0							0.08		0.11		0.14	0.16		0.18		0.21		0.22			0.25		0.23
—— Tank 8	0							0.01		0.02		0.02	0.02		0.02		0.02		0.01			0		0
—— Tank 9	0							0		0		0.01	0		0		0.01		0			0		0

Sampling Event 1999-2000

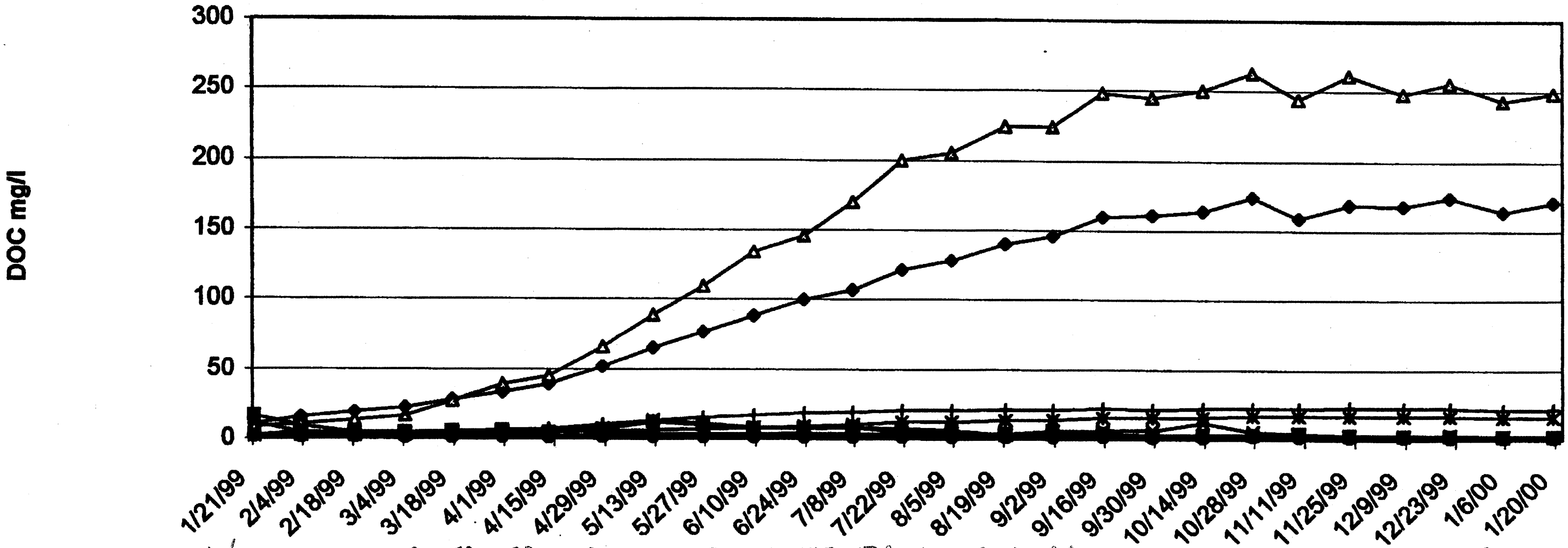
Figure 14. Surface Water TOC



2' water		21-Jan	3-Feb	18-Feb	4-Mar	31-Mar	13-Apr	28-Apr	12-May	26-May	9-Jun	23-Jun	7-Jul	4-Aug	19-Aug	1-Sep	15-Sep	29-Sep	13-Oct	27-Oct	9-Nov	8-Dec	21-Dec	5-Jan	19-Jan
1.5	◆ Tank 1	12.3	16	20.3	24.3	33.4	41.4	52.9	69.5	80.02	96.1	105	113.8	135	142	151	164	161	174	172	172	180	176	169	173
	■ Tank 2	18.5	9.7	4.8	5	6	4.3	7.4	13.5	11.6	9.2	9.1	9.32	4.9	3.9	6.6	4.4	3.7	3.7	3.3	4.3	3	3.6	2.3	2.4
4	△ Tank 3	9.7	12	14.6	18.3	40.5	47.8	68.2	88.6	115	143	161	184.5	215	228	239	262	260	270	286	274	272	263	253	259
	× Tank 4	14.4	5.1	3.7	4.6	5.1	5.1	7.6	13.6	11.8	9.1	9.2	8.91	7.6	3.1	6.4	6.5	6	13.1	6.2	4.9	3.1	3.4	3.1	2.7
4	✱ Tank 5	2.2	2.5	3.3	5.4	7.9	10.8	10.8	11.37	12.3	11.3	12.3	12.5	14.4	14.8	15.9	16.6	17.1	18	19	17.9	18.5	17.3	17.6	18.5
	● Tank 6	2.9	1.5	1.4	1.6	1.5	1.5	1.6	1.4	1.4	1.6	1.7	1.93	1.7	1.7	1.9	2	1.7	1.6	2	1.9	1.9	1.5	1.4	1.4
1.5	+ Tank 7	3.8	3.9	4.1	5	7.7	11	14.8	17.8	21.8	22.8	24.9	23.6	25.5	23.1	25.2	26.4	25.7	25.2	26.7	27.2	26.4	26.4	25.3	29.2
	— Tank 8	5.4	4.1	1.4	1.7	1.9	1.9	3.1	3	3.8	4	5	4.62	4	2.8	3.6	3.2	3	2.6	2.1	2.9	2.1	2	1.6	1.4
	— Tank 9	1.9	1.5	1.2	1.2	1.1	1.2	1.5	1	1.1	1.1	1.1	1.19	1.2	1.1	1.4	1.6	1.2	1.2	1.3	1.4	1.2	1.3	1.1	1.2

Sampling Event 1999-2000

Figure 15. Surface Water DOC

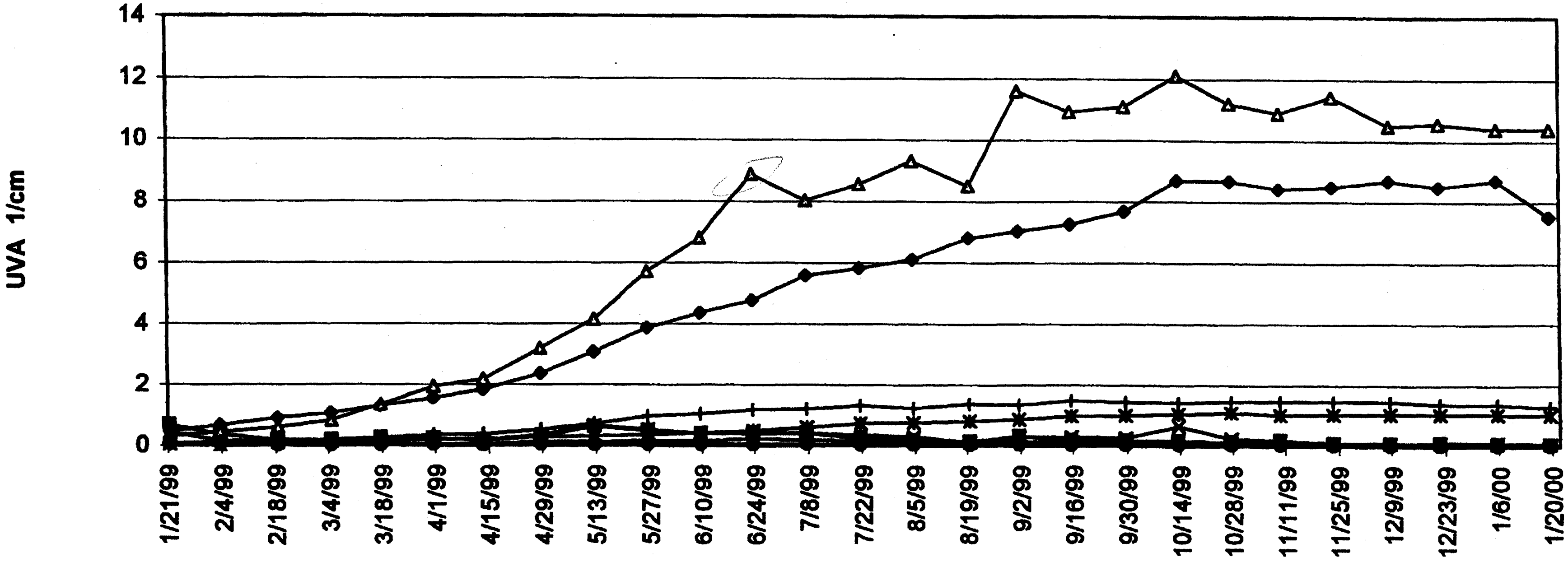


Total Days		13	28	59	73	86	101	129	143	157	172	199	214	226	240	254	283	296	313	329	358	
	21-Jan	3-Feb	18-Feb	17-Mar	31-Mar	13-Apr	28-Apr	26-May	9-Jun	23-Jun	7-Jul	4-Aug	19-Aug	1-Sep	15-Sep	29-Sep	27-Oct	9-Nov	23-Nov	8-Dec	5-Jan	19-Jan
◆ Tank 1	10.7	16	19.7	28	33.4	39.3	51.8	76.9	88.3	99.6	106.5	128	140	146	160	161	174	159	169	168	164	171
■ Tank 2	16.8	9.6	4.5	5.4	5.6	4.2	6.6	9.9	7.4	7.3	8.05	3.7	3.5	5.9	3.9	3	2.8	4	2.7	2.6	1.9	2.2
△ Tank 3	8.6	10.7	13.4	27.2	39.4	45.1	66.1	109	134	146	170.1	205	224	224	248	245	263	244	261	248	243	249
× Tank 4	11.3	4.7	3.5	4.4	4.8	4.6	7.5	11.1	8.2	8.3	8.28	6.3	3	5.6	6.2	6	5.4	4.1	3	2.7	2.6	2.4
✱ Tank 5	1.9	2.3	2.5	3.5	4	4.3	5.4	6.9	7.6	8.9	10.3	12.4	13.5	14.1	15.5	15.6	16.8	16.6	16.6	16.8	16	16.1
● Tank 6	1.8	1.4	1.2	1	1.3	1	1.2	1.4	1.3	1.4	1.39	1.2	1.4	1.4	1.6	1.2	1.9	1.5	1.8	1.5	1.1	1.2
+ Tank 7	2.2	4.8	3.6	5	6.3	6.9	10.3	15.7	17.2	18.6	19.54	20.8	21.6	21.1	22.6	21.8	22.6	22.6	23.2	22.7	21.5	21.9
— Tank 8	2.8	1.8	1.4	1.4	1.7	1.5	2.8	3.5	3.2	4	3.66	3.2	2.7	3.1	3	2.2	1.8	2.1	2.2	1.7	1.2	1.3
— Tank 9	1.12	1.3	1.3	1.1	1.1	1	1	1.1	1	1.2	1.07	1.1	1.1	1.1	1.2	1.1	1.2	1.1	1.1	1	1	1.1

1.5 →
4' anoxic 4 →
4 →
1.5' anoxic 1.5 →

Sampling Event 1999-2000

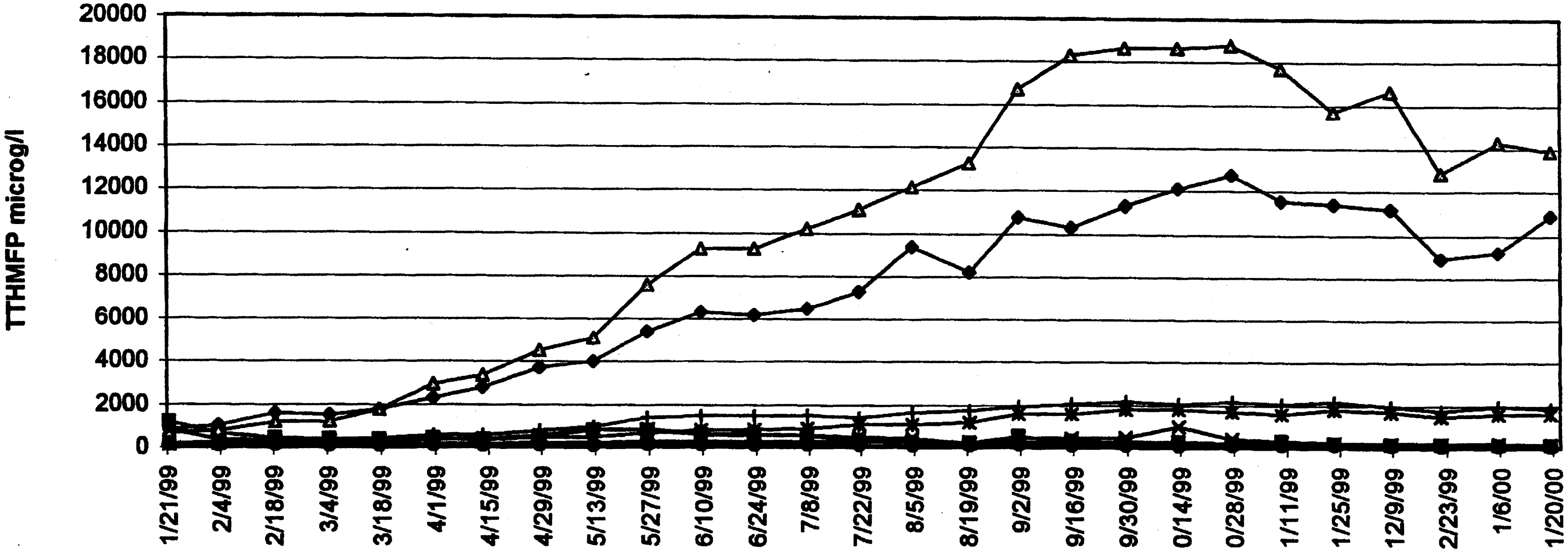
Figure 16. Surface Water UVA-254nm



	21-Jan	3-Feb	18-Feb	4-Mar	31-Mar	13-Apr	28-Apr	12-May	26-May	9-Jun	23-Jun	7-Jul	4-Aug	19-Aug	1-Sep	15-Sep	29-Sep	13-Oct	27-Oct	9-Nov	8-Dec	21-Dec	5-Jan	19-Jan
◆ Tank 1	0.463	0.687	0.9	1.08	1.56	1.84	2.36	3.07	3.86	4.36	4.77	5.58	6.11	6.82	7.04	7.28	7.69	8.73	8.71	8.45	8.72	8.52	8.74	7.54
■ Tank 2	0.671	0.377	0.192	0.193	0.249	0.176	0.303	0.623	0.481	0.396	0.396	0.421	0.183	0.15	0.312	0.184	0.164	0.173	0.123	0.194	0.095	0.105	0.077	0.082
△ Tank 3	0.323	0.455	0.611	0.833	1.94	2.17	3.19	4.15	5.71	6.82	8.92	8.05	9.34	8.53	11.6	10.92	11.09	12.11	11.21	10.89	10.5	10.57	10.4	10.4
✕ Tank 4	0.439	0.171	0.132	0.171	0.201	0.194	0.355	0.656	0.524	0.394	0.416	0.413	0.309	0.112	0.283	0.303	0.273	0.632	0.246	0.192	0.101	0.116	0.114	0.093
✱ Tank 5	0.058	0.009	0.097	0.139	0.198	0.222	0.285	0.313	0.355	0.411	0.495	0.609	0.749	0.808	0.876	0.977	1	1.04	1.09	1.01	1.03	1.04	1.04	1.02
● Tank 6	0.052	0.029	0.028	0.026	0.029	0.024	0.035	0.038	0.047	0.034	0.047	0.05	0.037	0.034	0.042	0.038	0.035	0.033	0.031	0.03	0.027	0.023	0.02	0.02
+ Tank 7	0.083	0.128	0.156	0.21	0.359	0.37	0.532	0.717	0.968	1.03	1.16	1.2	1.23	1.37	1.34	1.49	1.44	1.42	1.46	1.45	1.45	1.37	1.36	1.29
— Tank 8	0.102	0.055	0.039	0.047	0.056	0.047	0.123	0.118	0.173	0.144	0.222	0.181	0.164	0.12	0.152	0.13	0.096	0.091	0.069	0.072	0.041	0.036	0.029	0.029
— Tank 9	0.015	0.016	0.017	0.017	0.02	0.018	0.021	0.019	0.022	0.019	0.019	0.02	0.02	0.02	0.02	0.019	0.019	0.02	0.02	0.019	0.019	0.02	0.022	0.02

Sampling Event 1990-2000

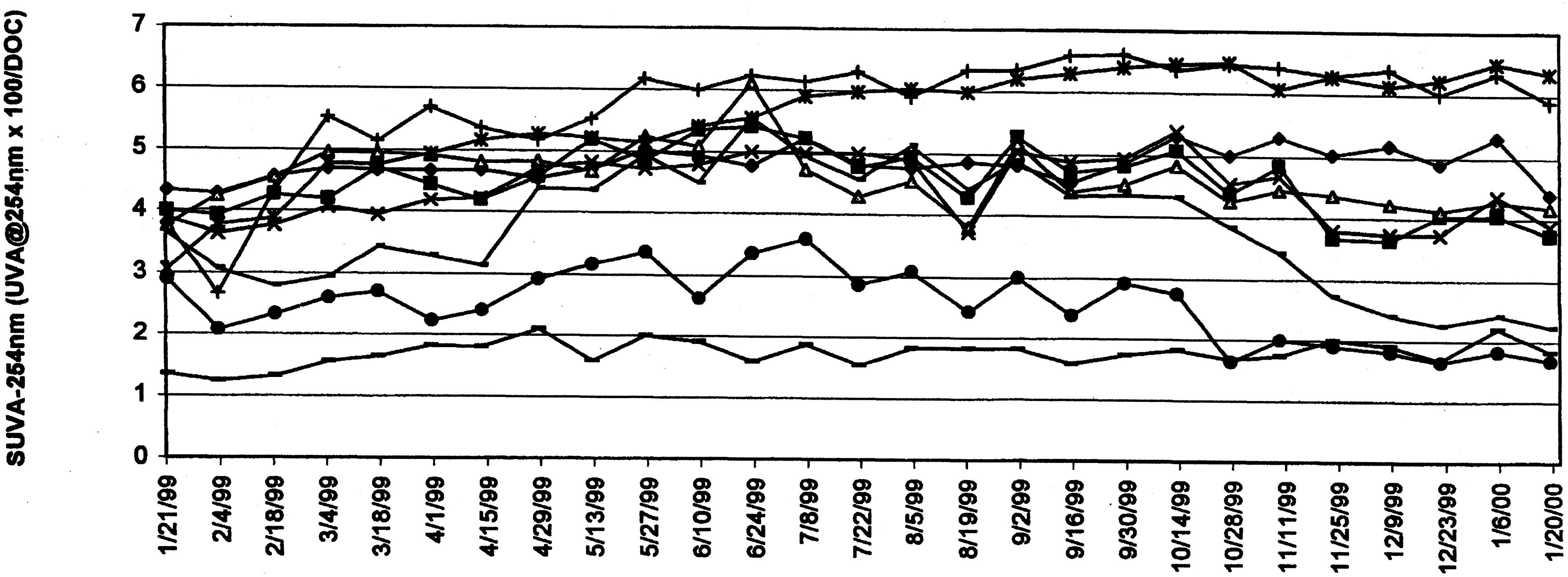
Figure 17. Surface Water TTHMFP



	21-Jan	3-Feb	18-Feb	4-Mar	31-Mar	13-Apr	28-Apr	12-May	26-May	9-Jun	23-Jun	7-Jul	4-Aug	19-Aug	1-Sep	15-Sep	29-Sep	13-Oct	27-Oct	9-Nov	8-Dec	21-Dec	5-Jan	19-Jan
—◆—Tank 1	838	1060	1620	1530	2313	2790	3720	4020	5420	6330	6190	6490	9396	8200	10780	10300	11300	12110	12750	11560	11200	8900	9200	10900
—■—Tank 2	1210	685	419	368	422	361	492	817	810	597	558	571	270	245	537	334	278	306	218	334	172	173	144	141
—△—Tank 3	664	779	1178	1200	2968	3360	4530	5120	7600	9300	9300	10200	12150	13260	16720	18270	18640	18640	18760	17700	16660	12870	14300	13880
—✕—Tank 4	816	376	316	310	405	364	564	830	850	622	616	554	432	212	485	470	494	1000	436	328	211	203	213	176
—✱—Tank 5	146	179	229	262	387	411	469	480	682	797	829	897	1071	1174	1588	1584	1800	1800	1697	1600	1698	1484	1596	1597
—●—Tank 6	154	100	103	84	117	88	100	84	130	110	98	100	90	97	126	112	100	76	107	113	101	78	69	60
—+—Tank 7	178	234	334	335	562	565	781	970	1389	1493	1489	1496	1630	1740	1940	2070	2170	2060	2170	2080	1960	1750	1970	1870
—–—Tank 8	219	122	123	124	169	151	243	216	284	273	303	278	262	212	282	256	213	166	146	178	121	100	82	86
——Tank 9	84	76	81	70	68	78	63	50	56	57	58	48	68	63	57	50	52	63	65	60	55	56	55	61

Sampling Event 1999-2000

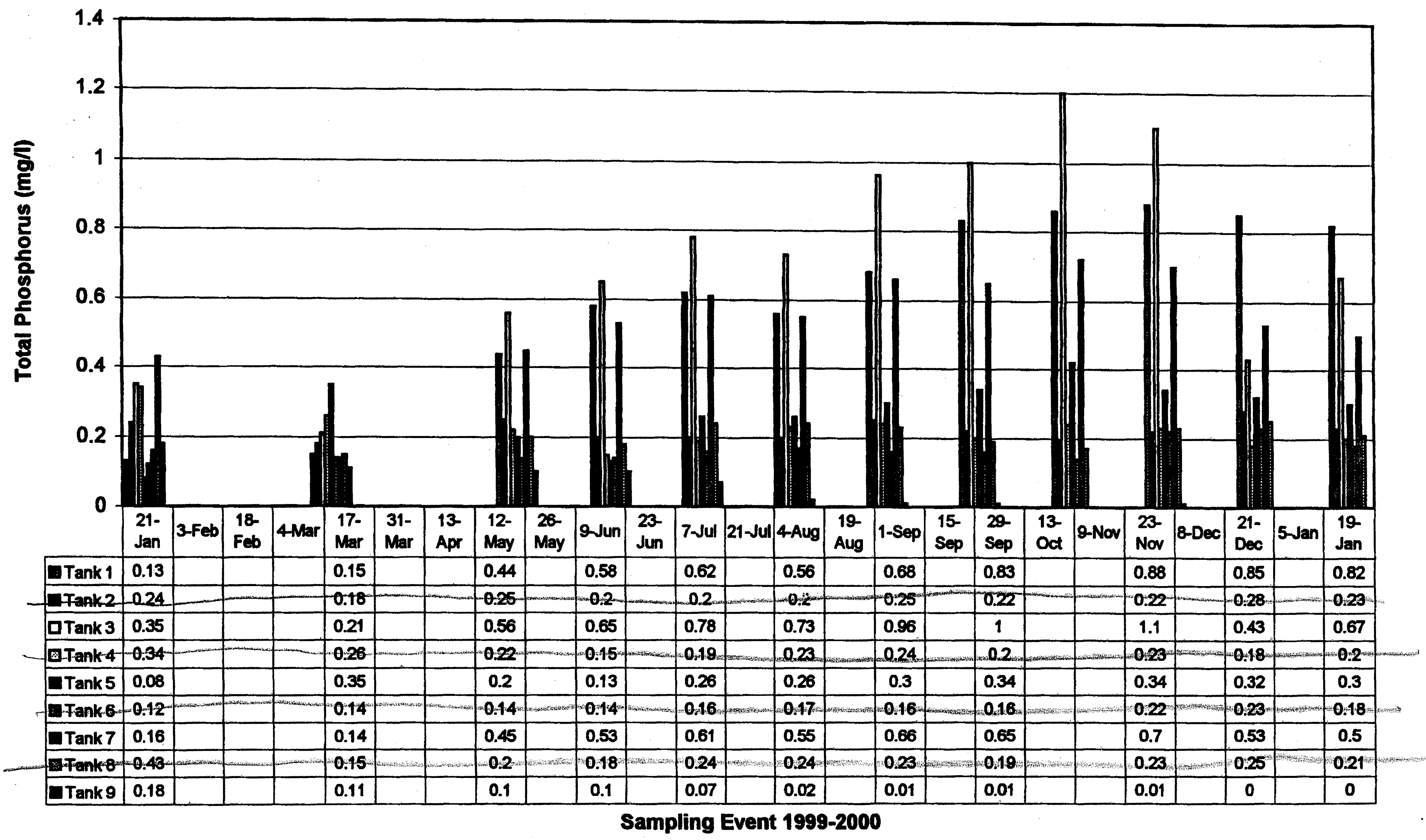
Figure 18. Surface Water Specific Absorbance



	21-Jan	3-Feb	18-Feb	4-Mar	31-Mar	13-Apr	28-Apr	12-May	26-May	9-Jun	23-Jun	7-Jul	4-Aug	19-Aug	1-Sep	15-Sep	29-Sep	13-Oct	27-Oct	9-Nov	8-Dec	21-Dec	5-Jan	19-Jan
1.5 ◆ Tank 1	4.33	4.29	4.57	4.7	4.67	4.68	4.56	4.71	5.02	4.94	4.79	5.24	4.77	4.87	4.82	4.55	4.87	5.32	5.01	5.31	5.19	4.9	5.33	4.41
~~■ Tank 2~~	3.99	3.93	4.27	4.2	4.45	4.19	4.59	5.19	4.86	5.35	5.42	5.23	4.95	4.29	5.29	4.72	4.82	5.09	4.39	4.85	3.65	4.04	4.05	3.73
4 △ Tank 3	3.76	4.25	4.56	4.96	4.92	4.81	4.83	4.68	5.24	5.09	6.11	4.73	4.56	3.81	5.18	4.4	4.53	4.84	4.26	4.46	4.23	4.13	4.28	4.18
~~× Tank 4~~	3.88	3.64	3.77	4.07	4.19	4.22	4.73	4.82	4.72	4.8	5.01	4.99	4.9	3.73	5.05	4.89	4.96	5.4	4.56	4.68	3.74	3.74	4.38	3.88
4 ✱ Tank 5	3.05	3.78	3.88	4.79	4.95	5.16	5.28	5.22	5.14	5.41	5.56	5.91	6.04	5.99	6.21	6.3	6.41	6.46	6.49	6.08	6.13	6.23	6.5	6.34
~~● Tank 6~~	2.89	2.07	2.33	2.6	2.23	2.4	2.92	3.17	3.36	2.62	3.36	3.6	3.08	2.43	3	2.38	2.92	2.75	1.63	2	1.8	1.64	1.82	1.67
1.5 + Tank 7	3.77	2.67	4.33	5.53	5.7	5.36	5.17	5.52	6.17	5.99	6.24	6.14	5.91	6.34	6.35	6.59	6.61	6.37	6.46	6.42	6.39	6.01	6.33	5.89
~~— Tank 8~~	3.64	3.06	2.79	2.94	3.29	3.13	4.39	4.37	4.944	4.5	5.55	4.95	5.13	4.44	4.9	4.33	4.36	4.33	3.83	3.43	2.41	2.25	2.42	2.23
— Tank 9	1.34	1.23	1.31	1.55	1.82	1.8	2.1	1.58	2.00	1.9	1.58	1.87	1.82	1.82	1.82	1.58	1.73	1.82	1.67	1.73	1.9	1.67	2.2	1.82

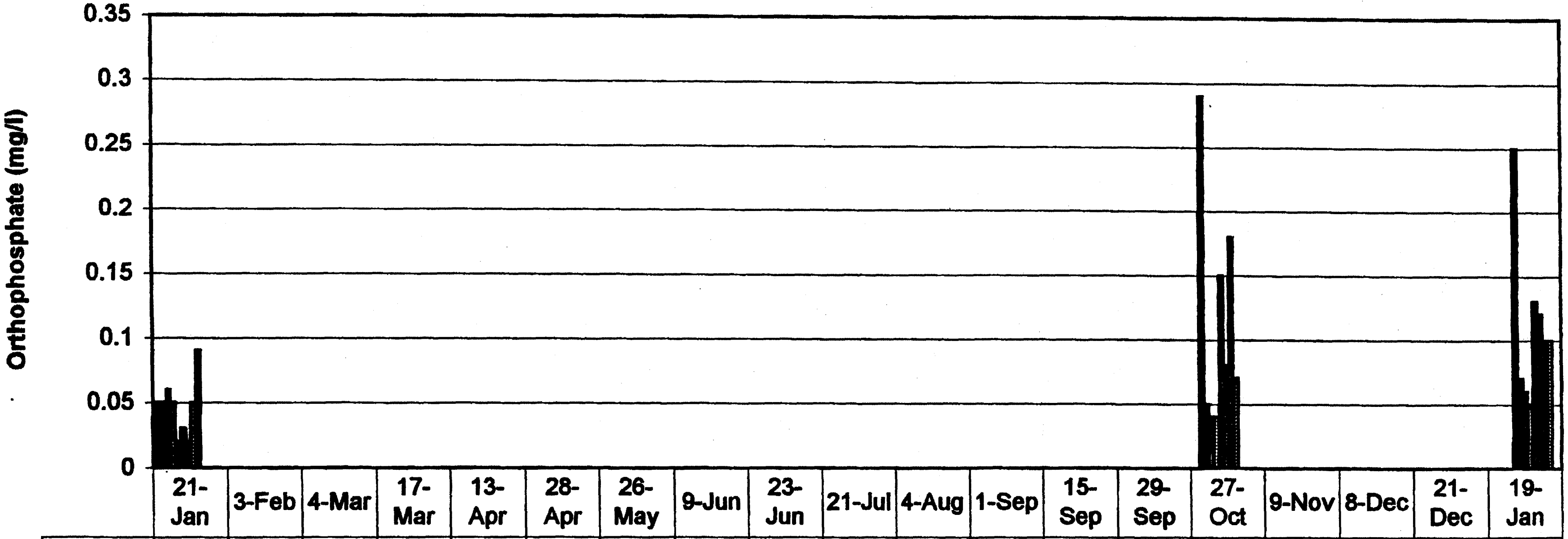
Sampling Event 1999-2000

Figure 19. Surface Water Total Phosphorus



	21-Jan	3-Feb	18-Feb	4-Mar	17-Mar	31-Mar	13-Apr	12-May	26-May	9-Jun	23-Jun	7-Jul	21-Jul	4-Aug	19-Aug	1-Sep	15-Sep	29-Sep	13-Oct	9-Nov	23-Nov	8-Dec	21-Dec	5-Jan	19-Jan
■ Tank 1	0.13				0.15			0.44		0.58		0.62		0.56		0.68		0.83			0.88		0.85		0.82
~~■ Tank 2~~	~~0.24~~				~~0.18~~			~~0.25~~		~~0.2~~		~~0.2~~		~~0.2~~		~~0.25~~		~~0.22~~			~~0.22~~		~~0.28~~		~~0.23~~
□ Tank 3	0.35				0.21			0.56		0.65		0.78		0.73		0.96		1			1.1		0.43		0.67
~~▨ Tank 4~~	~~0.34~~				~~0.26~~			~~0.22~~		~~0.15~~		~~0.19~~		~~0.23~~		~~0.24~~		~~0.2~~			~~0.23~~		~~0.18~~		~~0.2~~
■ Tank 5	0.08				0.35			0.2		0.13		0.26		0.26		0.3		0.34			0.34		0.32		0.3
~~▨ Tank 6~~	~~0.12~~				~~0.14~~			~~0.14~~		~~0.14~~		~~0.16~~		~~0.17~~		~~0.16~~		~~0.16~~			~~0.22~~		~~0.23~~		~~0.18~~
■ Tank 7	0.16				0.14			0.45		0.53		0.61		0.55		0.66		0.65			0.7		0.53		0.5
~~▨ Tank 8~~	~~0.43~~				~~0.15~~			~~0.2~~		~~0.18~~		~~0.24~~		~~0.24~~		~~0.23~~		~~0.19~~			~~0.23~~		~~0.25~~		~~0.21~~
■ Tank 9	0.18				0.11			0.1		0.1		0.07		0.02		0.01		0.01			0.01		0		0

Figure 20. Surface Water Orthophosphate



	21-Jan	3-Feb	4-Mar	17-Mar	13-Apr	28-Apr	26-May	9-Jun	23-Jun	21-Jul	4-Aug	1-Sep	15-Sep	29-Sep	27-Oct	9-Nov	8-Dec	21-Dec	19-Jan
■ Tank 1	0.05														0.29				0.25
■ Tank 2	0.05														0.05				0.07
□ Tank 3	0.06														0.04				0.06
▨ Tank 4	0.05														0.04				0.05
■ Tank 5	0.02														0.15				0.13
▨ Tank 6	0.03														0.08				0.12
■ Tank 7	0.02														0.18				0.1
▨ Tank 8	0.05														0.07				0.1
■ Tank 9	0.09														0				0

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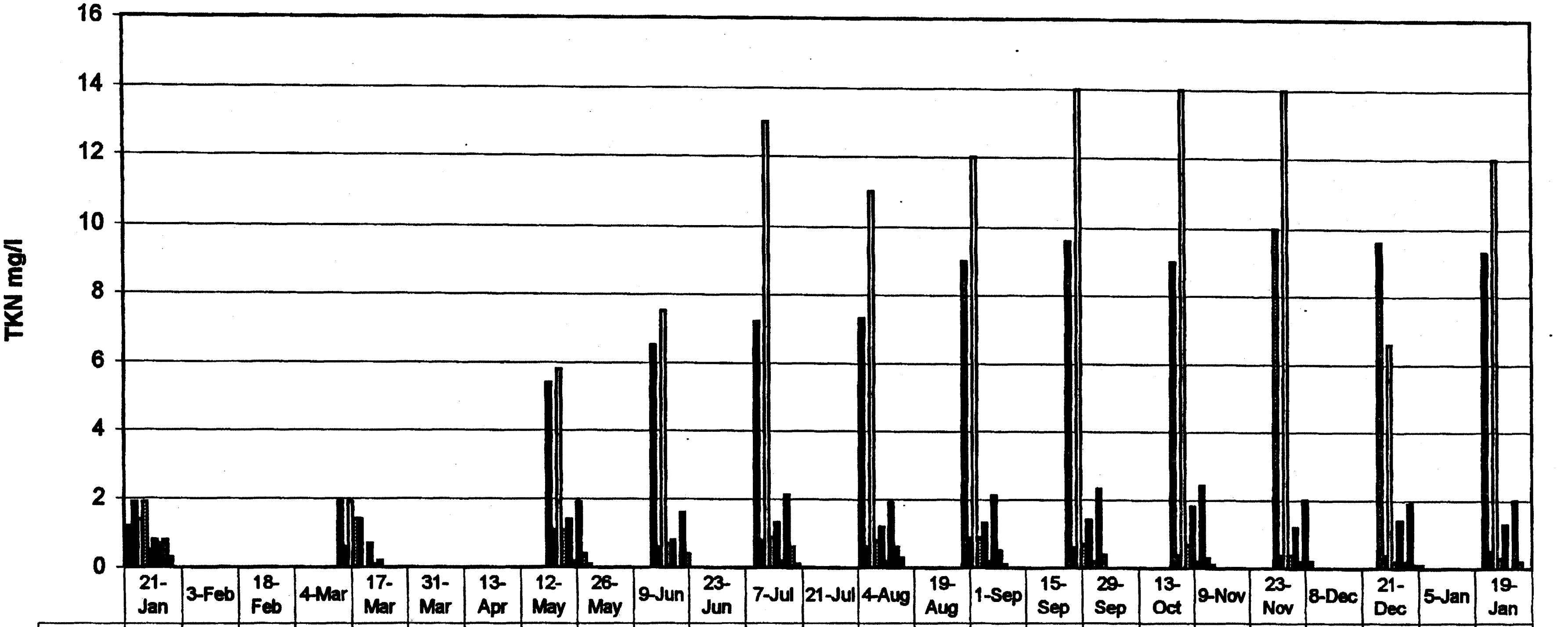
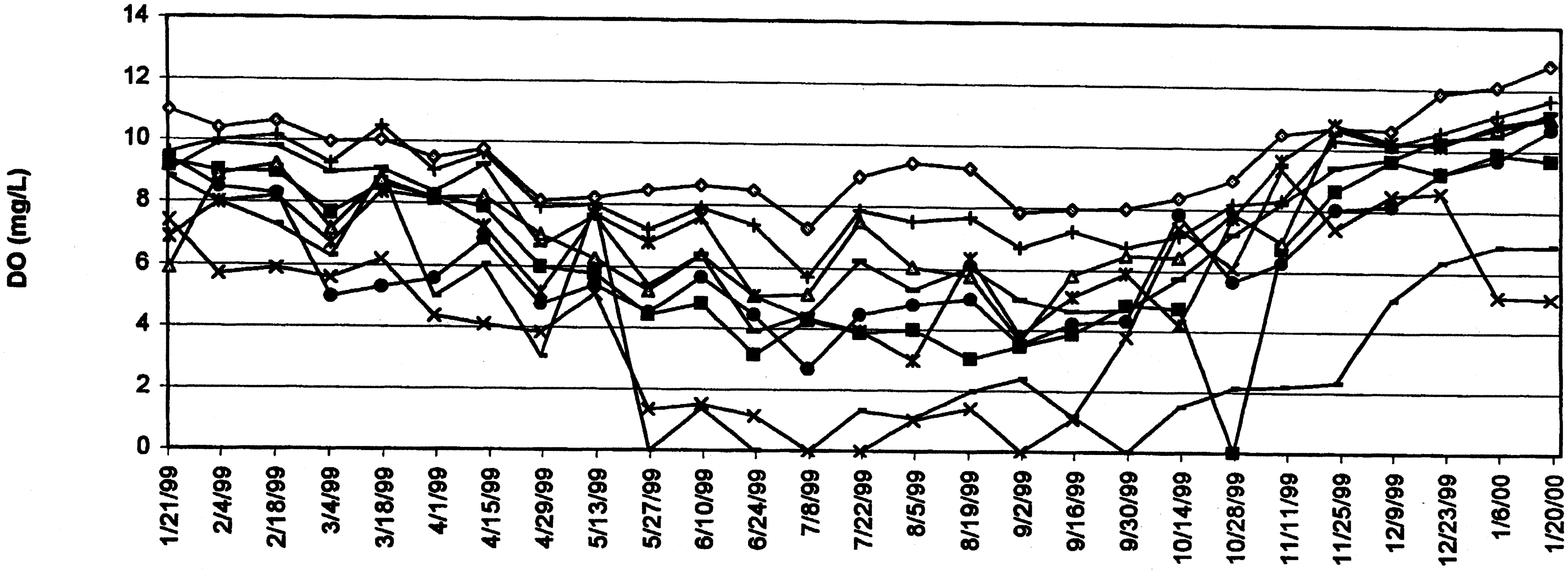
Figure 21. Surface Water Total Kjeldalhl Nitrogen



	21-Jan	3-Feb	18-Feb	4-Mar	17-Mar	31-Mar	13-Apr	12-May	26-May	9-Jun	23-Jun	7-Jul	21-Jul	4-Aug	19-Aug	1-Sep	15-Sep	29-Sep	13-Oct	9-Nov	23-Nov	8-Dec	21-Dec	5-Jan	19-Jan
■ Tank 1	1.2				1.9			5.4		6.5		7.2		7.3		9		9.6			10		9.6		9.3
■ Tank 2	1.9				0.6			1.1		0.6		0.8		0.6		0.9		0.6			0.4		0.4		0.5
□ Tank 3	1.4				1.9			5.8		7.5		13		11		12		14			14		6.6		12
⊠ Tank 4	1.9				1.4			1.1		0.7		0.9		0.8		0.9		0.7			0.4		0.2		0.3
■ Tank 5	0.5				1.4			1.4		0.8		1.3		1.2		1.3		1.4			1.2		1.4		1.3
▨ Tank 6	0.8				0			0.2		0		0.2		0.2		0.2		0.2			0.2		0.2		0
■ Tank 7	0.7				0.7			1.9		1.6		2.1		1.9		2.1		2.3			2		1.9		2
▨ Tank 8	0.8				0.1			0.4		0.4		0.6		0.6		0.5		0.4			0.2		0.1		0.2
■ Tank 9	0.3				0.2			0.1		0		0.1		0.3		0.1		0			0		0.1		0

Figure 22. Surface Water Dissolved Oxygen



		21-Jan	3-Feb	18-Feb	4-Mar	31-Mar	13-Apr	28-Apr	12-May	26-May	9-Jun	23-Jun	7-Jul	4-Aug	19-Aug	1-Sep	15-Sep	29-Sep	13-Oct	27-Oct	9-Nov	8-Dec	21-Dec	5-Jan	19-Jan
	—■— Tank 1	9.3	9	8.99	7.67	8.22	7.89	5.97	5.77	4.42	4.81	3.12	4.27	3.97	3.03	3.46	3.86	4.82	4.74	0	6.74	9.63	9.24	9.9	9.68
	~~—▲— Tank 2~~	~~5.9~~	~~8.9~~	~~9.24~~	~~7.18~~	~~8.15~~	~~8.24~~	~~7.03~~	~~6.26~~	~~5.21~~	~~6.4~~	~~5.06~~	~~5.12~~	~~6.05~~	~~5.77~~	~~3.63~~	~~5.83~~	~~6.48~~	~~6.45~~	~~7.9~~	~~6.96~~	~~10.18~~	~~10.27~~	~~10.76~~	~~11.1~~
4	—✕— Tank 3	7.4	5.7	5.9	5.6	4.35	4.08	3.83	5.11	1.34	1.51	1.13	0	1.01	1.42	0	1.08	3.78	7.4	6.1	9.34	8.49	8.6	5.2	5.14
	~~—✱— Tank 4~~	~~6.9~~	~~8~~	~~8.2~~	~~6.72~~	~~8.16~~	~~7.28~~	~~5.14~~	~~7.68~~	~~6.8~~	~~7.61~~	~~5.07~~	~~4.33~~	~~2.98~~	~~6.37~~	~~3.8~~	~~5.11~~	~~5.9~~	~~4.2~~	~~7.75~~	~~9.62~~	~~10.26~~	~~10.15~~	~~10.9~~	~~11.13~~
	—●— Tank 5	9.4	8.5	8.29	4.98	5.58	6.87	4.74	5.38	4.51	5.68	4.44	2.67	4.81	5.01	3.5	4.23	4.31	7.84	5.65	6.29	8.15	9.25	9.68	10.72
	~~—+— Tank 6~~	~~9.6~~	~~10~~	~~10.17~~	~~9.27~~	~~9.07~~	~~9.63~~	~~7.89~~	~~7.99~~	~~7.22~~	~~7.92~~	~~7.38~~	~~5.7~~	~~7.54~~	~~7.68~~	~~6.73~~	~~7.28~~	~~6.77~~	~~7.14~~	~~8.17~~	~~8.31~~	~~10.15~~	~~10.6~~	~~11.2~~	~~11.69~~
1.5	—-— Tank 7	8.8	8	7.29	6.3	5	6.03	3.04	7.97	0	1.37	0	0	1.07	1.97	2.4	1.17	0	1.5	2.13	2.18	5.06	6.33	6.88	6.89
	~~—— Tank 8~~	~~9~~	~~9.9~~	~~9.8~~	~~8.96~~	~~8.39~~	~~9.26~~	~~6.66~~	~~7.63~~	~~5.41~~	~~6.4~~	~~3.89~~	~~4.45~~	~~5.29~~	~~6.07~~	~~4.99~~	~~4.62~~	~~4.68~~	~~5.73~~	~~7.2~~	~~8.22~~	~~9.7~~	~~10.4~~	~~10.5~~	~~11.3~~
	—◇— Tank 9	11	10.4	10.65	9.97	9.47	9.76	8.11	8.22	8.47	8.65	8.5	7.3	9.43	9.27	7.85	7.97	8	8.36	8.96	10.5	10.67	11.88	12.1	12.8

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and sediment-water boundary. The return to aerobic conditions from an anaerobic state may have also coprecipitated iron oxides and DOC. This would have lowered the DOC and TOC concentrations in the surface water in tanks 1 and 3 in the fall. Peat soil iron concentrations were high in tanks 1 – 4. Total iron concentrations ranged from 14000 to 17000 mg/Kg at the start of the experiment.

While surface water TOC and DOC concentrations in tanks 1 and 3 stabilized and then decreased in October 1999 to January 2000, the TTHMFP concentrations (Figure 17) and specific absorbance values decreased. These changes suggest a shift in the composition of DOC and TOC in the impounded surface water from more humic-like substances to less refractory compounds. Possible explanations include removal by coprecipitation of humic matter with iron and aluminum oxides, less microbial breakdown of organic matter to THM precursor organic carbon as water temperature decreased, and shifts in microbial community composition and population.

Experiment #2 results were similar to those seen in the first experiment for the tanks with no water exchange and shallow water depths. Tank 3 (4 ft. peat, 2 ft. water) followed by tank 1 (1.5 ft. peat, 2 ft. water), tank 7 (1.5 ft. peat, 7 ft. water), and tank 5 (4 ft. peat, 7 ft. water) had the highest increases in TOC, DOC, THMFP, color, EC, total P, bromide, and alkalinity. Tank 3 DOC was initially 8.6 mg/l in January 21, 1999 and reached 263 mg/l by October 27, 1999. By the end of the study, the DOC was 249 mg/l. The initial DOC concentration in tank 1 was 10.7 mg/l and up to 174 mg/l after ten months of flooding (October 27, 1999). The DOC had stabilized and was 171 mg/l by January 19, 2000. In Experiment #1, the initial DOC in tank 3 was 23.2 mg/l in July 1998 and reached 135 mg/l after ten weeks. In tank 1 of the first experiment, the initial DOC was 8 mg/l and by the tenth week DOC was 39.4 mg/l. Both experimental results showed that peat soils that are flooded significantly raise the concentrations of organic carbon and other water quality constituents in overlying waters, especially in shallow depths with little or no water exchange. The data in the second experiment also showed that recently leached peat soil, such as from heavy rainfall, can remove most of the soluble or weakly absorbed organic carbon from the soil. Thereby, reducing the amount of DOC and THMFP in surface and pore water of waterlogged peat soils. In the Delta, similar observations are seen in drainage water quality after a field is leached or during the wet winter. Winter drainage DOC and THMFP concentrations are higher than during the summer (CDWR, 1990; CDWR, 1994).

Those tanks (2,4,6,8) with continuous flow (i.e., 1.5 surface water volume exchanges per week) had better water quality from dilution and removal (flushing) of buildup of organic matter and nutrients. Tank 2 (1.5 ft. peat, 2 ft. water) initial DOC was 16.8 mg/l and had decreased to about 5 mg/l in four weeks. Tank 4 (4 ft. peat, 2 ft. water) DOC dropped from a starting DOC of 11.3 mg/l to less than 5 mg/l after two weeks.

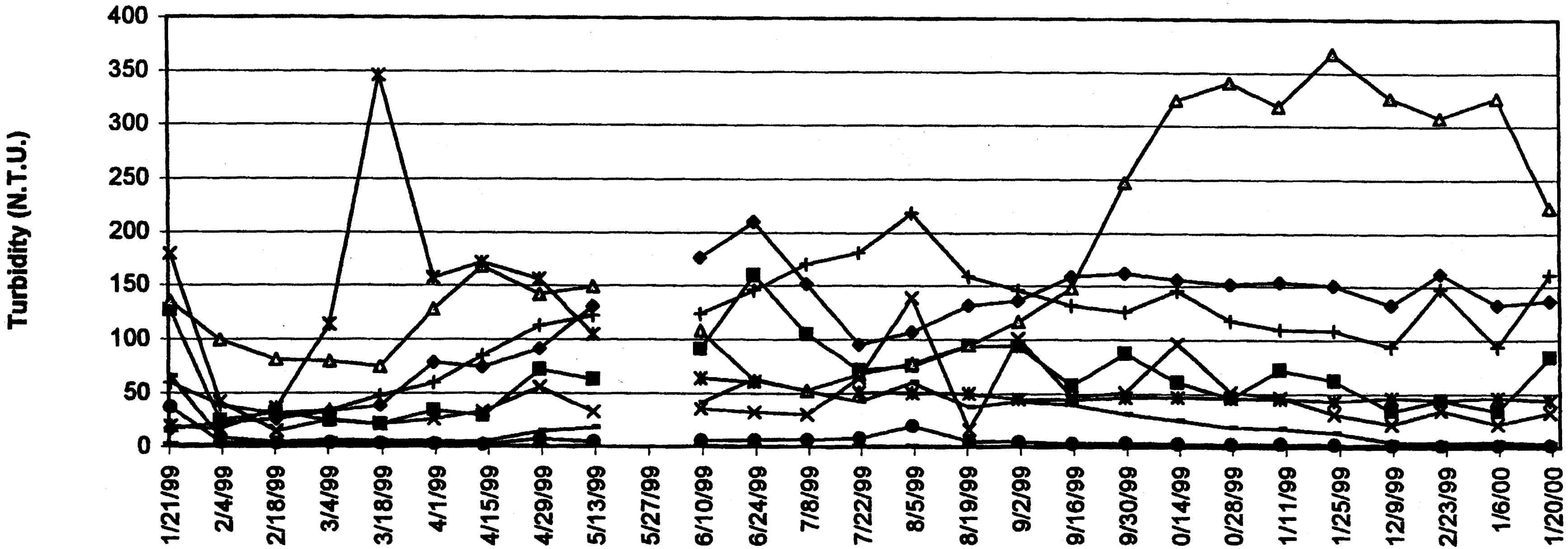
Surface water samples were taken in July and August for chlorophyll *a* analyses to determine if algae were growing in the covered tanks. The results indicated that the covers were effective. The high turbidity readings in the surface water were most likely from decomposing suspended matter and bacteria and the formation of iron and aluminum oxides (Figure 23).

Flooded peat soils can also release nutrients to surface water. Phosphorus and nitrogen loads increased with time in tanks # 1- 4 (Figures 19 – 21 and 24 – 25) and the levels are attributed to the higher starting P and N soil batch concentrations than in the second soil batch used in tanks # 5 – 8. Some levels could be considered as being at eutrophic levels (AWWARF, 1989; Vollenwieder and Kerekes, 1980.) Other data, including surface water color, alkalinity, and pH, are presented in the Appendix.

The last samples that were collected from Experiment #2 were on January 21, 2000. Work was then suspended at the SMARTS facility. The MWQI Advisory Group decided that an extension of the experiment was not necessary. The submersible pumps in the tanks were shut off and water flows to the tanks that had continuously received water during the study were terminated. Water in all the tanks remained stagnant for the next eight months. Although the one-year study ended in January 2000, field measurements and TOC/DOC samples of surface water in the tanks were taken on June 13, 2000 and later on September 7, 2000 (surface and peat soil water). Inspection of the inside of the tanks showed no apparent algae growth or measurable evaporation of water in the nine covered tanks. A comparison of the January 21, June 13, and September 7, 2000 field measurements and laboratory results showed that surface water EC, TOC, and DOC continued to increase under static conditions during the eight-month period after the experiment had officially ended (Table 8). The data suggests that the seasonal trends would have repeated if the full experiment continued into a second year.

The EC, TOC, and DOC levels had appeared to plateau during the last quarter of the experiment (Sept 1999 – January 2000) as water temperatures fell. The June 2000 samples indicated that an annual cycle would have been seen if the experiment had continued for another year. All the tanks that continuously received water exchange for a year (tanks 2,4,6, and 8) showed there was still a supply of organic carbon available. Surface water tank 2 (1.5 ft. peat, 2 ft. water) TOC increased by about 24 mg/l and tank 4 (4 ft. peat, 2 ft. water) TOC by about 47 mg/l during the five-month period of stagnation. Surface water TOC in tank 6 (1.5 ft. peat, 7 ft. water) increased by about 4 mg/l and in tank 8 (4 ft. peat, 7 ft. water) by about 13 mg/l. The differences in the increase of TOC and DOC being attributed to the peat soil mass (soil depth), water depths (2 ft. vs. 7 ft.) and different starting amounts of soluble organic carbon between soil batches 1 and 2 used in tanks 1 – 4 and 5 – 8, respectively. Besides different submerged soil batches, the consistently lower values in surface water quality constituents (e.g., TOC/DOC, EC) between tanks 1 – 4 and 5 – 8 are also due to the water depth (dilution) differences. Water depths were 2 feet in the former group and 7 feet in the latter. In Experiment #1, we found that a simple mixing ratio to compute dilution of constituents was not applicable for the water depths, constituents, and conditions we studied. This is because many of the constituents that comprise organic carbon, nutrients, and EC are not conservative.

Figure 23. Surface Water Turbidity



	21-Jan	3-Feb	18-Feb	4-Mar	31-Mar	13-Apr	28-Apr	12-May	26-May	9-Jun	23-Jun	7-Jul	4-Aug	19-Aug	1-Sep	15-Sep	29-Sep	13-Oct	27-Oct	9-Nov	8-Dec	21-Dec	5-Jan	19-Jan
◆ Tank 1	16.8	21.9	25.7	33.3	78.7	74.3	91.3	131		176	210	152	107	132	136	159	162	156	152	154	133	162	133	137
■ Tank 2	127	24.7	32.2	24	34.5	28.9	71.9	62.8		90.9	160	105	75.2	94.4	93.6	57.7	87.3	60.8	46.2	72	34	44.1	34	84.2
△ Tank 3	135	99.4	81.5	79.6	128	168	142	149		108	61.8	52.7	77.4	94.8	117	148	247	324	341	318	326	308	326	224
✕ Tank 4	180	42.1	14.3	25.4	25.6	33.5	56	33.1		35.4	32.4	30.1	139	15.9	101	47.6	51	96.5	51.8	47	21.4	34.3	21.4	32.5
✱ Tank 5	19.3	16.4	36.5	114	157	172	156	105		63.8	60.6		50.5	50	44.8	44	46.3	46.9	46	45	46.5	44.7	46.5	43.5
● Tank 6	36.9	4.4	3.46	3.73	2.69	2.11	7.45	4.74		6.08	6.48	6.52	19.3	5.6	5.05	3.25	3.56	3.4	2.67	3	2.2	1.99	2.2	1.92
+ Tank 7	59.6	39.2	31.2	34.2	59.8	84.8	113	122		124	146	170	218	159	146	132	126	146	118	110	93.5	148	93.5	161
— Tank 8	65.6	8.5	4.2	6.3	5.22	4.78	14.8	18		41.4	63.7	52.4	60.3	37.2	42.5	39.5	30.7	24.9	18.2	17	5.26	4.86	5.26	3.89
— Tank 9	2.1	1.4	1.12	2.91	1.31	0.61	0.96	0.55		0.62	0.44		0.39	0.65	0.45	0.49	0.38	0.59	0.76	1	0.83	0.5	0.83	0.45

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Figure 24. Surface Water Ammonia

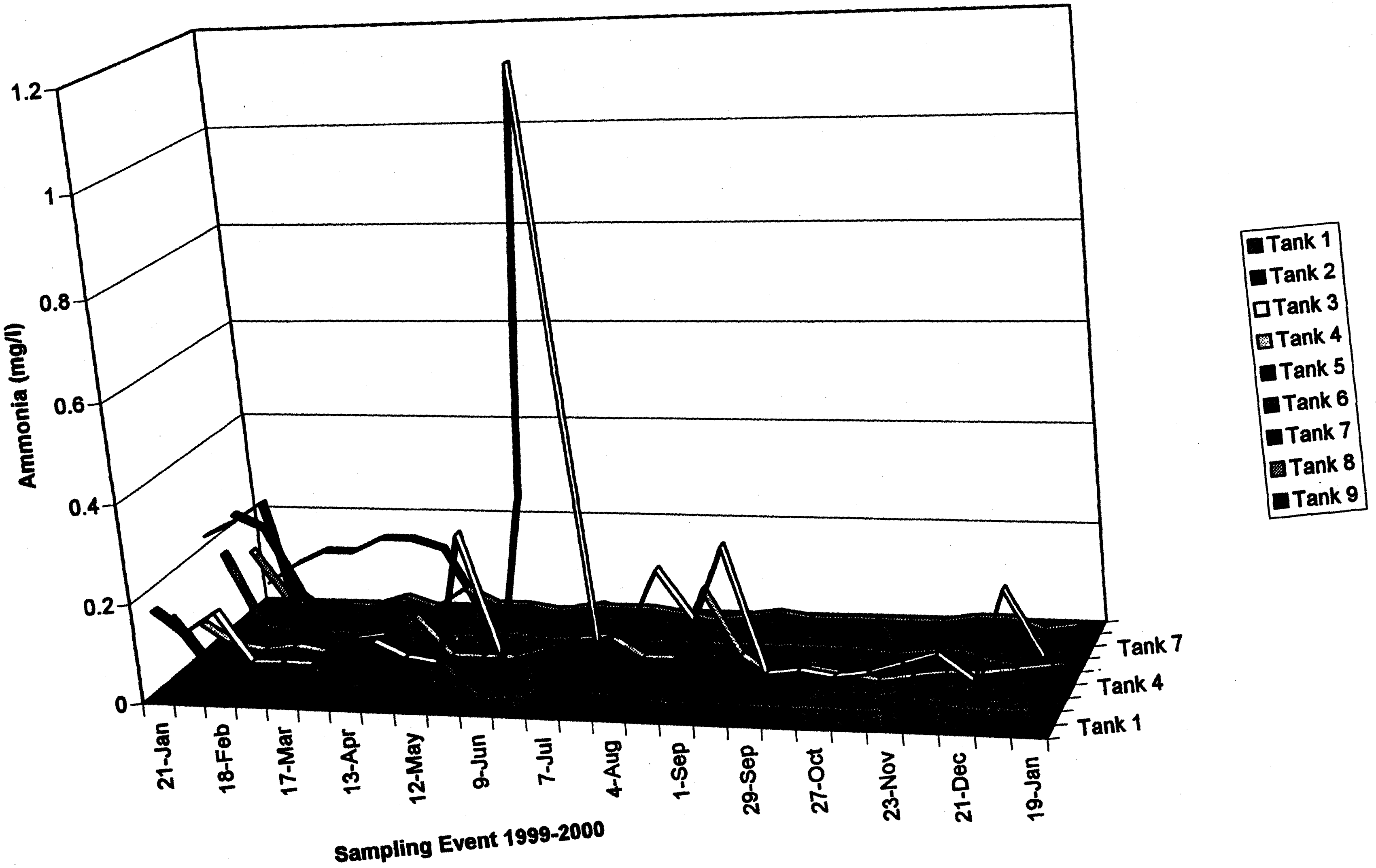
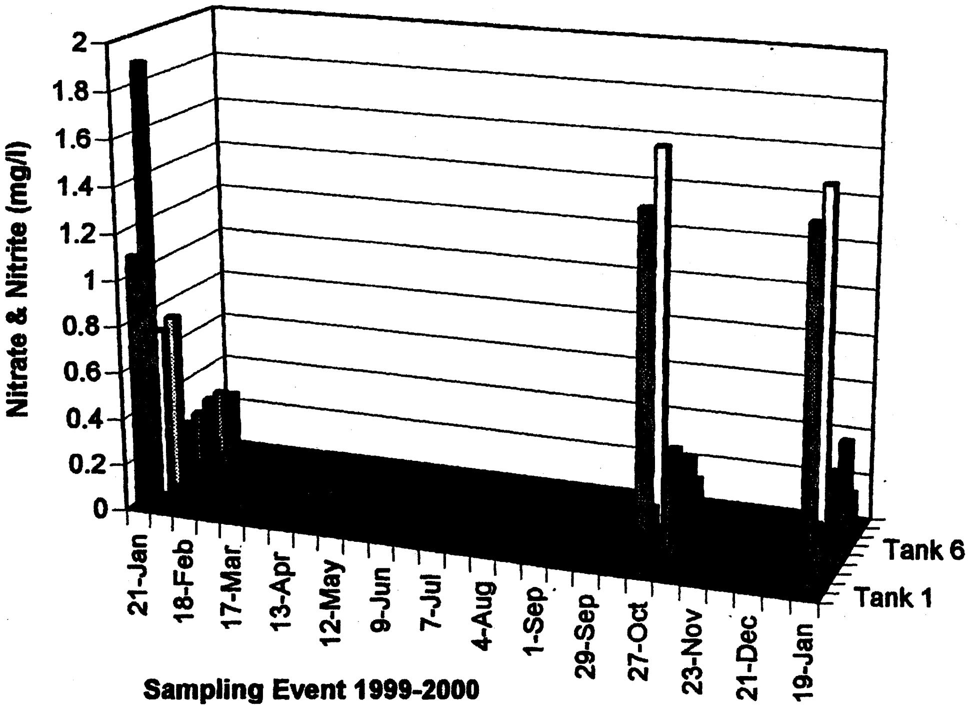


Figure 25. Surface Water Nitrate & Nitrite



	21-Jan	3-Feb	18-Feb	4-Mar	17-Mar	31-Mar	13-Apr	12-May	26-May	9-Jun	23-Jun	7-Jul	21-Jul	4-Aug	19-Aug	1-Sep	15-Sep	29-Sep	13-Oct	9-Nov	23-Nov	8-Dec	21-Dec	5-Jan	19-Jan
■ Tank 1	1.1																								1.5
■ Tank 2	1.9																								0.26
□ Tank 3	0.72																								1.6
▨ Tank 4	0.75																								0.31
■ Tank 5	0.24																								0.37
▩ Tank 6	0.25																								0.16
■ Tank 7	0.28																								0.43
▨ Tank 8	0.28																								0.17

Table 8. Comparison of January, June, and September 2000 Samples

Surface water samples

	Tank 1	**Tank 2f**	**Tank 3**	**Tank 4f**	**Tank 5**	**Tank 6f**	**Tank 7**	**Tank 8f**	**Tank 9**
TOC1	173	2.4	259	2.7	18.5	1.4	29.2	1.4	1.2
TOC2	218	26.3	329	49.9	22.1	5.8	33.5	14.6	1.5
TOC3	**237**	**40.9**	**354**	**81.8**	**26.4**	**9.3**	**31.5**	**17.2**	**1.4**
DOC1	171	2.2	249	2.4	16.1	1.2	21.9	1.3	1.1
DOC2	219	26.2	322	48.3	21.5	5.5	30.7	14.1	1.6
DOC3	**242**	**40.7**	**370**	**79.6**	**27.3**	**8.8**	**30.5**	**17.1**	**1.3**
Temp1	13.9	11.7	12.2	11.7	11.5	11.3	11.4	11.3	11.1
Temp2	25.1	26.1	25.6	26.3	27.3	28.2	28.7	29.1	29.2
Temp3	**20.8**	**21.3**	**20.3**	**21.2**	**22.2**	**22.3**	**22.1**	**22.7**	**22.6**
EC1	992	193	1755	193	277	189	246	190	189
EC2	1330	382.2	2278	603	301	195	282	266	205
EC3	**1485**	**449**	**2455**	**780**	**290**	**176**	**295**	**299**	**203**
DO1	9.68	11.1	5.14	11.13	10.72	11.69	6.89	11.3	12.8
DO2	2.54	2.7	1.58	<1	1.55	1.7	1.3	<1	3.4
DO3	**4.8**	**4.03**	**3.69**	**2.58**	**3.86**	**4.5**	**2.57**	**3.03**	**6.2**
PH1	7.26	7.45	7.44	7.54	7.41	7.2	7.18	7.26	7.86
PH2	7.03	6.98	7.29	6.92	6.78	6.97	7	6.92	7.37
PH3	**7.21**	**7.21**	**7.45**	**7.26**	**7.17**	**7.17**	**7.6**	**7.23**	**7.54**
Turb1	137	84.2	224	32.5	43.5	1.92	161	3.89	.45
Turb2	33.5	32.5	281	33.3	29.1	7.15	94.3	34.1	.42
Turb3	**134**	**26.2**	**347**	**50.3**	**33.2**	**31.3**	**61.6**	**14.6**	**0.65**

TOC and DOC and DO (dissolved oxygen) in mg/l. EC in µS/cm
Temp refers to water temperature °C
Turb refers to turbidity in ntu
1 refers to January 21, 2000 value.
2 refers to June 13, 2000 value.
3 refers to September 7, 2000 value.

Note test conditions. Water flows and circulation pumps inside all tanks were stopped on January 21, 2000. All tanks remained covered. No evidence of algal blooms or evaporation when surface water samples were taken on June 13 and September 7, 2000. Tank 9 was a control tank with no peat soil but filled with city tap water.

Tank Comparisons

The experimental tanks were paired to compare differences from the effects of surface water exchange. The odd numbered tanks had no water additions after filling. The even numbered tanks continuously received water at the rate of 1.5 surface water volume exchanges per week. Because two dissimilar soil batches were used, we are unable to compare the effects of different water depths (2 vs. 7 ft.) in tanks with the same soil batch. However, these comparisons were performed in the three-month 1998 Experiment #1 study, where one single soil batch was used. Those results showed that water depth did dilute the concentrations of constituents but not in a straightforward simple mixing ratio based on water depth. The measured constituents such as TOC, DOC, and EC did not behave conservatively. Components of these constituents consist of both conservative and non-conservative fractions.

The Experiment #2 tank pairs and conditions are shown below:

Tank Pair Tanks	Peat soil depth	Peat soil batch	Water depth
1 and 2	1.5 ft.	1 (high soluble organic carbon)	2 ft.
3 and 4	1.5 ft.	1 (high soluble organic carbon)	2 ft.
5 and 8	4 ft.	2 (low soluble organic carbon)	7 ft.
6 and 7	4 ft.	2 (low soluble organic carbon)	7 ft.

The general seasonal trend observed in peat water samples in all the 8 tanks was that DOC, TTHMFP, and EC levels behaved similar. Concentrations increased sharply through the spring and began declining in the summer (Figures 26 – 37). The trend was independent of the soil batch (high vs. low soluble organic carbon) and soil layer depth (1.5 vs. 4 ft.) that was flooded and water depths (2 vs. 7 ft.). Surface water DOC, TTHMFP, and EC in the tanks (#1,3,5,7) that received no water exchange also had a similar pattern, where the levels increased gradually to late October before stabilizing (about less than 10% change from previous measurement). These same constituents increased and peaked in May before declining in tanks (#2,4,6,8) that had water exchanges.

The declining DOC, TTHMFP, and EC levels in the peat soil water in the second half of the year and the gradual increases seen in the surface water suggest that a dynamic equilibrium was in progress between the surface and soil waters. A comparison of the surface and peat soil water quality at the end of the one-year experiment (1/21/00) is shown in Table 9.

Two sampling events occurred later to see if these constituent concentrations had changed after the circulation pumps and water exchanges were terminated. These later samplings (6/13/00 and 9/7/00), therefore, occurred under stagnant conditions in the tanks for up to eight months. The results of these additional samples for DOC and EC are included in Figures 26-29 and 34-37, respectively. Surface and peat soil water samples were collected except at the June 13, 2000 event. The measurements included the standard field parameters (EC, temperature, DO, pH, turbidity), TOC, DOC, UVA254nm, and ammonia. The results are included in the Appendix.

The additional two samplings taken after the experiment ended suggest that under stagnant conditions there could be a repeat of the seasonal trend seen in the first year. Organic carbon and mineral salts were still available from the peat soil. Surface water DOC and EC continued to increase from the degradation of peat and the diffusion of the peat soil water constituents. Peat soil water DOC generally increased during the eight-month stagnant period. Surface water EC had increased and peat soil water EC declined. It appears that organic carbon had not been completely leached out from the peat even in the case of the second soil batch, which produced low DOC concentrations in the study. DOC continued to originate from the twenty-month submerged peat while some EC constituents were leached from the soil. The data also showed that EC alone cannot be used as a reliable predictor of DOC movement and mechanisms in the Delta islands.

Table 9. End of Year One Sample DOC, TTHMFP, and EC Results

January 19-20, 2000 samples

Tank #	1	2	3	4	5	6	7	8
Peat Soil Water DOC	460	225	332	251	35	30.6	42.2	77.5
Surface Water DOC	171	2.2	249	2.4	16.1	1.2	21.9	1.3
Peat Soil Water THMFP	28100	17700	21400	17100	3050	2580	3470	5300
Surface Water TTHMFP	10900	141	13880	176	1597	60	1870	86
Peat Soil Water EC	2974	2198	3292	2881	689	620	1036	1294
Surface Water EC	992	193	1755	193	277	189	246	190

DOC in mg/l, TTHMFP in µg/l, and EC in µS/cm. Study began January 13, 1999.

Figure 26. Tanks 1 & 2 DOC

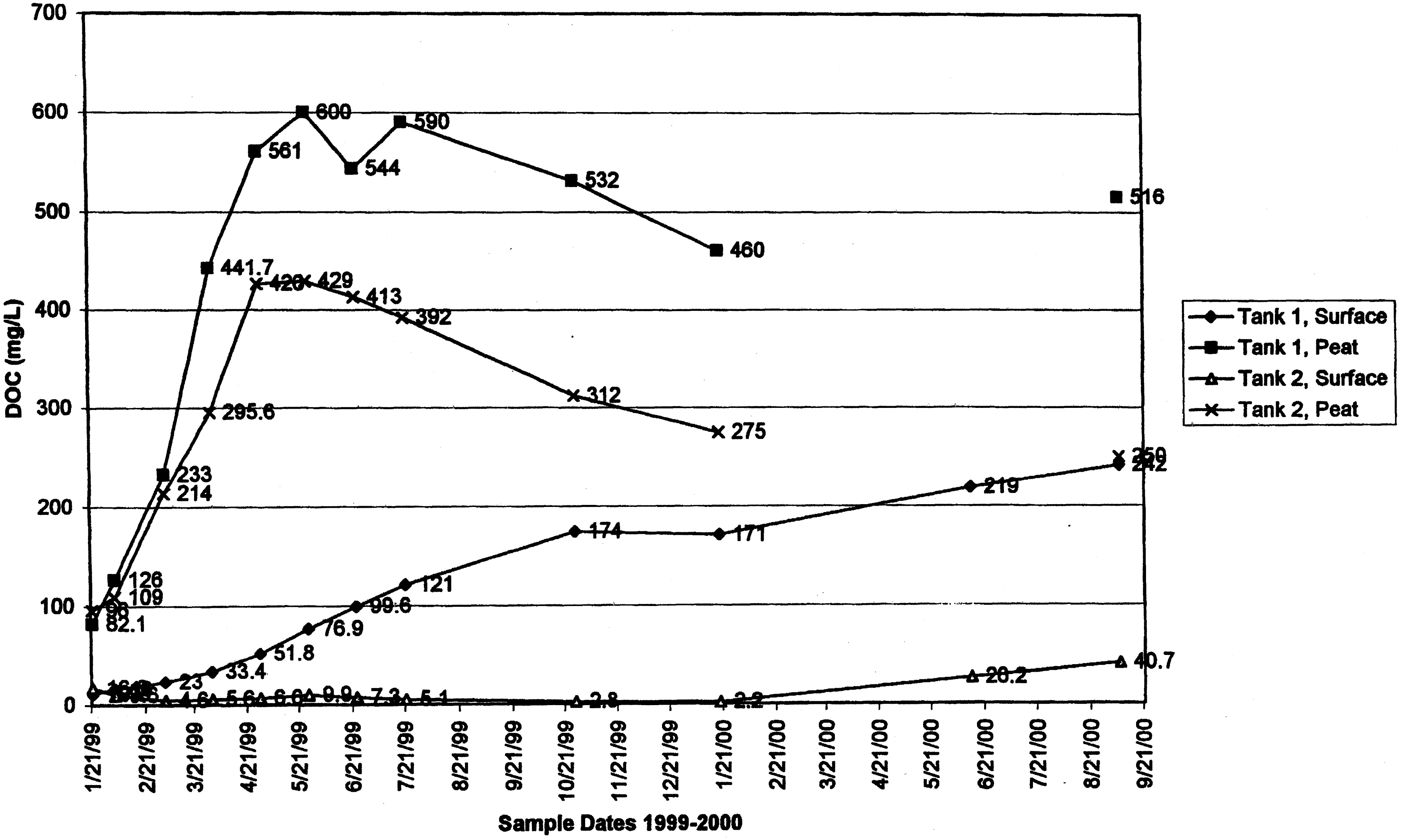


Figure 27. Tanks 3 & 4 DOC

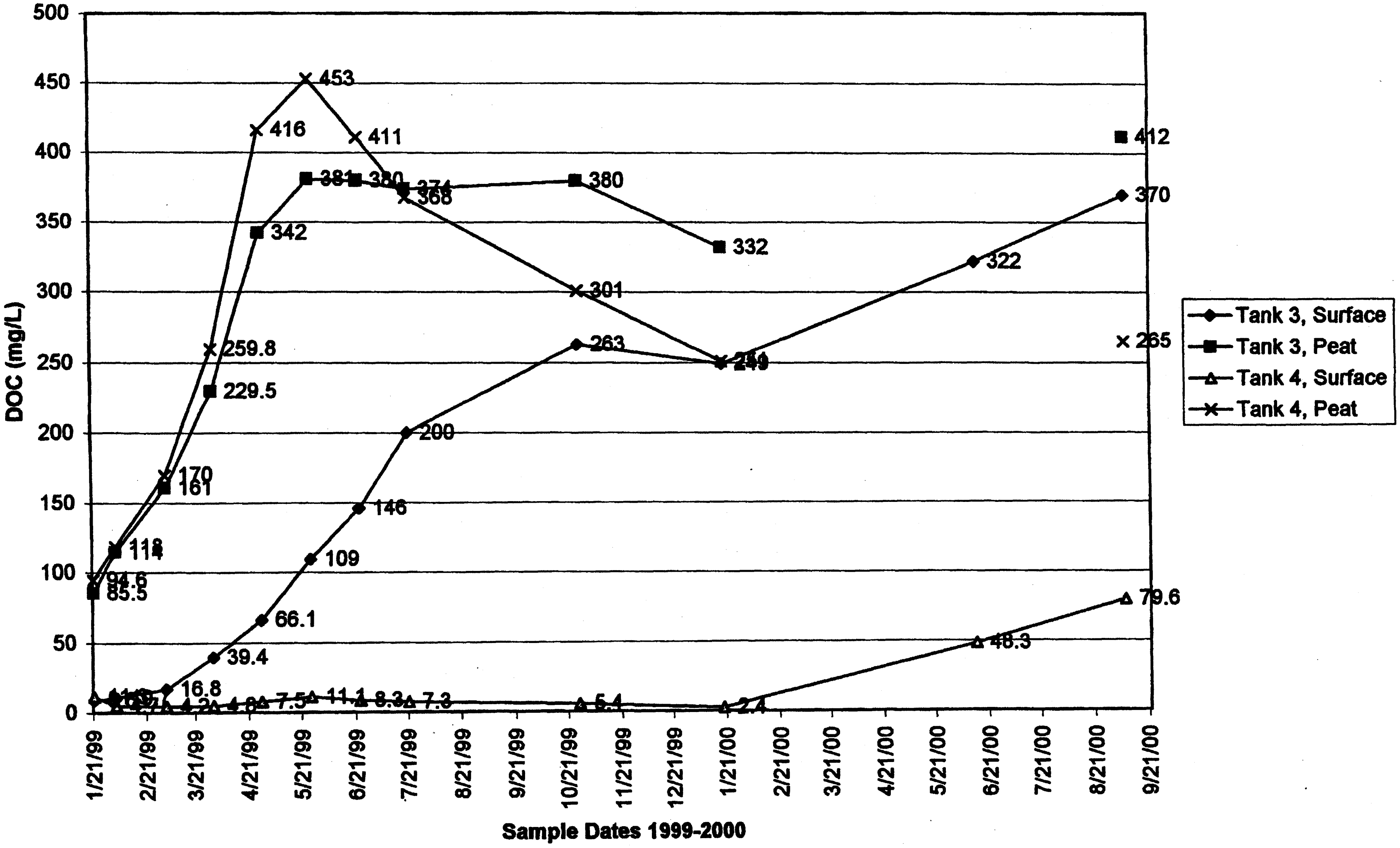


Figure 28. Tanks 5 & 8 DOC

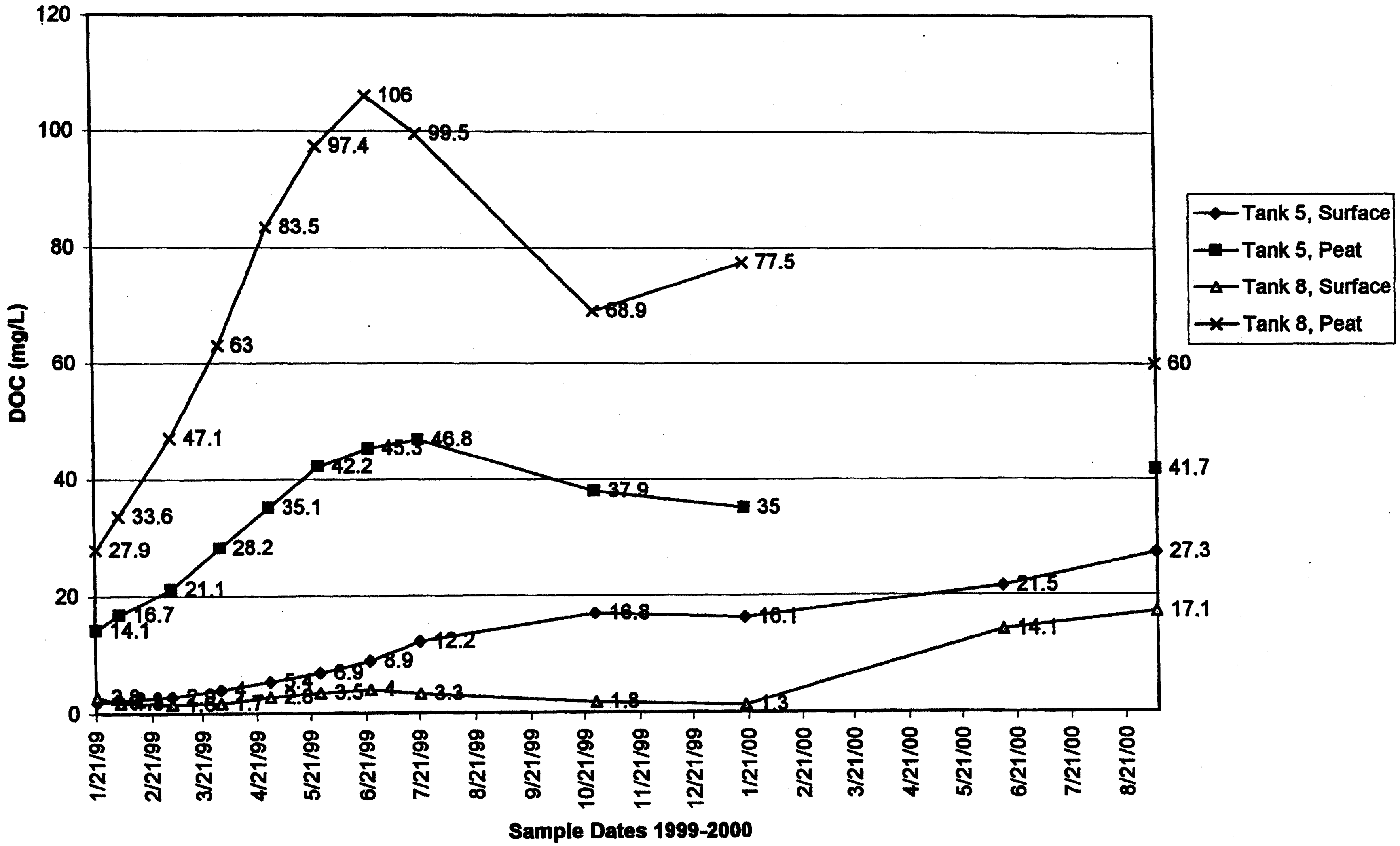


Figure 29. Tanks 6 & 7 DOC

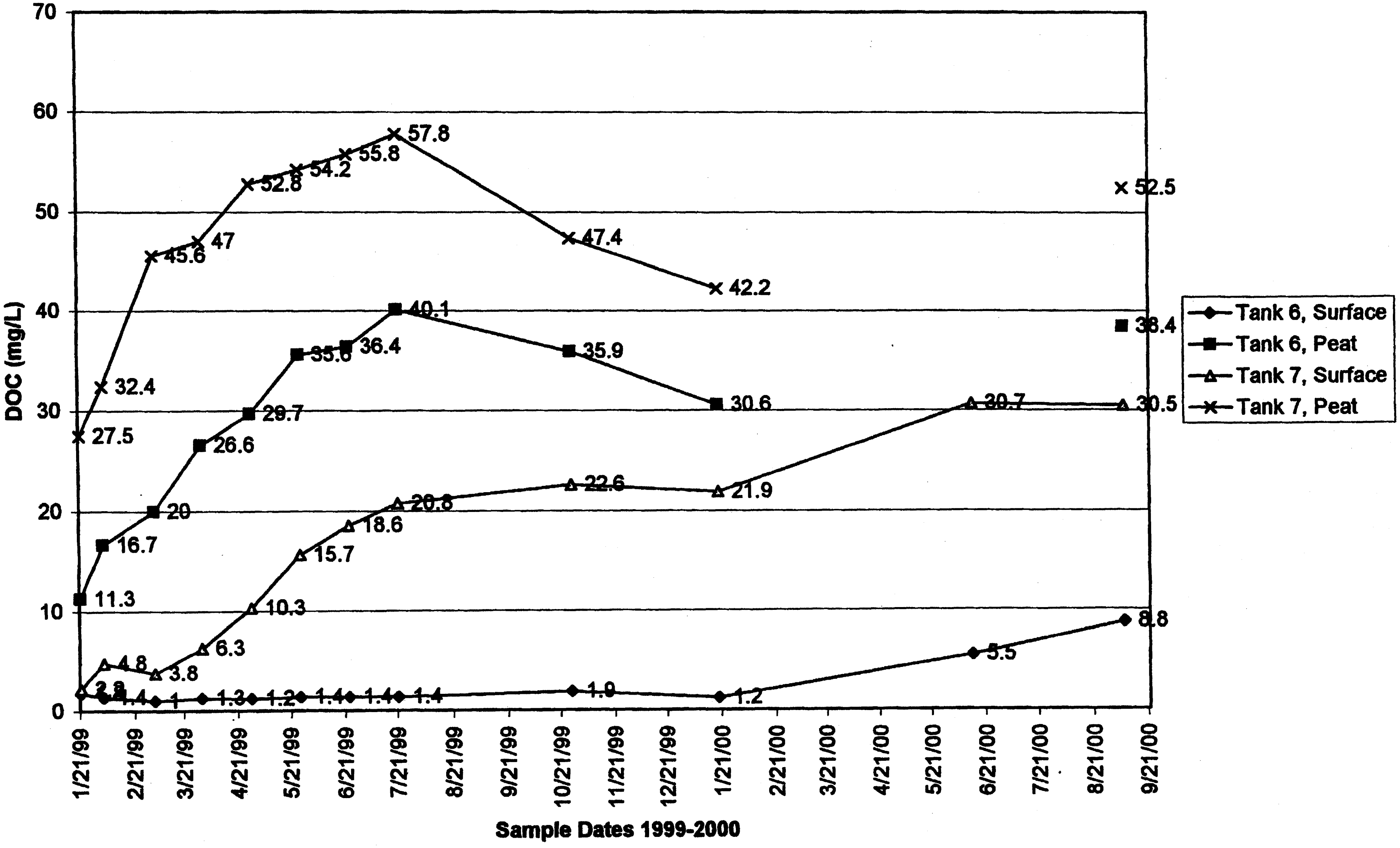
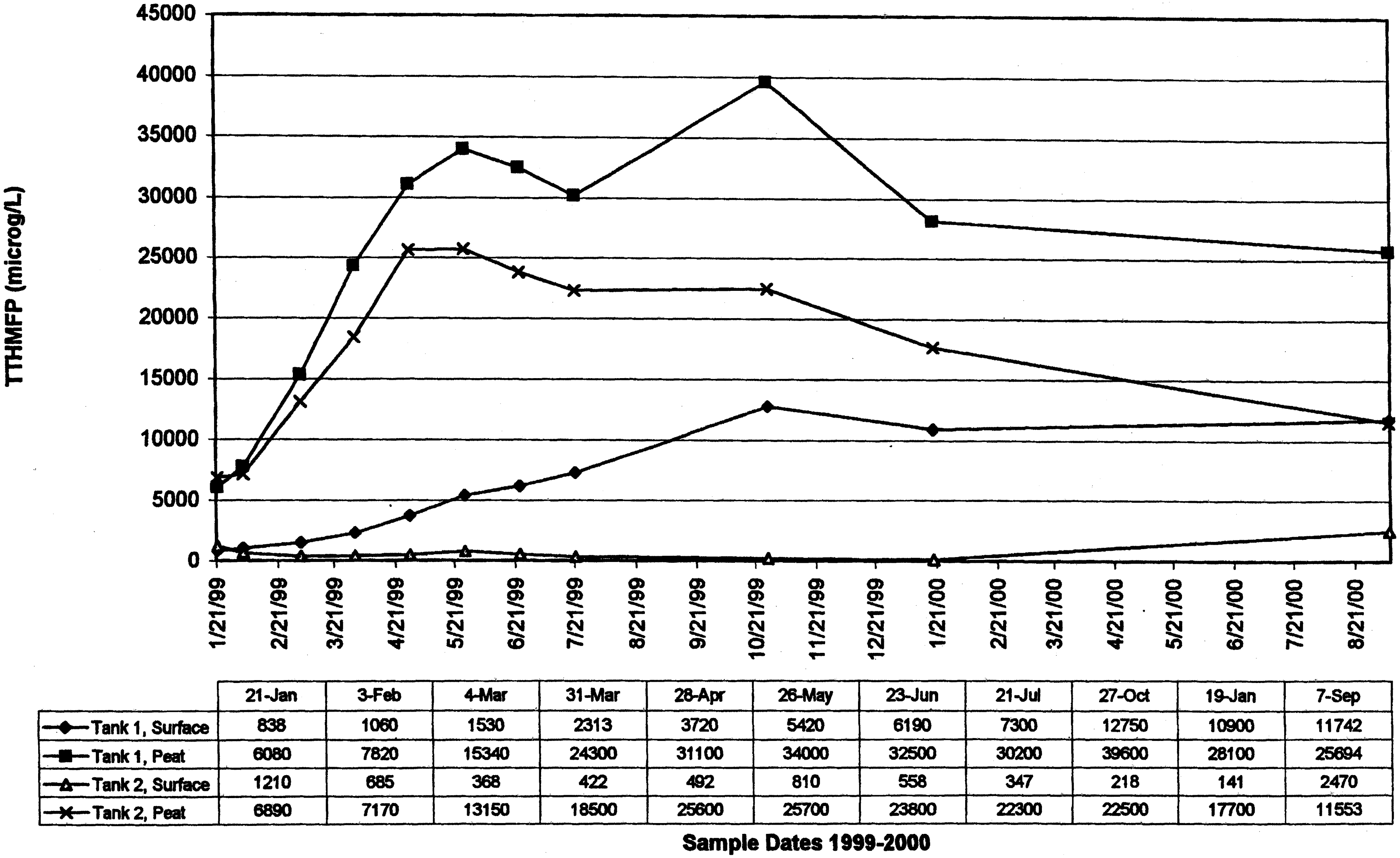
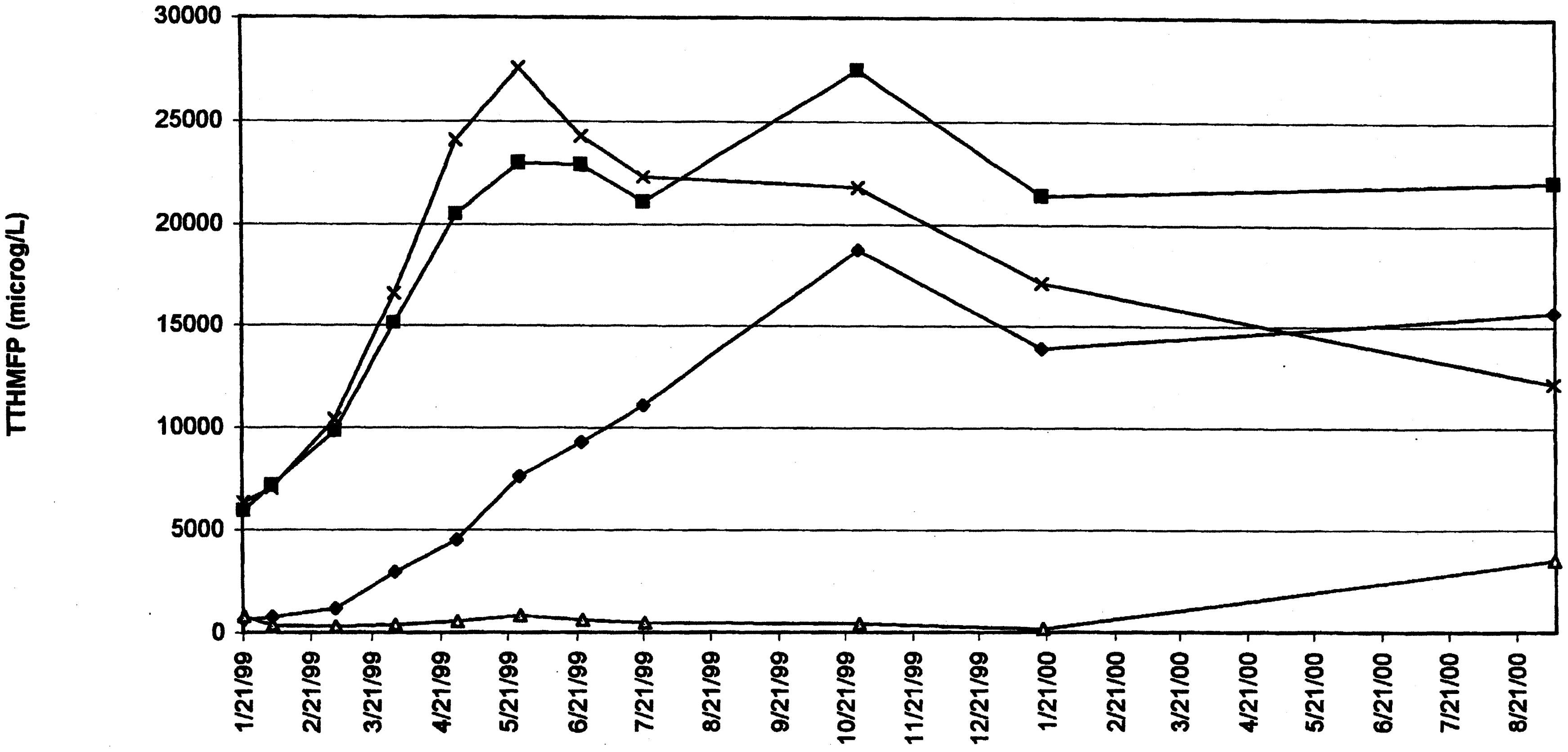


Figure 30. Tanks 1 & 2 TTHMFP



	21-Jan	3-Feb	4-Mar	31-Mar	28-Apr	26-May	23-Jun	21-Jul	27-Oct	19-Jan	7-Sep
—◆—Tank 1, Surface	838	1060	1530	2313	3720	5420	6190	7300	12750	10900	11742
—■—Tank 1, Peat	6080	7820	15340	24300	31100	34000	32500	30200	39600	28100	25694
—△—Tank 2, Surface	1210	685	368	422	492	810	558	347	218	141	2470
—✕—Tank 2, Peat	6890	7170	13150	18500	25600	25700	23800	22300	22500	17700	11553

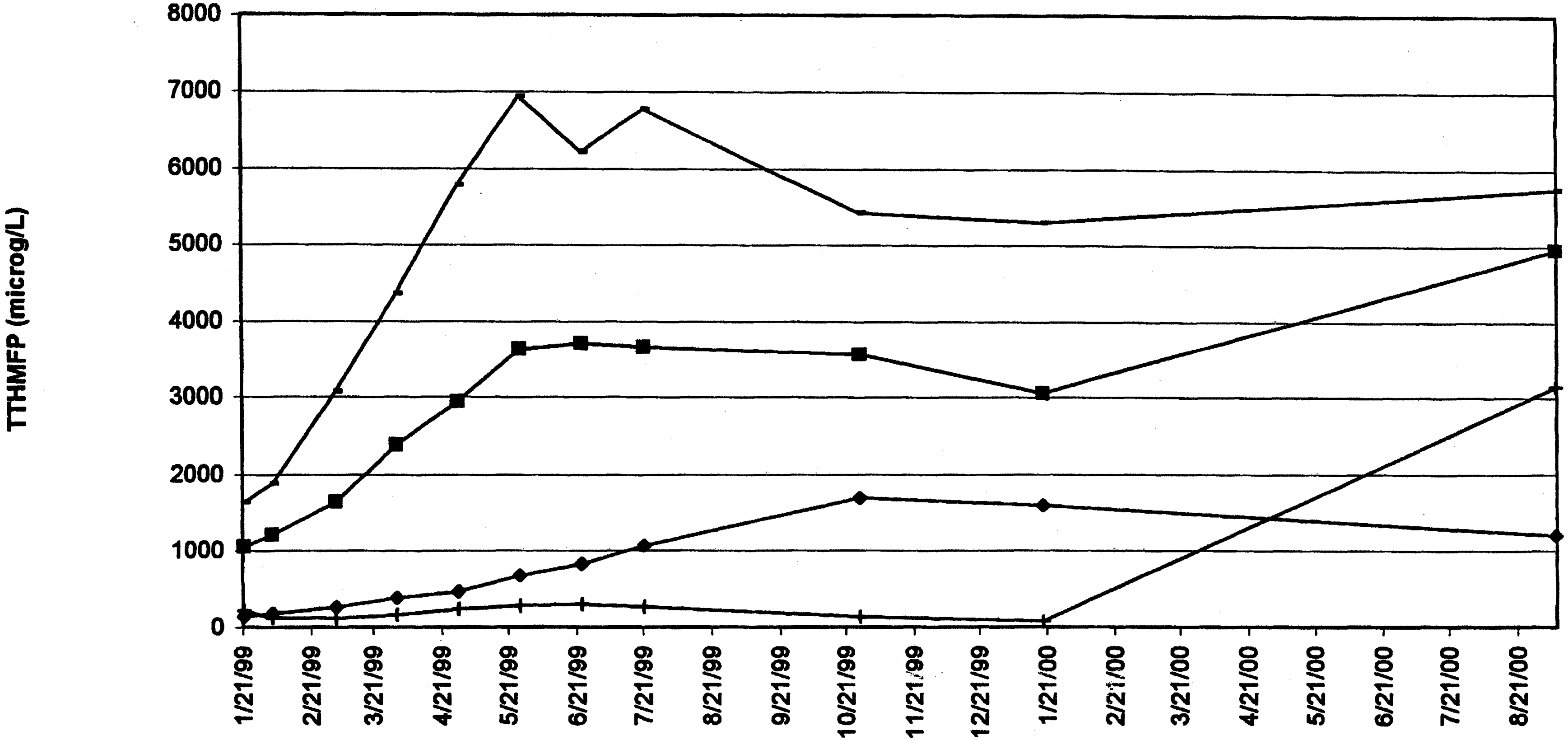
Figure 31. Tanks 3 & 4 TTHMFP



	21-Jan	3-Feb	4-Mar	31-Mar	28-Apr	26-May	23-Jun	21-Jul	27-Oct	19-Jan	7-Sep
—◆— Tank 3, Surface	664	779	1200	2968	4530	7600	9300	11100	18760	13880	15664
—■— Tank 3, Peat	5950	7150	9850	15120	20500	23000	22900	21100	27500	21400	22091
—△— Tank 4, Surface	816	376	310	405	564	850	616	488	436	176	3506
—×— Tank 4, Peat	6330	7050	10420	16600	24100	27600	24300	22300	21800	17100	12191

Sample Dates 1999-2000

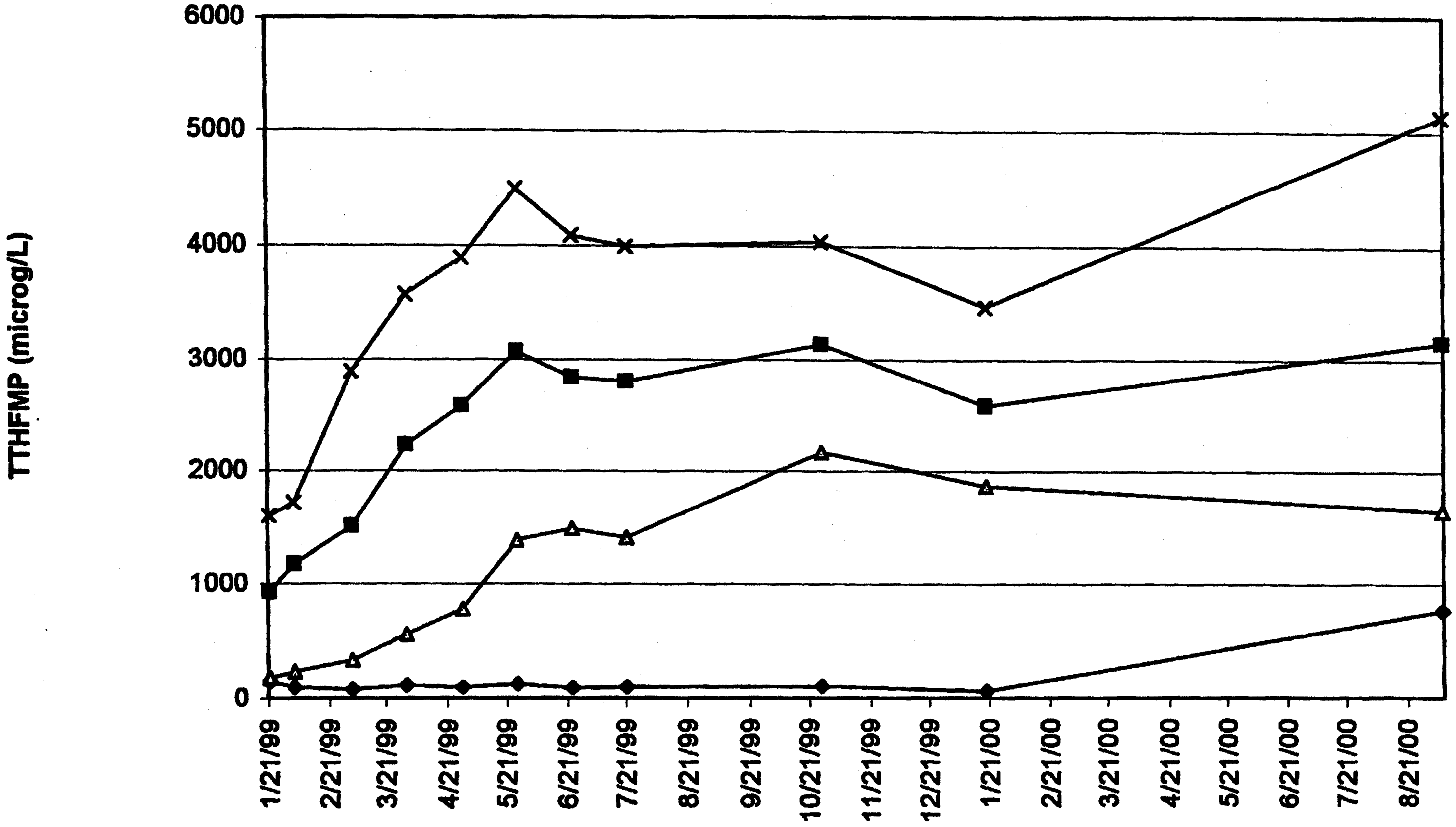
Figure 32. Tanks 5 & 8 TTHMFP



	21-Jan	3-Feb	4-Mar	31-Mar	28-Apr	26-May	23-Jun	21-Jul	27-Oct	19-Jan	7-Sep
◆ Tank 5, Surface	146	179	262	387	469	682	829	1067	1697	1597	1203
■ Tank 5, Peat	1056	1209	1640	2386	2940	3630	3700	3660	3560	3050	4954
+ Tank 8, Surface	219	122	124	169	243	284	303	272	146	86	3142
— Tank 8, Peat	1634	1880	3070	4360	5780	6940	6220	6770	5420	5300	5747

Sample Dates 1999-2000

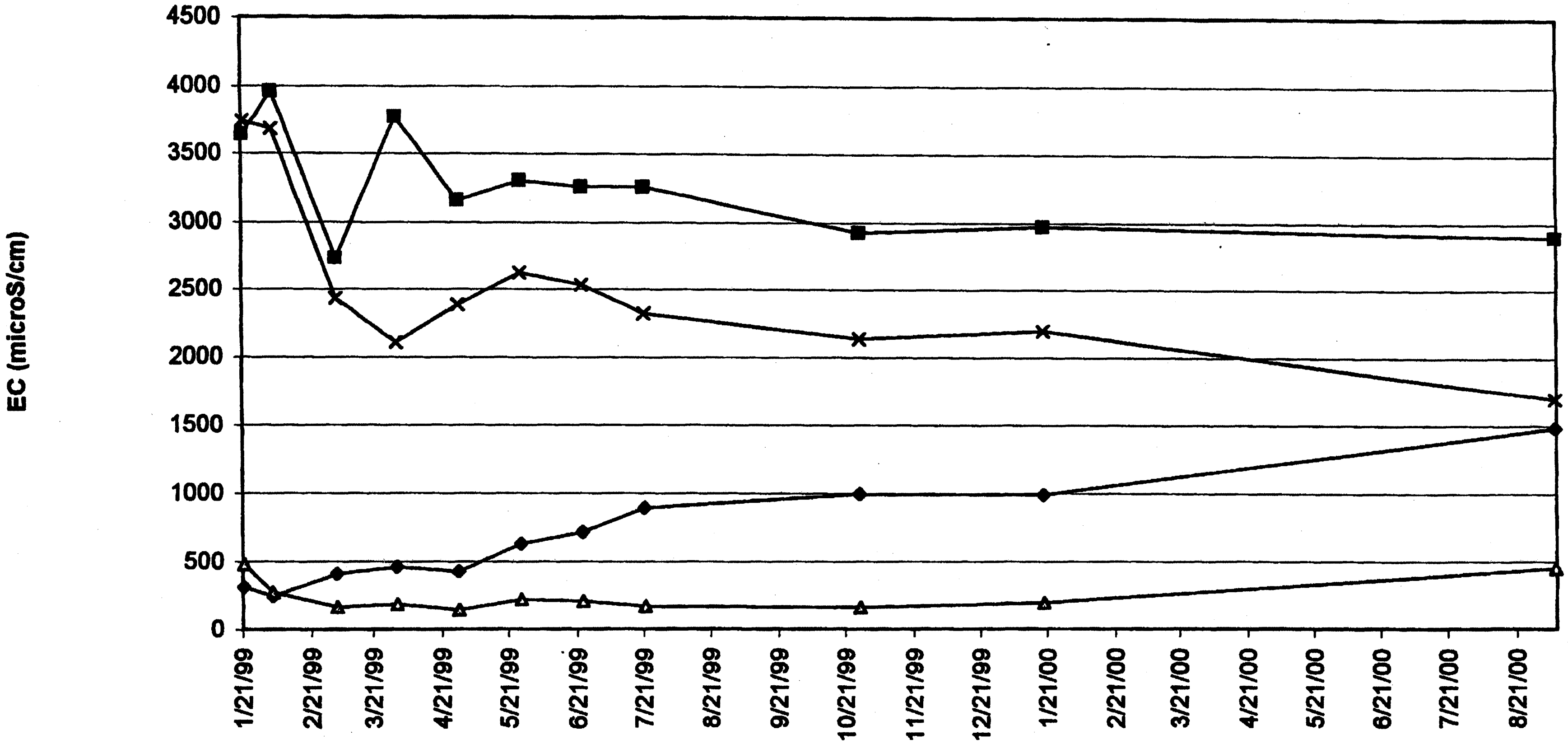
Figure 33. Tanks 6 & 7 TTHMFP



	21-Jan	3-Feb	4-Mar	31-Mar	28-Apr	26-May	23-Jun	21-Jul	27-Oct	19-Jan	7-Sep
—◆— Tank 6, Surface	154	100	84	117	100	130	98	104	107	60	773
—■— Tank 6, Peat	927	1181	1510	2234	2580	3070	2840	2800	3140	2580	3156
—△— Tank 7, Surface	178	234	335	562	781	1389	1489	1410	2170	1870	1646
—✕— Tank 7, Peat	1600	1720	2890	3570	3890	4500	4090	3990	4040	3470	5142

Sample Dates 1999-2000

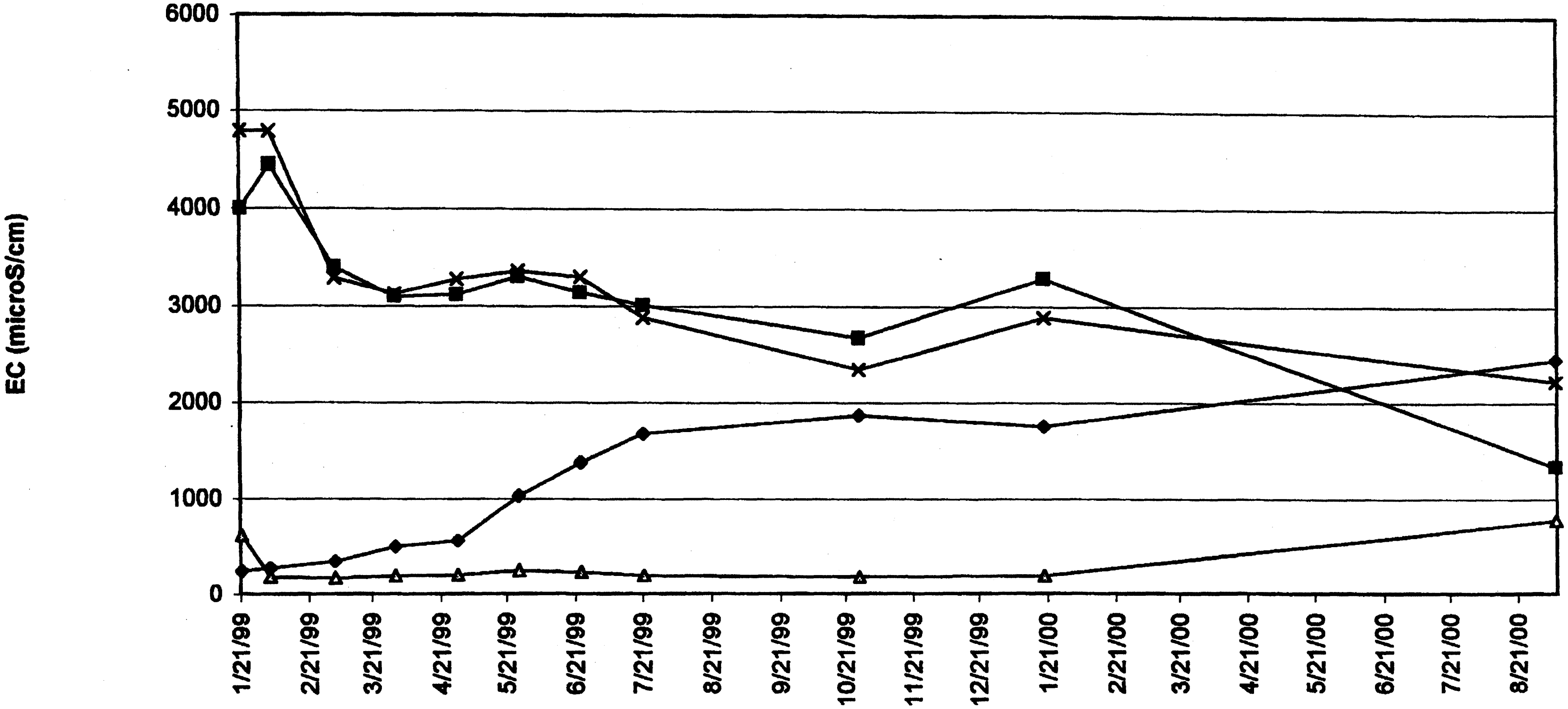
Figure 34. Tanks 1 & 2 EC



	21-Jan	3-Feb	4-Mar	31-Mar	28-Apr	26-May	23-Jun	21-Jul	27-Oct	19-Jan	7-Sep
—◆— Tank 1, Surface	312	244	411	461	428	632	717	896	995	992	1485
—■— Tank 1, Peat	3640	3960	2730	3770	3159	3310	3260	3260	2925	2974	2895
—△— Tank 2, Surface	483	276	166	186	145	219	209	169	160	193	449
—×— Tank 2, Peat	3740	3680	2430	2110	2383	2620	2530	2320	2138	2198	1702

Sample Dates 1999-2000

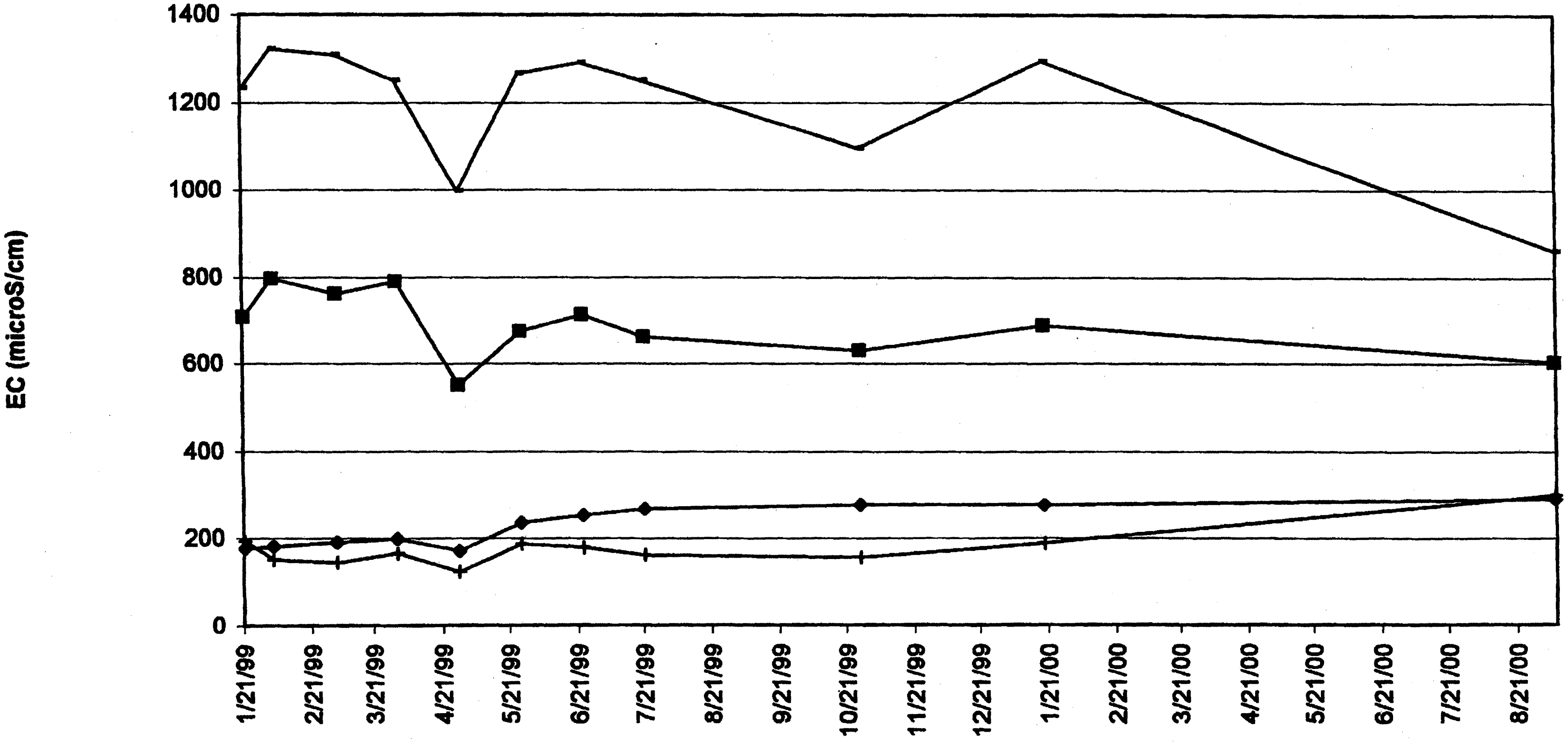
Figure 35. Tanks 3 & 4 EC



	21-Jan	3-Feb	4-Mar	31-Mar	28-Apr	26-May	23-Jun	21-Jul	27-Oct	19-Jan	7-Sep
—◆— Tank 3, Surface	248	276	348	500	563	1029	1378	1675	1864	1755	2455
—■— Tank 3, Peat	4000	4450	3400	3100	3115	3310	3140	3010	2672	3292	1332
—△— Tank 4, Surface	621	187	175	198	203	251	234	199	179	193	780
—×— Tank 4, Peat	4800	4790	3290	3130	3280	3360	3300	2880	2344	2881	2226

Sample Dates 1999-2000

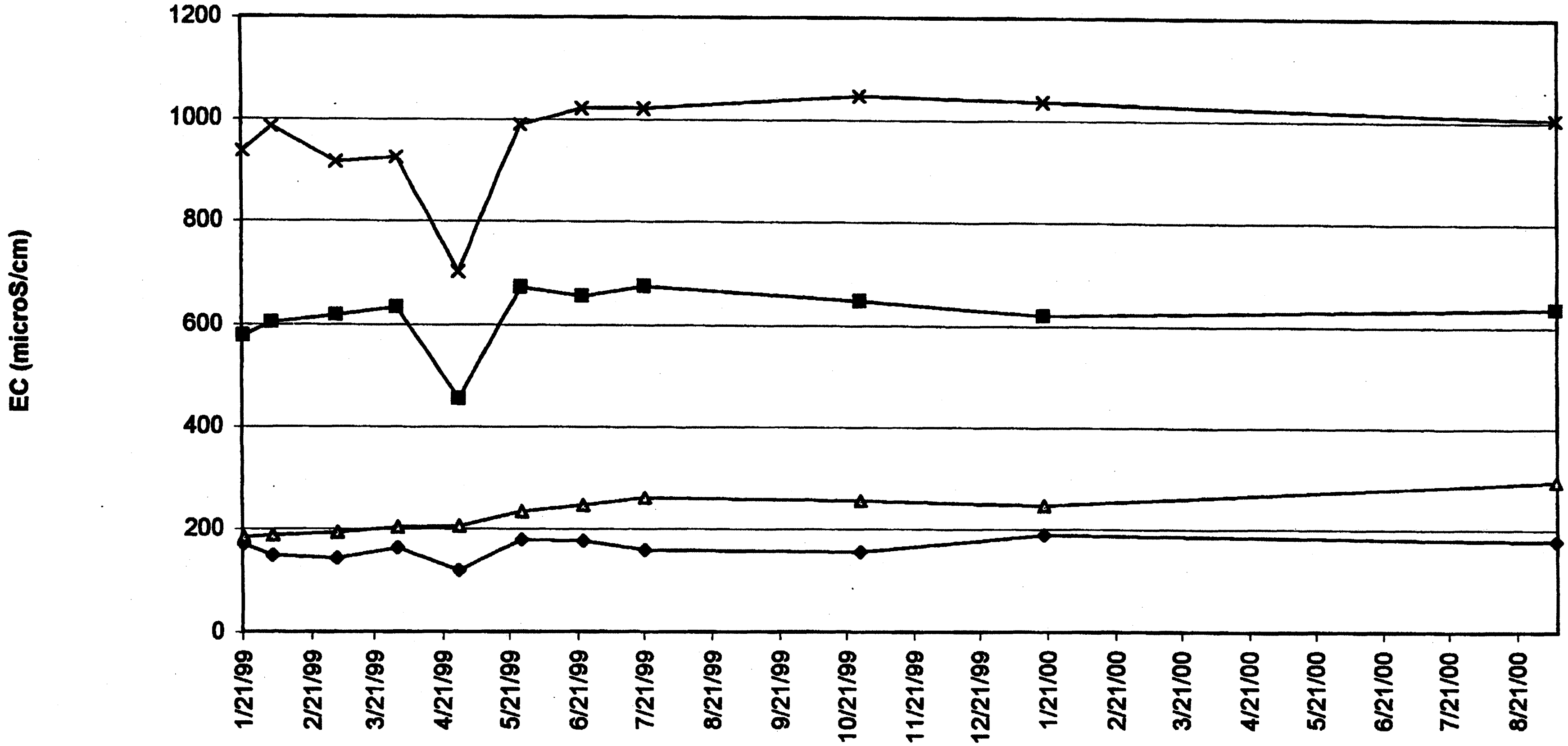
Figure 36. Tanks 5 & 8 EC



	21-Jan	3-Feb	4-Mar	31-Mar	28-Apr	26-May	23-Jun	21-Jul	27-Oct	19-Jan	7-Sep
◆ Tank 5, Surface	177	182	191	199	171	236	253	268	277	277	290
■ Tank 5, Peat	708	797	761	790	550	676	714	663	631	689	603
+ Tank 8, Surface	194	152	145	166	124	187	180	162	157	190	299
— Tank 8, Peat	1232	1321	1308	1250	998	1265	1291	1249	1096	1294	861

Sample Dates 1999-2000

Figure 37. Tanks 6 & 7 EC



	21-Jan	3-Feb	4-Mar	31-Mar	28-Apr	26-May	23-Jun	21-Jul	27-Oct	19-Jan	7-Sep
◆ Tank 6, Surface	170	148	142	163	119	179	177	158	155	189	176
■ Tank 6, Peat	578	604	619	635	455	673	656	675	648	620	636
△ Tank 7, Surface	184	188	193	204	206	234	246	261	256	246	295
× Tank 7, Peat	936	985	915	924	702	990	1021	1021	1046	1036	1006

Sample Dates 1999-2000

Data Validation

Data scatter or anomalies often occur in nature because of stochastic and deterministic processes. There is randomness in measurements and random errors occur from sampling and laboratory analyses. Duplicate samples and analyses for each sample are prohibitively expensive and unnecessary. The quality of results can be established to be consistently good through field and laboratory QA/QC procedures. In this study, at each sampling event, a blind duplicate was given to the laboratory from one of the tank samples chosen at random. Field blanks were given to check for sample contamination during sampling.

Sample duplicates are environmental samples divided into two separate aliquots and analyzed independently to determine the repeatability of the analytical method. The relative percent difference (RPD) of the duplicate results must fall within established control limits. The results for the DWR Bryte Laboratory are summarized below. All of the sample duplicate analyses that were performed were reviewed. While most duplicates fell within the control limits, the highest RPDs occurred in analyses for particulate matter samples (e.g., TOC, TKN, TP), which typically have the widest variation among all analytes. The greater RPDs are attributed to the collection of the samples and nonhomogeneous mixing or distribution rather than problems with precision and accuracy. Internal laboratory quality control measures, such as matrix spikes and method blanks, were used in conjucntion with RPDs of the duplicate samples to determine if the batch of samples had acceptable results. No samples were rejected on the basis of recoveries or RPDs outside of the limits. Data for the non-duplicate samples were used in the data analysis. The duplicate sample values of each sampling event are presented with the data in the Appendix.

The most important water quality constituents of interest in this study, which included organic carbon, UVA_{254nm}, total alkalinity, bromide, and TTHMFP, had the best recoveries. The RPD and field blank results supplemented with internal QC and calibration of the laboratory and field instruments, give us some idea of the precision and accuracy of the measurements. Based on these data and the observed data trends, we are confident about the results, including concerns about taking single water samples.

Field Blank Recoveries

Analyte	Reporting Limit	Total Analyses Reviewed	Recoveries Outside of Limits	Recoveries Outside of Limits (%)
Total Kjeldahl Nitrogen	0.1	17	1	6
Total Phosphorus	0.01	18	2	11
Dissolved Ammonia	0.01	27	0	0
Ortho-phosphate	0.01	2	0	0
Total Iron	0.005	26	1	4

Drinking Water Pre-Treatment Constituents

Analyte	Acceptance RPD (%)	Method (EPA)	Total Analyses	Recoveries Outside Limits	Frequency of Samples Out of Limits (%)
TOC	15	415.1(T)	27	7	26
DOC	15	415.1(D)	27	0	0
UVA	15	415.1(D)	27	2	7
Alkalinity	15	2320B	12	0	0
Bromide	15	300	12	0	0

Nutrient Constituents

Analyte	Acceptance RPD (%)	Method (EPA)	Total Analyses	Recoveries Outside Limits	Frequency of Samples Out of Limits (%)
Ammonia	15	350.1	27	5	19
Nitrate + Nitrite	30	4500-NO3-F (modified)	3	0	0
Total Kjeldahl Nitrogen	30	351.2	12	3	25
Orthophosphate	30	4500-P-F	3	0	0
Total Phosphorus	30	365.4	12	0	0

Treated Drinking Water Constituents

Analyte	Acceptance RPD (%)	Method (EPA)	Total Analyses	Recoveries Outside Limits	Frequency of Samples Out of Limits (%)
Bromodichloromethane	20	**	27	0	0
Bromoform	20	**	27	0	0
Chloroform	20	**	27	0	0
Dibromochloromethane	20	**	27	1	4
Total THMFP	20	**	27	0	0

**DWR THMFP Reactivity Test (7 day)

Discussion

When soil comes in contact with water, there are physical, chemical, and biological interactions that release particulate matter and dissolved constituents into the water. The major processes by which material is released to water include water erosion, decomposition, dissolution, desorption, and oxidation-reduction reactions. Processes that remove material from water include sedimentation, immobilization (uptake), precipitation, and sorption. The seasonal water quality changes that were observed in the surface water and peat soil pore water were attributed to these processes.

There were seasonal patterns in TOC/DOC concentrations in the simulated flooded peat soil environment. The trend appears to be related to seasonal temperature affects on microbial activities in the flooded peat soil and water. Microbes (e.g., bacteria, fungi) breakdown the organic matter and the rate roughly doubles or quadruples for every ten degrees rise in temperature. TOC/DOC production and buildup was slowest in the cold winter and rapidly increased in the warm spring and hot summer months. The TOC/DOC concentrations remained steady through the fall as temperatures began declining.

This study and the extensive list of papers cited show that organic matter degradation is a continuous process in flooded peat soil environments. Organic matter decomposition does not require oxygen. Anaerobic bacteria in the reduced environment will utilize other inorganic compounds (e.g., sulfate) as electron acceptors to breakdown organic matter. The porosity of peat soil and natural tendency to reach a chemical equilibrium through molecular diffusion causes soil water quality to affect the overlying surface water quality in a flooded wetland. Degradation is slower but never ceases in the reduced environment unless temperatures fall below 5°C. As a result, soluble organic matter accumulates in this large soil layer. The anaerobic soil layer, therefore, holds and provides a steady supply of organic matter and nutrients.

Anaerobic bacteria growth (non-photosynthetic) and associated processes (e.g., organic fermentation of organic carbon) and the physical process of equilibrium are independent of light. Photo-degradation plays a small role relative to other processes such as microbial degradation on organic carbon transformations, especially in the turbid Delta waters.

Predicting the water quality impact or organic carbon loading from flooded lands cannot be determined by soil organic carbon (SOC) analyses alone. Soil organic carbon consists of weakly bound and strongly bound fractions. Peat soils of similar SOC concentrations can have significantly different proportions of these two fractions. It is the weakly bound or weakly adsorbed colloidal organic carbon fraction that becomes the dissolved organic carbon when in contact with water. The data (e.g., specific absorbance and TTHMFP) showed that the DOC from submerged peat soil were humic and contained THM precursors. The strongly bound organic fraction eventually degraded and became a source of DOC during the study.

New or other soil test methods that involve filtration or centrifuging wet soil sample extracts for DOC and other constituents (e.g., iron, manganese) are needed to supplement SOC analyses to assess the "DOC formation potential" of a submerged soil. SOC data cannot serve as a reliable indicator of DOC release from wet soils. Two soil batches of similar SOC concentration in Experiment #2 were significantly different in their contribution of DOC to water primarily because of recent exposure to different environmental conditions prior to flooding.

The constraints of the SMARTS facility limited the experiments to studying only three factors that could affect seasonal water quality in a shallow flooded peat soil environment. The three factors were surface water depth, surface water exchange rate, and peat soil depth. All three were determined to be controlling factors. Other contributing factors, such as wetland plants and primary productivity, were not addressed and are probably better studied in the field. The high eutrophication potential (e.g., nutrient concentrations) seen in some of the experimental tanks could result in additional seasonal increases in organic carbon production in wetlands and become the dominant source of carbon as the wetland matures. The exclusion of studying organic carbon production from algae and higher plants does not lessen the value of the SMARTS study. Some wetland areas will be barren (>4 ft. deep) and partially vegetated so these results are still representative of the non-vegetated areas. The results also show the potential contribution of organic carbon, nutrients, and minerals from flooded Delta islands.

From the perspective of protecting drinking water quality, wetland management and planning schemes may need to adjust water depth, water exchange rates, timing and duration of flooding to minimize organic carbon levels. This may conflict with desired wetland designs for maximizing ecological benefits. Most biologically productive wetlands have large shallow (1.5 – 2 feet) areas that are permanently flooded. Water depths over 4 feet are usually too deep for wetland plants to become established.

The poorest water quality occurred under conditions of shallow water depth (2 ft.) and no surface water exchange. Those tanks that continuously received an exchange of new water at the rate of 1 to 1.5 surface water volumes per week had water quality similar to the incoming water supply due to constant dilution and flushing.

Shallow peat soil layers (1.5 and 4 feet deep) that had been submerged (2 and 7 feet) and had continuous surface water exchanged for a year, continued to release DOC eight months after the second experiment ended. Samples taken five months (6/21/00) and eight months (9/7/00) after the one-year study ended (12/21/99) strongly suggest that the seasonal cycle would repeat itself and that organic carbon was still available from the peat soil as the biogeochemical processes were repeated.

Iterations of the SMARTS experiments or similar experiments are needed to relate different Delta soils and conditions to DOC availability. The soils used in the study were taken from Twitchell Island, which is managed by DWR. Testing soil from other soil locations could yield different results because of spatial and temporal variations in Delta soils. As the peat decomposes and soil moistures change, the network of cracks, crevices, and macropores shrink and swell. These natural changes in soil structure affect leaching and flux rates of solute transport (Chertkov and Ravina, 1999; Nemati et. al., 2000; Perret et. al., 1999; Perret et. al., 2000). The study of solute leaching (De Rooji and Stagnitti, 2000; Larsson and Jarvis, 2000; Perret et. al., 2000; Ren, et. al., 2000; Si and Kachanoski, 2000) requires more than simple gross measurements of soil porosity or bulk density, which do not provide true flux measurements. Besides differences in soil structure, there will be changes in mineral and organic composition from weathering and farming.

The last extensive soil survey of the Delta was conducted sixty years ago and showed a mosaic of different mineral and organic soil types (USDA, 1941). Soil and pore water measurements that contained DOC data are few (e.g., Twitchell, Holland) and incomparable to the SMARTS peat water data due to unknown soil-to-water contact times of the field samples as well as soil differences and land use conditions. More soils related data are needed to determine what are the characteristics and variability of typical Delta soils.

The results of the study and literature review have identified some potential actions that may help reduce the impacts on the drinking water quality of the Delta, in particular, DOC loads, from converting agricultural lands to shallow wetland habitats. They include:

1. <u>Considering soil type and characteristics of proposed wetland sites.</u> Areas with mineral soils have less organic matter than organic peat soils in the Delta. This should result in less availability of DOC when flooded. Prior land use history also affects the soil characteristics (Hontoria, et. al., 1999).

2. <u>Reducing plant matter in fields prior to initial flooding.</u> As plant residues are submerged, cellulose material decomposes and contributes to the levels of DOC. Over time, the more resistant lignin fractions remain and decompose more slowly. Initial DOC concentrations can be lowered by removing or enhancing (tilling) the breakdown of crop residues in the fields (Bergman, et. al., 2000; Zak, et. al., 1999).

3. <u>Plowing agricultural soils prior to initial flooding to increase oxidation of peat soil to reduce the soil organic carbon content.</u> Non-tilled field studies (Cronan, et. al., 1999; Mahieu, et. al., 1999; Rhoton, 2000; Rochette and Angers, 1999; Schomberg and Jones, 1999; Steiner, et. al., 1999; Studerdert, et. al., 2000; Wander, et. al., 1999) show that soil organic carbon accumulated because of slower decay of crop root residues than in tilled fields. By plowing the fields in the warm summer and fall months, carbon loss via carbon dioxide releases from microbial decay will reduce the organic carbon concentrations in peat soils planned for inundation. Tilling during the cooler months was less effective in organic matter breakdown (Rhochette and Angers, 1999). Compaction of the soils prior to flooding could result in more soil organic carbon and DOC in the pore water. Plowing also disrupts the preferential flow pattern of surface water through

soil (Ogden, et. al., 2000). Disturbance of the soil macropore networks may reduce the leaching and diffusion rates of solutes in the soil column (De Rooji and Stagnitti, 2000; Perret, et. al., 1999). Land on or adjacent to the levees, however, should not be plowed as this would increase subsidence and erosion of the levees.

4. Flooding and removing drainage from agricultural fields prior to long-term inundation. Weakly adsorbed organic matter and minerals can be desorbed from the soils by rainfall, irrigation, or ponding (Kaiser and Zech, 1999). Removal of the drainage from these events will reduce the high DOC and EC laden pore water from the fields prior to permanent flooding.

5. Managing flushing and subsurface water flows. Stagnant conditions, such as in confined, non-tidal wetlands, can lead to a buildup of DOC, nutrients, and EC over time. Subsurface flow (e.g., seepage) would reduce the soil-to-water contact time in the peat soil that allows these increases. Water exchange would dilute and disperse these constituents.

6. Minimizing repeated wet and dry cycles of wetland soils. Studies of the effects of wetting and drying wetland soils show that alternating oxidation-reduction conditions can increase DOC and nutrient concentrations in the pore waters (Franzluebbers, et. al., 2000; Borken, et. al., 2000). The availability of DOC from re-wetted, exposed wetland surface soils was demonstrated in saturated paste extracts from a two-year old Holland Tract pond site (Jones and Stokes, 1995). Pore water DOC concentrations had doubled from an average starting value of 32 mg/l to about 69 mg/l after a 30 day holding time. There does not appear to be a leaching out of organic carbon from submerged peat.

Due to different field conditions and the manner in which each of the proposed actions are implemented alone or in combination, further studies should be directed on determining what are the most effective methods and how they should be conducted.

Conclusion

The experiments showed that for the protection of drinking water quality, the manipulation or selection of criteria for designing and operating confined wetlands or shallow water storage reservoirs should evaluate peat soil characteristics and flooding depths, water exchange rates, timing and duration of storage and releases, and applied water quality.

Peat soil is a rich source of organic carbon and nutrients. Under certain conditions of flooding and containment (e.g., nontidal), the floodwater concentrations of organic carbon, trihalomethane formation potential, EC, and nutrients can reach high concentrations. Municipal water utilities are concerned about these potential increases. Higher TOC levels in the Sacramento-San Joaquin Delta would force the use of more chemical coagulants at downstream municipal water treatment plants to meet new USEPA drinking water regulations for water supply TOC limits at their intakes.

Six proposed actions were developed for incorporation in a plan that restores agricultural land in the Delta to shallow wetland habitats. The combined actions could help reduce soil organic carbon and DOC availability in the fields prior to flooding and enhance the dilution and dispersion of organic carbon and nutrients released from the inundated soils. They are:

1. Selecting proposed wetland sites with low organic carbon release potential;
2. Removing crop residues in the fields prior to initial flooding;
3. Plowing the fields during the warm months prior to initial flooding (Note: Land on or adjacent to the levees, however, should not be plowed as this would increase subsidence and erosion of the levees.);
4. Flooding and draining the fields prior to long-term flooding;
5. Allowing water exchanges and movement across the wetlands; and
6. Minimizing repeated wet and dry periods on the wetlands.

The effectiveness of each action and in combination with each other are expected to vary with different field conditions and how the actions are conducted. Further studies can provide specific guidance on the best operating procedure for each action.

The study did not examine the contribution of organic matter from algae and higher plants, which may surpass that from peat soil as the wetlands develop.

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Appendices

SPECIAL MULTIPURPOSE APPLIED RESEARCH TECHNOLOGY STATION (SMARTS)

EXPERIMENT 2 - January 21, 1999 through January 20, 2000

Surface and monitoring well (piezometer) water data

Sampling wells (#1, 2, 3, 4) placed in tanks 5 & 8 (4 ft. peat soil, 7 ft. water)
#1 at 1' below peat soil surface #3 at 3' below peat soil surface
#2 at 2' below peat soil surface #4 at 4' below peat soil surface
ORP and pH measurements in enclosed chamber. Water pumped to chamber.
Measurements taken when EC was steady.
Negative Mv (millivolts) indicate anaerobic (reducing) conditions

Date: February 21, 1999

	EC	Temp.	pH		EC	Temp.	pH
TANK 8				TANK 5			
Surface Water	140	8.0		Surface Water	187	8.3	
#1	755	6.8	5.53 @ -139Mv	#1	260		6.06 @ -55Mv
#2	1030		5.38 @ -140Mv	#2	379	7.4	5.73 @ -74Mv
#3	925		5.45 @ -143Mv	#3	335	7.6	5.77 @ -76Mv
#4	955	6.8	5.74 @ -132Mv	#4	525	7.1	5.84 @ -197Mv

Date: March 17, 1999

	EC	Temp.	pH		EC	Temp.	pH
TANK 8				TANK 5			
Surface Water	150	14.6		Surface Water	186	15.4	
#1	500	15.5	5.93 @ -153Mv	#1	515	16.8	5.23 @ -138Mv
#2	1060	16.1	5.85 @ -172Mv	#2	573	16.8	5.39 @ -148Mv
#3	1100	15.9	5.85 @ -176Mv	#3	555	17.2	5.43 @ -141Mv
#4	970	17.2	6.02 @ -173Mv	#4	604	17	5.91 @ -168Mv

Date: April 13, 1999

	EC	Temp.	pH		EC	Temp.	pH
TANK 8				TANK 5			
Surface Water	167	16.5		Surface Water	199	16.3	
#1	697	17.1	6.21 @ -155Mv	#1	350	17.2	5.96 @ -125Mv
#2	1100	16.9	6.04 @ -160Mv	#2	325	17.9	5.78 @ -109Mv
#3	1065	17.3	6.04 @ -160Mv	#3	507	18	5.75 @ -122Mv
#4	967	17.4	6.2 @ -179Mv	#4	373	16.8	6.13 @ -185Mv

Date: May 12, 1999

	EC	Temp.	pH		EC	Temp.	pH
TANK 8				TANK 5			
Surface Water	158	23.1		Surface Water	227	22.0	
#1	759	22.3	6.1 @ -156Mv	#1	343	22.8	6.10 @ -48Mv
#2	918	22.1	6.09 @ -156Mv	#2	437	23.4	5.85 @ -100Mv
#3	1014	21.3	6.07 @ -160Mv	#3	545	23.3	5.80 @ -115Mv
#4	983	22.4	6.25 @ -164Mv	#4	556	23.0	6.24 @ -174Mv

SPECIAL MULTIPURPOSE APPLIED RESEARCH TECHNOLOGY STATION (SMARTS)

SAMPLING RESULTS FOR EXPERIMENT 2

Study of the Effects of Water Flow, Water Depth, and Peat Soil Depth on DOC Levels in Surface Water from Flooded Delta Island Soils

START-UP **SAMPLE DATE: December 29, 1998**

PEAT SOIL RESULTS

Analyses	Tank 1	Tank 2	Tank 3	Tank 4	Tank 5	Tank 6	Tank 7	Tank 8
Soil Organic Matter (mg/Kg) Walkely-Black Method	70000	46000	39000	48000	41000	39000	49000	40000
% Organic Matter (Gravimetric)	18	13	13	14	12	22	14	9.8
% Ash Content	56	62	63	63	14	19	21	28
% Moisture	26	24	24	23	74	59	65	62
Nitrate (mg/Kg)	16	16	12	12	1.3	1.3	1.3	2.6
Total Nitrogen (mg/Kg)	3900	3400	3300	3000	1800	1500	1800	1700
Total Kjeldahl Nitrogen (mg/Kg)	3900	3400	3300	3000	1800	1500	1800	1700
Total Phosphorus (mg/Kg)	839	751	613	700	148	211	500	186
Bromide (mg/Kg)	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Sulfate (mg/Kg)	440	290	390	380	68	150	120	230
Total Iron (mg/Kg)	15000	17000	17000	14000	2900	4000	7200	5700

NOTE: BSK Laboratories report units as SOM (soil organic matter) for the Walkley-Black method.
This is INCORRECT reporting unit. Walkley-Black method states "soil organic carbon" should be used.
BSK lab manager stated BSK uses both terms interchangeably. (personal communication)

PECIAL MULTIPURPOSE APPLIED RESEARCH TECHNOLOGY STATION (SMARTS)

EXPERIMENT 2 - January 21, 1999 through January 20, 2000

URFACE WATER

EVENT 1

Sample date: January 21, 1999

PARAMETER	TANK 1	TANK 2	TANK 3	TANK 4	TANK 5	TANK 6	TANK 7	TANK 8	TANK 9	Dup. TANK 6	Water Supply*	QA/QC RPD
OC (mg/L)	12.3	18.5	9.7	14.4	2.2	2.9	3.8	5.4	1.9	3.8		26.87
DOC (mg/L)	10.7	16.8	8.6	11.3	1.9	1.8	2.2	2.8	1.12	1.9	1.3	5.41
VA (mg/L)	0.463	0.671	0.323	0.439	0.058	0.052	0.083	0.102	0.015	0.049	0.022	5.94
pecific Absorbance Calc.	4.33	3.99	3.76	3.88	3.05	2.89	3.77	3.64	1.34	2.58	1.69	11.34
Alkalinity (mg/L)	38.1	49.5	49	53.5	129	42.5	40.2	45.1	46.9	41.3	31	2.86
mmonia (mg/L)	0.18	0.14	0.09	0.08	0.24	0.18	0.24	0.14	0.05	0.18		0.00
romide (mg/L)	0.02	0.08	0.01	0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.00
Color (Color Units)	70	250	125	350	40	60	100	140	5	60		0.00
tal Iron (mg/L)											0.489	
Nitrate + Nitrite (mg/L)	1.1	1.9	0.72	0.75	0.24	0.25	0.28	0.28	0.24	0.26		3.92
tal Kjeldahl Nitrogen (mg/L)	1.2	1.9	1.4	1.9	0.5	0.8	0.7	0.8	0.3	0.7		13.33
s. Orthophosphate (mg/L)	0.05	0.05	0.06	0.05	0.02	0.03	0.02	0.05	0.09	0.04		28.57
Total Phosphorus (mg/L)	0.13	0.24	0.35	0.34	0.08	0.12	0.16	0.43	0.18	0.12		0.00
tal Sulfate (mg/L)											22	
Bromodichloromethane (ug/L)	58	110	44	56	16	14	18	19	11	14		0.00
romoform (ug/L)	<30	<50	<20	<30	<10	<10	<10	<10	<10	<10		0.00
hloroform (ug/L)	780	1100	620	760	130	140	160	200	73	139		0.72
Dibromochloromethane (ug/L)	<30	<50	<20	<30	<10	<10	<10	<10	<10	10		0.00
TOTAL THMFP (ug/L)	838	1210	664	816	146	154	178	219	84	163		5.68
Chlorophyll-a												
eophytin-a												
Field Measurements:												
Temperature	12.0	12.0	11.8	11.7	12.1	11.9	11.9	11.9	11.6	11.9	11.9	
EC	312	483	248	621	177	170	184	194	170	170	116	
DO	9.3	5.9	7.4	6.9	9.4	9.6	8.8	9.0	11.0	9.6		
pH	6.6	6.7	6.9	7.1	7.0	7.1	7.0	7.0	7.2	7.1	8.3	
Turbidity	16.8	127.0	135.0	180.0	19.3	36.9	59.6	65.6	2.1	36.9		

NOTES: Water Supply Tank resampled on January 27, 1999, due to rust in the water supply line and the line was not adequately purged. Data shown is from January 27 resample.

Fresh water flow was started to even-numbered tanks on January 21.

SPECIAL MULTIPURPOSE APPLIED RESEARCH TECHNOLOGY STATION (SMARTS)

EXPERIMENT 2 - January 21, 1999 through January 20, 2000

SURFACE WATER

EVENT 2

Sample date: February 3, 1999

PARAMETER	TANK 1	TANK 2	TANK 3	TANK 4	TANK 5	TANK 6	TANK 7	TANK 8	TANK 9	Dup. TANK 8	Water Supply	QA/QC RPD
TOC (mg/L)	16.0	9.7	12.0	5.1	2.5	1.5	3.9	4.1	1.5	3.9		5.0
DOC (mg/L)	16.0	9.6	10.7	4.7	2.3	1.4	4.8	1.8	1.3	1.7	1.1	5.71
UVA (mg/L)	0.687	0.377	0.455	0.171	0.087	0.029	0.128	0.055	0.016	0.045	0.018	20.0
Specific Absorbance Calc.	4.29	3.93	4.25	3.64	3.78	2.07	2.67	3.06	1.23	2.65	1.64	14.3
Alkalinity (mg/L)											42	
Ammonia (mg/L)	0.13	0.05	0.13	0.04	0.27	0.03	0.21	0.04	0.09	0.04		0.0
Bromide (mg/L)											<0.01	
Color (Color Units)	140	80	200	60	50	10	70	40	<5	40		0.0
Total Iron (mg/L)											0.352	
Nitrate + Nitrite (mg/L)												
Total Kjeldahl Nitrogen (mg/L)												
Dis. Orthophosphate (mg/L)												
Total Phosphorus (mg/L)												
Dissolved Sulfate (mg/L)											20	
Bromodichloromethane (ug/L)	90	55	59	28	19	11	24	12	11	12		0.00
Bromoform (ug/L)	<50	<20	<30	16	<10	<10	<20	<10	<10	<10		0.0
Chloroform (ug/L)	970	610	720	320	160	89	210	110	65	100		9.5
Dibromochloromethane (ug/L)	<50	20	<30	12	<10	<10	<20	<10	<10	<10		0
TOTAL THMFP (ug/L)	1060	685	779	376	179	100	234	122	76	112		8.5
Chlorophyll-a												
Pheophytin-a												
Field Measurements:												
Temperature	8.8	8.4	7.8	7.7	8.7	8.0	7.9	7.9	7.4	7.9	9	
EC	244	276	276	187	182	148	188	152	173	152	154	
DO	9.0	8.9	5.7	8.0	8.5	10.0	8.0	9.9	10.4	9.9	10.2	
pH	6.8	7.0	7.1	7.2	7.3	7.3	7.3	7.2	7.3	7.2	7.11	
Turbidity	21.9	24.7	99.4	42.1	16.4	4.4	39.2	8.5	1.4	8.5	2.5	

PECIAL MULTIPURPOSE APPLIED RESEARCH TECHNOLOGY STATION (SMARTS)

EXPERIMENT 2 - January 21, 1999 through January 20, 2000

URFACE WATER

EVENT 3

Sample date: February 18, 1999

PARAMETER	TANK 1	TANK 2	TANK 3	TANK 4	TANK 5	TANK 6	TANK 7	TANK 8	TANK 9	Dup. TANK 6	Water Supply	QA/QC RPD
OC (mg/L)	20.3	4.8	14.6	3.7	3.3	1.4	4.1	1.4	1.2	1.2		15.38
DOC (mg/L)	19.7	4.5	13.4	3.5	2.5	1.2	3.6	1.4	1.3	1.2	1	0.00
UVA (mg/L)	0.9	0.192	0.611	0.132	0.097	0.028	0.156	0.039	0.017	0.024	0.016	15.38
pecific Absorbance Calc.	4.57	4.27	4.56	3.77	3.88	2.33	4.33	2.79	1.31	2.00	1.60	15.38
Alkalinity (mg/L)											39	
mmonia (mg/L)	0.03	0.02	0.03	0.03	0.31	0.02	0.07	0.02	0.12	0.02		0.00
romide (mg/L)											<0.01	
Color (Color Units)	160	60	240	40	40	5	40	15	<5	10		66.67
otal Iron (mg/L)											0.506	
Nitrate + Nitrite (mg/L)												
otal Kjeldahl Nitrogen (mg/L)												
is. Orthophosphate (mg/L)												
Total Phosphorus (mg/L)												
issolved Sulfate (mg/L)											18	
Bromodichloromethane (ug/L)	120	29	78	26	19	11	24	13	10	11		0.00
romoform (ug/L)	<50	<10	<30	<10	<10	<10	<10	<10	<10	<10		0.00
Chloroform (ug/L)	1500	390	1100	290	210	92	310	110	71	94		2.15
Dibromochloromethane (ug/L)	<50	<10	<30	<10	<10	<10	<10	<10	<10	<10		0.00
TOTAL THMFP (ug/L)	1620	419	1178	316	229	103	334	123	81	105		1.92
Chlorophyll-a												
heophytin-a												
Field Measurements:												
Temperature	10.9	10.7	10.6	10.6	10.5	10.3	10.3	10.4	10	10.3	10	
EC	386	166	302	172	186	139	191	142	172	139	141	
DO	8.99	9.24	5.9	8.2	8.29	10.17	7.29	9.8	10.65	10.17	10.2	
pH	6.47	6.56	6.4	6.5	6.67	6.66	6.68	6.52	6.75	6.66	6.72	
Turbidity	25.7	32.2	81.5	14.3	36.5	3.46	31.2	4.2	1.12	3.46		

SPECIAL MULTIPURPOSE APPLIED RESEARCH TECHNOLOGY STATION (SMARTS)

EXPERIMENT 2 - January 21, 1999 through January 20, 2000

SURFACE WATER

EVENT 4

Sample date: March 4,1999

PARAMETER	TANK 1	TANK 2	TANK 3	TANK 4	TANK 5	TANK 6	TANK 7	TANK 8	TANK 9	Dup. TANK 4	Water Supply	QA/QC RPD
TOC (mg/L)	24.3	5.0	18.3	4.6	5.4	1.6	5.0	1.7	1.2	4.7		4.26
DOC (mg/L)	23.0	4.6	16.8	4.2	2.9	1.0	3.8	1.6	1.1	4.4	0.9	9.09
UVA (mg/L)	1.08	0.193	0.833	0.171	0.139	0.026	0.21	0.047	0.017	0.171	0.017	0.0
Specific Absorbance Calc.	4.70	4.20	4.96	4.07	4.79	2.60	5.53	2.94	1.55	3.89	1.89	9.52
Alkalinity (mg/L)											41	
Ammonia (mg/L)	0.02	0.03	0.03	0.04	0.01	0.02	0.02	0.03	0.12	0.04		0.0
Bromide (mg/L)											<0.01	
Color (Color Units)	200	70	240	60	160	15	120	15	<5	50		40.0
Total Iron (mg/L)											0.358	
Nitrate + Nitrite (mg/L)												
Total Kjeldahl Nitrogen (mg/L)												
Dis. Orthophosphate (mg/L)												
Total Phosphorus (mg/L)												
Dissolved Sulfate (mg/L)											22	
Bromodichloromethane (ug/L)	130	28	100	30	22	10	25	14	10	30		0.00
Bromoform (ug/L)	<50	<10	<50	<10	<10	<10	<10	<10	<10	<10		0.0
Chloroform (ug/L)	1400	340	1100	280	240	74	310	110	60	290		6.9
Dibromochloromethane (ug/L)	<50	<10	<50	<10	<10	<10	<10	<10	<10	<10		0.00
TOTAL THMFP (ug/L)	1530	368	1200	310	262	84	335	124	70	320		6.2
Chlorophyll-a												
Pheophytin-a												
Field Measurements:												
Temperature	13.4	12.5	12.7	12.4	13.2	12.2	12.6	12.4	12.2	12.4	12.2	
EC	411	166	348	175	191	142	193	145	171	175	142	
DO	7.67	7.18	5.6	6.72	4.98	9.27	6.3	8.96	9.97	6.72	9.5	
pH	6.34	6.41	6.22	6.13	6.30	6.73	6.53	6.66	7.05	6.13	6.46	
Turbidity	33.3	24	79.6	25.4	114	3.73	34.2	6.3	2.91	25.4		

SPECIAL MULTIPURPOSE APPLIED RESEARCH TECHNOLOGY STATION (SMARTS)

EXPERIMENT 2 - January 21, 1999 through January 20, 2000

SURFACE WATER

EVENT 5

Sample date: March 17,1999

PARAMETER	TANK 1	TANK 2	TANK 3	TANK 4	TANK 5	TANK 6	TANK 7	TANK 8	TANK 9	Dup. TANK 2	Water Supply	QA/QC RPD
TOC (mg/L)	28.4	6.4	29.6	4.8	13.0	1.6	7.0	1.8	1.2	5.4		16.95
DOC (mg/L)	28.0	5.4	27.2	4.4	3.5	1.0	5.0	1.4	1.1	5.6	0.8	3.64
UVA (mg/L)	1.31	0.255	1.35	0.174	0.167	0.027	0.257	0.048	0.018	0.253	0.014	0.79
Specific Absorbance Calc.	4.68	4.72	4.96	3.95	4.77	2.70	5.14	3.43	1.64	4.52	1.75	4.42
Alkalinity (mg/L)	38	47	88	47	24	42	33	42	51	46	45	2.15
Ammonia (mg/L)	0.02	0.02	0.03	0.03	<0.01	0.02	<0.01	0.03	0.15	0.02		0.00
Bromide (mg/L)	0.14	0.03	0.17	0.09	0.03	<0.01	0.03	<0.01	<0.01	0.03	<0.01	0.00
Color (Color Units)	200	50	250	50	250	5	125	5	<5	70		33.33
Total Iron (mg/L)											0.83	
Nitrate + Nitrite (mg/L)												
Total Kjeldahl Nitrogen (mg/L)	1.9	0.6	1.9	1.4	1.4	<0.1	0.7	0.1	0.2	0.5		18.18
Dis. Orthophosphate (mg/L)												
Total Phosphorus (mg/L)	0.15	0.18	0.21	0.26	0.35	0.14	0.14	0.15	0.11	0.17		5.71
Dissolved Sulfate (mg/L)											21	
Bromodichloromethane (ug/L)	170	36	80	32	22	10	30	14	10	34		5.71
Bromoform (ug/L)	<100	<20	<100	<10	<10	<10	<10	<10	<10	<10		0.00
Chloroform (ug/L)	1600	340	1700	280	260	67	380	100	56	360		5.71
Dibromochloromethane (ug/L)	<100	<20	<100	11	<10	<10	<10	<10	<10	<10		0.00
TOTAL THMFP (ug/L)	1770	376	1780	323	282	77	410	114	66	394		4.68
Chlorophyll-a												
Pheophytin-a												
Field Measurements:												
Temperature	13.2	12.8	12.8	12.5	13.2	12.9	13.0	12.8	12.6	12.8	13.2	
EC	432	167	424	178	191	143	195	146	170	167	152	
DO	8.61	8.77	6.2	8.37	5.3	10.5	9.01	9.1	10.05	8.77	10.7	
pH	6.2	6.5	6.45	6.46	6.29	6.57	6.65	6.59	7.11	6.50	6.42	
Turbidity	38.9	20.9	74.8	21.1	346	3.32	47.8	5.13	0.85	20.9		

SPECIAL MULTIPURPOSE APPLIED RESEARCH TECHNOLOGY STATION (SMARTS)

EXPERIMENT 2 - January 21, 1999 through January 20, 2000

SURFACE WATER

EVENT 6

Sample date: March 31,1999

PARAMETER	TANK 1	TANK 2	TANK 3	TANK 4	TANK 5	TANK 6	TANK 7	TANK 8	TANK 9	Dup. TANK 8	Water Supply	QA/QC RPD
TOC (mg/L)	33.4	6.0	40.5	5.1	7.9	1.5	7.7	1.9	1.1	1.7	1.0	11.1
DOC (mg/L)	33.4	5.6	39.4	4.8	4.0	1.3	6.3	1.7	1.1	1.7	1.0	0.00
UVA (mg/L)	1.56	0.249	1.94	0.201	0.198	0.029	0.359	0.056	0.02	0.058	0.016	3.5
Specific Absorbance Calc.	4.67	4.45	4.92	4.19	4.95	2.23	5.70	3.29	1.82	3.41	1.60	3.5
Alkalinity (mg/L)											47	
Ammonia (mg/L)	0.07	0.03	0.06	0.06	<0.01	0.02	<0.01	0.05	0.15	0.04		22.2
Bromide (mg/L)											<0.01	
Color (Color Units)	250	80	400	50	350	5	180	10	<5	15		40.0
Total Iron (mg/L)											0.161	
Nitrate + Nitrite (mg/L)												
Total Kjeldahl Nitrogen (mg/L)												
Dis. Orthophosphate (mg/L)												
Total Phosphorus (mg/L)												
Dissolved Sulfate (mg/L)											25	
Bromodichloromethane (ug/L)	220	42	270	42	27	12	41	18	10	17		5.71
Bromoform (ug/L)	<83.3	<20	<83.3	<10	<10	<10	<20	<10	<10	<10		0.0
Chloroform (ug/L)	2000	360	2600	350	350	95	500	140	58	130		7.4
Dibromochloromethane (ug/L)	93	20	98	13	10	10	21	11	<10	11		0.00
TOTAL THMFP (ug/L)	2313	422	2968	405	387	117	562	169	68	158		6.7
Chlorophyll-a												
Pheophytin-a												
Field Measurements:												
Temperature	11.7	11.1	11.7	11.3	12.1	12.1	12.1	11.9	11.9	11.9	13.6	
EC	461	186	500	198	199	163	204	166	129	166	170	
DO	8.22	8.15	4.35	8.16	5.58	9.07	5.0	8.39	9.47	8.39	9.29	
pH	6.96	7.15	7.08	7.34	7.10	7.33	7.18	7.38	7.62	7.38	7.15	
Turbidity	78.7	34.5	128	25.6	157	2.69	59.8	5.22	1.31	5.22	1.32	

PECIAL MULTIPURPOSE APPLIED RESEARCH TECHNOLOGY STATION (SMARTS)

EXPERIMENT 2 - January 21, 1999 through January 20, 2000

URFACE WATER

EVENT 7

Sample date: April 13, 1999

PARAMETER	TANK 1	TANK 2	TANK 3	TANK 4	TANK 5	TANK 6	TANK 7	TANK 8	TANK 9	Dup. TANK 4	Water Supply	QA/QC RPD
OC (mg/L)	41.4	4.3	47.8	5.1	10.8	1.5	11.0	1.9	1.2	5.0		1.98
OC (mg/L)	39.3	4.2	45.1	4.6	4.3	1.0	6.9	1.5	1.0	4.5	0.8	2.20
UVA (mg/L)	1.84	0.176	2.17	0.194	0.222	0.024	0.37	0.047	0.018	0.193	0.013	0.52
pecific Absorbance Calc.	4.68	4.19	4.81	4.22	5.16	2.40	5.36	3.13	1.80	4.29	1.63	1.68
Alkalinity (mg/L)												
mmonia (mg/L)	0.04	0.03	0.08	0.07	<0.01	0.03	<0.01	0.03	0.13	0.08		13.33
romide (mg/L)											<0.01	
Color (Color Units)	350	60	600	7	250	5	200	5	<5	60		
otal Iron (mg/L)											0.084	
Nitrate + Nitrite (mg/L)												
otal Kjeldahl Nitrogen (mg/L)												
is. Orthophosphate (mg/L)												
Total Phosphorus (mg/L)												
issolved Sulfate (mg/L)											20.0	
romodichloromethane (ug/L)	280	39	340	41	31	13	45	21	11	41		0.00
romoform (ug/L)	<100	<10	<100	<10	<10	<10	<20	<20	<10	<10		0.00
Chloroform (ug/L)	2400	310	2900	310	370	75	520	130	57	310		0.00
Dibromochloromethane (ug/L)	110	12	120	13	10	<10	<20	<20	10	13		0.00
TOTAL THMFP (ug/L)	2790	361	3360	364	411	88	565	151	78	364		0.00
Chlorophyll-a												
heophytin-a												
Field Measurements:												
Temperature	15.0	14.8	14.3	14.4	14.6	14.5	14.4	14.8	14.0	14.4	15.1	
EC	465	142	410	149	195.3	127	157.2	161	133	149	150.6	
DO	7.89	8.24	4.08	7.28	6.87	9.63	6.03	9.26	9.76	7.28	9.37	
pH	6.7	6.91	6.76	6.73	6.74	7.21	6.96	7.08	7.75	6.73	7.06	
Turbidity	74.3	28.9	168	33.5	172	2.11	84.8	4.78	0.61	33.5	0.9	

SPECIAL MULTIPURPOSE APPLIED RESEARCH TECHNOLOGY STATION (SMARTS)

EXPERIMENT 2 - January 21, 1999 through January 20, 2000

SURFACE WATER

EVENT 8

Sample date: April 28, 1999

PARAMETER	TANK 1	TANK 2	TANK 3	TANK 4	TANK 5	TANK 6	TANK 7	TANK 8	TANK 9	Dup. TANK 4	Water Supply	QA/QC RPD
TOC (mg/L)	52.9	7.4	68.2	7.6	10.8	1.6	14.8	3.1	1.5	8.8		14.63
DOC (mg/L)	51.8	6.6	66.1	7.5	5.4	1.2	10.3	2.8	1.0	8.7	0.8	14.81
UVA (mg/L)	2.36	0.303	3.19	0.355	0.285	0.035	0.532	0.123	0.021	0.343	0.012	3.44
Specific Absorbance Calc.	4.56	4.59	4.83	4.73	5.28	2.92	5.17	4.39	2.10	3.94	1.50	18.23
Alkalinity (mg/L)											45	
Ammonia (mg/L)	0.03	0.04	0.05	0.11	<0.01	0.02	0.03	0.07	<0.01	0.11		0.0
Bromide (mg/L)											<0.01	
Color (Color Units)	500	125	700	125	350	10	400	40	<5	125		0.0
Total Iron (mg/L)											0.054	
Nitrate + Nitrite (mg/L)												
Total Kjeldahl Nitrogen (mg/L)												
Dis. Orthophosphate (mg/L)												
Total Phosphorus (mg/L)												
Dissolved Sulfate (mg/L)											17	
Bromodichloromethane (ug/L)	410	60	550	70	39	13	61	23	11	74		5.56
Bromoform (ug/L)	<100	<20	<167	<20	<20	<10	<20	<10	<10	33		N/A
Chloroform (ug/L)	3200	410	3800	470	430	87	720	220	52	510		8.1
Dibromochloromethane (ug/L)	110	22	180	24	<20	<10	<20	<10	<10	26		8.00
TOTAL THMFP (ug/L)	3720	492	4530	564	469	100	781	243	63	643		13.0
Chlorophyll-a												
Pheophytin-a												
Field Measurements:												
Temperature	15.3	14.9	15.1	14.5	15.4	15.2	15.7	15.4	15.7	14.5	15.9	
EC	427.6	145	563	202.6	170.5	118.6	206.4	124.4	142.5	202.6	121.7	
DO	5.97	7.03	3.83	5.14	4.74	7.89	3.04	6.66	8.11	5.14	8.4	
pH	7.03	7.0	6.72	6.76	6.61	7.0	6.74	7.01	7.24	6.76	6.83	
Turbidity	91.3	71.9	142	56	156	7.45	113	14.8	0.96	56		

SPECIAL MULTIPURPOSE APPLIED RESEARCH TECHNOLOGY STATION (SMARTS)

EXPERIMENT 2 - January 21, 1999 through January 20, 2000

SURFACE WATER

EVENT 9

Sample date: May 12, 1999

PARAMETER	TANK 1	TANK 2	TANK 3	TANK 4	TANK 5	TANK 6	TANK 7	TANK 8	TANK 9	Dup. TANK 6	Water Supply	QA/QC RPD
TOC (mg/L)	69.5	13.5	88.6	13.6	11.37	1.4	17.8	3	1	1.2		15.38
DOC (mg/L)	65.2	12	88.7	13.6	6	1.2	13.0	2.7	1.2	1.2	0.9	0.00
UVA (mg/L)	3.07	0.623	4.15	0.656	0.313	0.038	0.717	0.118	0.019	0.034	0.011	11.11
Specific Absorbance Calc.	4.71	5.19	4.68	4.82	5.22	3.17	5.52	4.37	1.58	2.83	1.22	11.11
Alkalinity (mg/L)	74	57	203	69	23	47	38	45	51	43	40	8.89
Ammonia (mg/L)	0.03	0.04	0.04	0.03	<0.01	0.02	0.02	0.04	<0.01	0.02		0.00
Bromide (mg/L)	0.56	0.1	0.95	<0.01	0.04	<0.01	0.08	0.01	<0.01	<0.01	<0.01	0.00
Color (Color Units)	600	150	800	150	250	10	400	50	<5	10		0.00
Total Iron (mg/L)											0.014	
Nitrate + Nitrite (mg/L)												
Total Kjeldahl Nitrogen (mg/L)	5.4	1.1	5.8	1.1	1.4	0.2	1.9	0.4	0.1	0.1		66.67
Dis. Orthophosphate (mg/L)												
Total Phosphorus (mg/L)	0.44	0.25	0.56	0.22	0.2	0.14	0.45	0.2	0.1	0.14		0.00
Dissolved Sulfate (mg/L)											19.0	
Bromodichloromethane (ug/L)	420	77	620	110	30	<10	60	16	<10	<10		0.00
Bromoform (ug/L)	<125	<30	<250	<30	<20	<10	<30	<10	<10	<10		0.00
Chloroform (ug/L)	3600	740	4500	720	450	84	910	200	50	76		10.00
Dibromochloromethane (ug/L)	<125	<30	<250	<20	<20	<10	<30	<10	<10	<10		0.00
TOTAL THMFP (ug/L)	4020	817	5120	830	480	84	970	216	50	76		10.00
Chlorophyll-a												
Pheophytin-a												
Field Measurements:												
Temperature	20.8	20.8	20.1	19.8	20.8	20.9	21.3	21.4	20.8	20.9	20.9	
EC	574	206	825	249	222	152	222	159	175	152	147	
DO	5.77	6.26	5.11	7.68	5.38	7.99	7.97	7.63	8.22	7.99	8.96	
pH	6.64	6.89	6.81	7.16	7.05	7.11	6.97	7.25	7.43	7.11	7.01	
Turbidity	131	62.8	149	33.1	105	4.74	122	18	0.55	4.74		

SPECIAL MULTIPURPOSE APPLIED RESEARCH TECHNOLOGY STATION (SMARTS)

EXPERIMENT 2 - January 21, 1999 through January 20, 2000

SURFACE WATER

EVENT 10

	Sample date: May 26, 1999											
PARAMETER	TANK 1	TANK 2	TANK 3	TANK 4	TANK 5	TANK 6	TANK 7	TANK 8	TANK 9	Dup. TANK 2	Water Supply	QA/QC RPD
TOC (mg/L)	80.02	11.6	115	11.8	12.3	1.4	21.8	3.8	1.1	10.3		11.87
DOC (mg/L)	76.9	9.9	109	11.1	6.9	1.4	15.7	3.5	1.1	9.7	0.8	2.04
UVA (mg/L)	3.86	0.481	5.71	0.524	0.355	0.047	0.968	0.173	0.022	0.503	0.013	4.47
Specific Absorbance Calc.	5.02	4.86	5.24	4.72	5.14	3.36	6.17	4.94	2.00	5.19	1.63	6.51
Alkalinity (mg/L)											44	
Ammonia (mg/L)	0.09	0.04	0.3	0.03	<0.01	0.03	0.02	0.04	<0.01	0.04		0.0
Bromide (mg/L)											<0.01	
Color (Color Units)	800	175	800	125	250	15	400	70	<5	150		15.3
Total Iron (mg/L)											0.129	
Nitrate + Nitrite (mg/L)												
Total Kjeldahl Nitrogen (mg/L)												
Dis. Orthophosphate (mg/L)												
Total Phosphorus (mg/L)												
Dissolved Sulfate (mg/L)											20.0	
Bromodichloromethane (ug/L)	620	90	1000	110	42	10	89	24	<10	88		2.25
Bromoform (ug/L)	<167	<20	<250	<30	<42	<10	<30	<10	<10	<20		0.0
Chloroform (ug/L)	4800	720	6600	740	640	120	1300	260	56	730		1.3
Dibromochloromethane (ug/L)	<167	<20	<250	<30	<20	<10	<30	<10	<10	<20		0.00
TOTAL THMFP (ug/L)	5420	810	7600	850	682	130	1389	284	56	818		0.9
Chlorophyll-a												
Pheophytin-a												
Field Measurements:												
Temperature	21.7	22.0	21.6	21.6	22.1	22.6	22.9	22.9	22.9	22	23.4	
EC	632	219	1029	251	236	179	234	187	180	219	161	
DO	4.42	5.21	1.34	6.8	4.51	7.22	<1	5.41	8.47	5.21	7.67	
pH	6.7	6.91	6.74	7.14	6.64	6.94	6.64	6.91	7.13	6.91	6.86	
Turbidity												

PECIAL MULTIPURPOSE APPLIED RESEARCH TECHNOLOGY STATION (SMARTS)

EXPERIMENT 2 - January 21, 1999 through January 20, 2000

URFACE WATER

EVENT 11

Sample date: June 9, 1999

PARAMETER	TANK 1	TANK 2	TANK 3	TANK 4	TANK 5	TANK 6	TANK 7	TANK 8	TANK 9	Dup. TANK 6	Water Supply	QA/QC RPD
OC (mg/L)	96.1	9.2	143	9.1	11.3	1.6	22.8	4	1.1	1.4		13.33
DOC (mg/L)	88.3	7.4	134	8.2	7.6	1.3	17.2	3.2	1.0	1.3	1.0	0.00
UVA (mg/L)	4.36	0.396	6.82	0.394	0.411	0.034	1.03	0.144	0.019	0.034	0.015	0.00
pecific Absorbance Calc.	4.94	5.35	5.09	4.80	5.41	2.62	5.99	4.50	1.90	2.62	1.50	0.00
Alkalinity (mg/L)	99	61	319	64	24	48	44	47	49	48	51	0.00
mmonia (mg/L)	0.02	0.02	0.05	0.03	0.01	0.02	<0.01	0.03	<0.01	0.02		0.00
romide (mg/L)	0.92	0.08	1.85	0.1	0.05	<0.01	0.11	0.02	<0.01	<0.01	<0.01	0.00
Color (Color Units)	800	175	1000	120	200	15	450	60	<5	10		40.00
otal Iron (mg/L)											0.076	
Nitrate + Nitrite (mg/L)												
otal Kjeldahl Nitrogen (mg/L)	6.5	0.6	7.5	0.7	0.8	<0.1	1.6	0.4	<0.1	0.1		N/A
is. Orthophosphate (mg/L)												
Total Phosphorus (mg/L)	0.58	0.2	0.65	0.15	0.13	0.14	0.53	0.18	0.1	0.13		7.41
issolved Sulfate (mg/L)											23.0	
romodichloromethane (ug/L)	730	67	1300	82	47	10	93	23	<10	10		0.00
romoform (ug/L)	<167	<20	<250	<20	<20	<10	<50	<10	<10	<10		0.00
Chloroform (ug/L)	5600	530	8000	540	750	100	1400	250	57	94		6.19
Dibromochloromethane (ug/L)	<167	<20	<250	<20	<20	<10	<50	<10	<10	<10		0.00
TOTAL THMFP (ug/L)	6330	597	9300	622	797	110	1493	273	57	104		5.61
Chlorophyll-a												
heophytin-a												
Field Measurements:												
Temperature	19.2	19.7	19.0	18.9	19.3	19.8	20.1	19.9	20.0	19.8	20.9	
EC	664	211	1177	232	243	181	238	185	182	181	176	
DO	4.81	6.4	1.51	7.61	5.68	7.92	1.37	6.4	8.65	7.92	8.85	
pH	6.75	7.11	6.89	7.27	7.07	7.07	6.97	7.22	7.56	7.07	7.04	
Turbidity	176	90.9	108	35.4	63.8	6.08	124	41.4	0.62	6.08	1.15	

SPECIAL MULTIPURPOSE APPLIED RESEARCH TECHNOLOGY STATION (SMARTS)

EXPERIMENT 2 - January 21, 1999 through January 20, 2000

SURFACE WATER

EVENT 12

Sample date: June 23, 1999

PARAMETER	TANK 1	TANK 2	TANK 3	TANK 4	TANK 5	TANK 6	TANK 7	TANK 8	TANK 9	Dup. TANK 8	Water Supply	QA/QC RPD
TOC (mg/L)	105	9.1	161	9.2	12.3	1.7	24.9	5	1.1	5.7		13.0
DOC (mg/L)	99.6	7.3	146	8.3	8.9	1.4	18.6	4	1.2	4.1	1.1	2.47
UVA (mg/L)	4.77	0.396	8.92	0.416	0.495	0.047	1.16	0.222	0.019	0.205	0.015	7.9
Specific Absorbance Calc.	4.79	5.42	6.11	5.01	5.56	3.36	6.24	5.55	1.58	5.00	1.36	10.4
Alkalinity (mg/L)											49	
Ammonia (mg/L)	0.03	0.02	0.38	0.05	<0.01	0.02	0.02	0.04	0.02	0.04	<0.01	0.0
Bromide (mg/L)											<0.01	
Color (Color Units)	1000	125	1600	100	250	15	600	100	<5	100		0.0
Total Iron (mg/L)											0.054	
Nitrate + Nitrite (mg/L)											0.09	
Total Kjeldahl Nitrogen (mg/L)											0.1	
Dis. Orthophosphate (mg/L)											0.08	
Total Phosphorus (mg/L)											0.12	
Dissolved Sulfate (mg/L)											17.0	
Bromodichloromethane (ug/L)	790	68	1400	86	49	<10	89	23	<10	24		4.26
Bromoform (ug/L)	<250	<20	<357	<20	<20	<10	<50	<10	<10	<10		0.0
Chloroform (ug/L)	5400	490	7900	530	780	98	1400	280	58	310		10.1
Dibromochloromethane (ug/L)	<250	<20	<357	<20	<20	<10	<50	<10	<10	<10		0.00
TOTAL THMFP (ug/L)	6190	558	9300	616	829	98	1489	303	58	334		9.7
Chlorophyll-a												
Pheophytin-a												
Field Measurements:												
Temperature	25.5	26.0	25.3	25.9	26.1	26.4	27.0	26.8	26.7	26.8	25.6	
EC	717	209	1378	234	253	177	246	180	185	180	165	
DO	3.12	5.06	1.13	5.07	4.44	7.38	<1	3.89	8.5	3.89	8.61	
pH	6.57	6.79	6.73	6.98	6.81	7.02	6.77	7.25	7.27	7.25	6.79	
Turbidity	210	160	61.8	32.4	60.6	6.48	146	63.7	0.44	63.7	1.23	

PECIAL MULTIPURPOSE APPLIED RESEARCH TECHNOLOGY STATION (SMARTS)

EXPERIMENT 2 - January 21, 1999 through January 20, 2000

URFACE WATER

EVENT 13

Sample date: July 7, 1999

PARAMETER	TANK 1	TANK 2	TANK 3	TANK 4	TANK 5	TANK 6	TANK 7	TANK 8	TANK 9	Dup. TANK 2	Water Supply	QA/QC RPD
OC (mg/L)	113.8	9.32	184.5	8.91	12.5	1.93	23.6	4.62	1.19	9.3		0.43
OC (mg/L)	106.5	8.05	170.1	8.28	10.3	1.39	19.54	3.66	1.07	8.04	1.1	0.12
UVA (mg/L)	5.58	0.421	8.05	0.413	0.609	0.05	1.2	0.181	0.02	0.419	0.017	0.48
pecific Absorbance Calc.	5.24	5.23	4.73	4.99	5.91	3.60	6.14	4.95	1.87	5.21	1.55	0.35
Alkalinity (mg/L)	142	57	438	62	31	44	52	47	53	58	47	1.74
mmonia (mg/L)	0.02	0.06	1.2	0.07	<0.01	0.02	0.01	0.04	<0.01	0.06		0.00
romide (mg/L)	1.38	0.11	2.68	0.11	0.09	<0.01	0.14	0.02	0.01	0.11	<0.01	0.00
Color (Color Units)	1400	140	1600	80	350	20	500	80	<5	150		6.90
otal Iron (mg/L)											0.338	
Nitrate + Nitrite (mg/L)												
otal Kjeldahl Nitrogen (mg/L)	7.2	0.8	13	0.9	1.3	0.2	2.1	0.6	0.1	0.9		11.76
is. Orthophosphate (mg/L)												
Total Phosphorus (mg/L)	0.62	0.2	0.78	0.19	0.26	0.16	0.61	0.24	0.07	0.23		13.95
issolved Sulfate (mg/L)											16.0	
romodichloromethane (ug/L)	890	71	1700	74	47	<10	96	18	<10	69		2.86
romoform (ug/L)	<250	<20	<357	<20	<20	<10	<50	<10	<10	<20		0.00
Chloroform (ug/L)	5600	500	8500	480	850	100	1400	260	48	490		2.02
Dibromochloromethane (ug/L)	<250	<20	<357	<20	<20	<10	<50	<10	<10	<20		0.00
TOTAL THMFP (ug/L)	6490	571	10200	554	897	100	1496	278	48	559		2.12
Chlorophyll-a												
heophytin-a												
Field Measurements:												
Temperature	22.7	23.2	22.9	22.8	23.1	23.3	24.2	23.8	25.0	23.2	22.5	
EC	780	177	1513	195	254	139	246	144	183	177	149	
DO	4.27	5.12	<1	4.33	2.67	5.7	<1	4.45	7.3	5.12	6.45	
pH	6.37	6.64	6.76	6.94	7.05	7.19	7.23	7.33	7.24	6.64		
Turbidity	152	105	52.7	30.1		6.52	170	52.4		105		

SPECIAL MULTIPURPOSE APPLIED RESEARCH TECHNOLOGY STATION (SMARTS)

EXPERIMENT 2 - January 21, 1999 through January 20, 2000

SURFACE WATER

EVENT 14

	Sample date: July 21, 1999											
PARAMETER	TANK 1	TANK 2	TANK 3	TANK 4	TANK 5	TANK 6	TANK 7	TANK 8	TANK 9	Dup. TANK 2	Water Supply	QA/QC RPD
TOC (mg/L)	134	6.1	211	8.6	15.5	1.9	26.4	3.5	1.2	5.8		5.0
DOC (mg/L)	121	5	200	7	12.2	1.4	20.8	3.3	1.3	4.8	0.9	6.06
UVA (mg/L)	5.82	0.244	8.6	0.365	0.729	0.04	1.31	0.151	0.02	0.259	0.015	5.9
Specific Absorbance Calc.	4.81	4.78	4.30	5.00	5.98	2.86	6.30	4.58	1.54	5.40	1.67	12.0
Alkalinity (mg/L)											41	
Ammonia (mg/L)	0.04	0.03	0.09	0.08	<0.01	0.02	<0.01	0.04	<0.01	0.02		40.0
Bromide (mg/L)											<0.01	
Color (Color Units)	1000	125	1500	120	300	15	525	80	<5	100		22.2
Total Iron (mg/L)											0.142	
Nitrate + Nitrite (mg/L)												
Total Kjeldahl Nitrogen (mg/L)												
Dis. Orthophosphate (mg/L)												
Total Phosphorus (mg/L)												
Dissolved Sulfate (mg/L)											22	
Bromodichloromethane (ug/L)	1100	47	2100	78	67	10	110	22	11	49		4.17
Bromoform (ug/L)	<250	<10	<500	<20	<30	<10	<50	<10	<10	<10		0.0
Chloroform (ug/L)	6200	300	9000	410	1000	94	1300	250	58	320		6.4
Dibromochloromethane (ug/L)	<250	<10	<500	<20	<30	<10	<50	<10	<10	<10		0.00
TOTAL THMFP (ug/L)	7300	347	11100	488	1067	104	1410	272	69	369		6.1
Chlorophyll-a	<0.05	<0.05	<0.05	4.14	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05		0.00
Pheophytin-a	<0.05	<0.05	<0.05	0.12	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05		0.00
Field Measurements:												
Temperature	19.8	20.1	20.2	19.8	20.2	20.4	21.0	20.8	21.2	20.1	20.9	
EC	851	162	1597	192	260	146	251	150	185	162	149	
DO	3.86	7.52	<1	3.91	4.47	7.87	1.31	6.23	8.97	7.52	8.55	
pH	6.24	6.39	6.75	6.75	7.03	7.11	7.08	7.41	7.62	6.39	7.05	
Turbidity	95.3	71.8	67.9	64.6	51.4	7.84	181	42.5	0.72	71.8		

SPECIAL MULTIPURPOSE APPLIED RESEARCH TECHNOLOGY STATION (SMARTS)

EXPERIMENT 2 - January 21, 1999 through January 20, 2000

SURFACE WATER

EVENT 15

Sample date: August 4, 1999

PARAMETER	TANK 1	TANK 2	TANK 3	TANK 4	TANK 5	TANK 6	TANK 7	TANK 8	TANK 9	Dup. TANK 4	Water Supply	QA/QC RPD
TOC (mg/L)	135	4.9	215	7.6	14.4	1.7	25.5	4	1.2	7.6		0.00
DOC (mg/L)	128	3.7	205	6.3	12.4	1.2	20.8	3.2	1.1	6.3	0.8	0.00
UVA (mg/L)	6.11	0.183	9.34	0.309	0.749	0.037	1.23	0.164	0.02	0.31	0.014	0.32
Specific Absorbance Calc.	4.77	4.95	4.56	4.90	6.04	3.08	5.91	5.13	1.82	4.92	1.75	0.32
Alkalinity (mg/L)	178	46	497	58	34	46	55	45	58	56	39	3.51
Ammonia (mg/L)	0.04	0.01	0.12	0.04	<0.01	0.02	0.01	0.03	<0.01	0.04		0.00
Bromide (mg/L)	1.93	0.05	3.71	0.1	0.09	<0.01	0.16	0.02	<0.01	0.1	<0.01	0.00
Color (Color Units)	1000	35	1000	80	175	15	300	40	<5	60		28.57
Total Iron (mg/L)											0.225	
Nitrate + Nitrite (mg/L)												
Total Kjeldahl Nitrogen (mg/L)	7.3	0.6	11	0.8	1.2	0.2	1.9	0.6	0.3	0.9		11.76
Dis. Orthophosphate (mg/L)												
Total Phosphorus (mg/L)	0.56	0.2	0.73	0.23	0.26	0.17	0.55	0.24	0.02	0.29		23.08
Dissolved Sulfate (mg/L)											20	
Bromodichloromethane (ug/L)	7740	40	2300	72	71	10	130	22	11	71		1.40
Bromoform (ug/L)	1390	<10	<500	<20	<30	<10	<50	<10	<10	<20		0.00
Chloroform (ug/L)	266	230	9300	360	1000	80	1500	240	57	350		2.82
Dibromochloromethane (ug/L)		<10	550	<20	<30	<10	<50	<10	<10	<20		0.00
TOTAL THMFP (ug/L)	9396	270	12150	432	1071	90	1630	262	68	421		2.58
Chlorophyll-a												
Pheophytin-a												
Field Measurements:												
Temperature	23.8	24.1	24.2	23.6	24	23.9	24.6	24.6	24.9	23.6	22.6	
EC	896	169	1675	199	268	158	261	162	190	199	159	
DO	3.97	6.05	1.01	2.98	4.81	7.54	1.07	5.29	9.43	2.98	8.54	
pH	6.31	6.52	6.72	6.85	7.01	7.16	7	7.13	7.43	6.85	6.95	
Turbidity	107	75.2	77.4	139	50.5	19.3	218	60.3	0.39	139	1.76	

SPECIAL MULTIPURPOSE APPLIED RESEARCH TECHNOLOGY STATION (SMARTS)

EXPERIMENT 2 - January 21, 1999 through January 20, 2000

SURFACE WATER

EVENT 16

Sample date: August 19, 1999

PARAMETER	TANK 1	TANK 2	TANK 3	TANK 4	TANK 5	TANK 6	TANK 7	TANK 8	TANK 9	Dup. TANK 8	Water Supply	QA/Q RPD
TOC (mg/L)	142	3.9	228	3.1	14.8	1.7	23.1	2.8	1.1	3.2		13.3
DOC (mg/L)	140	3.5	224	3	13.5	1.4	21.6	2.7	1.1	2.6	1.2	3.77
UVA (mg/L)	6.82	0.15	8.53	0.112	0.808	0.034	1.37	0.12	0.02	0.116	0.021	3.3
Specific Absorbance Calc.	4.87	4.29	3.81	3.73	5.99	2.43	6.34	4.44	1.82	4.46	1.75	0.3
Alkalinity (mg/L)											58	
Ammonia (mg/L)	0.03	0.03	0.24	0.04	0.01	0.02	0.01	0.02	<0.01	0.03		40.0
Bromide (mg/L)											<0.01	
Color (Color Units)	1200	70	1750	40	250	10	595	70	<5	60		15.3
Total Iron (mg/L)											0.081	
Nitrate + Nitrite (mg/L)												
Total Kjeldahl Nitrogen (mg/L)												
Dis. Orthophosphate (mg/L)												
Total Phosphorus (mg/L)												
Dissolved Sulfate (mg/L)											18	
Bromodichloromethane (ug/L)	1400	35	2600	32	74	13	140	22	11	21		4.65
Bromoform (ug/L)	<357	<10	<500	<10	<30	<10	<50	<10	<10	<10		0.0
Chloroform (ug/L)	6800	210	10000	180	1100	84	1600	190	52	170		11.1
Dibromochloromethane (ug/L)	<357	<10	660	<10	<30	<10	<50	<10	<10	<10		0.00
TOTAL THMFP (ug/L)	8200	245	13260	212	1174	97	1740	212	63	191		10.4
Chlorophyll-a	<0.05	<0.05	<0.05	<0.05	0.23	<0.05	<0.05	<0.05	0.94	0.66		n/a
Pheophytin-a	<0.05	<0.05	<0.05	<0.05	0.19	<0.05	<0.05	<0.05	<0.05	<0.05		0.00
Field Measurements:												
Temperature	21.6	21.8	22	21.5	22.2	21.8	22.9	22.5	23.1	22.5	22.0	
EC	903	198	1731	198	270	187	261	188	187	188	194	
DO	3.03	5.77	1.42	6.37	5.01	7.68	1.97	6.07	9.27	6.07	8.05	
pH	6.84	6.88	7.12	7.04	6.90	7.25	6.95	7.2	8.37	7.2	7.03	
Turbidity	132	94.4	94.8	15.9	50	5.6	159	37.2	0.65	37.2		

SPECIAL MULTIPURPOSE APPLIED RESEARCH TECHNOLOGY STATION (SMARTS)

EXPERIMENT 2 - January 21, 1999 through January 20, 2000

SURFACE WATER

EVENT 17

Sample date: September 1, 1999

PARAMETER	TANK 1	TANK 2	TANK 3	TANK 4	TANK 5	TANK 6	TANK 7	TANK 8	TANK 9	Dup. TANK 4	Water Supply	QA/QC RPD
OC (mg/L)	151	6.6	239	6.4	15.9	1.9	25.2	3.6	1.4	6.6		3.08
DOC (mg/L)	146	5.9	224	5.6	14.1	1.4	21.1	3.1	1.1	5.6	1.2	0.00
UVA (mg/L)	7.04	0.312	11.6	0.283	0.876	0.042	1.34	0.152	0.02	0.281	0.023	0.71
Specific Absorbance Calc.	4.82	5.29	5.18	5.05	6.21	3.00	6.35	4.90	1.82	5.02	1.92	0.71
Alkalinity (mg/L)	181	62	536	62	34	54	61	55	54	61	55	1.63
Ammonia (mg/L)	0.03	0.11	0.14	0.18	0.01	0.02	<0.01	0.03	<0.01	0.18		0.00
Bromide (mg/L)	2.44	0.07	4.56	0.07	0.11	0.01	0.18	0.02	<0.01	0.07	<0.01	0.00
Color (Color Units)	1200	150	1600	150	300	10	480	70	<5	140		6.90
Total Iron (mg/L)											0.155	
Nitrate + Nitrite (mg/L)												
Total Kjeldahl Nitrogen (mg/L)	9	0.9	12	0.9	1.3	0.2	2.1	0.5	0.1	0.9		0.00
Dis. Orthophosphate (mg/L)												
Total Phosphorus (mg/L)	0.68	0.25	0.96	0.24	0.3	0.16	0.66	0.23	0.01	0.25		4.08
Dissolved Sulfate (mg/L)											22	
Bromodichloromethane (ug/L)	1800	67	3000	65	88	16	140	22	<10	61		6.35
Bromoform (ug/L)	<357	<20	<500	<20	<30	<10	<50	<10	<10	<20		0.00
Chloroform (ug/L)	8600	470	13000	420	1500	110	1800	260	57	400		4.88
Dibromochloromethane (ug/L)	380	<20	720	<20	<30	<10	<50	<10	<10	<20		0.00
TOTAL THMFP (ug/L)	10780	537	16720	485	1588	126	1940	282	57	461		5.07
Chlorophyll-a												
Pheophytin-a												
Field Measurements:												
Temperature	21.8	21.9	22.0	22.0	22.7	22.1	22.7	22.3	23.0	22.0	21.9	
EC	938	205	1781	204	273	184	265	185	186	204	187	
DO	3.46	3.63	<1	3.8	3.5	6.73	2.4	4.99	7.85	3.8	7.54	
pH	6.85	6.68	7.12	6.88	6.73	7.17	7.0	1.08	8.18	6.88	6.9	
Turbidity	136	93.6	117	101	44.8	5.05	146	42.5	0.45	101		

SPECIAL MULTIPURPOSE APPLIED RESEARCH TECHNOLOGY STATION (SMARTS)

EXPERIMENT 2 - January 21, 1999 through January 20, 2000

SURFACE WATER

EVENT 18

Sample date: September 15, 1999

PARAMETER	TANK 1	TANK 2	TANK 3	TANK 4	TANK 5	TANK 6	TANK 7	TANK 8	TANK 9	Dup. TANK 2	Water Supply	QA/QC RPD
TOC (mg/L)	164	4.4	262	6.5	16.6	2	26.4	3.2	1.6	4.4		0.0
DOC (mg/L)	160	3.9	248	6.2	15.5	1.6	22.6	3	1.2	4	1.4	2.53
UVA (mg/L)	7.28	0.184	10.92	0.303	0.977	0.038	1.49	0.13	0.019	0.177	0.023	3.8
Specific Absorbance Calc.	4.55	4.72	4.40	4.89	6.30	2.38	6.59	4.33	1.58	4.43	1.64	6.4
Alkalinity (mg/L)											64	
Ammonia (mg/L)	0.03	0.02	0.29	0.05	0.01	0.02	0.01	0.04	0.01	0.02		0.0
Bromide (mg/L)											<0.01	
Color (Color Units)	1200	80	1800	80	250	10	40	70	<5	100		22.2
Total Iron (mg/L)											0.254	
Nitrate + Nitrite (mg/L)												
Total Kjeldahl Nitrogen (mg/L)												
Dis. Orthophosphate (mg/L)												
Total Phosphorus (mg/L)												
Dissolved Sulfate (mg/L)											26	
Bromodichloromethane (ug/L)	1800	44	3500	70	84	16	170	26	<10	42		4.65
Bromoform (ug/L)	<500	<10	<500	<20	<30	<10	<50	<10	<10	<10		0.0
Chloroform (ug/L)	8500	290	14000	400	1500	96	1900	230	50	280		3.5
Dibromochloromethane (ug/L)	<500	<10	770	<20	<30	<10	<50	<10	<10	<10		0.00
TOTAL THMFP (ug/L)	10300	334	18270	470	1584	112	2070	256	50	322		3.6
Chlorophyll-a												
Pheophytin-a												
Field Measurements:												
Temperature	21.3	21.7		21.9	22.1	21.7	22.1	22.2	22.4	21.7	21.5	
EC	926	218		227	271	213	262	213	186	218	214	
DO	3.86	5.83		5.11	4.23	7.28	1.17	4.62	7.97	5.83	7.9	
pH	7.32	7.10		6.91	6.96	7.52	6.95	7.02	8.53	7.10	7.04	
Turbidity	159	57.7		47.6	44	3.25	132	39.5	0.49	57.7		

PECIAL MULTIPURPOSE APPLIED RESEARCH TECHNOLOGY STATION (SMARTS)

EXPERIMENT 2 - January 21, 1999 through January 20, 2000

URFACE WATER

EVENT 19

Sample date: September 29, 1999

PARAMETER	TANK 1	TANK 2	TANK 3	TANK 4	TANK 5	TANK 6	TANK 7	TANK 8	TANK 9	Dup. TANK 6	Water Supply	QA/QC RPD
OC (mg/L)	161	3.7	260	6	17.1	1.7	25.7	3	1.2	1.3		26.67
OC (mg/L)	158	3.4	245	5.5	15.6	1.2	21.8	2.2	1.1	1.2	1	0.00
UVA (mg/L)	7.69	0.164	11.09	0.273	1	0.035	1.44	0.096	0.019	0.034	0.018	2.90
pecific Absorbance Calc.	4.87	4.82	4.53	4.96	6.41	2.92	6.61	4.36	1.73	2.83	1.80	2.90
Alkalinity (mg/L)	177	62	526	65	43	63	68	62	59	64	54	1.57
mmonia (mg/L)	0.03	<0.01	0.04	0.01	<0.01	0.02	<0.01	0.03	<0.01	0.01		66.67
romide (mg/L)	2.78	0.04	2.63	0.08	0.12	<0.01	0.21	0.02	0.01	0.01	<0.01	
Color (Color Units)	1200	80	2000	80	300	10	600	60	<5	10		0.00
otal Iron (mg/L)											0.376	
Nitrate + Nitrite (mg/L)												
otal Kjeldahl Nitrogen (mg/L)	9.6	0.6	14	0.7	1.4	0.2	2.3	0.4	<0.1	0.2		0.00
is. Orthophosphate (mg/L)												
Total Phosphorus (mg/L)	0.83	0.22	1	0.2	0.34	0.16	0.65	0.19	0.01	0.15		6.45
issolved Sulfate (mg/L)											16	
romodichloromethane (ug/L)	2000	38	3800	74	100	14	170	23	<10	14		0.00
romoform (ug/L)	<357	<10	<500	<20	<30	<10	<50	<10	<10	<10		0.00
Chloroform (ug/L)	8900	240	14000	420	1700	86	2000	190	52	88		2.30
Dibromochloromethane (ug/L)	400	<10	840	<20	<30	<10	<50	<10	<10	<10		0.00
TOTAL THMFP (ug/L)	11300	278	18640	494	1800	100	2170	213	52	102		1.98
Chlorophyll-a												
heophytin-a												
Field Measurements:												
Temperature	22.6	22.4	22.2	22.5	23.6	22.6	23.1	22.7	22.9	22.6	21.6	
EC	964	190	1819	198	277	186	265	188	188	186	160	
DO	4.82	6.48	3.78	5.90	4.31	6.77	<1	4.68	8	6.77	8.48	
pH	7.17	7.19	7.45	6.97	6.65	6.99	6.68	6.82	8.35	6.99	6.78	
Turbidity	162	87.3	247	51	46.3	3.56	126	30.7	0.38	3.56		

SPECIAL MULTIPURPOSE APPLIED RESEARCH TECHNOLOGY STATION (SMARTS)

EXPERIMENT 2 - January 21, 1999 through January 20, 2000

SURFACE WATER

EVENT 20

Sample date: October 13, 1999

PARAMETER	TANK 1	TANK 2	TANK 3	TANK 4	TANK 5	TANK 6	TANK 7	TANK 8	TANK 9	Dup. TANK 4	Water Supply	QA/QC RPD
TOC (mg/L)	174	3.7	270	13.1	18	1.6	25.2	2.6	1.2	12.9		1.54
DOC (mg/L)	164	3.4	250	11.7	16.1	1.2	22.3	2.1	1.1	11.8	0.8	0.85
UVA (mg/L)	8.73	0.173	12.11	0.632	1.04	0.033	1.42	0.091	0.02	0.633	0.016	0.1
Specific Absorbance Calc.	5.32	5.09	4.84	5.40	6.46	2.75	6.37	4.33	1.82	5.36	2.00	0.6
Alkalinity (mg/L)											44	
Ammonia (mg/L)	0.03	<0.01	0.05	0.03	<0.01	0.02	<0.01	0.03	<0.01	0.02		40.0
Bromide (mg/L)											<0.01	
Color (Color Units)	1500	80	2000	180	300	10	525	50	<5	180		0.0
Total Iron (mg/L)											0.705	
Nitrate + Nitrite (mg/L)												
Total Kjeldahl Nitrogen (mg/L)												
Dis. Orthophosphate (mg/L)												
Total Phosphorus (mg/L)												
Dissolved Sulfate (mg/L)											12	
Bromodichloromethane (ug/L)	2100	36	3800	160	100	<10	160	16	8	160		0.00
Bromoform (ug/L)	<357	<10	<500	<30	<50	<10	<50	<10	<1	<30		0.0
Chloroform (ug/L)	9600	270	14000	840	1700	76	1900	150	53	850		1.1
Dibromochloromethane (ug/L)	410	<10	840	<30	<50	<10	<50	<10	2	<30		0.00
TOTAL THMFP (ug/L)	12110	306	18640	1000	1800	76	2060	166	63	1010		1.0
Chlorophyll-a												
Pheophytin-a												
Field Measurements:												
Temperature	21.3	20.9	20.8	21.3	22	20.7	21.2	21.1	20.9	21.3	20.5	
EC	976	152	1839	237	278	144	260	149	189	237	141	
DO	4.74	6.45	7.4	4.20	7.84	7.14	1.5	5.73	8.36	4.20	7.96	
pH	7.38	7.39	7.87	7.14	7.07	7.35	7.05	7.20	8.55	7.14	6.96	
Turbidity	156	60.8	324	96.5	46.9	3.4	146	24.9	0.59	96.5		

PECIAL MULTIPURPOSE APPLIED RESEARCH TECHNOLOGY STATION (SMARTS)

EXPERIMENT 2 - January 21, 1999 through January 20, 2000

URFACE WATER

EVENT 21

Sample date: October 27, 1999

PARAMETER	TANK 1	TANK 2	TANK 3	TANK 4	TANK 5	TANK 6	TANK 7	TANK 8	TANK 9	Dup. TANK 8	Water Supply	QA/QC RPD
OC (mg/L)	172	3.3	286	6.2	19	2	26.7	2.1	1.3	2.1		0.00
OC (mg/L)	174	2.8	263	5.4	16.8	1.9	22.6	1.8	1.2	1.8	1.1	0.00
UVA (mg/L)	8.71	0.123	11.21	0.246	1.09	0.031	1.46	0.069	0.02	0.064	0.019	7.52
pecific Absorbance Calc.	5.01	4.39	4.26	4.56	6.49	1.63	6.46	3.83	1.67	3.56	1.73	7.52
Alkalinity (mg/L)	164	51	525	61	41	49	63	50	58	51	50	1.98
mmonia (mg/L)	0.03	0.02	0.04	0.02	0.01	0.02	0.01	0.03	<0.01	0.03		0.00
romide (mg/L)	3.09	0.03	5.82	0.07	0.13	<0.01	0.22	0.01	<0.01	0.01	<0.01	0.00
Color (Color Units)	1400	80	1600	100	375	10	600	35	<5	35		0.00
otal Iron (mg/L)											2.63	
Nitrate + Nitrite (mg/L)	1.5	0.25	1.7	0.4	0.39	0.11	0.28	0.15	<0.01	0.16		6.45
otal Kjeldahl Nitrogen (mg/L)	9	0.4	14	0.7	1.8	0.2	2.4	0.3	0.1	0.4		28.57
is. Orthophosphate (mg/L)	0.29	0.05	0.04	0.04	0.15	0.08	0.18	0.07	<0.01	0.07		0.00
Total Phosphorus (mg/L)	0.86	0.19	1.2	0.24	0.42	0.14	0.72	0.17	<0.01	0.2		16.22
issolved Sulfate (mg/L)											16	
romodichloromethane (ug/L)	2300	28	3900	66	97	11	170	16	9	14		13.33
romoform (ug/L)	<357	<10	<500	<20	<50	<10	<50	<10	<1	<10		0.00
Chloroform (ug/L)	10000	190	14000	370	1600	96	2000	130	54	110		16.67
Dibromochloromethane (ug/L)	450	<10	860	<20	<50	<10	<50	<10	2	<10		0.00
TOTAL THMFP (ug/L)	12750	218	18760	436	1697	107	2170	146	65	124		16.30
Chlorophyll-a												
heophytin-a												
Field Measurements:												
Temperature	16.9	17.1	17.2	17.2	17.6	16.8	16.9	17.2	16.6	17.2	16.9	
EC	995	160	1864	179	277	155	256	157	188	157	155	
DO	<1	7.9	6.1	7.75	5.65	8.17	2.13	7.20	8.96	7.20		
pH	7.09	7.93	7.49	7.15		7.3	6.75	7.73	8.44	7.73		
Turbidity	152	46.2	341	51.8	46	2.67	118	18.2	0.76	18.2		

SPECIAL MULTIPURPOSE APPLIED RESEARCH TECHNOLOGY STATION (SMARTS)

EXPERIMENT 2 - January 21, 1999 through January 20, 2000

SURFACE WATER

EVENT 22

Sample date: November 9, 1999

PARAMETER	TANK 1	TANK 2	TANK 3	TANK 4	TANK 5	TANK 6	TANK 7	TANK 8	TANK 9	Dup. TANK 6	Water Supply	QA/QC RPD
TOC (mg/L)	172	4.3	274	4.9	17.9	1.9	27.2	2.9	1.4	1.6		17.1
DOC (mg/L)	159	4	244	4.1	16.6	1.5	22.6	2.1	1.1	1.4	1.5	6.90
UVA (mg/L)	8.45	0.194	10.89	0.192	1.01	0.03	1.45	0.072	0.019	0.03	0.025	0.0
Specific Absorbance Calc.	5.31	4.85	4.46	4.68	6.08	2.00	6.42	3.43	1.73	2.14	1.67	6.9
Alkalinity (mg/L)											62	
Ammonia (mg/L)	0.03	0.01	0.05	0.01	0.02	0.01	<0.01	0.03	<0.01	0.01		0.0
Bromide (mg/L)											<0.01	
Color (Color Units)	1500	80	2000	80	300	5	400	40	<5	10		66.6
Total Iron (mg/L)											0.806	
Nitrate + Nitrite (mg/L)												
Total Kjeldahl Nitrogen (mg/L)												
Dis. Orthophosphate (mg/L)												
Total Phosphorus (mg/L)												
Dissolved Sulfate (mg/L)											18	
Bromodichloromethane (ug/L)	2200	44	3800	48	100	13	180	18	8	13		0.00
Bromoform (ug/L)	<357	<10	<500	<10	<50	<10	<50	<10	<1	<10		0.0
Chloroform (ug/L)	8900	290	13000	280	1500	100	1900	160	50	95		5.1
Dibromochloromethane (ug/L)	460	<10	900	<10	<50	<10	<50	<10	2	<10		0.00
TOTAL THMFP (ug/L)	11560	334	17700	328	1600	113	2080	178	60	108		4.5
Chlorophyll-a												
Pheophytin-a												
Field Measurements:												
Temperature	14.6	15.1	14.7	14.5	15.2	14.7	14.9	14.8	14.7	14.7	15.3	
EC	964	175	1904	185	277	139	207	174	188	139	182	
DO	6.74	6.96	9.34	9.62	6.29	8.31	2.18	8.22	10.5	8.31		
pH	7.45	7.45	8.02	7.81	7.36	7.47	7.18	7.45	8.53	7.47		
Turbidity	154	72	318	47	45	3	110	17	1	3		

SPECIAL MULTIPURPOSE APPLIED RESEARCH TECHNOLOGY STATION (SMARTS)

EXPERIMENT 2 - January 21, 1999 through January 20, 2000

SURFACE WATER
EVENT 23

Sample date: November 23, 1999

PARAMETER	TANK 1	TANK 2	TANK 3	TANK 4	TANK 5	TANK 6	TANK 7	TANK 8	TANK 9	Dup. TANK 2	Water Supply	QA/QC RPD
TOC (mg/L)	179	3.4	267	3.4	19.3	1.8	26.0	2.7	1.3	3.0		12.50
DOC (mg/L)	169	2.7	261	3	16.6	1.8	23.2	2.2	1.1	2.7	1.7	0.00
UVA (mg/L)	8.52	0.099	11.43	0.114	1.04	0.034	1.46	0.06	0.022	0.106	0.033	6.83
Specific Absorbance Calc.	5.04	3.67	4.38	3.80	6.27	1.89	6.29	2.73	2.00	3.93	1.94	6.83
Alkalinity (mg/L)	147	59	486	59	43	59	59	59	57	59	60	0.00
Ammonia (mg/L)	0.03	0.03	0.07	0.02	<0.01	0.02	0.01	0.03	<0.01	0.03		0.00
Bromide (mg/L)	3.46	0.02	6.29	0.03	0.15	<0.01	0.25	0.01	0.01	0.02	<0.01	0.00
Color (Color Units)	1500	70	2000	60	400	5	400	25	<5	50		33.33
Total Iron (mg/L)											0.486	
Nitrate + Nitrite (mg/L)												
Total Kjeldahl Nitrogen (mg/L)	10	0.4	14	0.4	1.2	0.2	2	0.2	<0.1	0.3		28.57
Dis. Orthophosphate (mg/L)												
Total Phosphorus (mg/L)	0.88	0.22	1.1	0.23	0.34	0.22	0.7	0.23	0.01	0.22		0.00
Dissolved Sulfate (mg/L)											26	
Bromodichloromethane (ug/L)	2200	23	3700	30	100	12	180	16	8	24		4.26
Bromoform (ug/L)	<357	<10	<833	<10	<50	<10	<50	<10	<1	<10		0.00
Chloroform (ug/L)	9200	180	12000	210	1700	120	2000	160	57	200		10.53
Dibromochloromethane (ug/L)	<357	<10	<833	<10	<50	<10	<50	<10	1	<10		0.00
TOTAL THMFP (ug/L)	11400	203	15700	240	1800	132	2180	176	66	224		9.84
Chlorophyll-a												
Pheophytin-a												
Field Measurements:												
Temperature	10.3	10.1	10.2	9.9	10.8	10.1	10	10.1	9.9	10.1	12.1	
EC	1019	203	1894	204	285	202	259	202	193	203	215	
DO	8.65	10.7	7.42	10.84	8.05	10.3	2.32	9.40	10.73	10.7		
pH	7.5	7.34	7.75	7.5	7.11	7.16	6.87	7.15	8.3	7.34		
Turbidity	151	62.7	368	30.8	42.8	2.6	109	13.2	0.7	62.7		

SPECIAL MULTIPURPOSE APPLIED RESEARCH TECHNOLOGY STATION (SMARTS)

EXPERIMENT 2 - January 21, 1999 through January 20, 2000

SURFACE WATER

EVENT 24

Sample date: December 8, 1999

PARAMETER	TANK 1	TANK 2	TANK 3	TANK 4	TANK 5	TANK 6	TANK 7	TANK 8	TANK 9	Dup. TANK 4	Water Supply	QA/QC RPD
TOC (mg/L)	180	3	272	3.1	18.5	1.9	26.4	2.1	1.2	3.0		3.2
DOC (mg/L)	168	2.6	248	2.7	16.8	1.5	22.7	1.7	1.0	2.7	1.4	0.00
UVA (mg/L)	8.72	0.095	10.5	0.101	1.03	0.027	1.45	0.041	0.019	0.098	0.022	3.0
Specific Absorbance Calc.	5.19	3.65	4.23	3.74	6.13	1.80	6.39	2.41	1.90	3.63	1.57	3.0
Alkalinity (mg/L)											55	
Ammonia (mg/L)	0.06	0.04	0.09	0.03	<0.01	0.02	0.04	0.04	<0.01	0.03		0.0
Bromide (mg/L)											<0.01	
Color (Color Units)	1750	20	2000	40	400	15	400	20	<5	40		0.0
Total Iron (mg/L)											0.645	
Nitrate + Nitrite (mg/L)												
Total Kjeldahl Nitrogen (mg/L)												
Dis. Orthophosphate (mg/L)												
Total Phosphorus (mg/L)												
Dissolved Sulfate (mg/L)											19	
Bromodichloromethane (ug/L)	2200	22	3900	31	98	10	160	11	8	30		3.28
Bromoform (ug/L)	<357	<10	<500	<10	<50	<1	<50	<10	<1	<10		0.0
Chloroform (ug/L)	9000	150	12000	180	1600	91	1800	110	47	180		0.0
Dibromochloromethane (ug/L)	<357	<10	760	<10	<50	<1	<50	<10	<1	<10		0.00
TOTAL THMFP (ug/L)	11200	172	16660	211	1698	101	1960	121	55	210		0.4
Chlorophyll-a												
Pheophytin-a												
Field Measurements:												
Temperature	9.0	8.7	8.6	8.4	9.5	8.8	8.7	8.8	8.3	8.4	10.0	
EC	1024	197	1840	202	284	193	258	193	193	202	189	
DO	9.63	10.18	8.49	10.26	8.15	10.15	5.06	9.7	10.67	10.30		
pH	7.5	7.48	7.69	7.53	7.49	7.46	7.45	7.7	8.32	7.53	7.24	
Turbidity	133	34	326	21.4	46.5	2.2	93.5	5.26	0.83	21.4	2.35	

SPECIAL MULTIPURPOSE APPLIED RESEARCH TECHNOLOGY STATION (SMARTS)

EXPERIMENT 2 - January 21, 1999 through January 20, 2000

SURFACE WATER

EVENT 25

Sample date: December 21, 1999

PARAMETER	TANK 1	TANK 2	TANK 3	TANK 4	TANK 5	TANK 6	TANK 7	TANK 8	TANK 9	Dup. TANK 4	Water Supply	QA/QC RPD
TOC (mg/L)	176	3.6	263	3.4	17.3	1.5	26.4	2	1.3	3.3		2.99
DOC (mg/L)	174	2.6	256	3.1	16.7	1.4	22.8	1.6	1.2	3.1	1.2	0.00
UVA (mg/L)	8.52	0.105	10.57	0.116	1.04	0.023	1.37	0.036	0.02	0.131	0.018	12.15
Specific Absorbance Calc.	4.90	4.04	4.13	3.74	6.23	1.64	6.01	2.25	1.67	4.23	1.50	12.15
Alkalinity (mg/L)	144	57	425	60	43	55	56	57	54	60	57	0.00
Ammonia (mg/L)	0.04	0.04	0.04	0.03	0.01	<0.01	0.02	0.04	<0.01	0.03		0.00
Bromide (mg/L)	3.58	0.03	6.61	0.04	0.15	<0.01	0.25	<0.01	<0.01	0.04	<0.01	0.00
Color (Color Units)	1750	50	2000	50	350	<5	600	10	<5	40		22.22
Total Iron (mg/L)											0.427	
Nitrate + Nitrite (mg/L)												
Total Kjeldahl Nitrogen (mg/L)	9.6	0.4	6.6	0.2	1.4	0.2	1.9	0.1	0.1	0.3		40.00
Dis. Orthophosphate (mg/L)												
Total Phosphorus (mg/L)	0.85	0.28	0.43	0.18	0.32	0.23	0.53	0.25	<0.01	0.23		24.39
Dissolved Sulfate (mg/L)											14	
Bromodichloromethane (ug/L)	1900	23	3100	33	84	9	150	12	7	34		2.99
Bromoform (ug/L)	<357	<10	<500	<10	<50	<1	<50	<1	<1	<10		0.00
Chloroform (ug/L)	7000	150	9100	170	1400	68	1600	87	48	180		5.71
Dibromochloromethane (ug/L)	<357	<10	670	<10	<50	1	<50	1	1	<10		0.00
TOTAL THMFP (ug/L)	8900	173	12870	203	1484	78	1750	100	56	214		5.28
Chlorophyll-a												
Pheophytin-a												
Field Measurements:												
Temperature	12.1	10.4	10.6	10.4	11.3	10.4	10.4	10.4	9.8	10.4	11.1	
EC	1006	187	1815	194	284	183	254	183	194	194	184	
DO	9.24	10.27	8.6	10.15	9.25	10.6	6.33	10.40	11.88	10.15		
pH	7.15	7.50	7.75	7.64	7.30	7.33	7	7.40	7.92	7.64		
Turbidity	162	44.1	308	34.3	44.7	1.99	148	4.86	0.5	34.3	2.12	

SPECIAL MULTIPURPOSE APPLIED RESEARCH TECHNOLOGY STATION (SMARTS)

EXPERIMENT 2 - January 21, 1999 through January 20, 2000

SURFACE WATER

EVENT 26

Sample date: January 5, 2000

PARAMETER	TANK 1	TANK 2	TANK 3	TANK 4	TANK 5	TANK 6	TANK 7	TANK 8	TANK 9	Dup. TANK 6	Water Supply	QA/QC RPD
TOC (mg/L)	169	2.3	253	3.1	17.6	1.4	25.3	1.6	1.1	1.0		33.3
DOC (mg/L)	164	1.9	243	2.6	16.0	1.1	21.5	1.2	1.0	1	0.9	9.52
UVA (mg/L)	8.74	0.077	10.4	0.114	1.04	0.02	1.36	0.029	0.022	0.02	0.018	0.0
Specific Absorbance Calc.	5.33	4.05	4.28	4.38	6.50	1.82	6.33	2.42	2.20	2.00	2.00	9.5
Alkalinity (mg/L)											58	
Ammonia (mg/L)	0.04	0.04	0.22	0.04	0.01	<0.01	0.01	0.02	<0.01	0.01		N/A
Bromide (mg/L)											<0.01	
Color (Color Units)	2000	50	1750	50	350	10	600	10	5	10		0.0
Total Iron (mg/L)											0.472	
Nitrate + Nitrite (mg/L)												
Total Kjeldahl Nitrogen (mg/L)												
Dis. Orthophosphate (mg/L)												
Total Phosphorus (mg/L)												
Dissolved Sulfate (mg/L)											20	
Bromodichloromethane (ug/L)	2000	18	3500	33	96	9	170	11	8	9		0.00
Bromoform (ug/L)	<357	<10	<500	<10	<50	<1	<50	<1	<1	<1		0.0
Chloroform (ug/L)	7200	126	10000	180	1500	59	1800	69	46	58		1.7
Dibromochloromethane (ug/L)	<357	<10	800	<10	<50	1	<50	2	1	1		0.00
TOTAL THMFP (ug/L)	9200	144	14300	213	1596	69	1970	82	55	68		1.4
Chlorophyll-a												
Pheophytin-a												
Field Measurements:												
Temperature	8.9	8.3	8.9	8.2	8.9	8.1	8.3	8.1	7.5	8.1	9.6	
EC	953	181	1698	187	270	180	243	180	124	180	182	
DO	9.9	10.76	5.2	10.90	9.68	11.2	6.88	10.50	12.1	11.2		
pH	6.12	6.10	6.5	6.9	6.66	6.71	6.74	6.90	6.94	6.71		
Turbidity	138	25.2	223	30.5	41.9	2.35	134	18.1	3.05	2.35		

PECIAL MULTIPURPOSE APPLIED RESEARCH TECHNOLOGY STATION (SMARTS)

EXPERIMENT 2 - January 21, 1999 through January 20, 2000

URFACE WATER

EVENT 27

Sample date: January 19, 2000

PARAMETER	TANK 1	TANK 2	TANK 3	TANK 4	TANK 5	TANK 6	TANK 7	TANK 8	TANK 9	Dup. TANK 8	Water Supply	QA/QC RPD
OC (mg/L)	173	2.4	259	2.7	18.5	1.4	29.2	1.4	1.2	1.3		7.41
DOC (mg/L)	171	2.2	249	2.4	16.1	1.2	21.9	1.3	1.1	1.3	1.2	0.00
UVA (mg/L)	7.54	0.082	10.4	0.093	1.02	0.02	1.29	0.029	0.02	0.028	0.021	3.51
pecific Absorbance Calc.	4.41	3.73	4.18	3.88	6.34	1.67	5.89	2.23	1.82	2.15	1.75	3.51
Alkalinity (mg/L)	146	55	402	54	43	53	53	53	52	54	38	1.87
mmonia (mg/L)	0.04	0.06	0.09	0.05	0.01	<0.01	0.01	0.03	<0.01	0.03		0.00
romide (mg/L)	3.48	0.02	6.38	0.03	0.13	<0.01	0.23	<0.01	<0.01	<0.01	<0.01	0.00
Color (Color Units)	1750	35	1400	50	350	5	800	15	5	15		0.00
otal Iron (mg/L)											1.35	
Nitrate + Nitrite (mg/L)	1.5	0.26	1.6	0.31	0.37	0.16	0.43	0.17	<0.01	0.17		0.00
Total Kjeldahl Nitrogen (mg/L)	9.3	0.5	12	0.3	1.3	<0.1	2	0.2	<0.1	0.1		66.67
is. Orthophosphate (mg/L)	0.25	0.07	0.06	0.05	0.13	0.12	0.1	0.1	<0.1	0.11		9.52
Total Phosphorus (mg/L)	0.82	0.23	0.67	0.2	0.3	0.18	0.5	0.21	<0.1	0.19		10.00
issolved Sulfate (mg/L)											25	
Bromodichloromethane (ug/L)	2200	21	3300	26	97	8	170	11	8	10		9.52
romoform (ug/L)	<357	<10	<500	<10	<50	<1	<50	<1	<1	<1		0.00
Chloroform (ug/L)	8700	120	9800	150	1500	51	1700	73	51	68		7.09
Dibromochloromethane (ug/L)	<357	<10	780	<10	<50	1	<50	2	2	1		66.67
TOTAL THMFP (ug/L)	10900	141	13880	176	1597	60	1870	86	61	79		8.48
Chlorophyll-a												
heophytin-a												
Field Measurements:												
Temperature	13.9	11.7	12.2	11.7	11.5	11.3	11.4	11.3	11.1	11.3	11.7	
EC	992	193	1755	193	277	189	246	190	189	190		
DO	9.68	11.1	5.14	11.13	10.72	11.69	6.89	11.30	12.8	11.30	163	
pH	7.26	7.45	7.44	7.54	7.41	7.2	7.18	7.26	7.86	7.26		
Turbidity	137	84.2	224	32.5	43.5	1.92	161	3.89	0.45	3.89		

SPECIAL MULTIPURPOSE APPLIED RESEARCH TECHNOLOGY STATION (SMARTS)

EXPERIMENT 2 - January 21, 1999 through January 20, 2000

SURFACE WATER

EVENT 28

Sample date: June 21, 2000

PARAMETER	TANK 1	TANK 2	TANK 3	TANK 4	TANK 5	TANK 6	TANK 7	TANK 8	TANK 9	Dup. TANK 3	Water Supply	QA/QC RPD
TOC (mg/L)	218	26.3	329	49.9	22.1	5.8	33.5	14.6	1.5	329		0.00
DOC (mg/L)	219	26.2	322	48.3	21.5	5.5	30.7	14.1	1.6	326		1.23
UVA (mg/L)												
Specific Absorbance Calc.												
Alkalinity (mg/L)												
Ammonia (mg/L)												
Bromide (mg/L)												
Color (Color Units)												
Total Iron (mg/L)												
Nitrate + Nitrite (mg/L)												
Total Kjeldahl Nitrogen (mg/L)												
Dis. Orthophosphate (mg/L)												
Total Phosphorus (mg/L)												
Dissolved Sulfate (mg/L)												
Bromodichloromethane (ug/L)												
Bromoform (ug/L)												
Chloroform (ug/L)												
Dibromochloromethane (ug/L)												
TOTAL THMFP (ug/L)												
Chlorophyll-a												
Pheophytin-a												
Field Measurements:												
Temperature	25.1	26.1	25.6	26.3	27.3	28.2	28.7	29.1	29.2	25.6		
EC	1330	382.2	2278	603	301	195	282	266	205	2278		
DO	2.54	2.7	1.58	<1	1.55	1.7	1.3	<1	3.4	1.58		
pH	7.03	6.98	7.29	6.92	6.78	6.97	7	6.92	7.37	7.29		
Turbidity	33.5	32.5	281	33.3	29.1	7.15	94.3	34.1	0.42	281		

SPECIAL MULTIPURPOSE APPLIED RESEARCH TECHNOLOGY STATION (SMARTS)

EXPERIMENT 2 - January 21, 1999 through January 20, 2000

URFACE WATER EVENT 29	Sample date: September 7, 2000											
PARAMETER	TANK 1	TANK 2	TANK 3	TANK 4	TANK 5	TANK 6	TANK 7	TANK 8	TANK 9	Dup. TANK 4	Water Supply	QA/QC RPD
OC (mg/L)	237	40.9	354	81.8	26.4	9.3	31.5	17.2	1.4	80		2.48
DOC (mg/L)	242	40.7	370	79.6	27.3	8.8	30.5	17.1	1.3	80.8		1.50
UVA (mg/L)	15.5	1.95	15	3.62	1.66	0.631	1.89	0.896	0.025	3.71		2.46
pecific Absorbance Calc.	6.40	4.79	4.05	4.55	6.08	7.17	6.20	5.24	1.92	4.59		0.96
Alkalinity (mg/L)												
mmonia (mg/L)	0.06	0.03	0.05	0.03	0.02	0.02	0.02	0.03	0.02	0.02		40.00
romide (mg/L)												
Color (Color Units)												
otal Iron (mg/L)												
Nitrate + Nitrite (mg/L)												
otal Kjeldahl Nitrogen (mg/L)												
is. Orthophosphate (mg/L)												
Total Phosphorus (mg/L)												
issolved Sulfate (mg/L)												
Bromodichloromethane (ug/L)												
romoform (ug/L)												
hloroform (ug/L)												
Dibromochloromethane (ug/L)												
TOTAL THMFP (ug/L)	0	0	0	0	0	0	0	0	0	0		######
Chlorophyll-a												
heophytin-a												
Field Measurements:												
Temperature	20.8	21.3	20.3	21.2	22.2	22.3	22.1	22.7	22.6	21.2		
EC	1485	449	2455	780	290	176	295	299	203	780		
DO	4.8	4.03	3.69	2.58	3.86	4.5	2.57	3.03	6.2	2.58		
pH	7.21	7.21	7.45	7.26	7.17	7.17	7.6	7.23	7.54	7.26		
Turbidity	134	26.2	347	50.3	33.2	31.3	61.6	14.6	0.65	50.3		

PECIAL MULTIPURPOSE APPLIED RESEARCH TECHNOLOGY STATION (SMARTS)

EXPERIMENT 2 - January 21, 1999 through January 20, 2000

eat Water

JANUARY 1999

Sample date: January 21, 1999

ARAMETER	TANK 1	TANK 2	TANK 3	TANK 4	TANK 5	TANK 6	TANK 7	TANK 8
OC (mg/L)	92.5	109	94.5	98	162	87.5	220	201
DOC (mg/L)	82.1	96	85.5	94.6	14.1	11.3	27.5	27.9
VA (mg/L)	2.23	2.82	2.52	2.56	0.467	0.389	1.53	0.892
Specific Absorbance Calc.	2.72	2.94	2.95	2.71	3.31	3.44	5.56	3.20
lkalinity (mg/L)	72.3	152	114	119	34.2	28.8	54.5	35.5
mmonia (mg/L)	0.98	1.1	0.87	1.1	2.8	3.4	4.5	4.1
Bromide (mg/L)	1.04	0.72	0.64	0.68	0.31	0.2	0.24	0.28
olor (Color Units)	250	400	310	300	625	750	750	750
Nitrate + Nitrite (mg/L)	13	12	11	16	0.01	<0.01	0.02	<0.01
otal Kjeldahl Nitrogen (mg/L)	12	20	12	12	46	15	18	150
is. Orthophosphate (mg/L)	0.07	0.04	0.02	0.02	<0.01	<0.01	0.04	<0.01
Total Phosphorus (mg/L)	0.94	2.9	1.3	1.9	5.1	1.9	2.4	23
romodichloromethane (ug/L)	840	900	730	840	200	150	200	240
Bromoform (ug/L)	<167	<250	<167	<250	<50	<50	<83	<83
hloroform (ug/L)	5000	5700	5000	5200	790	720	1400	1300
ibromochloromethane (ug/L)	240	290	220	290	66	57	<83	94
TOTAL THMFP (ug/L)	6080	6890	5950	6330	1056	927	1600	1634
ield Measurements:								
Temperature	10.8	10.2	9.8	9.9	10.4	10.3	10.3	10.4
EC	3640	3740	4000	4800	708	578	936	1232
O	2.2	4.0	4.1	2.1	2.5	1.8	0.9	1.1
pH	5.8	6.2	5.9	5.9	6.1	6.1	6.1	5.9

SPECIAL MULTIPURPOSE APPLIED RESEARCH TECHNOLOGY STATION (SMARTS)

EXPERIMENT 2 - January 21, 1999 through January 20, 2000

Peat Water

FEBRUARY 1999

Sample date: February 3, 1999

PARAMETER	TANK 1	TANK 2	TANK 3	TANK 4	TANK 5	TANK 6	TANK 7	TANK 8
TOC (mg/L)	140	118	121	120	32.3	24	42.5	41.5
DOC (mg/L)	126	109	114	118	16.7	16.7	32.4	33.6
UVA (mg/L)	4.8	4.09	3.54	4.09	0.6	0.589	1.63	1.88
Specific Absorbance Calc.	3.81	3.75	3.11	3.47	3.59	3.53	5.03	5.60
Alkalinity (mg/L)	147	203	169	173	41	41	90	57
Ammonia (mg/L)	2.0	1.5	1.5	1.6	2.9	3.4	4.5	4.3
Bromide (mg/L)	0.96	0.77	0.94	0.79	0.3	0.21	0.25	0.32
Nitrate + Nitrite (mg/L)								
Total Kjeldahl Nitrogen (mg/L)	13	12	12	13	10	7.5	9.4	10
Dis. Orthophosphate (mg/L)								
Total Phosphorus (mg/L)	1.4	1	0.86	0.73	0.77	0.7	1.3	0.95
Bromodichloromethane (ug/L)	1100	960	1100	940	230	180	220	280
Bromoform (ug/L)	<250	<250	<250	<250	<50	<50	<100	<100
Chloroform (ug/L)	6400	5900	5700	5800	900	940	1500	1600
Dibromochloromethane (ug/L)	320	310	350	310	79	61	<100	<110
TOTAL THMFP (ug/L)	7820	7170	7150	7050	1209	1181	1720	1880
Field Measurements:								
Temperature	7.9	7.3	7.6	7.3	7.3	7.4	7.5	7.8
EC	3960	3680	4450	4790	797	604	985	1321
DO	1.1	1.1	1.3	1.4	2.8	1.1	1.0	1.5
pH	6.0	6.2	6.0	5.9	6.3	6.1	6.1	6.0

NOTES:

PECIAL MULTIPURPOSE APPLIED RESEARCH TECHNOLOGY STATION (SMARTS)

EXPERIMENT 2 - January 21, 1999 through January 20, 2000

eat Water

MARCH 1999

Sample date: March 4, 1999

ARAMETER	TANK 1	TANK 2	TANK 3	TANK 4	TANK 5	TANK 6	TANK 7	TANK 8
C (mg/L)	256	229	175	188	28.2	23.7	51.6	52.9
DOC (mg/L)	233	214	161	170	21.1	20	45.6	47.1
VA (mg/L)	12.14	9.22	6.39	7.34	1.02	0.974	3.29	2.49
Specific Absorbance Calc.	5.21	4.31	3.97	4.32	4.83	4.87	7.21	5.29
kalinity (mg/L)	413	469	309	319	64	66	166	125
mmonia (mg/L)	4.5	2.9	3.1	3	2.9	3.7	4.5	4.8
Bromide (mg/L)	1.77	1.76	1.73	1.58	0.33	0.25	0.33	0.09
itrate + Nitrite (mg/L)								
Total Kjeldahl Nitrogen (mg/L)								
Dis. Orthophosphate (mg/L)								
otal Phosphorus (mg/L)								
Bromodichloromethane (ug/L)	1800	1600	1400	1400	240	210	290	400
romoform (ug/L)	<500	<500	<357	<357	<100	<100	<167	<167
hloroform (ug/L)	13000	11000	8000	8600	1300	1300	2600	2500
Dibromochloromethane (ug/L)	540	550	450	420	100	<100	<167	170
TOTAL THMFP (ug/L)	15340	13150	9850	10420	1640	1510	2890	3070
Field Measurements:								
Temperature	10.9	10.1	10.3	9.9	9.5	9.9	10.5	10
EC	2730	2430	3400	3290	761	619	915	1308
DO	1.21	1.4	1.22	1.36	3.7	1.98	1.67	1.25
pH	6.03	6.21	5.89	5.73	5.99	5.9	5.83	5.76

OTES:

SPECIAL MULTIPURPOSE APPLIED RESEARCH TECHNOLOGY STATION (SMARTS)

EXPERIMENT 2 - January 21, 1999 through January 20, 2000

Peat Water

MARCH(2) 1999

Sample date: March 31, 1999

PARAMETER	TANK 1	TANK 2	TANK 3	TANK 4	TANK 5	TANK 6	TANK 7	TANK 8
TOC (mg/L)	446.8	296.2	234.4	265.6	35.6	29.1	52.7	68.4
DOC (mg/L)	441.7	295.6	229.5	259.8	28.2	26.6	47.0	63.0
UVA (mg/L)	18.6	14	11.3	13	1.55	1.61	3.12	3.41
Specific Absorbance Calc.	4.21	4.74	4.92	5.00	5.50	6.05	6.64	5.41
Alkalinity (mg/L)	845	731	502	596	91	90	228	215
Ammonia (mg/L)	9.0	4.7	4.6	4.8	3.4	4.2	5.0	5.4
Bromide (mg/L)	1.62	3.18	3.13	3.18	0.41	0.33	0.41	0.77
Nitrate + Nitrite (mg/L)								
Total Kjeldahl Nitrogen (mg/L)	32	20	18	17	12	9.9	11.0	11.0
Dis. Orthophosphate (mg/L)								
Total Phosphorus (mg/L)	2.0	1.4	1.1	0.98	1.7	1.4	3.6	1.6
Bromodichloromethane (ug/L)	2900	2500	2300	2500	290	240	330	550
Bromoform (ug/L)	<1250	<833	<500	<833	<83.3	<83.3	<125	<167
Chloroform (ug/L)	20000	15000	12000	13000	2000	1900	3100	3600
Dibromochloromethane (ug/L)	1400	1000	820	1100	96	94	140	210
TOTAL THMFP (ug/L)	24300	18500	15120	16600	2386	2234	3570	4360
Field Measurements:								
Temperature	11.3	9.9	9.6	9.4	11.7	12.4	12.7	12.5
EC	3770	2110	3100	3130	790	635	924	1250
DO	<1.0	<1.0	<1.0	<1.0	3.8	2.57	1.48	1.91
pH	6.13	6.29	6.02	6.0	6.28	6.28	6.27	6.11

NOTES:

PECIAL MULTIPURPOSE APPLIED RESEARCH TECHNOLOGY STATION (SMARTS)

EXPERIMENT 2 - January 21, 1999 through January 20, 2000

eat Water

APRIL 1999

	Sample date: April 28, 1999							
ARAMETER	TANK 1	TANK 2	TANK 3	TANK 4	TANK 5	TANK 6	TANK 7	TANK 8
OC (mg/L)	570	427	333	406	47.1	38	56.4	87.8
DOC (mg/L)	561	426	342	416	35.1	29.7	52.8	83.5
VA (mg/L)	26.8	26.8	15.8	16.9	2.05	1.84	3.4	4.8
Specific Absorbance Calc.	4.78	6.29	4.62	4.06	5.84	6.20	6.44	5.75
lkalinity (mg/L)	985	1074	1451	1023	121	115	269	290
mmonia (mg/L)	11.61	6.72	6.45	6.93	3.07	4.06	4.86	5.27
Bromide (mg/L)	5.36	5.31	5.53	5.76	0.47	0.38	0.52	1.08
itrate + Nitrite (mg/L)								
otal Kjeldahl Nitrogen (mg/L)	93.4	32.4	28.9	31.3	7.5	11.9	11.6	12.7
Dis. Orthophosphate (mg/L)								
otal Phosphorus (mg/L)	12.14	1.71	1.16	1.28	0.68	1.5	2.72	1.37
Bromodichloromethane (ug/L)	4500	4000	3300	3900	330	280	410	800
romoform (ug/L)	<1250	<1250	<833	<833	<100	<100	<167	<250
hloroform (ug/L)	25000	20000	16000	19000	2500	2200	3300	4700
Dibromochloromethane (ug/L)	1600	1600	1200	1200	110	100	180	280
TOTAL THMFP (ug/L)	31100	25600	20500	24100	2940	2580	3890	5780
Field Measurements:								
Temperature	15.9	14.4	14	13.4	11.9	11.8	12.7	14.3
EC	3159	2383	3115	3280	550	454.8	702	998
DO	<1	1.61	1.64	1.2	3.56	4.6	1.39	<1
pH	6.06	6.44	6.17	6.13	6.45	6.27	6.13	6.01

NOTES:

SPECIAL MULTIPURPOSE APPLIED RESEARCH TECHNOLOGY STATION (SMARTS)

EXPERIMENT 2 - January 21, 1999 through January 20, 2000

Peat Water

MAY 1999

Sample date: May 26, 1999

PARAMETER	TANK 1	TANK 2	TANK 3	TANK 4	TANK 5	TANK 6	TANK 7	TANK 8
TOC (mg/L)	615	450	412	486	46.2	40	61.8	103
DOC (mg/L)	600	429	381	453	42.2	35.6	54.2	97.4
UVA (mg/L)	30.2		20.4	28.1	2.27	1.93	3.7	5.36
Specific Absorbance Calc.	5.03		5.35	6.20	5.38	5.42	6.83	5.50
Alkalinity (mg/L)	1040	1080	910	1040	147	140	305	357
Ammonia (mg/L)	16.9	9.84	9.07	10.02	3.23	4.69	5.97	6.31
Bromide (mg/L)	7.45	5.09	5.83	6.72	0.42	0.34	0.5	1.28
Nitrate + Nitrite (mg/L)								
Total Kjeldahl Nitrogen (mg/L)	53	34	28	35	7.2	7.4	9.7	13.0
Dis. Orthophosphate (mg/L)								
Total Phosphorus (mg/L)	2.2	1.5	1.2	1.4	0.97	0.71	1.7	1.2
Bromodichloromethane (ug/L)	5000	3700	4000	4600	330	270	400	940
Bromoform (ug/L)	<1250	<1250	<833	<1250	<100	<100	<167	<250
Chloroform (ug/L)	29000	22000	19000	23000	3300	2800	4100	6000
Dibromochloromethane (ug/L)	<1250	<1250	<833	<1250	<100	<100	<167	<250
TOTAL THMFP (ug/L)	34000	25700	23000	27600	3630	3070	4500	6940
Field Measurements:								
Temperature	20.5	20.6	20.4	20.9	20.3	21.3	22.5	22.1
EC	3310	2620	3310	3360	676	673	990	1265
DO	<1	<1	<1	1.02	4.77	3.61	1.57	1.85
pH	6.25	6.28	6.07	6.13	6.26	6.22	6.11	6.06

NOTES:

SPECIAL MULTIPURPOSE APPLIED RESEARCH TECHNOLOGY STATION (SMARTS)

EXPERIMENT 2 - January 21, 1999 through January 20, 2000

Peat Water

JUNE 1999

Sample date: June 23, 1999

PARAMETER	TANK 1	TANK 2	TANK 3	TANK 4	TANK 5	TANK 6	TANK 7	TANK 8
TOC (mg/L)	571	421	393	443	52.3	41.2	66.1	105
DOC (mg/L)	544	413	380	411	45.3	36.4	55.8	106.0
UVA (mg/L)	35.9	24.2	23.5	30.5	2.63	2.29	4.28	6.05
Specific Absorbance Calc.	6.60	5.86	6.18	7.42	5.81	6.29	7.67	5.71
Alkalinity (mg/L)	1000	978	915	1074	172	165	313	384
Ammonia (mg/L)	21.0	12	11	12	3.7	4.8	7.1	7.50
Bromide (mg/L)	9.71	6.64	6.78	7.61	0.51	0.4	0.66	1.63
Nitrate + Nitrite (mg/L)								
Total Kjeldahl Nitrogen (mg/L)	54	32	28	31	7.8	8	12	15.0
Dis. Orthophosphate (mg/L)								
Total Phosphorus (mg/L)	2.0	1.2	1.3	1.4	1.2	0.96	2.6	1.2
Bromodichloromethane (ug/L)	5500	3800	3900	4300	300	240	390	920
Bromoform (ug/L)	<1250	<1250	<833	<1250	<125	<100	<167	<250
Chloroform (ug/L)	27000	20000	19000	20000	3400	2600	3700	5300
Dibromochloromethane (ug/L)	<1250	<1250	<833	<1250	<125	<100	<167	<250
TOTAL THMFP (ug/L)	32500	23800	22900	24300	3700	2840	4090	6220
Field Measurements:								
Temperature	22.4	23.1	23.4	23.0	21.3	23.6	23.9	23.2
EC	3260	2530	3140	3300	714	658	1021	1291
DO	<1	<1	<1	<1	<1	<1	<1	<1
pH	6.29	6.35	6.18	6.21	6.38	6.21	6.04	6.04

NOTES:

SPECIAL MULTIPURPOSE APPLIED RESEARCH TECHNOLOGY STATION (SMARTS)

EXPERIMENT 2 - January 21, 1999 through January 20, 2000

Peat Water

July 1999

Sample date: July 21, 1999

PARAMETER	TANK 1	TANK 2	TANK 3	TANK 4	TANK 5	TANK 6	TANK 7	TANK 8
TOC (mg/L)	600	410	383	386	53.9	44.2	63.3	44.2
DOC (mg/L)	590	392	374	368	46.8	40.1	57.8	99.5
UVA (mg/L)	36.3	25.5	22.5	23.5	2.92	2.49	3.46	6.64
Specific Absorbance Calc.	6.15	6.51	6.02	6.39	6.24	6.21	5.99	6.67
Alkalinity (mg/L)	922	1007	845	937	184	181	326	380
Ammonia (mg/L)	25	17	12	15	3.9	5.4	7.8	7.90
Bromide (mg/L)	10.2	7.09	6.92	7.49	0.59	0.38	0.71	1.8
Nitrate + Nitrite (mg/L)								
Total Kjeldahl Nitrogen (mg/L)	54	36	31	36	8.2	10	12	13.0
Dis. Orthophosphate (mg/L)								
Total Phosphorus (mg/L)	2.0	1.5	1.2	1.3	1.2	1.4	1.7	1.1
Bromodichloromethane (ug/L)	6200	4300	4100	4200	360	300	490	1100
Bromoform (ug/L)	<2500	<1250	<833	<833	<125	<125	<167	<250
Chloroform (ug/L)	24000	18000	16000	17000	3300	2500	3500	5400
Dibromochloromethane (ug/L)	<2500	<1250	1000	1100	<125	<125	<167	270
TOTAL THMFP (ug/L)	30200	22300	21100	22300	3660	2800	3990	6770
Field Measurements:								
Temperature	18.8	17.7	19.2	18.7	19.8	18.8	20.6	20.9
EC	3260	2320	3010	2880	663	675	1021	1249
DO	<1	<1	<1	<1	<1	<1	<1	<1
pH	6.24	6.33	6.19	6.15	6.27	6.27	6.09	6.02
NOTES:								

SPECIAL MULTIPURPOSE APPLIED RESEARCH TECHNOLOGY STATION (SMARTS)

EXPERIMENT 2 - January 21, 1999 through January 20, 2000

eat Water

OCTOBER 1999

Sample date: October 27, 1999

PARAMETER	TANK 1	TANK 2	TANK 3	TANK 4	TANK 5	TANK 6	TANK 7	TANK 8
OC (mg/L)	548	315	379	312	52	43.8	51	72.2
DOC (mg/L)	532	312	380	301	37.9	35.9	47.4	68.9
VA (mg/L)	28.66	18.08	20.24	17.52	2.58	2.46	3.99	4.32
Specific Absorbance Calc.	5.39	5.79	5.33	5.82	6.81	6.85	8.42	6.27
lkalinity (mg/L)	920	864	811	856	180	194	348	325
mmonia (mg/L)	30	23	19	23	4.1	5	9.3	8.00
Bromide (mg/L)	11.8	6.28	8.82	7.14	0.47	0.45	0.84	1.41
itrate + Nitrite (mg/L)	0.48	0.14	0.02	0.03	0.2	0.83	0.18	<0.01
Total Kjeldahl Nitrogen (mg/L)	55	43	40	38	9.7	12	14	14.0
Dis. Orthophosphate (mg/L)	1.4	0.6	0.9	0.63	0.87	0.53	1.1	0.68
otal Phosphorus (mg/L)	2.5	2.1	2.3	2.1	2.2	2.2	3	1.6
Bromodichloromethane (ug/L)	7800	4400	5900	4600	360	340	640	1000
romoform (ug/L)	<1250	<833	<833	<833	<100	<100	<167	<167
hloroform (ug/L)	30000	17000	20000	16000	3200	2800	3400	4200
Dibromochloromethane (ug/L)	1800	1100	1600	1200	<100	<100	<167	220
TOTAL THMFP (ug/L)	39600	22500	27500	21800	3560	3140	4040	5420
Field Measurements:								
Temperature	14.5	15.2	16	15.9	15.5	14.4	14.4	14.9
EC	2925	2138	2672	2344	631	648	1046	1096
pH	6.31	6.32	6.23	6.18	6.05	6.17	6	5.89

OTES:

SPECIAL MULTIPURPOSE APPLIED RESEARCH TECHNOLOGY STATION (SMARTS)

EXPERIMENT 2 - January 21, 1999 through January 20, 2000

Peat Water

JANUARY 2000

Sample date: January 20, 2000

PARAMETER	TANK 1	TANK 2	TANK 3	TANK 4	TANK 5	TANK 6	TANK 7	TANK 8
TOC (mg/L)	462	276	335	265	39	33.8	47.6	83.4
DOC (mg/L)	460	275	332	251	35	30.6	42.2	77.5
UVA (mg/L)	26.6	17.7	20.6	17.4	2.88	2.36	4.47	5.32
Specific Absorbance Calc.	5.78	6.44	6.20	6.93	8.23	7.71	10.59	6.86
Alkalinity (mg/L)	928	904	904	952	208	202	363	429
Ammonia (mg/L)	25	19	17	19	3.1	3.6	6.8	7.3
Bromide (mg/L)	10.3	6.06	9.33	7.1	0.53	0.4	0.83	1.78
Nitrate + Nitrite (mg/L)	0.32	0.09	0.02	0.04	0.7	0.46	0.39	<0.01
Total Kjeldahl Nitrogen (mg/L)	52	38	38	35	8.3	7.7	12	13
Dis. Orthophosphate (mg/L)	1.3	0.73	0.93	0.57	0.7	0.66	1.3	0.84
Total Phosphorus (mg/L)	2.1	1.7	1.4	1.5	1.6	1.2	2.7	1.5
Bromodichloromethane (ug/L)	6100	3700	5100	4100	350	280	570	1100
Bromoform (ug/L)	<1250	<833	<833	<833	<100	<100	<125	<250
Chloroform (ug/L)	22000	14000	15000	12000	2700	2300	2900	4200
Dibromochloromethane (ug/L)	<1250	<833	1300	1000	<100	<100	<125	<250
TOTAL THMFP (ug/L)	28100	17700	21400	17100	3050	2580	3470	5300
Field Measurements:								
Temperature	11.4	11.2	10.8	10.7	10.8	10.9	10.6	10.6
EC	2974	2198	3292	2881	689	620	1036	1294
pH								

NOTES:

PECIAL MULTIPURPOSE APPLIED RESEARCH TECHNOLOGY STATION (SMARTS)

EXPERIMENT 2 - January 21, 1999 through January 20, 2000

eat Water

SEPTEMBER 2000

Sample date: September 7, 2000

ARAMETER	TANK 1	TANK 2	TANK 3	TANK 4	TANK 5	TANK 6	TANK 7	TANK 8	Dup. Tank 4	QA/QC RPD
OC (mg/L)	493	249	393	270	41.6	41.1	57.2	67.9	294	8.51
DOC (mg/L)	516	250	412	265	41.7	38.4	52.5	60.0	284	6.92
VA (mg/L)	22.6	13.6	19.8	18.2	2.96	1.97	2.82	3.25	18.8	3.24
Specific Absorbance Calc.	4.38	5.44	4.81	6.87	7.10	5.13	5.37	5.42	6.62	3.68
Alkalinity (mg/L)										
mmonia (mg/L)	33	26	21	24	4.2	5.2	9.8	8.9	24	0.00
Bromide (mg/L)										
itrate + Nitrite (mg/L)										
Total Kjeldahl Nitrogen (mg/L)										
Dis. Orthophosphate (mg/L)										
otal Phosphorus (mg/L)										
Bromodichloromethane (ug/L)										
romoform (ug/L)										
hloroform (ug/L)										
Dibromochloromethane (ug/L)										
TOTAL THMFP (ug/L)	0	0	0	0	0	0	0	0	0	#DIV/0!
Field Measurements:										
Temperature	20	20.7	21.1	19.6	19.4	19.6	19.1	19.8	19.6	
EC	2895	1702	1332	2226	603	636	1006	861	2226	
pH	6.31	6.27	6.32	6.38	6.18	6.31	6.16	6.05	6.38	

OTES: