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TRihalomethane Formation Potential in Two Kentucky  
Reservoirs

By

Richard Scott Pirkle  
B.S., Georgia Institute of Technology, 2002

A Thesis  
Submitted to the Faculty of the  
Graduate School of the University of Louisville  
In Partial Fulfillment of the Requirements  
for the Degree of

Master of Sciences

Department of Biology  
University of Louisville  
Louisville, Kentucky

May 2007

TRIHALOMETHANE FORMATION POTENTIAL IN TWO KENTUCKY  
RESERVOIRS

By

Richard Scott Pirkle  
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A Thesis Approved on

Date

by the following Thesis Committee:

---

Thesis Director

## **DEDICATION**

This thesis is dedicated to the memory of  
Dr. Jeffrey Jack  
who gave me a greater appreciation  
for the environment around me and the ability  
to work to restore a portion of it for  
generations to come.

## ACKNOWLEDGEMENTS

I would like to thank Dr. James Alexander for stepping in as my major advisor and working so diligently with me over the past few months. I would also like to thank Dr. Clara Leuthart and Dr. Margaret Carreiro for their comments and instruction during the preparation of this thesis. To my wife, Rachel, I would like to say that this thesis would not have been possible with her support and I thank her for a “patience that passes all understanding”. I would also like to thank my family members: Edwin and Lois Pirkle (parents), David, Amy, Bailey, and Kayleigh Pirkle (brother and his family), Terry, Wanda, and Micah Jones (in-laws and brother-in-law) for their continued support and prayers throughout the past three years. Also, countless thanks go to all those who helped in the field and the lab (David Word, Wesley Daniel, Christopher Owen, Robbie Johnson, Sarah Wolfe, Lindsey Saunders, Stacy Pritchard, and Rich Shultz). Without each of these people, the work may have been too much to handle and it definitely would not have been as much fun. I would also like to thank the United States Environmental Protection Agency whose funding made this work possible through grants given to Dr. Jeffrey Jack and Dr. Paul Bukaveckas. I would also like to acknowledge the hard work of the EPA Region 4 Lab at Western Kentucky University in Bowling Green, KY known as the WATERS lab which is run by Ms. Jana Fattic.

## ABSTRACT

### TRIHALOMETHANE FORMATION POTENTIAL IN TWO KENTUCKY RESERVOIRS

Richard Scott Pirkle

May 12, 2007

Water treatment facilities strive to provide potable drinking water to the community which they service. The most common way of insuring drinkable water that is free of pathogens is water chlorination, but this can lead to the production of carcinogenic disinfection byproducts. This study looks at two drinking water reservoirs that have known United States Environmental Protection Agency minimum contaminant level violations of trihalomethanes (THMs), a disinfection byproduct. Physical and chemical parameters of the two lakes were measured over the course of 13 months and analyses indicated that nitrate and soluble reactive phosphorus, along with temperature and pH, played a significant role in determining the THM formation potential (THMFP) in the lakes. A bench-top scale experiment used to determine if air oxidation could reduce THMFP showed that air oxidation could consistently reduce THMFP in finished drinking water, but raw water oxidation leads to variable reductions and increases in THMFP.

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## INTRODUCTION

The production of potable drinking water, free of potential pathogens, is vital for reducing illness and is a primary goal for the successful water treatment facility. Treatment facilities have employed various highly effective measures to reduce the amount of water-borne disease-causing agents, such as the bacteria *Salmonella typhi* (typhoid fever), *Vibrio cholerae* (cholera), and *Shigella* species (dysentery) (Johnson et al. 1990), but the most commonly used method of disinfection is water chlorination (Clark and Sivangensen 1998). Though successful in producing potable drinking water, this process can lead to the production of disinfection byproducts (DBPs) when chlorine reacts with natural organic matter (NOM) present in the source water. One important class of DBPs is the trihalomethanes (THMs), which include organic hydrocarbons that are one or more carbons in length. THMs include, for example, chloroform ( $\text{CHCl}_3$ ), bromoform ( $\text{CHBr}_3$ ), and chlorodibromomethane ( $\text{CHClBr}_2$ ). The production of trihalomethanes has come under increased scrutiny, as THMs are known to be carcinogens in laboratory animals (Singer 1999) and have also been tied to higher incidence of rectal and bladder cancer in humans (Simpson and Hayes 1998). Recent regulations (2004) by the United States Environmental Protection Agency (USEPA) have reduced the allowable amount of THMs in finished water from 100  $\mu\text{g/L}$  to 80  $\mu\text{g/L}$ . This reduction has required some water companies to aggressively treat source waters in an effort to remove THM precursors before chlorination.

Though the potential hazards from THMs and other DBPs are well known, little is known about the exact composition of the natural organic matter that is the source of the problem. Various studies (Rook 1976, Stevens et al. 1976, Reckhow et al. 1990) have shown a strong link between humic substances (nonpolar components of natural organic matter) and THM formation potential (THMFP, which is operationally defined as the total amount of natural organic matter that is available in source water that will react during the chlorination process and form THMs). Other work has indicated a correlation between THMFP and algal production (Jack et al. 2002, Palmstrom et al. 1988, Graham et al., 1998, Schmidt et al. 1998) as well as increases in THMFP due to microbial decomposition of organic matter (Bukaveckas in press). The latter sources of THM precursors will lead to organic material that is part of the dissolved organic carbon pool and thus is not removable via pre-chlorination filtration. Dissolved organic carbon (DOC) refers to organic material from plants, animals, and microbes that are broken down through decomposition into smaller molecules that enter into solution. These compounds include carbohydrates, lipids, and proteins, but it also includes a complex array of organic acids and other compounds from the microbial breakdown of dead organic matter.

The processes of coagulation with subsequent flocculation are capable of binding and removing DOC from source water. However, in areas with high source water DOC, coagulation may not remove sufficient amounts of DOC (or the specific organic components of DOC) that will lead to the creation of THM levels above USEPA standards. Water treatment plants may choose to pre-oxidize source water with potassium permanganate or some other strong oxidizers (Jiang and Lloyd 2002) before

treating with a flocculant such as ferric chloride. Enhanced coagulation (the use of excessive amounts of coagulants or extremely strong oxidants (Miltner et al. 1994)) has also been used as a method of reducing DOC in waters with high organic loads.

However, this requires the use of chemicals that are known to be hazardous to the environment and treatment facility personnel. Current approaches to reduce THM levels in finished drinking water focus on reducing the THM formation potential of source water prior to chlorination. The reactivity rate of chlorine with NOM is a function of treatment type, contact time, the characteristics of the distribution system, and source water characteristics (Boccelli et al. 2003).

Ozonation is an alternative disinfection process in which ozone is used to inactivate microbial contaminants in source water (Elovitz et al. 2000). This process results in little production of halogenated DPBs, but can lead to the production of bromate ( $\text{BrO}_3^-$ ) in waters that are bromine rich (USEPA 1998). Bromate has also been shown to have adverse effects on human health. Ozone is also an environmental hazard, and improper handling of this oxidizer could result in unsafe conditions for employees at water treatment facilities (Bascom 1996).

However, some water companies may find that even the current methods are insufficient to address their THMFP problems. The relative importance of various forms of THM precursors is thought to be influenced by site-dependent factors, including watershed characteristics (soils, land-use) and source water conditions (Jack et al. 2002). Therefore the development of a general treatment protocol that will be effective for all water companies is unlikely.

I examined a particular system in central Kentucky (USA) where high organic loads in the source waters have led to levels of DBPs (especially THMs) above current USEPA standards. I first compared the two lakes to determine if significant differences in chemical and physical traits between the two lakes might be found and to determine whether or not these differences affect THM production. The THM violations tended to occur during times when the source water reservoirs were stratified and anoxic in the lower layers. The highly reducing conditions present during stratification may enhance the production of THM precursors. THM levels also tend to be higher in the distribution system than in the source water, which suggests that THM precursors are not being sufficiently degraded by the processes currently used by the plant operators. I hypothesized that air oxidation of the source waters might prove effective in reducing THMFP in the source waters. The air oxidation process does not require the use of harsh chemical oxidizers and poses little risk to the environment and water treatment plant employees. This reduction could then allow the plant operators to successfully manage the THM levels by conventional methods and avoid water quality violations.

## METHODS

### *Study Sites*

Willisburg Lake (37° 49.64'N, 85° 9.78'W (NAD83/WGS84)) is located 12 miles northeast of Springfield, KY and is the primary water source for the Springfield Water and Sewer Commission. Willisburg Lake has an average depth of 2.5 meters, with a maximum depth of about 15 meters at full pool. The lake has a surface area of approximately 53 hectares and a watershed of approximately 960 hectares. The surrounding watershed is dominated by forest (67% landcover, predominantly deciduous forest), a modest amount of agriculture (31% landcover of which most is pasture/hay/field) with a small percentage (1%) designated for residential landuse (See Figure 1 for an aerial photograph with the approximate sampling location marked). Willisburg Lake has three stream inputs; these streams are intermittent during summers with low precipitation. Willisburg Lake is monomictic with a stratified period beginning between late March and early April. During early to mid-October the lake becomes isothermic.

Springfield Reservoir (37° 41.19'N, 85° 13.89'W (NAD83/WGS84)) is a small (6 hectare) reservoir with a watershed of approximately 65 hectares. A man-made impoundment, Springfield Reservoir has no perennial stream input (see Figure 2 for aerial photograph); the major inflows of water come from water pumped from Willisburg Lake and rain water. Springfield Reservoir also exhibits monomictic thermal cycles,

above the bottom of the lake (total of four grab samples) using a translucent 10-liter Van Dorn water sampler. Care was taken with the bottom sample to not disturb the benthic substrate and any grab sample that contained a large amount of sediments was released and another grab sample was taken. After the lake became isothermal, only the surface and bottom samples were taken at monthly intervals. The water samples were transferred to clean containers and brought back to the lab, on ice, for processing. Beginning in May 2005, a finished water sample (post-processed and chlorinated) was concurrently collected from a water tap in the treatment plant. Hydrolab parameters were not gathered from the finished water samples.

Samples were prepared for analysis within 8 hours of collection. For each collected depth, whole water samples were subsampled for nutrient analysis. Four 500-mL bottles were filled (three of which were preserved with concentrated  $H_2SO_4$ , the other kept cold) and sent the next day to the Water Analysis Training Education and Research Services (WATERS) Laboratory at Western Kentucky University for analysis of ammonia, total Kjeldahl nitrogen, nitrate/nitrite, total phosphorous, soluble reactive phosphorous (SRP), chloride, and silicon dioxide levels. The concentrations were determined by standard methods (See Table 1 for particular APHA [1998] methods). Total Kjeldahl nitrogen consists of organic nitrogen plus ammonia-nitrogen ( $NH_3-N$ ). The THMFP for each depth collected was determined using Standard Method 5710B (APHA 1998). To summarize the standard procedure, a one liter dark amber glass bottle was filled with water from each depth and lake sampled. The water was then quenched (saturated) with chlorine and incubated for seven days upon which the sample was

**Table 1**Standard Methods from APHA for Analysis of Nutrients

<b>Analysis</b>	<b>Method</b>
DOC	SM 5310 B
Ammonia	SM 4500-NH3 D
TKN	SM 4500-Norg B
Nitrate	SM 4110 B
SRP	SM 4500-P B&E
TP	SM 4500-P B&E
Chloride	SM 4110 B
Silica	SM 3111 D

Standard Methods were taken from APHA 1998 in accordance with USEPA guidelines for analysis of these nutrients.



analyzed by purge and trap gas chromatographic – mass spectrometric method (performed at Beckmar Environmental Laboratory in Louisville, KY, USA with a Hewlett Packard 5890 Series II/5971 gas chromatograph/mass selective detector with a Teckmar LSC-2000 purge and trap concentrator (Standard Method 6232C; APHA 1998)). Results were reported as the four major components of THMFP (chloroform ( $\text{CHCl}_3$ ), bromodichloromethane ( $\text{CHBrCl}_2$ ), chlorodibromomethane ( $\text{CHClBr}_2$ ), and bromoform ( $\text{CHBr}_3$ )). THMFP was assumed to be the sum of these four haloforms. A portion of the remaining water was filtered through an ashed glass fiber filter (0.5  $\mu\text{m}$  pore size, 47 mm, Pall Type A/E) in order to ascertain particulate organic carbon (POC) levels. The filtered water was collected and sent to the WATERS lab at WKU for analysis of dissolved organic carbon (Table 1). Lastly, a subsample of water was filtered through MCE (mixture of cellulose acetate and cellulose nitrate) filters (Fisherbrand, pore size of 0.45  $\mu\text{m}$ ). Chlorophyll a levels (acid corrected for phaeo pigments) were determined by fluorometric methods with a Turner Designs fluorometer Model 10-AU.

#### Air Oxidation Experiment

Beginning in August 2005, extra water samples were taken (using the methodology from above) from the lake and plant and were prepared for the air oxidation experiment. All samples were allowed to warm to room temperature (approximately 22°C). Redox potential was measured at the outset and at the conclusion of the aeration period to ensure that air oxidization was occurring. Redox potential was determined using an Orion Redox Probe (Model 967800) and an Orion pH Meter (Model 420A). The bottle tops were removed from the four replicate water samples and the initial redox potential was determined. One sample was then resealed and used as a reference sample.

The remaining samples were aerated at a controlled air velocity for approximately 16 hours. Final redox potential was recorded for the aerated samples which were then prepared for incubations to determine THMFP along with the previously sealed reference sample. THMFP was quantified using a standardized method that mimics processes occurring during water treatment (APHA, 1998). Samples were buffered to pH 7.0; chlorine demand was quenched with excess chlorine and incubated at 25°C for seven days. Upon completion of the incubation period, THM concentrations were determined using the purge and trap gas chromatographic-mass spectrometric method described above.

#### *Statistical Analysis*

I analyzed the data using SAS (Version 9.1.3, 2004). A repeated measures mixed model was chosen to eliminate temporal pseudoreplication. THMFP was chosen as the response variable and the lakes were used as subjects. The mixed procedure allows for the modeling of covariance structure in regards to the measured response variables (i.e. THMFP). The appropriate covariance structure was selected using the log likelihood function method and chi square tests for the significance of model against other related covariance structures. For all analyses, the compound symmetry (the assumption that the within subject variance is homogeneous as well as the covariance to be homogenous) model was significantly better than variance component (in which the assumption is only that the within subject variance is homogenous) model. To begin, all measured variables were used for the covariance matrix and backwards elimination was used to remove non-significant effects from the model.

## RESULTS

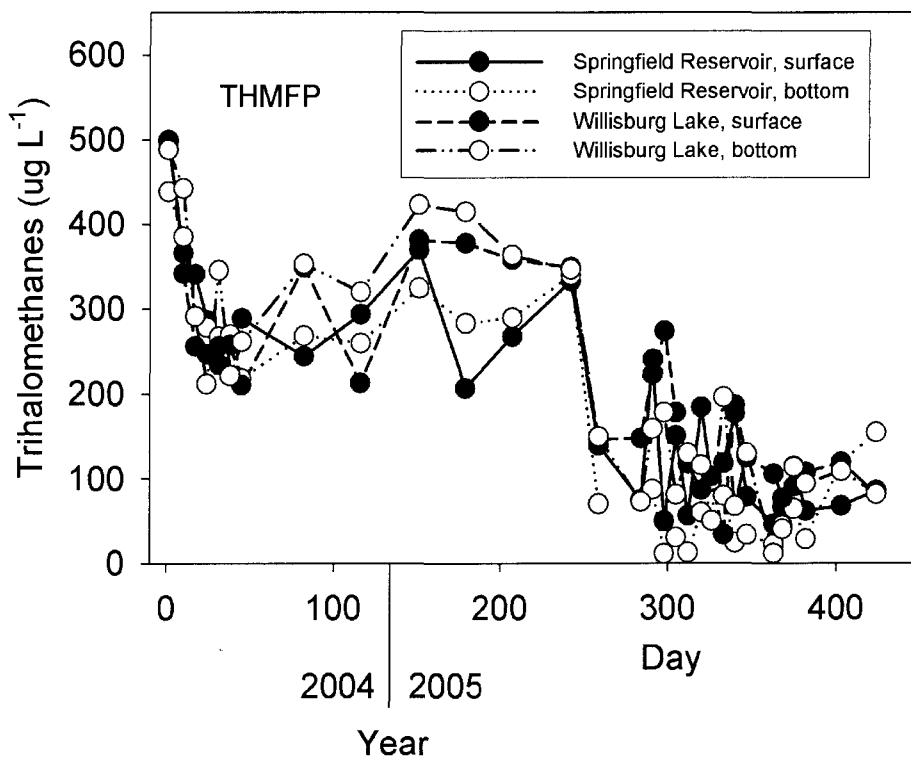
### *Comparative Study*

Average THMFP for Willisburg Lake and Springfield Reservoir was similar throughout the study period (August 2004 – October 2005). Surface water samples from Willisburg Lake had an average THMFP of 209.99  $\mu\text{g/L}$  (SE = 21.24) while Springfield Reservoir had a slightly lower average THMFP concentrations of 190.88  $\mu\text{g/L}$  (SE = 22.48) though the difference was not statistically significant. Bottom water samples for both lakes averaged 208.65  $\mu\text{g/L}$  (SE = 25.55) and 167.24 (SE = 24.51) for Willisburg Lake and Springfield Reservoir, respectively. A time series analysis of THMFP over the study period showed a general downward trend in THMFP concentration (see Figure 6) that was apparent in both surface and bottom samples of each lake.

Statistical analysis of THMFP as a response variable, and all other measured physical and chemical parameters of the water, resulted in significant covariation between some measured parameters. Backwards elimination was used to remove factors one at a time in order to find the principle factors that were related to THMFP. The procedure resulted in four parameters being significant at a level of  $p < 0.05$ : Nitrate ( $p = 0.0064$ ), SRP ( $p = 0.0370$ ), temperature ( $p = 0.0016$ ), and pH ( $p = 0.0008$ ). Two other variables (DOC and chlorides) were near statistical significance ( $p = 0.0546$  and  $0.0761$ , respectively). The depth from which the water was taken was not found to be statistically significant ( $p = 0.3845$ , see Table 2) in explaining THMFP.

Figure 6

Trihalomethane Formation Potential Profile



Trihalomethane formation potential in both lakes at surface and bottom. At the beginning of the study (August 2004), THMFP was highest but generally trended downward throughout the rest of the 14<sup>th</sup> month study period. The study began (Day 0) on Julian date 04233 and ended (Day 424) on Julian date 05290.

**Table 2**Mixed Procedure Table for Comparative Study

<b>Effect</b>	<b>F-Statistic</b>	<b>P-value</b>
Depth	2.10	0.3845
Day	9.45	<0.0001
DOC	3.81	0.0546
Nitrate	7.87	0.0064
SRP	4.51	0.0370
Chlorides	3.23	0.0761
Temperature	10.77	0.0016
pH	12.07	0.0008

Significant results of the mixed model analysis after backwards elimination. The significant Day effect identifies that THMFP changed over time. Depth from which the sample was collected had no statistically discernible effect on THMFP while nitrate, SRP, temperature, and pH all showed statistically significant results. DOC and chloride concentrations were nearly statistically significant.

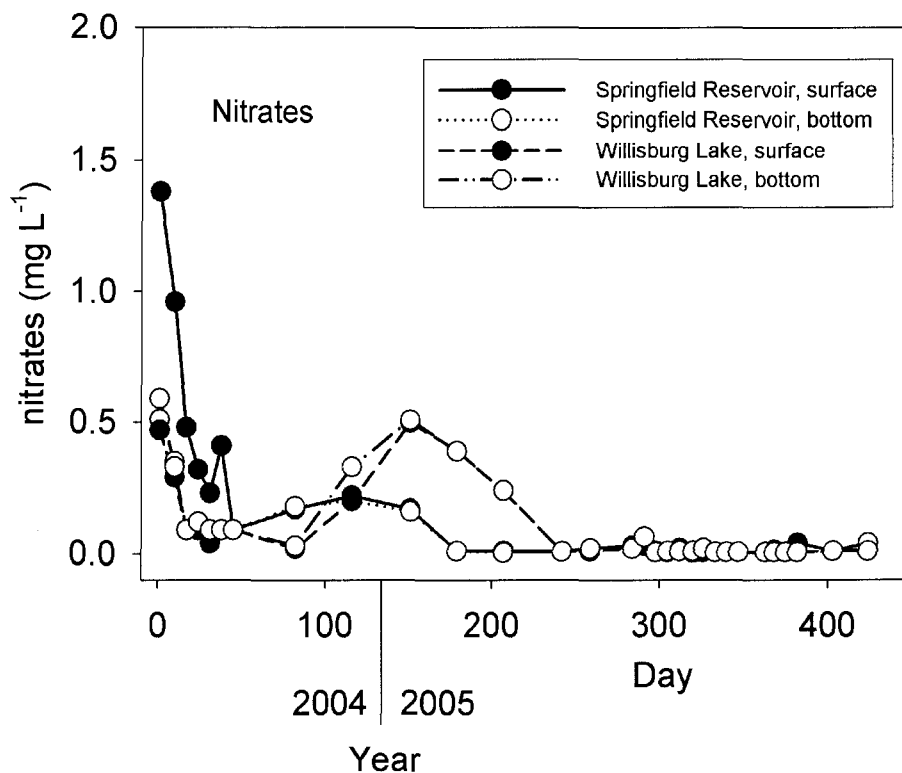
Nitrate concentrations at the beginning of the study period averaged  $0.61 \text{ mg L}^{-1}$ , but by Day 17 the concentrations were 70% lower. Nitrate concentrations increased slightly for Willisburg Lake towards the end of 2004 and the beginning of 2005 but by Day 242 (Julian date 05108), Willisburg Lake and Springfield Reservoir had consistently low nitrate concentrations which remained low through the end of the study period (see Figure 7).

Soluble reactive phosphorus (SRP) concentrations were higher and more variable for both lakes and depths during the beginning of the sampling period (see Figure 8). Consistent values were seen for both lakes and depths after Day 151 (Julian date 05017) until an increase was seen in SRP concentrations for Springfield bottom samples.

Temperature and pH profiles in both lakes throughout the study period are typical for mid-latitude lakes (see Figures 9 and 10, respectively). The water temperatures at the lake bottoms were different between the two lakes at the beginning of the sampling period until October 2004 (when both lakes turned over) with Willisburg Lake having colder hypolimnion temperatures during the initial stratified period (August 2004 to late October 2004). After mixis, bottom and surface water temperatures were very similar, with the largest single difference between them during that time being no more than 1.5 degrees C. Surface water temperature was similar for both lakes throughout the sampling period. Differences in pH at depth were found, but both lakes responded similarly during the sampling period with generally higher pH at the surface (most likely driven by algal activity) and more neutral pH at the bottom during stratified periods. While the lakes were isothermal, the pH in both lakes at both depths was generally slightly basic.

Figure 7

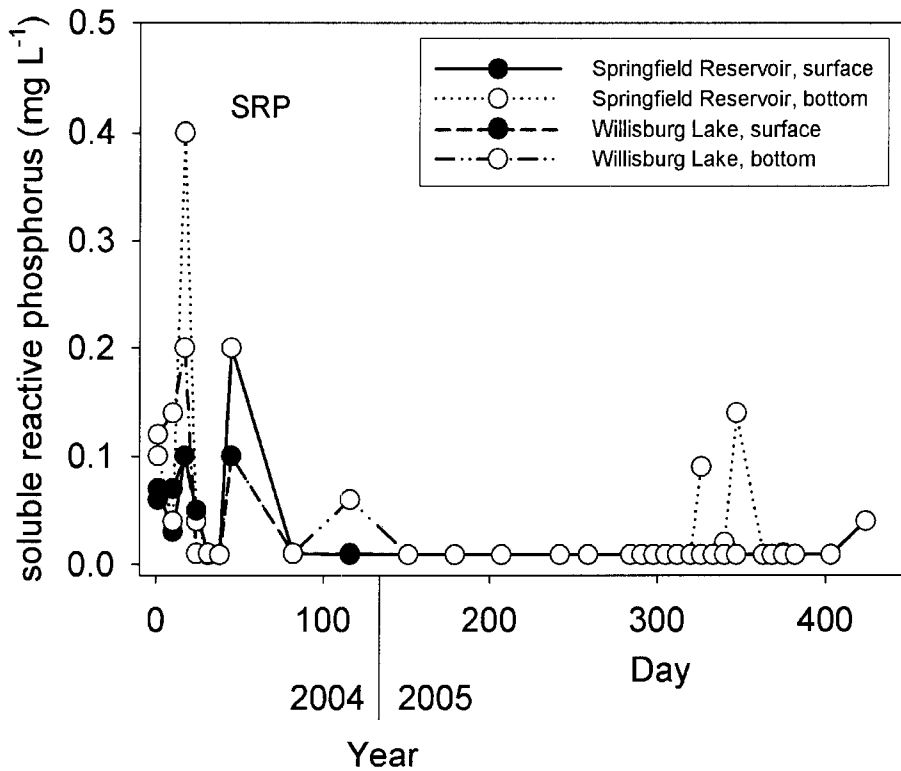
Nitrate Concentration Profile



Nitrate concentrations were high for both lakes and depths at the start of the sampling period (from August 2004 to October 2004, during the first stratified time). Isothermal conditions resulted in an increase in nitrate concentrations which were reduced at the start of the second measured stratified period (April 2005, Day 242, Julian date 05108).

Figure 8

Soluble Reactive Phosphorus Profile

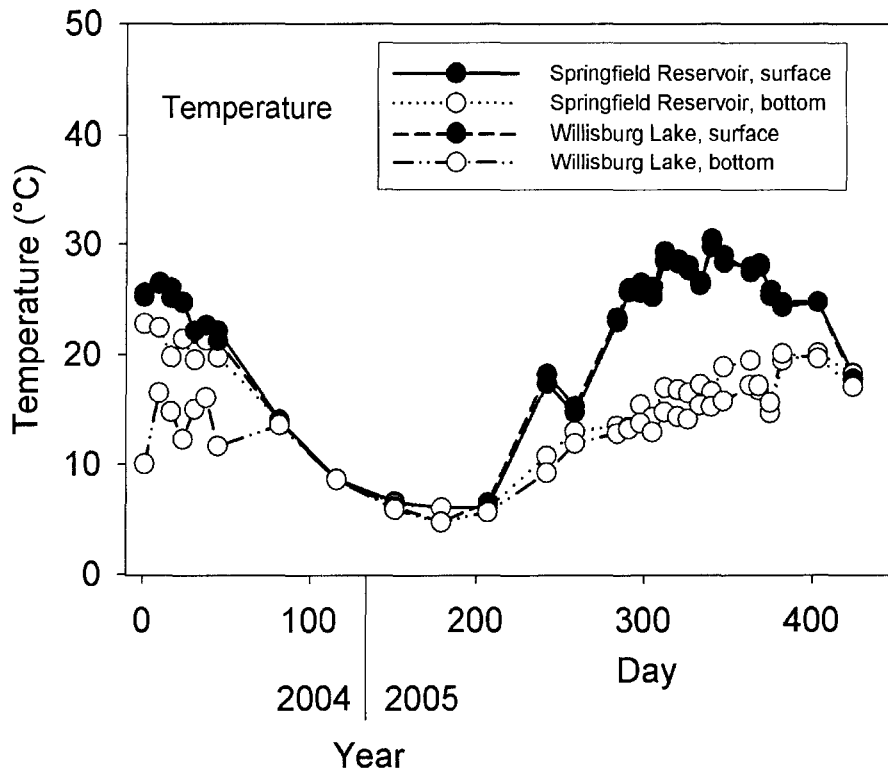


Soluble reactive phosphorus concentrations for both lakes and depths were higher during the beginning of the study period and then remained low throughout most of the rest of the study. Increased SRP in Springfield Reservoir's bottom water may be due to the addition of cupric sulfate by the water company in order to reduce algal growth 2 weeks prior to the increase in SRP.



**Figure 9**

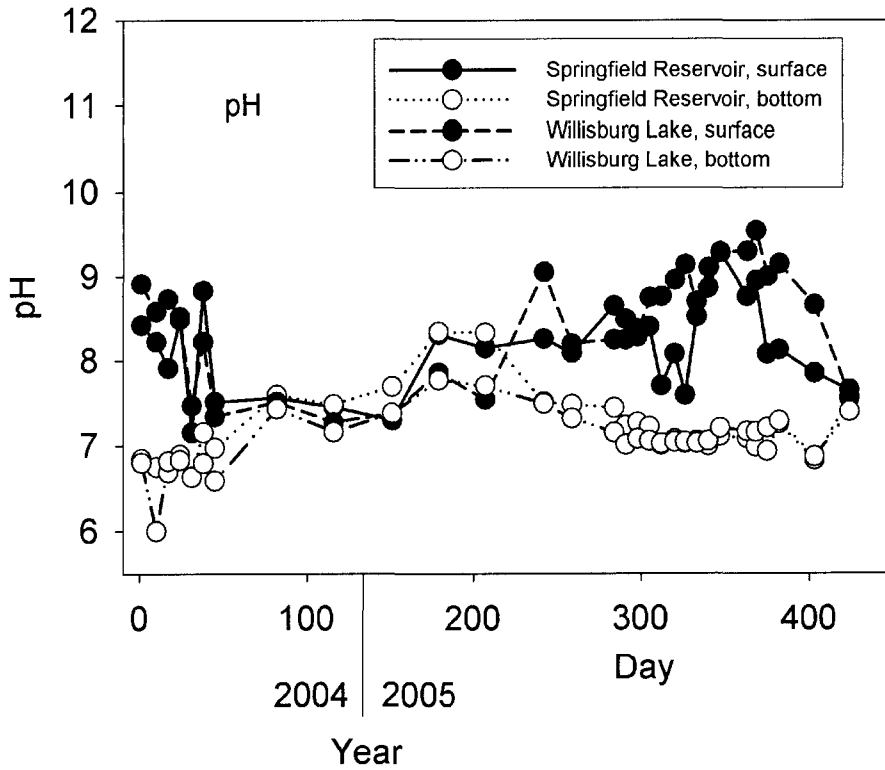
Temperature Profile



Temperature profile for Willisburg Lake and Springfield Reservoir during the study period. Surface water temperatures for both lakes were very similar throughout the study period while bottom water temperatures from Willisburg Lake were lower than Springfield Reservoir during the beginning of the study. During the second measured stratification period, the bottom water temperatures were very similar for both lakes.

**Figure 10**

pH Profile



pH of bottom water samples from both lakes were circumneutral during most of the study period. High pH values were obtained at the surface and were likely driven by algal production during stratified periods at both lakes.

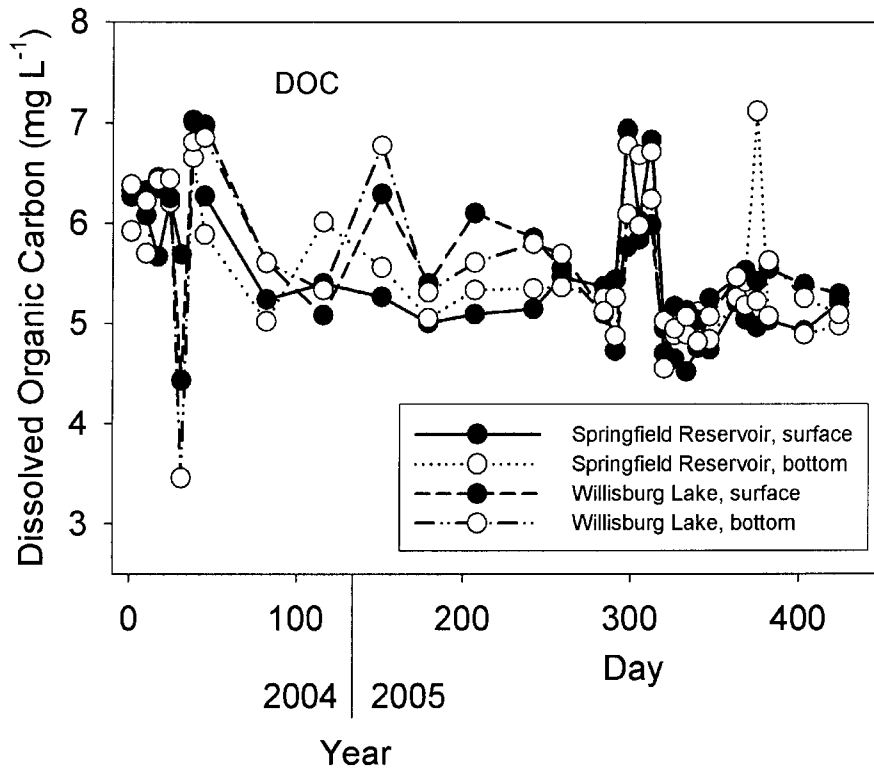
DOC concentrations were highly variable (see Figure 11). DOC concentrations generally declined throughout the study period and samples taken from Willisburg Lake and Springfield Reservoir were similar to each other at both depths sampled. Free chloride concentrations found in the lakes were similar to each other and followed the same pattern in both lakes and both depths (see Figure 12). Chloride concentrations for both lakes and depths decreased during isothermal periods but remained consistent and higher during both stratified periods.

#### *Air Oxidation Experiment*

Results from the aeration experiments were variable and depended on site. Hypolimnion samples from both lakes showed high variability, and were statistically insignificant. THMFP for Willisburg Lake and Springfield Reservoir throughout the time period sampled responded variably (increases and decreases) to aeration (see Figure 13). Statistical analysis of these changes in THMFP from before aeration to after of Willisburg Lake and Springfield Reservoir gave non-significant results due to the manipulation ( $p = 0.4480$  and  $p = 0.2533$ , respectively, see Table 3). However, THMFP in finished water was consistently reduced as much as 50% by aeration throughout the seven weeks of sampling ( $p < 0.0001$ , see Figure 13).

**Figure 11**

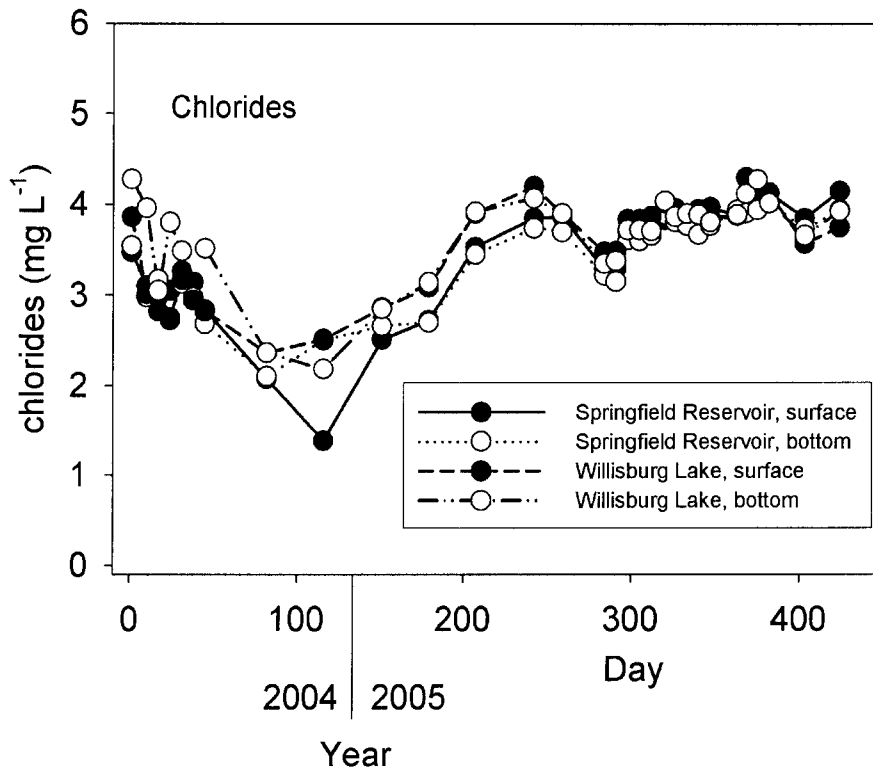
Dissolved Organic Carbon Profile



Dissolved organic carbon concentrations were variable in both lakes and at surface and bottom. DOC concentrations declined slightly towards the end of the study period.

Figure 12

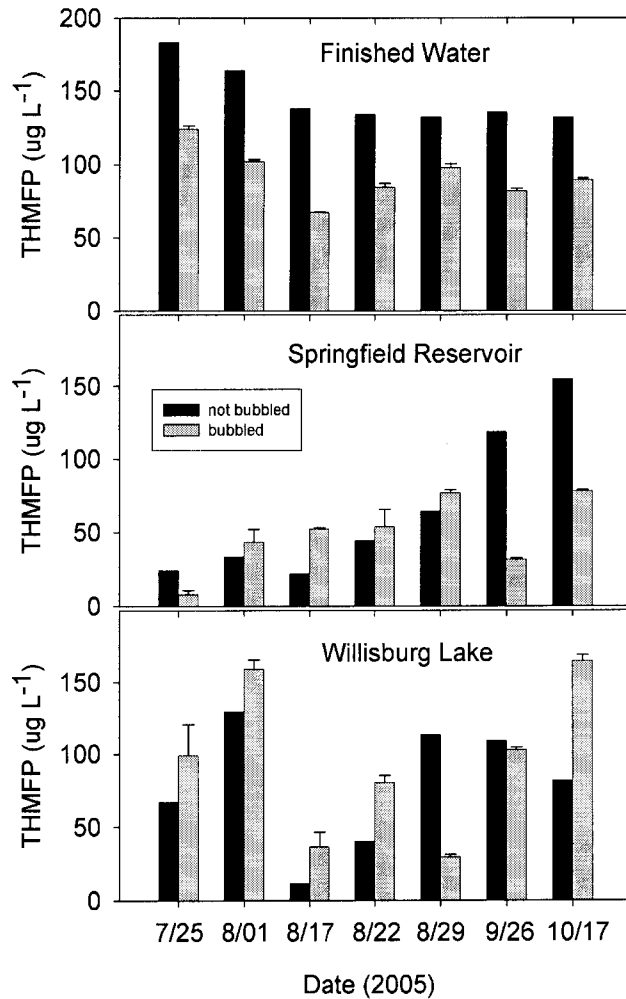
Chloride Profile



Chloride concentrations were similar for both lakes and depths during the entire sampling period. A decrease in chloride concentrations was observable after the first stratification period (October 2004) and a subsequent increase towards the end of the isothermal period (April 2005) resulting in chloride concentrations similar to those at the beginning of the study.

**Figure 13**

Air Oxidation Experiment



Results from the bench-top scale air oxidation experiment. Dark bars represent the THMFPP of the samples that were split off and not bubbled while the lighter bars are the average THMFPP of the three aerated samples. Finished water showed a significant ( $p < 0.0001$ ) reduction in THMFPP during each week sampled, while raw water from the hypolimnion of both lakes showed no consistent pattern of reduction by aeration, and often resulted in an increase in THMFPP.

**Table 3**Mixed Procedure Table for Air Oxidation Experiment

<b>Site</b>	<b>F-Statistic</b>	<b>P-value</b>
Finished Water	29.02	<0.0001
Springfield Bottom	1.36	0.2533
Willisburg Bottom	0.59	0.4880

The mixed procedure analysis for the aeration experiment shows a highly significant difference in THMFP due to manipulation (aeration) for finished water samples while raw water samples from both lakes hypolimnion show no significant results.

## CONCLUSIONS

The significant lake factors that correlated best with THMFP in our study are specifically related to the nutrients (nitrate and SRP) and conditions (water temperature and pH) of the lake. During this period the lakes were eutrophic (Nürnberg 1996) and nutrient levels were similar to other mesotrophic/eutrophic lakes in this region.

Temperature ranges and approximate lake turnover times were also consistent with other warm monomictic, mid-latitude lakes in the area (Bukaveckas, in press). THMFP was highest when nutrient concentrations were high. The increase in nitrate and SRP during the beginning of the study may indicate an algal mediated THMFP. Jack et al. in 2002 found that extra cellular products (ECPs) and algal senescence were identified as the likely causative factor for increasing the precursors to THM production. In another study, Arruda and Fromm (1989) showed a positive correlation with THMFP and the trophic state of a lake suggesting autochthonous production of precursors as a possible source THMFP.

The overall decline in THMFP over the 14 month study may be explainable by climate differences between 2004 and 2005. The National Oceanographic and Atmospheric Administrations' (NOAA) Palmer Drought Severity Index demonstrates a decrease in rainfall from the beginning of the sampling period to the end, with the region experiencing an Unusual Moist Spell or Very Moist Spell during the end of 2004 to Near Normal or Moderate Drought through October 2005 (From the NOAA National Climatic Data Center). The decrease in rainfall would lead to a decrease in allochthonous inputs



(DOC, phosphorus, and nitrate) from the watershed surrounding Willisburg Lake and Springfield Reservoir. These in turn could reduce the amount of algal productivity and hence reduce source of the THM precursors. Higher concentrations of THMFP during the isothermal period may be due to hypolimnetic release of organic precursors (e.g. humic acids). The increase in THMFP due to hypolimnetic production of THM precursors has been observed in other regional lakes (Taylorsville Lake, Taylorsville, KY), and a similar mechanism may be responsible for the high THMFP during isothermal periods (Bukaveckas, in press). Further work in characterizing the exact composition of the precursor pool would be needed to determine if these hypotheses are correct.

Though THMFP in raw water was highest during the beginning of the study period and the isothermal period between 2004 and 2005, Springfield Water Company only reported USEPA THM violations during months when the source water was stratified. Finished water samples taken (May 2005 – October 2005, a stratified period) show that a significant amount of DOC “survives” the coagulation/flocculation process employed by the Springfield Water Company. Average DOC levels were reduced by approximately 50%, leaving a significant amount of possible organic precursors available for additional formation of THMs during distribution.

In the case of Springfield Water Company, the amounts of NOM and the particular constituents (i.e. the NOM quality) of the THM precursor pool have lead to the need for the water treatment facility to modify its methodologies. The constituents of the THM precursor pool may vary based on the mechanism by which they form (hypolimnetic formation vs. extra cellular products formation), and one method of

precursor reduction may not sufficiently reduce THMFP. For Springfield Water Company, air oxidation subsequent to chlorination during stratified periods may be a valuable tool for reducing THMFP.

In the bench-top scale experiments, 16 hours of aeration was able to reduce the amounts of THM precursors in 1-liter of finished drinking water by as much 52%. This reduction was enough to lower THMFP levels from above current USEPA standards to acceptable levels. I believe that this change occurs by the process of air oxidation which is known to degrade organic based materials (Denney 1971). The degradation occurs through the formation of a free radical on the carbon molecule leading to the oxidation of that molecule. Oxidation of THM precursors may “inactivate” them such that they would not add to the THMFP. Levels of dissolved organic carbon (DOC) measured during this study indicates that the processes used at the Springfield Water Treatment Plant (SWTP) may not effectively remove important small organic molecules that contribute to THMFP. Levels of DOC in raw water averaged 5.16 mg/L (SE = 0.08 mg/L) during the sampling period for which the aeration experiment took place, while DOC levels in processed finished water were only reduced to an average of 2.86 mg/L (SE = 0.05 mg/L). POC levels in the finished water during this period were negligible and the remaining DOC is likely the primary THM precursor source. At a bench top scale, air oxidation of finished water was capable of significantly reducing THMFP ( $p < 0.0001$ ). Technological advances would be necessary to implement any air oxidation methods to finished drinking water, but I believe that possible environmental and health benefits might be worth the effort.

In the raw unfiltered water, manipulation resulted in either drastic decreases in THMFP after air oxidation or increases in THMFP of up to 400%. The variability in THMFP reduction may be due to differences in the microbial communities that might respond differently to changing redox potentials during oxidation. Further work identifying microbial community structure would be needed in order to ascertain whether or not this hypothesis is valid. If valid, future work could aim at manipulating microbial community structures in storage basins that could be aerated to reduce THMFP without the need for strong oxidizers. Technological adjustments for the basin and aeration units would be achievable with relative ease as existing flocculation basins could be easily converted to aeration basins.

The findings of this study show the importance of understanding watershed level processes (watershed landuse) and their possible implication for THMFP during different climatic patterns and thermal status (isothermal vs. stratified). A single process may not sufficiently reduce THM precursors, though further work characterizing the constituents that make up the precursor pool, and how those precursors form, would certainly allow for a greater understanding of the exact mechanisms that lead to these differences and methods of control. My results show that eutrophication may have an impact on THMFP for this particular system and the implementation of a Best Management Practices to reduce nutrient loading may reduce THMFP in Willisburg Lake. This in turn could reduce the organic carbon load that is being processed at the treatment facility. A reduction in carbon loads at the treatment facility could allow current methodologies of reducing known THM precursors (TOC, DOC) to function at a level that might avoid USEPA violations.

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## APPENDICES

The following appendix contains the raw data which was used for statistical mixed procedure analysis using SAS version 9.1.3 and described in the Methods section. Blank spaces indicate no data was taken. All units are in mg L<sup>-1</sup> unless otherwise noted.

Lake	Date	Julian Date	Day	Depth	DOC	Ammonia
Springfield	8/20/2004	04233	1	Surf	6.265	0.09
Springfield	8/29/2004	04242	10	Surf	6.075	0.09
Springfield	9/5/2004	04249	17	Surf	5.667	0.09
Springfield	9/12/2004	04256	24	Surf	6.225	0.09
Springfield	9/19/2004	04263	31	Surf	5.689	0.09
Springfield	9/26/2004	04270	38	Surf		0.09
Springfield	10/3/2004	04277	45	Surf	6.272	0.09
Springfield	11/9/2004	04314	82	Surf	5.237	0.09
Springfield	12/13/2004	04348	116	Surf	5.398	0.45
Springfield	1/17/2005	05017	151	Surf	5.264	0.09
Springfield	2/14/2005	05045	179	Surf	5.004	0.09
Springfield	3/14/2005	05073	207	Surf	5.092	0.09
Springfield	4/18/2005	05108	242	Surf	5.146	0.09
Springfield	5/5/2005	05125	259	Surf	5.466	0.09
Springfield	5/30/2005	05150	284	Surf	5.3705	0.09
Springfield	6/6/2005	05157	291	Surf	5.436	0.09
Springfield	6/13/2005	05164	298	Surf	6.935	0.09
Springfield	6/20/2005	05171	305	Surf	6.022	0.09
Springfield	6/27/2005	05178	312	Surf	6.842	0.01
Springfield	7/5/2005	05186	320	Surf	4.945	0.13
Springfield	7/11/2005	05192	326	Surf	4.639	0.07
Springfield	7/18/2005	05199	333	Surf	4.515	0.009
Springfield	7/25/2005	05206	340	Surf	4.752	0.06
Springfield	8/1/2005	05213	347	Surf	4.735	0.009
Springfield	8/17/2005	05229	363	Surf	5.213	0.02
Springfield	8/22/2005	05234	368	Surf	5.042	0.04
Springfield	8/29/2005	05241	375	Surf	4.964	0.13
Springfield	9/5/2005	05248	382	Surf	5.028	0.009
Springfield	9/26/2005	05269	403	Surf	4.924	0.03
Springfield	10/17/2005	05290	424	Surf	5.209	0.009

Lake	Date	Day	Depth	TKN	Nitrate	SRP
Springfield	8/20/2004	1	Surf	0.09	1.38	0.07
Springfield	8/29/2004	10	Surf	0.09	0.96	0.03
Springfield	9/5/2004	17	Surf	0.09	0.48	0.1
Springfield	9/12/2004	24	Surf	1.16	0.32	0.05
Springfield	9/19/2004	31	Surf	0.88	0.23	0.009
Springfield	9/26/2004	38	Surf	0.8	0.41	0.009
Springfield	10/3/2004	45	Surf	0.56	0.09	0.2
Springfield	11/9/2004	82	Surf	0.56	0.17	0.01
Springfield	12/13/2004	116	Surf	0.07	0.22	0.009
Springfield	1/17/2005	151	Surf	0.07	0.17	0.009
Springfield	2/14/2005	179	Surf	0.28	0.0096	0.009
Springfield	3/14/2005	207	Surf	0.14	0.01	0.009
Springfield	4/18/2005	242	Surf	1.295	0.007	0.009
Springfield	5/5/2005	259	Surf	0.63	0.02	0.009
Springfield	5/30/2005	284	Surf	1.26	0.0295	0.009
Springfield	6/6/2005	291	Surf	1.75	0.0458	0.009
Springfield	6/13/2005	298	Surf	0.91	0.01	0.009
Springfield	6/20/2005	305	Surf	0.98	0.01	0.009
Springfield	6/27/2005	312	Surf	1.043	0.02	0.009
Springfield	7/5/2005	320	Surf		0.01	0.009
Springfield	7/11/2005	326	Surf		0.005	0.009
Springfield	7/18/2005	333	Surf		0.005	0.009
Springfield	7/25/2005	340	Surf		0.005	0.009
Springfield	8/1/2005	347	Surf		0.005	0.009
Springfield	8/17/2005	363	Surf		0.005	0.009
Springfield	8/22/2005	368	Surf		0.013	0.009
Springfield	8/29/2005	375	Surf		0.005	0.009
Springfield	9/5/2005	382	Surf		0.04	0.009
Springfield	9/26/2005	403	Surf		0.009	0.009
Springfield	10/17/2005	424	Surf		0.04	0.04



Lake	Date	Day	Depth	TP	Chlorides	Silica
Springfield	8/20/2004	1	Surf	0.15	3.47	1.68
Springfield	8/29/2004	10	Surf	0.25	3.1	2.99
Springfield	9/5/2004	17	Surf	0.3	2.98	1.95
Springfield	9/12/2004	24	Surf	0.13	3.05	2.97
Springfield	9/19/2004	31	Surf	0.12	3.26	3.14
Springfield	9/26/2004	38	Surf	0.11	3.14	3.23
Springfield	10/3/2004	45	Surf	0.4	2.84	2.89
Springfield	11/9/2004	82	Surf	0.07	2.07	1.55
Springfield	12/13/2004	116	Surf	0.49	1.38	3.4
Springfield	1/17/2005	151	Surf	0.14	2.51	6.5
Springfield	2/14/2005	179	Surf	0.06	2.72	6.71
Springfield	3/14/2005	207	Surf	0.02	3.53	1.19
Springfield	4/18/2005	242	Surf	0.009	3.85	1.032
Springfield	5/5/2005	259	Surf	0.009	3.87	0.398
Springfield	5/30/2005	284	Surf	0.26	3.2897	0.299
Springfield	6/6/2005	291	Surf	0.1	3.2923	0.689
Springfield	6/13/2005	298	Surf	0.05	3.7	1.241
Springfield	6/20/2005	305	Surf	0.03	3.71	1.239
Springfield	6/27/2005	312	Surf	0.19	3.84	0.603
Springfield	7/5/2005	320	Surf	0.09	3.83	1.829
Springfield	7/11/2005	326	Surf	0.11	3.89	3.648
Springfield	7/18/2005	333	Surf	0.06	3.79	3.648
Springfield	7/25/2005	340	Surf	0.06	3.88	1.102
Springfield	8/1/2005	347	Surf	0.15	3.86	1.515
Springfield	8/17/2005	363	Surf	0.17	3.88	2.465
Springfield	8/22/2005	368	Surf	0.2	4	3.123
Springfield	8/29/2005	375	Surf	0.17	3.98	5.404
Springfield	9/5/2005	382	Surf	0.17	4.13	4.929
Springfield	9/26/2005	403	Surf	0.14	3.85	2.664
Springfield	10/17/2005	424	Surf	0.23	4.15	2.106

Lake	Date	Day	Depth	THM Total (ug/L)	Chl a (ug/L)	Pheo a (ug/L)
Springfield	8/20/2004	1	Surf	498.1	37.4	15.4
Springfield	8/29/2004	10	Surf	365.6	193.9	-11.2
Springfield	9/5/2004	17	Surf	341.1	134.3	4.5
Springfield	9/12/2004	24	Surf	286.4	99.5	5.2
Springfield	9/19/2004	31	Surf	234.6	62.0	5.6
Springfield	9/26/2004	38	Surf		43.8	2.4
Springfield	10/3/2004	45	Surf	288.7	27.4	4.7
Springfield	11/9/2004	82	Surf	244.2	11.4	6.9
Springfield	12/13/2004	116	Surf	294	10.9	6.6
Springfield	1/17/2005	151	Surf	369.2	9.4	14.1
Springfield	2/14/2005	179	Surf	206.6	16.2	8.9
Springfield	3/14/2005	207	Surf	267.7	27.7	6.3
Springfield	4/18/2005	242	Surf	333	9.4	5.5
Springfield	5/5/2005	259	Surf	139.1	9.9	9.2
Springfield	5/30/2005	284	Surf	75.1	44.0	2.0
Springfield	6/6/2005	291	Surf	240.6	66.1	0.8
Springfield	6/13/2005	298	Surf	49.5	30.1	3.3
Springfield	6/20/2005	305	Surf	150.7	36.9	27.1
Springfield	6/27/2005	312	Surf	56.2		
Springfield	7/5/2005	320	Surf	184.2		
Springfield	7/11/2005	326	Surf	95.5		
Springfield	7/18/2005	333	Surf	117.8		
Springfield	7/25/2005	340	Surf	176.8		
Springfield	8/1/2005	347	Surf	78.4		
Springfield	8/17/2005	363	Surf	46.3		
Springfield	8/22/2005	368	Surf	66.7		
Springfield	8/29/2005	375	Surf	114.2		
Springfield	9/5/2005	382	Surf	61.6		
Springfield	9/26/2005	403	Surf	67.8		
Springfield	10/17/2005	424	Surf	85.7		

Lake	Date	Day	Depth	POC	Temperature	DO
Springfield	8/20/2004	1	Surf	8.79	25.24	6.71
Springfield	8/29/2004	10	Surf	13.83	26.52	8.38
Springfield	9/5/2004	17	Surf	10.80	25.11	7.41
Springfield	9/12/2004	24	Surf	9.71	24.69	12.4
Springfield	9/19/2004	31	Surf	7.37	21.9	4.75
Springfield	9/26/2004	38	Surf	9.06	22.44	8.5
Springfield	10/3/2004	45	Surf	4.36	22.14	7.03
Springfield	11/9/2004	82	Surf	2.10	14.08	5.13
Springfield	12/13/2004	116	Surf	3.63	8.65	6.58
Springfield	1/17/2005	151	Surf	1.87	6.59	11.15
Springfield	2/14/2005	179	Surf	6.46	6.04	12.89
Springfield	3/14/2005	207	Surf	4.43	6.06	8.97
Springfield	4/18/2005	242	Surf	5.31	17.35	4.55
Springfield	5/5/2005	259	Surf	1.47	14.75	9.24
Springfield	5/30/2005	284	Surf	1.47	23	9.33
Springfield	6/6/2005	291	Surf	10.59	25.71	13.34
Springfield	6/13/2005	298	Surf	8.80	25.67	8.18
Springfield	6/20/2005	305	Surf	8.24	25.28	7.7
Springfield	6/27/2005	312	Surf	6.25	28.52	5.2
Springfield	7/5/2005	320	Surf	4.98	28.28	6.14
Springfield	7/11/2005	326	Surf	5.21	27.66	4.12
Springfield	7/18/2005	333	Surf	6.75	26.6	9.3
Springfield	7/25/2005	340	Surf	4.00	29.76	10.92
Springfield	8/1/2005	347	Surf	15.26	28.37	12.62
Springfield	8/17/2005	363	Surf	7.43	27.98	4.55
Springfield	8/22/2005	368	Surf	14.07	27.98	6.45
Springfield	8/29/2005	375	Surf	10.00	25.86	4.22
Springfield	9/5/2005	382	Surf	6.75	24.36	4.65
Springfield	9/26/2005	403	Surf	6.80	24.81	3.31
Springfield	10/17/2005	424	Surf	5.66	18.29	2.89

Lake	Date	Day	Depth	pH	SpCond
Springfield	8/20/2004	1	Surf	8.42	206
Springfield	8/29/2004	10	Surf	8.22	191
Springfield	9/5/2004	17	Surf	7.91	204.3
Springfield	9/12/2004	24	Surf	8.49	199.1
Springfield	9/19/2004	31	Surf	7.15	197.2
Springfield	9/26/2004	38	Surf	8.83	210.6
Springfield	10/3/2004	45	Surf	7.51	221.1
Springfield	11/9/2004	82	Surf	7.56	266.1
Springfield	12/13/2004	116	Surf	7.45	275.2
Springfield	1/17/2005	151	Surf	7.3	263.9
Springfield	2/14/2005	179	Surf	8.31	284.2
Springfield	3/14/2005	207	Surf	8.15	301.7
Springfield	4/18/2005	242	Surf	8.26	315.6
Springfield	5/5/2005	259	Surf	8.09	312.2
Springfield	5/30/2005	284	Surf	8.65	295.2
Springfield	6/6/2005	291	Surf	8.49	250.9
Springfield	6/13/2005	298	Surf	8.38	234.4
Springfield	6/20/2005	305	Surf	8.4	246.1
Springfield	6/27/2005	312	Surf	7.7	259
Springfield	7/5/2005	320	Surf	8.08	237.8
Springfield	7/11/2005	326	Surf	7.59	246.6
Springfield	7/18/2005	333	Surf	8.52	244.9
Springfield	7/25/2005	340	Surf	8.86	212.4
Springfield	8/1/2005	347	Surf	9.28	193.2
Springfield	8/17/2005	363	Surf	8.76	194.2
Springfield	8/22/2005	368	Surf	8.95	196.3
Springfield	8/29/2005	375	Surf	8.08	208.1
Springfield	9/5/2005	382	Surf	8.13	217.7
Springfield	9/26/2005	403	Surf	7.85	224
Springfield	10/17/2005	424	Surf	7.65	245.5

Lake	Date	Julian Date	Day	Depth	DOC	Ammonia
Springfield	8/20/2004	04233	1	Bottom	5.922	0.09
Springfield	8/29/2004	04242	10	Bottom	5.699	0.09
Springfield	9/5/2004	04249	17	Bottom	6.453	0.09
Springfield	9/12/2004	04256	24	Bottom	6.2	0.09
Springfield	9/19/2004	04263	31	Bottom		0.09
Springfield	9/26/2004	04270	38	Bottom	6.653	0.09
Springfield	10/3/2004	04277	45	Bottom	5.885	0.09
Springfield	11/9/2004	04314	82	Bottom	5.019	0.09
Springfield	12/13/2004	04348	116	Bottom	6.015	1.4
Springfield	1/17/2005	05017	151	Bottom	5.56	0.09
Springfield	2/14/2005	05045	179	Bottom	5.051	0.09
Springfield	3/14/2005	05073	207	Bottom	5.332	0.09
Springfield	4/18/2005	05108	242	Bottom	5.35	0.09
Springfield	5/5/2005	05125	259	Bottom	5.366	0.09
Springfield	5/30/2005	05150	284	Bottom	5.255	0.09
Springfield	6/6/2005	05157	291	Bottom	5.261	0.09
Springfield	6/13/2005	05164	298	Bottom	6.786	0.09
Springfield	6/20/2005	05171	305	Bottom	6.686	0.06
Springfield	6/27/2005	05178	312	Bottom	6.716	0.2
Springfield	7/5/2005	05186	320	Bottom	5.022	0.09
Springfield	7/11/2005	05192	326	Bottom	4.884	0.09
Springfield	7/18/2005	05199	333	Bottom	4.887	0.04
Springfield	7/25/2005	05206	340	Bottom	5.111	0.009
Springfield	8/1/2005	05213	347	Bottom	4.834	0.17
Springfield	8/17/2005	05229	363	Bottom	5.26	0.13
Springfield	8/22/2005	05234	368	Bottom	5.414	0.36
Springfield	8/29/2005	05241	375	Bottom	7.112	0.02
Springfield	9/5/2005	05248	382	Bottom	5.072	0.009
Springfield	9/26/2005	05269	403	Bottom	4.886	0.06
Springfield	10/17/2005	05290	424	Bottom	4.974	0.009

Lake	Date	Day	Depth	TKN	Nitrate	SRP
Springfield	8/20/2004	1	Bottom	0.09	0.51	0.1
Springfield	8/29/2004	10	Bottom	0.09	0.35	0.04
Springfield	9/5/2004	17	Bottom	0.09	0.09	0.4
Springfield	9/12/2004	24	Bottom	0.56	0.1	0.04
Springfield	9/19/2004	31	Bottom	1.26	0.09	0.009
Springfield	9/26/2004	38	Bottom	0.7	0.09	0.009
Springfield	10/3/2004	45	Bottom	0.84	0.09	0.1
Springfield	11/9/2004	82	Bottom	0.595	0.18	0.01
Springfield	12/13/2004	116	Bottom	0.77	0.2	0.01
Springfield	1/17/2005	151	Bottom	0.56	0.16	0.009
Springfield	2/14/2005	179	Bottom	0.56	0.0096	0.009
Springfield	3/14/2005	207	Bottom	0.7	0.004	0.009
Springfield	4/18/2005	242	Bottom	1.12	0.007	0.009
Springfield	5/5/2005	259	Bottom	0.7	0.01	0.009
Springfield	5/30/2005	284	Bottom	1.085	0.02	0.009
Springfield	6/6/2005	291	Bottom	1.05	0.0312	0.009
Springfield	6/13/2005	298	Bottom	0.94	0.01	0.009
Springfield	6/20/2005	305	Bottom	1.855	0.005	0.009
Springfield	6/27/2005	312	Bottom	1.533	0.01	0.009
Springfield	7/5/2005	320	Bottom		0.004	0.009
Springfield	7/11/2005	326	Bottom		0.02	0.09
Springfield	7/18/2005	333	Bottom		0.005	
Springfield	7/25/2005	340	Bottom		0.005	0.02
Springfield	8/1/2005	347	Bottom		0.005	0.14
Springfield	8/17/2005	363	Bottom		0.005	0.009
Springfield	8/22/2005	368	Bottom		0.005	0.009
Springfield	8/29/2005	375	Bottom		0.005	0.01
Springfield	9/5/2005	382	Bottom		0.005	0.009
Springfield	9/26/2005	403	Bottom		0.009	0.009
Springfield	10/17/2005	424	Bottom		0.04	0.04

Lake	Date	Day	Depth	TP	Chlorides	Silica
Springfield	8/20/2004	1	Bottom	0.16	3.54	2.54
Springfield	8/29/2004	10	Bottom	0.2	2.98	2.05
Springfield	9/5/2004	17	Bottom	0.3	3.17	5.53
Springfield	9/12/2004	24	Bottom	0.13	2.72	2.27
Springfield	9/19/2004	31	Bottom	0.17	3.13	3.9
Springfield	9/26/2004	38	Bottom	0.1	2.97	3.54
Springfield	10/3/2004	45	Bottom	0.6	2.68	3.11
Springfield	11/9/2004	82	Bottom	0.07	2.1	1.86
Springfield	12/13/2004	116	Bottom	0.35	2.5	3.5
Springfield	1/17/2005	151	Bottom	0.13	2.66	6.75
Springfield	2/14/2005	179	Bottom	0.13	2.7	5.96
Springfield	3/14/2005	207	Bottom	0.13	3.45	0.8
Springfield	4/18/2005	242	Bottom	0.009	3.74	3.109
Springfield	5/5/2005	259	Bottom	0.01	3.7	0.498
Springfield	5/30/2005	284	Bottom	0.3	3.222	1.175
Springfield	6/6/2005	291	Bottom	0.19	3.1515	2.032
Springfield	6/13/2005	298	Bottom	0.11	3.61	1.17
Springfield	6/20/2005	305	Bottom	0.26	3.6	2.798
Springfield	6/27/2005	312	Bottom	0.2	3.66	1.677
Springfield	7/5/2005	320	Bottom	0.28	3.89	2.608
Springfield	7/11/2005	326	Bottom	0.45	3.81	3.104
Springfield	7/18/2005	333	Bottom		3.77	3.104
Springfield	7/25/2005	340	Bottom	0.52	3.67	3.765
Springfield	8/1/2005	347	Bottom	0.51	3.77	4.12
Springfield	8/17/2005	363	Bottom	0.26	3.94	2.593
Springfield	8/22/2005	368	Bottom	0.1	3.91	3.68
Springfield	8/29/2005	375	Bottom	0.84	3.94	3.679
Springfield	9/5/2005	382	Bottom	0.16	4.03	4.086
Springfield	9/26/2005	403	Bottom	0.15	3.73	2.623
Springfield	10/17/2005	424	Bottom	0.26	3.94	1.6

Lake	Date	Day	Depth	THM Total (ug/L)	Chl a (ug/L)	Pheo a (ug/L)
Springfield	8/20/2004	1	Bottom	438.1	16.0	22.2
Springfield	8/29/2004	10	Bottom	384.7	59.0	4.3
Springfield	9/5/2004	17	Bottom	291.6	14.6	10.8
Springfield	9/12/2004	24	Bottom	278.3	70.6	9.8
Springfield	9/19/2004	31	Bottom	267.2	28.1	8.4
Springfield	9/26/2004	38	Bottom	269.9	30.4	5.0
Springfield	10/3/2004	45	Bottom	217.9	24.6	7.8
Springfield	11/9/2004	82	Bottom	268.5	10.7	8.2
Springfield	12/13/2004	116	Bottom	260	11.3	8.5
Springfield	1/17/2005	151	Bottom	324.5	8.5	13.6
Springfield	2/14/2005	179	Bottom	283.2	15.8	11.3
Springfield	3/14/2005	207	Bottom	289.6	28.2	6.6
Springfield	4/18/2005	242	Bottom	339.9	10.5	11.8
Springfield	5/5/2005	259	Bottom	70	11.1	17.5
Springfield	5/30/2005	284	Bottom		18.7	5.8
Springfield	6/6/2005	291	Bottom	86.9	19.5	9.0
Springfield	6/13/2005	298	Bottom	10.9	18.6	11.1
Springfield	6/20/2005	305	Bottom	29.9	17.9	14.6
Springfield	6/27/2005	312	Bottom	12.5		
Springfield	7/5/2005	320	Bottom	59.6		
Springfield	7/11/2005	326	Bottom	97.9		
Springfield	7/18/2005	333	Bottom	79.5		
Springfield	7/25/2005	340	Bottom	24.1		
Springfield	8/1/2005	347	Bottom	33.5		
Springfield	8/17/2005	363	Bottom	21.9		
Springfield	8/22/2005	368	Bottom	44.3		
Springfield	8/29/2005	375	Bottom	64.5		
Springfield	9/5/2005	382	Bottom	28		
Springfield	9/26/2005	403	Bottom	118.6		
Springfield	10/17/2005	424	Bottom	154.6		



Lake	Date	Day	Depth	POC	Temperature	DO
Springfield	8/20/2004	1	Bottom	6.72	22.76	0.79
Springfield	8/29/2004	10	Bottom	9.14	22.42	0.29
Springfield	9/5/2004	17	Bottom	4.09	19.76	0.33
Springfield	9/12/2004	24	Bottom	5.97	21.41	0.52
Springfield	9/19/2004	31	Bottom	7.11	19.52	0.61
Springfield	9/26/2004	38	Bottom	5.97	21.27	1.31
Springfield	10/3/2004	45	Bottom	3.39	19.73	2.8
Springfield	11/9/2004	82	Bottom	2.38	14.06	4.41
Springfield	12/13/2004	116	Bottom	4.21	8.61	6.55
Springfield	1/17/2005	151	Bottom	2.18	6.37	9.95
Springfield	2/14/2005	179	Bottom	5.34	6.06	12.66
Springfield	3/14/2005	207	Bottom	5.84	5.96	8.65
Springfield	4/18/2005	242	Bottom	4.37	10.78	1.64
Springfield	5/5/2005	259	Bottom	0.59	13.02	2.31
Springfield	5/30/2005	284	Bottom	0.59	13.49	0.14
Springfield	6/6/2005	291	Bottom	5.88	13.41	0.19
Springfield	6/13/2005	298	Bottom	5.54	15.43	0.14
Springfield	6/20/2005	305	Bottom	5.00	14.3	0.23
Springfield	6/27/2005	312	Bottom	4.98	16.95	0.23
Springfield	7/5/2005	320	Bottom	3.96	16.77	0.24
Springfield	7/11/2005	326	Bottom	4.98	16.49	0.21
Springfield	7/18/2005	333	Bottom	5.75	17.24	0.24
Springfield	7/25/2005	340	Bottom	1.00	16.6	0.18
Springfield	8/1/2005	347	Bottom	8.00	18.9	0.26
Springfield	8/17/2005	363	Bottom	8.58	19.46	0.11
Springfield	8/22/2005	368	Bottom	16.16	16.78	0.12
Springfield	8/29/2005	375	Bottom	6.46	14.66	0.14
Springfield	9/5/2005	382	Bottom	8.33	19.43	0.2
Springfield	9/26/2005	403	Bottom	7.05	20.1	0.6
Springfield	10/17/2005	424	Bottom	6.33	18.22	2.71

Lake	Date	Day	Depth	pH	SpCond
Springfield	8/20/2004	1	Bottom	6.84	229
Springfield	8/29/2004	10	Bottom	6.75	263
Springfield	9/5/2004	17	Bottom	6.69	370.6
Springfield	9/12/2004	24	Bottom	6.89	321.3
Springfield	9/19/2004	31	Bottom	6.64	366.2
Springfield	9/26/2004	38	Bottom	7.15	228.2
Springfield	10/3/2004	45	Bottom	6.97	223
Springfield	11/9/2004	82	Bottom	7.59	266.6
Springfield	12/13/2004	116	Bottom	7.48	277
Springfield	1/17/2005	151	Bottom	7.69	300.1
Springfield	2/14/2005	179	Bottom	8.34	284.6
Springfield	3/14/2005	207	Bottom	8.33	303.8
Springfield	4/18/2005	242	Bottom	7.51	317.7
Springfield	5/5/2005	259	Bottom	7.48	319.1
Springfield	5/30/2005	284	Bottom	7.44	339.2
Springfield	6/6/2005	291	Bottom	7.23	358.8
Springfield	6/13/2005	298	Bottom	7.27	339
Springfield	6/20/2005	305	Bottom	7.22	350.3
Springfield	6/27/2005	312	Bottom	7.01	379.2
Springfield	7/5/2005	320	Bottom	7.07	351.9
Springfield	7/11/2005	326	Bottom	7.03	356.6
Springfield	7/18/2005	333	Bottom	7.05	359.6
Springfield	7/25/2005	340	Bottom	7	381.6
Springfield	8/1/2005	347	Bottom	7.11	372.7
Springfield	8/17/2005	363	Bottom	7.08	376.4
Springfield	8/22/2005	368	Bottom	6.98	407.2
Springfield	8/29/2005	375	Bottom	6.93	448.9
Springfield	9/5/2005	382	Bottom	7.25	412.8
Springfield	9/26/2005	403	Bottom	6.83	401.8
Springfield	10/17/2005	424	Bottom	7.55	247.5

<b>Lake</b>	<b>Date</b>	<b>Julian Date</b>	<b>Day</b>	<b>Depth</b>	<b>DOC</b>	<b>Ammonia</b>
Willisburg	8/20/2004	04233	1	Surf	6.322	0.09
Willisburg	8/29/2004	04242	10	Surf	6.323	0.09
Willisburg	9/5/2004	04249	17	Surf	6.351	0.09
Willisburg	9/12/2004	04256	24	Surf	6.249	0.09
Willisburg	9/19/2004	04263	31	Surf	4.424	0.09
Willisburg	9/26/2004	04270	38	Surf	7.018	0.09
Willisburg	10/3/2004	04277	45	Surf	6.97	0.09
Willisburg	11/9/2004	04314	82	Surf	5.605	0.09
Willisburg	12/13/2004	04348	116	Surf	5.081	0.6
Willisburg	1/17/2005	05017	151	Surf	6.29	0.09
Willisburg	2/14/2005	05045	179	Surf	5.398	0.09
Willisburg	3/14/2005	05073	207	Surf	6.102	0.09
Willisburg	4/18/2005	05108	242	Surf	5.857	0.09
Willisburg	5/5/2005	05125	259	Surf	5.553	0.09
Willisburg	5/30/2005	05150	284	Surf	5.097	0.09
Willisburg	6/6/2005	05157	291	Surf	4.725	0.09
Willisburg	6/13/2005	05164	298	Surf	5.766	0.09
Willisburg	6/20/2005	05171	305	Surf	5.839	0.09
Willisburg	6/27/2005	05178	312	Surf	5.984	0.09
Willisburg	7/5/2005	05186	320	Surf	4.701	0.09
Willisburg	7/11/2005	05192	326	Surf	5.17	0.02
Willisburg	7/18/2005	05199	333	Surf	5.126	0.04
Willisburg	7/25/2005	05206	340	Surf	5.034	0.009
Willisburg	8/1/2005	05213	347	Surf	5.248	0.009
Willisburg	8/17/2005	05229	363	Surf	5.46	0.09
Willisburg	8/22/2005	05234	368	Surf	5.533	0.1
Willisburg	8/29/2005	05241	375	Surf	5.424	0.13
Willisburg	9/5/2005	05248	382	Surf	5.546	0.009
Willisburg	9/26/2005	05269	403	Surf	5.39	0.05
Willisburg	10/17/2005	05290	424	Surf	5.293	0.009

Lake	Date	Day	Depth	TKN	Nitrate	SRP
Willisburg	8/20/2004	1	Surf	0.09	0.47	0.06
Willisburg	8/29/2004	10	Surf	0.09	0.29	0.07
Willisburg	9/5/2004	17	Surf	0.09	0.09	0.1
Willisburg	9/12/2004	24	Surf	0.42	0.09	0.05
Willisburg	9/19/2004	31	Surf	0.39	0.04	0.009
Willisburg	9/26/2004	38	Surf	0.42	0.09	0.009
Willisburg	10/3/2004	45	Surf	0.525	0.09	0.1
Willisburg	11/9/2004	82	Surf	0.595	0.02	0.01
Willisburg	12/13/2004	116	Surf	0.7	0.2	0.01
Willisburg	1/17/2005	151	Surf	0.42	0.5	0.009
Willisburg	2/14/2005	179	Surf	0.49	0.39	0.009
Willisburg	3/14/2005	207	Surf	0.67	0.24	0.009
Willisburg	4/18/2005	242	Surf	0.7	0.007	0.009
Willisburg	5/5/2005	259	Surf	1.15	0.01	0.009
Willisburg	5/30/2005	284	Surf	0.98	0.02	0.009
Willisburg	6/6/2005	291	Surf	0.6	0.0365	0.009
Willisburg	6/13/2005	298	Surf	0.81	0.005	0.009
Willisburg	6/20/2005	305	Surf	0.88	0.01	0.009
Willisburg	6/27/2005	312	Surf		0.01	0.009
Willisburg	7/5/2005	320	Surf		0.004	0.009
Willisburg	7/11/2005	326	Surf		0.005	0.009
Willisburg	7/18/2005	333	Surf		0.005	0.009
Willisburg	7/25/2005	340	Surf		0.005	0.009
Willisburg	8/1/2005	347	Surf		0.005	0.009
Willisburg	8/17/2005	363	Surf		0.005	0.009
Willisburg	8/22/2005	368	Surf		0.005	0.009
Willisburg	8/29/2005	375	Surf		0.005	0.009
Willisburg	9/5/2005	382	Surf		0.005	0.009
Willisburg	9/26/2005	403	Surf		0.009	0.009
Willisburg	10/17/2005	424	Surf		0.009	0.04

Lake	Date	Day	Depth	TP	Chlorides	Silica
Willisburg	8/20/2004	1	Surf	0.19	3.86	2.66
Willisburg	8/29/2004	10	Surf	0.15	3.01	2.34
Willisburg	9/5/2004	17	Surf	0.1	2.82	2.91
Willisburg	9/12/2004	24	Surf	0.08	2.75	2.55
Willisburg	9/19/2004	31	Surf	0.08	3.17	4.03
Willisburg	9/26/2004	38	Surf	0.07	2.94	3.34
Willisburg	10/3/2004	45	Surf	0.4	2.82	2.96
Willisburg	11/9/2004	82	Surf	0.07	2.36	3.3
Willisburg	12/13/2004	116	Surf	0.5	2.51	3.23
Willisburg	1/17/2005	151	Surf	0.15	2.86	7.77
Willisburg	2/14/2005	179	Surf	0.15	3.09	7.26
Willisburg	3/14/2005	207	Surf	0.009	3.9	2.44
Willisburg	4/18/2005	242	Surf	0.009	4.2	0.747
Willisburg	5/5/2005	259	Surf	0.009	3.9	1.023
Willisburg	5/30/2005	284	Surf	0.3	3.4788	1.054
Willisburg	6/6/2005	291	Surf	0.05	3.4843	0.907
Willisburg	6/13/2005	298	Surf	0.01	3.84	0.214
Willisburg	6/20/2005	305	Surf	0.01	3.84	1.189
Willisburg	6/27/2005	312	Surf	0.14	3.87	0.443
Willisburg	7/5/2005	320	Surf	0.1	4.02	1.822
Willisburg	7/11/2005	326	Surf	0.1	3.96	1.427
Willisburg	7/18/2005	333	Surf	0.08	8.05	1.303
Willisburg	7/25/2005	340	Surf	0.12	3.95	2.407
Willisburg	8/1/2005	347	Surf	0.18	3.97	2.507
Willisburg	8/17/2005	363	Surf	0.1	3.88	2.664
Willisburg	8/22/2005	368	Surf	0.53	4.3	2.972
Willisburg	8/29/2005	375	Surf	0.15	4.21	4.063
Willisburg	9/5/2005	382	Surf	0.1	4.13	3.224
Willisburg	9/26/2005	403	Surf	0.22	3.57	4.371
Willisburg	10/17/2005	424	Surf	0.25	3.75	2.274

Lake	Date	Day	Depth	THM Total (ug/L)	Chl a (ug/L)	Pheo a (ug/L)
Willisburg	8/20/2004	1	Surf	500	22.9	13.7
Willisburg	8/29/2004	10	Surf	341.8	77.5	1.8
Willisburg	9/5/2004	17	Surf	256.4	22.9	3.6
Willisburg	9/12/2004	24	Surf	246.7	30.2	3.7
Willisburg	9/19/2004	31	Surf	256.1	19.3	3.9
Willisburg	9/26/2004	38	Surf	258.2	17.1	6.5
Willisburg	10/3/2004	45	Surf	210	25.3	3.0
Willisburg	11/9/2004	82	Surf	349.1	14.5	6.4
Willisburg	12/13/2004	116	Surf	212.7	8.5	6.0
Willisburg	1/17/2005	151	Surf	380.9	12.6	10.8
Willisburg	2/14/2005	179	Surf	377.4	23.2	14.6
Willisburg	3/14/2005	207	Surf	358.2	15.2	6.8
Willisburg	4/18/2005	242	Surf	348.8	14.2	6.3
Willisburg	5/5/2005	259	Surf	146.1	9.1	6.6
Willisburg	5/30/2005	284	Surf	147.8	9.5	5.2
Willisburg	6/6/2005	291	Surf	223.3	8.3	4.2
Willisburg	6/13/2005	298	Surf	274.1	14.6	8.3
Willisburg	6/20/2005	305	Surf	177.9	19.1	9.0
Willisburg	6/27/2005	312	Surf	117.2		
Willisburg	7/5/2005	320	Surf	86.6		
Willisburg	7/11/2005	326	Surf	102.6		
Willisburg	7/18/2005	333	Surf	33.8		
Willisburg	7/25/2005	340	Surf	186.9		
Willisburg	8/1/2005	347	Surf	124.9		
Willisburg	8/17/2005	363	Surf	105.8		
Willisburg	8/22/2005	368	Surf	77		
Willisburg	8/29/2005	375	Surf	90.8		
Willisburg	9/5/2005	382	Surf	107.8		
Willisburg	9/26/2005	403	Surf	119.3		
Willisburg	10/17/2005	424	Surf	81.4		

Lake	Date	Day	Depth	POC	Temperature	DO
Willisburg	8/20/2004	1	Surf	8.78	25.55	7.13
Willisburg	8/29/2004	10	Surf	10.36	26.42	6.44
Willisburg	9/5/2004	17	Surf	3.94	26.01	11.46
Willisburg	9/12/2004	24	Surf	5.97	24.82	9.4
Willisburg	9/19/2004	31	Surf	4.27	22.14	6.55
Willisburg	9/26/2004	38	Surf	4.03	22.64	18.84
Willisburg	10/3/2004	45	Surf	3.39	21.22	7.55
Willisburg	11/9/2004	82	Surf	3.73	13.92	4.05
Willisburg	12/13/2004	116	Surf	2.72	8.58	3.74
Willisburg	1/17/2005	151	Surf	2.79	6.15	9.89
Willisburg	2/14/2005	179	Surf	5.24	4.75	14.24
Willisburg	3/14/2005	207	Surf	2.07	6.52	8.64
Willisburg	4/18/2005	242	Surf	6.28	18.19	5.8
Willisburg	5/5/2005	259	Surf	4.39	15.31	12.63
Willisburg	5/30/2005	284	Surf	4.40	23.34	6.73
Willisburg	6/6/2005	291	Surf	8.48	26.04	8.14
Willisburg	6/13/2005	298	Surf	2.92	26.53	7.04
Willisburg	6/20/2005	305	Surf	5.26	26.13	12.4
Willisburg	6/27/2005	312	Surf	8.50	29.35	12.54
Willisburg	7/5/2005	320	Surf	15.02	28.6	12.59
Willisburg	7/11/2005	326	Surf	18.40	28.11	11.91
Willisburg	7/18/2005	333	Surf	10.00	26.31	8.58
Willisburg	7/25/2005	340	Surf	6.01	30.49	10.23
Willisburg	8/1/2005	347	Surf	8.19	29.02	11.98
Willisburg	8/17/2005	363	Surf	8.80	27.52	7.64
Willisburg	8/22/2005	368	Surf	18.00	28.29	9.95
Willisburg	8/29/2005	375	Surf	10.19	25.38	5.86
Willisburg	9/5/2005	382	Surf	7.50	24.75	8.52
Willisburg	9/26/2005	403	Surf	7.22	24.82	4.24
Willisburg	10/17/2005	424	Surf	3.25	17.75	3.12

Lake	Date	Day	Depth	pH	SpCond
Willisburg	8/20/2004	1	Surf	8.91	176
Willisburg	8/29/2004	10	Surf	8.58	183
Willisburg	9/5/2004	17	Surf	8.73	188.1
Willisburg	9/12/2004	24	Surf	8.52	195.4
Willisburg	9/19/2004	31	Surf	7.47	187.6
Willisburg	9/26/2004	38	Surf	8.22	206.5
Willisburg	10/3/2004	45	Surf	7.34	216.3
Willisburg	11/9/2004	82	Surf	7.51	251.3
Willisburg	12/13/2004	116	Surf	7.27	256.9
Willisburg	1/17/2005	151	Surf	7.38	235.4
Willisburg	2/14/2005	179	Surf	7.86	257.4
Willisburg	3/14/2005	207	Surf	7.54	286.8
Willisburg	4/18/2005	242	Surf	9.05	280.7
Willisburg	5/5/2005	259	Surf	8.2	290.8
Willisburg	5/30/2005	284	Surf	8.25	308.4
Willisburg	6/6/2005	291	Surf	8.25	305.7
Willisburg	6/13/2005	298	Surf	8.28	307.3
Willisburg	6/20/2005	305	Surf	8.75	301.8
Willisburg	6/27/2005	312	Surf	8.76	263.8
Willisburg	7/5/2005	320	Surf	8.96	222.2
Willisburg	7/11/2005	326	Surf	9.14	211.1
Willisburg	7/18/2005	333	Surf	8.7	230.7
Willisburg	7/25/2005	340	Surf	9.1	227.5
Willisburg	8/1/2005	347	Surf	9.29	210.6
Willisburg	8/17/2005	363	Surf	9.3	205.1
Willisburg	8/22/2005	368	Surf	9.54	201.5
Willisburg	8/29/2005	375	Surf	9	204.7
Willisburg	9/5/2005	382	Surf	9.15	216.1
Willisburg	9/26/2005	403	Surf	8.66	228.6
Willisburg	10/17/2005	424	Surf	7.58	254.9



<b>Lake</b>	<b>Date</b>	<b>Julian Date</b>	<b>Day</b>	<b>Depth</b>	<b>DOC</b>	<b>Ammonia</b>
Willisburg	8/20/2004	04233	1	Bottom	6.38	0.09
Willisburg	8/29/2004	04242	10	Bottom	6.217	0.09
Willisburg	9/5/2004	04249	17	Bottom	6.429	0.09
Willisburg	9/12/2004	04256	24	Bottom	6.439	0.09
Willisburg	9/19/2004	04263	31	Bottom	3.459	0.09
Willisburg	9/26/2004	04270	38	Bottom	6.815	0.09
Willisburg	10/3/2004	04277	45	Bottom	6.855	0.09
Willisburg	11/9/2004	04314	82	Bottom	5.607	0.09
Willisburg	12/13/2004	04348	116	Bottom	5.331	0.3
Willisburg	1/17/2005	05017	151	Bottom	6.776	0.1
Willisburg	2/14/2005	05045	179	Bottom	5.31	0.09
Willisburg	3/14/2005	05073	207	Bottom	5.613	0.09
Willisburg	4/18/2005	05108	242	Bottom	5.799	0.09
Willisburg	5/5/2005	05125	259	Bottom	5.695	0.09
Willisburg	5/30/2005	05150	284	Bottom	5.118	0.09
Willisburg	6/6/2005	05157	291	Bottom	4.873	0.09
Willisburg	6/13/2005	05164	298	Bottom	6.093	0.09
Willisburg	6/20/2005	05171	305	Bottom	5.976	0.09
Willisburg	6/27/2005	05178	312	Bottom	6.239	0.09
Willisburg	7/5/2005	05186	320	Bottom	4.546	0.01
Willisburg	7/11/2005	05192	326	Bottom	4.945	0.09
Willisburg	7/18/2005	05199	333	Bottom	5.067	0.03
Willisburg	7/25/2005	05206	340	Bottom	4.813	0.009
Willisburg	8/1/2005	05213	347	Bottom	5.069	0.02
Willisburg	8/17/2005	05229	363	Bottom	5.465	0.17
Willisburg	8/22/2005	05234	368	Bottom	5.181	0.06
Willisburg	8/29/2005	05241	375	Bottom	5.223	0.22
Willisburg	9/5/2005	05248	382	Bottom	5.628	0.009
Willisburg	9/26/2005	05269	403	Bottom	5.253	0.02
Willisburg	10/17/2005	05290	424	Bottom	5.092	0.009

Lake	Date	Day	Depth	TKN	Nitrate	SRP
Willisburg	8/20/2004	1	Bottom	0.09	0.59	0.12
Willisburg	8/29/2004	10	Bottom	0.09	0.33	0.14
Willisburg	9/5/2004	17	Bottom	0.09	0.09	0.2
Willisburg	9/12/2004	24	Bottom	1.01	0.12	0.01
Willisburg	9/19/2004	31	Bottom	0.65	0.09	0.01
Willisburg	9/26/2004	38	Bottom	0.63	0.09	0.009
Willisburg	10/3/2004	45	Bottom	1.08	0.09	0.2
Willisburg	11/9/2004	82	Bottom	0.035	0.03	0.01
Willisburg	12/13/2004	116	Bottom	0.56	0.33	0.06
Willisburg	1/17/2005	151	Bottom	0.7	0.51	0.009
Willisburg	2/14/2005	179	Bottom	0.07	0.39	0.009
Willisburg	3/14/2005	207	Bottom	0.6	0.24	0.009
Willisburg	4/18/2005	242	Bottom	0.77	0.007	0.009
Willisburg	5/5/2005	259	Bottom	0.67	0.02	0.009
Willisburg	5/30/2005	284	Bottom	0.84	0.02	0.009
Willisburg	6/6/2005	291	Bottom	0.91	0.0638	0.009
Willisburg	6/13/2005	298	Bottom	0.84	0.005	0.009
Willisburg	6/20/2005	305	Bottom	1.015	0.01	0.009
Willisburg	6/27/2005	312	Bottom		0.01	0.009
Willisburg	7/5/2005	320	Bottom		0.01	0.009
Willisburg	7/11/2005	326	Bottom		0.02	0.009
Willisburg	7/18/2005	333	Bottom		0.005	0.009
Willisburg	7/25/2005	340	Bottom		0.005	0.009
Willisburg	8/1/2005	347	Bottom		0.005	0.009
Willisburg	8/17/2005	363	Bottom		0.005	0.009
Willisburg	8/22/2005	368	Bottom		0.005	0.009
Willisburg	8/29/2005	375	Bottom		0.005	0.009
Willisburg	9/5/2005	382	Bottom		0.005	0.009
Willisburg	9/26/2005	403	Bottom		0.009	0.009
Willisburg	10/17/2005	424	Bottom		0.009	0.04

Lake	Date	Day	Depth	TP	Chlorides	Silica
Willisburg	8/20/2004	1	Bottom	0.17	4.28	3
Willisburg	8/29/2004	10	Bottom	0.2	3.96	2.55
Willisburg	9/5/2004	17	Bottom	0.5	3.05	3.42
Willisburg	9/12/2004	24	Bottom	0.2	3.8	2.85
Willisburg	9/19/2004	31	Bottom	0.13	3.48	2.99
Willisburg	9/26/2004	38	Bottom	0.1		
Willisburg	10/3/2004	45	Bottom	1	3.51	3.65
Willisburg	11/9/2004	82	Bottom	0.08	2.36	3.83
Willisburg	12/13/2004	116	Bottom	0.54	2.18	3.13
Willisburg	1/17/2005	151	Bottom	0.18	2.85	7.55
Willisburg	2/14/2005	179	Bottom	0.09	3.14	10.96
Willisburg	3/14/2005	207	Bottom	0.009	3.92	2.72
Willisburg	4/18/2005	242	Bottom	0.009	4.07	1.329
Willisburg	5/5/2005	259	Bottom	0.009	3.9	1.748
Willisburg	5/30/2005	284	Bottom	0.22	3.3488	1.324
Willisburg	6/6/2005	291	Bottom	0.09	3.3755	1.659
Willisburg	6/13/2005	298	Bottom	0.01	3.72	1.763
Willisburg	6/20/2005	305	Bottom	0.04	3.72	2.912
Willisburg	6/27/2005	312	Bottom	0.12	3.71	1.207
Willisburg	7/5/2005	320	Bottom	0.07	4.04	1.881
Willisburg	7/11/2005	326	Bottom	0.08	3.87	3.145
Willisburg	7/18/2005	333	Bottom	0.09	3.9	3.145
Willisburg	7/25/2005	340	Bottom	0.08	3.89	2.167
Willisburg	8/1/2005	347	Bottom	0.12	3.81	2.613
Willisburg	8/17/2005	363	Bottom	0.1	3.89	2.794
Willisburg	8/22/2005	368	Bottom	0.1	4.12	2.454
Willisburg	8/29/2005	375	Bottom	0.14	4.28	3.121
Willisburg	9/5/2005	382	Bottom	0.17	4.02	4.948
Willisburg	9/26/2005	403	Bottom	0.16	3.66	4.204
Willisburg	10/17/2005	424	Bottom	0.13	3.93	2.865

Lake	Date	Day	Depth	THM Total (ug/L)	Chl a (ug/L)	Pheo a (ug/L)
Willisburg	8/20/2004	1	Bottom	488.5	7.5	12.4
Willisburg	8/29/2004	10	Bottom	442.1	9	5.9
Willisburg	9/5/2004	17	Bottom	291.5	14.9	6.8
Willisburg	9/12/2004	24	Bottom	211.5	13.8	4.3
Willisburg	9/19/2004	31	Bottom	345.5	11.4	5.6
Willisburg	9/26/2004	38	Bottom	221.4	13.6	4.8
Willisburg	10/3/2004	45	Bottom	261.5	5.8	4.4
Willisburg	11/9/2004	82	Bottom	352.7	12.8	6.7
Willisburg	12/13/2004	116	Bottom	320.1	8.2	7.1
Willisburg	1/17/2005	151	Bottom	422.4	10.5	13.4
Willisburg	2/14/2005	179	Bottom	414.5	26.5	11.4
Willisburg	3/14/2005	207	Bottom	362.9	20.1	16.9
Willisburg	4/18/2005	242	Bottom	346.6	19.1	16.7
Willisburg	5/5/2005	259	Bottom	149.5	13.2	6.4
Willisburg	5/30/2005	284	Bottom	72.7	11.1	12.0
Willisburg	6/6/2005	291	Bottom	158.9	9.0	12.2
Willisburg	6/13/2005	298	Bottom	178.3	9.1	13.4
Willisburg	6/20/2005	305	Bottom	80.8	14.0	19.9
Willisburg	6/27/2005	312	Bottom	129.5		
Willisburg	7/5/2005	320	Bottom	115.6		
Willisburg	7/11/2005	326	Bottom	49.8		
Willisburg	7/18/2005	333	Bottom	196.2		
Willisburg	7/25/2005	340	Bottom	67.2		
Willisburg	8/1/2005	347	Bottom	129.7		
Willisburg	8/17/2005	363	Bottom	11.6		
Willisburg	8/22/2005	368	Bottom	40		
Willisburg	8/29/2005	375	Bottom	113.6		
Willisburg	9/5/2005	382	Bottom	94.4		
Willisburg	9/26/2005	403	Bottom	108.9		
Willisburg	10/17/2005	424	Bottom	81.7		

Lake	Date	Day	Depth	POC	Temperature	DO
Willisburg	8/20/2004	1	Bottom	4.69	10.03	3.89
Willisburg	8/29/2004	10	Bottom	6.23	16.49	0.25
Willisburg	9/5/2004	17	Bottom	1.89	14.8	0.35
Willisburg	9/12/2004	24	Bottom	3.70	12.29	0.51
Willisburg	9/19/2004	31	Bottom	4.00	14.99	0.33
Willisburg	9/26/2004	38	Bottom	3.79	16.08	0.56
Willisburg	10/3/2004	45	Bottom	1.56	11.67	0.51
Willisburg	11/9/2004	82	Bottom	3.76	13.58	1.31
Willisburg	12/13/2004	116	Bottom	3.63	8.6	3.41
Willisburg	1/17/2005	151	Bottom	1.85	5.88	7.16
Willisburg	2/14/2005	179	Bottom	5.88	4.7	11.63
Willisburg	3/14/2005	207	Bottom	3.55	5.62	8.28
Willisburg	4/18/2005	242	Bottom	6.36	9.26	3.01
Willisburg	5/5/2005	259	Bottom	1.46	11.91	2.61
Willisburg	5/30/2005	284	Bottom	1.46	12.83	0.23
Willisburg	6/6/2005	291	Bottom	5.52	13.26	0.18
Willisburg	6/13/2005	298	Bottom	2.60	13.77	0.16
Willisburg	6/20/2005	305	Bottom	2.83	12.95	0.22
Willisburg	6/27/2005	312	Bottom	2.97	14.77	0.16
Willisburg	7/5/2005	320	Bottom	5.20	14.37	0.17
Willisburg	7/11/2005	326	Bottom	3.68	14.11	0.18
Willisburg	7/18/2005	333	Bottom	5.80	15.38	0.19
Willisburg	7/25/2005	340	Bottom	-0.40	15.26	0.15
Willisburg	8/1/2005	347	Bottom	3.50	15.77	0.31
Willisburg	8/17/2005	363	Bottom	4.95	17.21	0.18
Willisburg	8/22/2005	368	Bottom	7.71	17.18	0.23
Willisburg	8/29/2005	375	Bottom	7.21	15.62	0.21
Willisburg	9/5/2005	382	Bottom	5.81	20.08	0.37
Willisburg	9/26/2005	403	Bottom	5.88	19.66	0.47
Willisburg	10/17/2005	424	Bottom	4.00	17.05	2

<b>Lake</b>	<b>Date</b>	<b>Day</b>	<b>Depth</b>	<b>pH</b>	<b>SpCond</b>
Willisburg	8/20/2004	1	Bottom	6.8	282
Willisburg	8/29/2004	10	Bottom	6	289
Willisburg	9/5/2004	17	Bottom	6.82	305
Willisburg	9/12/2004	24	Bottom	6.83	310
Willisburg	9/19/2004	31	Bottom	6.63	284.3
Willisburg	9/26/2004	38	Bottom	6.79	302.7
Willisburg	10/3/2004	45	Bottom	6.59	311.3
Willisburg	11/9/2004	82	Bottom	7.43	334.5
Willisburg	12/13/2004	116	Bottom	7.16	257.9
Willisburg	1/17/2005	151	Bottom	7.38	242.1
Willisburg	2/14/2005	179	Bottom	7.77	258
Willisburg	3/14/2005	207	Bottom	7.7	286.6
Willisburg	4/18/2005	242	Bottom	7.49	294.7
Willisburg	5/5/2005	259	Bottom	7.32	297.9
Willisburg	5/30/2005	284	Bottom	7.15	304.8
Willisburg	6/6/2005	291	Bottom	7.01	300.4
Willisburg	6/13/2005	298	Bottom	7.08	303.1
Willisburg	6/20/2005	305	Bottom	7.05	304.3
Willisburg	6/27/2005	312	Bottom	7.02	309.3
Willisburg	7/5/2005	320	Bottom	7.04	314.4
Willisburg	7/11/2005	326	Bottom	7.04	312
Willisburg	7/18/2005	333	Bottom	7.03	320.1
Willisburg	7/25/2005	340	Bottom	7.05	322.3
Willisburg	8/1/2005	347	Bottom	7.2	320.7
Willisburg	8/17/2005	363	Bottom	7.16	319.2
Willisburg	8/22/2005	368	Bottom	7.15	325.7
Willisburg	8/29/2005	375	Bottom	7.2	326.9
Willisburg	9/5/2005	382	Bottom	7.28	280.2
Willisburg	9/26/2005	403	Bottom	6.87	311.8
Willisburg	10/17/2005	424	Bottom	7.4	258.1

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### PUBLICATIONS:

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