Evaluation of an Intensive Data Collection System for Tennessee Surface Water Quality Assessment and Watershed Model Calibration

A Thesis Presented for the
Master of Science
Degree
The University of Tennessee, Knoxville

Hannah Marie Armstrong
August 2011

Copyright © 2011 by Hannah Armstrong
All rights reserved.

DEDICATION

This work is dedicated to my grandparents,
Seth and Sharon Armstrong
who instilled in me at an early age the importance of education.

ACKNOWLEDGEMENTS

Special thanks to Tennessee Department of Environment and Conservation for providing the funding for this project with grant #Z-06-033972-00 and to the University of Tennessee Extension.

I would also like to thank my committee members, Dr. Joanne Logan, Dr. Forbes Walker, Dr. Daniel Yoder, and Dr. Shawn Hawkins, for their guidance and support in making this a successful project. Dr. Yoder, your advice and sense of humor were always a welcome relief. Dr. Hawkins, thank you for your patience and giving your time when often you didn't have it to give. Thank you for giving me the opportunity to grow intellectually and to meet fellow colleagues with such diverse backgrounds. Wesley Wright, thank you for making our project possible and for teaching me a small portion of your instrumentation expertise, but most importantly, thanks for being a friend.

To my parents, sisters, and family, thank you for your constant support through all of my endeavors. And finally, I would like to thank Justin for his unfailing patience and love while sacrificing so much while I pursued my degree, and for his allowing me to retire once it is complete.

ABSTRACT

Water quality regulators, such as the Tennessee Department of Environment and Conservation, are challenged by data scarcity when identifying surface water quality impairment causes and pollutant sources. Surface water quality model users also seek to identify pollutant sources and design and place best management practices to efficiently improve water quality, but have insufficient data for model calibration. This research documents the design and evaluation of a novel, intensive water quality data collection system consisting of a automatic sampler, bi-weekly grab sampling, and a long term deployment sonde. System design characteristics that were emphasized included a focus on gathering data for common impairment causes (pathogens, siltation, nutrients, and dissolved oxygen-DO) and water quality criteria not currently being evaluated (pH and temperature rate of change and diurnal DO fluctuations). In addition, the system was designed to gather data for watershed model calibration in rural, un-gauged watersheds because agriculture is listed as the predominant source of water quality impairment in Tennessee. Thus, the system was unmanned to reduce labor input, self-powered because of limited access to the electrical grid, provided sample preservation (refrigeration at low pH), and included stage measurement. Two identical prototype systems were installed in adjacent ecoregion 67g watersheds in Greene County, Tennessee: Lick Creek, impaired for pathogens, nutrients, and low DO, and Little Chucky Creek, which is unimpaired and a former ecoregion reference stream.

The two primary objectives of this research were to evaluate the system power demand and determine whether a large water quality dataset improved impairment cause

and source identification. A 270 watt solar panel power supply ultimately failed at Lick Creek during the summer when the refrigerated sampler cooling demand peaked, but was sufficient at Little Chucky Creek. System power supply design equations are provided, but with optimization the power supply used would likely be sufficient. The data collected did significantly improve insight into impairment cause identification. For example, total phosphorus rather than total nitrogen concentrations and low DO appeared to be a potential cause of impairment at Lick Creek. The system design was reliable and could be used to calibrate watershed models to improve source assessment.

TABLE OF CONTENTS

DEDICATION iii
ACKNOWLEDGEMENTS iv
ABSTRACT v
TABLE OF CONTENTS vii
LIST OF TABLES ix
LIST OF FIGURES x
CHAPTER I Literature Review and Research Needs 1
Clean Water Act 1
Tennessee General Water Quality Criteria 1
Stream Assessment 3
Nutrient Criteria 7
Dissolved Oxygen 9
Water Temperature and pH 11
Pathogens 11
Improving Impairment Cause Assessment 12
Improving Impairment Source Identification 13
Current Problems 15
Research Need 16
CHAPTER II Objectives and Materials and Methods 18
Research Objectives 18
Research Method 19
Water Quality Monitoring and Sampling Equipment 19
Refrigerated Sampler 21
Grab Samples 22
YSI Sonde 22
System Power Supply 23
Data Acquisition and Communications 25
Rain Gauges 26
Composite Stream Sample Chemical Analyses 26
Grab Samples 31
Quality Control/Quality Assurance 33
Stage Discharge Curve Development 33
CHAPTER III Refrigerated Sampler Performnace and Power Demand 36
One Solar Panel and Two Batteries 36
Two Solar Panels and Three Batteries 39
Solar Panel Voltage 39
Current Measurements 41
Refrigerated Sampler Performance 43
Power System Design 49
Summary 54
CHAPTER IV Water Quality Analysis 55
Dissolved Oxygen Concentrations 55

Percent Saturation with all DO concentrations 57
Diurnal DO Variations 63
Causes of low DO 68
BOD 72
E.Coli 72
Flow Measurement 77
Nutrient Concentrations 78
Nitrogen 80
Phosphorus 88
Water pH 88
Water Temperature 91
SWAT Inputs 94
CHAPTER V 95
Recommendations 95
System Power Supply 95
Water Quality and Stream Discharge 95
Summary 96
LIST OF REFERENCES 98
APPENDIX 101
Vita 214

LIST OF TABLES

Table 1. The 90th percentile of reference total phosphorus and nitrate + nitrite data by ecological subregion (TDEC, 2008c). 8
Table 2. TDEC dissolved oxygen sampling report for Lick Creek (TDEC, 1995-2010). 56
Table 3. Correlation coefficients of significant relationships between water quality parameters at Lick Creek and Little Chucky Creek. 62
Table 4. P-values and correlation coefficients for the magnitude of DO swings and other water quality parameters for both streams. 66

LIST OF FIGURES

Figure 1. Tennessee watershed monitoring groups (Arnwine et al., 2010) 1
Figure 2. Tennessee Level IV sub-ecoregions (Arnwine et al., 2000). 1
Figure 3. Water quality criteria evaluate flow chart of criteria. Colored boxes identify the major causes of impairment. 5
Figure 4. (A) Causes (Arnwine et al., 2010) and (B) sources (Arnwine et al., 2010) of impairment in Tennessee streams and rivers. 6
Figure 5. Conceptual model of data collection system. Shaded boxes represent measured parameters. 17
Figure 6. Components of the water quality monitoring system. 20
Figure 7. Water quality monitoring system power schematic. 24
Figure 8. Green squares represent water quality monitoring locations. Black X's represent rain gauge locations. Watersheds outlined in black contribute to Lick Creek; white outline is Little Chucky Creek. Blue streams are fully supporting of their designated uses while the red streams are impaired (TDEC, 2010). 27
Figure 9. Sample processing diagram. 28
Figure 10. Cross-section of Lick Creek showing pixilated velocities creating by the RiverSurveyor. 35
Figure 11. Time periods considered while designing water quality monitoring system. . 37
Figure 12. Battery voltage over time at Little Chucky Creek (A) and Lick Creek (B). ... 38
Figure 13. Maximum panel voltage per day (black circles) and total daily solar radiation (blue triangles) at the Lick Creek monitoring station. 40
Figure 14. Current Sensor #1 plotted against current sensor #2 with the regression line and 95% prediction band at A. Little Chucky Creek and B. Lick Creek..... 42
Figure 15. Watt-hrs required by the sampler (black filled circles), the panel temperature (blue line), and the sampler chamber temperature (red line) for A. Little Chucky Creek and B. Lick Creek. The sample preservation temperature goal of 4°C is illustrated with a horizontal red line. 44
Figure 16. Plot A describes the amp-hrs required to cool 6 liters of sample liquid. Plot B describes the amp-hrs per day required to maintain sample liquid at 3^0C (Teledyne ISCO, 2003). 46
Figure 17. A. Actual power consumption (solid line) and the ISCO predicted power demand (dashed line) and B. relationship between energy and panel temperature at Little Chucky Creek. 47
Figure 18. A. Actual power consumption (solid line) and the ISCO predicted power demand (dashed line) and B. relationship between energy and panel temperature at Lick Creek. 48
Figure 19. A. Watt-hrs available for charging along with corresponding average battery voltage per day and B. energy demanded vs. energy supplied during July through October charging cycle at Little Chucky Creek. 51
Figure 20. A. Watt-hrs available for charging along with corresponding average battery voltage per day and B. energy demanded vs. energy supplied during July through October charging cycle at Lick Creek. 53

Figure 21. Plot A shows the dissolved oxygen readings at Little Chucky Creek and the state standard of 5 mg/L. Plot B shows the percent saturation of dissolved oxygen. Plots on the adjacent page describe the same conditions for Lick Creek. 58
Figure 22. Diurnal DO swings at Little Chucky Creek (A) and Lick Creek (B). 64
Figure 23. Chlorophyll a values at Little Chucky Creek were highest beginning in the spring through September. 67
Figure 24. Little Chucky Creek dissolved oxygen readings below 5 mg/l are plotted in graph A, time of occurance in graph B, water temperature at low DO reading in graph C, and water depth at low DO reading in graph D. The adjacent stack plots describes the same conditions at Lick Creek. 69
Figure 25. BOD five day concentrations for Little Chucky Creek and Lick Creek. 73
Figure 26. Box plots of *E. coli* concentrations measured during this study (UT) and historical water quality data (TDEC) in Little Chucky Creek (CH) and Lick Creek (LC). The water quality criteria of 941 cfu/100 mL is illustrated by the reference line..... 76
Figure 27. The RiverSurveyor and velocity-area method were used at Little Chucky Creek to compare discharge results (plot A). Only the RiverSurveyor system was used at Lick Creek (plot B). Discharge measurements were fit with a curve to predict discharge at future stages. 79
Figure 28. A) Organic nitrogen, B) ammonia, and C) nitrate+nitrite levels for Little Chucky Creek. Filled triangles represent the measured parameter and circles represent the percent of total nitrogen. The adjacent plots describe the same data for Lick Creek. 81
Figure 29. Nitrate + nitrite box plot with state standard of 1.12 mg-N/L for Little Chucky Creek and Lick Creek. 85
Figure 30. Box plots of nitrate + nitrite values per month and the state standard of 1.12 mg-N/L for Little Chucky Creek in plot A and Lick Creek in plot B. 87
Figure 31. Total phoshorus concentrations and the ecoregion reference standard of 0.09 mg-P/L for Little Chucky Creek and Lick Creek. 89
Figure 32. Box plots of total phophorus values per month with state standard of 0.09 mg-P/L for Little Chucky Creek in plot A and Lick Creek in plot B. 90
Figure 33. pH and the 24 hour maximum changes in pH over time at Little Chucky Creek (A) and Lick Creek (B). The general water quality criteria range of 6.0 to 9.0 is shown. 92
Figure 34. Water temperature and water temperature change at Little Chucky Creek (A) and Lick Creek (B). The TDEC water quality criteria maximum temperature of 30.5^{0}C is illustrated..... 93

CHAPTER I

LITERATURE REVIEW AND RESEARCH NEEDS

Clean Water Act

The Clean Water Act (CWA) led to regulations by the U.S. Environmental Protection Agency (EPA) that protect surface water quality (Congress, 1972). These regulations include a requirement to establish surface water quality criteria. In general, criteria define conditions necessary to meet designated uses with public input. For example, the Tennessee Department of Environment and Conservation (TDEC) identifies nine uses and water quality criteria for wadeable streams (TDEC, 2008c).

Tennessee General Water Quality Criteria

States usually implement their own plans to fulfill the requirements set by the CWA. Tennessee uses a watershed approach to assess water quality and ecological integrity in wadeable streams (Arnwine et al., 2000; TDEC, 2008c). This approach divides the 55 major watersheds (hydrologic unit code 8) in Tennessee into five groups (Figure 1). One of these groups is monitored or assessed each year in a rotating five-year cycle (Arnwine et al., 2010). The watershed approach also divided the eight Level III ecoregions in Tennessee into twenty-five smaller Level IV sub-ecoregions (Figure 2). The division led to criteria established in part by surveys of high quality "reference steams" with each sub-ecoregion that reflect natural variability in water quality parameters within the state's different physiographic areas (Arnwine et al., 2000).

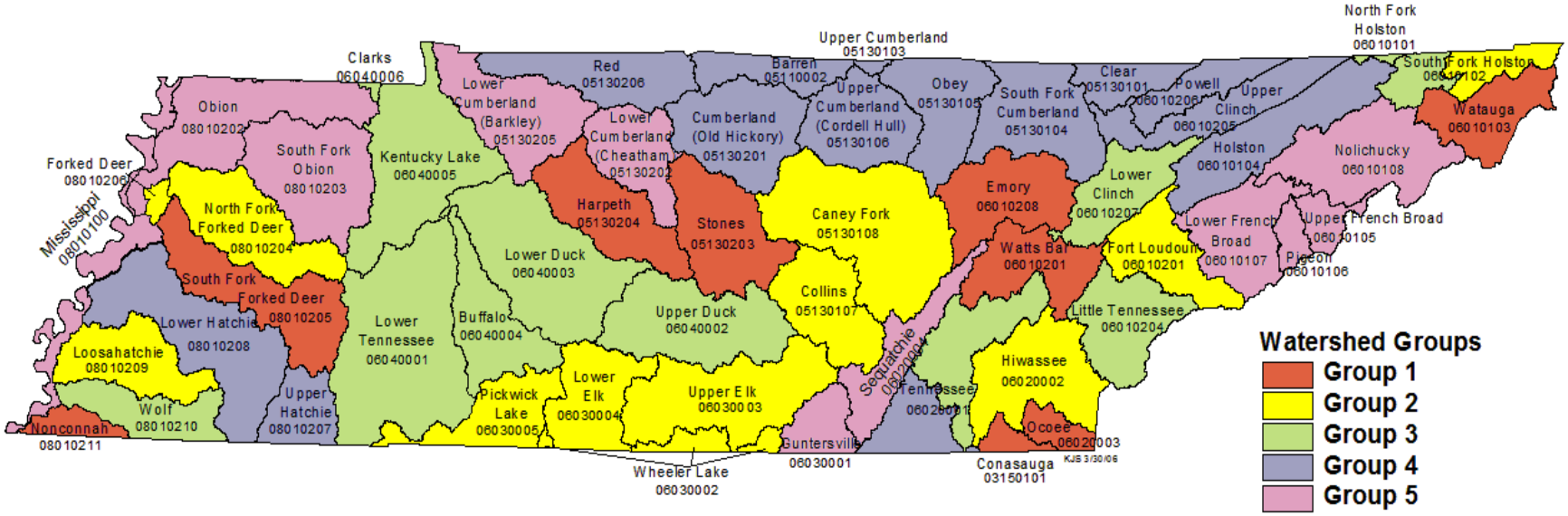
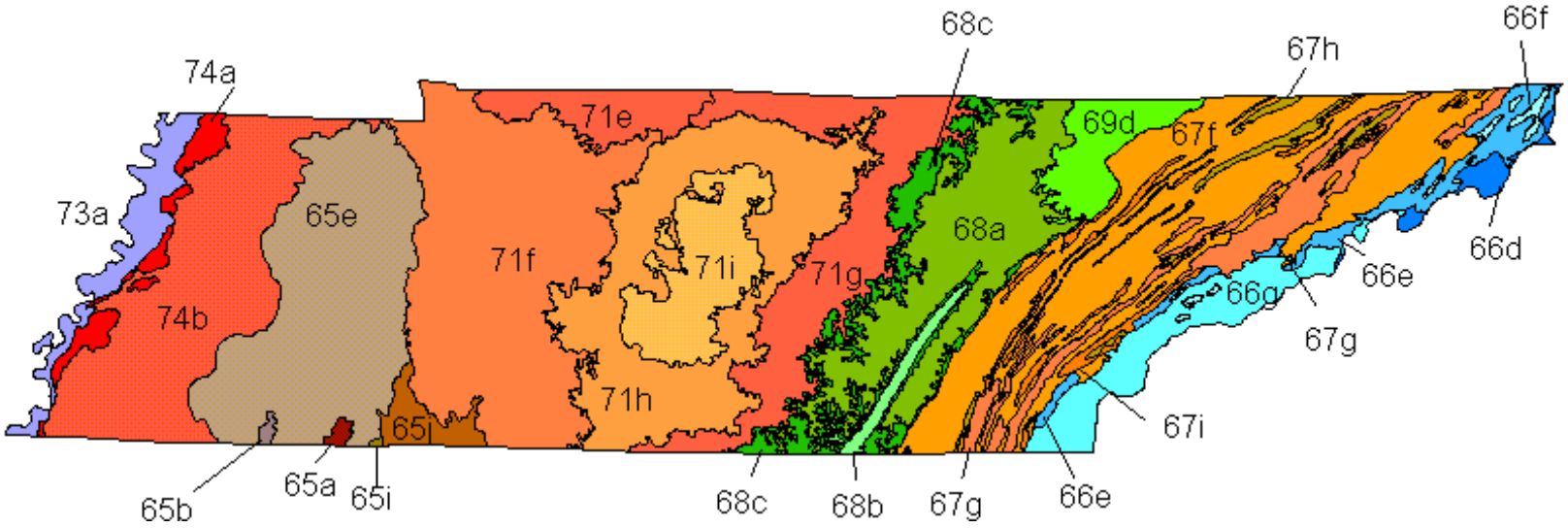


Figure 1. Tennessee watershed monitoring groups (Arnwine et al., 2010)



65a Blackland Prairie

65b Flatwoods/Alluvial Prairie Margins

65e Southeastern Plains and Hills

65i Fall Line Hills

65j Transition Hills

66d Southern Igneous Ridges & Mtns

66e Southern Sedimentary Ridges

66f Limestone Valleys and Coves

66g Southern Metasedimentary Mtns.

67f Southern Limestone/Dolomite Valleys and Low Rolling Hills

67g Southern Shale Valleys

67h Southern Sandstone Ridges

67i Southern Dissected Ridges & Knobs

68a Cumberland Plateau

68b Sequatchie Valley

68c Plateau Escarpment

69d Cumberland Mountains

71e Western Pennyroyal Karst

71f Western Highland Rim

71g Eastern Highland Rim

71h Outer Nashville Basin

71i Inner Nashville Basin

73a Northern Mississippi Alluvial Plain

74a Bluff Hills

74b Loess Plains

Figure 2. Tennessee Level IV sub-ecoregions (Arnwine et al., 2000).

Wadeable streams within each sub-ecoregion are assigned multiple designated uses that fall into the following nine categories: domestic water supply, industrial water supply, fish and aquatic life, trout stream, naturally reproducing trout stream, recreation, irrigation, livestock watering and wildlife, and navigation (TDEC, 2008c). Water quality criteria are specified for each use, and streams classified with multiple uses are assigned the most protective criteria. All streams are designated for the recreation and fish and aquatic life (FAL) uses that generally carry the most stringent water quality criteria. The criteria for FAL use in Tennessee is narrative and states that "waters shall not be modified through the addition of pollutants or through physical alteration to the extent that the diversity and/or productivity of aquatic biota…are substantially decreased or adversely affected"(TDEC, 2008a). This criteria is evaluated using biorecons or semi-quantitative single habitat (SQKICK OR SQBANK) type macroinvertebrate surveys. Biorecons are rapid assessments used for streams that are obviously impaired. When compliance is questionable, SQKICK or SQBANK surveys are used as a more rigorous assessment method and generate a score that is compared with Tennessee Macroinvertebrate Index (TMI) criteria. The TMI criteria are based on seven biometrics that count taxa richness and the number of individual organisms found, such as nutrient tolerant macroinvertebrates (TDEC, 2006b).

The Tennessee Ecoregion Project, established the Level IV sub-ecoregion reference streams that have been used to develop water quality criteria including the expected TMI score (Arnwine et al., 2000). These reference streams represent the best conditions for all streams with like characteristics. The best conditions reflect the least impacted physical habitats and biological communities as well as general water quality.

Biocriteria established by SQKICK and SQBANK surveys in ecoregion reference streams are a primary basis for water quality assessment in Tennessee. However, the FAL use also includes the most restrictive standards for dissolved oxygen (DO), pH, turbidity, temperature, nutrients, and habitat. Note that if all other use criteria are met but the FAL biocriteria is not, then individual components of a required habitat evaluation are typically listed as the impairment cause, even if the total habitat score meets the ecoregion standards (TDEC, 2007). The required habitat evaluation examines modification of the stream and provides a section for visual impairment source assessment.

Stream Assessment

The CWA requires that implementing states summarize surface water quality using two reports. The "305(b)" report summarizes the status of water quality and lists the most common impairment causes and sources for impairments (Arnwine et al., 2010). The "303(d)" list is a compilation of water bodies that do not have adequate water quality to meet their designated uses (TDEC, 2010).

The 2010 305(b) Report on the status of water quality in Tennessee states that "once it has been determined that a stream, river, or reservoir is not fully supporting of its designated uses, it is necessary to determine what the pollutant is (cause) and where it is coming from (source)" (Arnwine et al., 2010). The most stringent criteria are associated with the FAL and recreation uses. Recreational use sets the most stringent pathogen indicator (*E. coli*) concentration criteria. The FAL use sets the most strict criteria for pH, temperature, dissolved oxygen, and biological integrity. The majority of stream assessments are determined by the biological integrity evaluations (biorecons, SQKICK

or SQBANK). When biological integrity criteria is impaired, the causes are defaulted to water quality indicators that are outside the normal range of measurements (DO, pH, and/or nutrient concentrations) or observational data from habitat surveys such as siltation and habitat or flow alteration (Figure 3). Defaulted causes associated with the loss of biological integrity form the bulk of total impairments in Tennessee (Arnwine et al., 2010). When multiple causes are listed, they are not prioritized for importance, which could result in ineffective management attempts to restore the biological integrity. In some cases, it may not be possible to identify the foremost cause due to a lack of biological diversity or productivity because only quarterly data is collected to evaluate water quality. A more rigorous approach to cause identification and prioritizing defaulted causes for biological integrity impairment is needed to improve the stream assessment process in Tennessee. The 2010 305(b) report lists habitat alteration, pathogens, siltation, and nutrients as the top causes of impairment in Tennessee streams and rivers, as shown in Figure 4 (Arnwine et al., 2010).

According to the 2010 305(b) Report, agriculture accounts for 42% of impaired stream miles in Tennessee (Figure 4). In many watersheds, this may be the result from agricultural land uses simply being dominant in the landscape. Sources of impairment are now more or less anecdotally listed based on visual inspections of the landscape surrounding streams where water quality samples are collected. It would be beneficial to incorporate a more comprehensive watershed modeling technique that improves source identification on a whole watershed basis. Some watershed models, such as the Soil and Water Assessment Tool (SWAT), can also be used to evaluate which BMPs would most effectively improve water quality.

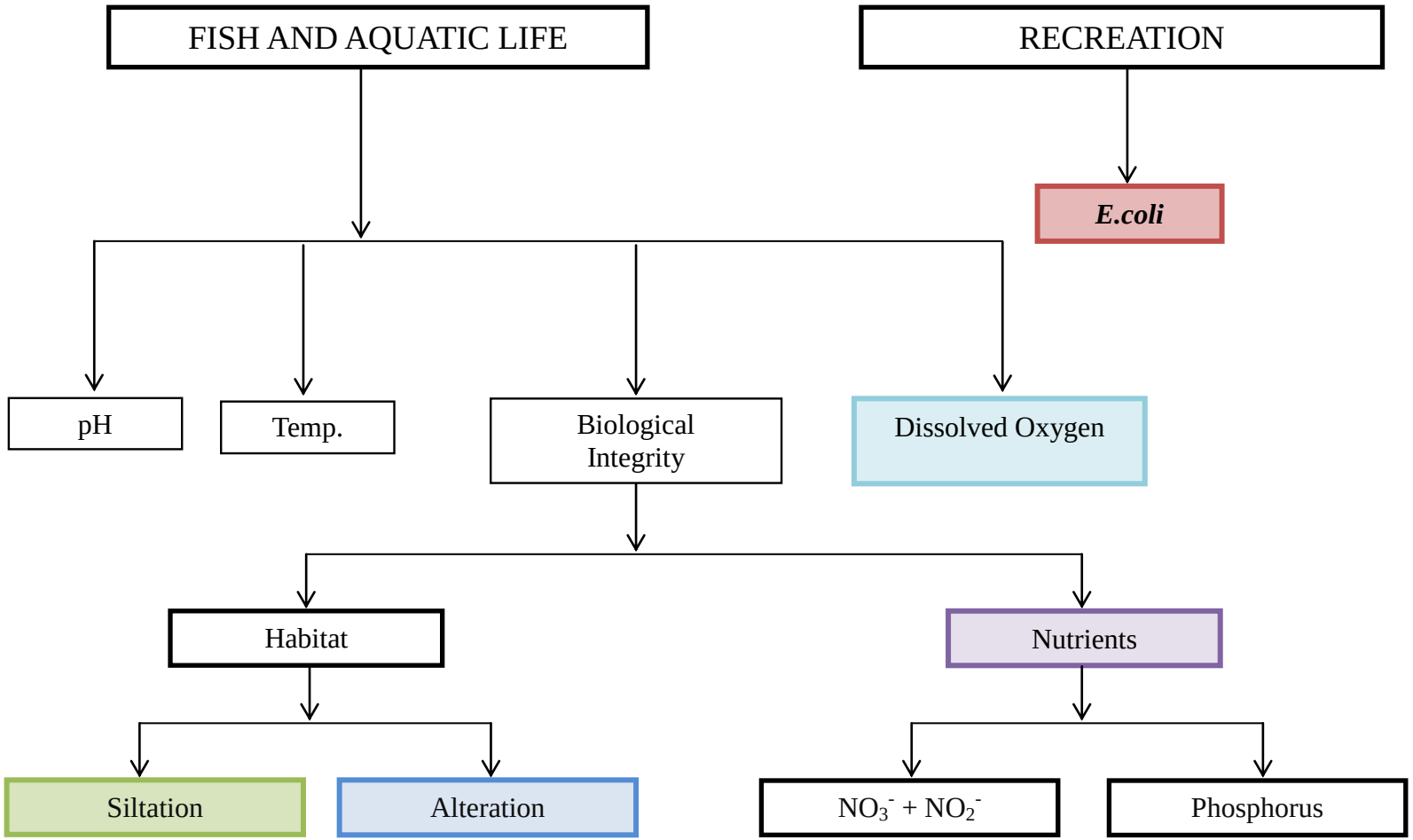


Figure 3. Water quality criteria evaluate flow chart of criteria. Colored boxes identify the major causes of impairment.

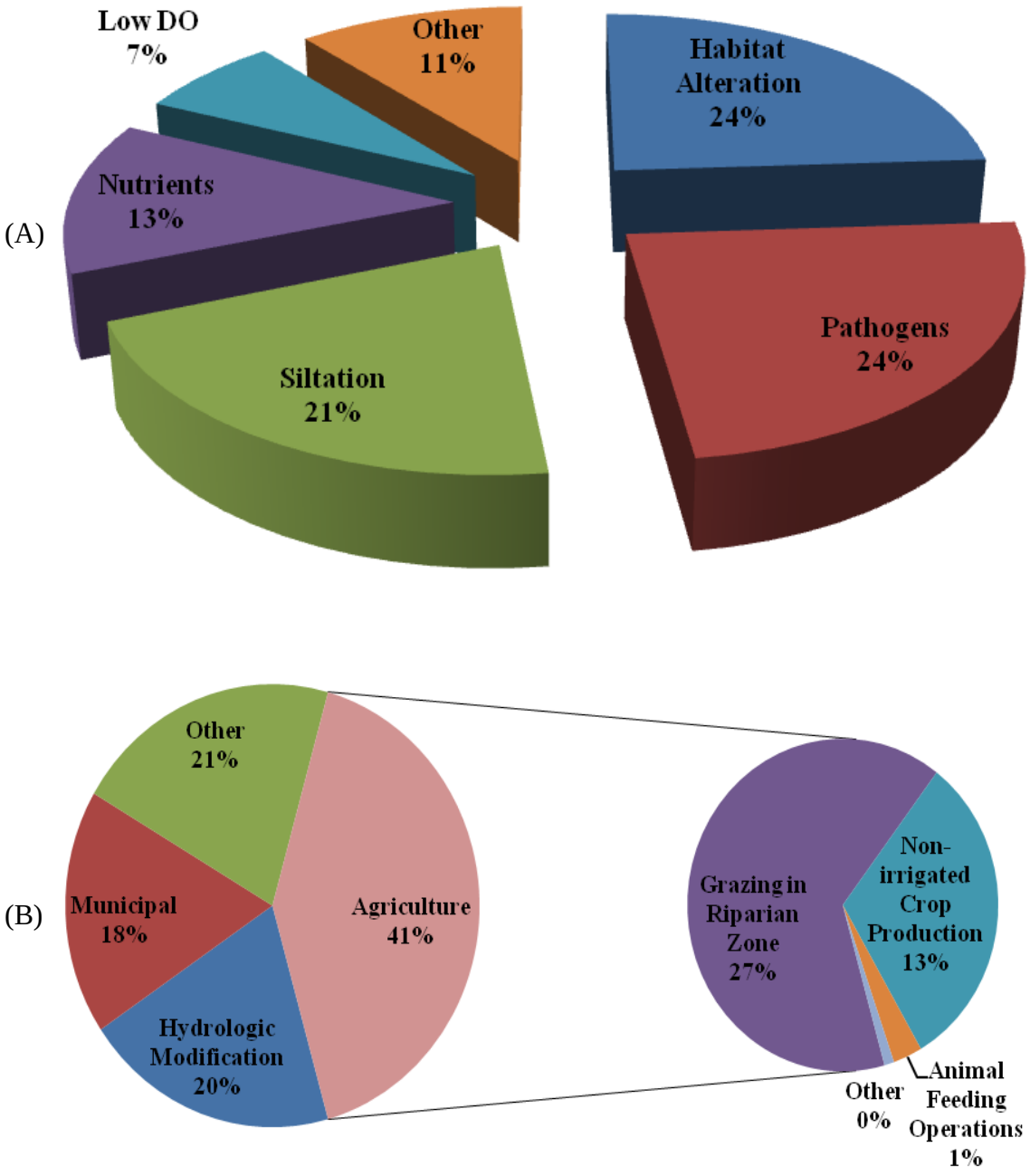


Figure 4. (A) Causes (Arnwine et al., 2010) and (B) sources (Arnwine et al., 2010) of impairment in Tennessee streams and rivers.

Nutrient Criteria

EPA has mandated that states adopt nutrient criteria into water quality standards because of the frequent citing of nutrients as an impairment cause (TDEC, 2007). In Tennessee, nutrients are the fourth leading cause of impairment (Figure 4) (Arnwine et al., 2010). To develop these criteria, TDEC maintains a statewide monitoring system of 104 reference stream stations that are assessed during the watershed cycle (TDEC, 2007). Chemical and bacteriological sampling as well as macroinvertebrate surveys are conducted to evaluate reference and impaired streams. Samples are collected by TDEC staff following procedures adapted from EPA (TDEC, 2008b). A quality assurance program ensures that data are reliable, and quality control samples are collected at a minimum of ten percent of sampling events (TDEC, 2006a).

During the late 1990s, a dataset of chemical, physical, and biological samples was collected from reference streams in each sub-ecoregion (TDEC, 2007). This data was analyzed to develop guidance for interpretation of nutrient data which have a narrative water quality criteria. The 90^{th} percentile of the reference stream total phosphorus and nitrate + nitrite data was adapted as the most appropriate criteria level (Table 1) (Arnwine et al., 2001). The use of this percentile bases nutrient guidelines on cause and effect with high nutrient content being associated with failing biocriteria scores (TDEC, 2007). Streams with nutrient levels lower than the 90^{th} percentile of ecoregion reference stream data are considered to be in compliance with the narrative data. Streams with levels higher than the 90^{th} percentile and that have failing biocriteria scores are in violation of the narrative nutrient criteria and are placed as such on the 303(d) list (Arnwine et al., 2001).

Table 1. The 90th percentile of reference total phosphorus and nitrate + nitrite data by ecological subregion (TDEC, 2008c).

Ecoregion	Total Phosphorus (mg/L)	Nitrate + Nitrite (mg-N/L)
73a	0.32	0.35
74a	0.17	0.25
74b	0.12	1.04
65a, 65b, 65e, 65i	0.1	0.32
65j	0.04	0.25
71e	0.04	3.69
71f	0.05	0.38
71g	0.05	0.93
71h	0.09	0.93
71i	0.24	0.93
68a	0.03	0.22
68b	0.08	0.48
68c	0.03	0.34
69d	0.03	0.27
67f, 67h, 67i	0.04	1.12
67g	0.09	1.12
66d	0.02	0.52
66e	0.02	0.30
66f	0.03	0.30
66g	0.02	0.30

Dissolved Oxygen

The dissolved oxygen (DO) concentration is critical to the health of surface water aquatic systems. Oxygen accumulates in the water by surface air diffusion, aeration from turbulence, and photosynthesis of aquatic plants (Arnwine & Denton, 2003). Natural factors affecting the DO concentration in streams include:

a. *Algae and aquatic plants.* Oxygen is produced by photosynthesis during the daylight hours by aquatic plants and algae. At night when photosynthesis ceases, oxygen is consumed through plant and algae respiration.
b. *Flow patterns.* Oxygen concentrations are much higher in air than water, and the difference causes oxygen to dissolve in the water. This process is enhanced by turbulence in streams.
c. *Water Temperature.* Cold water can hold more oxygen than warm water, so DO concentrations during the winter tend to be higher than those found during the summer months. When water temperature is warmer, the amount of oxygen that can be dissolved before saturation is reached is limited. In addition to seasonal effects, water temperature can be affected by high-temperature discharges into the stream, or by the degree of stream shading.
d. *Barometric Pressure.* Decreasing barometric pressure and increasing altitude tend to release oxygen out of solution, decreasing the DO level.
e. *Groundwater.* Groundwater typically carries a low DO, so when discharged into a stream via baseflow may lower the stream DO concentrations (Arnwine & Denton, 2003).

Pollution may cause depletions in DO levels, often resulting in shifts of the aquatic life to forms that can tolerate lower DO concentrations, which in turn lowers biocriteria scores during the SQKICK and SQBANK surveys. Important pollutants include organic wastes and fertilizers. Organic wastes are degraded by in-stream bacteria which consume oxygen during that degradation process. Fertilizers stimulate the excessive growth of algae which can increase natural diurnal swings in the concentration, and which also cause low DO when algae biomass dies and is degraded by bacteria.

In 2002, TDEC conducted a diurnal dissolved oxygen study at 49 reference streams and 40 test sites in 15 ecological subregions (Arnwine & Denton, 2003). Locations considered "test sites" were assessed as impaired due to organic enrichment and/or low dissolved oxygen and listed on the 2002 303(d) list. Temperature and DO probes were installed from late July through October, when DO levels should be at their lowest concentrations due to high water temperatures and low stream flows. Each site was monitored for approximately seven days with temperature and dissolved oxygen readings recorded every thirty minutes (Arnwine & Denton, 2003). For example, Little Chucky Creek was monitored as a reference stream in ecoregion 67g. Of the 334 DO readings for this creek, six were below the standard of 5 mg/L. The magnitude of the lowest reading was 3.8 mg/L while the longest duration of readings less than 5 mg/L was 17 hours. The data showed that typically a 2 mg/L fluctuation occurred during each 24-hour period (Arnwine & Denton, 2003). The General Water Quality Criteria for FAL states that diurnal DO fluctuations should not be substantially different than those found in that region's reference streams (TDEC, 2008c). However, the diurnal DO fluctuations of test streams are not currently evaluated.

Water Temperature and pH

The diurnal DO study conducted by TDEC also evaluated water temperature fluctuations. Water temperature affects the oxygen content of the water as temperatures rise and fall; the warmer the water, the lower the oxygen content (Arnwine & Denton, 2003). Tennessee's General Water Quality Criteria for the FAL use states that stream temperature should not exceed 30.5ºC and the maximum rate of change shall not exceed 2^0C per hour (TDEC, 2008c). The majority of the monitoring data from TDEC include one stream temperature measurement and the temperature rate of change standard is not evaluated. Rate of temperature change is important especially in streams that are shallow where the temperature can change quickly affecting DO and aquatic organisms.

Tennessee's water quality criteria also establishes rate of change standards for pH: the levels should not fluctuate more than one pH unit over a 24 hour period and should have a pH range from 6.0 – 9.0 (TDEC, 2008c). The pH rate of change standard is not regularly evaluated.

Pathogens

Pathogens are disease-causing organisms that pose health hazards to the general public if ingested from a stream. *Escherichia coli* (*E. coli*) is used as an indicator of fecal pollution and potential pathogen contamination and is monitored by TDEC as part of the watershed cycle. All streams in Tennessee are classified for recreational use, which carries the most stringent criteria for pathogen levels. Individual samples must not exceed 941 CFU per 100 mL (TDEC, 2008c). The 2010 305(b) report lists pathogens as the leading cause of impairments in Tennessee streams (Figure 4) (Arnwine et al., 2010).

Improving Impairment Cause Assessment

Collecting a large dataset to evaluate the state standards could improve the assessment process but may be expensive, challenging, and time consuming. One solution might be to create an unmanned system to collect the most important water quality data (Figure 4-A). A University of Wisconsin study with the Discovery Farms Program implemented a system to assess annual nutrient and sediment losses from agricultural runoff. The selection of equipment and procedures were based on the need for accurate data collection during the full range of weather conditions (Frame & Cooley, 2009). Hydrologic and water quality data were collected from a small watershed on Soaring Eagle Dairy from December 2004 to October 2006.

The stations consisted of aluminum, clam-style enclosures that housed flow equipment, water samplers, and communications for data collection and real-time programming. The system was powered by a solar panel, but the wattage was not specified. A refrigerated, automatic ISCO® sampler with 24, one- liter bottles was used to collect surface runoff samples that flowed through an H-type flume used to get continuous measurement of flow rate. A Campbell Scientific CR10X datalogger was used to control equipment and read and store data. The automatic sampler was programmed to collect on variable time intervals during runoff events. Samples were collected from the sampler within 24 hours of the end of the event and processed by the lab within three days of the event. The samples were analyzed for pH, conductivity, chloride, total phosphorus unfiltered, dissolved reactive phosphorus, nitrate + nitrite, ammonium, total kjeldahl nitrogen, suspended sediment, and total dissolved solids (Frame & Cooley, 2009). Winter months required much more maintenance than normal with freezing

temperatures creating ice in the sampling lines and flumes (Frame & Cooley, 2009). Although this study focused on collecting samples for runoff instead of surface water, the concept of an unmanned collection system is the same. A water quality sampling system combined with a water quality model may provide the information necessary to make a more accurate stream assessment in Tennessee.

Improving Impairment Source Identification

The Soil and Water Assessment Tool (SWAT) model has been in continuous development over the past 30 years by the USDA Agricultural Research Service. SWAT predicts the effect of management decisions on large, ungauged watersheds. It was also incorporated by the U.S. Environmental Protection Agency into the Better Assessment Science Integrating Point and Nonpoint Sources (BASINS) model. Within SWAT, a watershed is divided into multiple sub-watersheds which are further subdivided into hydrologic response units that consist of homogeneous land use, management, and soil characteristics. A SWAT simulation on these units can be used to identify pollutant sources within a particular watershed—for example, row crops on steep lands vs. row crops on flat lands vs. livestock agriculture. It can be used to identify the most effective best management practices for reducing pollutant loads in impaired watersheds and also to assess total maximum daily loads for point sources of wastewater effluent. SWAT can also be used to undergird policy decisions in regards to point and non-point source pollutants and to prioritize impairment causes. Recently, a graphical user input interface was developed for SWAT for analysis of watershed hydrology and pollutant source modeling (Gassman et al., 2007) SWAT could be used to improve source assessment in Tennessee.

SWAT is a basin-scale, continuous-time model that operates on a daily time step and is designed to predict the impact of management on water, sediment, and agricultural chemical yields in large, ungauged watersheds (Gassman et al., 2007). It is not a field scale or flood event model, but operates on the watershed as a whole. Major components of the model include digital elevation models which digitize the terrain for the watersheds of interest. Other components are crop growth and weather simulators that can illustrate a wide range of crop rotations and grassland or pasture systems as well as predict and generate weather inputs. Soil type and weather data such as daily precipitation and maximum and minimum temperatures are also inputs. SWAT allows users to specify the current land use characterization and management routines (Gassman et al., 2007)

However, the major challenge when using SWAT is the lack of calibration data in rural, agricultural watersheds. Quite often in Tennessee the only available water quality data, on both stream chemical and physical parameters is the state 303(d) monitoring data which is only collected quarterly as part of the five year watershed cycle (Arnwine et al., 2010). Stream discharge data is critically important to calibrate this model, but is rarely available in the rural, agricultural watersheds in Tennessee. Rainfall and weather data are also important, but rural watersheds often have poorly distributed weather stations or even rain gauges, if they are available at all. One criticism of using such limited data is that it takes many years of data to properly calibrate the model, during which time the land use patterns change making the model calibration suspect. TDEC could benefit by using SWAT to rigorously establishing impairment sources, which are now largely identified by visual inspection of small sections of the watershed near the monitoring site. However, in order to calibrate and verify the model, an intensive water

quality sampling system is needed to provide a comprehensive dataset for such calibration and verification.

Current Problems

Data scarcity may affect the ability of the Tennessee Department of Environment and Conservation (TDEC) to accurately identify stream impairment causes and sources of impairment. Currently, only quarterly water quality data are collected in a five year watershed cycle. For example, the entire TDEC sampling report for Lick Creek (TN06010108035), a stream listed as impaired for low dissolved oxygen (DO), consists of only 14 DO readings from 1995-2010 (TDEC, 1995-2010). Of those 14 measurements, 4 are below the state standard of 5 mg/L, but occurred during low flow and high temperatures in the summer. These DO concentrations may in fact represent a natural condition. Further, the source of impairment is listed as pasture grazing (TDEC, 2010), though this assessment is made simply with a visual investigation of the surrounding land use patterns. It is clearly difficult for TDEC to make a proper assessment of stream cause and impairment source with such small amounts of data and without the benefit of a watershed model to consider the impact of the basin wide land use on water quality.

Certainly there is not enough water quality data collected in the five year watershed evaluation cycle to calibrate and validate watershed models such as the Soil and Water Assessment Tool (SWAT) (Gassman et al., 2007). SWAT is designed for use in rural, ungauged, agricultural watersheds and could add rigor to the impairment source identification process in Tennessee, as well as provide direction for which best management practices would most efficiently improve water quality. In reality, stream

discharge data is crucial to calibrate the model (Gassman et al., 2007) and is often missing in rural, agricultural watersheds in Tennessee.

Data scarcity represents a current problem that TDEC could perhaps address with a sample collection system that could generate a short-term, intensive data set for identifying impairment causes and sources of impairment An unmanned system to collect such data would minimize TDEC labor and automatically collect an abundance of data unlike the current typical five-year manual monitoring cycle.

Research Need

A water quality data collection system is needed to improve impairment cause and source identification. The Literature Review has indicated that TDEC lacks sufficient data to properly assess parameters including nutrient, DO, pH and temperature. In addition, TDEC bases source assessments on observational data, a process that could be improved by utilizing a watershed model like SWAT. However, SWAT requires a large calibration data set.

These needs could be met with a self-powered system used to collect daily composite samples and continuously monitor in-stream parameters. Composite samples collected by such an unmanned, self-powered system would need to be preserved (refrigerated at pH < 2) for nutrient analysis. Ideally, more frequent grab samples would be collected for *E. coli* which cannot be preserved. A conceptual model of the sample collection system is provided in Figure 5. Parameters in shaded boxes symbolize specific components that are either important impairment causes (Figure 4) or require more intensive data for proper water quality criteria evaluation, and those that are important to properly calibrate the SWAT watershed model for improved source assessment.

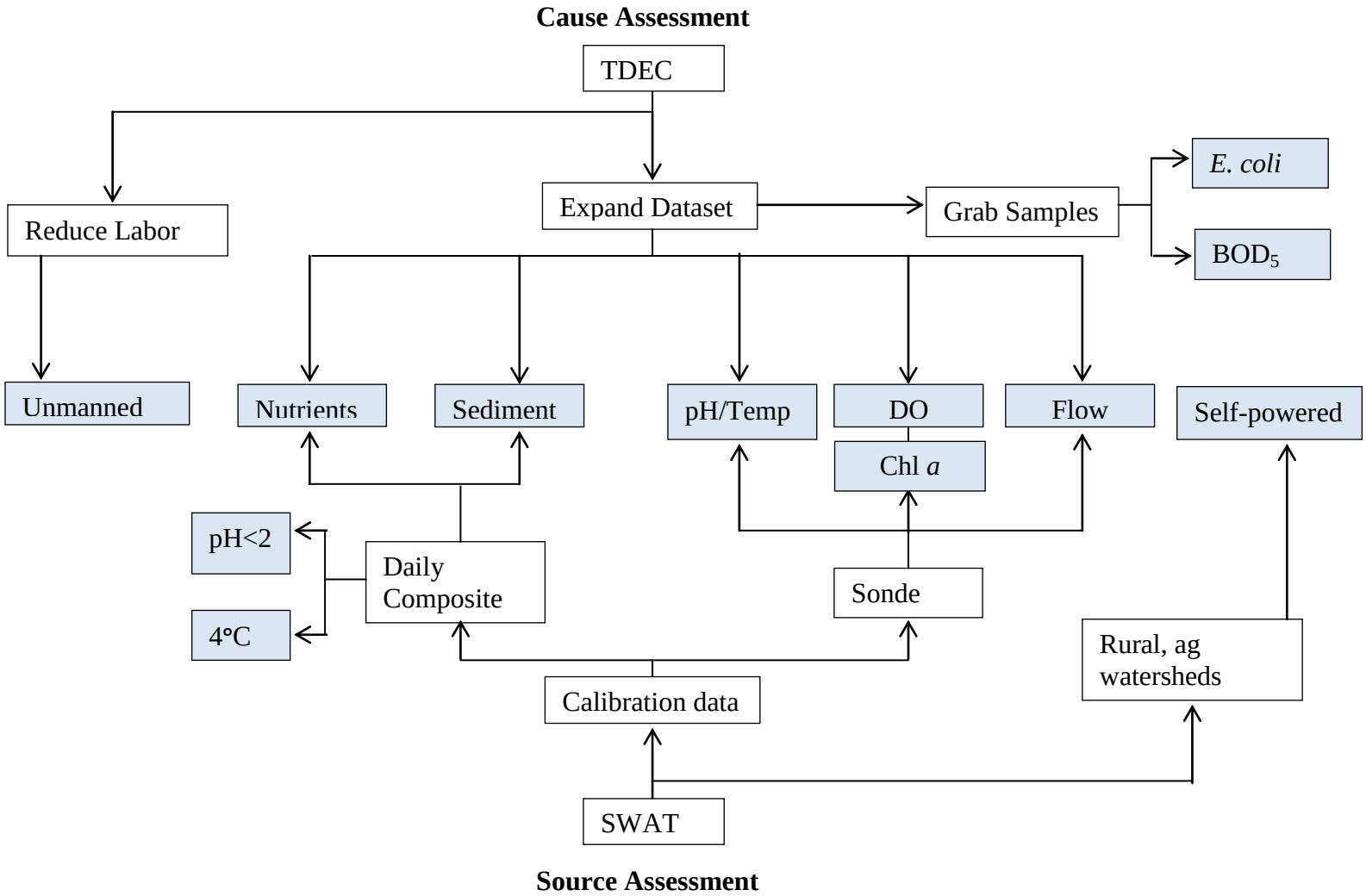


Figure 5. Conceptual model of data collection system. Shaded boxes represent measured parameters.

CHAPTER II

OBJECTIVES AND MATERIALS AND METHODS

Research Objectives

Data scarcity presents a challenge to TDEC when conducting water quality assessments identifying impairment causes and sources. An intense water quality dataset could improve stream assessment and be used to calibrate watershed models for better pollutant source assessment. Thus, the objectives for this study were:

1) To design and evaluate an intensive water quality data collection.

2) To compare the intensive dataset collected with the system to the small dataset collected by TDEC as part of the watershed cycle and to the state standards, and assess whether the larger dataset improves the assessment process.

- For dissolved oxygen, evaluate whether the state criteria are being met, including for the diurnal DO fluctuations, and compare the DO datasets for an impaired and unimpaired stream.
- For *E. coli*, evaluate whether the maximum criterion is regularly being met in both an impaired and unimpaired stream.
- For nutrient concentrations, evaluate whether the criteria are being met and compare the dataset for an impaired and unimpaired stream.
- For pH and temperature, evaluate whether the maximum, minimum, and rate of change criteria are being met in both an impaired and unimpaired stream.

Research Method

Two prototype surface water quality monitoring stations were installed on streams in Greene County, Tennessee within Ecoregion 67, the "Ridge and Valley" physiographic region, and sub-ecoregion g, the "Southern Shale Valleys" (Figure 2) (Arnwine et al., 2000). One station was built on Little Chucky Creek, a fully supporting and former ecoregion reference stream at Denver Bible Road (N $36^0$07.461′, W $83^0$03.192′). The other station was built on Lick Creek (N $36^0$08.737′, W $83^0$07.887′) that is listed as impaired for nutrients, low DO and *E. coli*.

Water Quality Monitoring and Sampling Equipment

At each location, an 8' x 8' (2.44 m x 2.44 m) deck was built to elevate the monitoring and sampling equipment above the estimated flood stage (Figure 6). A fiberglass weather resistant enclosure (model 200-071, 1.07 m x 71.12 cm x 91.44 cm, Tracom, Alpharetta, GA) was mounted on the deck to house all the water quality monitoring and sampling components. A YSI (Yellow Springs, OH) multi-parameter sonde (model 6600V2-4) was fixed stationary in the water and connected to a model CR1000 data logger (Campbell Scientific®, Logan, UT) by a vented cable (model 6192, YSI, Yellow Springs, OH). The enclosure also held a cell phone modem (MTCBA-G-F4, Multi-Tech Systems Inc., Mounds View, MN), relay (model 558-D1D07, Crydom, San Diego, CA), charge controller (model C35 photovoltaic charge/DC load controller, Xantrex, Elkhart, IN), three 30 Amp current sensors (model 1122 30 amp current sensor, Phidgets, Alberta, Canada), and three deep cycle marine batteries. Two 135 Watt solar panels (model KD135SX-UPU, Kyocera, Scottsdale, AZ) and a tipping bucket rain gauge (model TR-525USW, Texas Electronics, Dallas, Texas) were also mounted on the deck.

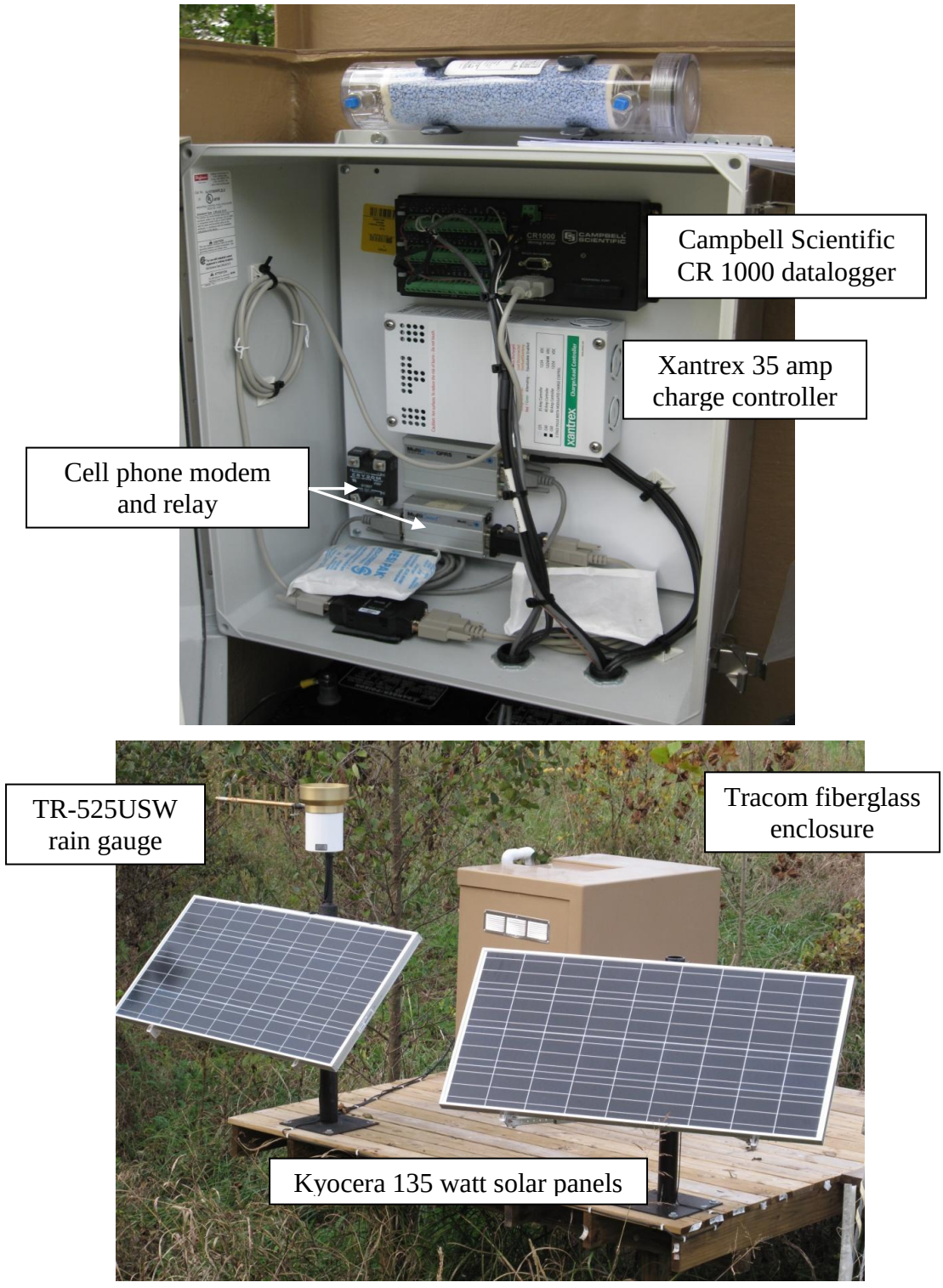


Figure 6. Components of the water quality monitoring system.

Refrigerated Sampler

Composite surface water samples were automatically collected over a period of 14 days between regular maintenance visits. Because the samples could not be analyzed immediately, a refrigerated sampler was used to prevent sample degradation. The water quality stations employed ISCO Avalanche refrigerated samplers (model 68-2979-003, Teledyne Isco, Lincoln, NE) equipped with 14 wedge-shaped polypropylene, 950 mL sample bottles (model 68-2970-001, Teledyne Isco, Lincoln, NE). The samplers were programmed to draw a 110 mL sub-sample through a clear polyethylene suction line from the stream every three hours beginning at 3:00 a.m., yielding an 880 mL composite sample for each day. Before and after the sampler pumped, it purged the suction line to remove any standing water. The sampler was programmed to allow for bottle exchange every two weeks with a full set of composite samples for each day except for the exchange day. Each sample bottle was spiked with a hydrochloric acid solution to aid the refrigeration in preserving the water sample. The cooling effectiveness of the sampler's refrigeration system was monitored using a copper constantan thermocouple to ensure that the sample chamber temperature stayed below the target temperature of 4^{0}C. Surface water samples collected by the sampler were analyzed for total suspended solids, Total Kjeldahl Nitrogen, ammonia, nitrate + nitrite, total phosphorus, total orthophosphate, and total organic carbon. Thus, these samples could help address three common causes of stream impairment, siltation, high nutrient concentrations, and low DO, caused by high organic carbon concentrations (Figure 4-A). These samples were analyzed at the Biosystems Engineering and Soil Science Department Water Quality Laboratory.

Grab Samples

Parameters such as *E. coli* and biochemical oxygen demand (BOD) cannot be preserved (even with refrigeration) and must be analyzed within 6 hours of collection (TDEC, 2008b). Biweekly grab samples were utilized to evaluate these parameters when the refrigerated sampler was serviced. One liter BOD_5 samples were collected near the center of the stream and used as an indicator for excessive organic matter pollution that can cause low DO concentration. *E. coli* samples were similarly collected but in sterile 100 mL bottles. Both samples were stored on ice until they were analyzed in the lab. These samples were analyzed at the Biosystems Engineering and Soil Science Department Water Quality Laboratory.

YSI Sonde

A multi-parameter sonde (model 6600V2-4, YSI, Yellow Springs, OH) was used to measure stream temperature (^{0}C), specific conductivity (mS/cm), depth (cm), pH, oxidation reduction potential (mV), chlorophyll (mg/L), turbidity (NTU) and dissolved oxygen (mg/L) using probe model numbers 6560, 6560, 6565, 6565, 6025, 6136, and 6150, respectively. These probes were equipped with wipers that cleaned the surface of the optical sensor before each measurement. The sonde provided water quality data for DO, temperature, and pH, parameters that cannot currently be assessed with quarterly samples collected every fifth year. Further, the sonde was designed for extended deployment and required minimal maintenance after installation, which is ideal for this unmanned monitoring and sampling system. The sonde depth was provided by a pressure transducer with atmospheric correction provided by a vented cable attached to a large desiccant pack (model 6192, YSI, Yellow Springs, OH). This enabled the system to

provide flow data after a stage discharge curve was developed, and is a critical piece of data for watershed model calibration. Data was collected from the sonde every five minutes and averaged every fifteen minutes into the data logger's final storage.

The sonde was encased in a protective pipe and mounted in the stream so that no movement would occur. At the Little Chucky Creek installation, the probe end was passed through a concrete block and the main body of the sonde was fastened to three metal stakes driven into the bed of the stream. At Lick Creek, the sonde was mounted to two fiberglass rails driven into the stream bed. A 1/8" (3.18 mm) stainless steel wire cable was connected to the sonde and to a post on the deck to prevent the sonde from washing down stream during high flows.

System Power Supply

The majority of the locations where this sampling system is needed, including the locations in this study, are rural and do not have access to electricity. Thus, the system was designed to be self-powered (Figure 7). Three 115 amp-hr, deep-cycle marine batteries wired in parallel were used to power the water quality stations. Two 135 watt solar panels (model KD135SX-UPU, Kyocera, Scottsdale, AZ) were used to charge the batteries and provide system power. A 35 Amp charge controller (model C35 photovoltaic charge/DC load controller, Xantrex, Elkhart, IN) was used to protect the battery bank from over-charge and over-discharge. Thirty amp current sensors (model 1122 30 amp current sensor, Phidgets, Alberta, Canada) were installed in series at three locations within the system to record solar energy production and the system power consumption (Figure 7).

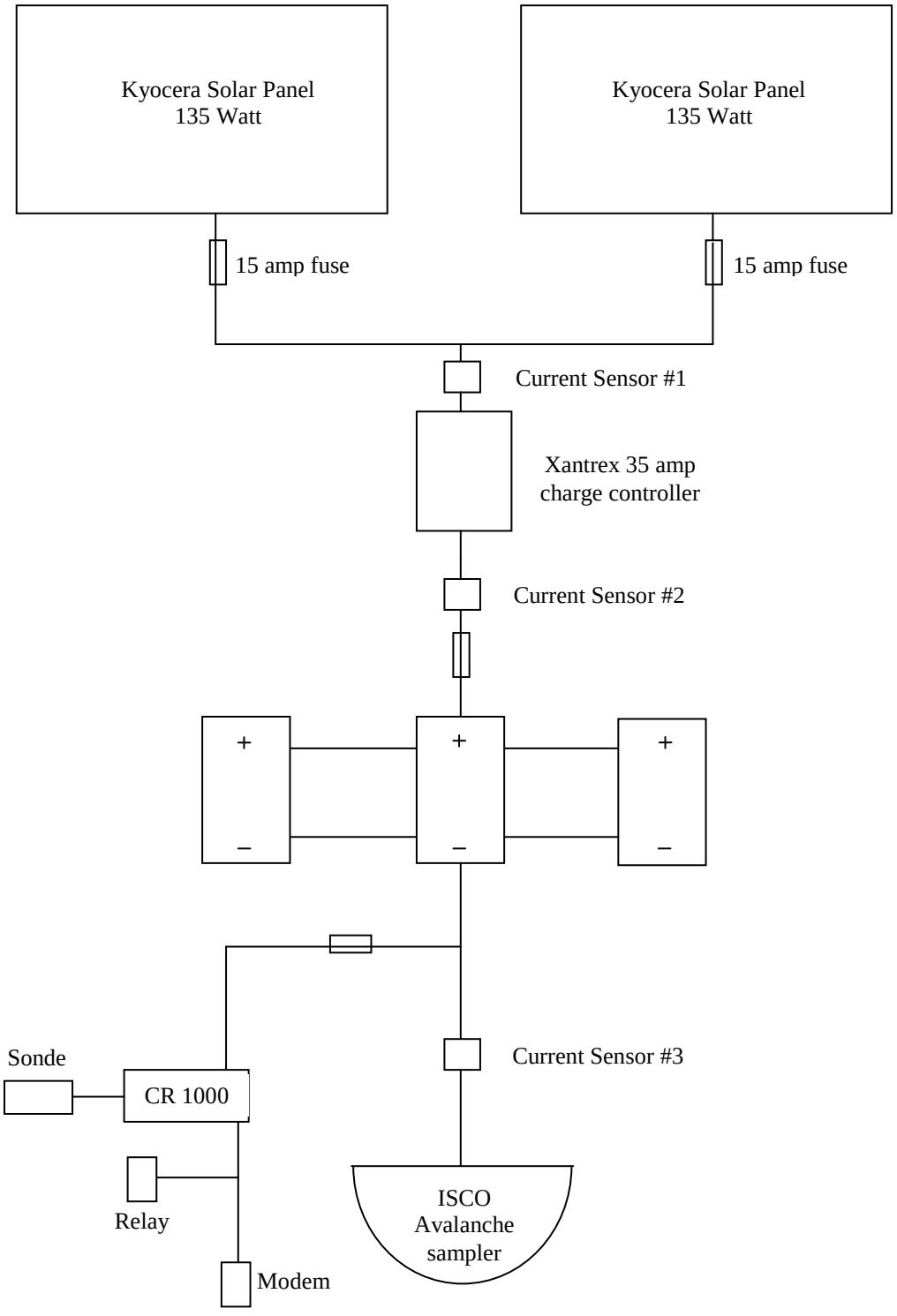


Figure 7. Water quality monitoring system power schematic.

The Phidget current sensors were calibrated by varying the current input from 0.25 amps to 20 amps and recording the sensor output. Based on this calibration, the sensor voltage output was converted to current (amps). Energy (watt-hours) was calculated over 5 seconds using the calculated current multiplied by the voltage at each sensor location and the 5 second time period. Energy values were totalized every fifteen minutes.

Data Acquisition and Communications

The system design requirements, namely being unmanned and self-powered for use in rural agricultural watersheds, indicated a need to log all of the data continuously and for the system to be accessible by remote communication. A Campbell Scientific CR1000 datalogger was used to store rainfall and ambient temperature data, energy production and consumption data, refrigerated sampler temperature, and water quality data from the sonde. A cell-phone modem (Multi-Tech, model MTCBA-G-F4) provided remote monitoring through LoggerNet software (Campbell Scientific, Logan, UT). The modem signal was broadcast via a Yagi antenna (L-com, model HG909Y-NF). A relay (Crydom, model 558-D1D07) was used to limit power to the modem during the day from 9 a.m. to 5 p.m. to conserve energy. Remote data collection worked best at the Lick Creek location. The water quality station at Little Chucky Creek tended to have poor cell service, so data were usually collected manually at this site during routine bi-weekly maintenance visits.

Rain Gauges

Rainfall data were collected to understand changes in water quality parameters such as turbidity or nitrogen levels, which are often affected by runoff. This data is also required for water quality model calibration. Rain gauges not only provide rainfall amounts, but also give time-varying information in relation to the storm event. The centroids of the sub-watersheds upstream from the Lick Creek station and the centroid of the Little Chucky Creek watershed were targeted to build a rain gauge network using tipping bucket rain gauges (Texas Electronics Dallas, TX; model TR-525USW) shown in Figure 8. Both water quality stations were also equipped with rain gauges. Rain gauges not located at the water quality stations used a HOBO pendant data logger (model UA-002-64) to store rainfall data and ambient temperature every five minutes.

Composite Stream Sample Chemical Analyses

Every fourteen days, preserved water quality samples were collected from the refrigerated samplers at both water quality stations and processed at the department of Biosystems Engineering and Soil Science Water Quality Lab at the University of Tennessee (Figure 9). The polypropylene bottles used in the refrigerated samplers were washed prior to use with soap and water, rinsed with a 1:1 solution of HCl, rinsed with tap water, and finally rinsed with distilled water. All other glassware and plasticware used in processing samples were washed in the same manner. After the bottles dried, a 2:1 solution of HCl and deionized water was added to prevent sample degradation in the refrigerated sample (TDEC, 2008b). The samples were returned to the lab in coolers of ice.

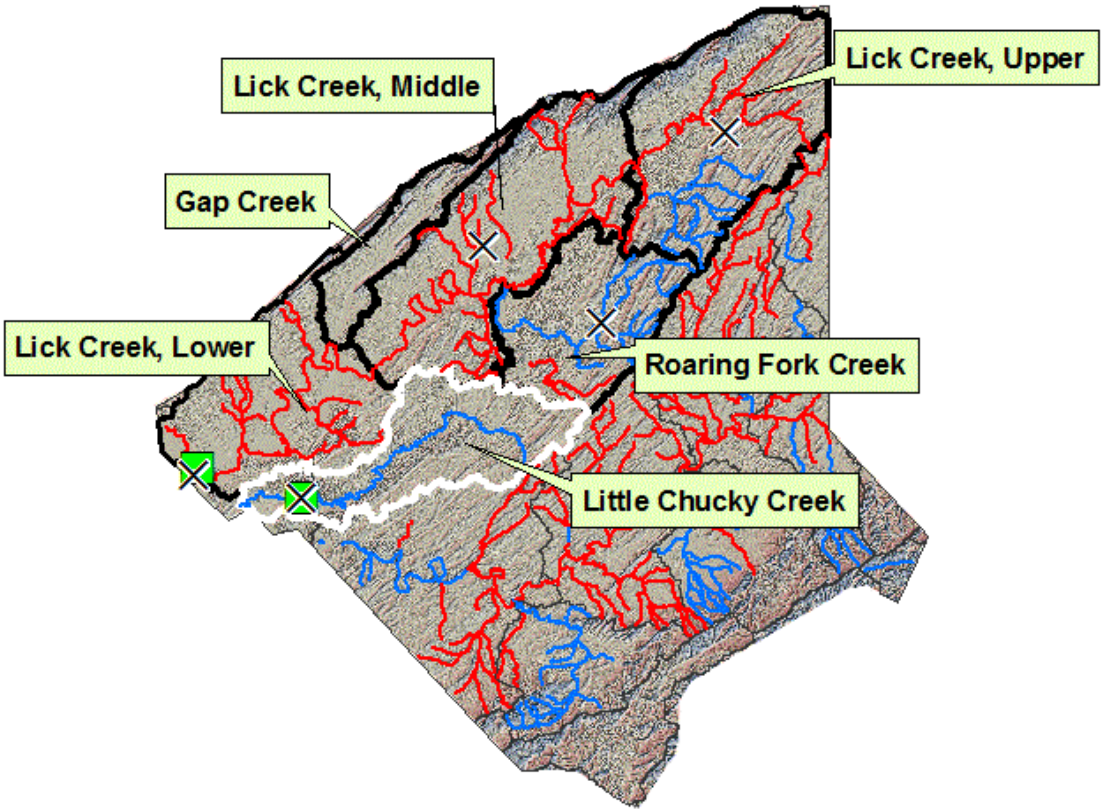


Figure 8. Green squares represent water quality monitoring locations. Black X's represent rain gauge locations. Watersheds outlined in black contribute to Lick Creek; white outline is Little Chucky Creek. Blue streams are fully supporting of their designated uses while the red streams are impaired (TDEC, 2010).

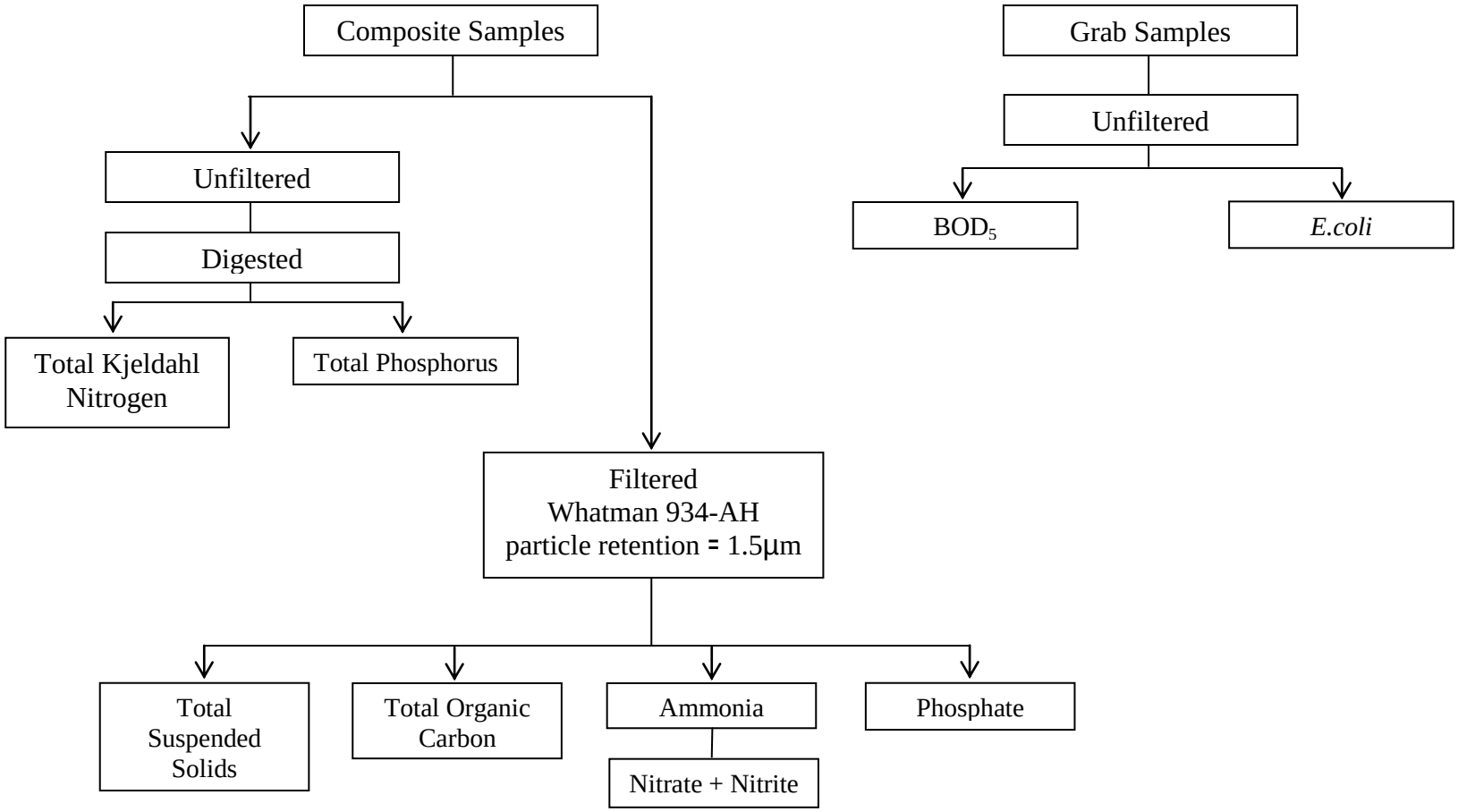


Figure 9. Sample processing diagram.

Total Suspended Solids. Total suspended solids were measured by Standard Method 2540 D (Eaton et al., 2005a). Whatman 47 mm diameter glass microfiber filters were placed on a vacuum filter flask and a well-mixed, 100 mL sample aliquot was poured through the filter followed by a distilled water rinse. The filter was placed in an aluminum dish and dried at 103 to 105ºC overnight. The filter was cooled in a desiccator and weighed again. Total suspended solids were calculated as follows:

mg total suspended solids per L = (A – B) x 1000 ÷ sample volume in mL

where:

A = weight of filter + dried residue, mg

B = weight of filter, mg

Total Kjeldahl Nitrogen (TKN). Analysis of TKN was based on EPA method 351.2, which uses a sample digestion to convert organic nitrogen to ammonium (EPA, 1993b). Prior to digestion, digestion tubes were filled with 25mL of unfiltered samples and 5mL of digestion catalyst. The catalyst was comprised of sulfuric acid, potassium sulfate and mercuric sulfate. Glass stirring rods were inserted into the tubes to prevent boiling overflow. Samples were digested in a Fisher Scientific aluminum block digester for 4 hours at a temperature of 370^0C. After digestion, the samples were cooled and deionized water was added to fill the tubes back to 25mL. The samples were then analyzed on a SKALAR flow injection analysis spectrophotometer (San^{++}) using a colorimetric technique quantified at 660 nm wavelength.

Ammonia. Ammonia analysis was based on the USEPA Nessler Method adapted from Standard Method 4500-NH_3 B and C (Eaton et al., 2005a). A filtered 25 mL sample aliquot was mixed with mineral stabilizer, polyvinyl alcohol dispersing agent, and

Nessler reagent. The mineral stabilizer, zinc sulfate, complexes hardness in the sample that might otherwise interfere with the analysis. The polyvinyl alcohol dispersing agent aids in the yellow color formation when the Nessler reagent reacts with ammonium ions in the sample. The intensity of the yellow color corresponds to the ammonia concentration and was quantified with a Thermo Spectronic Genesys 6 spectrophotometer at 425 nm wavelength.

Nitrate + Nitrite (NO_3^- + NO_2^-). Nitrate plus nitrite analysis was based on EPA method 353.2 (EPA, 1978). Filtered composite samples were processed using this colorimetric technique on a SKALAR flow injection spectrophotometer (San^{++}). Sodium hydroxide was first added to neutralize the samples. After neutralization, the filtered sample was passed through a column containing granulated copper-cadmium to reduce nitrate to nitrite. The nitrite was determined by diazotizing with sulfanilamide and coupling with N-(1-naphthyl) ethylenediamine dihydrochloride to form a colored azo dye quantified at 540 nm wavelength.

Total Phosphorus. A total phosphorus analysis (EPA method 365.4) was performed on the TKN digest using a SKALAR flow injection spectrophotometer colorimetric technique. When the samples are digested with potassium and mercuric sulfate and sulfuric acid, organic phosphorus is oxidized to ortho-phosphate. Ammonium heptamolybdate and potassium antimony (III) oxide tartrate react in a sulfuric acid solution with the digested samples, creating an antimony-phospho-molybdate complex. Ascorbic acid was added to reduce this complex to an intense blue color which was measured at 600 nm wavelength.

Total Orthophosphate. Total orthophosphate, also known as reactive phosphorus or soluble phosphorus, was measured using EPA method 365.1 (EPA, 1993a). Composite samples were filtered through Whatman 47mm diameter glass microfiber filters and processed using this colorimetric technique on the SKALAR flow injection spectrophotometer (San^{++}). The resulting blue complex is measured at 600 nm wavelength and is correlated to the phosphorus concentration.

Total Organic Carbon. Total organic carbon (TOC) was measured using a Shimadzu TOC-VCPH total organic carbon analyzer with Shimadzu ASI-V automatic sample injector based on the EPA method 415.1 (EPA, 1974). Forty-milliliter glass vials were filled with a filtered aliquot of each composite sample and inserted into the ASI-V automatic sampler. Carrier gas was used to sparge the sample to eliminate inorganic carbon, and the remaining total carbon in the sample was injected into a combustion tube filled with an oxidation catalyst heated to 680^0C. The total carbon components were combusted to carbon dioxide which was detected by a non-dispersive infrared gas analyzer.

Grab Samples

Composite samples collected by the refrigerated samplers and that can be reasonably preserved by simple refrigeration provide daily nutrient data. However, some parameters cannot easily be preserved by refrigeration and must be analyzed within 6 hours of collection. These parameters are evaluated by collecting biweekly grab samples analyzed for biochemical oxygen demand (BOD) and *Escherichi coli* (*E. coli*). Both sets of samples build a comprehensive dataset that would allow for an intensive stream assessment.

E. coli. *E. coli* samples were processed within six hours of collection using the Standard Method 9223 via the Colilert® system (IDEXX Laboratories, Westbrook, MA) of analysis. All bottles used to collect and process these pathogen indicator samples were sterile. An aliquot of the grab sample was diluted with sterile water and thoroughly mixed with Colilert® reagent. This 100 mL mixture was sealed in an IDEXX Quanti-Tray and incubated at 35^0C for 18 hours. During the incubation period, the reagent detects the presence or absence of total coliforms and *E. coli*. Each tray is compared to the standard tray supplied by IDEXX. A yellow color darker than the standard indicates a positive test for total coliforms. If yellow is observed, the tray is checked for fluorescence by placing under a UV light. If fluorescence is observed that is greater than or equal to the standard, then the wells are positive for *E. coli*. The number of large and small positive wells determine the *E. coli* most probable number (MPN) for that sample by using the MPN table provided with the Quanti-Tray (IDEXX Laboratories, Westbrook, MA).

Biochemical Oxygen Demand (BOD). BOD was measured using Standard Methods 5210 B and C (Eaton et al., 2005b). Briefly, the method consisted of filling a 300 mL BOD bottle to overflowing with an undiluted grab sample to which a nitrification inhibitor was added to prevent nitrogenous oxygen demand. Dilution water was prepared for the BOD standard in accordance with *Standard Methods* and mixed with PolySeed® innoculum. This mixture was added to the 300 mL sample and the initial dissolved oxygen (DO) was measured using a HACH DO meter. The bottle was topped with a glass stopper and water seal and incubated at 20^0C for five days. On the fifth day, final DO was measured and BOD_5 was calculated by the following equation:

$$BOD_{5,}\ mg/L = \frac{(D1-D2) - (B1-B2)f}{P}$$

where:

D1= DO of sample immediately after preparation, mg/L

D2= DO of sample after 5 day incubation, mg/L

P= decimal volumetric fraction of sample used

B1= DO of seed control before incubation, mg/L

B2= DO of seed control after incubation, mg/L

f= (volume of seed in sample)/(volume of seed in seed control)

Quality Control/Quality Assurance

Duplicate samples were collected at a minimum of ten percent of sampling events. Blanks were incorporated into the chemical analysis as well as replicates. Instrument repeatability was monitored closely to ensure accurate results. Glassware and plasticware used in the lab were washed with an acid rinse, rinsed with tap water, and finally rinsed with deionized water. The polypropylene bottles used in the refrigerated samplers were properly washed, labeled, and preserved with acid before each sampling trip. The grab sampler bucket was washed with laboratory detergent and rinsed with deionized water before sampling and rinsed with stream water on location before taking the actual grab sample. Sample pH was checked periodically to determine if the preservative solution was effective ($pH < 2$).

Stage Discharge Curve Development

Flow measurement is crucial in order to determine pollutant loads and is required to calibrate water quality models such as SWAT. At Lick Creek and Little Chucky Creek stage-discharge curves were developed to estimate flow rate based on depth measured by

the sonde. The stage-discharge relationship was established using the wading velocity-area method and the RiverSurveyor system at Little Chucky Creek. Only the RiverSurveyor system was used at Lick Creek due to higher flows, which would have made wading hazardous.

Velocity-Area Method. The width of the stream was measured at a stable cross-section and divided into equal increments. The total depth at the center of each increment was recorded, and velocity was measured at 20, 60, and 80 percent of the total depth by a Swoffer Model 3000 flow meter and Top Set Wading Rod. Velocities were averaged and flow rate was calculated for each increment. Total discharge was determined by summing the incremental discharges. Discharge was measured multiple times throughout the year (March, May, June, October 2010) to reflect high, low, and normal flows.

RiverSurveyor. The velocity-area method worked well at Little Chucky Creek because the flows are typically shallow and the creek can be waded safely. However, Lick Creek tends to be much deeper at high flows and was dangerous to wade. Instead of the velocity-area method, a SonTek RiverSurveyor system was used at Lick Creek. The RiverSurveyor employs a highly accurate Acoustic Doppler Profiler (ADP) system designed specifically to measure stream discharge, 3-dimensional water currents, and depths from a moving or stationary vessel. The system transmits real-time kinematic (RTK) position data through a GPS receiver in a hand-held mobile device (RiverSurveyor). The RiverSurveyor was connected to a pulley system to move the raft across the stream while continuously collecting and calculating velocity measurements. Data collected by the system was sent using Bluetooth remote communication to the mobile device, and then uploaded to a PC where stream cross-sections and total stream

velocity could be viewed (Figure 10). This method worked well at both streams and provided data quickly and safely with minimal effort.

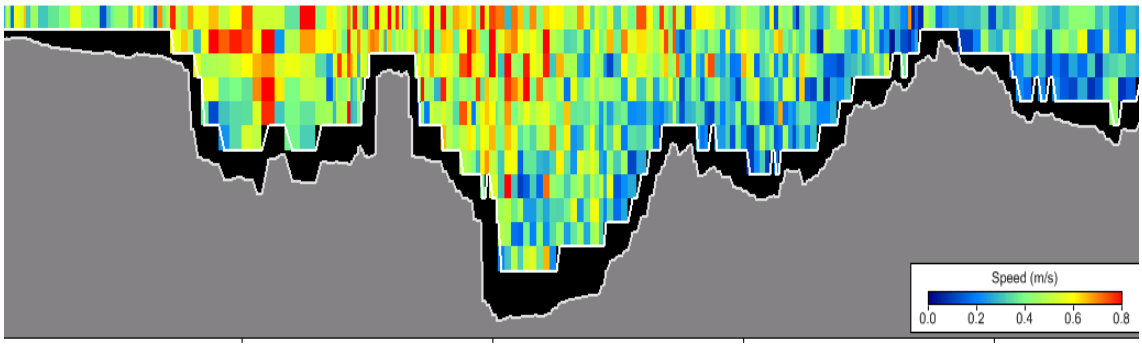


Figure 10. Cross-section of Lick Creek showing pixilated velocities creating by the RiverSurveyor.

CHAPTER III

REFRIGERATED SAMPLER PERFORMNACE AND POWER DEMAND

The water quality monitoring system designed for this study must be self-powered because typically the locations that need monitoring do not have AC power. Specifically, the power supply system must be able to support the YSI Sonde whose sensors take measurements every five minutes and are self-cleaning, the datalogger, and most importantly, the refrigerated sampler. Important design specifications include constructing the system in such a way that allows for efficient operation during summer months when ambient temperature is at its peak (requiring maximum refrigeration) and winter months when power generation potential is low due to poor solar input (Figure 11). This study empirically determined which time period controlled the design.

One Solar Panel and Two Batteries

Initially, the systems were operated with a single 135 Watt solar panel and two 115 amp-hour, deep-cycle marine batteries from August 13, 2009 through October 29, 2009. This design proved to be inadequate to power the system. The battery voltage at Little Chucky Creek began dropping consistently below the sampler shutdown setpoint of 10.8 volts on September 13, 2009 and reached its lowest point of 8.81 volts on September 26, 2009 (Figure 12). At Lick Creek, the battery voltage first dropped below the shutdown point on September 19, 2009 and reached its lowest voltage of 10.37 on September 22nd.

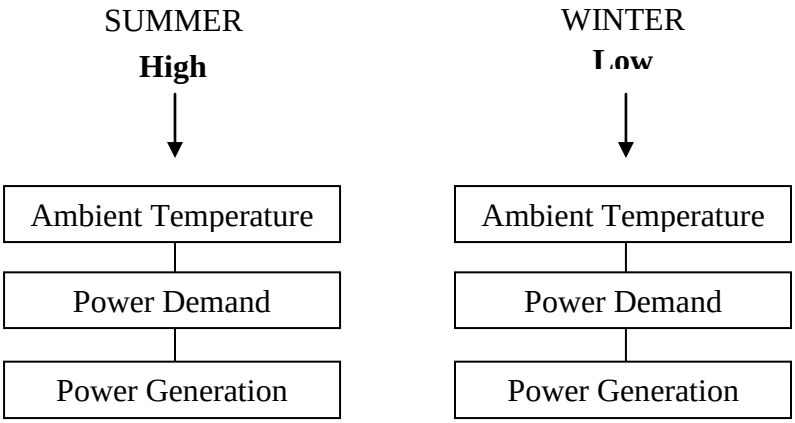


Figure 11. Time periods considered while designing water quality monitoring system.

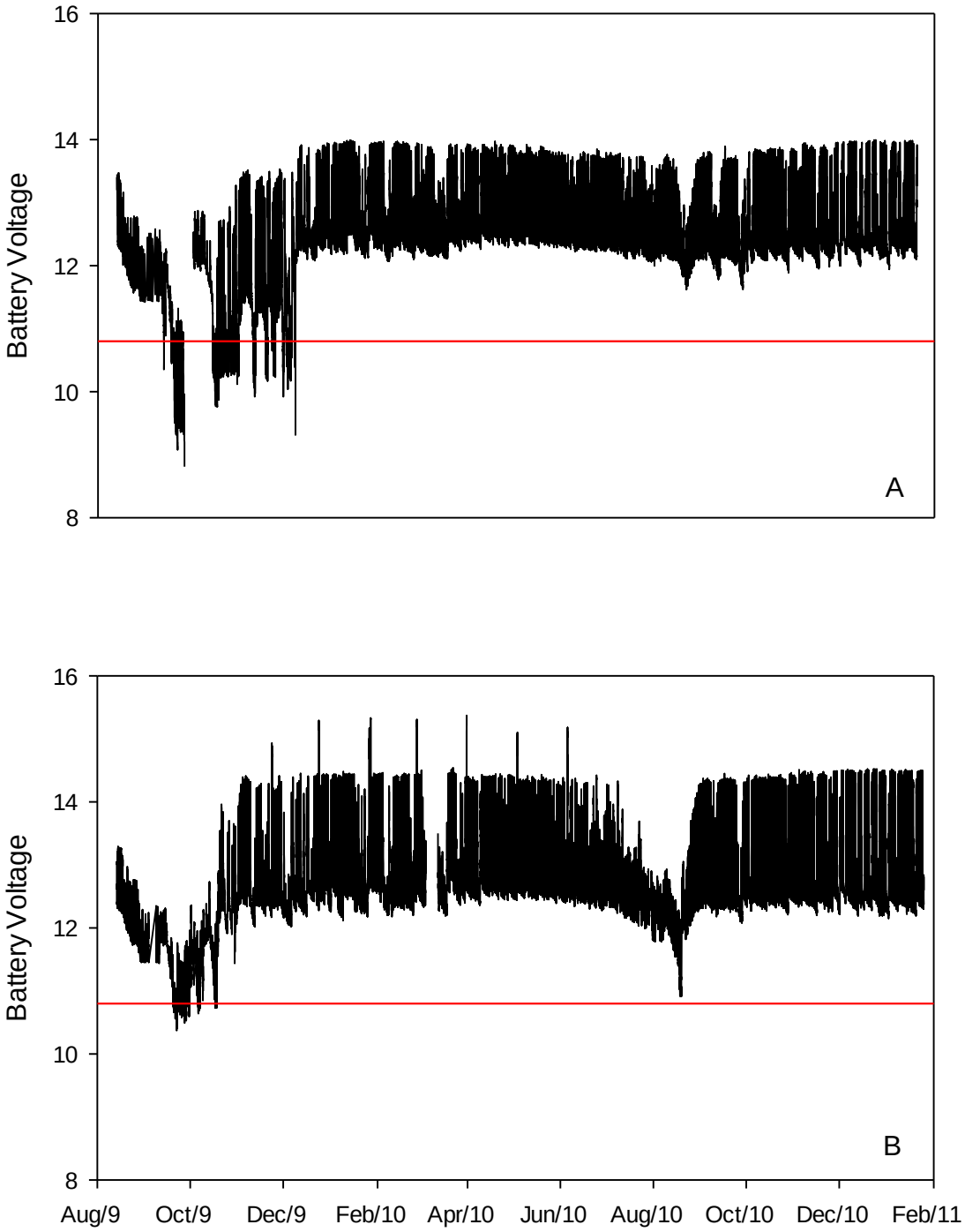


Figure 12. Battery voltage over time at Little Chucky Creek (A) and Lick Creek (B).

Two Solar Panels and Three Batteries

An additional solar panel and battery were added to maintain a consistent voltage throughout all external conditions (Figure 12). Even after an additional panel and battery were added on October 29, 2009, battery voltage at Little Chucky Creek dropped below the shutdown setpoint 17.8 percent of the time until the battery bank was replaced on December 8, 2009, after which the batteries retained their voltage. Battery voltage at Lick Creek remained above the shutdown setpoint of 10.8 after the extra panel and battery was added, but when summer temperatures increased the need for more power to refrigerate the sampler, battery voltage began to decline in mid-July 2010 and reached a low of 10.91 volts on August 19, 2010. At this time, the batteries at Lick Creek were removed and charged back to 12.5 volts. The system at Little Chucky Creek also experienced a decline in battery voltage during this time period, but did not drop below the sampler shutdown voltage (Figure 12).

Solar Panel Voltage

Solar panel voltage as well as the current readings in sensor one (between the solar panels and charge controller) and sensor two (between the charge controller and batteries) fluctuated depending on the time of day and solar radiation. Solar radiation was measured at the weather station at the Lick Creek location, but was not available at Little Chucky Creek (Figure 13). A critical design feature of the system was making certain that the battery voltage remained above 10.8 volts, as this is the shutdown set-point of the sampler. During July and August, the maximum panel voltage decreased to near 12 volts

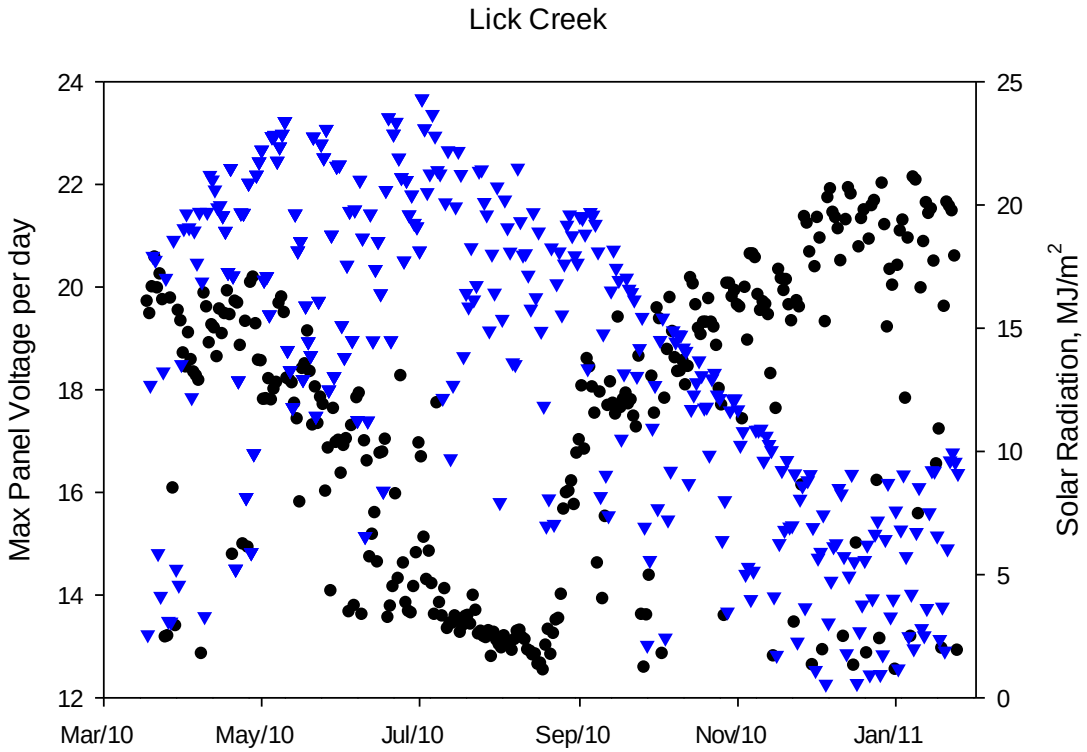


Figure 13. Maximum panel voltage per day (black circles) and total daily solar radiation (blue triangles) at the Lick Creek monitoring station.

because the sampler was requiring the maximum amount of power to keep cool, but the solar panels could not keep up with the demand even when solar radiation was high. Other than the hottest months of the year and when solar radiation was lowest, the maximum panel voltage was maintained at or above 16 volts.

Current Measurements

Three 30 amp current sensors were installed in March 2010 to monitor total power production and consumption (Figure 7). The first sensor was installed between the solar panels and charge controller to measure amperage production by the solar panels. The second sensor was installed between the charge controller and the batteries to measure actual charging current, and the third between the batteries and the sampler to measure current use. The third current sensor is crucial to determine power demands by the sampler. Six sensors were calibrated by varying the current directed to the sensor. The calibrations were near identical with an R^2 of 0.9999 for each sensor. Based on this calibration, the equation of the line used in programming the datalogger was $y = 15.435x - 38.5110$, where y is current to the sensor and x is the sensor output voltage. Sensor #1 and #2 should read the same current measurement due to their location within the system (Figure 7). Both sensor outputs plotted against each other resulted in a line with a slope of 1.00 at Little Chucky Creek and 1.01 at Lick Creek, illustrating that the sensors are capable of accurately reproducing results (Figure 14).

Energy drawn by the sampler measured by current sensor #3 was directly correlated to panel temperature (measured at the datalogger inside enclosure) with Spearman correlation coefficients of 0.85 and $P<0.05$ at Little Chucky Creek and 0.83.

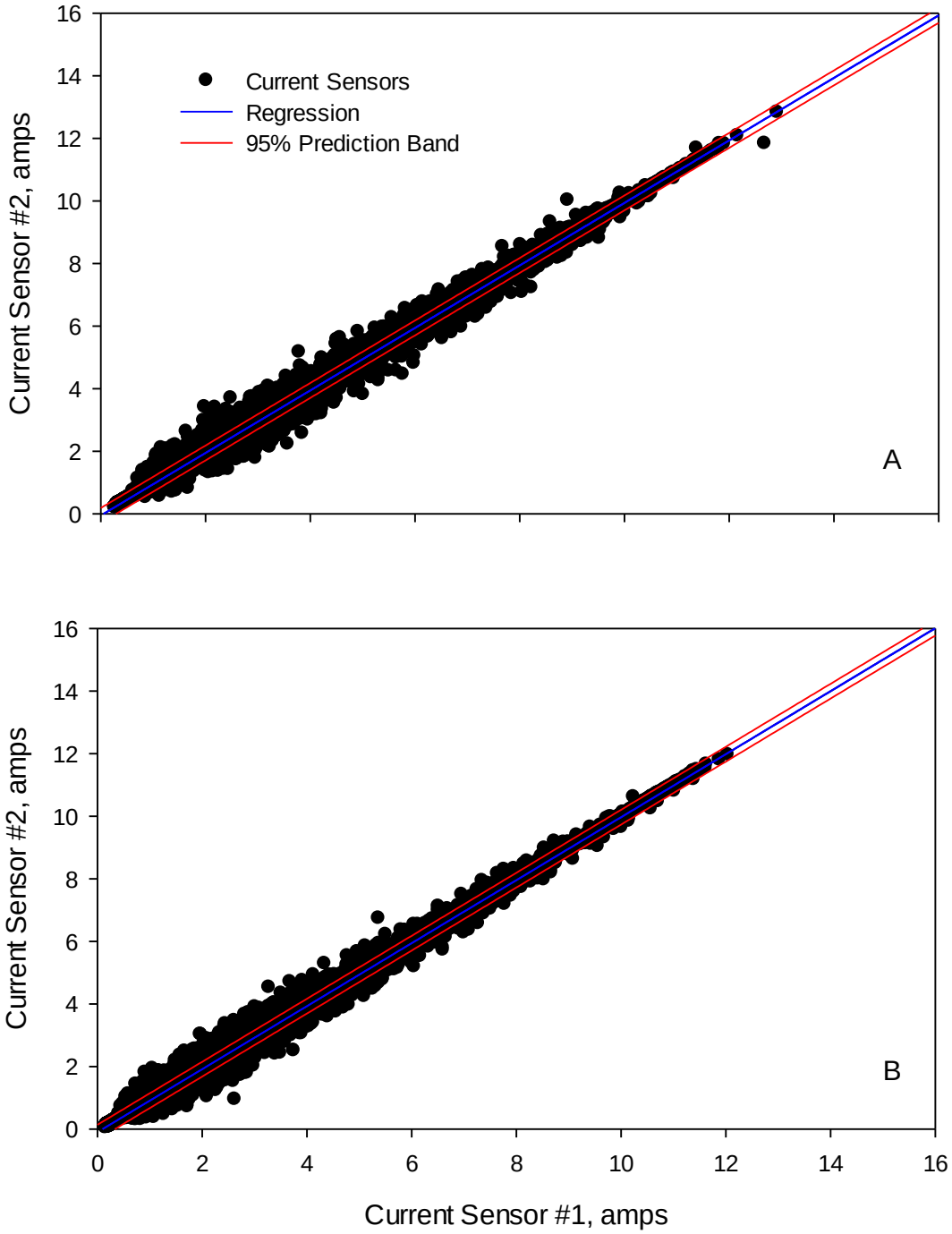


Figure 14. Current Sensor #1 plotted against current sensor #2 with the regression line and 95% prediction band at A. Little Chucky Creek and B. Lick Creek

and $P<0.05$ at Lick Creek. As panel temperature increased, the number of watt-hours consumed by the sampler increased in order to maintain the sampler chamber temperature goal of 4^0C (Figure 15). Plot A shows the amount of watt-hrs required by the sampler at Little Chucky Creek as the panel temperature increases. Plot B shows the same for Lick Creek.

Refrigerated Sampler Performance

In figure 15, the spikes in the sampler temperature occur on days when the chamber was opened to exchange bottles for analysis. When the battery voltage at Lick Creek rapidly decreased in August 2010, the samplers were switched from Lick Creek to Little Chucky Creek to troubleshoot what might be causing the problem. Before the switch, the sampler at Little Chucky Creek maintained a constant chamber temperature of below 4^0C for 55.4 percent of the time (Figure 15). When the sampler from Lick Creek was installed at Little Chucky Creek, the chamber temperature was below 4^0C for 97 percent of the time. The time period after the switch included the winter of 2010 when ambient temperatures were lower so a higher percentage was expected, but the sampler also maintained a lower temperature during the remainder of the summer. At Lick Creek before the sampler switch, the chamber temperature stayed below the temperature goal for 85 percent of the time (Figure 15). After the Little Chucky Creek sampler was installed at Lick Creek, the temperature goal was met 92 percent of the time. This percentage was expected to be higher since the winter values were included. Figure 15 also illustrates that the panel temperature at Lick Creek was higher during the summer, which forced the sampler to work harder to keep cool. Around the time of peak panel

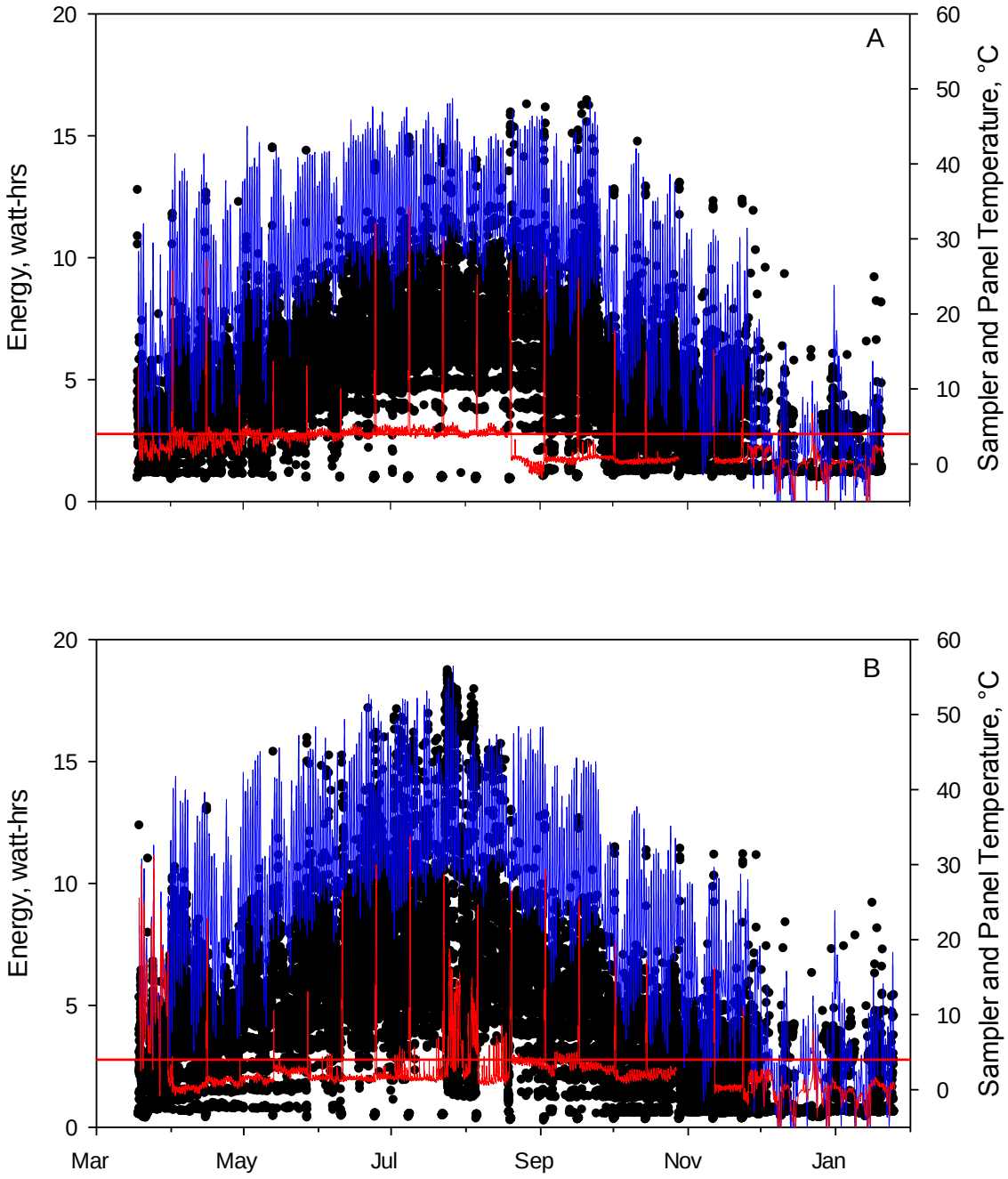


Figure 15. Watt-hrs required by the sampler (black filled circles), the panel temperature (blue line), and the sampler chamber temperature (red line) for A. Little Chucky Creek and B. Lick Creek. The sample preservation temperature goal of 4°C is illustrated with a horizontal red line.

temperature, the sampler did not maintain the temperature goal because battery voltage began to decline to 10.91 volts.

The manual for the ISCO Avalanche refrigerated sampler lists an equation to determine the expected power consumption depending on the programmed sampling routine (Teledyne ISCO, 2003). The equation combines amp-hours needed to cool the sample volume of water and the amp-hours per day needed to maintain the sample temperature at 3^0C for the number of days required. Two plots are provided by the manual to illustrate the relationship between ambient temperature and the amp-hours required to cool and to maintain the temperature of the collected sample volume (Figure 16). Using the equations of the lines from each plot (to cool $y = 0.4671x+6.1786$, to maintain $y = 1.632x-10.1$ where y is amp-hours and x is ambient temperature) and the average panel temperature per day from the system, the predicted required amp-hours per day per liter of sample can be calculated.

The actual amp-hours per day used by the sampler averaged 12.3% higher at Little Chucky Creek (Figure 17-A) and 18.2% higher at Lick Creek (Figure 18-A) than the manual-predicted power consumption during two of the hottest sampling cycles of the year from July 9 through August 18. Sharp decreases from 52 amp-hrs per day to 22 amp-hrs per day on July 21st and 61 to 36 on August 4th at Little Chucky Creek were observed at the end of the sampling cycle when the sampler was empty and the next sample cycle had not begun. At Lick Creek the decreases were 60 amp-hrs per day to 24 on July 21st and 67 to 34 on August 4th. These two sampling cycles required an average 55.11 ± 7.89 amp-hrs per day at Little Chucky Creek and 59.29 ± 10.91 amp-hrs per day at Lick Creek. The sampler at Lick Creek required an average of 13.3% more amp-hours

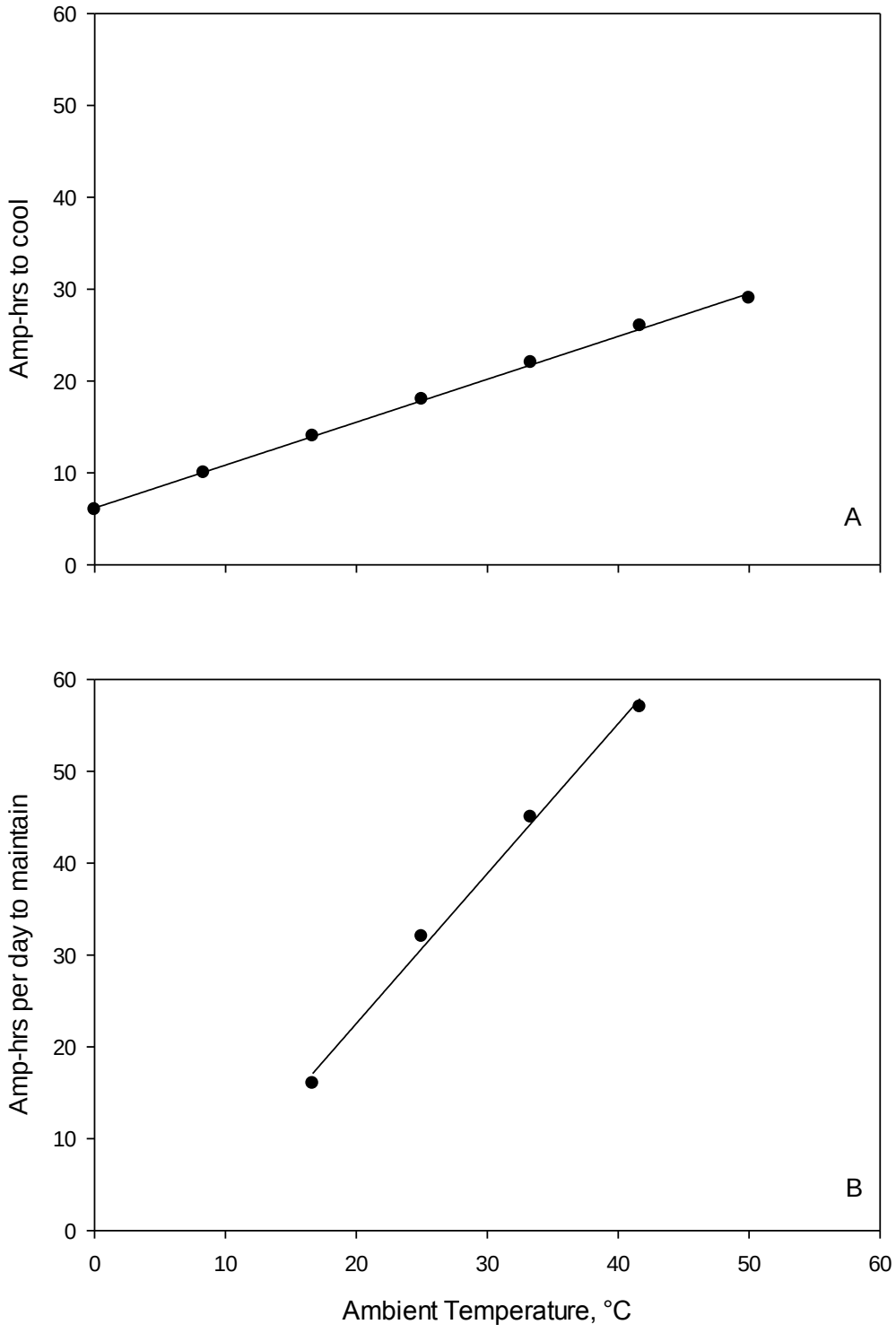


Figure 16. Plot A describes the amp-hrs required to cool 6 liters of sample liquid. Plot B describes the amp-hrs per day required to maintain sample liquid at 3^0C (Teledyne ISCO, 2003).

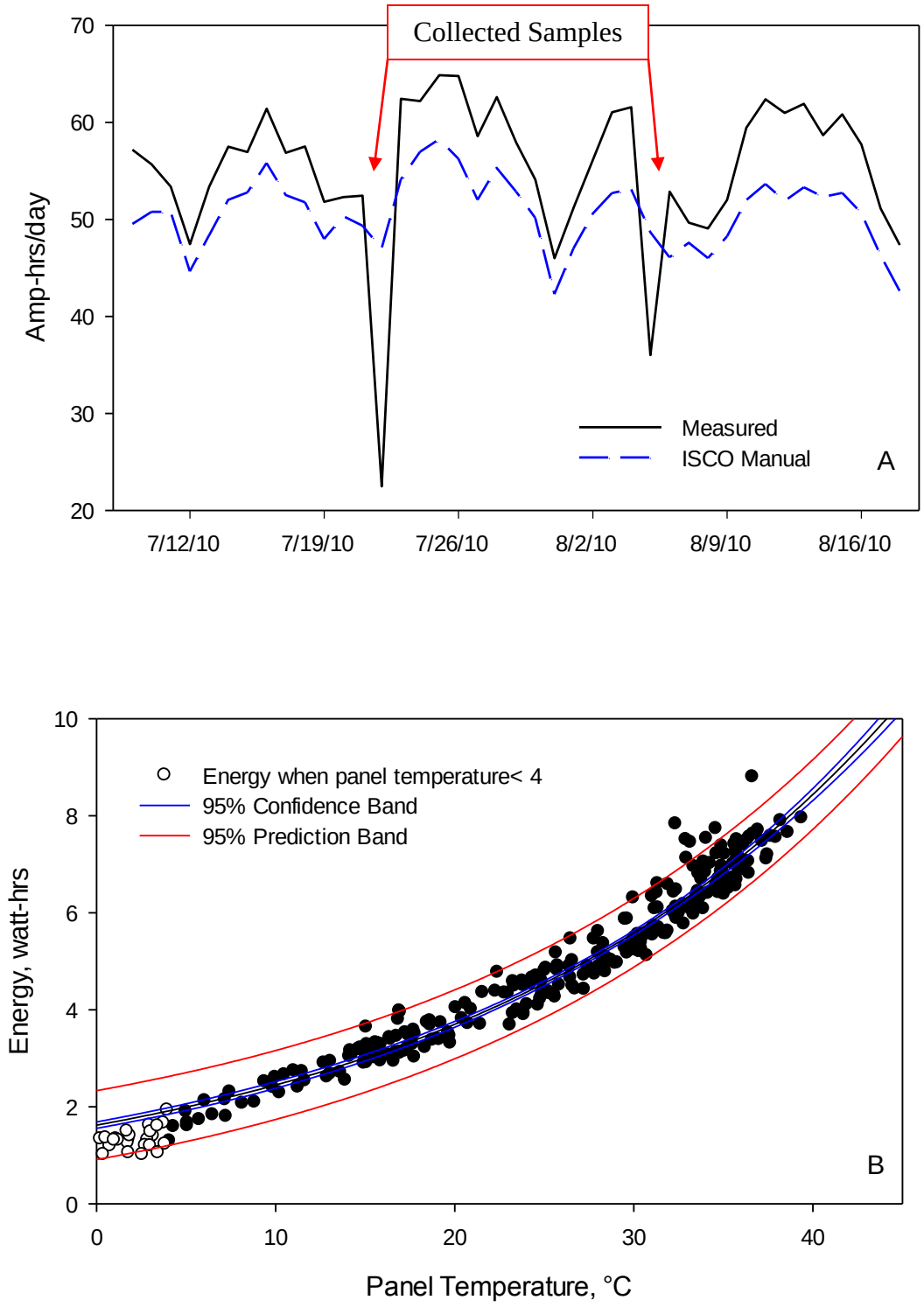


Figure 17. A. Actual power consumption (solid line) and the ISCO predicted power demand (dashed line) and B. relationship between energy and panel temperature at Little Chucky Creek.

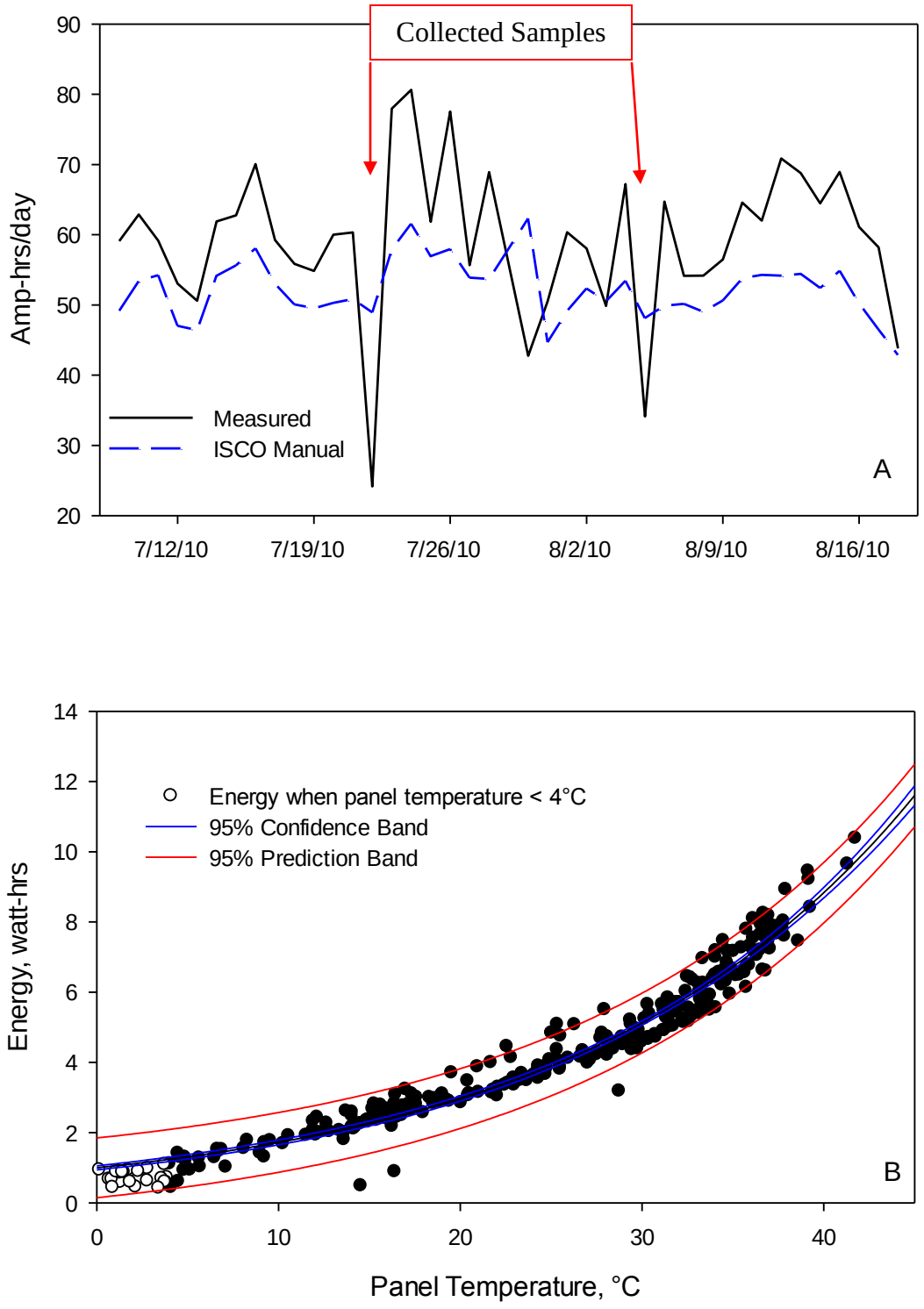


Figure 18. A. Actual power consumption (solid line) and the ISCO predicted power demand (dashed line) and B. relationship between energy and panel temperature at Lick Creek.

per day than Little Chucky Creek. This may have been because the station at Lick Creek was exposed to the sun all day with minimal shade on the sampler enclosure.

Power System Design

Energy Required vs. Panel Temperature

Energy demanded by the sampler has an exponential relationship with panel temperature (Figure 17-B, 18-B). As panel temperature increases, energy needed by the sampler rises in an accelerating fashion. The temperatures below 4°C were plotted, but were not used in determining the relationship because of their minimal impact on required energy. The equation for Little Chucky Creek was calculated to be $y = 148.04e^{0.04x}$ where y is watt-hours and x is panel temperature (Figure 17-B). At Lick Creek, the equation was $y = 96.11e^{0.05x}$ where y is watt-hours and x is panel temperature (Figure 18-B). Lick Creek used more energy and amp-hrs per day during the hottest weeks of the summer, which turned out to be the worst case scenario for power-system design implications. Energy usage recorded when panel temperatures were above 30^0C at Lick Creek also have an exponential relationship of $y = 101.82e^{0.05x}$.

The equation derived from the energy used at temperatures greater than 30^0C is the design point for selecting the battery bank to power this water quality monitoring system in the Greene County, Tennessee region. The panel temperature at Lick Creek reached a high of 41.7^0C on July 30, 2010. Using the design equation, at this temperature the sampler would need 821 watt-hrs per day or 68 amp-hrs per day, assuming 12 volts, to maintain the system. Designing for the worst conditions includes factoring in a safety margin to support the system if it is subjected to several days of high temperatures with minimal solar radiation to produce energy. To function for three days without consistent

energy production, the battery bank will need to provide a minimum of 204 amp-hrs at that ambient temperature. The three deep-cycle marine batteries used in this study would provide 345 amp-hrs assuming a fully-charged state at the beginning of the foul weather period. Other areas utilizing this system may adjust the equation up or down the curve depending on their normal climate.

Energy Supplied vs. Energy Demanded

The system relies upon two 135 watt solar panels to keep the battery bank charged to an operable level. Current created by the solar panels is measured at current sensor #1 before the charge controller, and the current being supplied to the batteries is measured at current sensor #2 between the charge controller and the batteries. The difference between the energy demanded by the sampler and the energy supplied to the batteries is the available energy used to charge the batteries (energy supplied – energy demanded = energy for charging) not accounting for temperature and heat losses. The system at Little Chucky Creek charged the batteries 88% of the time, but sampler demand exceeded the supply on 37 occasions. Figure 19-A illustrates watt-hrs available for charging at Little Chucky Creek and the corresponding average battery voltage over time. Values below the zero reference line represent periods when the sampler energy demands exceeded the supply to the batteries. The energy demands averaged 27.6% higher than the supply during the exceedences. Over half of the non-charging periods occurred between July and October 2010 (Figure 19-A). Figure 19-B illustrates the supply to batteries and the demand by the sampler during this summer period of low charging. During this time,

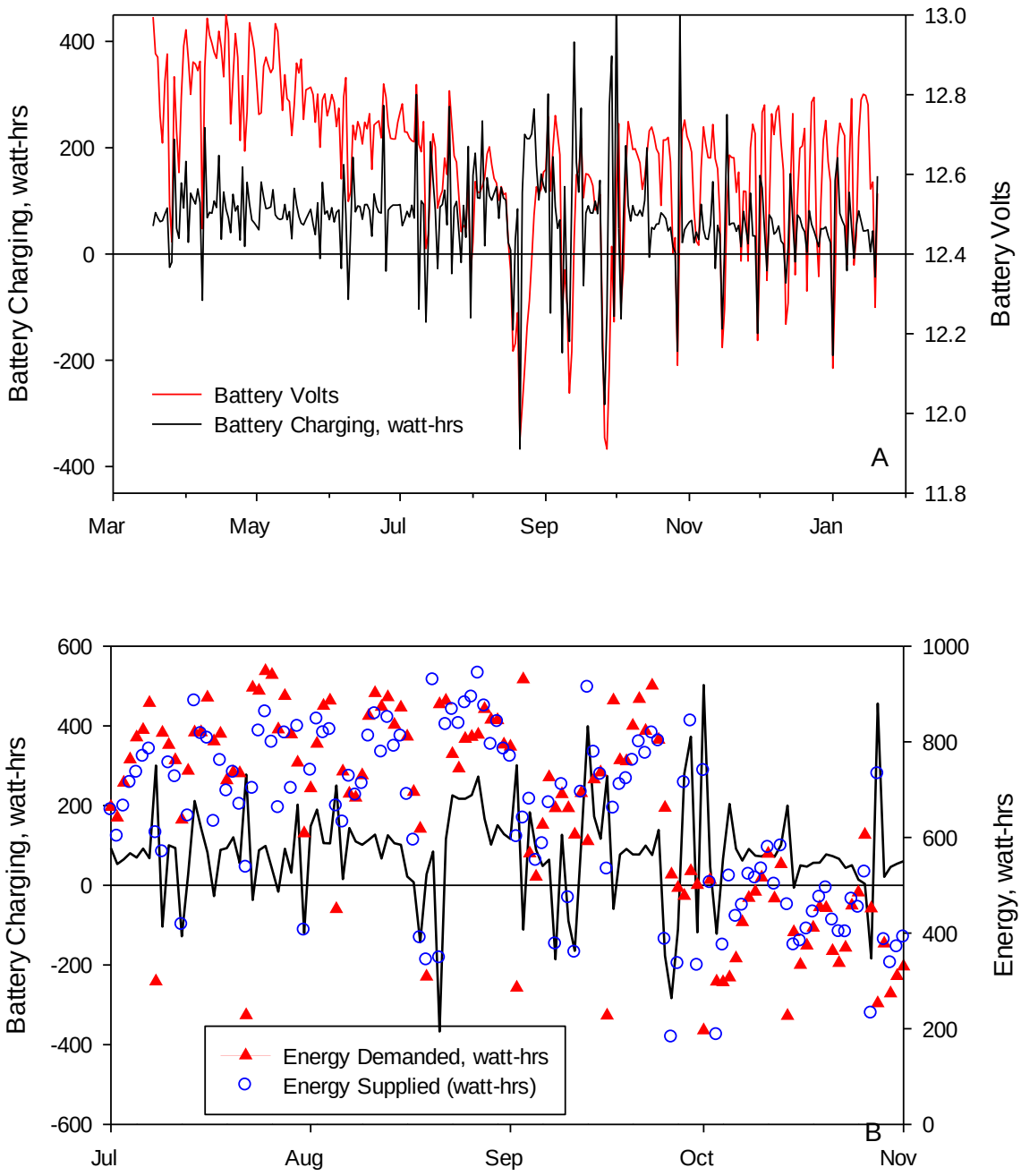


Figure 19. A. Watt-hrs available for charging along with corresponding average battery voltage per day and B. energy demanded vs. energy supplied during July through October charging cycle at Little Chucky Creek.

demands averaged 29.5% higher than supply, but the battery bank remained charged to average 12.3 volts and did not fall below the sampler shutdown set point of 10.8 volts.

The battery voltage at Lick Creek began to decline in mid-July 2010 and reached a low of 10.91 volts by mid-August. The system charged the batteries 89% of the time with 35 supply exceedences (Figure 20-A). The energy demands during those exceedences were 21.9% higher than energy supply. Of the 35 overdrawn occurrences, 18 were between the months of July and October with demands averaging 16% higher than supply during this time period, but battery voltage averaged 12.2 volts. Before the batteries dropped to a low of 10.91 volts on August 19, the system experienced three consecutive days of negative battery charging (Figure 20-B). The average battery voltage for each day was 11.75, 11.60, and 11.20 which were all above the sampler shutdown voltage. The batteries were able to support the system for three days, but the fourth day reached the low voltage, and the batteries had to be recharged outside the system.

Both systems experienced similar conditions during the periods when no watt-hrs were available to charge the batteries, but Lick Creek failed, while Little Chucky did not. The difference between the two systems may be the result of panel temperature, which is measured at the datalogger inside the enclosure. Lick Creek had a higher average panel temperature 52.8% of the time from March 2010 through January 2011, with temperatures averaging 15% higher than Little Chucky Creek. Spearman rank order correlation calculated a significant ($P<0.0001$) negative relationship with a coefficient of -0.354 between average battery voltage per day and average panel temperature per day at Lick Creek. The same test calculated an insignificant relationship at Little Chucky Creek.

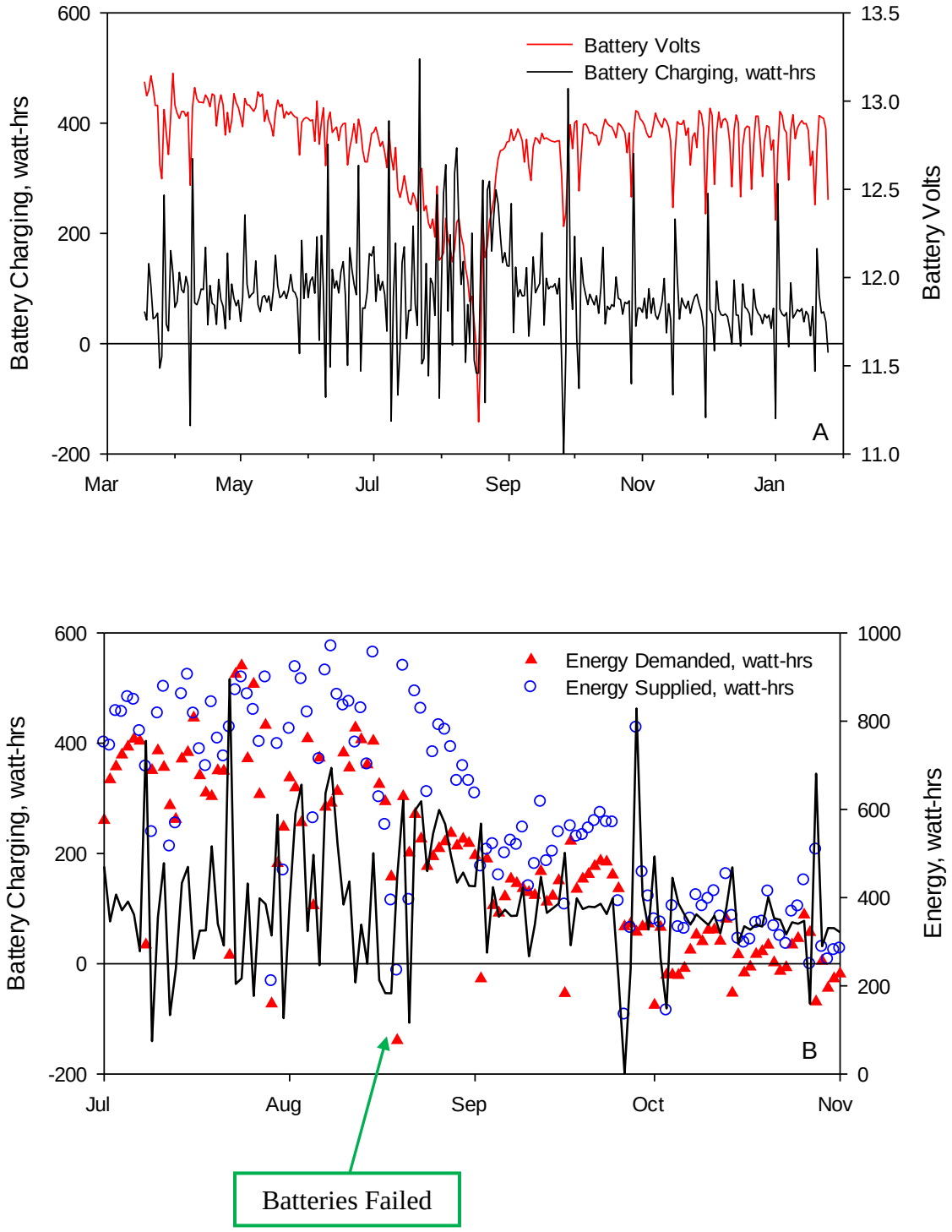


Figure 20. A. Watt-hrs available for charging along with corresponding average battery voltage per day and B. energy demanded vs. energy supplied during July through October charging cycle at Lick Creek.

Summary

Overall, the system performed well except during the most demanding months of the year when temperatures and energy consumption were high. Battery voltage remained consistently above 12 volts at both monitoring sites after an additional solar panel and battery were added (Figure 12). The exception at Lick Creek was for a short period in late summer 2010 in which batteries were removed from the system, recharged, and returned to the system during the same day, resulting in minimum data loss. During the same time period, Little Chucky Creek experienced a slight downward trend in battery voltage, but the system never dropped below the sampler shutdown voltage of 10.8 volts. Otherwise, reliable battery voltage allowed the temperature inside the sampler chamber to meet or stay below the temperature goal of 4^0C 97% of the time at Little Chucky Creek and 92% at Lick Creek.

High panel temperatures may have influenced the decline in battery voltage at Lick Creek, suggesting that the enclosure housing the sampler and batteries should be well ventilated and could benefit from natural shade as well. If the area utilizing the system is not conducive to shade, then an additional solar panel should be added to ensure that battery voltage is maintained through periods of high demand. If the system had been designed based on the published power guidelines for the refrigerated sampler, it is likely that the system would have failed regularly especially when cooling demands were high in the heat of the summer. Based on the watt-hours used by the sampler, a more appropriate equation to size the battery bank is derived from Lick Creek ($y = 96.11e^{(0.05x)}$ where y is watt-hours and x is panel temperature).

CHAPTER IV

WATER QUALITY ANALYSIS

Dissolved Oxygen Concentrations

Tennessee General Water Quality Criteria for ecoregion 67g states that "the dissolved oxygen content shall not be less than 5 mg/L with diurnal fluctuations not being substantially different from those found in that ecoregion's reference streams"(TDEC, 2008a). The goal for the data collected in this study was to identify principle factors controlling dissolved oxygen (DO) for an impaired and unimpaired stream. In TDEC's sampling report for Lick Creek, the DO levels dropped below the state standard for four out of 14 sampling events. All of the low readings were in the summer months (except for one event at the end of April) when the DO was likely at its lowest concentration (Table 2) (TDEC, 1995-2010). Lick Creek's listed impaired DO status is based solely on fourteen samples taken over a course of five years. In addition, a short two- week study was conducted by TDEC to evaluate diurnal DO fluctuations in ecoregion reference streams (Arnwine & Denton, 2003). This 2002 study is used as a basis to assess the "diurnal fluctuations" portion of the water quality criteria for DO (TDEC, 2008a). No comprehensive data is available to make an accurate assessment of impairment or to properly characterize diurnal variations.

DO concentrations were measured at Little Chucky Creek every five minutes and averaged every fifteen minutes over the course of 17 months. Lick Creek was similarly monitored for 12 months. The daily maximum and minimum DO concentration was identified along with the time, depth, and temperature at which each occurred.

Table 2. TDEC dissolved oxygen sampling report for Lick Creek (TDEC, 1995-2010).

Date	Sampling Time	DO
8/17/2000	8:00	7.64
3/6/2001	12:35	14.02
7/20/2005	12:16	5.88
8/17/2005	11:32	4.90
9/28/2005	12:02	4.84
10/25/2005	11:30	7.66
11/16/2005	11:48	7.07
1/18/2006	11:32	9.08
2/21/2006	11:22	13.09
3/20/2006	12:02	9.57
4/24/2006	11:00	3.86
5/16/2006	11:20	8.60
6/20/2006	12:00	6.54
7/27/2010	11:15	4.79

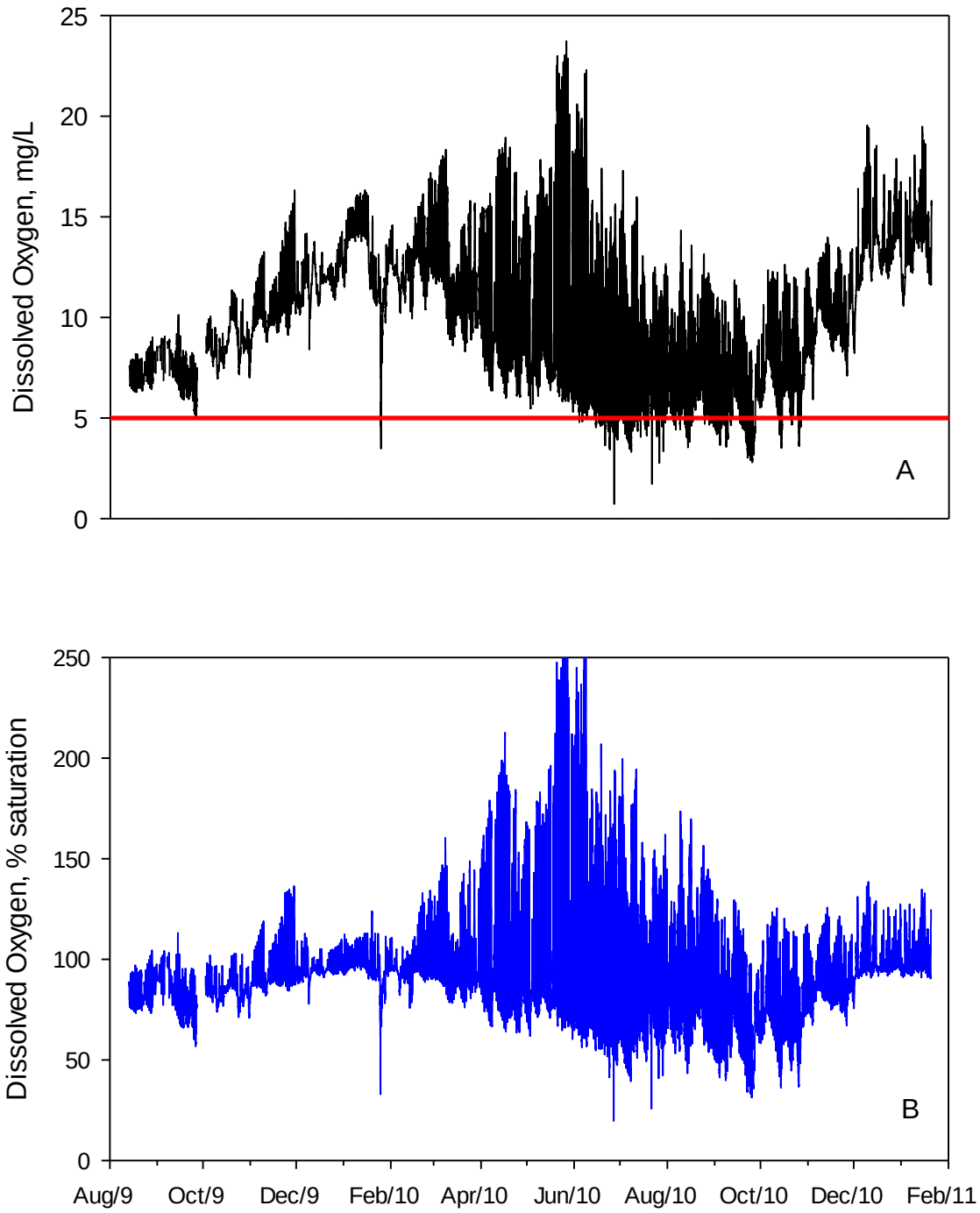
Percent Saturation with all DO concentrations

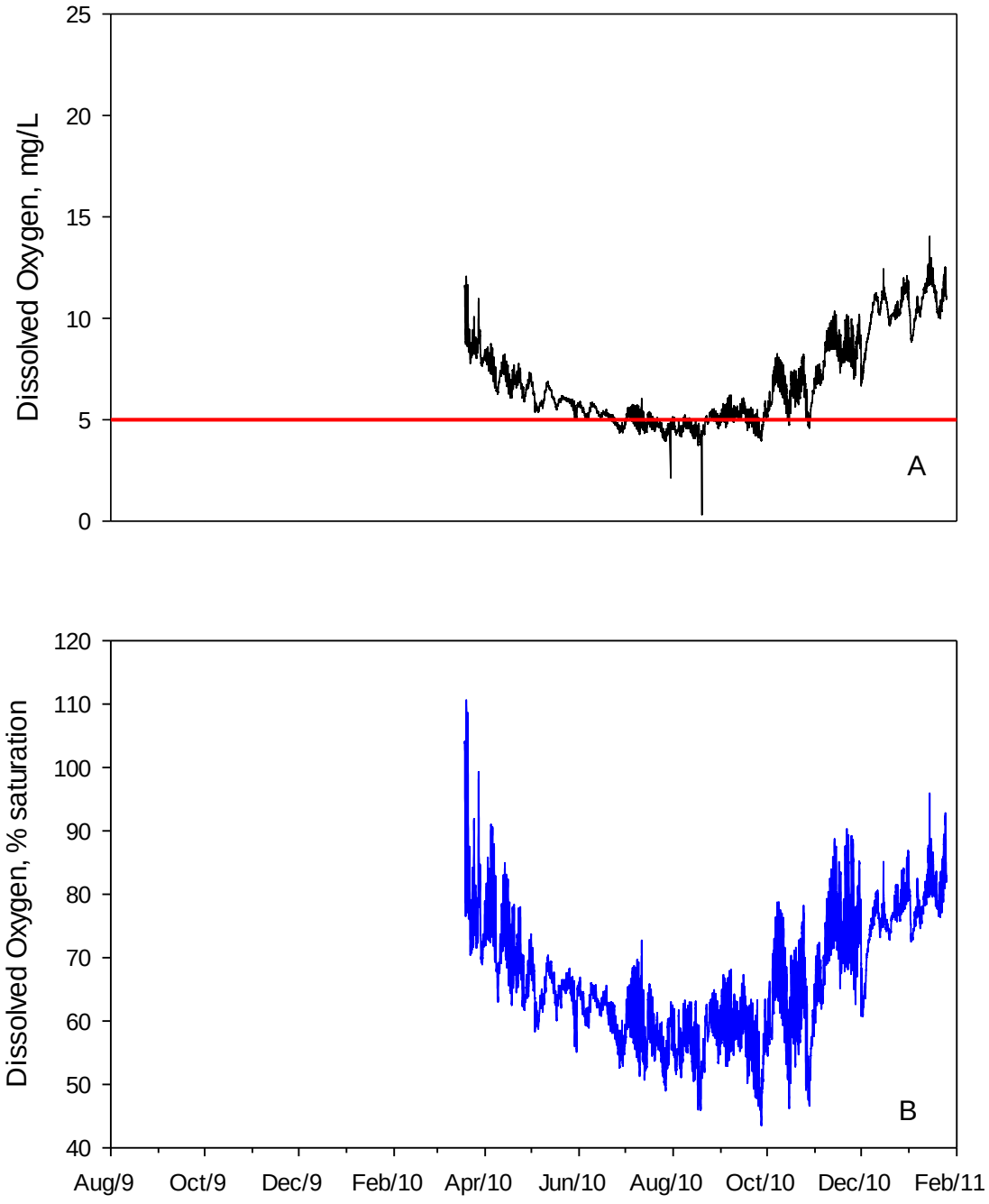
Dissolved oxygen concentrations at Little Chucky Creek fell below the state standard of 5 mg/L during 6% of the 48,878 readings taken by the YSI Sonde (Figure 21). The percent saturation of dissolved oxygen during the low DO readings dropped to fifty percent (Figure 21). Typically, the saturation levels averaged 91.32%, but the summer months brought on super saturation conditions. Little Chucky Creek flows were very shallow during the summer, and the sonde probes could have been close enough to the water surface to produce super saturation readings. Suspended algae and plantlife could also cause a surge in oxygen content during the daylight hours as photosynthesis occurs.

Beginning in March of 2010 after equipment was repaired, data collection resumed at Lick Creek. Of the subsequent total 29,908 dissolved oxygen measurements (March 2010 – January 2011), 21.6% fell below the state standard of 5 mg/L (Figure 21). Although Lick Creek is listed as impaired for low dissolved oxygen and Little Chucky Creek is not, Lick Creek exhibits the same general increases and decreases in dissolved oxygen as seen at Little Chucky Creek. Percent saturation at Lick Creek averaged 66.45% (Figure 21). One primary difference between the two streams is that Lick Creek is much deeper than Little Chucky Creek with not as much mixing to aerate the water.

Correlation coefficients were calculated to find relationships between DO concentrations and other parameters for each stream using the Spearman rank order nonparametric correlation coefficients. A significant relationship was found between all DO values and all depth values at both Little Chucky Creek and Lick Creek (p-value <0.0001), with positive correlation coefficients of 0.447 and 0.647.

Figure 21. Plot A shows the dissolved oxygen readings at Little Chucky Creek and the state standard of 5 mg/L. Plot B shows the percent saturation of dissolved oxygen. Plots on the adjacent page describe the same conditions for Lick Creek.


Dissolved Oxygen, mg/L
25
20
15
10
5
0
A
Dissolved Oxygen, % saturation
250
200
150
100
50
0
B
Aug/9
Oct/9
Dec/9
Feb/10
Apr/10
Jun/10
Aug/10
Oct/10
Dec/10
Feb/11


Dissolved Oxygen, mg/L
25
20
15
10
5
0
A
Dissolved Oxygen, % saturation
120
110
100
90
80
70
60
50
40
B
Aug/9
Oct/9
Dec/9
Feb/10
Apr/10
Jun/10
Aug/10
Oct/10
Dec/10
Feb/11

Deeper water tends to have a cooler temperature, so can hold more oxygen than shallow, warm water. All DO concentrations and temperature measurements showed a significant (p-value< 0.0001) strong negative relationship with correlation coefficients of -0.745 at Little Chucky Creek and -0.942 at Lick Creek. As water temperature increases, the DO concentration decreases at both streams. Changes in the temperature can vary according to the season and depth of the stream. Little Chucky Creek is shallow and the temperature warms more quickly than the deeper Lick Creek.

Other parameters with significant (p-value <0.0001) negative relationships to DO concentrations in both streams were turbidity (NTU) and *E. coli* (MPN) (Table 3). Correlation coefficients for turbidity and *E.coli* versus all DO measurements at Little Chucky Creek were -0.39 and -0.71 respectively, and at Lick Creek coefficients were -0.70 and -0.81. Generally, these negative relationships indicate that as turbidity and *E. coli* levels increase, DO concentrations decrease. Increased turbidity levels cloud the water and prevent sunlight from passing through, which inhibits plant growth that produces oxygen. Also related to turbidity is total suspended solids (TSS) which has a significant negative relationship with DO at both streams for the same reason. DO has a negative relationship with total phosphorus (P) with a coefficient of -0.27 at Little Chucky Creek and -0.21 at Lick Creek (Table 3). However, total phosphorus is positively correlated with total suspended solids and turbidity at Little Chucky Creek with coefficients of 0.21 and 0.69, respectively and at Lick Creek coefficients were 0.32 and 0.45, respectively. This suggests that phosphorus is being transported by sediment which creates higher turbidity and total suspended solid values, but lowers the DO concentration.

Table 3. Correlation coefficients of significant relationships between water quality parameters at Lick Creek and Little Chucky Creek.

Lick Creek											Little Chucky Creek								
N	-0.29	0.18		-0.26	-0.26	0.32						-0.12	0.38		0.45			0.35		**N**
	P	0.35	0.45	0.37	-0.21	0.32						0.20		0.21	-0.27	0.39	0.69	0.64	**P**	
		PO_4	0.50	0.33	-0.48	0.45							0.20	0.20		0.30	0.68	**PO_4**		
			TSS	0.20	-0.38	0.58	0.31					0.23		0.32	-0.24	0.34	**TSS**			
				TOC	-0.18		-0.19	0.25			0.58	0.16	0.11	0.50	-0.36	**TOC**			
					DO	-0.70	0.44		-0.81		-0.71	-0.37	0.49	-0.39	**DO**				
						NTU		0.27	0.68			0.11		**NTU**					
							Flow	0.26				-0.14	**Flow**						
								Chl *a*				**Chl *a***							
									MPN		**MPN**								

As previously mentioned, *E.coli* has a significant negative relationship with DO. In addition, *E. coli* has a positive relationship with total organic carbon (TOC) at Little Chucky Creek with a correlation coefficient of 0.58 meaning that as *E.coli* concentrations increase, so do total organic carbon concentrations. Both parameters have negative relationships with DO at Little Chucky Creek (Table 3) showing that organic matter and bacteria decrease DO concentrations. Total organic carbon and *E. coli* have negative relationships with DO at Lick Creek, but do not have a significant relationship with each other.

Diurnal DO Variations

The 2002 diurnal dissolved oxygen study conducted by TDEC was based on a very limited (two week) assessment of the minimum dissolved oxygen levels and the magnitude of the diurnal swings in selected reference streams and test sites. The study also evaluated how long and how often the dissolved oxygen was below 5 mg/L (Arnwine & Denton, 2003). The daily minimum and maximum DO for Little Chucky Creek and Lick Creek are provided in Figure 22. Data from Little Chucky Creek show significant diurnal swings, while Lick Creek shows very little diurnal variation (Figure 22).

To evaluate the source of the large diurnal swings and the magnitude of the diurnal variation, correlation coefficients were evaluated for several different parameters. The average depth per day and the magnitude of the DO swings had a significant (p-value <0.0001) negative relationship with a correlation coefficient of -0.413. Depth and magnitude of swings at Lick Creek had an insignificant (p-value >0.05) relationship to DO.

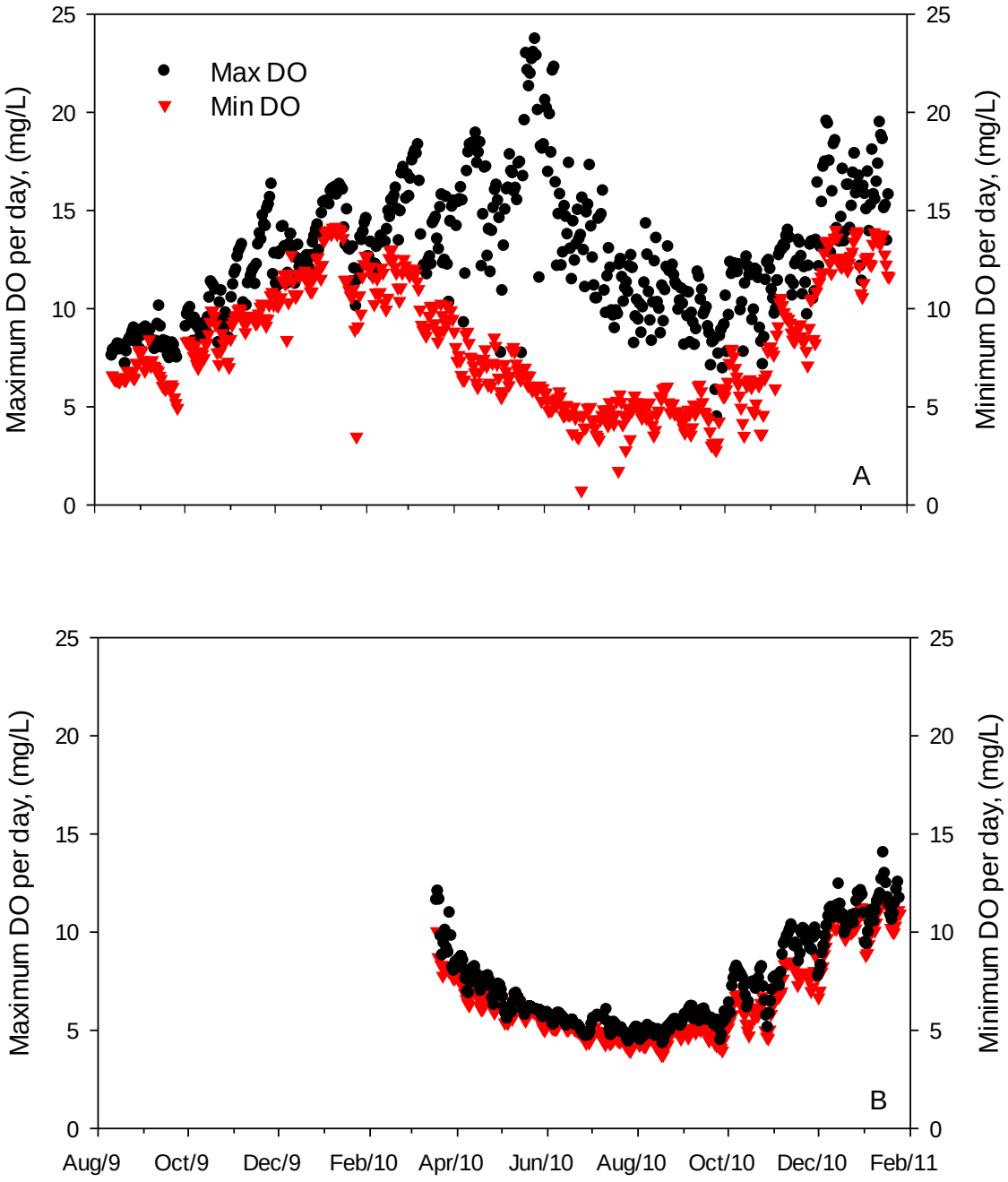


Figure 22. Diurnal DO swings at Little Chucky Creek (A) and Lick Creek (B).

As depth increases, the magnitude of DO variation decreases (Table 4). This could be a response to a decrease in the amount of sunlight penetrating the depths and stimulating plant growth. Little or no plant growth results in no DO variation due to plant respiration. Water temperature was also evaluated with the magnitude of DO swings and had a significant (p-value <0.0001) positive relationship with a correlation coefficient of 0.710 at Little Chucky Creek, but was insignificant (p-value >0.05) at Lick Creek. If the water temperature is high, the minimum DO concentration will be lower than normal, which increases the magnitude of the DO variation. Relationships between DO swings and turbidity were insignificant (p-value>0.05) for both streams. Little Chucky Creek has a rock bottom and is typically free from sediment cloudiness. Lick Creek is more turbid, but this causes little variation in the maximum and minimum daily DO measurements.

A positive significant relationship (p-value<0.0001) between chlorophyll *a* and DO variation was calculated at Little Chucky Creek, with a correlation coefficient of 0.283 (Table 4). An abundance of chlorophyll *a* could consume more oxygen through respiring and decomposing than it produces, causing a decrease in the amount of dissolved oxygen available in the stream. Chlorophyll *a* values were highest beginning in the spring through September (Figure 23). The system did not measure sessile algae, but there could have been increased algae growth leading to an initial excessive oxygen production then a sharp decline as algae decayed. The longest period that Little Chucky Creek stayed below 5mg/L was for 35 hours and 30 minutes. Lick Creek, which is listed as impaired for low dissolved oxygen, stayed below 5 mg/L for a continuous stretch of 178 hours and 15 minutes.

Table 4. P-values and correlation coefficients for the magnitude of DO swings and other water quality parameters for both streams.

	Little Chucky Creek	Lick Creek
Parameter	Magnitude of DO Swings	Magnitude of DO Swings
Depth, cm	-0.413, P<0.05	0.0799, P>0.05
Turbidity, NTU	0.0158, P>0.05	-0.0761, P>0.05
Chlorophyll *a*, µg/L	0.283, P<0.05	-0.0171, P>0.05
Temperature, ^{0}C	0.710, P<0.05	0.0720, P>0.05

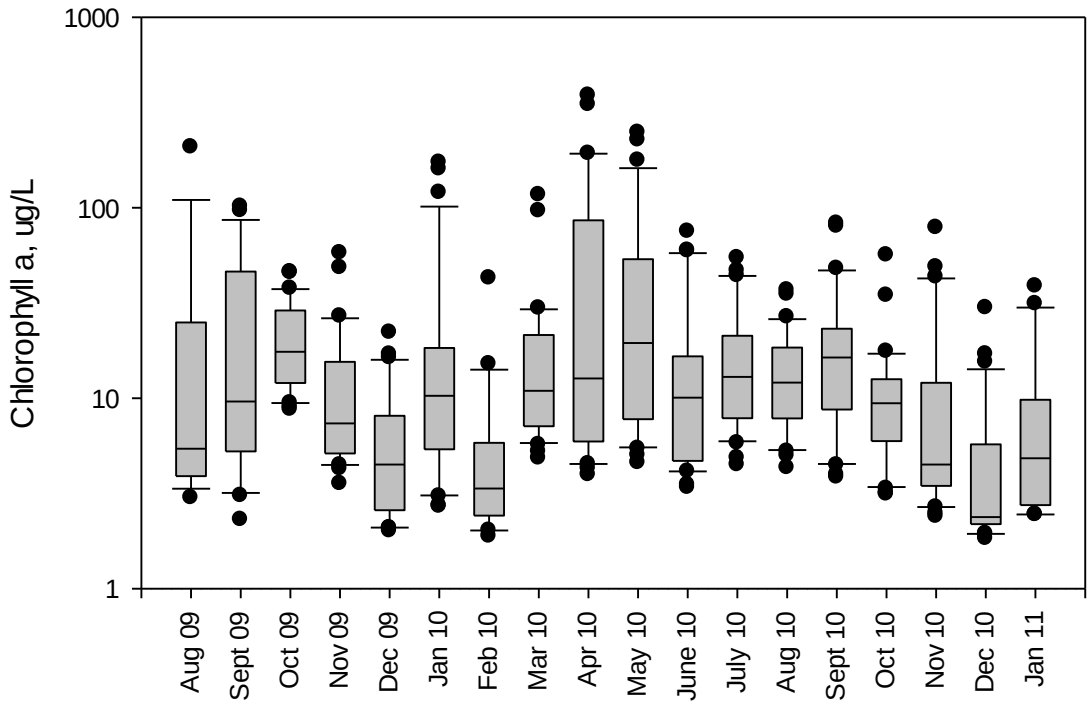


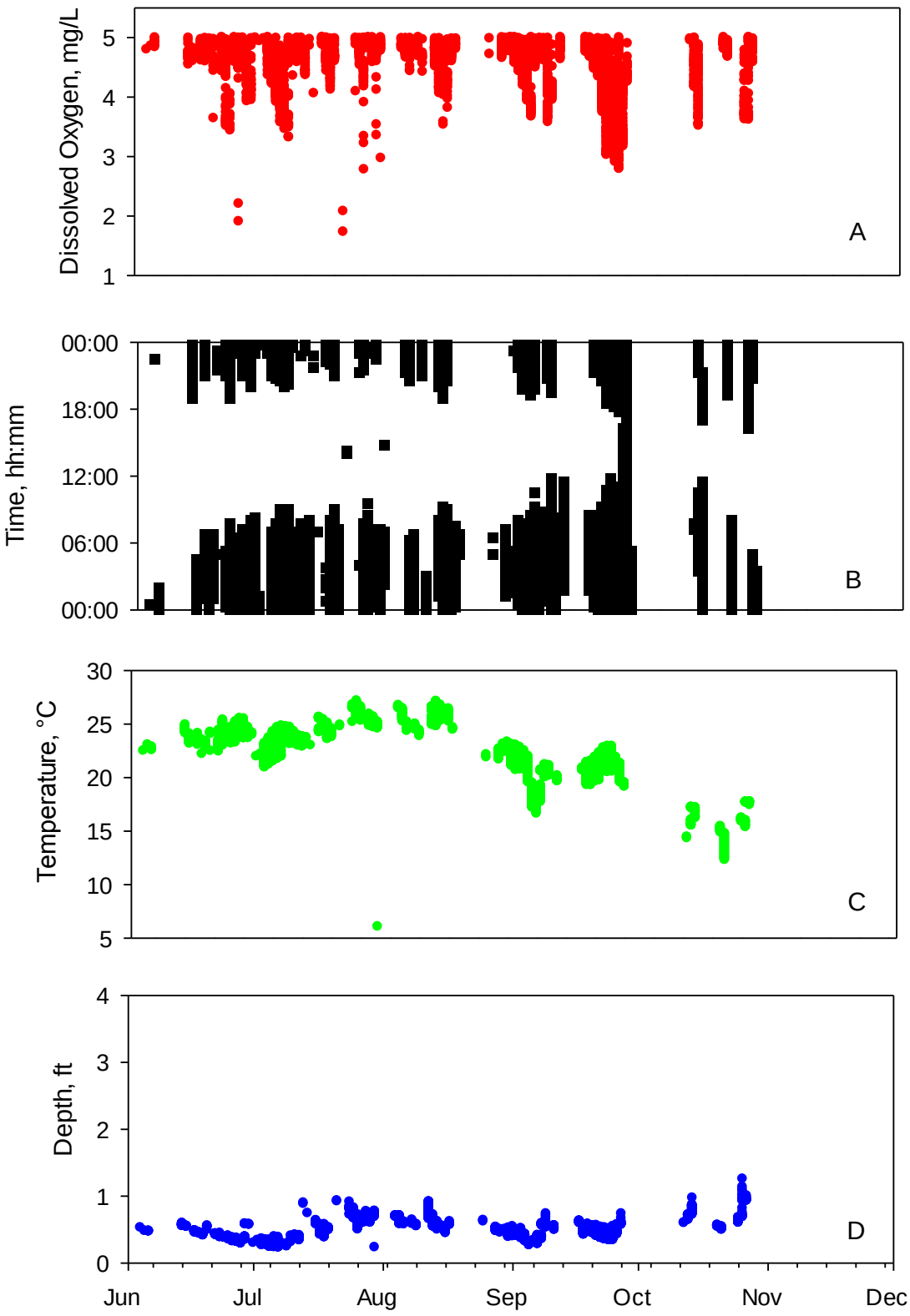
Figure 23. Chlorophyll a values at Little Chucky Creek were highest beginning in the spring through September.

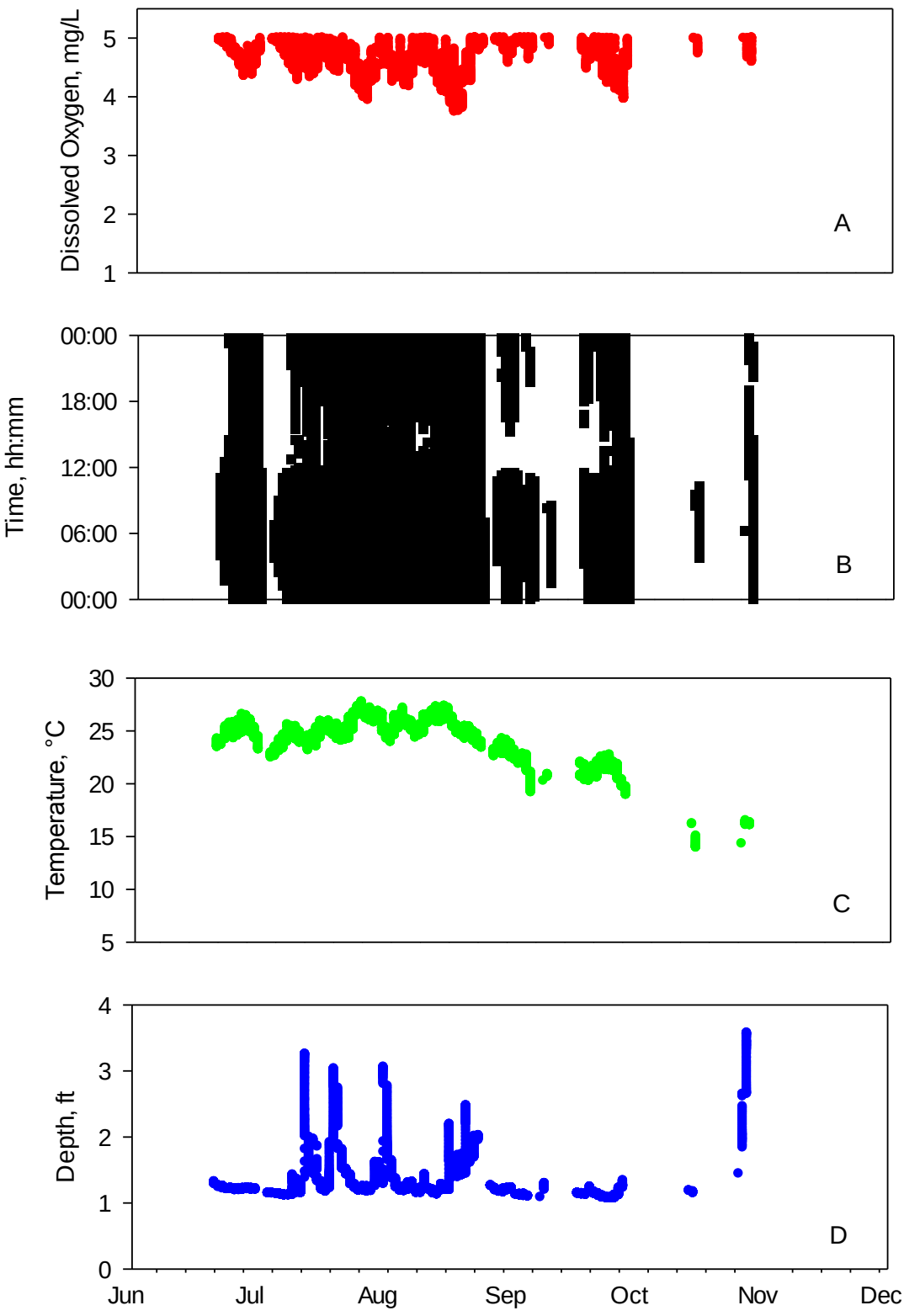
Causes of low DO

Since Lick Creek is listed as impaired due to low dissolved oxygen, it is important to evaluate when the periods of low DO occurred and under what conditions (Figure 24). All dates with corresponding DO readings less than the state standard of 5 mg/L were plotted in Figure 24, which illustrates that DO values below the standard only occur during the hottest times of the year from June through October. The DO readings below 5 mg/L were measured intermittently throughout the day. Relationships between DO readings below 5 mg/L and time of day and stream depth were significant (p-value<0.0001), but had weak correlation coefficients of 0.0989 and 0.0570 respectively. Correspondingly, the low DO (<5 mg/L) only occurred when the water temperature was above 15^0C, indicating that water temperature is the driving force behind Lick Creek's low dissolved oxygen readings. The Spearman rank correlation coefficient between DO values <5 mg/L and temperature displayed a moderately negative relationship of -0.386 and p-value<0.0001.

Dissolved oxygen readings at Little Chucky Creek were also below the standard of 5 mg/L during the warmest months of the year from June until early November (Figure 24). Low DO readings (<5 mg/L) with depth and temperature had significant (p-value<0.0001) positive relationships correlation coefficients of 0.228 and 0.181. Although the low readings occurred when water temperatures were above 15^0C, they only occurred between six o'clock in the evening and mid-morning of the following day, suggesting that diurnal fluctuations are the cause of low DO at Little Chucky Creek. During daylight hours, photosynthesis occurs and produces oxygen, but at night plants respire and consume oxygen, lowering the dissolved oxygen content of the stream.

Figure 24. Little Chucky Creek dissolved oxygen readings below 5 mg/l are plotted in graph A, time of occurance in graph B, water temperature at low DO reading in graph C, and water depth at low DO reading in graph D. The adjacent stack plots describes the same conditions at Lick Creek.


Dissolved Oxygen, mg/L
5
4
3
2
1
A
Time, hh:mm
00:00
18:00
12:00
06:00
00:00
B
Temperature, °C
30
25
20
15
10
5
C
Depth, ft
4
3
2
1
0
D
Jun
Jul
Aug
Sep
Oct
Nov
Dec


Dissolved Oxygen, mg/L
5
4
3
2
1
A
Time, hh:mm
00:00
18:00
12:00
06:00
00:00
B
Temperature, °C
30
25
20
15
10
5
C
Depth, ft
4
3
2
1
0
D
Jun
Jul
Aug
Sep
Oct
Nov
Dec

This plant respiration is amplified in the summer when plant growth is abundant and occurs during the evening, night, and mid-morning period of low DO readings.

Low DO concentrations only occurred during warm weather at both Lick Creek and Little Chucky Creek, but for different reasons. Lick Creek low DO was driven by water temperature while Little Chucky Creek was diurnal fluctuations. Lick Creek is listed as impaired for low DO and Little Chucky Creek is not. Both causes of low DO are naturally occurring, but based on the state standard both streams should be listed. Little Chucky Creek is not listed because the standard is a simple regulation that does not account for the complex parameters affecting DO.

BOD

Biochemical oxygen demand (BOD) was measured as an indicator of gross organic contamination from sources such as failing septic system effluent or animal waste. TDEC does not measure BOD, nor is there a state standard to apply. BOD five day readings were similar for both streams. Of thirty measurements at Lick Creek and Little Chucky Creek, the means were 1.80 mg/L and 1.64 mg/L and standard deviations 1.02 mg/L and 0.75 mg/L, respectively. Box plots for both streams illustrate that the median concentrations for Lick Creek are higher than those of Little Chucky Creek (Figure 25). The data show that large amounts of discharged organic matter or degradation does not occur at either stream, suggesting that elevated BOD is not a primary cause of measured low DO.

E.Coli

E. coli is used as an indicator of potential pathogen and fecal pollution in surface waters. Pathogens are disease causing organisms, often originating from fecal waste,

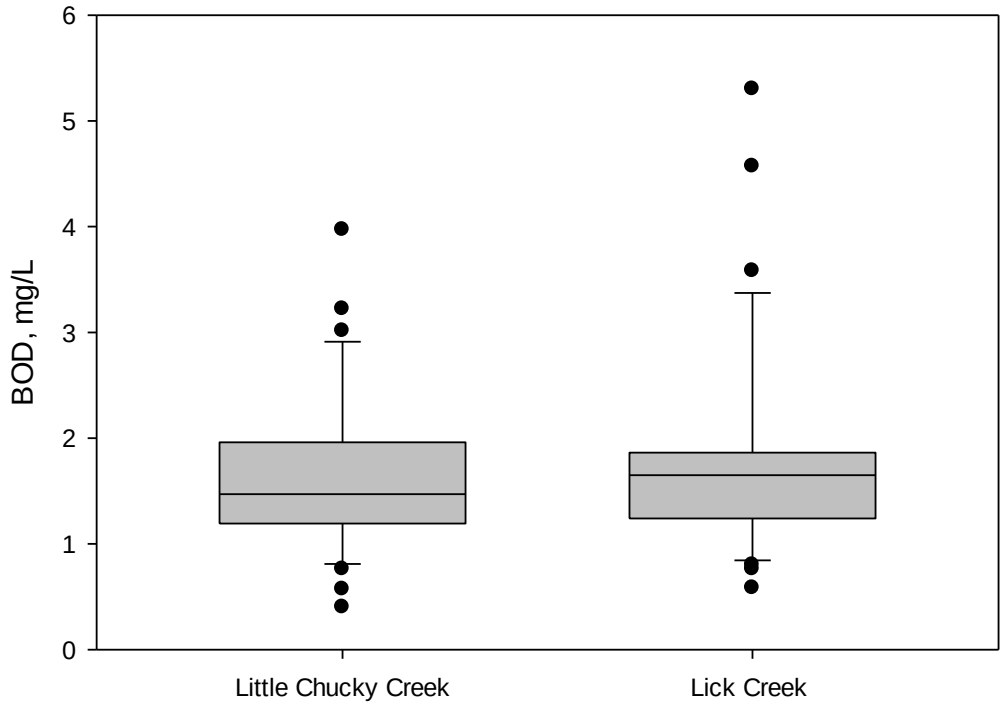


Figure 25. BOD five day concentrations for Little Chucky Creek and Lick Creek.

that pose health risks to the general public using streams recreationally. The Tennessee General Water Quality Criteria states that streams must not exceed 126 colony forming units (cfu)/100 mL as a geometric mean of at least five consecutive samples taken over a period of thirty days, with individual samples being collected at intervals of not less than 12 hours (TDEC, 2008a). Alternatively, the criterion is set at a maximum of 941 cfu/100 mL in any individual sample. For surface water assessment, TDEC generally employs the 941 cfu/100 ml standard.

The Lick Creek segment (TN 06010108035-2000)evaluated in this study is listed as impaired for recreation use because of high concentrations of *E. coli* (TDEC, 2010). Little Chucky Creek is not listed as impaired. TDEC sampled Lick Creek on thirteen occasions over the past decade, with eleven samples taken in 2005 and 2006, one in 2000 and one in 2010. Only one sample taken on January 18, 2006 of 9870 cfu/100 mL exceeded the state criteria of 941 cfu/ 100 mL. At Little Chucky Creek, TDEC used fecal coliforms as a pathogen indicator for most of the samples, but later began using *E. coli.* None of the seven *E. coli* samples collected from 1998-2000 were above the criteria.

For this study, twenty-two samples were taken from Lick Creek and Little Chucky Creek between February 4, 2010 through January 13, 2011 and evaluated for *E. coli*. Only two samples from each location exceeded the standard. Two dilutions of 1:50 and 1:10 were used during the analysis to assess the relative accuracy of the *E. coli* assay and to assure a successful analysis if the low dilution was higher than the assay detection limit of 2419.6 cfu/100 mL. The replicate results were highly correlated, with Spearman correlation coefficients of 0.89 for Little Chucky Creek and 0.74 for Lick Creek. Wilcoxon sign-rank nonparametric test calculated an insignificant test statistic

(p>0.8274) showing no evidence that the two dilutions are different from zero. An average of the two dilutions were used to evaluate correlations between flow, average turbidity and DO. *E. coli* concentrations had no significant relationships to flow at either stream. Average turbidity and DO per day had significant relationships with *E. coli* concentrations at Lick Creek, with p-values<0.05 and correlation coefficients of 0.68 and -0.81 respectively, and at Little Chucky Creek a significant relationship with DO with a coefficient of -0.71 (Table 3). Sediment carrying bacteria and organic matter may both increase turbidity and *E. coli* levels. The bacteria break down organic matter and consume oxygen, resulting in lower DO concentrations as *E. coli* increases. On July 27, 2010, TDEC measured the *E.coli* concentration at Lick Creek at 308 cfu/100 ml. During the same time period on July 8 and 22, samples collected and analyzed for this study at the 1:10 dilution were found to have concentrations of 305 and 246 cfu/100 mL, respectively.

Data collected by the University of Tennessee and TDEC were compared in a box plot (Figure 26). The median values and distributions are similar and show that exceedences of the standard were rare, but did occur. Based on these historical measurements by TDEC, the justification for listing Lick Creek appears questionable, as is citing pasture grazing as the source of the one high *E. coli* concentration. The more extensive data set collected in this study shows that Little Chucky Creek, a former ecoregion reference stream, has *E.coli* concentrations that are distributed similarly to Lick Creek. Although Lick Creek is listed as impaired because of high *E.coli* concentrations, Little Chucky Creek is not, but clearly exceeds the maximum standard occasionally.

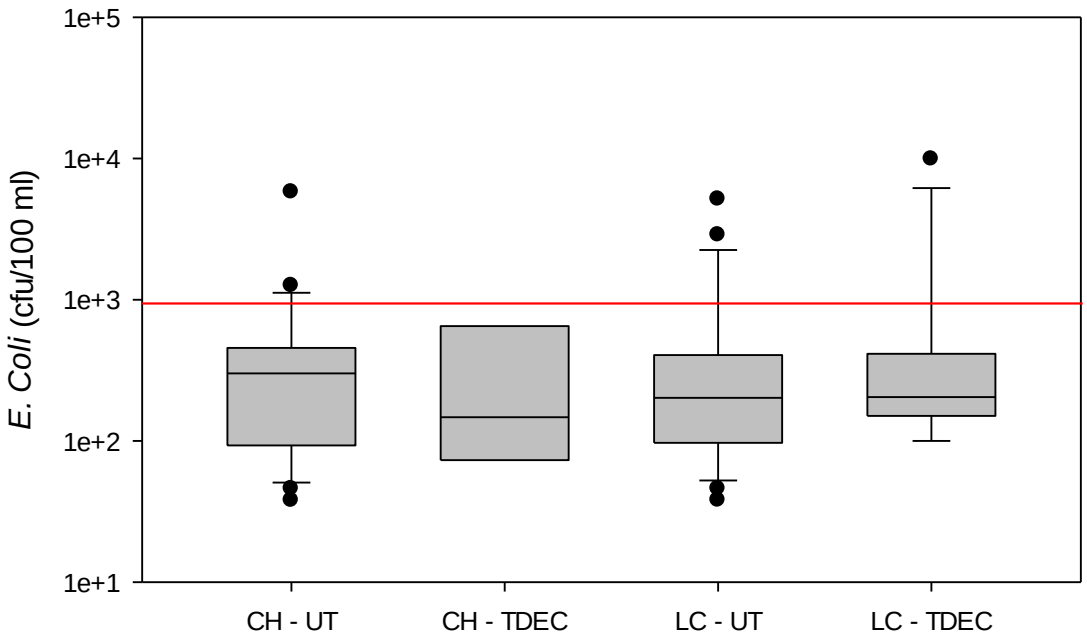


Figure 26. Box plots of *E. coli* concentrations measured during this study (UT) and historical water quality data (TDEC) in Little Chucky Creek (CH) and Lick Creek (LC). The water quality criteria of 941 cfu/100 mL is illustrated by the reference line.

Flow Measurement

Tennessee's General Water Quality Criteria has broad requirements for surface water flow. For fish and aquatic life and recreation uses, the criteria simply states that flows should support each use (TDEC, 2008a). Measuring various water quality parameters yields concentrations that can be compared to the standards, but without an additional comparison to the current stream flow, the measured mass transport cannot be quantified. Although the water quality criteria does not state flow requirements, the interpretations of the narrative nutrient criteria suggests that nutrient criteria should have a different flow requirement than other fish and aquatic life criteria. TDEC recommends a 30Q5 flow, which is the average low flow that occurs for 30 consecutive days with a statistical frequency of once every five years (Arnwine et al., 2001). Typically, TDEC rarely measures stream flow, and the vast majority of the rural agricultural watersheds, including Little Chucky and Lick Creek, are ungauged. Water quality models such as SWAT also require flow data for proper calibration, which should be used to improve source assessments and to prioritize BMP installations. For this study, two methods of calculating stream flow were evaluated: the Velocity-area method, and the RiverSurveyor.

The velocity-area method is suitable for streams that can be waded safely, but is not advised for streams such as Lick Creek that tend to be deeper. At Lick Creek, the RiverSurveyor system was used to safely obtain the flow measurement without wading. Both methods were used at Little Chucky Creek to compare results. Measurements taken at Little Chucky Creek by the RiverSurveyor and velocity-area method were very similar, with discharge readings of 13.80 cfs, 14.23 cfs and 2.12 cfs, 2.10 cfs respectively (Figure

27). The RiverSurveyor required minimal effort to measure the stream discharge at Lick Creek and was used at a stage of 3.5 feet with a discharge of 217.27 cfs. Stage-discharge curves were calculated by using the RiverSurveyor discharge results. These curves encompassed 71.3% of all stage readings at Lick Creek and 62.5% at Little Chucky Creek. The RiverSurveyor functioned well with most flows, but had some difficulty travelling across Little Chucky Creek when flow depths were less than 0.5 feet due to the fins on the bottom of the instrument. Either system would benefit TDEC by obtaining crucial flow data.

Nutrient Concentrations

Nitrogen is an essential plant nutrient that occurs in several forms within an ecosystem: organic nitrogen, ammonia, nitrate, or nitrite. All of these different forms degrade water quality if pollution causes the concentrations to be too high. Phosphorus is also an essential nutrient, and is normally considered the limiting nutrient in most freshwater ecosystems. Excess amounts of nitrates and phosphorus can accelerate eutrophication, causing rapid algae growth and altering the types of fish and aquatic life in streams. These changes can increase water temperature and decrease dissolved oxygen, which affects the overall stream health (EPA, 2010c).The samples collected by the ISCO Avalanche were analyzed for Total Kjeldahl Nitrogen (TKN), ammonia, nitrate + nitrite, total phosphorus, and orthophosphate. TKN is a sum of ammonia and organic nitrogen and is added to nitrate plus nitrite to form total nitrogen (EPA, 2010c). Each measurement represented a composite sample for one day, and samples were collected over a period of 15 months at both Little Chucky Creek and Lick Creek.

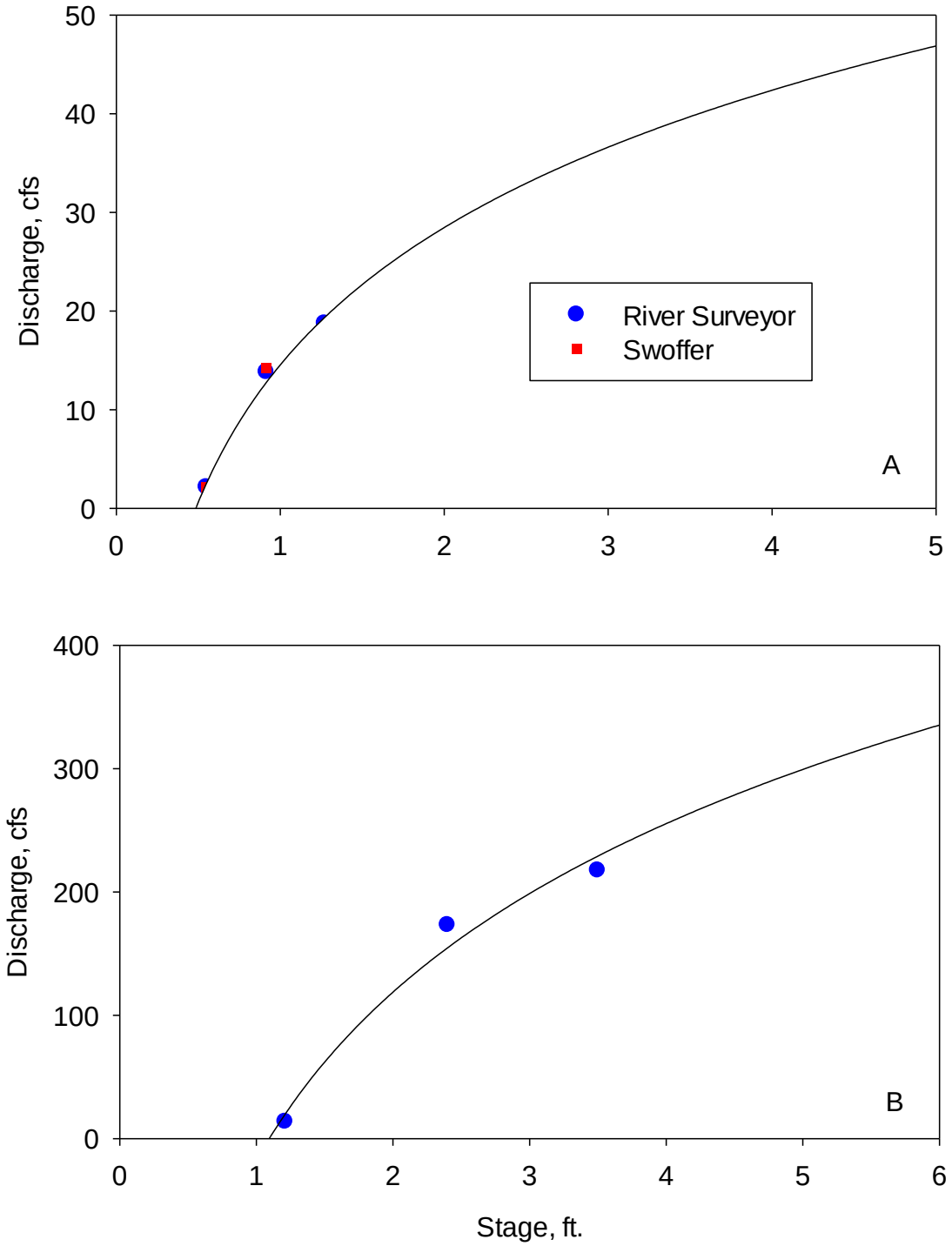


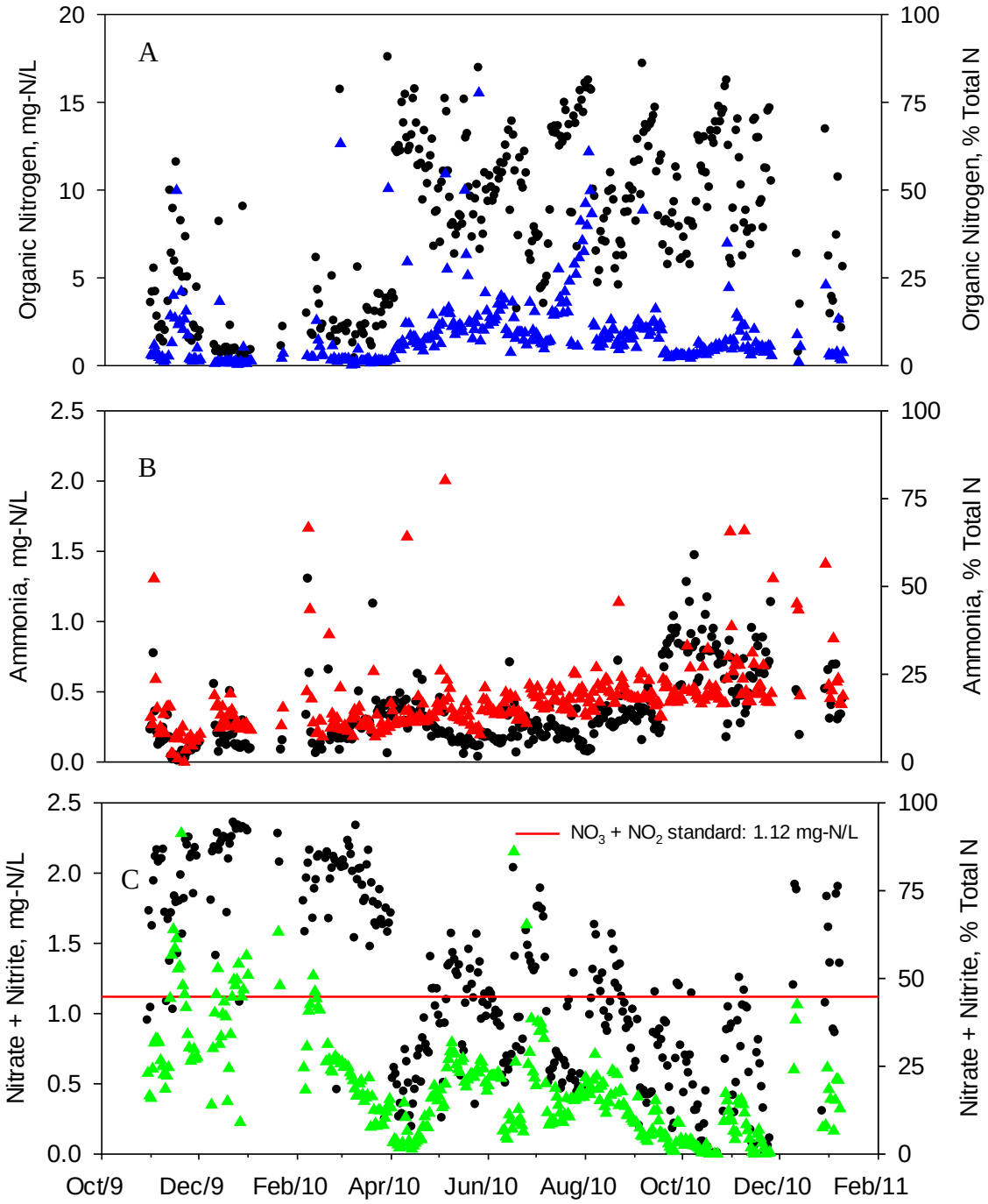
Figure 27. The RiverSurveyor and velocity-area method were used at Little Chucky Creek to compare discharge results (plot A). Only the RiverSurveyor system was used at Lick Creek (plot B). Discharge measurements were fit with a curve to predict discharge at future stages.

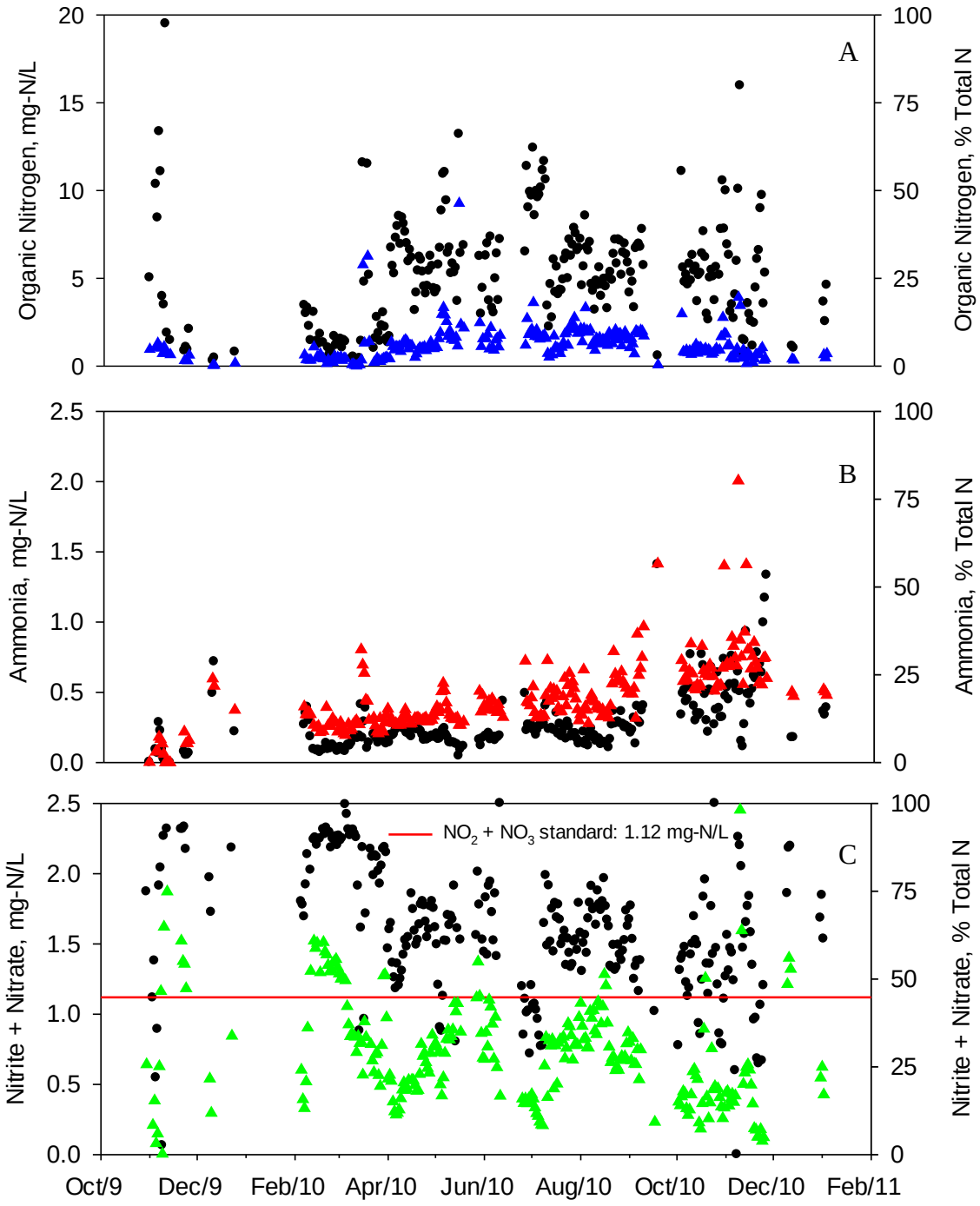
Interpretations of Tennessee's Narrative Nutrient Criterion states that criteria should be applied as a monthly average limit, but TDEC data rarely plots multiple points per month. Instead, multiple samples are collected seasonally, as part of the five year watershed cycle (Arnwine et al., 2001). It is possible that the data collected each month are averaged over the year and then compared to the state standard. The standards vary according to ecoregion and the reference stream data for each. The state standards are derived from reference stream data that is also collected seasonally with up to 20 points per stream (Arnwine et al., 2001). The 90^{th} percentile of this data is used to set the standard for nutrient criteria (TDEC, 2007). This study evaluated the bulk of the nutrient data from both Little Chucky Creek and Lick Creek through comparison to the state standard for ecoregion 67g.

Nitrogen

Organic nitrogen, ammonia, and nitrate + nitrite concentrations and the percentages of total nitrogen each represented are provided in Figure 28 for Little Chucky Creek and Lick Creek, respectively. Low concentrations of total nitrogen occurred from January to April of 2010 in Little Chucky Creek, with concentrations averaging 0.79 ± 2.15 mg-N/L (Figure 28). During the same period, the percentages of nitrate + nitrite in Plot C increased to an average 75% of total measured nitrogen. Increases in the percent of nitrate + nitrite in the composite samples to a maximum of 93% of total measured nitrogen during March could be the result of runoff from recently fertilized pastures. According to the USDA 2010 crop data (Service, 2010), the majority of land use around Little Chucky Creek was pasture, with some small plots of corn and soybeans in the creek bottomlands, which are surrounded by deciduous forest. Typically, producers fertilize

Figure 28. A) Organic nitrogen, B) ammonia, and C) nitrate+nitrite levels for Little Chucky Creek. Filled triangles represent the measured parameter and circles represent the percent of total nitrogen. The adjacent plots describe the same data for Lick Creek.


A
Organic Nitrogen, mg-N/L
Organic Nitrogen, % Total N
B
Ammonia, mg-N/L
Ammonia, % Total N
C
NO3 + NO2 standard: 1.12 mg-N/L
Nitrate + Nitrite, mg-N/L
Nitrate + Nitrite, % Total N
Oct/9
Dec/9
Feb/10
Apr/10
Jun/10
Aug/10
Oct/10
Dec/10
Feb/11


A
Organic Nitrogen, mg-N/L
Organic Nitrogen, % Total N
B
Ammonia, mg-N/L
Ammonia, % Total N
C
NO2 + NO3 standard: 1.12 mg-N/L
Nitrite + Nitrate, mg-N/L
Nitrite + Nitrate, % Total N
Oct/9
Dec/9
Feb/10
Apr/10
Jun/10
Aug/10
Oct/10
Dec/10
Feb/11

pastures and crops in the Spring based on soil test results or previous application rates. The University of Tennessee recommends up to 120 lbs/ac of nitrogen for grass pasture/hay and summer annual grass and 120 to 240 lbs/ac of nitrogen for corn depending on the amount of bushels per acre (Hubert J. Savoy & Joines, 2009). After nitrate + nitrite percentages peaked in March, both percentages and concentrations dropped to a low of 8% and 0.036 mg-N/L on April 14th (Figure 28). Numbers continued to rise and fall before peaking again on June 17th at 2.15 mg-N/L and 81% of total nitrogen. Concentrations and percentages declined through November, reaching a low of 0.012 mg-N/L at 3% total nitrogen. Plots A and C for Lick Creek show the same trends for the Spring months, but nitrate + nitrite percentages tend to be higher throughout the rest of the year when compared to Little Chucky Creek (Figure 28). The B plots for both streams show a steady increase in ammonia concentrations beginning in March with 0.39 mg-N/L at Little Chucky Creek and 0.80 mg-N/L at Lick Creek and climbing until late fall to 2.00 mg-N/L, then declining beginning in November to 0.42 mg-N/L at Little Chucky Creek and in December to 0.47 mg-N/L .

The nitrogenous nutrient criteria for ecoregion 67g, which contains Lick and Little Chucky Creek is 1.12 mg-N/L (TDEC, 2007). Nitrate + nitrite concentrations at Little Chucky Creek exceeded the standard for 6.7% (24 of 358)) of the samples collected, and at Lick Creek the concentrations exceeded the standard for 14.8% (39 of 263) of the samples collected (Figure 29). The median concentration at Lick Creek was 70.7% higher than the median at Little Chucky Creek. Nitrate + nitrite concentrations were grouped by month and evaluated using box plots. Spikes in the concentration above the standard occurred during the month of February at both locations, corresponding to

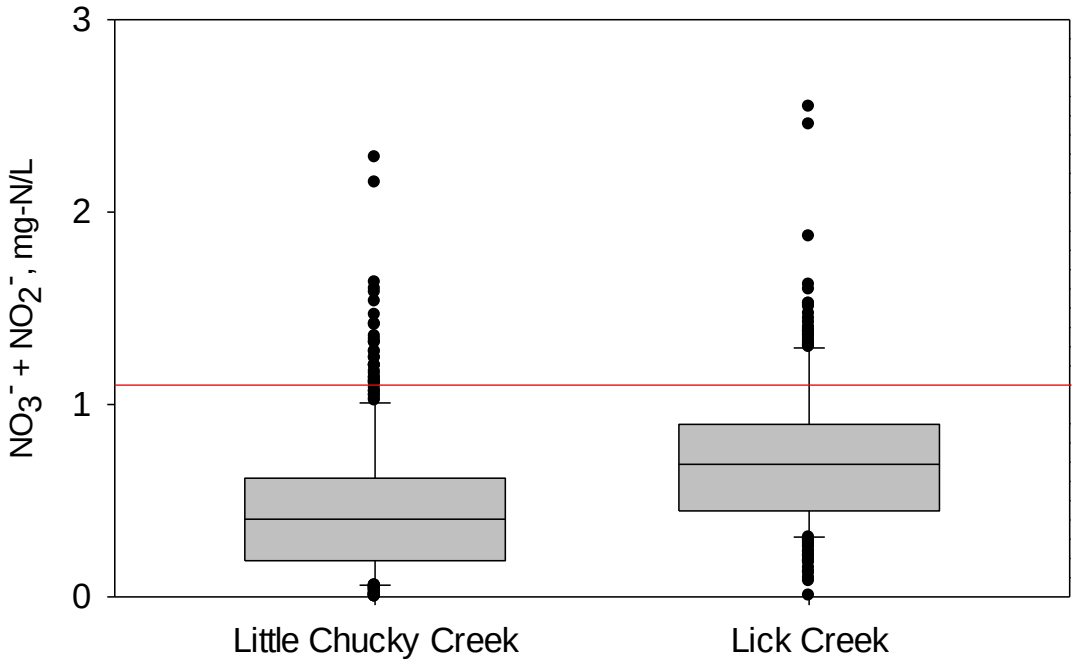


Figure 29. Nitrate + nitrite box plot with state standard of 1.12 mg-N/L for Little Chucky Creek and Lick Creek.

the peaks in percentages of total nitrogen on Figure 28. Concentrations in March exceeded the standard at Lick Creek in 21.4% of samples.

High concentrations in March could be the result of runoff from fertilized pastures. Figure 30-A for Little Chucky Creek shows that nitrate + nitrite values declined in March and April to 0.03 mg-N/L, then increased slightly from May through August, with two exceedences in June of 2.15 and 1.63 mg-N/L. Concentrations decreased again in September through November to 0.01 mg-N/L with an increase in December to 1.06 mg-N/L. Figure 30-B for Lick Creek shows a decrease in April to 0.28 mg-N/L, but beginning in May through September the median values for each month are higher, rivaling the median concentration of March.

At Little Chucky Creek, TDEC collected fourteen samples from 1996 through 2000 for an average nitrate + nitrite concentration of 0.57 ± 0.27 mg-N/L (TDEC, 1995-2010). In this study, the 358 samples collected by the refrigerated sampler and analyzed for nitrate + nitrite had a mean and standard deviation of 0.46 mg-N/L and 0.37 mg-N/L. TDEC collected samples for nitrate and nitrite on this particular stretch of Lick Creek multiple times in 2005 and 2006 and one time in 2000 and 2010 for a total of thirteen samples. The mean and standard deviation for those samples were 0.73 mg-N/L and 0.36 mg-N/L respectively (TDEC, 1995-2010). In this study, for the 263 samples collected by the refrigerated sampler at Lick Creek, the mean and standard deviation were 0.73 mg-N/L and 0.38 mg-N/L. The stretch of Lick Creek sampled in this study is not listed as impaired on the 303(d) list for fish and aquatic life use due to nitrate and nitrites, but the reach of Lick Creek directly upstream from our sampling station is listed as impaired for nitrate and nitrites. TDEC collected thirteen samples for nitrate and nitrite

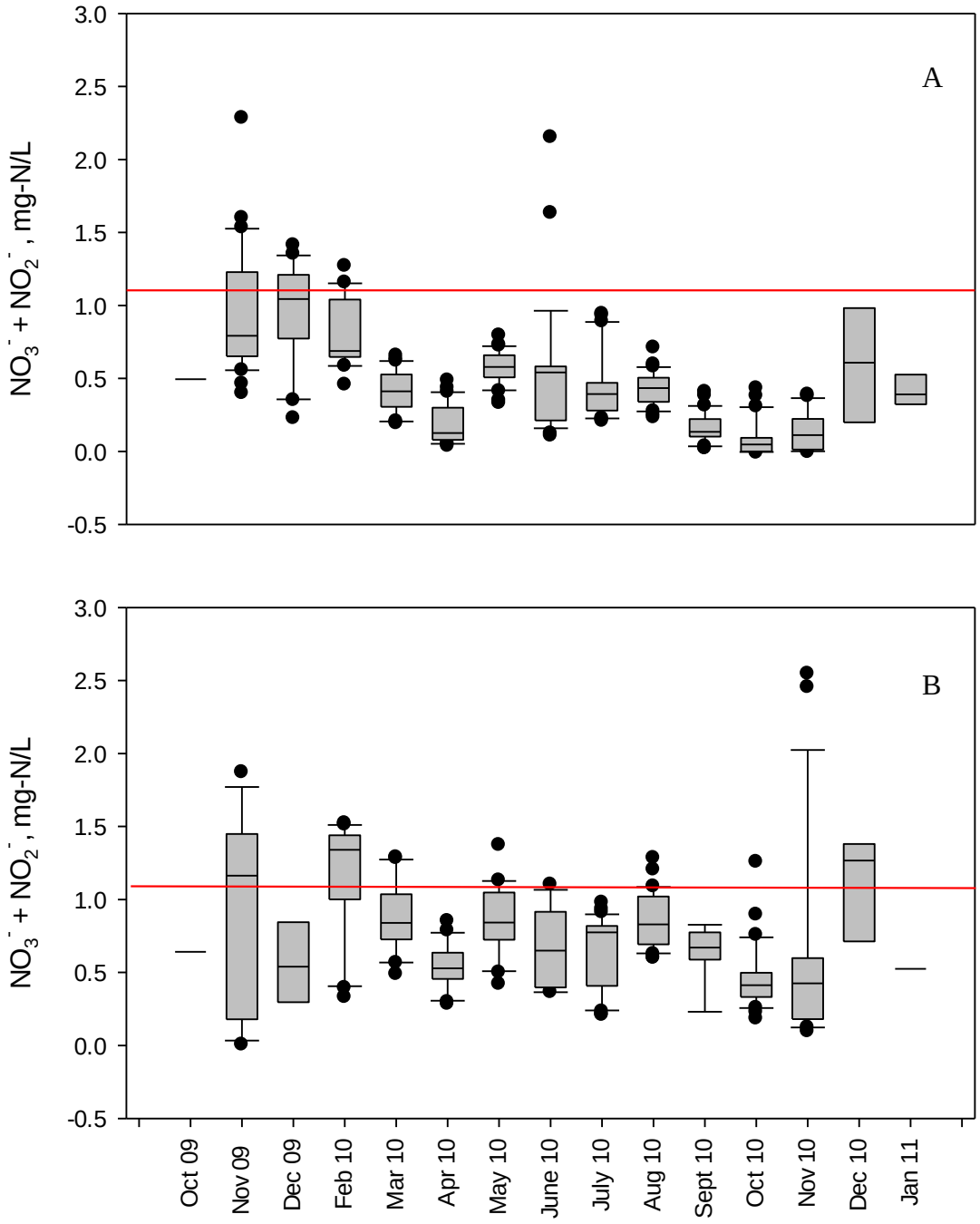


Figure 30. Box plots of nitrate + nitrite values per month and the state standard of 1.12 mg-N/L for Little Chucky Creek in plot A and Lick Creek in plot B.

from the upstream reach, and the mean and standard deviation were similar to the unimpaired stretch of Lick Creek at 0.75 mg-N/L and 0.35 mg-N/L (TDEC, 1995-2010). The difference between the two reaches is that the section in this study passed the ecoregion biocriteria scores while the upstream, impaired reach did not.

Phosphorus

The phosphorus nutrient criteria for ecoregion 67g, which contains Lick and Little Chucky Creek is 0.09 mg-P/L (TDEC, 2007). Total phosphorus concentrations at Little Chucky Creek exceeded the standard in 82.3% (293 of 358) of the samples collected in our study. In addition, Lick Creek exceeded the standard in 81.2% (212 of 263) of the samples (Figure 31). TDEC samples collected at Little Chucky Creek had a mean and standard deviation of 0.07 mg-P/L and 0.11mg-P/L, respectively(TDEC, 1995-2010). In this study, samples collected by the refrigerated sampler had a mean and standard deviation of 0.31 mg-P/L and 0.55 mg-P/L. At Lick Creek, TDEC data showed a mean and standard deviation of 0.14 mg-P/L and 0.10 mg-P/L, while for this study the mean and standard deviation for Lick Creek were 0.22 mg-P/L and 0.16 mg-P/L. Total phosphorus concentrations from both streams were grouped by month using box plots (Figure 32). The median monthly concentration for Little Chucky Creek and Lick Creek were above the ecoregion criteria every month except for February and March. Neither stream is listed on the 303(d) list as impaired for total phosphorus(TDEC, 2010).

Water pH

Water pH levels affect the chemical and biological processes that occur in streams (EPA, 2010b). For example, a significant change in alkalinity (ability to neutralize acidic

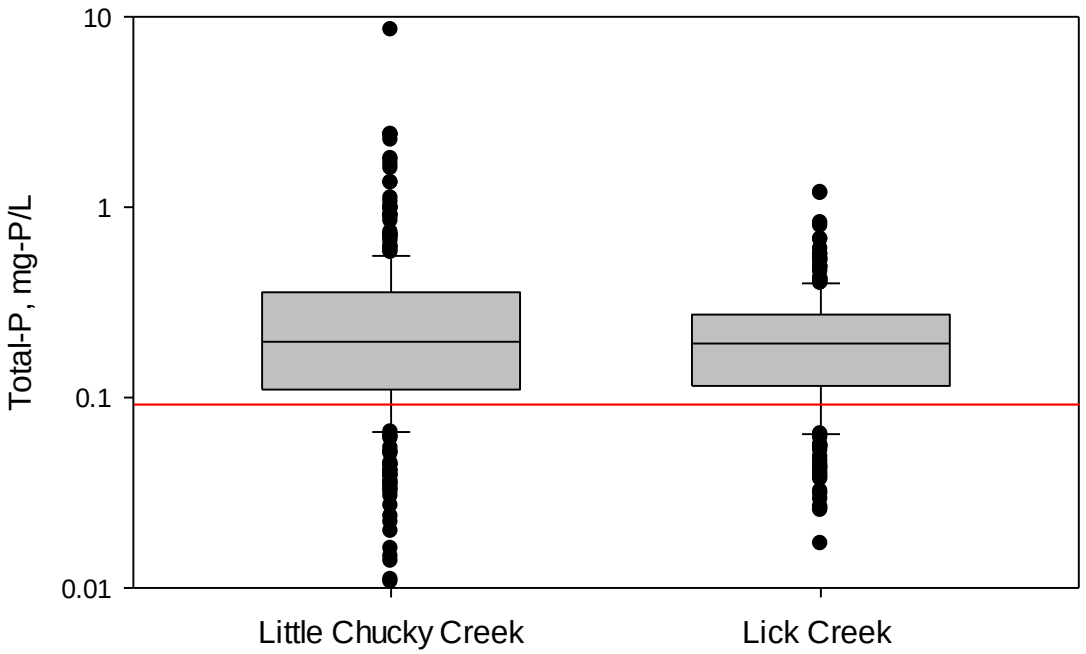


Figure 31. Total phoshorus concentrations and the ecoregion reference standard of 0.09 mg-P/L for Little Chucky Creek and Lick Creek.

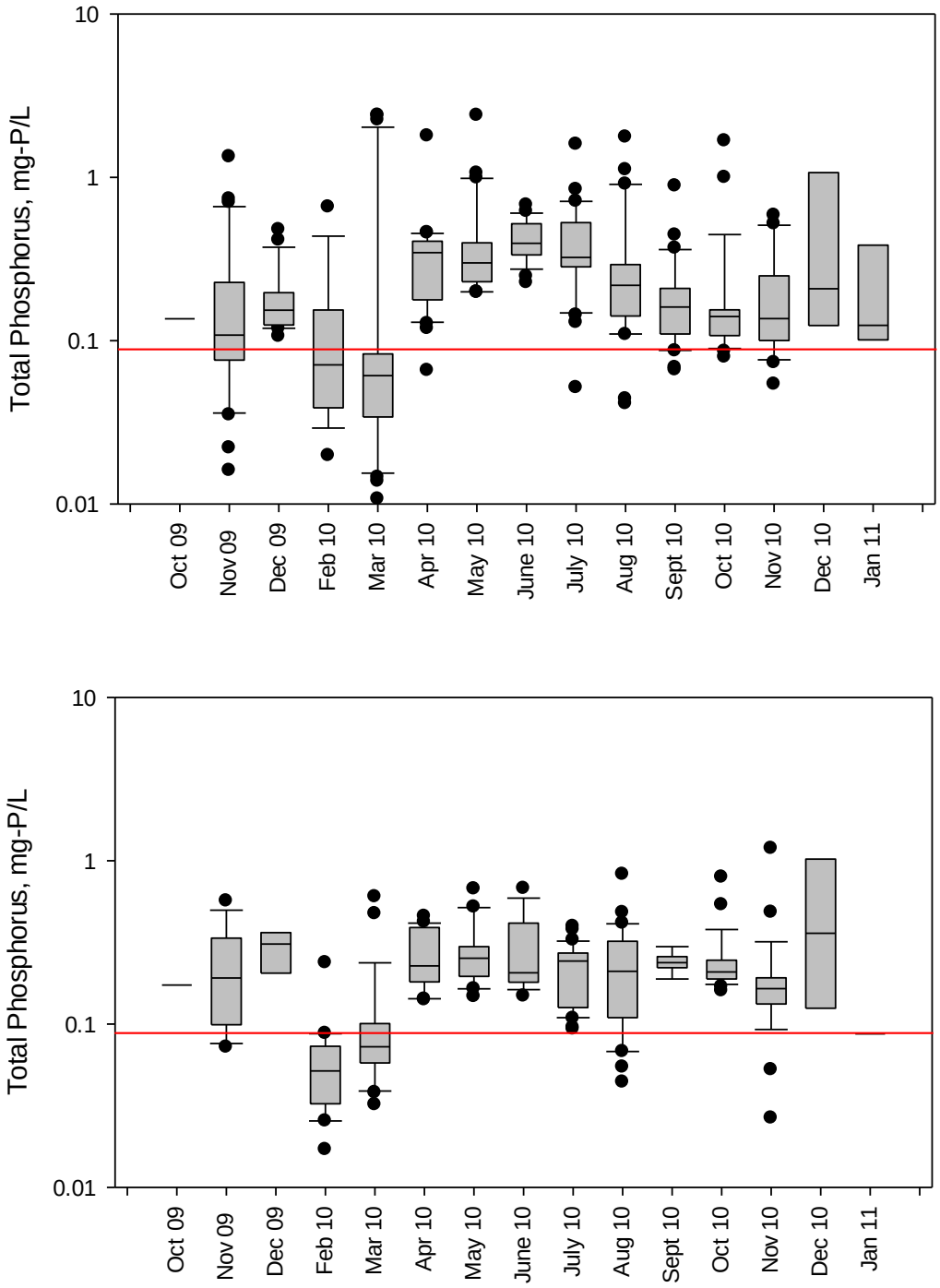


Figure 32. Box plots of total phophorus values per month with state standard of 0.09 mg-P/L for Little Chucky Creek in plot A and Lick Creek in plot B.

pollution) over a short period of time can result in repercussions on aquatic life such as respiratory failure and habitat alteration. Water pH levels above 9 increase the toxicity of ammonia, while levels below 5.5 increase the toxicity of metals (Arnwine & Graf, 2009). Tennessee's general water quality criteria states that pH levels for wadeable streams should stay within the range of 6.0 to 9.0 and should not fluctuate more than one unit over a period of 24 hour (TDEC, 2008a). However, TDEC has not evaluated the time rate of change with actual data. In this study, Little Chucky Creek pH levels were between 8 and 8.75 during 92.5% of measurements, with the change between daily values never greater than 0.5 units (Figure 33). The pH levels only exceeded the upper limit of 9 on five consecutive occasions on May 20, 2010 from 2 p.m. to 3 p.m. At Lick Creek, the pH was slightly more acidic, with 99% of the values falling between 7.5 and 8.5 (Figure 33). The difference between daily readings never exceeded 0.5 units.

Water Temperature

Benthic macroinvertebrates and other aquatic organisms require a certain temperature range for their optimal health (EPA, 2010a). Quite often one of the key factors affecting temperature is the lack of riparian vegetation around streams, which can result in quick temperature increases during the heat of summer due to lack of shading. The general water quality criteria for Tennessee states that water temperature should not exceed 30.5^0C, and the maximum rate of change should not exceed 2^0C per hour (TDEC, 2008a). Stream temperature at Little Chucky Creek stayed well below the upper temperature limit (Figure 34), and the hourly temperature changes were well below the standard rate of change criterion. Lick Creek temperatures also met both requirements (Figure 34).

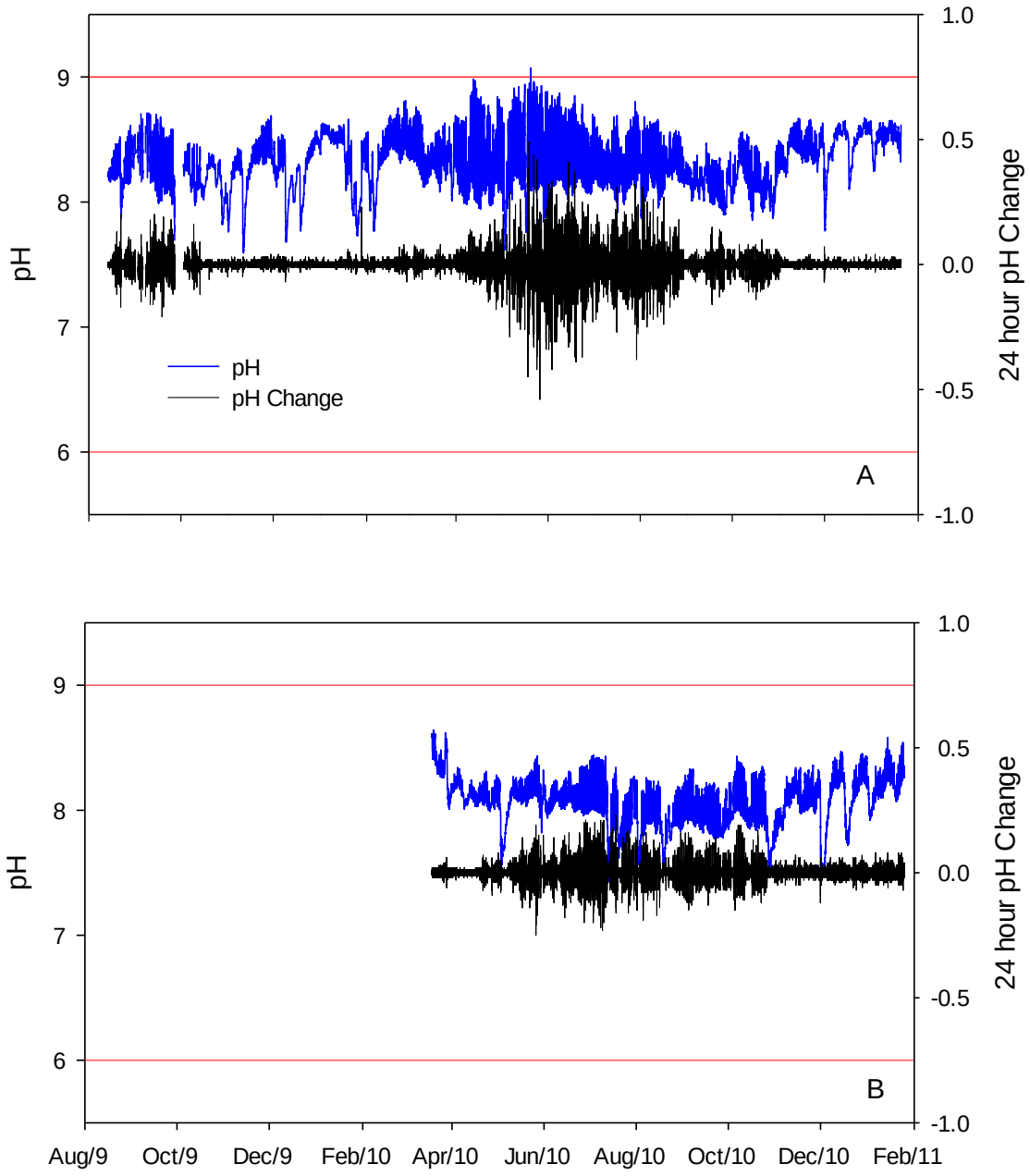


Figure 33. pH and the 24 hour maximum changes in pH over time at Little Chucky Creek (A) and Lick Creek (B). The general water quality criteria range of 6.0 to 9.0 is shown.

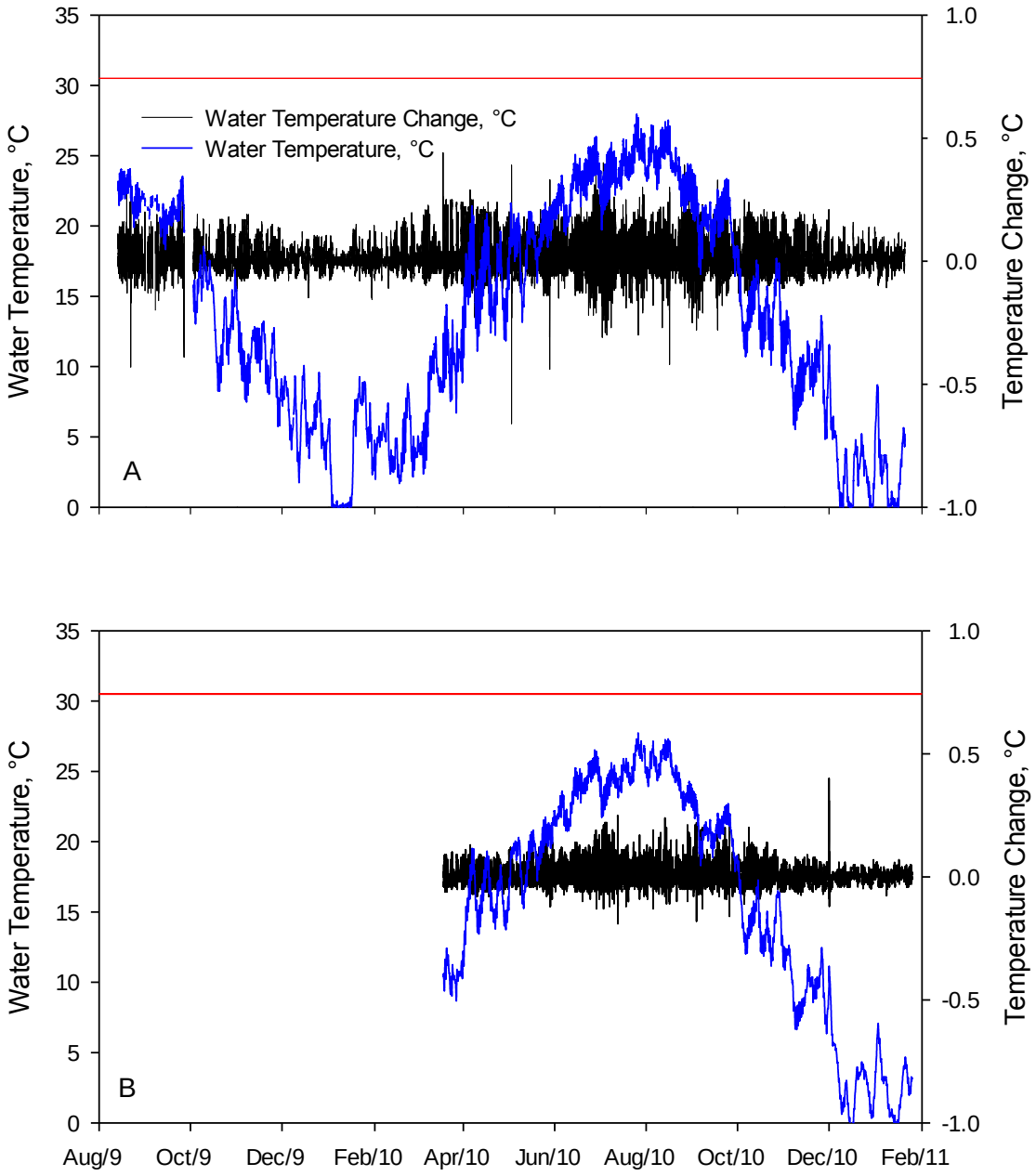


Figure 34. Water temperature and water temperature change at Little Chucky Creek (A) and Lick Creek (B). The TDEC water quality criteria maximum temperature of 30.5^{0}C is illustrated.

Temperature and pH levels have criteria that apply to how the parameters change over time, but rarely if ever does TDEC monitor these hourly or daily differences.

SWAT Inputs

The types of samples collected by this system were based on the SWAT model inputs for model calibration. The model operates on a daily time step and should have daily loading results for flow, sediment, organic nitrogen, organic phosphorus, nitrate plus nitrite, ammonia, mineral phosphorus, DO, chlorophyll *a*, BOD, and bacteria (Neitsch et al., 2004). This system used the refrigerated sampler to collect daily composite samples that can be preserved for sediment, nitrogen, phosphorus, and ammonia analysis. The sonde collected daily in-stream parameters for the DO and chlorophyll *a* inputs. Biological and bacteriological samples could not be sampled on a daily basis because they cannot be preserved and must be analyzed within six hours of collection. It was not practical to travel to station locations on a daily basis to collect these samples. Instead, bi-weekly grab samples were collected and analyzed for BOD and bacteria. In addition, stage discharge curves were developed to estimate the daily flow.

This system is not only capable of collecting enough data to calibrate the SWAT model, but also to evaluate parameters such as pH, temperature, or diurnal DO that carry specific criteria that is not evaluated due to a lack of data. TDEC can utilize this system to target impaired streams and further investigate the cause of impairment while evaluating the appropriateness of the ecoregion criteria. Source assessments can then be improved by applying this large dataset to the SWAT model for calibration and validation.

CHAPTER V

RECOMMENDATIONS

A limiting factor for water quality monitoring can be collecting enough data to accurately make an assessment of whether use criteria are being met and what sources are responsible when impairment is identified. Also, the data being collected now by TDEC is wholly insufficient to calibrate WQ models such as SWAT that could better identify sources. An intensive monitoring system was developed during this study and deployed to collect a large dataset over a relatively short time period (approximately one year) that must be serviced only every two weeks. Monitoring stations were deployed in ecoregion 67g on Lick Creek and Little Chucky Creek.

System Power Supply

The power supply for the monitoring system in this study failed at Lick Creek during the summer months when cooling demands from the sampler were high and the solar potential was decreasing. We empirically determined that the power supply was insufficient. One improvement to the system would be to change the angle of the solar panels twice a year for optimal power production. In the winter, the panels should be turned at a steeper angle and more flat in the summer. Proper ventilation inside the enclosure and shade may also extend the life of the batteries and allow the sampler to become more efficient in meeting chamber temperature goals.

Water Quality and Stream Discharge

The Tennessee General Water Quality Criteria states that diurnal fluctuations should not be "substantially different than the fluctuations noted in reference streams in

that region" (TDEC, 2008a). TDEC does not monitor for the diurnal fluctuation criteria, so no data exists to properly evaluate this standard. Metrics should be parameterized and criteria set for the diurnal DO variations specifically for the magnitude of the DO swings and also for the duration that the DO concentrations are below the minimum criteria of 5 mg/L.

The Water Quality Criteria also lists standards for *E. coli* of a maximum of 941 cfu/100 mL for one sample or 126 cfu/100 mL as a geometric mean of at least five samples collected over a period of thirty days. TDEC does not collect enough data to apply the geometric mean criteria, so the maximum limit is applied. Currently in ecoregion 67, 6 percent of the data from reference streams are above the maximum limit of 941 cfu/100 mL, but streams are still listed as impaired with only one exceedence. An alternative to applying the maximum limit would be to compare a certain percentile of the reference data to the criteria.

Another crucial dataset that TDEC does not collect is discharge data. Many of the streams that the SWAT model targets are in rural ungauged watersheds, and without adequate discharge data, the model cannot be calibrated. The monitoring system in this study utilized the velocity- area method and the RiverSurveyor system to develop stage-discharge curves to estimate flow rate. Flows lower and higher than those measured should be targeted to further define the stage-discharge curves for nutrient load concentrations.

Summary

TDEC has the challenging task of evaluating every wadeable stream in Tennessee to determine if use criteria are being met. Limited funds and staffing make the job of

collecting an adequate amount of data more difficult. A solution to this issue could be deploying intensive data collection systems on targeted impaired streams to help accurately identify the cause and source of impairment. The system employs a refrigerated sampler for composite samples that can be preserved and a multi-parameter sonde for in-stream parameters such as DO, pH, or temperature. Grab samples are also collected for biological parameters that cannot be preserved. This unmanned system is capable of collecting continuous data in remote locations where access to electricity is unavailable. The resulting dataset can be used to better assess water quality use criteria. This system may also provide an intensive dataset that could be used to calibrate HUC-12 and/or HUC-8 surface water quality models, such as the Soil and Water Assessment Tool, that can be used to provide a more rigorous assessment of pollutant sources and prioritization of management practices that will most efficiently improve water quality. Model users often face the same challenge as TDEC in that the amount of data available in the rural, agricultural watersheds that the model targets is sparse and generally not current.

LIST OF REFERENCES

Arnwine, D.H., Broach, J.I., Cartwright, L.K., Denton, G.M. 2000. Tennessee Ecoregion Project, (Ed.) TDEC. Nashville.
Arnwine, D.H., Denton, G.M. 2003. Evaluation of Regional Dissolved Oxygen Patterns of Wadeable Streams in Tennessee Based on Diurnal and Daylight Monitoring, (Ed.) TDEC. Nashville.
Arnwine, D.H., Denton, G.M., Cartwright, L.K., Graf, M.H. 2010. 2010 305(b) Report The Status of Water Quality in Tennessee, (Ed.) TDEC. Nashville.
Arnwine, D.H., Denton, G.M., Wang, S.H. 2001. Development of Regionally-Based Interpretations of Tennessee's Narrative Nutrient Criterion, (Ed.) TDEC. Nashville.
Arnwine, D.H., Graf, M.H. 2009. Probabilistic Monitoring of Wadeable Streams in Tennessee, (Ed.) TDEC, Vol. 4- Water Chemistry. Nashville.
Congress, U.S. 1972. Clean Water Act, (Ed.) EPA, Vol. Public Law 92-500.
Eaton, A.D., Clesceri, L.S., Rice, E.W., Greenberg, A.E., Franson, M.A.H. 2005a. Standard Methods for the Examination of Water and Wastewater, American Public Health Association.
Eaton, A.D., Clesceri, L.S., Rice, E.W., Greenberg, A.E., Franson, M.A.H. 2005b. Standard Methods for the Examination of Water and Wastewater. in: *Method 5210 B and C*.
EPA. 2010a. 5.3 Temperature. in: *Water: Monitoring and Assessment*, Vol. 2011.
EPA. 2010b. 5.4 pH. in: *Water: Monitoring and Assessment*, Vol. 2011.
EPA. 2010c. 5.7 Nitrates. in: *Water: Monitoring and Assessment*, Vol. 2011.
EPA. 1993a. Determination of Phosphorus by Semi-Automated Colorimetry. in: *Method 365.1*, (Ed.) EPA.
EPA. 1993b. Determination of Total Kjeldahl Nitrogen by Semi-Automated Colorimetry. in: *Method 351.2*.
EPA. 1978. Nitrogen, Nitrate-Nitrite (Colorimetric, Automated, Cadmium Reduction). in: *Method 353.2*.
EPA. 1974. Organic Carbon, Total (Combustion Or Oxidation). in: *Method 415.1*.
Frame, D., Cooley, E. 2009. Equipment, Procedures, and Sampling, (Ed.) U.o.W. Extension.
Gassman, P.W., Reyes, M.R., Green, C.H., Arnold, J.G. 2007. The Soil and Water Assessment Tool: Historical Development, Applications, and Future Research Directions. *Transactions of the ASABE*, **Vol. 50(4)**, 1211-1250.
Hubert J. Savoy, J., Joines, D. 2009. Lime and Fertilizer Recommendations
for the Various Crops of Tennessee, (Ed.) U.o.T. Extension.
Neitsch, S.L., Arnold, J.G., Kiniry, J.R., Srinivasan, R., Williams, J.R. 2004. Soil and Water Assessment Tool Input/Output File Documentation. Temple, Texas.
Service, N.A.S. 2010. Land Use Data, (Ed.) USDA.
TDEC. 2008a. General Water Quality Criteria, Division of Water Pollution Control. Nashville.
TDEC. 2006a. Quality Assurance Plan for 106 Monitoring in the Division of Water Pollution Control. 3 ed, (Ed.) D.o.W.P. Control, Vol. 1, Division of Water Pollution Control. Nashville, TN.

TDEC. 2008b. Quality System Standard Operating Procedure for Chemical and Bacteriological Sampling of Surface Water, (Ed.) D.o.W.P. Control, Division of Water Pollution Control. Nashville, TN.
TDEC. 2006b. Quality System Standard Operating Procedure for Macroinvertebrate Stream Surveys, (Ed.) D.o.W.P. Control, Vol. October 2006 Revision. Nashville, Tennessee.
TDEC. 2008c. Rules of the Tennessee Department of Environment and Conservation Division of Water Pollution Control. in: *Chapter 1200-4-3, General Water Quality Criteria*, Division of Water Pollution Control, Nashville, TN.
TDEC. 1995-2010. TDEC Database.
TDEC. 2007. Tennessee's Plan for Nutrient Criteria Development, Division of Water Pollution Control. Nashville.
TDEC. 2010. Year 2010 303(d) List, Division of Water Pollution Control. Nashville.
Teledyne ISCO. 2003. Avalanche Installation and Operation Guide.

APPENDIX

Campbell Scientific CR 1000 datalogger programs for Lick Creek and Little Chucky Creek.

```
'CR1000
'Lick Creek and Little Chucky Creek
'Wesley C Wright
'August 13, 2009
'Added cell modem control October 1, 2009
'Rain gage and SDI-12 Sondes
'Added 3 current sensors March 4,2010
'Sensor @ PV before charge controller; Sensor after charge controller before battery; Sensor between battery and Isco Avalanche sampler.

'Declare Variables and Units
Public Batt_Volt
Public PTemp_C
Public MProbe(9)
Public Rain_mm
Public NowMin_3
Public RTime(9)
Public CellCon_4
Public Temp_C
Public Current(3)
Public PVolt
Public Energy(3)
Public FanRelay_1

Alias MProbe(1)=Temp
Alias MProbe(2)=SpCond
Alias MProbe(3)=Depth
Alias MProbe(4)=pH
Alias MProbe(5)=ORP
Alias MProbe(6)=Turb
Alias MProbe(7)=Chl
Alias MProbe(8)=ODOsat
Alias MProbe(9)=ODO

Units Batt_Volt=Volts
Units PTemp_C=Deg C
Units Rain_mm=mm
Units Temp=deg C
Units SpCond=mS/cm
Units Depth=ft
Units ORP=mV
Units Turb=NTU
```

```
Units Chl=mg/l
Units ODOsat=% saturation
Units ODO=mg/l
Units Temp_C=Deg C
Units Current=Amps
Units PVolt=Volts
Units Energy=watthr

'Define Data Tables
DataTable(Table1,True,-1)
DataInterval(0,15,Min,10)
Average(1,PTemp_C,FP2,False)
Average(1,Temp_C,FP2,False)
Average(1,Temp,FP2,False)
Average(1,SpCond,FP2,False)
Average(1,Depth,FP2,False)
Average(1,pH,FP2,False)
Average(1,ORP,FP2,False)
Average(1,Turb,FP2,False)
Average(1,Chl,FP2,False)
Maximum(1,ODOsat,FP2,False,True)
Average(1,ODO,FP2,False)
Average(1,Batt_Volt,FP2,False)
Average(1,PVolt,FP2,False)
Average(1,Current(1),FP2,False)
Average(1,Current(2),FP2,False)
Average(1,Current(3),FP2,False)
Totalize(1,Energy(1),FP2,False)
Totalize(1,Energy(2),FP2,False)
Totalize(1,Energy(3),FP2,False)
EndTable

DataTable(Table2,True,-1)
DataInterval(0,1440,Min,10)
Totalize(1,Energy(1),FP2,False)
Totalize(1,Energy(2),FP2,False)
Totalize(1,Energy(3),FP2,False)
EndTable

'Main Program
BeginProg
Scan(5,Sec,1,0)
'Default Datalogger Battery Voltage measurement Batt_Volt:
Battery(Batt_Volt)
'Wiring Panel Temperature measurement PTemp_C:
```

```
PanelTemp(PTemp_C,_60Hz)
'Type T (copper-constantan) Thermocouple measurements Temp_C:
TCDiff(Temp_C,1,mV2_5C,1,TypeT,PTemp_C,True,0,_60Hz,1,0)
'SE volt measurement of the three current sensors
VoltSe (Current(),3,mv5000,3,1,0,250,0.015435,-38.5)
'Panel voltage
VoltSe (PVolt,1,mV5000,6,1,0,250,0.0044,0)
'Energy calculation over 5 seconds
Energy(1)=Current(1)*PVolt*0.001389
Energy(2)=Current(2)*13.5*0.001389
Energy(3)=Current(3)*Batt_Volt*0.001389

'SDI-12 Multiprobe measurements Temp, SpCond, Depth,
'pH, ORP, Turb, Chl, ODOsat, and ODO:
If IfTime(13,15,Min)=True Then
SDI12Recorder(Temp,7,"0","M!",1,0)
EndIf

'Cell modem power control
RealTime (RTime(1))
NowMin_3=RTime(4)*60+RTime(5)
If NowMin_3>=540 AND NowMin_3<1020
CellCon_4=1
Else
CellCon_4=0
EndIf
PortSet (9,CellCon_4)

'Call Data Tables and Store Data
CallTable(Table1)
CallTable(Table2)

NextScan
EndProg
```

Table 1-A. Daily average readings for DO, turbidity, chlorophyll *a*, water temperature, pH and depth from the sonde at Little Chucky Creek.

Table 1-A continued						
Date	**DO (mg/L)**	**Turbidity (NTU)**	**Chlorophyll *a* (mg/L)**	**Water Temperature (^{0}C)**	**pH**	**Depth (ft)**
8/13/2009	7.08	24.22	3.89	23.03	8.22	0.66
8/14/2009	6.98	23.72	3.35	22.67	8.21	0.60
8/15/2009	6.96	21.67	2.99	22.96	8.21	0.54
8/16/2009	6.99	19.46	4.28	22.95	8.25	0.50
8/17/2009	6.98	20.05	9.39	22.91	8.49	0.47
8/18/2009	7.02	19.43	25.00	22.68	8.26	0.46
8/19/2009	6.94	21.75	37.58	22.94	8.26	0.48
8/20/2009	6.98	23.02	4.19	23.17	8.29	0.56
8/21/2009	6.94	26.78	4.15	23.39	8.30	0.50
8/22/2009	6.85	227.89	12.09	22.42	8.02	1.04
8/23/2009	7.28	53.42	6.57	21.37	8.09	0.82
8/24/2009	7.49	30.78	3.75	21.07	8.20	0.57
8/25/2009	7.38	52.19	3.89	21.71	8.27	0.47
8/26/2009	7.34	60.58	8.23	21.81	8.28	0.41
8/27/2009	7.33	44.72	51.79	21.70	8.28	0.37
8/28/2009	7.23	83.23	207.77	21.41	8.50	0.42
8/29/2009	7.86	47.48	109.81	21.74	9.21	0.42
8/30/2009	7.77	51.78	5.36	21.54	9.83	0.50
8/31/2009	8.29	17.33	5.43	21.21	10.09	0.41
9/1/2009	8.45	23.50	5.90	16.92	20.05	0.33

Table 1-A continued						
Date	**DO (mg/L)**	**Turbidity (NTU)**	**Chlorophyll *a* (mg/L)**	**Water Temperature (^{0}C)**	**pH**	**Depth (ft)**
9/2/2009	8.34	23.10	6.67	20.78	9.72	0.37
9/4/2009	8.08	56.09	5.34	21.40	9.10	0.35
9/5/2009	8.40	221.85	9.61	21.50	9.49	0.34
9/7/2009	8.71	52.83	3.25	20.15	13.72	0.27
9/8/2009	8.31	39.69	2.30	21.48	9.46	0.28
9/9/2009	8.06	169.75	3.07	20.85	9.80	0.38
9/10/2009	7.63	71.39	6.07	20.15	9.00	0.52
9/11/2009	7.39	104.30	4.18	19.91	8.28	0.55
9/12/2009	7.39	94.81	4.89	20.56	8.28	0.48
9/13/2009	7.49	35.20	5.94	19.93	8.30	0.35
9/14/2009	7.63	33.38	5.58	19.75	8.28	0.28
9/15/2009	7.16	44.04	18.28	20.09	8.23	0.27
9/16/2009	6.76	28.07	21.96	20.55	8.19	0.26
9/17/2009	6.79	54.54	61.48	20.77	8.21	0.28
9/18/2009	6.82	131.11	79.65	20.79	8.22	0.42
9/19/2009	6.87	153.80	52.23	21.13	8.23	0.39
9/20/2009	6.56	139.07	96.21	21.03	8.19	0.39
9/21/2009	6.41	97.72	101.23	20.80	8.18	0.34
9/22/2009	6.80	55.05	43.45	21.08	8.23	0.42
9/23/2009	6.88	65.97	48.93	21.44	8.22	0.45
9/24/2009	6.50	45.30	28.36	22.18	8.20	0.36
9/25/2009	6.03	40.81	29.00	22.54	8.16	0.33
9/26/2009	5.83	155.12	34.25	21.13	8.03	0.80

Table 1-A continued						
Date	**DO (mg/L)**	**Turbidity (NTU)**	**Chlorophyll *a* (mg/L)**	**Water Temperature (^{0}C)**	**pH**	**Depth (ft)**
10/2/2009	8.69	17.53	11.94	15.63	8.25	0.91
10/3/2009	8.77	34.76	11.71	15.01	8.29	0.99
10/4/2009	8.98	67.02	35.47	13.95	8.31	0.96
10/5/2009	8.90	115.96	29.79	14.87	8.31	1.03
10/6/2009	8.45	92.72	25.60	15.99	8.29	1.12
10/7/2009	7.95	100.44	45.53	17.25	8.16	1.63
10/8/2009	8.63	42.19	26.96	15.65	8.19	1.48
10/9/2009	8.17	54.52	18.52	16.88	8.53	1.19
10/10/2009	7.24	74.32	33.40	17.83	8.02	1.13
10/11/2009	8.05	71.82	37.59	16.57	8.16	1.18
10/12/2009	8.06	54.39	45.88	15.81	8.16	1.14
10/13/2009	8.10	73.06	34.04	16.52	8.20	1.17
10/14/2009	7.85	84.95	13.39	16.42	8.10	1.65
10/15/2009	8.44	72.10	12.21	15.65	8.09	1.98
10/16/2009	8.59	51.99	12.08	14.77	8.09	1.82
10/17/2009	9.11	25.18	9.54	12.61	8.16	1.58
10/18/2009	9.84	28.36	11.64	10.62	8.23	1.44
10/19/2009	10.36	19.38	14.86	9.33	8.30	1.35
10/20/2009	10.28	18.81	9.42	9.51	8.30	1.29
10/21/2009	10.15	10.60	8.73	10.20	8.31	1.26
10/22/2009	9.86	24.70	12.02	11.26	8.31	1.23
10/23/2009	8.75	53.28	19.30	13.65	8.26	1.24
10/24/2009	7.68	33.70	23.34	14.38	8.15	1.20

Table 1-A continued						
Date	**DO (mg/L)**	**Turbidity (NTU)**	**Chlorophyll *a* (mg/L)**	**Water Temperature (^{0}C)**	**pH**	**Depth (ft)**
10/25/2009	8.92	19.70	16.50	11.83	8.22	1.28
10/26/2009	9.38	17.52	26.72	11.43	8.25	1.24
10/27/2009	8.63	62.48	24.28	12.33	8.15	1.50
10/28/2009	8.68	169.63	28.53	14.19	7.87	2.46
10/29/2009	8.95	87.66	15.11	13.95	7.96	1.74
10/30/2009	8.39	40.73	9.01	15.47	8.03	1.64
10/31/2009	7.60	82.32	12.73	15.47	8.01	1.79
11/1/2009	8.91	169.48	48.35	13.65	7.84	2.90
11/2/2009	9.69	39.22	20.03	12.21	8.00	1.80
11/3/2009	10.00	23.34	5.10	11.44	8.15	1.60
11/4/2009	10.36	21.88	5.13	10.46	8.24	1.50
11/5/2009	10.42	26.30	4.87	10.25	8.26	1.45
11/6/2009	10.81	24.73	6.16	9.15	8.29	1.41
11/7/2009	10.92	26.25	15.57	9.07	8.32	1.38
11/8/2009	10.88	19.64	20.36	9.58	8.32	1.35
11/9/2009	10.84	29.24	26.87	9.85	8.31	1.32
11/10/2009	9.76	102.75	57.79	10.98	8.19	1.81
11/11/2009	8.98	255.82	20.56	12.24	7.67	5.41
11/12/2009	9.68	69.36	15.50	12.30	7.89	1.87
11/13/2009	10.09	58.73	8.15	11.69	8.10	1.42
11/14/2009	10.15	96.04	4.66	11.52	8.18	1.28
11/15/2009	10.28	80.86	4.26	11.55	8.24	1.19
11/16/2009	10.47	46.65	3.55	11.07	8.30	1.14

Table 1-A continued						
Date	DO (mg/L)	Turbidity (NTU)	Chlorophyll *a* (mg/L)	Water Temperature (^{0}C)	pH	Depth (ft)
11/17/2009	10.40	51.67	5.13	11.78	8.35	1.09
11/18/2009	9.95	31.90	6.08	12.88	8.37	1.06
11/19/2009	10.39	23.06	6.15	12.02	8.39	1.04
11/20/2009	11.11	23.20	8.03	9.96	8.40	1.01
11/21/2009	11.43	24.01	10.38	9.32	8.41	0.98
11/22/2009	11.47	32.73	6.71	8.73	8.43	0.95
11/23/2009	11.78	33.42	6.13	10.06	8.47	0.95
11/24/2009	11.22	46.43	9.78	11.67	8.45	0.93
11/25/2009	10.95	66.22	6.01	12.09	8.45	0.91
11/26/2009	11.44	90.74	4.58	9.96	8.46	0.88
11/27/2009	12.13	110.05	4.44	8.49	8.51	0.86
11/28/2009	12.60	94.77	9.24	7.00	8.50	0.83
11/29/2009	12.84	80.00	8.21	6.90	8.50	0.82
11/30/2009	10.74	109.83	8.71	8.65	8.36	1.08
12/1/2009	11.35	262.32	16.27	8.03	8.33	1.40
12/2/2009	10.69	155.77	14.46	8.37	8.23	1.42
12/3/2009	10.57	111.85	10.42	8.96	8.18	1.38
12/4/2009	11.37	63.16	6.66	8.29	8.33	1.13
12/5/2009	11.51	58.59	5.40	7.14	8.36	1.13
12/6/2009	12.48	101.89	5.93	5.49	8.39	1.32
12/7/2009	12.59	164.86	7.58	4.80	8.38	1.13
12/8/2009	11.97	189.39	6.81	6.11	8.42	1.03
12/9/2009	10.43	316.48	22.10	8.29	7.83	4.39

Table 1-A continued						
Date	**DO (mg/L)**	**Turbidity (NTU)**	**Chlorophyll *a* (mg/L)**	**Water Temperature (^{0}C)**	**pH**	**Depth (ft)**
12/10/2009	11.19	107.23	8.72	7.00	7.84	1.48
12/11/2009	12.61	66.72	4.23	3.83	8.05	1.05
12/12/2009	13.19	49.05	2.90	2.55	8.14	0.92
12/13/2009	12.14	38.53	3.71	5.27	8.19	1.13
12/14/2009	11.22	82.79	6.43	8.17	8.03	1.25
12/15/2009	10.78	68.39	3.90	9.53	8.06	1.00
12/16/2009	11.57	97.73	2.84	7.56	8.19	0.90
12/17/2009	12.32	108.70	2.23	5.39	8.27	0.83
12/18/2009	11.89	191.50	8.07	5.17	8.21	1.68
12/19/2009	11.96	133.96	16.96	4.59	7.85	2.79
12/20/2009	11.90	46.27	8.47	5.50	7.96	1.92
12/21/2009	12.13	26.75	6.36	5.55	8.11	1.32
12/22/2009	12.03	23.38	4.48	6.30	8.25	1.17
12/23/2009	11.98	29.19	3.89	6.54	8.33	1.11
12/24/2009	11.70	46.17	2.18	7.34	8.37	1.04
12/25/2009	11.27	29.75	2.15	8.45	8.40	1.07
12/26/2009	11.65	40.49	2.73	7.42	8.42	1.08
12/27/2009	12.34	48.54	2.51	5.31	8.44	0.98
12/28/2009	12.57	36.32	2.08	4.83	8.49	0.93
12/29/2009	13.03	39.98	2.01	3.94	8.52	0.89
12/30/2009	13.25	14.34	2.07	3.66	8.50	0.86
12/31/2009	12.33	18.54	2.58	5.08	8.46	0.86
1/1/2010	12.40	29.11	3.26	5.80	8.48	0.86

Table 1-A continued						
Date	**DO (mg/L)**	**Turbidity (NTU)**	**Chlorophyll *a* (mg/L)**	**Water Temperature (^{0}C)**	**pH**	**Depth (ft)**
1/2/2010	13.40	160.71	3.23	2.90	8.58	0.81
1/3/2010	14.31	112.22	4.88	0.52	8.59	0.77
1/4/2010	14.51	103.60	3.05	0.05	8.59	0.80
1/5/2010	14.59	194.54	5.39	0.03	8.58	0.80
1/6/2010	14.63	152.88	7.82	0.11	8.57	0.73
1/7/2010	14.52	108.56	13.75	0.01	8.54	0.78
1/8/2010	14.71	32.53	9.12	0.01	8.52	0.72
1/9/2010	15.00	90.15	8.36	0.02	8.54	0.68
1/10/2010	14.94	186.52	6.84	0.06	8.51	0.67
1/11/2010	15.05	102.76	10.11	0.04	8.52	0.66
1/12/2010	14.68	535.75	12.47	0.07	8.51	0.66
1/13/2010	14.94	678.47	13.70	0.06	8.54	0.67
1/14/2010	14.98	213.27	18.04	0.10	8.54	0.66
1/15/2010	14.94	219.92	17.61	0.22	8.54	0.64
1/16/2010	14.67	192.60	11.97	0.50	8.55	0.64
1/17/2010	12.48	253.49	26.82	3.94	8.38	1.24
1/18/2010	11.98	107.61	21.18	6.49	8.22	1.35
1/19/2010	12.63	36.56	18.34	6.30	8.39	1.00
1/20/2010	11.74	25.40	11.02	7.29	8.37	0.92
1/21/2010	11.32	231.04	22.93	8.36	8.28	1.42
1/22/2010	10.98	390.35	119.91	7.64	7.97	1.82
1/23/2010	11.64	188.70	172.34	7.92	7.99	1.35
1/24/2010	10.99	257.76	159.37	8.02	8.05	1.32

Table 1-A continued

Date	DO (mg/L)	Turbidity (NTU)	Chlorophyll *a* (mg/L)	Water Temperature (^{0}C)	pH	Depth (ft)
1/25/2010	8.62	621.40	23.59	8.52	7.80	3.13
1/26/2010	10.59	448.80	10.29	5.83	7.86	1.31
1/27/2010	11.29	335.63	5.63	4.87	7.97	1.03
1/28/2010	11.54	201.35	5.44	5.80	8.22	1.08
1/29/2010	12.35	11.03	2.70	5.14	8.38	1.19
1/30/2010	12.98	57.20	2.72	3.02	8.41	1.32
1/31/2010	13.21	159.73	3.26	3.47	8.38	1.47
2/1/2010	13.31	254.04	3.95	3.25	8.36	1.44
2/2/2010	12.36	183.69	10.45	4.35	8.16	2.03
2/3/2010	12.25	152.82	10.13	5.13	8.03	2.19
2/4/2010	12.60	22.63	5.91	4.85	8.21	1.73
2/5/2010	11.89	241.58	15.07	5.20	7.97	3.05
2/6/2010	11.07	103.16	13.99	5.86	7.91	2.80
2/7/2010	11.64	70.30	6.79	5.18	8.09	1.82
2/8/2010	12.14	31.24	3.74	5.55	8.30	1.53
2/9/2010	11.37	39.46	3.11	6.80	8.32	1.43
2/10/2010	12.23	34.66	3.39	4.00	8.35	1.42
2/11/2010	12.78	29.60	2.70	3.10	8.42	1.34
2/12/2010	12.49	30.67	2.23	3.20	8.43	1.30
2/13/2010	12.01	37.71	2.03	3.13	8.46	1.26
2/14/2010	11.67	133.36	2.02	3.75	8.48	1.21
2/15/2010	12.68	60.39	2.12	4.45	8.51	1.23
2/16/2010	13.54	73.41	3.79	2.73	8.55	1.20

Table 1-A continued						
Date	**DO (mg/L)**	**Turbidity (NTU)**	**Chlorophyll *a* (mg/L)**	**Water Temperature (^{0}C)**	**pH**	**Depth (ft)**
2/17/2010	13.59	57.38	2.02	2.04	8.55	1.15
2/18/2010	13.94	40.16	2.73	2.69	8.56	1.07
2/19/2010	13.66	7.29	1.88	4.19	8.57	0.97
2/20/2010	13.45	8.06	2.33	4.95	8.57	0.94
2/21/2010	13.35	7.70	3.89	5.83	8.58	0.92
2/22/2010	12.44	9.10	42.59	7.38	8.53	0.94
2/23/2010	11.57	8.25	3.31	8.16	8.46	0.93
2/24/2010	12.61	8.11	3.19	6.44	8.51	0.91
2/25/2010	13.95	8.14	3.04	4.05	8.58	0.88
2/26/2010	14.35	8.10	3.28	3.69	8.60	0.85
2/27/2010	14.13	8.76	4.73	3.68	8.56	0.83
2/28/2010	13.51	9.33	5.57	3.78	8.49	0.82
3/1/2010	14.14	10.51	6.88	4.30	8.52	0.80
3/2/2010	13.31	10.89	9.76	4.42	8.49	0.82
3/3/2010	13.82	11.10	15.12	4.23	8.51	0.87
3/4/2010	13.76	13.88	20.31	4.71	8.49	0.79
3/5/2010	14.25	17.77	21.47	4.38	8.50	0.77
3/6/2010	14.13	18.74	23.03	4.97	8.46	0.75
3/7/2010	14.02	22.38	21.90	5.43	8.44	0.74
3/8/2010	13.55	11.42	28.14	7.25	8.42	0.73
3/9/2010	12.29	11.43	29.58	8.89	8.37	0.74
3/10/2010	11.05	12.61	25.08	10.00	8.30	0.72
3/11/2010	10.31	20.90	19.89	10.36	8.26	0.72

Table 1-A continued						
Date	**DO (mg/L)**	**Turbidity (NTU)**	**Chlorophyll *a* (mg/L)**	**Water Temperature (^{0}C)**	**pH**	**Depth (ft)**
3/12/2010	10.06	14.47	11.70	10.71	8.41	0.78
3/13/2010	10.03	13.07	7.11	11.29	8.29	0.90
3/14/2010	10.11	21.32	6.36	9.90	8.29	0.82
3/15/2010	10.68	9.66	6.99	9.01	8.33	0.80
3/16/2010	11.13	9.35	5.68	8.76	8.37	0.76
3/17/2010	10.98	10.44	6.53	8.65	8.35	0.73
3/18/2010	11.46	10.27	13.09	10.08	8.37	0.71
3/19/2010	11.25	11.60	5.23	11.19	8.34	0.69
3/20/2010	11.11	11.24	7.33	11.96	8.33	0.66
3/21/2010	10.25	10.94	10.94	11.93	8.27	0.65
3/22/2010	10.31	15.11	9.51	10.20	8.31	0.77
3/23/2010	11.83	11.54	10.54	9.24	8.42	0.80
3/24/2010	11.99	11.94	10.08	10.51	8.42	0.71
3/25/2010	10.29	12.81	11.16	10.87	8.31	0.68
3/26/2010	10.50	12.10	8.75	9.94	8.34	0.75
3/27/2010	12.26	11.50	7.16	9.50	8.44	0.73
3/28/2010	10.49	38.14	16.25	10.56	8.32	0.81
3/29/2010	9.92	233.57	116.63	10.87	8.10	1.56
3/30/2010	11.22	48.04	96.13	10.94	8.35	1.12
3/31/2010	11.54	18.07	4.84	11.55	8.48	1.07
4/1/2010	11.19	22.24	4.71	13.50	8.45	0.98
4/2/2010	10.67	21.34	4.90	15.58	8.38	0.94
4/3/2010	9.85	27.13	6.11	16.47	8.32	0.90

Table 1-A continued						
Date	**DO (mg/L)**	**Turbidity (NTU)**	**Chlorophyll *a* (mg/L)**	**Water Temperature (^{0}C)**	**pH**	**Depth (ft)**
4/4/2010	10.48	21.51	4.50	16.82	8.34	0.87
4/5/2010	10.30	19.99	4.62	17.74	8.34	0.85
4/6/2010	9.88	8.76	3.96	19.23	8.28	0.84
4/7/2010	9.68	9.38	4.27	18.90	8.30	0.81
4/8/2010	7.86	178.65	125.39	16.61	8.12	1.06
4/9/2010	9.71	344.04	128.95	14.18	8.21	1.62
4/10/2010	11.46	132.56	116.77	13.66	8.44	1.09
4/11/2010	11.48	11.93	73.57	14.74	8.50	0.96
4/12/2010	11.27	19.41	190.85	15.62	8.44	0.91
4/13/2010	11.17	9.95	192.20	16.57	8.39	0.87
4/14/2010	11.05	18.38	41.48	17.51	8.35	0.85
4/15/2010	10.62	17.30	18.19	18.43	8.33	0.83
4/16/2010	10.30	13.97	5.37	19.07	8.29	0.81
4/17/2010	9.69	25.26	6.89	18.47	8.28	0.80
4/18/2010	10.74	34.56	6.51	15.77	8.34	0.78
4/19/2010	11.10	21.33	11.54	14.45	8.38	0.77
4/20/2010	9.18	17.42	9.66	14.12	8.26	0.77
4/21/2010	9.83	22.23	12.25	14.18	8.32	0.86
4/22/2010	11.02	22.61	9.34	14.40	8.37	0.82
4/23/2010	10.46	13.13	11.42	16.56	8.29	0.79
4/24/2010	7.90	24.50	18.11	17.60	8.14	0.80
4/25/2010	9.04	32.28	20.50	18.08	8.25	0.98
4/26/2010	7.57	20.95	13.16	17.00	8.20	0.87

Table 1-A continued

Date	DO (mg/L)	Turbidity (NTU)	Chlorophyll *a* (mg/L)	Water Temperature (^{0}C)	pH	Depth (ft)
4/27/2010	8.91	40.30	15.82	14.56	8.27	1.01
4/28/2010	10.65	367.52	75.51	13.39	8.38	1.24
4/29/2010	10.83	123.46	387.78	13.80	8.39	0.94
4/30/2010	10.39	76.78	347.09	15.49	8.35	0.85
5/1/2010	9.10	27.68	19.48	17.46	8.28	0.80
5/2/2010	8.42	317.94	7.78	19.93	8.20	0.77
5/3/2010	6.98	382.40	99.28	19.66	7.79	2.20
5/4/2010	8.48	48.56	18.43	19.64	7.98	1.38
5/5/2010	9.17	30.35	6.41	18.98	8.19	1.05
5/6/2010	9.23	22.04	5.42	19.29	8.25	0.93
5/7/2010	9.80	70.96	8.66	19.69	8.28	0.86
5/8/2010	9.58	24.70	4.58	19.48	8.33	0.81
5/9/2010	10.97	26.23	5.89	16.21	8.43	0.76
5/10/2010	10.67	30.50	6.57	14.23	8.42	0.73
5/11/2010	10.12	36.45	6.06	15.15	8.40	0.73
5/12/2010	9.88	32.20	13.02	17.03	8.38	0.72
5/13/2010	10.03	40.10	20.18	18.33	8.34	0.71
5/14/2010	9.42	53.73	40.68	19.83	8.30	0.68
5/15/2010	9.73	55.21	76.44	19.90	8.31	0.65
5/16/2010	8.72	42.63	176.76	19.95	8.29	0.71
5/17/2010	7.28	140.26	247.39	19.62	7.87	1.36
5/18/2010	8.75	54.57	226.41	19.00	8.11	0.85
5/19/2010	9.67	31.10	7.76	18.07	8.27	0.72

Table 1-A continued						
Date	**DO (mg/L)**	**Turbidity (NTU)**	**Chlorophyll *a* (mg/L)**	**Water Temperature (^{0}C)**	**pH**	**Depth (ft)**
5/20/2010	12.33	29.83	5.00	17.35	8.42	0.68
5/21/2010	9.25	27.35	7.97	18.42	8.30	0.64
5/22/2010	10.36	26.34	9.68	19.02	8.36	0.63
5/23/2010	11.58	29.43	19.81	19.84	8.36	0.62
5/24/2010	10.82	31.51	35.85	20.16	8.32	0.57
5/25/2010	10.76	29.22	80.27	20.53	8.31	0.54
5/26/2010	9.38	30.96	54.27	20.22	8.30	0.52
5/27/2010	10.69	34.54	9.27	19.88	8.35	0.52
5/28/2010	8.97	63.55	41.24	20.08	8.24	0.75
5/29/2010	8.16	66.50	50.59	20.10	8.15	1.20
5/30/2010	9.15	40.57	35.53	20.90	8.18	0.69
5/31/2010	8.85	31.59	53.59	21.16	8.21	0.59
6/1/2010	8.61	30.20	59.24	21.21	8.22	0.63
6/2/2010	9.85	36.78	59.48	21.51	8.31	0.62
6/3/2010	9.88	34.95	9.59	21.97	8.38	0.56
6/4/2010	8.48	38.45	4.35	22.24	8.32	0.51
6/5/2010	9.37	46.59	4.11	22.32	8.33	0.50
6/6/2010	7.57	56.92	4.75	22.29	8.28	0.48
6/7/2010	10.53	46.10	3.50	20.74	8.39	0.51
6/8/2010	10.73	49.70	3.39	20.45	8.42	0.48
6/9/2010	7.03	47.98	4.27	20.38	8.28	0.52
6/10/2010	7.19	48.82	5.38	20.80	8.31	0.79
6/11/2010	8.56	47.34	5.06	21.78	8.30	0.90

Table 1-A continued						
Date	**DO (mg/L)**	**Turbidity (NTU)**	**Chlorophyll *a* (mg/L)**	**Water Temperature (^{0}C)**	**pH**	**Depth (ft)**
6/12/2010	8.18	33.38	4.44	22.70	8.30	0.62
6/13/2010	7.13	35.82	17.60	23.56	8.22	0.73
6/14/2010	7.24	30.28	43.82	24.12	8.27	0.73
6/15/2010	8.02	29.95	10.94	23.41	8.29	0.54
6/16/2010	8.10	27.55	74.97	23.36	8.31	0.51
6/17/2010	7.51	28.92	22.41	23.78	8.28	0.48
6/18/2010	8.32	60.34	6.20	22.77	8.36	0.44
6/19/2010	6.69	60.79	4.76	23.18	8.28	0.47
6/20/2010	7.14	75.61	4.92	23.32	8.31	0.54
6/21/2010	8.45	84.00	4.49	23.46	8.33	0.49
6/22/2010	7.11	69.33	8.15	23.34	8.31	0.44
6/23/2010	6.87	60.22	12.46	24.24	8.33	0.44
6/24/2010	7.85	58.63	11.47	24.37	8.28	0.39
6/25/2010	7.81	65.33	15.84	24.20	8.26	0.42
6/26/2010	7.13	71.36	10.52	24.43	8.24	0.38
6/27/2010	8.12	73.35	15.13	24.85	8.23	0.38
6/28/2010	6.97	57.52	17.74	24.84	8.20	0.38
6/29/2010	6.28	39.75	15.82	24.33	8.22	0.46
6/30/2010	7.67	24.97	16.25	23.52	8.33	0.51
7/1/2010	8.73	23.43	11.97	22.62	8.34	0.39
7/2/2010	8.34	18.57	20.30	21.38	8.31	0.37
7/3/2010	7.18	12.99	46.61	22.21	8.30	0.37
7/4/2010	6.88	15.28	54.44	22.73	8.27	0.35

Table 1-A continued						
Date	**DO (mg/L)**	**Turbidity (NTU)**	**Chlorophyll *a* (mg/L)**	**Water Temperature (^{0}C)**	**pH**	**Depth (ft)**
7/5/2010	6.41	18.85	30.62	23.19	8.25	0.33
7/6/2010	5.87	11.60	43.85	23.46	8.23	0.33
7/7/2010	5.95	6.58	43.55	23.69	8.21	0.33
7/8/2010	8.06	6.67	17.84	24.34	8.22	0.36
7/9/2010	7.02	9.27	28.69	24.00	8.22	0.34
7/10/2010	7.72	8.11	27.39	24.08	8.23	0.41
7/11/2010	8.66	10.27	10.62	23.55	8.26	0.44
7/12/2010	5.81	9.38	13.61	23.12	8.19	0.55
7/13/2010	6.33	61.75	21.27	23.49	8.25	1.16
7/14/2010	7.47	62.72	6.44	23.77	8.28	0.87
7/15/2010	7.88	67.54	4.85	23.97	8.22	0.73
7/16/2010	7.11	54.11	4.46	24.85	8.22	0.64
7/17/2010	6.06	39.89	5.80	24.88	8.17	0.55
7/18/2010	5.94	28.90	6.64	24.64	8.20	0.55
7/19/2010	6.05	22.49	10.71	24.15	8.22	0.98
7/20/2010	6.99	87.27	7.28	24.24	8.19	1.16
7/21/2010	6.48	97.59	7.39	24.35	8.10	0.85
7/22/2010	7.61	95.51	7.85	24.66	8.18	0.87
7/23/2010	7.64	86.80	12.24	25.11	8.25	0.80
7/24/2010	7.00	113.47	7.92	25.86	8.27	0.79
7/25/2010	6.43	105.84	12.36	26.62	8.28	0.80
7/26/2010	6.20	155.94	12.92	26.21	8.28	0.69
7/27/2010	6.64	89.65	13.34	25.38	8.31	0.72

Table 1-A continued

Date	DO (mg/L)	Turbidity (NTU)	Chlorophyll *a* (mg/L)	Water Temperature (^{0}C)	pH	Depth (ft)
7/28/2010	6.60	108.09	14.85	25.66	8.32	0.76
7/29/2010	6.57	100.26	16.55	25.48	8.28	0.78
7/30/2010	7.16	99.04	15.24	25.25	8.65	0.83
7/31/2010	6.62	90.04	12.71	24.07	8.31	0.78
8/1/2010	6.25	184.29	19.03	23.70	8.09	1.54
8/2/2010	7.12	100.03	11.12	24.45	8.12	1.31
8/3/2010	6.86	70.67	6.32	25.32	8.17	1.10
8/4/2010	6.26	104.42	5.24	25.85	8.19	0.95
8/5/2010	5.94	107.76	5.86	25.94	8.19	0.67
8/6/2010	6.03	94.83	9.47	24.79	8.26	0.90
8/7/2010	6.76	96.88	14.83	24.68	8.36	0.81
8/8/2010	6.78	132.57	11.74	24.02	8.32	0.65
8/9/2010	7.91	141.16	7.90	24.34	8.28	0.62
8/10/2010	7.45	178.14	10.41	25.32	8.29	0.72
8/11/2010	7.25	118.86	12.07	25.85	8.36	0.95
8/12/2010	5.89	114.26	23.44	25.81	8.23	0.78
8/13/2010	5.39	108.97	23.25	26.02	8.16	0.64
8/14/2010	5.83	57.10	18.97	26.15	8.17	0.58
8/15/2010	6.90	67.43	35.00	26.15	8.18	0.55
8/16/2010	6.71	71.07	36.82	25.91	8.20	0.53
8/17/2010	6.25	56.38	26.61	24.79	8.23	0.83
8/18/2010	6.44	50.14	17.43	24.28	8.27	0.78
8/19/2010	6.48	47.48	16.83	24.18	8.23	0.84

Table 1-A continued						
Date	**DO (mg/L)**	**Turbidity (NTU)**	**Chlorophyll *a* (mg/L)**	**Water Temperature (^{0}C)**	**pH**	**Depth (ft)**
8/20/2010	7.69	54.78	14.91	24.54	8.31	1.09
8/21/2010	6.72	106.05	18.42	24.22	8.25	0.82
8/22/2010	7.31	85.95	14.34	24.09	8.28	0.97
8/23/2010	7.74	84.79	11.79	23.49	8.34	0.99
8/24/2010	7.71	94.11	7.83	22.48	8.35	0.73
8/25/2010	7.04	94.69	6.39	22.53	8.31	0.66
8/26/2010	7.17	133.83	5.74	22.27	8.29	0.59
8/27/2010	7.41	128.09	4.98	22.43	8.27	0.58
8/28/2010	6.99	111.71	4.31	22.90	8.26	0.54
8/29/2010	6.72	81.82	10.71	23.08	8.22	0.51
8/30/2010	6.84	70.49	17.97	23.03	8.19	0.51
8/31/2010	6.36	98.36	15.12	22.50	8.21	0.48
9/1/2010	6.37	106.11	18.15	22.09	8.20	0.48
9/2/2010	6.68	74.41	9.24	22.01	8.19	0.46
9/3/2010	5.68	97.53	8.93	21.88	8.15	0.44
9/4/2010	5.29	70.44	5.24	20.58	8.08	0.39
9/5/2010	6.59	60.72	13.13	18.61	8.14	0.32
9/6/2010	6.38	83.55	12.84	18.50	8.17	0.34
9/7/2010	6.37	66.46	8.12	19.56	8.20	0.36
9/8/2010	4.74	77.52	24.91	20.61	8.10	0.46
9/9/2010	6.06	78.06	21.53	20.80	8.14	0.71
9/10/2010	6.11	69.55	34.50	20.40	8.18	0.62
9/11/2010	5.48	64.45	21.26	20.16	8.12	0.59

Table 1-A continued						
Date	**DO (mg/L)**	**Turbidity (NTU)**	**Chlorophyll *a* (mg/L)**	**Water Temperature (^{0}C)**	**pH**	**Depth (ft)**
9/12/2010	6.50	29.43	21.89	21.00	8.13	0.99
9/13/2010	8.03	66.51	4.44	19.51	8.29	0.78
9/14/2010	7.63	72.54	3.85	19.29	8.21	0.64
9/15/2010	7.17	70.11	3.96	19.92	8.16	0.64
9/16/2010	6.58	54.85	5.41	20.39	8.08	0.65
9/17/2010	5.86	116.06	8.10	21.39	8.06	0.64
9/18/2010	6.13	109.74	11.75	20.69	8.07	0.52
9/19/2010	6.07	93.45	15.60	20.70	8.08	0.55
9/20/2010	5.72	119.29	22.58	21.04	8.12	0.54
9/21/2010	5.20	75.85	31.63	21.28	8.08	0.49
9/22/2010	4.53	56.93	22.13	21.88	8.06	0.47
9/23/2010	4.70	77.05	21.64	21.90	8.03	0.44
9/24/2010	4.50	88.40	47.77	21.85	8.01	0.42
9/25/2010	3.84	119.39	82.44	21.38	7.95	0.42
9/26/2010	3.85	72.36	79.64	20.29	7.94	0.48
9/27/2010	6.01	32.74	38.19	19.16	8.11	0.92
9/28/2010	6.60	33.52	17.13	18.21	8.19	0.76
9/29/2010	6.78	45.58	10.71	17.63	8.20	0.70
9/30/2010	5.96	42.28	12.90	18.15	8.05	0.68
10/1/2010	6.59	51.66	13.01	17.48	8.10	0.56
10/2/2010	7.33	42.41	12.19	15.96	8.17	0.49
10/3/2010	7.02	41.89	11.19	14.39	8.17	0.42
10/4/2010	8.23	41.72	9.26	12.90	8.26	0.43

Table 1-A continued

Date	DO (mg/L)	Turbidity (NTU)	Chlorophyll *a* (mg/L)	Water Temperature (^{0}C)	pH	Depth (ft)
10/5/2010	8.97	42.91	8.04	12.21	8.35	0.45
10/6/2010	8.94	54.69	9.41	12.13	8.38	0.44
10/7/2010	8.65	86.58	10.46	12.75	8.37	0.45
10/8/2010	8.26	71.67	17.58	14.11	8.31	0.46
10/9/2010	7.83	60.98	13.22	14.38	8.26	0.47
10/10/2010	7.50	39.97	5.95	14.78	8.25	0.49
10/11/2010	7.27	41.18	9.09	15.26	8.21	0.55
10/12/2010	6.44	28.99	12.58	15.32	8.12	0.61
10/13/2010	5.72	51.93	15.30	16.50	8.05	0.68
10/14/2010	4.89	51.25	9.49	16.58	7.98	0.84
10/15/2010	7.56	28.93	7.75	13.81	8.19	0.93
10/16/2010	7.62	29.64	6.50	12.69	8.17	0.62
10/17/2010	7.68	25.05	13.51	12.36	8.16	0.54
10/18/2010	7.57	20.84	11.54	12.77	8.17	0.53
10/19/2010	7.17	25.28	12.34	13.39	8.12	0.50
10/20/2010	5.73	26.09	9.78	14.84	7.99	0.53
10/21/2010	5.89	40.35	7.36	13.45	7.98	0.52
10/22/2010	6.95	116.90	3.92	12.57	8.06	0.58
10/23/2010	7.48	139.97	3.13	11.84	8.12	0.52
10/24/2010	7.22	124.23	3.17	12.89	8.14	0.51
10/25/2010	5.13	94.32	3.35	15.03	8.03	0.56
10/26/2010	5.49	70.63	3.79	16.31	8.07	1.03
10/27/2010	6.25	108.76	34.59	16.88	7.96	1.88

Table 1-A continued						
Date	**DO (mg/L)**	**Turbidity (NTU)**	**Chlorophyll *a* (mg/L)**	**Water Temperature (^{0}C)**	**pH**	**Depth (ft)**
10/28/2010	7.02	73.05	56.25	16.58	7.98	1.33
10/29/2010	8.00	46.01	6.21	13.92	8.12	0.92
10/30/2010	8.76	30.32	4.61	11.64	8.23	0.75
10/31/2010	8.88	29.08	3.70	11.23	8.28	0.68
11/1/2010	9.00	33.75	3.27	11.39	8.32	0.64
11/2/2010	8.76	33.05	2.90	12.25	8.34	0.62
11/3/2010	8.60	32.60	2.84	12.47	8.33	0.59
11/4/2010	8.23	69.52	27.60	12.29	8.29	1.17
11/5/2010	9.16	75.47	78.47	10.43	8.27	1.28
11/6/2010	10.06	56.48	48.66	8.82	8.34	0.97
11/7/2010	11.23	62.39	43.19	7.06	8.45	0.86
11/8/2010	11.39	112.35	36.57	7.01	8.49	0.77
11/9/2010	11.20	92.67	27.30	7.65	8.50	0.75
11/10/2010	10.94	78.89	17.85	8.32	8.50	0.69
11/11/2010	10.81	79.20	2.78	8.77	8.49	0.66
11/12/2010	10.94	74.34	2.39	8.89	8.49	0.63
11/13/2010	11.03	76.61	2.48	9.14	8.50	0.61
11/14/2010	10.72	51.08	2.67	9.25	8.48	0.60
11/15/2010	9.80	48.32	3.52	9.88	8.43	0.60
11/16/2010	9.12	63.41	3.93	10.84	8.39	0.86
11/17/2010	9.53	106.77	6.28	10.93	8.44	1.21
11/18/2010	10.09	88.46	4.72	9.33	8.44	0.98
11/19/2010	10.20	66.00	4.55	9.70	8.44	0.83

Table 1-A continued						
Date	**DO (mg/L)**	**Turbidity (NTU)**	**Chlorophyll *a* (mg/L)**	**Water Temperature (^{0}C)**	**pH**	**Depth (ft)**
11/20/2010	10.71	59.39	4.02	9.08	8.46	0.76
11/21/2010	10.72	62.07	3.56	9.71	8.48	0.71
11/22/2010	10.09	47.24	3.81	10.32	8.44	0.68
11/23/2010	9.24	45.25	4.92	10.52	8.37	0.67
11/24/2010	9.69	40.88	4.01	10.64	8.40	0.76
11/25/2010	9.17	44.24	4.42	12.22	8.41	0.77
11/26/2010	8.24	51.29	5.64	12.25	8.33	0.84
11/27/2010	10.49	44.45	4.69	8.14	8.46	1.05
11/28/2010	11.53	50.50	4.23	6.03	8.51	0.84
11/29/2010	11.64	57.43	4.75	6.40	8.52	0.76
11/30/2010	9.65	81.25	10.10	9.60	8.36	1.10
12/1/2010	9.66	167.76	29.76	9.73	7.87	3.41
12/2/2010	11.73	62.17	9.23	6.18	8.16	1.55
12/3/2010	12.25	57.03	5.28	5.75	8.31	1.24
12/4/2010	11.69	61.42	4.01	5.25	8.36	1.18
12/5/2010	12.11	62.41	7.02	5.09	8.40	1.46
12/6/2010	12.88	65.36	5.72	3.47	8.40	1.20
12/7/2010	13.77	46.67	15.42	1.62	8.49	1.09
12/8/2010	14.35	48.76	6.28	0.50	8.55	1.04
12/9/2010	14.48	50.14	2.30	0.34	8.55	1.01
12/10/2010	14.36	49.06	1.99	1.07	8.57	0.96
12/11/2010	13.59	51.63	1.94	2.69	8.57	0.94
12/12/2010	12.26	57.65	2.29	3.71	8.55	1.01

Table 1-A continued						
Date	**DO (mg/L)**	**Turbidity (NTU)**	**Chlorophyll *a* (mg/L)**	**Water Temperature (^{0}C)**	**pH**	**Depth (ft)**
12/13/2010	13.85	60.31	2.18	0.76	8.60	1.10
12/14/2010	14.47	61.45	2.35	0.07	8.58	0.99
12/15/2010	14.66	62.63	2.34	0.06	8.54	0.93
12/16/2010	13.81	68.93	3.68	0.09	8.52	1.21
12/17/2010	12.97	53.81	17.00	2.37	8.17	2.26
12/18/2010	12.58	42.69	6.85	4.22	8.24	1.68
12/19/2010	12.80	46.01	4.75	3.89	8.36	1.36
12/20/2010	13.64	45.72	3.42	2.44	8.46	1.20
12/21/2010	12.94	47.84	2.73	3.07	8.48	1.13
12/22/2010	12.63	50.07	2.49	4.44	8.50	1.13
12/23/2010	12.86	50.46	2.37	4.10	8.55	1.09
12/24/2010	13.41	51.74	2.18	3.02	8.57	1.03
12/25/2010	13.14	50.95	2.20	2.90	8.56	1.03
12/26/2010	13.72	48.08	1.99	1.99	8.59	1.05
12/27/2010	14.19	47.30	1.93	1.26	8.63	1.03
12/28/2010	14.55	40.25	2.04	0.32	8.61	0.98
12/29/2010	14.54	40.34	2.26	0.07	8.58	1.01
12/30/2010	14.46	36.64	1.83	0.67	8.59	0.98
12/31/2010	13.66	36.11	1.94	3.40	8.58	1.02
1/1/2011	11.50	34.76	7.50	6.92	8.47	1.18
1/2/2011	10.97	24.74	8.09	8.24	8.30	1.74
1/3/2011	12.75	23.72	5.68	4.52	8.36	1.32
1/4/2011	13.43	22.67	3.70	3.02	8.47	1.18

Table 1-A continued						
Date	**DO (mg/L)**	**Turbidity (NTU)**	**Chlorophyll *a* (mg/L)**	**Water Temperature (^{0}C)**	**pH**	**Depth (ft)**
1/5/2011	13.49	23.24	2.86	2.36	8.54	1.12
1/6/2011	13.50	23.88	2.48	3.06	8.57	1.11
1/7/2011	12.80	22.78	2.71	3.47	8.57	1.18
1/8/2011	13.19	18.72	4.05	2.93	8.54	1.47
1/9/2011	14.63	15.71	4.78	0.29	8.51	1.28
1/10/2011	14.62	15.44	3.36	0.08	8.54	1.26
1/11/2011	14.26	16.97	2.57	0.58	8.54	1.13
1/12/2011	14.56	16.61	2.44	0.53	8.57	1.11
1/13/2011	15.07	17.35	2.45	0.11	8.61	1.11
1/14/2011	15.07	16.33	18.46	0.04	8.58	1.15
1/15/2011	15.02	16.66	16.88	0.20	8.55	1.18
1/16/2011	14.90	13.83	31.19	0.73	8.57	1.09
1/17/2011	13.61	14.46	38.70	2.27	8.54	1.14
1/18/2011	13.21	14.42	4.88	3.65	8.52	1.16
1/19/2011	12.22	14.48	6.74	5.16	8.48	1.38
1/20/2011	12.64	13.81	10.37	4.82	8.42	1.30

Table 2-A. Daily average readings for DO, turbidity, chlorophyll *a*, water temperature, pH and depth from the sonde at Lick Creek.

Table 2-A continued

Date	DO (mg/L)	Turbidity (NTU)	Chlorophyll *a* (mg/L)	Water Temperature (^{0}C)	pH	Depth (ft)
3/18/2010	10.95	10.04	3.20	10.51	8.58	2.04
3/19/2010	10.15	10.35	2.92	10.38	8.52	2.08
3/20/2010	9.94	11.44	3.48	11.16	8.50	2.04
3/21/2010	8.88	13.34	5.46	11.59	8.41	1.96
3/22/2010	8.24	15.36	5.83	10.88	8.34	2.02
3/23/2010	8.62	16.76	4.96	9.77	8.36	2.46
3/24/2010	9.00	19.93	5.28	10.11	8.37	2.41
3/25/2010	8.64	18.46	9.65	10.46	8.33	2.18
3/26/2010	8.41	16.04	9.47	10.09	8.32	2.15
3/27/2010	9.39	14.92	5.51	9.72	8.44	2.26
3/28/2010	9.05	29.41	8.12	10.37	8.42	2.36
3/29/2010	7.92	104.14	19.09	10.62	8.13	4.09
3/30/2010	7.84	92.60	15.50	10.91	8.06	3.89
3/31/2010	8.16	51.93	9.76	11.23	8.15	3.26
4/1/2010	8.15	41.83	7.65	12.33	8.18	2.69
4/2/2010	8.08	34.85	6.28	13.90	8.21	2.42
4/3/2010	7.81	30.28	4.77	15.15	8.22	2.29
4/4/2010	7.86	28.96	4.22	16.05	8.25	2.20
4/5/2010	7.76	29.98	4.28	16.92	8.25	2.12
4/6/2010	7.39	32.11	4.38	18.18	8.22	2.06
4/7/2010	7.01	32.75	4.52	18.55	8.18	2.02

Table 2-A continued

Date	DO (mg/L)	Turbidity (NTU)	Chlorophyll *a* (mg/L)	Water Temperature (^{0}C)	pH	Depth (ft)
4/8/2010	6.51	34.60	5.72	17.71	8.12	2.06
4/9/2010	6.54	58.84	8.71	15.57	8.04	2.81
4/10/2010	7.13	68.95	9.16	14.57	8.08	3.22
4/11/2010	7.43	46.85	6.82	14.50	8.08	2.47
4/12/2010	7.63	34.54	4.58	15.03	8.13	2.23
4/13/2010	7.63	31.65	3.66	15.83	8.17	2.13
4/14/2010	7.35	32.89	3.57	16.71	8.14	2.02
4/15/2010	7.09	34.04	3.78	17.59	8.12	1.96
4/16/2010	6.75	34.31	4.06	18.34	8.09	1.91
4/17/2010	6.47	31.86	4.78	18.48	8.08	1.88
4/18/2010	6.72	29.94	3.99	17.08	8.11	1.84
4/19/2010	7.06	29.57	4.62	15.90	8.14	1.85
4/20/2010	6.98	28.91	4.97	15.24	8.12	1.82
4/21/2010	6.97	27.21	4.51	14.71	8.11	1.82
4/22/2010	7.21	27.72	4.59	14.66	8.15	1.89
4/23/2010	7.17	28.91	8.39	15.73	8.15	1.81
4/24/2010	6.67	29.52	11.74	16.78	8.08	1.79
4/25/2010	6.29	33.09	9.11	17.33	8.05	1.93
4/26/2010	6.03	34.71	6.35	17.27	8.02	2.02
4/27/2010	6.43	32.72	4.84	15.77	8.08	1.94
4/28/2010	6.69	33.04	4.75	14.58	8.09	1.97
4/29/2010	6.95	30.76	4.26	14.38	8.10	2.03
4/30/2010	7.05	30.67	3.54	15.05	8.13	1.88

Table 2-A continued

Date	DO (mg/L)	Turbidity (NTU)	Chlorophyll *a* (mg/L)	Water Temperature (^{0}C)	pH	Depth (ft)
5/1/2010	6.78	35.34	4.11	16.31	8.09	1.77
5/2/2010	6.32	38.42	3.73	18.10	8.06	1.69
5/3/2010	5.72	231.61	17.10	19.20	7.77	3.98
5/4/2010	5.59	214.97	17.07	19.43	7.69	5.70
5/5/2010	5.47	123.47	12.37	19.70	7.70	4.12
5/6/2010	5.73	67.13	7.94	19.45	7.83	2.47
5/7/2010	5.80	52.19	6.05	19.65	7.93	2.11
5/8/2010	5.74	46.25	4.74	19.82	8.00	1.91
5/9/2010	6.14	42.16	3.99	17.79	8.07	1.79
5/10/2010	6.55	40.09	4.17	16.15	8.11	1.73
5/11/2010	6.81	39.22	5.20	15.95	8.16	1.69
5/12/2010	6.60	37.95	5.69	17.02	8.13	1.68
5/13/2010	6.48	41.34	4.01	17.80	8.13	1.71
5/14/2010	6.21	43.29	3.59	19.07	8.10	1.68
5/15/2010	6.03	42.82	4.65	19.64	8.12	1.60
5/16/2010	5.78	43.95	10.11	20.06	8.10	1.54
5/17/2010	5.62	52.09	5.66	20.05	8.09	1.62
5/18/2010	5.81	58.43	9.18	19.86	8.09	1.88
5/19/2010	5.94	46.04	9.02	19.09	8.12	1.63
5/20/2010	6.04	48.40	10.05	18.18	8.09	1.56
5/21/2010	6.11	45.35	16.98	18.77	8.11	1.51
5/22/2010	6.04	46.20	14.80	19.14	8.13	1.53
5/23/2010	5.99	44.95	7.80	19.90	8.15	1.51

Table 2-A continued						
Date	**DO (mg/L)**	**Turbidity (NTU)**	**Chlorophyll *a* (mg/L)**	**Water Temperature (^{0}C)**	**pH**	**Depth (ft)**
5/24/2010	5.95	44.68	6.77	20.48	8.15	1.55
5/25/2010	5.94	43.78	4.11	20.76	8.18	1.50
5/26/2010	5.85	40.08	4.76	20.66	8.16	1.40
5/27/2010	5.79	39.49	3.30	20.60	8.17	1.38
5/28/2010	5.61	42.61	3.74	20.76	8.12	1.43
5/29/2010	5.46	75.14	6.17	20.59	8.06	1.75
5/30/2010	5.32	68.66	6.30	21.10	7.97	1.89
5/31/2010	5.71	49.84	4.11	21.62	8.13	1.62
6/1/2010	5.76	62.40	7.10	21.54	8.09	1.87
6/2/2010	5.62	67.82	6.54	21.60	8.02	1.87
6/3/2010	5.47	70.39	6.58	22.03	7.99	1.79
6/4/2010	5.28	55.22	6.12	22.51	8.00	1.55
6/5/2010	5.20	47.82	5.23	22.65	8.04	1.44
6/6/2010	5.16	45.01	5.22	22.94	8.04	1.42
6/7/2010	5.34	41.95	4.19	21.97	8.08	1.37
6/8/2010	5.59	41.68	4.29	21.53	8.10	1.44
6/9/2010	5.73	46.61	4.64	21.32	8.10	1.52
6/10/2010	5.72	50.07	4.91	21.20	8.09	1.61
6/11/2010	5.63	53.67	4.89	21.91	8.07	1.69
6/12/2010	5.43	47.97	4.68	22.74	8.04	1.61
6/13/2010	5.32	44.84	4.22	23.49	8.05	1.51
6/14/2010	5.17	42.96	3.98	24.23	8.07	1.46
6/15/2010	5.19	42.39	4.20	24.18	8.08	1.48

Table 2-A continued

Date	DO (mg/L)	Turbidity (NTU)	Chlorophyll *a* (mg/L)	Water Temperature (^{0}C)	pH	Depth (ft)
6/16/2010	5.32	49.66	4.55	23.94	8.09	1.61
6/17/2010	5.30	48.55	4.17	24.35	8.12	1.50
6/18/2010	5.36	44.60	3.74	23.93	8.13	1.45
6/19/2010	5.21	47.47	4.34	23.92	8.07	1.35
6/20/2010	5.12	47.51	4.15	24.04	8.05	1.33
6/21/2010	5.07	47.92	4.47	24.12	8.04	1.29
6/22/2010	5.04	45.35	4.36	24.17	8.06	1.24
6/23/2010	4.98	43.93	4.16	24.80	8.06	1.24
6/24/2010	4.84	41.60	4.04	25.07	8.08	1.21
6/25/2010	4.75	40.49	3.85	24.97	8.09	1.21
6/26/2010	4.61	42.33	3.88	25.19	8.07	1.20
6/27/2010	4.48	42.83	4.19	25.57	8.06	1.20
6/28/2010	4.55	42.59	4.09	25.64	8.07	1.21
6/29/2010	4.52	40.93	4.13	25.39	8.07	1.21
6/30/2010	4.69	41.32	4.21	24.79	8.07	1.21
7/1/2010	5.03	41.80	3.90	23.92	8.11	1.20
7/2/2010	5.30	43.28	3.91	22.66	8.13	1.18
7/3/2010	5.30	43.82	4.04	22.80	8.12	1.15
7/4/2010	5.23	95.79	4.31	23.19	8.11	1.15
7/5/2010	5.22	42.43	3.79	23.58	8.12	1.14
7/6/2010	5.12	40.23	3.93	24.00	8.11	1.13
7/7/2010	5.06	40.28	4.05	24.24	8.10	1.12
7/8/2010	5.00	38.79	3.90	24.80	8.11	1.11

Table 2-A continued						
Date	**DO (mg/L)**	**Turbidity (NTU)**	**Chlorophyll *a* (mg/L)**	**Water Temperature (^{0}C)**	**pH**	**Depth (ft)**
7/9/2010	4.82	38.66	4.37	24.88	8.06	1.11
7/10/2010	4.75	39.60	4.27	24.73	8.05	1.26
7/11/2010	5.05	36.34	3.72	24.45	8.09	1.22
7/12/2010	4.70	43.01	4.90	24.09	7.97	1.20
7/13/2010	4.65	221.26	16.10	23.73	7.67	2.57
7/14/2010	4.52	88.56	11.37	24.08	7.62	1.67
7/15/2010	4.91	55.01	7.26	24.39	7.83	1.65
7/16/2010	4.99	44.15	5.31	25.03	7.92	1.53
7/17/2010	4.78	40.70	5.21	25.33	7.95	1.25
7/18/2010	4.70	42.18	4.85	25.32	7.98	1.19
7/19/2010	4.64	62.81	6.20	24.90	7.89	1.35
7/20/2010	4.63	130.96	10.43	24.79	7.74	2.54
7/21/2010	4.92	110.70	10.33	24.43	7.78	2.15
7/22/2010	4.69	60.58	7.97	24.73	7.75	1.65
7/23/2010	4.65	52.08	7.09	25.19	7.77	1.47
7/24/2010	4.49	50.17	6.09	25.89	7.80	1.35
7/25/2010	4.24	47.65	5.60	26.87	7.83	1.25
7/26/2010	4.10	47.24	5.27	26.98	7.85	1.20
7/27/2010	4.13	45.33	5.78	26.47	7.88	1.21
7/28/2010	4.42	43.75	5.07	26.44	7.96	1.21
7/29/2010	4.40	44.58	5.40	25.99	7.94	1.21
7/30/2010	4.79	38.80	3.70	26.04	8.16	1.41
7/31/2010	4.70	41.13	4.88	25.40	7.98	1.44

Table 2-A continued

Date	DO (mg/L)	Turbidity (NTU)	Chlorophyll *a* (mg/L)	Water Temperature (^{0}C)	pH	Depth (ft)
8/1/2010	4.74	96.26	7.33	24.81	7.95	1.88
8/2/2010	4.44	127.74	14.31	24.47	7.61	1.99
8/3/2010	4.40	65.23	11.13	25.43	7.66	1.51
8/4/2010	4.60	44.02	6.34	25.91	7.87	1.29
8/5/2010	4.31	42.26	5.85	26.55	7.87	1.20
8/6/2010	4.34	41.28	6.06	25.70	7.87	1.21
8/7/2010	4.65	39.02	4.93	25.45	7.96	1.24
8/8/2010	4.86	40.46	4.73	24.78	7.97	1.27
8/9/2010	4.74	39.43	4.68	24.98	7.97	1.18
8/10/2010	4.71	42.06	4.74	25.51	7.97	1.18
8/11/2010	4.76	40.60	5.22	26.09	7.97	1.33
8/12/2010	4.58	40.11	5.22	26.56	7.99	1.21
8/13/2010	4.38	46.57	5.45	26.47	7.92	1.17
8/14/2010	4.31	47.67	6.50	26.50	7.91	1.14
8/15/2010	4.46	41.80	6.87	26.66	7.96	1.24
8/16/2010	4.29	40.77	9.19	26.67	7.93	1.21
8/17/2010	4.27	55.73	10.77	25.78	7.86	1.67
8/18/2010	4.02	46.80	11.26	25.08	7.69	1.45
8/19/2010	4.18	57.89	10.76	24.50	7.69	1.46
8/20/2010	4.46	46.55	7.47	24.81	7.78	1.55
8/21/2010	4.61	71.10	9.01	24.72	7.82	2.14
8/22/2010	5.03	49.81	6.35	24.44	7.93	1.70
8/23/2010	4.87	58.31	8.69	24.15	7.79	1.79

Table 2-A continued

Date	DO (mg/L)	Turbidity (NTU)	Chlorophyll *a* (mg/L)	Water Temperature (^{0}C)	pH	Depth (ft)
8/24/2010	5.14	56.05	8.59	23.40	7.84	1.82
8/25/2010	5.19	46.91	7.06	23.01	7.91	1.44
8/26/2010	5.18	46.10	6.26	22.87	7.93	1.31
8/27/2010	5.13	44.07	5.56	23.08	7.94	1.25
8/28/2010	5.06	42.42	8.60	23.31	7.95	1.21
8/29/2010	4.94	45.54	6.02	23.47	7.93	1.18
8/30/2010	4.76	43.70	6.46	23.50	7.90	1.17
8/31/2010	4.89	44.60	7.32	23.21	7.93	1.20
9/1/2010	5.08	42.94	7.83	22.92	7.97	1.19
9/2/2010	5.21	39.52	8.82	22.56	8.01	1.12
9/3/2010	5.11	39.01	11.61	22.52	7.99	1.12
9/4/2010	5.00	34.50	23.98	21.72	8.00	1.11
9/5/2010	5.26	33.26	22.53	19.96	8.03	1.10
9/6/2010	5.46	35.19	16.51	19.23	8.02	1.09
9/7/2010	5.50	43.17	64.30	19.72	8.01	1.08
9/8/2010	5.22	42.90	37.91	20.59	7.94	1.11
9/9/2010	5.20	42.47	13.85	20.93	7.95	1.26
9/10/2010	5.24	44.00	15.83	20.78	7.96	1.20
9/11/2010	5.27	48.03	12.81	20.43	7.92	1.23
9/12/2010	5.13	44.72	8.99	21.00	7.91	1.35
9/13/2010	5.30	41.74	9.67	20.17	7.92	1.41
9/14/2010	5.49	40.83	15.35	19.88	7.91	1.43
9/15/2010	5.59	39.96	21.78	20.22	7.96	1.25

Table 2-A continued						
Date	**DO (mg/L)**	**Turbidity (NTU)**	**Chlorophyll *a* (mg/L)**	**Water Temperature (^{0}C)**	**pH**	**Depth (ft)**
9/16/2010	5.39	41.57	19.10	20.59	7.95	1.16
9/17/2010	5.00	40.72	14.50	21.24	7.92	1.14
9/18/2010	4.86	38.67	14.40	21.09	7.92	1.13
9/19/2010	5.00	39.10	15.33	20.95	7.91	1.17
9/20/2010	5.07	38.95	27.93	21.25	7.91	1.20
9/21/2010	4.94	39.41	25.07	21.38	7.90	1.15
9/22/2010	4.68	40.13	40.73	21.88	7.86	1.12
9/23/2010	4.67	38.41	51.30	21.91	7.89	1.09
9/24/2010	4.70	38.85	15.71	21.94	7.89	1.07
9/25/2010	4.43	39.18	12.08	21.66	7.84	1.07
9/26/2010	4.28	39.15	9.34	20.93	7.82	1.09
9/27/2010	4.29	38.44	5.28	19.95	7.83	1.14
9/28/2010	4.91	35.55	5.22	19.09	7.88	1.32
9/29/2010	5.47	34.58	4.10	18.42	7.93	1.37
9/30/2010	5.33	34.60	4.43	18.75	7.89	1.32
10/1/2010	5.46	22.44	3.71	18.21	7.94	1.25
10/2/2010	5.80	22.29	3.60	16.91	8.00	1.20
10/3/2010	5.76	23.01	4.08	15.70	7.95	1.17
10/4/2010	6.37	20.99	3.70	14.17	8.02	1.17
10/5/2010	6.83	20.56	3.47	13.28	8.06	1.15
10/6/2010	7.25	19.73	2.98	12.74	8.12	1.15
10/7/2010	7.32	20.19	2.93	12.93	8.12	1.14
10/8/2010	7.14	23.92	3.49	13.80	8.10	1.14

Table 2-A continued

Date	DO (mg/L)	Turbidity (NTU)	Chlorophyll *a* (mg/L)	Water Temperature (^{0}C)	pH	Depth (ft)
10/9/2010	6.97	26.89	3.12	14.04	8.08	1.14
10/10/2010	6.84	20.95	3.00	14.34	8.06	1.14
10/11/2010	6.69	19.52	3.02	14.79	8.03	1.12
10/12/2010	6.40	21.53	3.16	14.95	7.98	1.12
10/13/2010	6.02	26.96	3.27	15.82	7.95	1.13
10/14/2010	5.46	25.84	3.30	16.51	7.91	1.18
10/15/2010	5.50	19.59	3.09	14.56	7.92	1.15
10/16/2010	6.31	28.98	3.11	13.12	8.01	1.28
10/17/2010	6.65	128.27	4.71	12.72	8.01	1.27
10/18/2010	6.67	104.30	4.93	12.61	7.99	1.22
10/19/2010	6.55	22.69	4.87	13.00	7.99	1.19
10/20/2010	6.43	25.96	5.31	14.09	7.96	1.27
10/21/2010	6.58	19.50	6.56	13.49	7.99	1.33
10/22/2010	6.77	16.32	7.54	12.79	8.00	1.33
10/23/2010	7.24	13.30	8.31	11.90	8.02	1.34
10/24/2010	7.40	16.02	10.64	12.35	8.02	1.34
10/25/2010	6.59	21.29	8.88	13.70	7.91	1.38
10/26/2010	5.69	22.22	8.30	14.98	7.82	1.44
10/27/2010	5.08	46.09	10.74	16.18	7.70	1.94
10/28/2010	4.88	97.56	18.87	16.19	7.58	3.29
10/29/2010	5.57	68.75	11.02	15.08	7.64	2.56
10/30/2010	6.15	26.92	9.69	13.20	7.72	1.78
10/31/2010	6.63	21.44	11.18	12.07	7.77	1.54

Table 2-A continued

Date	DO (mg/L)	Turbidity (NTU)	Chlorophyll *a* (mg/L)	Water Temperature (^{0}C)	pH	Depth (ft)
11/1/2010	7.05	17.43	11.03	11.66	7.83	1.43
11/2/2010	7.27	16.60	9.56	12.08	7.88	1.38
11/3/2010	7.27	15.00	6.57	12.19	7.92	1.34
11/4/2010	7.10	16.08	5.18	12.27	7.91	1.50
11/5/2010	7.00	20.00	6.17	11.09	7.89	2.16
11/6/2010	7.48	17.91	5.76	10.09	7.95	2.25
11/7/2010	8.25	13.78	5.53	8.50	8.03	1.85
11/8/2010	8.85	10.91	4.53	7.65	8.12	1.62
11/9/2010	8.96	11.13	4.76	7.57	8.11	1.51
11/10/2010	9.07	11.47	4.75	7.78	8.12	1.47
11/11/2010	9.19	10.98	4.46	8.01	8.14	1.41
11/12/2010	9.31	10.69	4.36	8.15	8.18	1.39
11/13/2010	9.42	10.18	4.54	8.37	8.20	1.38
11/14/2010	9.35	12.47	6.59	8.61	8.21	1.37
11/15/2010	8.77	25.76	6.85	9.29	8.16	1.33
11/16/2010	8.58	12.56	8.17	10.19	8.14	1.44
11/17/2010	8.29	12.93	8.05	10.72	8.13	1.77
11/18/2010	8.11	15.77	15.31	10.03	8.05	2.18
11/19/2010	8.32	13.56	31.09	10.04	8.07	1.95
11/20/2010	8.78	12.06	18.23	9.40	8.13	1.71
11/21/2010	9.00	11.63	13.38	9.51	8.16	1.56
11/22/2010	9.06	12.04	12.88	9.64	8.16	1.49
11/23/2010	8.67	12.68	15.09	9.94	8.15	1.46

Table 2-A continued

Date	DO (mg/L)	Turbidity (NTU)	Chlorophyll *a* (mg/L)	Water Temperature (^{0}C)	pH	Depth (ft)
11/24/2010	8.76	11.86	13.41	10.18	8.18	1.48
11/25/2010	8.79	12.03	9.24	11.18	8.20	1.50
11/26/2010	7.97	13.55	24.19	11.84	8.15	1.59
11/27/2010	8.13	13.11	37.14	9.34	8.10	1.80
11/28/2010	8.88	11.60	39.97	7.60	8.15	1.95
11/29/2010	9.52	9.61	58.43	7.12	8.23	1.84
11/30/2010	8.89	21.63	66.93	8.64	8.18	1.80
12/1/2010	7.15	205.23	31.71	10.11	7.55	6.14
12/2/2010	7.47	111.43	21.03	7.60	7.51	6.58
12/3/2010	8.13	65.78	14.39	5.83	7.55	6.33
12/4/2010	8.67	35.92	9.12	5.58	7.74	3.11
12/5/2010	9.09	23.64	6.54	5.28	7.91	2.84
12/6/2010	9.52	18.40	5.58	4.40	8.02	2.76
12/7/2010	9.99	15.03	4.79	3.13	8.10	2.46
12/8/2010	10.52	12.07	4.15	1.92	8.18	2.23
12/9/2010	10.91	10.24	3.66	1.08	8.23	2.09
12/10/2010	11.05	8.95	3.35	1.23	8.25	1.99
12/11/2010	10.90	7.86	3.06	1.86	8.25	1.94
12/12/2010	10.33	7.96	3.11	2.79	8.22	1.98
12/13/2010	10.45	8.82	3.70	1.50	8.26	2.08
12/14/2010	11.07	8.84	4.04	0.36	8.30	2.11
12/15/2010	11.41	8.01	4.56	-0.07	8.31	2.15
12/16/2010	11.17	9.09	3.05	-0.06	8.24	2.10

Table 2-A continued						
Date	**DO (mg/L)**	**Turbidity (NTU)**	**Chlorophyll *a* (mg/L)**	**Water Temperature (^{0}C)**	**pH**	**Depth (ft)**
12/17/2010	10.79	87.55	13.41	0.56	7.96	4.97
12/18/2010	10.26	72.23	12.03	2.22	7.78	6.03
12/19/2010	9.73	41.19	8.99	3.59	7.78	4.66
12/20/2010	10.00	24.61	6.49	3.39	7.94	3.22
12/21/2010	10.16	16.76	4.92	3.44	8.03	2.76
12/22/2010	10.16	12.52	4.00	3.91	8.10	2.58
12/23/2010	10.17	10.10	3.29	4.02	8.15	2.48
12/24/2010	10.33	8.68	3.10	3.56	8.19	2.34
12/25/2010	10.26	7.97	3.14	3.48	8.18	2.23
12/26/2010	10.50	7.56	2.97	2.85	8.24	2.22
12/27/2010	10.88	7.43	2.91	2.11	8.28	2.22
12/28/2010	11.32	7.45	2.78	1.14	8.30	2.14
12/29/2010	11.44	7.25	2.99	0.58	8.29	2.05
12/30/2010	11.46	6.79	3.16	1.00	8.28	2.01
12/31/2010	11.22	6.50	3.32	2.43	8.28	2.03
1/1/2011	10.30	10.97	4.50	4.49	8.19	2.19
1/2/2011	9.06	35.94	10.52	6.58	7.98	3.27
1/3/2011	9.13	33.46	9.87	5.94	7.98	3.45
1/4/2011	9.72	21.24	7.69	4.64	8.04	2.83
1/5/2011	10.18	16.09	7.14	3.37	8.08	2.48
1/6/2011	10.56	11.64	5.95	3.04	8.17	2.36
1/7/2011	10.44	10.10	5.76	3.16	8.17	2.40
1/8/2011	10.31	13.90	6.81	2.79	8.16	2.86

Table 2-A continued

Date	DO (mg/L)	Turbidity (NTU)	Chlorophyll *a* (mg/L)	Water Temperature (^{0}C)	pH	Depth (ft)
1/9/2011	10.80	16.66	6.59	1.33	8.18	3.09
1/10/2011	11.26	15.06	8.26	0.66	8.16	2.60
1/11/2011	11.41	12.69	8.24	0.73	8.17	2.39
1/12/2011	11.60	9.95	8.80	0.53	8.25	2.35
1/13/2011	11.97	8.53	8.41	0.20	8.30	2.28
1/14/2011	12.20	7.89	10.66	-0.05	8.33	2.31
1/15/2011	12.10	7.43	8.48	0.01	8.31	2.35
1/16/2011	11.88	7.26	10.09	0.51	8.30	2.27
1/17/2011	11.45	7.96	11.36	1.33	8.27	2.38
1/18/2011	11.09	8.40	13.62	2.30	8.24	2.47
1/19/2011	10.41	12.75	21.36	3.63	8.14	2.78
1/20/2011	10.27	13.77	19.58	4.20	8.14	3.03
1/21/2011	10.42	12.70	27.96	4.15	8.19	2.83
1/22/2011	10.86	11.73	37.40	3.22	8.25	2.64
1/23/2011	11.44	9.52	53.90	2.40	8.32	2.47
1/24/2011	11.77	8.35	61.74	2.54	8.35	2.34
1/25/2011	11.19	8.04	81.12	3.10	8.29	2.28

Table 3-A. Water quality parameters analyzed from the composite samples collected by the refrigerated sampler at Little Chucky Creek.

Table 3-A continued

Date	TSS (mg/L)	TN (mg/L)	TKN (mg/L)	Ammonia (mg/L)	% Ammonia	Organic N (mg/L)	% Organic N	NO_3^- +NO_2^- (mg/L)	% NO_3^- +NO_2^-	TP (mg/L)	PO_4 (mg/L)	TOC (mg/L)
10/30/2009	32.10	3.49	0.94	0.32	9.14	0.62	17.82	0.58	38.00	0.15	0.09	.
10/31/2009	23.50	2.65	0.82	0.27	10.08	0.55	20.81	0.41	69.00	0.13	0.04	.
11/1/2009	253.40	4.23	2.47	1.31	30.83	1.17	27.59	0.40	42.00	0.74	0.34	.
11/2/2009	86.50	4.13	1.45	0.59	14.25	0.87	20.92	0.61	65.00	0.31	0.11	.
11/3/2009	31.90	4.51	1.01	0.38	8.47	0.63	13.91	0.79	78.00	0.16	0.04	.
11/4/2009	27.40	4.29	0.66	0.20	4.73	0.46	10.72	0.82	85.00	0.11	0.02	.
11/5/2009	14.10	4.19	0.57	0.25	5.90	0.32	7.64	0.82	86.00	0.09	0.01	.
11/6/2009	19.80	4.24	0.72	0.23	5.45	0.49	11.53	0.79	83.00	0.10	0.02	.
11/7/2009	20.40	3.52	0.57	0.34	9.63	0.23	6.59	0.67	84.00	0.08	0.01	.
11/8/2009	17.30	3.29	0.53	0.20	6.17	0.33	9.88	0.62	84.00	0.08	0.01	.
11/9/2009	25.40	2.89	0.39	0.39	13.51	0.00	-0.14	0.56	87.00	0.07	0.01	.
11/10/2009	61.70	2.99	0.94	0.39	13.20	0.54	18.15	0.46	69.00	0.20	0.06	.
11/11/2009	315.10	5.68	3.22	0.39	6.93	2.83	49.78	0.56	43.00	1.33	0.69	.
11/12/2009	137.20	4.10	1.37	0.06	1.49	1.30	31.84	0.62	67.00	0.31	0.15	.
11/13/2009	60.70	8.96	4.05	0.06	0.61	4.00	44.59	1.11	55.00	0.27	0.13	.
11/14/2009	38.80	9.15	2.88	0.17	1.82	2.71	29.63	1.42	69.00	0.22	0.04	.
11/15/2009	23.60	17.25	10.17	0.19	1.12	9.98	57.83	1.60	41.00	0.70	0.03	.
11/16/2009	26.10	8.84	2.36	0.02	0.27	2.34	26.43	1.46	73.00	0.18	0.02	.
11/17/2009	28.90	9.49	2.70	0.17	1.75	2.54	26.73	1.53	72.00	0.11	0.02	.
11/18/2009	19.10	10.27	4.43	0.21	2.03	4.22	41.09	1.32	57.00	0.02	0.01	.

Table 3-A continued

Date	TSS (mg/L)	TN (mg/L)	TKN (mg/L)	Ammonia (mg/L)	% Ammonia	Organic N (mg/L)	% Organic N	NO_3^- +NO_2^- (mg/L)	% NO_3^- +NO_2^-	TP (mg/L)	PO_4 (mg/L)	TOC (mg/L)
11/19/2009	17.40	8.23	2.31	0.25	3.05	2.06	25.05	1.34	72.00	0.10	0.02	.
11/20/2009	45.20	12.75	2.64	0.00	0.00	2.64	20.71	2.28	79.00	0.21	0.02	.
11/21/2009	33.10	8.50	3.19	0.09	1.02	3.11	36.52	1.20	62.00	0.12	0.01	.
11/22/2009	20.60	6.93	1.90	0.16	2.32	1.74	25.09	1.14	73.00	0.24	0.00	.
11/23/2009	22.80	5.17	0.55	0.16	3.02	0.39	7.60	1.04	89.00	0.02	0.01	.
11/24/2009	21.00	4.29	0.52	0.19	4.36	0.33	7.78	0.85	88.00	0.08	0.00	.
11/25/2009	33.80	3.72	0.37	0.12	3.09	0.25	6.83	0.76	90.00	0.04	.	.
11/26/2009	29.90	3.48	0.55	0.15	4.34	0.40	11.36	0.66	84.00	0.08	.	.
11/27/2009	19.20	3.57	0.53	0.15	4.24	0.37	10.49	0.69	85.00	0.07	.	.
11/28/2009	31.20	4.47	1.16	0.17	3.82	0.99	22.19	0.75	74.00	0.14	.	.
11/29/2009	11.40	3.43	0.44	0.17	4.98	0.27	7.92	0.68	87.00	0.05	.	.
11/30/2009	23.30	3.60	0.55	0.20	5.53	0.35	9.75	0.69	85.00	0.07	.	.
12/9/2009	40.70	2.15	0.60	0.47	22.06	0.13	5.82	0.35	72.00	0.26	0.22	7.35
12/10/2009	26.40	3.88	0.55	0.39	10.17	0.15	3.90	0.75	86.00	0.15	0.13	6.05
12/11/2009	112.80	5.10	0.65	0.41	8.04	0.24	4.65	1.00	87.00	0.16	0.12	6.80
12/12/2009	102.60	8.92	3.89	0.24	2.72	3.65	40.90	1.14	56.00	0.48	0.17	12.92
12/13/2009	46.10	6.41	0.56	0.34	5.23	0.22	3.47	1.32	91.00	0.14	0.08	3.09
12/14/2009	60.90	4.01	0.55	0.39	9.84	0.15	3.77	0.78	86.00	0.14	0.09	5.47
12/15/2009	36.60	4.18	0.48	0.31	7.34	0.18	4.23	0.84	88.00	0.12	0.07	5.07
12/16/2009	23.00	4.94	0.53	0.28	5.65	0.25	4.98	1.00	89.00	0.11	0.07	3.54
12/17/2009	25.10	5.32	0.52	0.25	4.72	0.27	5.04	1.08	90.00	0.12	0.06	3.20
12/18/2009	296.70	4.81	0.48	0.35	7.19	0.14	2.87	0.98	90.00	0.21	0.16	3.56

Table 3-A continued

Date	TSS (mg/L)	TN (mg/L)	TKN (mg/L)	Ammonia (mg/L)	% Ammonia	Organic N (mg/L)	% Organic N	NO_3^- +NO_2^- (mg/L)	% NO_3^- +NO_2^-	TP (mg/L)	PO_4 (mg/L)	TOC (mg/L)
12/19/2009	348.50	2.42	0.76	0.49	20.07	0.28	11.36	0.37	69.00	0.41	0.41	7.31
12/20/2009	164.40	3.22	0.52	0.37	11.49	0.15	4.63	0.61	84.00	0.19	0.17	5.39
12/21/2009	109.70	4.28	0.51	0.33	7.74	0.18	4.16	0.85	88.00	0.18	0.12	4.14
12/22/2009	26.00	5.49	0.54	0.27	4.94	0.27	4.83	1.12	90.00	0.15	0.13	2.86
12/23/2009	10.10	5.82	0.33	0.26	4.38	0.08	1.31	1.24	94.00	0.12	0.11	3.67
12/24/2009	14.50	5.67	0.36	0.28	4.85	0.09	1.50	1.20	94.00	0.14	0.10	2.96
12/25/2009	16.40	5.95	0.46	0.24	3.95	0.22	3.72	1.24	92.00	0.16	0.12	2.83
12/26/2009	23.50	6.41	0.42	0.25	3.92	0.17	2.58	1.35	94.00	0.14	0.09	7.02
12/27/2009	154.60	2.32	1.32	0.27	11.69	1.05	45.17	0.23	43.00	0.28	0.12	2.85
12/28/2009	18.90	5.36	0.40	0.26	4.76	0.15	2.74	1.12	93.00	0.13	0.06	2.69
12/29/2009	17.20	5.57	0.39	0.28	4.94	0.11	2.03	1.17	93.00	0.12	0.07	2.56
12/31/2009	9.20	6.76	0.51	0.23	3.42	0.28	4.08	1.41	92.00	0.18	0.15	2.93
1/1/2010	12.30	6.14	0.50	0.23	3.70	0.27	4.40	1.27	92.00	0.32	0.28	3.10
.	.	.	.	.	.	.	.	.	.		.	.
1/20/2010	-0.80	7.68	0.68	0.26	3.37	0.42	5.47	1.58	91.00	0.01	.	4.07
1/21/2010	179.20	6.40	1.09	0.39	6.03	0.70	10.97	1.20	83.00	0.18	0.17	9.03
.	.	.	.	.	.	.	.	.	.	.	.	.
2/5/2010	246.00	3.78	1.06	0.50	13.28	0.56	14.78	0.61	72.00	0.66	0.52	5.02
2/6/2010	249.70	3.20	1.18	1.67	52.08	-0.49	-15.22	0.46	63.00	0.18	0.17	4.74
2/7/2010	258.20	4.31	0.93	1.09	25.20	-0.16	-3.62	0.76	78.00	0.14	.	5.07
2/8/2010	184.20	5.46	0.95	0.45	8.25	0.50	9.07	1.02	83.00	0.08	.	3.23
2/9/2010	153.20	5.46	0.74	0.28	5.11	0.47	8.51	1.07	86.00	0.05	.	2.40

Table 3-A continued

Date	TSS (mg/L)	TN (mg/L)	TKN (mg/L)	Ammonia (mg/L)	% Ammonia	Organic N (mg/L)	% Organic N	NO_3^- +NO_2^- (mg/L)	% NO_3^- +NO_2^-	TP (mg/L)	PO_4 (mg/L)	TOC (mg/L)
2/11/2010	208.60	8.39	2.77	0.20	2.42	2.57	30.62	1.27	67.00	0.41	0.22	8.94
2/12/2010	71.90	6.79	1.67	0.22	3.17	1.46	21.44	1.16	75.00	0.14	0.06	3.37
2/13/2010	90.20	6.29	1.39	0.30	4.69	1.09	17.38	1.11	78.00	0.22	0.22	6.92
2/14/2010	80.90	5.48	0.85	0.29	5.31	0.56	10.27	1.05	84.00	0.07	.	5.08
2/15/2010	63.10	5.34	0.80	0.18	3.37	0.62	11.61	1.03	85.00	.	.	2.56
.	.	.	.	.	.	.	.	.	.	.	.	.
2/19/2010	36.60	3.47	0.55	0.91	26.16	-0.35	-10.20	0.66	84.00	0.08	0.05	2.99
2/20/2010	11.70	4.03	0.57	0.24	6.03	0.33	8.12	0.78	86.00	0.04	0.02	2.06
2/21/2010	8.60	4.45	1.47	0.34	7.71	1.13	25.38	0.67	67.00	0.02	0.01	2.25
2/22/2010	4.60	3.39	0.74	0.31	9.18	0.43	12.70	0.60	78.00	0.04	0.01	1.74
2/23/2010	6.40	3.19	0.60	0.28	8.76	0.32	9.99	0.58	81.00	0.04	0.00	1.74
2/24/2010	6.30	3.57	0.55	0.31	8.71	0.24	6.71	0.68	85.00	0.03	0.00	1.87
2/25/2010	6.50	3.68	0.61	0.24	6.49	0.37	10.01	0.69	83.00	0.04	0.00	2.21
2/26/2010	84.90	16.10	13.16	0.53	3.29	12.63	78.48	0.66	18.00	8.50	5.37	70.71
2/27/2010	6.30	3.58	0.62	0.24	6.56	0.39	10.87	0.67	83.00	0.07	0.02	1.72
2/28/2010	2.50	3.44	0.59	0.23	6.71	0.36	10.45	0.64	83.00	0.03	0.03	1.72
3/1/2010	0.50	3.56	0.66	0.26	7.27	0.40	11.22	0.66	82.00	0.04	0.01	2.00
3/2/2010	5.80	3.27	0.54	0.23	6.94	0.31	9.52	0.62	84.00	0.02	0.00	1.90
3/3/2010	5.90	3.43	0.62	0.22	6.38	0.41	11.81	0.63	82.00	0.03	.	2.00
.	.	.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.	.	.
.	.	.	.	.	.	.	.	.	.	.	.	.

Table 3-A continued

Date	TSS (mg/L)	TN (mg/L)	TKN (mg/L)	Ammonia (mg/L)	% Ammonia	Organic N (mg/L)	% Organic N	NO_3^- +NO_2^- (mg/L)	% NO_3^- +NO_2^-	TP (mg/L)	PO_4 (mg/L)	TOC (mg/L)
3/5/2010	6.10	3.08	0.33	0.31	9.98	0.03	0.90	0.62	89.00	0.06	.	1.99
3/6/2010	4.30	2.93	0.37	0.18	6.25	0.19	6.34	0.58	87.00	0.08	0.01	2.20
3/7/2010	6.00	2.88	0.43	0.37	12.84	0.06	2.02	0.55	85.00	0.06	0.01	2.62
3/8/2010	52.70	2.88	0.57	0.32	11.08	0.25	8.58	0.52	80.00	0.10	0.03	3.55
3/9/2010	38.30	3.35	1.29	0.36	10.69	0.94	27.91	0.46	61.00	2.24	1.74	34.69
3/10/2010	21.30	1.96	0.13	0.39	19.94	-0.26	-13.37	0.41	93.00	2.40	1.97	42.52
3/11/2010	11.60	2.42	0.53	0.26	10.86	0.27	11.16	0.43	78.00	0.08	0.05	2.09
3/12/2010	15.90	2.74	0.52	0.26	9.32	0.26	9.67	0.50	81.00	0.08	0.03	2.63
3/13/2010	25.00	2.85	0.54	0.29	10.09	0.25	8.74	0.52	81.00	0.08	0.03	2.67
3/14/2010	18.40	2.45	0.58	0.29	11.88	0.29	11.68	0.42	76.00	0.07	0.03	3.13
3/15/2010	13.60	2.32	0.65	0.28	11.86	0.38	16.35	0.38	72.00	0.07	0.03	2.80
3/16/2010	17.20	2.44	0.67	0.29	11.75	0.38	15.62	0.40	73.00	0.08	0.03	2.27
3/17/2010	7.90	2.25	0.40	0.25	11.15	0.15	6.65	0.42	82.00	0.06	0.01	1.95
3/18/2010	6.20	2.78	0.38	0.23	8.15	0.15	5.51	0.54	86.00	0.05	0.01	1.98
.	.	.	.	.	.	.	.	.	.	.	.	.
3/19/2010	23.20	1.44	0.59	0.65	44.92	-0.06	-3.87	0.19	59.00	0.03	0.03	4.07
3/20/2010	16.20	2.36	0.54	0.18	7.64	0.36	15.28	0.41	77.00	0.04	0.03	2.52
3/21/2010	20.30	1.93	0.55	0.34	17.33	0.21	10.95	0.31	72.00	0.04	0.02	2.30
3/22/2010	20.40	1.45	0.50	0.20	14.01	0.30	20.36	0.21	66.00	0.04	0.01	2.66
3/23/2010	18.20	1.36	0.48	0.20	14.97	0.27	20.17	0.20	65.00	0.01	0.01	2.24
3/24/2010	28.80	1.94	0.57	0.28	14.14	0.29	15.03	0.31	71.00	0.04	0.01	1.74
3/25/2010	14.30	1.82	0.45	0.24	13.39	0.21	11.46	0.31	75.00	0.03	0.01	2.31

Table 3-A continued

Date	TSS (mg/L)	TN (mg/L)	TKN (mg/L)	Ammonia (mg/L)	% Ammonia	Organic N (mg/L)	% Organic N	NO_3^- +NO_2^- (mg/L)	% NO_3^- +NO_2^-	TP (mg/L)	PO_4 (mg/L)	TOC (mg/L)
3/26/2010	18.30	1.41	0.47	0.23	16.40	0.24	17.01	0.21	67.00	0.01	0.01	2.43
3/27/2010	14.90	1.39	0.48	0.22	15.76	0.26	19.00	0.20	65.00	0.01	0.01	1.80
3/28/2010	21.70	11.49	10.36	0.27	2.36	10.09	87.79	0.26	10.00	2.38	.	33.53
3/29/2010	16.20	1.90	0.57	0.25	13.02	0.32	17.12	0.30	70.00	0.03	0.03	2.44
3/30/2010	232.90	2.43	0.90	0.42	17.23	0.48	19.70	0.35	63.00	0.11	0.07	5.50
3/31/2010	103.60	2.64	0.91	0.37	13.89	0.54	20.54	0.39	66.00	0.10	0.04	6.13
4/1/2010	42.20	2.13	0.67	0.27	12.53	0.40	18.97	0.33	69.00	0.07	0.02	3.89
.	.	.	.	.	.	.	.	.	.	.	.	.
4/2/2010	25.00	1.68	1.32	0.29	17.29	1.03	61.27	0.08	21.00	0.41	0.01	3.97
4/3/2010	19.70	1.89	1.42	0.28	15.00	1.14	60.53	0.10	24.00	0.38	0.01	3.67
4/4/2010	18.30	1.88	1.45	0.28	14.85	1.17	62.47	0.10	23.00	0.37	0.01	3.91
4/5/2010	33.80	1.48	1.19	0.29	19.41	0.90	61.04	0.07	20.00	0.40	0.02	3.37
4/6/2010	38.60	1.86	1.67	0.28	14.75	1.39	74.77	0.04	10.00	0.40	0.01	3.49
4/7/2010	51.30	1.68	1.44	0.28	16.81	1.16	68.96	0.05	14.00	0.36	0.02	2.94
4/8/2010	387.20	3.12	2.76	0.36	11.62	2.40	77.06	0.08	11.00	0.43	0.07	4.15
4/9/2010	1224.00	9.12	7.51	1.60	17.57	5.90	64.73	0.36	18.00	1.79	0.17	10.42
4/10/2010	147.10	3.91	2.76	0.37	9.35	2.39	61.08	0.26	30.00	0.46	0.06	6.21
4/11/2010	94.50	2.75	2.03	0.32	11.59	1.71	62.26	0.16	26.00	0.40	0.03	4.56
4/12/2010	57.20	2.05	1.64	0.30	14.39	1.34	65.55	0.09	20.00	0.41	0.02	3.48
4/13/2010	95.50	2.17	1.94	0.29	13.39	1.65	75.89	0.05	11.00	0.43	0.04	3.39
4/14/2010	103.90	2.06	1.90	0.28	13.73	1.62	78.62	0.04	8.00	0.40	0.03	3.44
4/15/2010	69.60	1.82	1.57	0.31	17.06	1.26	68.89	0.06	14.00	0.46	0.05	3.15

Table 3-A continued

Date	TSS (mg/L)	TN (mg/L)	TKN (mg/L)	Ammonia (mg/L)	% Ammonia	Organic N (mg/L)	% Organic N	NO_3^- +NO_2^- (mg/L)	% NO_3^- +NO_2^-	TP (mg/L)	PO_4 (mg/L)	TOC (mg/L)
.	.	.	.	.	.	.	.	.	.	.	.	.
4/16/2010	61.70	1.87	1.53	0.47	24.94	1.06	56.80	0.08	18.00	0.15	0.05	3.73
4/17/2010	47.80	1.91	1.51	0.34	17.53	1.17	61.38	0.09	21.00	0.15	0.02	2.72
4/18/2010	78.70	2.10	1.52	0.31	14.79	1.21	57.42	0.13	28.00	0.19	0.03	2.50
4/19/2010	41.90	1.78	1.25	0.41	23.23	0.84	47.03	0.12	30.00	0.12	0.01	2.05
4/20/2010	82.50	2.23	1.78	0.29	12.86	1.49	66.80	0.10	20.00	0.19	0.03	2.47
4/21/2010	92.80	2.66	1.78	0.30	11.10	1.49	55.99	0.20	33.00	0.17	0.03	2.60
4/22/2010	72.30	3.06	1.88	0.30	9.78	1.58	51.64	0.27	39.00	0.17	0.02	2.28
4/23/2010	97.40	2.70	1.86	0.33	12.27	1.53	56.68	0.19	31.00	0.18	0.03	2.94
4/24/2010	73.90	2.85	2.02	0.32	11.20	1.70	59.57	0.19	29.00	0.20	0.02	2.65
4/25/2010	133.80	4.49	3.20	0.32	7.02	2.89	64.34	0.29	29.00	0.33	0.11	4.84
4/26/2010	78.00	3.15	1.38	0.32	10.14	1.06	33.82	0.40	56.00	0.19	0.03	2.49
4/27/2010	166.30	3.84	2.04	0.37	9.54	1.67	43.55	0.41	47.00	0.33	0.08	3.12
4/28/2010	291.80	4.58	2.43	0.42	9.13	2.01	43.90	0.49	47.00	0.38	0.08	3.96
.	.	.	.	.	.	.	.	.	.	.	.	.
4/29/2010	169.60	4.58	2.66	0.36	7.82	2.30	50.16	0.43	42.00	0.21	0.05	3.54
4/30/2010	77.40	3.59	1.90	0.65	18.10	1.25	34.98	0.38	47.00	0.13	0.05	4.29
5/1/2010	108.90	4.63	2.81	0.40	8.59	2.41	52.07	0.41	39.00	0.20	0.07	3.80
5/2/2010	170.30	5.49	3.47	0.43	7.90	3.03	55.17	0.46	37.00	0.27	0.10	4.15
5/3/2010	1642.00	14.39	12.92	2.00	13.93	10.92	75.91	0.33	10.00	2.39	0.24	8.19
5/4/2010	687.38	7.61	6.08	0.59	7.68	5.49	72.13	0.35	20.00	0.97	0.21	7.51
5/5/2010	273.89	5.95	3.74	0.45	7.63	3.29	55.26	0.50	37.00	0.43	0.13	5.38

Table 3-A continued

Date	TSS (mg/L)	TN (mg/L)	TKN (mg/L)	Ammonia (mg/L)	% Ammonia	Organic N (mg/L)	% Organic N	NO_3^- +NO_2^- (mg/L)	% NO_3^- +NO_2^-	TP (mg/L)	PO_4 (mg/L)	TOC (mg/L)
5/6/2010	219.90	6.21	3.49	0.53	8.46	2.96	47.72	0.61	44.00	0.40	0.17	4.68
5/7/2010	120.60	5.59	2.61	0.38	6.76	2.23	39.84	0.67	53.00	0.20	0.09	3.81
5/8/2010	126.80	5.98	2.75	0.33	5.47	2.42	40.48	0.73	54.00	0.23	0.08	3.33
5/9/2010	152.70	5.60	2.09	0.32	5.69	1.77	31.63	0.79	63.00	0.24	0.11	3.37
5/10/2010	148.00	5.60	2.40	0.32	5.77	2.07	37.06	0.72	57.00	0.22	0.09	2.89
5/11/2010	130.60	5.71	2.55	0.32	5.52	2.24	39.20	0.71	55.00	0.22	0.08	2.60
5/12/2010	131.60	5.45	2.63	0.30	5.48	2.33	42.81	0.64	52.00	0.22	0.08	2.83
.	.	.	.	.	.	.	.	.	.	.	.	.
5/13/2010	167.00	5.26	2.59	0.36	6.88	2.23	42.39	0.60	51.00	0.30	0.11	2.36
5/14/2010	128.40	4.79	2.22	0.30	6.16	1.92	40.15	0.58	54.00	0.26	0.10	2.28
5/15/2010	163.60	13.19	10.27	0.28	2.15	9.98	75.71	0.66	22.00	0.40	0.13	2.34
5/16/2010	532.91	9.77	6.75	0.43	4.40	6.32	64.70	0.68	31.00	1.06	0.23	3.91
5/17/2010	505.80	7.78	5.51	0.38	4.91	5.12	65.90	0.51	29.00	0.99	0.24	6.40
5/18/2010	195.60	4.96	2.84	0.33	6.60	2.51	50.64	0.48	43.00	0.35	0.15	4.81
5/19/2010	163.80	5.01	2.67	0.26	5.25	2.41	48.04	0.53	47.00	0.29	0.13	3.63
5/20/2010	112.00	4.18	1.75	0.23	5.43	1.52	36.45	0.55	58.00	0.20	0.12	2.54
5/21/2010	133.60	4.80	2.28	0.22	4.65	2.05	42.79	0.57	53.00	0.25	0.12	2.22
5/22/2010	144.00	5.17	2.68	0.24	4.54	2.45	47.32	0.56	48.00	0.30	0.12	2.30
5/23/2010	158.10	5.47	3.05	0.24	4.30	2.81	51.42	0.55	44.00	0.34	0.12	2.24
5/24/2010	137.90	18.33	15.77	0.25	1.35	15.52	84.68	0.58	14.00	0.24	0.12	1.97
5/25/2010	176.60	4.27	1.60	0.20	4.57	1.41	32.94	0.60	63.00	0.20	0.12	2.33
5/26/2010	208.20	4.98	2.42	0.37	7.35	2.05	41.22	0.58	51.00	0.32	0.10	1.63

Table 3-A continued

Date	TSS (mg/L)	TN (mg/L)	TKN (mg/L)	Ammonia (mg/L)	% Ammonia	Organic N (mg/L)	% Organic N	NO_3^- +NO_2^- (mg/L)	% NO_3^- +NO_2^-	TP (mg/L)	PO_4 (mg/L)	TOC (mg/L)
.	.	.	.	.	.	.	.	.	.	.	.	.
5/27/2010	178.20	5.42	2.46	0.45	8.22	2.02	37.22	0.67	55.00	0.30	0.10	3.16
5/28/2010	517.43	7.57	4.67	0.53	6.99	4.15	54.75	0.65	38.00	0.90	0.20	5.17
5/29/2010	309.90	6.25	3.55	0.44	7.01	3.12	49.88	0.61	43.00	0.53	0.14	5.35
5/30/2010	216.20	4.95	2.71	0.40	8.04	2.31	46.60	0.51	45.00	0.32	0.10	5.66
5/31/2010	180.20	5.09	3.10	0.36	7.04	2.74	53.88	0.45	39.00	0.31	0.09	4.58
6/1/2010	212.20	5.10	2.95	0.36	7.09	2.59	50.72	0.49	42.00	0.34	0.11	4.02
6/2/2010	215.30	5.26	2.83	0.37	7.03	2.46	46.71	0.55	46.00	0.38	0.10	2.90
6/3/2010	255.40	5.42	2.95	0.34	6.26	2.61	48.26	0.56	45.00	0.37	0.10	3.25
6/4/2010	267.60	5.60	3.13	0.34	6.13	2.79	49.79	0.56	44.00	0.38	0.11	3.03
6/5/2010	380.10	6.32	3.86	0.35	5.60	3.50	55.36	0.56	39.00	0.53	0.13	3.15
6/6/2010	382.50	5.95	3.53	0.37	6.28	3.15	52.99	0.55	41.00	0.58	0.15	3.07
6/7/2010	411.40	6.88	4.31	0.35	5.09	3.96	57.63	0.58	37.00	0.60	0.14	2.94
6/8/2010	291.60	6.26	3.77	0.34	5.35	3.43	54.77	0.56	40.00	0.45	0.11	2.65
6/9/2010	363.30	6.60	4.21	0.42	6.39	3.79	57.40	0.54	36.00	0.52	0.13	2.41
6/10/2010	267.80	3.28	2.55	0.49	15.08	2.05	62.63	0.16	22.00	0.52	0.18	4.63
6/11/2010	267.60	2.96	2.20	0.45	15.06	1.76	59.27	0.17	26.00	0.39	0.14	4.17
6/12/2010	83.20	2.69	2.15	0.35	13.03	1.80	66.87	0.12	20.00	0.43	0.11	4.18
6/13/2010	75.10	1.70	1.23	0.48	28.20	0.75	44.07	0.11	28.00	0.31	0.16	5.38
6/14/2010	84.00	5.22	3.98	0.35	6.78	3.62	69.45	0.28	24.00	0.62	0.13	4.38
6/15/2010	104.00	4.16	3.09	0.37	8.80	2.73	65.49	0.24	26.00	0.54	0.15	4.12
6/16/2010	75.20	2.80	2.01	0.46	16.49	1.55	55.32	0.18	28.00	0.36	0.14	4.38

Table 3-A continued

Date	TSS (mg/L)	TN (mg/L)	TKN (mg/L)	Ammonia (mg/L)	% Ammonia	Organic N (mg/L)	% Organic N	NO_3^- +NO_2^- (mg/L)	% NO_3^- +NO_2^-	TP (mg/L)	PO_4 (mg/L)	TOC (mg/L)
6/17/2010	93.90	11.71	2.18	0.30	2.55	1.88	16.06	2.15	81.00	0.36	0.13	4.14
6/18/2010	98.20	5.17	2.27	0.36	7.01	1.90	36.84	0.65	56.00	0.46	0.19	4.27
6/19/2010	68.40	3.23	2.25	0.34	10.63	1.90	59.00	0.22	30.00	0.41	0.13	3.90
6/20/2010	77.30	3.64	2.23	0.35	9.50	1.89	51.81	0.32	39.00	0.42	0.15	3.90
6/21/2010	104.20	2.87	1.76	0.31	10.85	1.45	50.42	0.25	39.00	0.38	0.18	3.67
6/22/2010	70.40	3.07	2.17	0.30	9.86	1.87	60.84	0.20	29.00	0.44	0.17	3.61
6/23/2010	91.60	2.15	1.45	0.28	12.78	1.18	54.69	0.16	33.00	0.30	0.13	3.58
6/25/2010	112.80	11.39	4.16	0.55	4.82	3.61	31.67	1.63	64.00	0.68	0.15	13.02
6/26/2010	108.50	4.77	1.94	0.52	10.91	1.42	29.81	0.64	59.00	0.27	0.08	4.34
6/27/2010	114.00	5.71	2.50	0.49	8.59	2.01	35.14	0.72	56.00	0.31	0.08	4.03
6/28/2010	143.50	7.83	3.56	0.48	6.11	3.08	39.35	0.96	55.00	0.33	0.11	3.42
6/29/2010	151.90	4.89	2.30	0.46	9.37	1.84	37.63	0.58	53.00	0.25	0.03	4.02
6/30/2010	148.80	4.61	2.21	0.53	11.56	1.68	36.39	0.54	52.00	0.23	0.03	3.92
7/1/2010	110.10	4.08	1.92	0.41	9.96	1.51	37.03	0.49	53.00	0.22	0.06	3.42
7/2/2010	126.00	5.94	1.77	0.47	7.98	1.29	21.79	0.94	70.00	0.29	0.01	2.79
7/3/2010	75.40	5.50	1.63	0.40	7.24	1.23	22.36	0.87	70.00	0.32	0.09	2.83
7/4/2010	68.50	5.47	1.34	0.38	6.91	0.96	17.56	0.93	76.00	0.33	0.10	4.35
7/5/2010	60.00	5.66	1.72	0.39	6.96	1.33	23.47	0.89	70.00	0.37	0.00	2.31
7/6/2010	75.60	5.42	1.77	0.40	7.35	1.37	25.26	0.82	67.00	0.32	0.00	3.14
7/7/2010	80.00	3.98	1.76	0.39	9.71	1.37	34.46	0.50	56.00	0.28	0.02	2.92
7/8/2010	116.10	3.25	1.94	0.50	15.47	1.43	44.16	0.30	40.00	0.17	0.09	3.58
7/9/2010	91.60	4.55	3.63	0.55	12.08	3.08	67.68	0.21	20.00	0.31	0.06	5.92

Table 3-A continued

Date	TSS (mg/L)	TN (mg/L)	TKN (mg/L)	Ammonia (mg/L)	% Ammonia	Organic N (mg/L)	% Organic N	NO_3^- +NO_2^- (mg/L)	% NO_3^- +NO_2^-	TP (mg/L)	PO_4 (mg/L)	TOC (mg/L)
7/10/2010	70.80	4.33	3.31	0.44	10.21	2.87	66.24	0.23	24.00	0.25	0.05	2.80
7/11/2010	83.80	4.43	3.47	0.45	10.25	3.01	68.07	0.22	22.00	0.25	0.05	4.22
7/12/2010	110.40	4.46	3.38	0.43	9.74	2.94	66.03	0.24	24.00	0.29	0.05	3.45
7/13/2010	297.63	8.09	6.01	0.50	6.21	5.51	68.08	0.47	26.00	0.71	0.10	5.29
7/14/2010	115.60	6.20	4.40	0.53	8.54	3.87	62.41	0.41	29.00	0.34	0.06	6.78
7/15/2010	99.50	5.48	3.94	0.37	6.82	3.57	65.08	0.35	28.00	0.32	0.05	6.64
7/16/2010	114.30	4.71	3.42	0.43	9.13	2.99	63.47	0.29	27.00	0.32	0.05	4.39
7/17/2010	117.80	5.64	4.60	0.38	6.78	4.22	74.78	0.23	18.00	0.43	0.05	3.88
7/18/2010	141.00	4.98	3.98	0.37	7.43	3.61	72.50	0.23	20.00	0.38	0.07	3.65
7/19/2010	222.82	4.69	3.45	0.40	8.56	3.05	65.02	0.28	26.00	0.32	0.10	4.50
7/20/2010	192.71	7.03	5.27	0.46	6.51	4.82	68.46	0.40	25.00	0.53	0.11	5.64
7/21/2010	106.80	3.02	1.76	0.45	14.78	1.31	43.45	0.28	42.00	0.14	0.06	4.97
7/22/2010	109.40	2.68	1.51	0.35	12.93	1.16	43.35	0.26	44.00	0.13	0.06	5.93
7/23/2010	158.00	8.16	6.42	0.64	7.81	5.78	70.84	0.39	21.00	0.43	0.09	7.19
7/24/2010	94.80	7.55	5.82	0.63	8.28	5.20	68.84	0.39	23.00	0.44	0.05	5.44
7/25/2010	99.50	3.29	1.60	0.49	14.91	1.11	33.70	0.38	51.00	0.05	0.05	5.05
7/26/2010	110.80	8.38	6.65	0.51	6.12	6.14	73.23	0.39	21.00	0.61	0.06	4.65
7/27/2010	124.70	10.52	8.67	0.45	4.28	8.22	78.15	0.42	18.00	0.71	0.06	4.21
7/28/2010	135.10	9.43	7.64	0.53	5.61	7.11	75.43	0.40	19.00	1.59	0.07	4.97
7/29/2010	142.50	9.02	6.98	0.49	5.39	6.49	71.95	0.46	23.00	0.69	0.07	4.56
7/30/2010	141.90	11.49	9.57	0.35	3.01	9.23	80.29	0.43	17.00	0.84	0.07	4.33
7/31/2010	133.80	10.09	8.30	0.33	3.24	7.97	78.99	0.40	18.00	0.71	0.06	3.92

Table 3-A continued

Date	TSS (mg/L)	TN (mg/L)	TKN (mg/L)	Ammonia (mg/L)	% Ammonia	Organic N (mg/L)	% Organic N	NO_3^- +NO_2^- (mg/L)	% NO_3^- +NO_2^-	TP (mg/L)	PO_4 (mg/L)	TOC (mg/L)
8/1/2010	471.13	15.00	12.59	0.42	2.81	12.17	81.14	0.54	16.00	1.76	0.15	4.63
8/2/2010	246.86	12.65	10.42	0.45	3.59	9.96	78.72	0.51	18.00	1.11	0.10	7.23
8/3/2010	167.50	11.05	9.03	0.37	3.39	8.65	78.35	0.46	18.00	0.91	0.09	7.27
8/4/2010	138.40	4.76	2.88	0.50	10.46	2.38	50.05	0.42	39.00	0.29	0.07	6.57
8/5/2010	95.20	4.67	2.61	0.36	7.75	2.25	48.08	0.47	44.00	0.24	0.07	6.13
8/6/2010	113.40	4.45	2.11	0.67	15.12	1.44	32.45	0.53	52.00	0.18	0.10	6.50
8/7/2010	94.90	4.83	1.68	0.55	11.37	1.13	23.47	0.71	65.00	0.14	0.08	4.46
8/8/2010	107.50	3.94	1.49	0.43	10.82	1.06	26.91	0.55	62.00	0.21	0.08	5.30
8/9/2010	124.80	4.13	2.09	0.52	12.51	1.57	37.96	0.46	50.00	0.11	0.08	4.75
8/10/2010	110.40	3.44	1.74	0.53	15.28	1.22	35.46	0.38	49.00	0.12	0.08	5.20
8/11/2010	135.90	4.65	2.51	0.57	12.24	1.94	41.66	0.48	46.00	0.14	0.08	4.92
8/12/2010	150.40	4.35	2.12	0.59	13.62	1.53	35.06	0.50	51.00	0.21	0.08	4.82
8/13/2010	152.20	3.69	2.20	0.58	15.73	1.61	43.70	0.34	41.00	0.23	0.08	5.89
8/14/2010	163.60	3.54	2.25	0.50	14.18	1.75	49.45	0.29	36.00	0.22	0.08	5.75
8/15/2010	158.80	4.75	3.10	0.49	10.40	2.60	54.77	0.37	35.00	0.21	0.11	6.88
8/16/2010	152.50	4.18	2.56	0.47	11.16	2.09	50.11	0.37	39.00	0.12	0.09	4.42
8/17/2010	157.80	4.30	2.44	0.42	9.72	2.03	47.08	0.42	43.00	0.20	0.09	4.12
8/18/2010	103.10	4.21	1.58	0.42	10.01	1.16	27.44	0.60	63.00	0.11	0.08	3.73
8/19/2010	105.20	4.42	1.85	0.48	10.81	1.38	31.14	0.58	58.00	0.15	0.08	4.80
8/20/2010	87.30	3.96	2.04	1.14	28.70	0.90	22.83	0.43	48.00	0.27	0.02	6.01
8/21/2010	73.60	4.71	2.20	0.54	11.42	1.66	35.28	0.57	53.00	0.28	0.04	3.87
8/22/2010	77.10	3.25	1.72	0.60	18.58	1.11	34.30	0.35	47.00	0.26	0.03	5.30

Table 3-A continued

Date	TSS (mg/L)	TN (mg/L)	TKN (mg/L)	Ammonia (mg/L)	% Ammonia	Organic N (mg/L)	% Organic N	NO_3^- +NO_2^- (mg/L)	% NO_3^- +NO_2^-	TP (mg/L)	PO_4 (mg/L)	TOC (mg/L)
8/23/2010	69.90	3.76	1.73	0.56	14.87	1.17	31.17	0.46	54.00	0.24	0.03	6.10
8/24/2010	106.30	4.40	2.43	0.52	11.80	1.91	43.46	0.44	45.00	0.31	0.03	6.03
8/25/2010	59.30	3.91	2.33	0.49	12.43	1.85	47.27	0.36	40.00	0.34	0.02	5.34
8/26/2010	69.80	3.51	2.01	0.48	13.52	1.53	43.62	0.34	43.00	0.22	0.02	4.69
8/27/2010	79.80	3.44	2.21	0.46	13.51	1.75	50.88	0.28	36.00	0.89	0.02	4.60
8/28/2010	84.70	3.19	1.98	0.47	14.62	1.51	47.37	0.27	38.00	0.04	0.02	5.21
8/29/2010	93.20	3.40	2.15	0.46	13.42	1.69	49.84	0.28	37.00	0.04	0.02	5.95
8/30/2010	101.50	3.69	2.58	0.45	12.28	2.13	57.77	0.25	30.00	0.40	0.03	5.16
8/31/2010	84.00	2.51	1.48	0.45	17.94	1.03	40.99	0.23	41.00	0.17	0.03	4.68
9/1/2010	89.10	4.02	3.04	0.46	11.42	2.58	64.30	0.22	24.00	0.37	0.03	5.03
9/2/2010	149.80	3.79	2.80	0.59	15.50	2.21	58.36	0.22	26.00	0.44	0.04	5.93
9/3/2010	90.60	4.73	2.93	0.63	13.32	2.30	48.55	0.41	38.00	0.21	0.02	3.12
9/4/2010	146.20	10.31	9.48	0.63	6.11	8.85	85.89	0.19	8.00	0.88	0.43	6.90
9/5/2010	106.50	3.14	2.55	0.48	15.14	2.08	66.24	0.13	19.00	0.24	0.04	4.90
9/6/2010	75.20	3.16	2.61	0.45	14.25	2.16	68.47	0.12	17.00	0.20	0.03	4.07
9/7/2010	76.90	3.11	2.55	0.46	14.68	2.09	67.37	0.13	18.00	0.21	0.03	4.05
9/8/2010	71.00	2.76	2.30	0.58	21.03	1.72	62.20	0.10	17.00	0.20	0.03	4.41
9/9/2010	70.50	2.80	2.40	0.48	17.26	1.92	68.44	0.09	14.00	0.18	0.03	3.48
9/10/2010	86.90	3.54	2.94	0.49	13.74	2.46	69.50	0.13	17.00	0.20	0.02	3.21
9/11/2010	94.10	3.55	2.95	0.43	11.99	2.52	71.01	0.14	17.00	0.24	0.02	3.68
9/12/2010	93.70	4.40	3.63	0.40	9.12	3.22	73.36	0.17	18.00	0.30	0.03	3.66
9/13/2010	103.20	3.91	2.56	0.41	10.48	2.15	55.06	0.30	34.00	0.20	0.02	4.02

Table 3-A continued

Date	TSS (mg/L)	TN (mg/L)	TKN (mg/L)	Ammonia (mg/L)	% Ammonia	Organic N (mg/L)	% Organic N	NO_3^- +NO_2^- (mg/L)	% NO_3^- +NO_2^-	TP (mg/L)	PO_4 (mg/L)	TOC (mg/L)
9/14/2010	33.60	3.67	1.98	0.42	11.48	1.56	42.50	0.38	46.00	0.15	0.02	3.44
9/15/2010	52.50	4.09	2.70	0.33	8.03	2.37	58.10	0.31	34.00	0.17	0.02	4.07
9/16/2010	44.90	3.41	2.36	0.32	9.39	2.04	59.83	0.24	31.00	0.17	0.02	6.58
9/17/2010	67.50	1.94	1.25	0.59	30.39	0.66	34.21	0.15	35.00	0.12	0.01	5.68
9/18/2010	42.90	1.98	1.34	0.53	26.82	0.81	40.77	0.14	32.00	0.11	0.01	4.02
9/19/2010	59.40	1.81	1.32	0.57	31.49	0.75	41.38	0.11	27.00	0.12	0.01	4.19
9/20/2010	40.00	1.58	0.99	0.53	33.59	0.45	28.63	0.14	38.00	0.07	0.01	3.76
9/21/2010	35.00	1.40	0.88	0.43	30.44	0.45	32.33	0.12	37.00	0.07	0.00	2.69
9/22/2010	44.40	1.31	0.98	0.46	34.88	0.53	40.22	0.07	25.00	0.10	0.01	3.98
9/23/2010	32.10	1.17	0.95	0.44	37.75	0.51	43.36	0.05	19.00	0.09	0.00	3.24
9/24/2010	44.70	1.22	1.07	0.51	41.39	0.57	46.49	0.03	12.00	0.12	0.00	4.77
9/25/2010	39.00	1.23	1.15	0.45	36.47	0.70	56.38	0.02	7.00	0.13	0.00	4.19
9/26/2010	41.30	1.12	1.03	0.43	37.92	0.60	53.52	0.02	9.00	0.11	0.00	3.74
9/27/2010	67.80	1.31	0.96	0.44	33.51	0.52	39.42	0.08	27.00	0.11	0.01	4.23
9/28/2010	48.20	2.09	1.08	0.45	21.43	0.63	30.11	0.23	48.00	0.12	0.01	3.99
9/29/2010	38.90	2.04	1.06	0.44	21.70	0.62	30.49	0.22	48.00	0.11	0.00	4.12
9/30/2010	35.80	1.57	1.08	0.51	32.77	0.57	36.41	0.11	31.00	0.11	0.00	4.65
10/2/2010	31.90	1.62	1.34	0.83	51.12	0.51	31.55	0.06	17.00	0.14	0.03	6.85
10/3/2010	26.50	1.65	1.19	0.51	30.99	0.68	41.02	0.10	28.00	0.11	0.03	4.78
10/4/2010	29.20	1.48	1.09	0.67	45.40	0.42	28.61	0.09	26.00	0.09	0.02	3.83
10/5/2010	24.80	1.37	1.06	0.50	36.27	0.56	40.76	0.07	23.00	0.09	0.01	4.43
10/6/2010	26.80	1.61	1.16	0.52	32.46	0.64	39.52	0.10	28.00	0.09	0.01	3.30

Table 3-A continued

Date	TSS (mg/L)	TN (mg/L)	TKN (mg/L)	Ammonia (mg/L)	% Ammonia	Organic N (mg/L)	% Organic N	NO_3^- +NO_2^- (mg/L)	% NO_3^- +NO_2^-	TP (mg/L)	PO_4 (mg/L)	TOC (mg/L)
10/7/2010	22.80	0.88	0.48	0.52	58.75	-0.04	-4.41	0.09	46.00	.	.	3.41
10/8/2010	31.30	1.39	1.12	0.47	33.98	0.65	46.53	0.06	19.00	0.08	0.01	2.93
10/9/2010	39.60	2.03	1.78	0.46	22.46	1.32	65.24	0.06	12.00	0.15	0.01	2.84
10/10/2010	51.00	1.88	1.65	0.45	23.68	1.20	63.95	0.05	12.00	0.14	0.01	2.48
10/11/2010	38.50	1.40	1.21	0.42	29.59	0.79	56.62	0.04	14.00	0.09	0.01	2.23
10/12/2010	40.20	1.81	1.67	0.68	37.50	1.00	55.15	0.03	7.00	0.15	0.01	2.59
10/13/2010	55.40	1.39	1.35	0.44	31.59	0.91	64.98	0.01	3.00	0.13	0.00	2.79
10/14/2010	23.50	1.15	1.11	0.48	41.75	0.63	54.75	0.01	3.00	0.12	0.01	4.14
10/15/2010	32.70	1.72	1.58	0.81	46.74	0.77	44.84	0.03	8.00	0.15	.	5.53
10/16/2010	21.20	1.72	1.42	0.54	31.52	0.87	50.66	0.07	18.00	0.11	.	4.17
10/17/2010	19.50	1.48	1.45	0.46	31.29	0.99	66.73	0.01	2.00	0.14	.	5.64
10/18/2010	17.30	1.44	1.44	0.51	35.43	0.93	64.53	0.00	0.05	0.10	.	4.43
10/19/2010	14.50	1.37	1.38	0.52	37.78	0.86	63.12	0.00	-1.00	0.11	.	4.02
10/20/2010	37.90	1.69	1.71	0.54	31.61	1.17	69.28	0.00	-1.00	0.14	0.00	6.31
10/21/2010	17.70	1.47	1.46	0.49	33.15	0.98	66.71	0.00	0.10	0.11	.	4.58
10/22/2010	19.00	1.63	1.65	0.45	27.61	1.20	73.67	0.00	-1.00	0.13	.	4.90
10/23/2010	16.00	1.48	1.47	0.45	30.44	1.02	69.30	0.00	0.30	0.15	.	4.74
10/24/2010	26.70	1.44	1.45	0.42	28.77	1.03	71.62	0.00	-0.40	0.13	.	3.64
10/25/2010	22.50	1.49	1.51	0.42	28.19	1.09	72.71	0.00	-1.00	0.14	0.00	2.99
10/26/2010	52.40	1.79	1.84	0.42	23.37	1.42	79.35	-0.01	-3.00	0.16	0.01	3.74
10/27/2010	1123.00	8.59	7.57	0.59	6.89	6.97	81.15	0.23	12.00	1.67	0.19	6.94
10/28/2010	418.50	7.11	5.20	0.75	10.59	4.45	62.54	0.43	27.00	1.00	0.09	7.20

Table 3-A continued

Date	TSS (mg/L)	TN (mg/L)	TKN (mg/L)	Ammonia (mg/L)	% Ammonia	Organic N (mg/L)	% Organic N	NO_3^- +NO_2^- (mg/L)	% NO_3^- +NO_2^-	TP (mg/L)	PO_4 (mg/L)	TOC (mg/L)
10/29/2010	252.82	4.77	3.09	1.64	34.39	1.45	30.34	0.38	35.00	0.45	0.08	9.34
10/30/2010	130.70	3.27	1.91	0.97	29.50	0.94	28.76	0.31	42.00	0.31	0.06	8.92
10/31/2010	86.30	3.26	2.10	0.64	19.76	1.46	44.68	0.26	36.00	0.19	0.05	7.45
11/1/2010	63.00	2.83	1.79	0.69	24.30	1.10	38.86	0.24	37.00	0.21	0.04	2.90
11/2/2010	337.00	4.37	3.65	0.73	16.61	2.92	66.82	0.16	17.00	0.58	0.12	6.94
11/3/2010	334.50	3.92	3.46	0.72	18.26	2.74	70.05	0.10	12.00	0.50	0.11	5.94
11/4/2010	252.80	3.33	2.65	0.69	20.74	1.96	59.02	0.15	20.00	0.36	0.09	4.94
11/5/2010	162.20	4.42	2.75	0.48	10.87	2.27	51.30	0.38	38.00	0.28	0.07	6.98
11/6/2010	60.20	3.16	1.57	0.59	18.75	0.98	31.12	0.36	50.00	0.17	0.04	6.84
11/7/2010	185.70	5.65	3.93	1.65	29.13	2.29	40.46	0.39	30.00	0.52	0.11	16.06
11/8/2010	46.90	3.69	2.13	0.51	13.67	1.63	44.06	0.35	42.00	0.18	0.03	6.33
11/9/2010	21.60	2.79	1.49	0.44	15.68	1.05	37.82	0.29	46.00	0.10	0.01	4.71
11/10/2010	18.20	2.21	1.29	0.43	19.40	0.86	38.71	0.21	42.00	0.08	0.01	4.13
11/11/2010	31.30	1.78	1.04	0.43	24.25	0.61	34.30	0.17	41.00	0.05	0.00	4.61
11/12/2010	40.60	2.04	1.57	0.78	38.00	0.80	38.92	0.11	23.00	0.15	0.02	4.10
11/13/2010	214.80	2.97	2.77	0.70	23.52	2.07	69.70	0.05	7.00	0.42	0.11	3.97
11/14/2010	24.10	1.84	1.79	0.49	26.80	1.30	70.26	0.01	3.00	0.17	0.03	3.32
11/15/2010	16.00	1.37	1.37	0.48	35.19	0.89	64.69	0.00	0.10	0.10	0.03	2.41
11/16/2010	25.60	1.65	1.61	0.54	32.82	1.07	64.77	0.01	2.00	0.14	0.03	2.82
11/17/2010	30.60	2.17	1.54	0.55	25.21	1.00	46.11	0.14	29.00	0.14	0.03	3.31
11/18/2010	19.80	2.35	1.59	0.48	20.54	1.11	47.07	0.17	32.00	0.13	0.03	4.97
11/19/2010	14.40	1.95	1.45	0.69	35.32	0.76	39.14	0.11	26.00	0.10	0.01	4.45

Table 3-A continued

Date	TSS (mg/L)	TN (mg/L)	TKN (mg/L)	Ammonia (mg/L)	% Ammonia	Organic N (mg/L)	% Organic N	NO_3^- +NO_2^- (mg/L)	% NO_3^- +NO_2^-	TP (mg/L)	PO_4 (mg/L)	TOC (mg/L)
11/20/2010	16.40	1.80	1.46	0.45	24.86	1.01	56.11	0.08	19.00	0.11	0.03	3.90
11/21/2010	16.30	1.39	1.21	0.43	31.08	0.78	55.97	0.04	13.00	0.11	0.02	3.30
11/22/2010	25.60	1.56	1.56	0.43	27.22	1.13	72.39	0.00	0.40	0.13	0.02	2.76
11/23/2010	24.00	1.50	1.52	0.43	28.38	1.10	73.20	-0.01	-2.00	0.13	0.02	3.25
11/24/2010	22.10	1.08	1.05	0.49	45.40	0.56	52.41	0.01	2.00	0.07	.	3.24
11/25/2010	21.30	1.26	1.21	1.31	103.38	-0.10	-7.74	0.01	4.00	0.08	0.02	2.93
12/10/2010	1537.11	5.55	2.89	1.13	20.31	1.76	31.72	0.60	48.00	1.34	1.05	12.12
12/11/2010	587.54	5.52	1.29	1.08	19.62	0.21	3.77	0.95	77.00	0.22	.	7.66
12/12/2010	174.20	6.27	1.56	0.47	7.53	1.09	17.34	1.06	75.00	0.13	0.13	3.92
12/28/2010	701.56	6.83	6.00	1.41	20.64	4.59	67.21	0.19	12.00	0.98	0.71	1.29
12/30/2010	177.90	2.10	1.20	0.55	26.03	0.65	31.08	0.20	43.00	0.20	0.16	0.92
12/31/2010	111.10	3.72	1.00	0.45	12.19	0.54	14.61	0.61	73.00	0.10	0.06	0.61
1/1/2011	153.90	3.17	1.13	0.51	16.05	0.62	19.52	0.46	64.00	0.12	0.10	0.85
1/2/2011	40.70	3.19	1.46	0.88	27.53	0.58	18.22	0.39	54.00	0.41	0.35	0.38
1/4/2011	281.90	2.06	1.33	0.57	27.62	0.76	37.02	0.16	35.00	0.22	0.17	0.14
1/5/2011	222.90	4.93	3.23	0.59	12.00	2.64	53.55	0.38	34.00	0.38	0.12	0.12
1/6/2011	53.50	3.20	0.84	0.42	13.18	0.41	12.96	0.53	74.00	0.11	0.07	30.91
1/7/2011	72.10	3.07	0.74	0.41	13.38	0.33	10.60	0.53	76.00	0.09	0.05	0.72
1/8/2011	105.50	2.64	1.21	0.47	17.81	0.74	28.00	0.32	54.00	0.10	0.07	0.63

Table 4-A. Water quality parameters analyzed from the composite samples collected by the refrigerated sampler at Lick Creek.

Table 4-A continued												
Date	TSS (mg/L)	TN (mg/L)	TKN (mg/L)	Ammonia (mg/L)	% Ammonia	Organic N (mg/L)	% Organic N	NO_3^- +NO_2^- (mg/L)	% NO_3^- +NO_2^-	TP (mg/L)	PO_4 (mg/L)	TOC (mg/L)
10/30/2009	43.20	3.80	0.96	0.00	0.05	0.95	25.13	0.64	75.00	0.17	0.13	
11/3/2009	156.50	2.09	1.16	0.08	3.65	1.08	51.75	0.21	45.00	0.37	0.22	
11/4/2009	170.20	3.08	1.38	0.08	2.66	1.30	42.20	0.38	55.00	0.57	0.36	
11/5/2009	70.30	1.60	1.25	0.18	11.38	1.07	66.75	0.08	22.00	0.40	0.26	
11/6/2009	52.00	1.85	1.19	0.17	8.97	1.02	55.35	0.15	36.00	0.31	0.19	
11/7/2009	41.20	3.63	0.85	0.13	3.69	0.72	19.81	0.63	76.00	0.21	0.15	
11/8/2009	41.20	6.31	1.16	0.06	0.97	1.10	17.43	1.16	82.00	0.20	0.12	
11/9/2009	23.50	0.79	0.77	0.00	0.00	0.77	97.45	0.00	3.00	0.08	0.06	
11/10/2009	18.90	7.92	0.74	0.00	0.00	0.74	9.37	1.62	91.00	0.12	0.04	
11/12/2009	23.30	8.94	0.65	0.00	0.00	0.65	7.29	1.87	93.00	0.08	0.04	
11/21/2009	28.90	7.28	0.54	0.22	3.01	0.32	4.36	1.52	93.00	0.12	0.04	
11/22/2009	39.50	6.59	0.49	0.14	2.05	0.35	5.33	1.38	93.00	0.12	0.04	
11/23/2009	14.70	6.45	0.44	0.14	2.11	0.30	4.64	1.36	93.00	0.07	0.03	
11/24/2009	49.20	6.03	0.79	0.16	2.64	0.63	10.48	1.18	87.00	0.19	0.07	
12/9/2009	72.30	3.03	0.64	0.60	19.69	0.05	1.48	0.54	79.00	0.31	0.28	7.43
12/10/2009	36.10	1.90	0.59	0.55	28.70	0.04	2.32	0.30	69.00	0.36	0.33	8.97
12/23/2009	28.40	4.28	0.54	0.37	8.73	0.17	3.97	0.84	87.00	0.21	0.15	9.50
2/5/2010	111.60	3.71	1.04	0.40	10.73	0.64	17.26	0.60	72.00	0.04	0.08	6.56
2/6/2010	29.50	2.45	0.71	0.34	14.01	0.37	14.94	0.39	71.00	0.04	0.08	2.88
2/7/2010	56.30	2.16	0.70	0.34	15.72	0.36	16.56	0.33	68.00	0.03	0.07	5.57

Table 4-A continued

Date	TSS (mg/L)	TN (mg/L)	TKN (mg/L)	Ammonia (mg/L)	% Ammonia	Organic N (mg/L)	% Organic N	NO_3^- +NO_2^- (mg/L)	% NO_3^- +NO_2^-	TP (mg/L)	PO_4 (mg/L)	TOC (mg/L)
2/8/2010	202.40	3.00	0.70	0.36	11.95	0.34	11.28	0.52	77.00	0.03	0.06	4.88
2/9/2010	64.90	4.68	0.68	0.34	7.33	0.34	7.24	0.90	85.00	0.02	0.04	3.73
2/11/2010	403.75	7.15	1.36	0.27	3.73	1.09	15.30	1.31	81.00	0.24	0.13	5.83
2/13/2010	244.30	7.52	0.78	0.25	3.29	0.53	7.05	1.52	90.00	0.08	0.10	4.25
2/14/2010	132.60	7.22	0.71	0.26	3.59	0.45	6.23	1.47	90.00	0.04	0.05	3.28
2/15/2010	44.00	7.57	0.90	0.22	2.84	0.69	9.05	1.51	88.00	0.08	0.08	2.19
2/17/2010	3.60	6.39	0.65	0.22	3.49	0.42	6.61	1.30	90.00	0.03	0.01	1.69
2/19/2010	33.80	7.24	0.54	0.39	5.45	0.14	2.00	1.51	93.00	0.09	0.05	1.84
2/20/2010	8.90	7.03	0.63	0.26	3.74	0.36	5.16	1.44	91.00	0.07	0.02	1.24
2/21/2010	12.00	6.78	0.48	0.26	3.88	0.21	3.16	1.42	93.00	0.06	0.02	1.24
2/22/2010	10.50	6.52	0.54	0.26	3.97	0.29	4.38	1.35	92.00	0.05	0.02	0.84
2/23/2010	20.20	6.29	0.52	0.32	5.01	0.20	3.23	1.30	92.00	0.05	0.02	1.07
2/24/2010	15.30	6.68	0.85	0.28	4.23	0.56	8.44	1.32	87.00	0.07	0.02	1.75
2/25/2010	14.50	6.71	0.67	0.28	4.22	0.39	5.84	1.36	90.00	0.07	0.02	1.48
2/26/2010	14.50	6.81	0.71	0.22	3.22	0.49	7.24	1.38	90.00	0.05	0.02	2.22
2/27/2010	30.70	6.81	0.65	0.24	3.45	0.41	6.05	1.39	90.00	0.06	0.02	1.28
2/28/2010	40.80	6.70	0.80	0.29	4.28	0.51	7.66	1.33	88.00	0.03	0.03	2.47
3/1/2010	15.30	6.29	0.59	0.26	4.12	0.33	5.19	1.29	91.00	0.03	0.01	1.14
3/2/2010	3.60	6.20	0.66	0.21	3.34	0.45	7.29	1.25	89.00	0.04	0.01	0.59
3/3/2010	6.00	6.24	0.62	0.20	3.12	0.43	6.88	1.27	90.00	0.04	0.01	0.96
3/5/2010	6.80	5.51	0.02	0.28	4.99	-0.26		1.24	100.00	0.07	0.03	1.85
3/6/2010	1.80	4.83	0.15	0.23	4.70	-0.08		1.06	97.00	0.10	0.02	1.26

Table 4-A continued

Date	TSS (mg/L)	TN (mg/L)	TKN (mg/L)	Ammonia (mg/L)	% Ammonia	Organic N (mg/L)	% Organic N	NO_3^- +NO_2^- (mg/L)	% NO_3^- +NO_2^-	TP (mg/L)	PO_4 (mg/L)	TOC (mg/L)
3/7/2010	3.30	4.43	0.33	0.24	5.39	0.09	2.11	0.93	92.00	0.07	0.00	0.85
3/8/2010	21.60	4.11	0.38	0.27	6.60	0.11	2.58	0.84	91.00	0.08	0.00	1.40
3/9/2010	107.40	4.14	0.32	0.29	6.93	0.04	0.90	0.86	92.00	0.07	0.00	0.68
3/10/2010	409.70	4.04	0.31	0.30	7.40	0.01	0.16	0.84	92.00	0.07	0.02	1.02
3/11/2010	271.00	4.07	0.36	0.28	6.86	0.08	1.87	0.84	91.00	0.09	0.01	0.98
3/12/2010	424.50	3.58	0.35	0.27	7.58	0.08	2.17	0.73	90.00	0.09	0.11	3.72
3/13/2010	421.67	4.88	1.15	0.80	16.48	0.34	7.07	0.84	76.00	0.21	0.43	19.64
3/14/2010	633.83	9.98	6.47	0.70	6.97	5.77	57.86	0.79	35.00	0.47	0.16	10.09
3/15/2010	287.33	5.50	1.95	0.64	11.57	1.32	23.92	0.80	65.00	0.19	0.24	3.29
3/16/2010	274.29	2.88	0.36	0.45	15.50	-0.08	-2.93	0.57	87.00	0.10	0.42	17.42
3/17/2010	122.20	10.89	6.70	0.44	4.02	6.26	57.49	0.95	38.00	0.60	0.24	6.88
3/18/2010	121.10	5.40	1.70	0.30	5.61	1.40	25.85	0.84	69.00	0.19	0.03	2.64
3/21/2010	9.90	4.00	0.52	0.32	7.97	0.20	5.07	0.79	87.00	0.04	0.02	2.35
3/22/2010	22.90	3.50	0.54	0.26	7.52	0.27	7.84	0.67	85.00	0.04	0.04	1.95
3/23/2010	24.10	3.26	0.67	0.22	6.72	0.45	13.86	0.58	79.00	0.06	0.02	1.72
3/24/2010	25.50	3.71	0.55	0.21	5.58	0.35	9.32	0.71	85.00	0.06	0.02	2.93
3/25/2010	20.10	3.80	0.58	0.32	8.28	0.27	7.07	0.73	85.00	0.06	0.01	3.27
3/26/2010	17.90	3.10	0.60	0.24	7.84	0.36	11.49	0.56	81.00	0.06	0.02	2.36
3/27/2010	23.70	2.81	0.65	0.22	7.81	0.43	15.19	0.49	77.00	0.07	0.02	1.94
3/28/2010	48.80	4.20	0.75	0.29	6.83	0.46	11.05	0.78	82.00	0.07	0.03	2.75
3/29/2010	165.70	6.48	0.84	0.34	5.29	0.50	7.73	1.27	87.00	0.09	0.08	6.60
3/30/2010	138.40	6.49	0.81	0.38	5.88	0.43	6.65	1.28	87.00	0.10	0.06	6.60

Table 4-A continued

Date	TSS (mg/L)	TN (mg/L)	TKN (mg/L)	Ammonia (mg/L)	% Ammonia	Organic N (mg/L)	% Organic N	NO_3^- +NO_2^- (mg/L)	% NO_3^- +NO_2^-	TP (mg/L)	PO_4 (mg/L)	TOC (mg/L)
3/31/2010	87.40	5.03	0.71	0.28	5.63	0.42	8.40	0.98	86.00	0.09	0.04	4.50
4/1/2010	96.00	4.08	1.69	0.32	7.82	1.37	33.61	0.54	59.00	0.29	0.03	3.41
4/2/2010	58.90	3.92	1.41	0.30	7.53	1.11	28.44	0.57	64.00	0.39	0.03	2.95
4/3/2010	58.70	3.52	1.20	0.28	7.92	0.93	26.27	0.52	66.00	0.33	0.03	2.27
4/4/2010	51.90	3.06	1.39	0.28	9.10	1.12	36.41	0.38	54.00	0.23	0.03	1.92
4/5/2010	62.40	2.70	1.34	0.27	9.90	1.07	39.75	0.31	50.00	0.41	0.03	1.90
4/6/2010	60.30	2.66	1.40	0.27	10.19	1.13	42.61	0.28	47.00	0.34	0.03	1.97
4/7/2010	69.20	2.42	1.10	0.27	11.05	0.84	34.68	0.30	54.00	0.41	0.03	1.91
4/8/2010	85.10	2.94	1.53	0.29	9.76	1.24	42.20	0.32	48.00	0.42	0.04	2.22
4/9/2010	137.10	3.54	1.77	0.34	9.58	1.43	40.43	0.40	50.00	0.40	0.06	3.53
4/10/2010	158.80	3.91	1.87	0.38	9.67	1.49	38.11	0.46	52.00	0.27	0.07	4.85
4/11/2010	87.60	4.00	1.73	0.34	8.38	1.39	34.86	0.51	57.00	0.40	0.04	4.29
4/12/2010	54.60	3.33	1.30	0.31	9.33	0.99	29.71	0.46	61.00	0.36	0.03	3.63
4/13/2010	63.00	3.51	1.44	0.28	7.83	1.16	33.02	0.47	59.00	0.46	0.03	2.78
4/14/2010	69.70	3.80	1.45	0.28	7.35	1.17	30.81	0.53	62.00	0.39	0.03	2.03
4/16/2010	68.50	3.17	0.82	0.32	9.95	0.50	15.80	0.53	74.00	0.14	0.05	2.01
4/17/2010	80.40	3.36	1.01	0.32	9.38	0.70	20.82	0.53	70.00	0.14	0.05	2.33
4/18/2010	80.00	3.44	1.25	0.32	9.28	0.93	27.08	0.49	64.00	0.19	0.05	1.80
4/19/2010	68.30	3.36	1.35	0.31	9.26	1.04	31.04	0.45	60.00	0.18	0.04	1.65
4/20/2010	70.30	3.33	1.30	0.30	8.86	1.00	30.13	0.46	61.00	0.19	0.04	1.55
4/21/2010	63.00	3.88	1.34	0.30	7.82	1.04	26.76	0.57	65.00	0.18	0.04	1.63
4/22/2010	61.20	4.90	1.41	0.31	6.35	1.10	22.53	0.79	71.00	0.18	0.05	1.75

Table 4-A continued

Date	TSS (mg/L)	TN (mg/L)	TKN (mg/L)	Ammonia (mg/L)	% Ammonia	Organic N (mg/L)	% Organic N	NO_3^- +NO_2^- (mg/L)	% NO_3^- +NO_2^-	TP (mg/L)	PO_4 (mg/L)	TOC (mg/L)
4/23/2010	69.80	4.31	1.20	0.32	7.41	0.88	20.53	0.70	72.00	0.18	0.05	1.62
4/24/2010	77.10	4.52	1.32	0.29	6.44	1.03	22.71	0.72	71.00	0.20	0.05	1.72
4/25/2010	75.90	4.39	1.48	0.30	6.73	1.19	27.05	0.66	66.00	0.19	0.05	1.64
4/26/2010	76.00	4.41	1.69	0.31	6.96	1.38	31.26	0.62	62.00	0.21	0.05	2.07
4/27/2010	57.90	4.02	1.45	0.30	7.54	1.14	28.40	0.58	64.00	0.17	0.05	1.89
4/28/2010	65.40	4.53	1.33	0.33	7.31	1.00	22.07	0.72	71.00	0.14	0.06	2.43
4/29/2010	88.00	5.23	1.46	0.37	7.15	1.09	20.80	0.85	72.00	0.25	0.10	2.79
4/30/2010	70.00	4.88	1.46	0.40	8.16	1.06	21.76	0.77	70.00	0.20	0.07	3.01
5/1/2010	91.50	5.43	1.92	0.36	6.59	1.56	28.78	0.79	65.00	0.24	0.07	3.02
5/2/2010	115.80	5.69	2.29	0.38	6.71	1.91	33.56	0.77	60.00	0.25	0.08	2.69
5/3/2010	395.50	6.68	3.46	0.51	7.58	2.95	44.19	0.73	48.00	0.52	0.14	5.19
5/4/2010	449.80	6.12	3.91	0.57	9.24	3.34	54.64	0.50	36.00	0.67	0.15	6.70
5/5/2010	267.09	5.29	3.43	0.51	9.70	2.92	55.15	0.42	35.00	0.48	0.13	6.47
5/6/2010	176.89	5.39	2.96	0.43	7.90	2.54	47.06	0.55	45.00	0.29	0.10	5.41
5/7/2010	135.50	5.26	2.06	0.37	7.11	1.69	32.08	0.72	61.00	0.23	0.09	4.15
5/8/2010	110.90	6.01	2.36	0.34	5.64	2.02	33.61	0.82	61.00	0.29	0.09	3.75
5/9/2010	111.20	5.77	1.84	0.32	5.53	1.52	26.35	0.89	68.00	0.20	0.07	3.23
5/10/2010	93.20	5.55	1.93	0.32	5.68	1.61	29.09	0.82	65.00	0.23	0.11	2.78
5/11/2010	85.40	5.50	1.77	0.31	5.59	1.46	26.56	0.84	68.00	0.17	0.10	2.92
5/12/2010	78.30	5.89	1.95	0.31	5.28	1.64	27.85	0.89	67.00	0.26	0.12	3.02
5/13/2010	81.90	6.24	1.47	0.32	5.11	1.15	18.43	1.08	76.00	0.16	0.14	2.12
5/14/2010	102.00	14.04	9.53	0.27	1.90	9.27	65.98	1.02	32.00	0.30	0.14	2.05

Table 4-A continued

Date	TSS (mg/L)	TN (mg/L)	TKN (mg/L)	Ammonia (mg/L)	% Ammonia	Organic N (mg/L)	% Organic N	NO_3^- +NO_2^- (mg/L)	% NO_3^- +NO_2^-	TP (mg/L)	PO_4 (mg/L)	TOC (mg/L)
5/15/2010	95.60	7.41	2.64	0.27	3.60	2.38	32.04	1.08	64.00	0.29	0.15	2.10
5/17/2010	69.10	6.34	2.47	0.29	4.59	2.17	34.32	0.87	61.00	0.26	0.12	2.43
5/27/2010	77.80	7.94	2.99	0.51	6.42	2.48	31.20	1.12	62.00	0.33	0.18	6.08
5/28/2010	58.90	7.56	1.48	0.36	4.79	1.12	14.80	1.37	80.00	0.19	0.05	2.46
5/29/2010	57.70	7.04	2.04	0.48	6.80	1.56	22.13	1.13	71.00	0.20	0.06	3.79
5/30/2010	68.10			0.41				0.86			0.06	3.56
5/31/2010	54.50	4.99	1.94	0.37	7.49	1.57	31.40	0.69	61.00	0.15	0.04	2.48
6/1/2010	68.50	5.22	2.21	0.39	7.54	1.82	34.83	0.68	58.00	0.18	0.04	3.17
6/2/2010	99.10	5.28	1.42	0.44	8.30	0.98	18.58	0.87	73.00	0.21	0.04	3.57
6/3/2010	84.00	5.99	2.59	0.39	6.51	2.20	36.73	0.77	57.00	0.18	0.06	4.44
6/4/2010	62.30	6.39	1.51	0.45	7.11	1.05	16.46	1.10	76.00	0.20	0.06	4.68
6/5/2010	78.70	6.00	1.34	0.43	7.23	0.91	15.16	1.05	78.00	0.22	0.06	4.45
6/6/2010	64.50	5.98	1.86	0.37	6.25	1.49	24.86	0.93	69.00	0.20	0.08	3.82
6/7/2010	56.10	4.96	1.94	0.36	7.22	1.58	31.92	0.68	61.00	0.17	0.06	3.82
6/8/2010	69.10	5.85	1.51	0.41	7.08	1.09	18.67	0.98	74.00	0.19	0.04	2.60
6/9/2010	42.60	4.88	2.13	0.37	7.59	1.76	36.04	0.62	56.00	0.15	0.04	2.96
6/11/2010	56.20	1.85		0.32	17.46	-0.32		0.42	100.00		0.04	5.68
6/25/2010	82.20	3.68	1.92	0.72	19.67	1.20	32.50	0.40	48.00	0.30	0.20	5.93
6/26/2010	38.40	4.76	3.14	0.43	9.11	2.71	56.88	0.37	34.00	0.53	0.33	6.21
6/27/2010	42.10	3.98	2.22	0.43	10.71	1.79	45.06	0.40	44.00	0.30	0.09	4.98
6/28/2010	46.10	3.99	2.38	0.41	10.17	1.98	49.51	0.36	40.00	0.41	0.12	3.79
6/29/2010	30.10	4.31	2.55	0.46	10.73	2.09	48.41	0.40	41.00	0.52	0.11	3.96

Table 4-A continued

Date	TSS (mg/L)	TN (mg/L)	TKN (mg/L)	Ammonia (mg/L)	% Ammonia	Organic N (mg/L)	% Organic N	NO_3^- +NO_2^- (mg/L)	% NO_3^- +NO_2^-	TP (mg/L)	PO_4 (mg/L)	TOC (mg/L)
6/30/2010	30.20	5.83	4.16	0.54	9.28	3.62	62.07	0.38	29.00	0.68	0.25	7.79
7/1/2010	28.50	3.95	2.05	0.36	9.07	1.69	42.82	0.43	48.00	0.38	0.06	3.64
7/2/2010	53.30	4.14	2.38	0.32	7.79	2.06	49.73	0.40	42.00	0.40	0.06	3.57
7/3/2010	58.80	3.46	1.98	0.32	9.23	1.66	47.95	0.33	43.00	0.28	0.05	3.10
7/4/2010	66.10	3.16	1.86	0.32	10.22	1.54	48.67	0.29	41.00	0.27	0.04	3.45
7/5/2010	62.30	3.14	1.93	0.34	10.78	1.60	50.73	0.27	38.00	0.25	0.06	3.74
7/6/2010	53.60	3.05	2.02	0.32	10.59	1.70	55.65	0.23	34.00	0.31	0.02	3.74
7/7/2010	48.20	3.05	2.11	0.34	10.97	1.78	58.24	0.21	31.00	0.30	0.04	3.67
7/8/2010	17.60	2.98	2.06	0.48	16.06	1.58	53.02	0.21	31.00	0.13	0.05	3.83
7/9/2010	39.10	4.26	1.46	0.73	17.11	0.73	17.11	0.63	66.00	0.11	0.07	4.37
7/10/2010	40.30	4.66	0.96	0.44	9.41	0.52	11.13	0.84	79.00	0.13	0.09	3.84
7/11/2010	30.80	3.05	1.24	0.53	17.36	0.71	23.24	0.41	59.00	0.09	0.06	3.50
7/12/2010	55.30	4.70	1.10	0.46	9.74	0.65	13.73	0.81	77.00	0.11	0.12	3.59
7/13/2010	192.56	5.66	2.23	0.52	9.20	1.71	30.24	0.77	61.00	0.24	0.17	4.27
7/14/2010	91.30	5.19	1.56	0.47	9.13	1.09	20.97	0.82	70.00	0.16	0.12	5.50
7/15/2010	50.80	3.61	1.53	0.51	14.12	1.02	28.18	0.47	58.00	0.11	0.07	4.91
7/16/2010	49.90	4.81	1.37	0.39	8.11	0.98	20.36	0.78	72.00	0.13	0.08	4.43
7/17/2010	37.30	3.31	1.08	0.36	10.95	0.72	21.62	0.50	67.00	0.10	0.07	4.10
7/18/2010	45.50	4.95	1.43	0.37	7.39	1.07	21.51	0.79	71.00	0.12	0.09	3.65
7/19/2010	122.60	5.43	1.80	0.47	8.65	1.33	24.52	0.82	67.00	0.19	0.12	4.56
7/20/2010	344.14	6.05	2.43	0.60	9.93	1.83	30.28	0.82	60.00	0.33	0.03	5.42
7/21/2010	300.50	6.04	2.33	0.41	6.72	1.93	31.90	0.84	61.00	0.27	0.09	6.09

Table 4-A continued

Date	TSS (mg/L)	TN (mg/L)	TKN (mg/L)	Ammonia (mg/L)	% Ammonia	Organic N (mg/L)	% Organic N	NO_3^- +NO_2^- (mg/L)	% NO_3^- +NO_2^-	TP (mg/L)	PO_4 (mg/L)	TOC (mg/L)
7/22/2010	76.60	4.77	1.74	0.55	11.52	1.19	24.89	0.68	64.00	0.12	0.07	6.34
7/23/2010	74.40	6.24	2.88	0.64	10.21	2.24	35.94	0.76	54.00	0.27	0.09	9.10
7/24/2010	88.00	6.73	2.60	0.49	7.28	2.11	31.32	0.93	61.00	0.24	0.09	7.09
7/25/2010	64.10	7.04	3.00	0.58	8.19	2.43	34.46	0.91	57.00	0.25	0.08	6.77
7/26/2010	72.50	7.05	3.29	0.53	7.50	2.76	39.21	0.85	53.00	0.25	0.09	6.65
7/27/2010	65.10	5.52	2.54	0.45	8.22	2.08	37.69	0.67	54.00	0.18	0.07	6.67
7/28/2010	77.20	5.70	2.25	0.38	6.64	1.87	32.84	0.78	61.00	0.26	0.09	4.60
7/29/2010	68.70	5.64	2.19	0.30	5.30	1.89	33.55	0.78	61.00	0.26	0.10	4.25
7/30/2010	68.50	5.96	2.49	0.34	5.75	2.15	36.09	0.78	58.00	0.23	0.10	3.88
7/31/2010	75.50	6.06	1.72	0.34	5.60	1.38	22.87	0.98	72.00	0.25	0.10	3.97
8/1/2010	97.40	7.58	2.80	0.66	8.72	2.14	28.24	1.08	63.00	0.41	0.14	3.93
8/2/2010	208.67	7.77	3.72	0.40	5.12	3.32	42.74	0.91	52.00	0.48	0.16	5.83
8/3/2010	70.80	6.04	2.41	0.37	6.19	2.03	33.68	0.82	60.00	0.30	0.12	7.37
8/4/2010	78.50	5.89	2.21	0.28	4.74	1.93	32.80	0.83	62.00	0.24	0.10	4.53
8/5/2010	76.20	5.89	2.51	0.44	7.51	2.07	35.19	0.76	57.00	0.25	0.08	4.82
8/6/2010	75.10	5.01	1.65	0.48	9.62	1.16	23.25	0.76	67.00	0.11	0.12	4.83
8/7/2010	80.80	6.32	1.79	0.45	7.06	1.35	21.30	1.02	72.00	0.15	0.12	3.85
8/8/2010	82.90	5.64	1.33	0.43	7.69	0.90	15.94	0.97	76.00	0.08	0.11	3.95
8/9/2010	79.70	6.53	1.98	0.40	6.09	1.58	24.21	1.03	70.00	0.12	0.12	3.70
8/10/2010	83.00	5.57	1.66	0.38	6.85	1.28	22.96	0.88	70.00	0.11	0.11	3.57
8/11/2010	68.60	5.80	2.01	0.39	6.72	1.62	27.96	0.86	65.00	0.07	0.12	3.41
8/12/2010	81.70	6.42	1.60	0.33	5.09	1.27	19.84	1.09	75.00	0.07	0.06	3.13

Table 4-A continued

Date	TSS (mg/L)	TN (mg/L)	TKN (mg/L)	Ammonia (mg/L)	% Ammonia	Organic N (mg/L)	% Organic N	NO_3^- +NO_2^- (mg/L)	% NO_3^- +NO_2^-	TP (mg/L)	PO_4 (mg/L)	TOC (mg/L)
8/13/2010	106.80	6.57	1.89	0.38	5.76	1.52	23.07	1.06	71.00	0.15	0.08	3.57
8/14/2010	73.70	5.94	1.81	0.34	5.77	1.47	24.75	0.93	69.00	0.16	0.13	3.45
8/15/2010	74.30	6.49	1.82	0.35	5.39	1.47	22.59	1.06	72.00	0.10	0.12	3.83
8/16/2010	78.60	7.24	1.55	0.37	5.06	1.18	16.34	1.28	79.00	0.18	0.15	3.02
8/17/2010	166.50	7.55	2.22	0.32	4.22	1.90	25.15	1.20	71.00	0.21	0.15	3.25
8/18/2010	66.90	6.22	2.06	0.41	6.53	1.66	26.69	0.94	67.00	0.21	0.12	2.71
8/19/2010	39.10	5.24	1.84	0.56	10.71	1.28	24.43	0.77	65.00	0.11	0.12	4.05
8/20/2010	78.80	5.43	2.52	0.79	14.58	1.73	31.82	0.66	54.00	0.35	0.07	7.10
8/21/2010	104.80	5.74	2.69	0.63	10.98	2.06	35.88	0.69	53.00	0.40	0.07	5.57
8/22/2010	87.20	5.15	2.08	0.58	11.34	1.50	29.09	0.69	60.00	0.33	0.06	5.67
8/23/2010	77.30	5.06	2.41	0.59	11.60	1.82	35.93	0.60	52.00	0.31	0.05	5.01
8/24/2010	92.50	5.21	2.44	0.58	11.16	1.85	35.63	0.63	53.00	0.32	0.07	4.59
8/25/2010	58.40	4.47	1.80	0.65	14.49	1.15	25.85	0.60	60.00	0.33	0.05	5.40
8/26/2010	65.00	5.26	2.27	0.58	10.95	1.70	32.25	0.67	57.00	0.29	0.04	3.84
8/27/2010	96.90	5.61	2.51	0.56	9.94	1.95	34.78	0.70	55.00	0.32	0.04	4.78
8/28/2010	55.00	5.13	2.16	0.53	10.37	1.63	31.68	0.67	58.00	0.82	0.04	3.92
8/29/2010	57.80	5.08	1.98	0.49	9.68	1.49	29.37	0.70	61.00	0.04	0.05	4.42
8/30/2010	58.00	5.04	1.54	0.49	9.79	1.05	20.81	0.79	69.00	0.05	0.05	3.88
8/31/2010	51.60	5.92	2.07	0.50	8.40	1.58	26.61	0.87	65.00	0.29	0.05	3.71
9/1/2010	56.00	5.30	1.75	0.49	9.23	1.27	23.88	0.80	67.00	0.27	0.05	3.55
9/2/2010	50.10	4.20	1.23	0.53	12.63	0.70	16.60	0.67	71.00	0.22	0.06	3.92
9/3/2010	64.00	5.98	2.32	0.32	5.30	2.00	33.46	0.83	61.00	0.22	0.05	6.33

Table 4-A continued

Date	TSS (mg/L)	TN (mg/L)	TKN (mg/L)	Ammonia (mg/L)	% Ammonia	Organic N (mg/L)	% Organic N	NO_3^- +NO_2^- (mg/L)	% NO_3^- +NO_2^-	TP (mg/L)	PO_4 (mg/L)	TOC (mg/L)
9/4/2010	58.80	5.73	2.87	0.92	16.00	1.95	34.08	0.65	50.00	0.24	0.06	4.64
9/5/2010	52.20	5.31	2.47	0.62	11.70	1.85	34.75	0.64	54.00	0.23	0.07	4.45
9/6/2010	57.80	6.03	2.71	0.67	11.14	2.04	33.82	0.75	55.00	0.24	0.08	4.28
9/7/2010	39.10	5.10	2.73	0.75	14.70	1.98	38.89	0.53	46.00	0.30	0.06	7.85
9/8/2010	48.30	5.99	2.68	0.97	16.15	1.72	28.62	0.75	55.00	0.25	0.06	6.10
9/17/2010	100.60	2.51	1.49	1.42	56.34	0.07	2.91	0.23	41.00	0.19	0.01	9.65
10/2/2010	89.90	5.37	3.70	0.73	13.56	2.98	55.44	0.38	31.00	0.38	0.02	13.82
10/3/2010	43.00	2.95	1.40	0.58	19.61	0.83	27.96	0.35	52.00	0.19	0.02	3.92
10/4/2010	42.00	3.28	1.46	0.67	20.52	0.78	23.86	0.41	56.00	0.22	0.01	5.38
10/5/2010	41.00	3.51	1.52	0.61	17.29	0.91	25.93	0.45	57.00	0.19	0.01	3.98
10/6/2010	29.70	3.27	1.34	0.58	17.86	0.76	23.11	0.44	59.00	0.19	0.01	4.92
10/7/2010	37.00	2.98	1.52	0.66	22.01	0.86	29.06	0.33	49.00	0.18	0.01	4.49
10/8/2010	35.50	2.76	1.52	0.85	30.68	0.67	24.30	0.28	45.00	0.17	0.01	4.36
10/9/2010	40.20	2.99	1.58	0.63	21.16	0.94	31.50	0.32	47.00	0.16	0.01	4.29
10/10/2010	39.50	3.32	1.43	0.53	16.02	0.90	27.11	0.43	57.00	0.17	0.01	4.15
10/11/2010	46.80	4.37	1.75	0.52	11.88	1.23	28.17	0.59	60.00	0.22	0.01	5.22
10/12/2010	46.60	3.98	1.28	0.55	13.92	0.73	18.34	0.61	68.00	0.17	0.01	4.48
10/13/2010	61.80	4.08	1.59	0.54	13.22	1.05	25.80	0.56	61.00	0.20	0.01	4.04
10/14/2010	108.40	3.98	1.60	0.55	13.86	1.05	26.42	0.54	60.00	0.26	0.01	5.92
10/15/2010	28.50	2.70	1.69	0.83	30.72	0.86	31.98	0.23	37.00	0.23	0.01	6.39
10/16/2010	32.30	2.38	1.56	0.66	27.56	0.91	38.27	0.18	34.00	0.19	0.01	4.71
10/17/2010	24.30	3.25	1.64	0.63	19.39	1.01	30.94	0.36	50.00	0.22	0.02	4.82

Table 4-A continued

Date	TSS (mg/L)	TN (mg/L)	TKN (mg/L)	Ammonia (mg/L)	% Ammonia	Organic N (mg/L)	% Organic N	NO_3^- +NO_2^- (mg/L)	% NO_3^- +NO_2^-	TP (mg/L)	PO_4 (mg/L)	TOC (mg/L)
10/18/2010	28.40	5.40	1.44	0.64	11.92	0.80	14.77	0.89	73.00	0.24	0.03	4.96
10/19/2010	37.10	7.11	1.55	0.61	8.63	0.93	13.13	1.26	78.00	0.23	0.05	5.04
10/20/2010	58.70	3.37	1.54	0.70	20.65	0.85	25.08	0.41	54.00	0.25	0.03	4.62
10/21/2010	45.30	2.49	1.35	0.67	27.09	0.68	27.24	0.26	46.00	0.20	0.02	3.82
10/22/2010	33.70	3.02	1.38	0.61	20.35	0.77	25.43	0.37	54.00	0.21	0.02	3.78
10/23/2010	23.00	4.74	1.39	0.51	10.75	0.88	18.64	0.76	71.00	0.21	0.02	3.88
10/24/2010	29.80	3.61	1.55	0.54	14.92	1.01	28.10	0.46	57.00	0.24	0.01	4.07
10/25/2010	44.20	2.15		0.55	25.52	-0.55		0.49	100.00		0.02	4.50
10/26/2010	49.00	3.54	1.46	0.55	15.44	0.91	25.86	0.47	59.00	0.21	0.02	3.33
10/27/2010	96.10	4.31	2.23	0.55	12.79	1.68	38.91	0.47	48.00	0.33	0.03	4.75
10/28/2010	308.47	5.25	3.44	0.67	12.84	2.77	52.76	0.41	34.00	0.79	0.11	6.65
10/29/2010	273.20	4.77	3.26	1.40	29.36	1.86	39.01	0.34	32.00	0.54	0.13	14.48
10/30/2010	80.60	3.65	2.51	0.69	18.86	1.82	49.89	0.26	31.00	0.29	0.06	8.90
10/31/2010	54.50	3.33	1.86	0.71	21.20	1.15	34.54	0.33	44.00	0.19	0.05	8.23
11/1/2010	29.20	3.83	1.89	0.69	17.87	1.21	31.52	0.44	51.00	0.19	0.04	8.27
11/2/2010	31.00	3.20	1.20	0.71	22.18	0.49	15.40	0.45	62.00	0.15	0.04	7.84
11/3/2010	32.00	2.95	1.41	0.89	30.26	0.51	17.45	0.35	52.00	0.16	0.04	7.12
11/4/2010	35.20	2.98	1.23	0.83	27.81	0.40	13.53	0.39	59.00	0.14	0.04	6.09
11/5/2010	48.30	3.33	1.42	0.75	22.35	0.68	20.25	0.43	57.00	0.19	0.05	7.45
11/6/2010	51.70	3.34	1.69	0.69	20.66	1.00	29.84	0.37	50.00	0.20	0.05	5.36
11/7/2010	354.00	7.78	5.92	2.01	25.80	3.91	50.32	0.42	24.00	1.19	0.42	16.72
11/8/2010	117.80	4.32	4.32	0.87	20.20	3.45	79.80		0.00	0.48		7.40

Table 4-A continued

Date	TSS (mg/L)	TN (mg/L)	TKN (mg/L)	Ammonia (mg/L)	% Ammonia	Organic N (mg/L)	% Organic N	NO_3^- +NO_2^- (mg/L)	% NO_3^- +NO_2^-	TP (mg/L)	PO_4 (mg/L)	TOC (mg/L)
11/9/2010	42.70	12.48	1.21	0.75	6.03	0.45	3.64	2.55	90.00	0.21	0.13	6.85
11/10/2010	29.40	12.36	1.49	0.56	4.51	0.93	7.53	2.45	88.00	0.16	0.07	6.80
11/11/2010	18.80	8.62	1.55	0.93	10.79	0.62	7.19	1.60	82.00	0.17	0.04	5.72
11/12/2010	16.80	3.78	1.56	1.41	37.28	0.15	3.94	0.50	59.00	0.19	0.08	4.66
11/13/2010	14.70	4.11	1.53	0.80	19.49	0.73	17.79	0.58	63.00	0.18	0.08	3.89
11/14/2010	16.50	4.18	1.42	0.81	19.27	0.61	14.68	0.62	66.00	0.17	0.07	3.72
11/15/2010	12.90	4.02	1.18	0.67	16.62	0.51	12.73	0.64	71.00	0.17	0.07	3.51
11/16/2010	15.40	3.64	0.96	0.76	20.79	0.21	5.69	0.60	74.00	0.13	0.07	3.43
11/17/2010	17.90	3.48	1.28	0.86	24.62	0.42	12.19	0.50	63.00	0.15	0.06	3.68
11/18/2010	22.30	2.98	1.38	0.71	23.87	0.66	22.23	0.36	54.00	0.20	0.06	4.72
11/19/2010	20.80	2.16	1.33	0.67	31.26	0.66	30.39	0.19	38.00	0.15	0.04	3.94
11/20/2010	24.00	2.01	1.23	0.57	28.25	0.66	32.91	0.18	39.00	0.13	0.04	4.22
11/21/2010	9.50	2.04	1.48	0.57	27.93	0.91	44.80	0.13	27.00	0.13	0.02	4.57
11/22/2010	11.60	2.17	1.61	0.55	25.54	1.05	48.59	0.13	26.00	0.13	0.02	4.95
11/23/2010	11.00	1.87	1.07	0.74	39.77	0.33	17.71	0.18	43.00	0.12	0.02	5.61
11/24/2010	4.10	1.60	1.17	0.75	46.83	0.42	26.45	0.10	27.00	0.05	0.02	5.19
11/25/2010	17.60	1.13	0.58	0.60	53.32	-0.02		0.12	48.00	0.03	0.02	4.67
12/10/2010	313.33	7.23	1.86	7.81		-5.95		1.21	74.00	1.18	1.01	16.84
12/11/2010	71.10	7.11	0.91	0.50	7.07	0.40	5.67	1.40	87.00	0.56	0.16	3.92
12/12/2010	18.90	6.66	0.81	0.47	7.08	0.34	5.12	1.32	88.00	0.16	0.08	2.75
12/31/2010	12.90	3.59	1.17	0.52	14.44	0.66	18.22	0.55	67.00	0.11	0.05	14.47
1/1/2011	10.10	3.74	0.98	0.51	13.51	0.47	12.68	0.62	74.00	0.07	0.03	5.16

Table 4-A continued

Date	TSS (mg/L)	TN (mg/L)	TKN (mg/L)	Ammonia (mg/L)	% Ammonia	Organic N (mg/L)	% Organic N	NO_3^- +NO_2^- (mg/L)	% NO_3^- +NO_2^-	TP (mg/L)	PO_4 (mg/L)	TOC (mg/L)
1/2/2011	41.80	3.08	1.19	0.48	15.59	0.71	23.03	0.43	61.00	0.10	0.08	2.52

Table 5-A. Battery volts, panel temperature, solar panel volts, energy readings and sampler temperature from Little Chucky Creek.

Table 5-A continued							
Date	**Battery Volts**	**Panel Temperature (^{0}C)**	**Solar Panel Volts**	**Current Sensor #1 (watt-hrs)**	**Current Sensor #2 (watt-hrs)**	**Current Sensor #3 (watt-hrs)**	**Sampler Temp. (^{0}C)**
8/13/2009	12.77	38.89	.	.	.	.	.
8/14/2009	12.60	33.41	.	.	.	.	.
8/15/2009	12.57	34.11	.	.	.	.	.
8/16/2009	12.44	32.79	.	.	.	.	.
8/17/2009	12.33	31.93	.	.	.	.	.
8/18/2009	12.23	31.41	.	.	.	.	.
8/19/2009	12.11	32.22	.	.	.	.	.
8/20/2009	12.07	32.64	.	.	.	.	.
8/21/2009	11.99	32.51	.	.	.	.	.
8/22/2009	11.92	31.79	.	.	.	.	.
8/23/2009	11.87	28.06	.	.	.	.	.
8/24/2009	11.93	30.43	.	.	.	.	.
8/25/2009	11.99	32.17	.	.	.	.	.
8/26/2009	12.00	32.32	.	.	.	.	.
8/27/2009	11.88	30.26	.	.	.	.	.
8/28/2009	11.62	28.60	.	.	.	.	.
8/29/2009	11.58	33.59	.	.	.	.	.
8/30/2009	11.52	36.14	.	.	.	.	.
8/31/2009	11.49	36.29	.	.	.	.	.
9/1/2009	10.26	16.15	.	.	.	.	.
9/2/2009	11.59	35.44	.	.	.	.	.

Table 5-A continued

Date	Battery Volts	Panel Temperature (^{0}C)	Solar Panel Volts	Current Sensor #1 (watt-hrs)	Current Sensor #2 (watt-hrs)	Current Sensor #3 (watt-hrs)	Sampler Temp. (^{0}C)
9/3/2009	11.76	36.33	.	.	.	.	.
9/4/2009	11.81	38.80	.	.	.	.	.
9/5/2009	11.76	39.36	.	.	.	.	.
9/7/2009	11.35	32.67	.	.	.	.	.
9/8/2009	11.81	39.28	.	.	.	.	.
9/9/2009	11.75	32.41	.	.	.	.	.
9/10/2009	11.88	31.73	.	.	.	.	.
9/11/2009	11.88	29.21	.	.	.	.	.
9/12/2009	11.54	30.65	.	.	.	.	.
9/13/2009	11.42	29.52	.	.	.	.	.
9/14/2009	11.70	30.47	.	.	.	.	.
9/15/2009	11.80	29.15	.	.	.	.	.
9/16/2009	11.52	29.53	.	.	.	.	.
9/17/2009	11.23	29.72	.	.	.	.	.
9/18/2009	10.88	30.00	.	.	.	.	.
9/19/2009	10.71	29.36	.	.	.	.	.
9/20/2009	10.25	25.91	.	.	.	.	.
9/21/2009	9.86	25.06	.	.	.	.	.
9/22/2009	10.17	29.95	.	.	.	.	.
9/23/2009	10.45	31.49	.	.	.	.	.
9/24/2009	10.46	31.97	.	.	.	.	.
9/25/2009	10.44	30.30	.	.	.	.	.
9/26/2009	9.78	47.25	.	.	.	.	.

Table 5-A continued

Date	Battery Volts	Panel Temperature (^{0}C)	Solar Panel Volts	Current Sensor #1 (watt-hrs)	Current Sensor #2 (watt-hrs)	Current Sensor #3 (watt-hrs)	Sampler Temp. (^{0}C)
10/2/2009	12.22	22.43	.	.	.	.	.
10/3/2009	12.29	22.06	.	.	.	.	.
10/4/2009	12.21	17.54	.	.	.	.	.
10/5/2009	12.23	22.41	.	.	.	.	.
10/6/2009	12.10	23.22	.	.	.	.	.
10/7/2009	12.23	25.82	.	.	.	.	.
10/8/2009	12.29	21.63	.	.	.	.	.
10/9/2009	12.31	25.33	.	.	.	.	.
10/10/2009	12.05	23.04	.	.	.	.	.
10/11/2009	11.99	21.24	.	.	.	.	.
10/12/2009	11.82	18.96	.	.	.	.	.
10/13/2009	11.83	23.98	.	.	.	.	.
10/14/2009	11.60	20.13	.	.	.	.	.
10/15/2009	10.96	18.27	.	.	.	.	.
10/16/2009	10.42	14.24	.	.	.	.	.
10/17/2009	9.93	10.81	.	.	.	.	.
10/18/2009	10.27	10.03	.	.	.	.	.
10/19/2009	10.89	11.85	.	.	.	.	.
10/20/2009	11.26	14.58	.	.	.	.	.
10/21/2009	11.44	16.91	.	.	.	.	.
10/22/2009	11.39	18.67	.	.	.	.	.
10/23/2009	10.79	21.48	.	.	.	.	.
10/24/2009	10.76	17.05	.	.	.	.	.

Table 5-A continued							
Date	**Battery Volts**	**Panel Temperature (^{0}C)**	**Solar Panel Volts**	**Current Sensor #1 (watt-hrs)**	**Current Sensor #2 (watt-hrs)**	**Current Sensor #3 (watt-hrs)**	**Sampler Temp. (^{0}C)**
10/25/2009	11.37	14.64	.	.	.	.	.
10/26/2009	11.61	15.47	.	.	.	.	.
10/27/2009	10.79	15.38	.	.	.	.	.
10/28/2009	11.21	21.22	.	.	.	.	.
10/29/2009	11.49	18.76	.	.	.	.	.
10/30/2009	11.57	24.43	.	.	.	.	.
10/31/2009	10.76	19.24	.	.	.	.	.
11/1/2009	11.36	16.68	.	.	.	.	.
11/2/2009	11.92	15.68	.	.	.	.	.
11/3/2009	11.98	14.90	.	.	.	.	.
11/4/2009	12.07	13.27	.	.	.	.	.
11/5/2009	12.09	13.34	.	.	.	.	.
11/6/2009	12.17	11.80	.	.	.	.	.
11/7/2009	12.15	13.60	.	.	.	.	.
11/8/2009	12.06	15.92	.	.	.	.	.
11/9/2009	11.81	14.25	.	.	.	.	.
11/10/2009	11.08	15.09	.	.	.	.	.
11/11/2009	10.64	14.92	.	.	.	.	.
11/12/2009	11.30	15.83	.	.	.	.	.
11/13/2009	11.90	16.08	.	.	.	.	.
11/14/2009	11.96	17.07	.	.	.	.	.
11/15/2009	11.95	17.54	.	.	.	.	.
11/16/2009	11.98	16.40	.	.	.	.	.

Table 5-A continued

Date	Battery Volts	Panel Temperature (^{0}C)	Solar Panel Volts	Current Sensor #1 (watt-hrs)	Current Sensor #2 (watt-hrs)	Current Sensor #3 (watt-hrs)	Sampler Temp. (^{0}C)
11/17/2009	11.74	17.97	.	.	.	.	.
11/18/2009	11.38	18.80	.	.	.	.	.
11/19/2009	10.98	14.51	.	.	.	.	.
11/20/2009	11.63	11.56	.	.	.	.	.
11/21/2009	12.05	12.39	.	.	.	.	.
11/22/2009	11.62	10.18	.	.	.	.	.
11/23/2009	11.43	15.83	.	.	.	.	.
11/24/2009	11.42	18.71	.	.	.	.	.
11/25/2009	11.53	17.37	.	.	.	.	.
11/26/2009	11.92	11.11	.	.	.	.	.
11/27/2009	11.98	10.47	.	.	.	.	.
11/28/2009	12.11	8.46	.	.	.	.	.
11/29/2009	11.94	9.81	.	.	.	.	.
11/30/2009	10.79	12.30	.	.	.	.	.
12/1/2009	11.69	8.17	.	.	.	.	.
12/2/2009	11.29	12.31	.	.	.	.	.
12/3/2009	10.65	10.65	.	.	.	.	.
12/4/2009	10.82	8.89	.	.	.	.	.
12/5/2009	10.66	5.60	.	.	.	.	.
12/6/2009	11.68	3.16	.	.	.	.	.
12/7/2009	11.83	3.14	.	.	.	.	.
12/8/2009	11.48	7.60	.	.	.	.	.
12/9/2009	12.38	14.46	.	.	.	.	.

Table 5-A continued							
Date	**Battery Volts**	**Panel Temperature (^{0}C)**	**Solar Panel Volts**	**Current Sensor #1 (watt-hrs)**	**Current Sensor #2 (watt-hrs)**	**Current Sensor #3 (watt-hrs)**	**Sampler Temp. (^{0}C)**
12/10/2009	12.65	5.06	.	.	.	.	.
12/11/2009	12.81	-1.97	.	.	.	.	.
12/12/2009	12.84	-1.93	.	.	.	.	.
12/13/2009	12.52	7.09	.	.	.	.	.
12/14/2009	12.55	11.94	.	.	.	.	.
12/15/2009	12.32	12.72	.	.	.	.	.
12/16/2009	12.67	5.15	.	.	.	.	.
12/17/2009	12.79	3.64	.	.	.	.	.
12/18/2009	12.44	4.22	.	.	.	.	.
12/19/2009	12.32	3.24	.	.	.	.	.
12/20/2009	12.31	3.26	.	.	.	.	.
12/21/2009	12.44	3.63	.	.	.	.	.
12/22/2009	12.61	7.23	.	.	.	.	.
12/23/2009	12.72	7.79	.	.	.	.	.
12/24/2009	12.69	10.34	.	.	.	.	.
12/25/2009	12.59	13.34	.	.	.	.	.
12/26/2009	12.73	6.17	.	.	.	.	.
12/27/2009	12.80	4.50	.	.	.	.	.
12/28/2009	12.79	4.47	.	.	.	.	.
12/29/2009	12.83	3.19	.	.	.	.	.
12/30/2009	12.78	3.70	.	.	.	.	.
12/31/2009	12.40	6.23	.	.	.	.	.
1/1/2010	12.67	5.92	.	.	.	.	.

Table 5-A continued

Date	Battery Volts	Panel Temperature (^{0}C)	Solar Panel Volts	Current Sensor #1 (watt-hrs)	Current Sensor #2 (watt-hrs)	Current Sensor #3 (watt-hrs)	Sampler Temp. (^{0}C)
1/2/2010	12.91	-1.70	.	.	.	.	.
1/3/2010	12.88	-4.90	.	.	.	.	.
1/4/2010	12.86	-4.71	.	.	.	.	.
1/5/2010	12.88	-3.14	.	.	.	.	.
1/6/2010	12.89	-1.46	.	.	.	.	.
1/7/2010	12.82	-4.12	.	.	.	.	.
1/8/2010	12.80	-4.20	.	.	.	.	.
1/9/2010	12.86	-5.11	.	.	.	.	.
1/10/2010	12.87	-2.37	.	.	.	.	.
1/11/2010	12.87	-4.22	.	.	.	.	.
1/12/2010	12.87	0.92	.	.	.	.	.
1/13/2010	12.92	-0.68	.	.	.	.	.
1/14/2010	12.92	1.14	.	.	.	.	.
1/15/2010	12.84	4.66	.	.	.	.	.
1/16/2010	12.78	4.68	.	.	.	.	.
1/17/2010	12.60	12.02	.	.	.	.	.
1/18/2010	12.69	11.88	.	.	.	.	.
1/19/2010	12.93	9.59	.	.	.	.	.
1/20/2010	12.40	11.61	.	.	.	.	.
1/21/2010	12.47	13.12	.	.	.	.	.
1/22/2010	12.40	10.20	.	.	.	.	.
1/23/2010	12.61	12.06	.	.	.	.	.
1/24/2010	12.36	12.32	.	.	.	.	.

Table 5-A continued

Date	Battery Volts	Panel Temperature (^{0}C)	Solar Panel Volts	Current Sensor #1 (watt-hrs)	Current Sensor #2 (watt-hrs)	Current Sensor #3 (watt-hrs)	Sampler Temp. (^{0}C)
1/25/2010	12.54	11.36	.	.	.	.	.
1/26/2010	12.75	3.44	.	.	.	.	.
1/27/2010	12.83	3.88	.	.	.	.	.
1/28/2010	12.78	8.22	.	.	.	.	.
1/29/2010	12.77	2.72	.	.	.	.	.
1/30/2010	12.75	2.94	.	.	.	.	.
1/31/2010	12.81	2.04	.	.	.	.	.
2/1/2010	12.87	1.44	.	.	.	.	.
2/2/2010	12.68	3.79	.	.	.	.	.
2/3/2010	12.68	5.66	.	.	.	.	.
2/4/2010	12.92	3.39	.	.	.	.	.
2/5/2010	12.41	7.14	.	.	.	.	.
2/6/2010	12.32	6.47	.	.	.	.	.
2/7/2010	12.36	3.43	.	.	.	.	.
2/8/2010	12.67	6.03	.	.	.	.	.
2/9/2010	12.47	8.93	.	.	.	.	.
2/10/2010	12.73	-0.52	.	.	.	.	.
2/11/2010	12.86	0.78	.	.	.	.	.
2/12/2010	12.88	-0.18	.	.	.	.	.
2/13/2010	12.89	0.12	.	.	.	.	.
2/14/2010	12.81	3.40	.	.	.	.	.
2/15/2010	12.80	2.95	.	.	.	.	.
2/16/2010	12.91	-0.60	.	.	.	.	.

Table 5-A continued

Date	Battery Volts	Panel Temperature (^{0}C)	Solar Panel Volts	Current Sensor #1 (watt-hrs)	Current Sensor #2 (watt-hrs)	Current Sensor #3 (watt-hrs)	Sampler Temp. (^{0}C)
2/17/2010	12.88	-0.17	.	.	.	.	.
2/18/2010	12.90	2.92	.	.	.	.	.
2/19/2010	12.83	6.38	.	.	.	.	.
2/20/2010	12.79	7.23	.	.	.	.	.
2/21/2010	12.77	9.98	.	.	.	.	.
2/22/2010	12.58	11.21	.	.	.	.	.
2/23/2010	12.41	9.84	.	.	.	.	.
2/24/2010	12.54	5.68	.	.	.	.	.
2/25/2010	12.86	0.95	.	.	.	.	.
2/26/2010	12.88	3.25	.	.	.	.	.
2/27/2010	12.80	3.02	.	.	.	.	.
2/28/2010	12.60	3.98	.	.	.	.	.
3/1/2010	12.70	6.00	.	.	.	.	.
3/2/2010	12.62	4.69	.	.	.	.	.
3/3/2010	12.74	3.76	.	.	.	.	.
3/4/2010	12.51	5.73	.	.	.	.	.
3/5/2010	12.82	5.24	.	.	.	.	.
3/6/2010	12.77	6.94	.	.	.	.	.
3/7/2010	12.77	7.75	.	.	.	.	.
3/8/2010	12.72	12.76	.	.	.	.	.
3/9/2010	12.66	15.40	.	.	.	.	.
3/10/2010	12.50	16.20	.	.	.	.	.
3/11/2010	12.42	15.72	.	.	.	.	.

Table 5-A continued

Date	Battery Volts	Panel Temperature (^{0}C)	Solar Panel Volts	Current Sensor #1 (watt-hrs)	Current Sensor #2 (watt-hrs)	Current Sensor #3 (watt-hrs)	Sampler Temp. (^{0}C)
3/12/2010	12.41	15.45	.	.	.	.	.
3/13/2010	12.57	14.29	.	.	.	.	.
3/14/2010	12.52	10.36	.	.	.	.	.
3/15/2010	12.48	10.13	.	.	.	.	.
3/16/2010	12.50	11.00	.	.	.	.	.
3/17/2010	12.31	11.51	.	.	.	.	.
3/18/2010	12.65	16.12	.	205.31	211.10	158.37	5.17
3/19/2010	12.90	16.34	.	383.07	371.86	294.04	2.41
3/20/2010	12.89	17.41	.	371.54	377.54	309.28	2.57
3/21/2010	12.75	15.49	.	299.97	349.73	288.91	2.47
3/22/2010	12.68	9.86	.	237.59	292.27	229.78	1.61
3/23/2010	12.83	11.64	.	304.02	317.73	242.98	1.72
3/24/2010	12.90	16.07	10.09	362.91	381.56	295.06	2.38
3/25/2010	12.52	13.06	8.57	176.19	231.07	256.05	2.11
3/26/2010	12.43	11.26	8.52	160.80	214.96	230.54	1.82
3/27/2010	12.85	12.88	6.79	465.03	466.45	250.60	1.86
3/28/2010	12.71	14.94	6.63	278.06	326.31	277.81	2.23
3/29/2010	12.60	13.64	8.19	233.28	289.21	259.59	2.04
3/30/2010	12.80	15.09	8.47	381.53	412.52	278.81	2.11
3/31/2010	12.92	16.73	6.54	382.17	384.77	298.37	2.25
4/1/2010	12.97	20.87	6.47	317.55	325.19	151.14	11.85
4/2/2010	12.89	24.88	8.68	455.35	462.35	440.24	4.17
4/3/2010	12.80	23.27	6.73	454.42	490.58	376.17	3.50

Table 5-A continued

Date	Battery Volts	Panel Temperature (^{0}C)	Solar Panel Volts	Current Sensor #1 (watt-hrs)	Current Sensor #2 (watt-hrs)	Current Sensor #3 (watt-hrs)	Sampler Temp. (^{0}C)
4/4/2010	12.88	24.68	6.63	487.83	495.96	392.66	3.51
4/5/2010	12.88	25.25	8.09	487.67	513.43	419.50	3.56
4/6/2010	12.86	27.24	8.92	536.34	546.64	424.12	3.40
4/7/2010	12.88	25.62	8.91	486.05	505.37	408.92	3.31
4/8/2010	12.46	18.76	8.44	178.06	236.31	323.35	2.78
4/9/2010	12.87	16.61	7.88	502.17	519.77	281.89	2.27
4/10/2010	12.99	16.95	8.51	363.26	365.78	297.42	2.26
4/11/2010	12.95	19.73	8.47	400.43	410.36	331.98	2.52
4/12/2010	12.93	21.44	8.49	417.14	431.71	355.09	2.76
4/13/2010	12.91	23.50	8.52	455.40	483.15	383.37	3.00
4/14/2010	12.89	25.56	6.78	483.72	502.34	414.89	3.07
4/15/2010	12.96	25.35	8.84	391.47	403.78	218.35	12.18
4/16/2010	12.91	26.41	9.22	479.60	497.61	469.76	4.53
4/17/2010	12.85	23.88	9.06	474.42	493.37	376.88	3.70
4/18/2010	13.00	18.36	8.94	379.57	393.85	309.02	2.80
4/19/2010	12.96	17.66	8.82	371.88	383.58	315.36	2.78
4/20/2010	12.72	17.21	8.67	285.32	341.48	301.53	2.82
4/21/2010	12.84	19.15	8.95	401.92	437.00	324.56	2.98
4/22/2010	12.95	19.66	8.77	403.38	419.09	338.17	2.93
4/23/2010	12.89	25.28	8.50	487.49	506.84	416.00	3.60
4/24/2010	12.68	24.91	9.36	390.47	446.31	420.20	3.73
4/25/2010	12.85	26.60	9.08	577.81	594.29	430.49	3.68
4/26/2010	12.66	20.75	7.11	313.36	370.60	356.26	3.02

Table 5-A continued

Date	Battery Volts	Panel Temperature (^{0}C)	Solar Panel Volts	Current Sensor #1 (watt-hrs)	Current Sensor #2 (watt-hrs)	Current Sensor #3 (watt-hrs)	Sampler Temp. (^{0}C)
4/27/2010	12.76	16.90	8.01	393.97	434.35	299.35	2.33
4/28/2010	12.98	16.58	9.11	368.41	381.18	286.99	2.20
4/29/2010	12.95	20.43	8.81	429.60	430.09	366.05	3.11
4/30/2010	12.91	24.05	7.12	456.31	452.29	393.72	3.33
5/1/2010	12.83	27.23	8.79	488.85	504.29	452.32	3.83
5/2/2010	12.75	32.55	7.26	599.01	620.43	574.85	4.37
5/3/2010	12.76	31.83	7.82	645.96	669.70	534.31	4.35
5/4/2010	12.87	30.74	9.52	596.05	597.63	490.63	4.04
5/5/2010	12.89	28.43	9.26	551.26	544.05	458.60	3.63
5/6/2010	12.87	28.97	9.08	552.89	561.77	475.60	3.75
5/7/2010	12.85	30.44	8.27	585.94	592.41	503.81	3.82
5/8/2010	12.87	26.73	8.01	559.68	546.03	424.84	3.54
5/9/2010	12.98	19.77	7.87	399.66	391.31	317.67	2.61
5/10/2010	12.96	17.76	8.73	342.67	356.86	289.94	2.46
5/11/2010	12.86	23.88	8.82	414.23	438.78	373.90	3.04
5/12/2010	12.76	27.83	8.79	487.58	520.67	454.12	3.47
5/13/2010	12.85	30.31	8.68	577.77	591.67	498.62	4.49
5/14/2010	12.79	31.71	8.98	579.40	599.19	534.40	3.93
5/15/2010	12.78	29.92	9.54	563.74	581.70	501.81	4.03
5/16/2010	12.70	28.45	8.96	487.06	516.92	488.13	4.02
5/17/2010	12.78	28.06	7.98	573.39	592.57	469.27	3.90
5/18/2010	12.88	25.85	8.10	501.61	525.17	432.55	3.66
5/19/2010	12.85	24.80	8.54	461.50	475.05	404.98	3.49

Table 5-A continued

Date	Battery Volts	Panel Temperature (^{0}C)	Solar Panel Volts	Current Sensor #1 (watt-hrs)	Current Sensor #2 (watt-hrs)	Current Sensor #3 (watt-hrs)	Sampler Temp. (^{0}C)
5/20/2010	12.89	24.90	8.22	477.53	471.25	413.20	3.31
5/21/2010	12.74	26.47	8.30	471.86	501.97	447.12	3.62
5/22/2010	12.81	28.27	7.79	521.20	542.99	477.69	3.65
5/23/2010	12.81	31.07	8.12	591.11	606.64	531.67	3.69
5/24/2010	12.82	29.94	8.21	592.23	602.70	518.48	3.54
5/25/2010	12.80	30.76	8.55	582.26	591.51	534.99	3.52
5/26/2010	12.73	29.51	9.11	513.50	543.18	506.62	3.46
5/27/2010	12.80	29.98	7.89	575.89	601.28	505.23	4.30
5/28/2010	12.67	28.63	8.41	444.38	470.41	478.87	3.81
5/29/2010	12.79	30.42	8.72	636.93	651.78	517.00	3.83
5/30/2010	12.80	31.91	8.55	592.60	614.39	539.31	3.94
5/31/2010	12.75	30.29	8.58	561.75	594.16	512.90	3.93
6/1/2010	12.77	30.62	8.12	567.83	595.97	531.39	4.19
6/2/2010	12.80	32.34	8.42	629.20	657.97	570.96	4.23
6/3/2010	12.78	33.03	8.05	635.80	649.52	589.34	4.20
6/4/2010	12.72	33.22	8.66	627.31	669.35	590.77	4.19
6/5/2010	12.77	33.03	8.48	648.16	670.74	587.66	4.08
6/6/2010	12.59	30.51	8.18	463.90	505.24	532.29	3.96
6/7/2010	12.80	28.74	8.17	629.05	650.00	481.86	3.53
6/8/2010	12.84	29.64	8.36	561.40	570.18	495.79	3.53
6/9/2010	12.53	27.44	8.42	343.36	384.22	469.48	3.55
6/10/2010	12.56	29.08	7.92	476.99	521.08	476.71	4.17
6/11/2010	12.73	33.36	8.48	723.46	754.88	572.84	4.10

Table 5-A continued

Date	Battery Volts	Panel Temperature (^{0}C)	Solar Panel Volts	Current Sensor #1 (watt-hrs)	Current Sensor #2 (watt-hrs)	Current Sensor #3 (watt-hrs)	Sampler Temp. (^{0}C)
6/12/2010	12.69	32.81	7.81	609.51	632.61	553.32	4.08
6/13/2010	12.73	35.06	8.58	672.23	702.97	612.40	4.22
6/14/2010	12.71	35.71	8.75	691.00	718.13	628.94	4.24
6/15/2010	12.68	33.70	7.64	642.48	673.56	608.28	4.53
6/16/2010	12.73	34.74	7.80	711.08	734.91	641.97	4.59
6/17/2010	12.71	35.53	8.20	718.46	737.29	644.29	4.53
6/18/2010	12.75	33.54	8.14	659.74	678.21	595.87	4.32
6/19/2010	12.61	33.90	8.09	573.70	617.02	583.47	4.09
6/20/2010	12.72	35.29	8.15	719.32	736.10	623.11	3.81
6/21/2010	12.73	35.03	8.03	682.95	703.27	614.15	3.75
6/22/2010	12.73	34.84	8.28	675.02	695.69	616.81	3.71
6/23/2010	12.69	37.48	8.29	736.51	766.90	690.04	4.01
6/24/2010	12.83	34.79	8.34	543.49	560.56	281.11	16.94
6/25/2010	12.79	35.79	7.94	638.41	657.59	689.88	5.30
6/26/2010	12.72	36.44	8.42	708.90	736.23	653.70	4.49
6/27/2010	12.69	37.42	8.47	737.22	770.63	682.15	4.39
6/28/2010	12.69	35.76	8.44	708.75	732.82	640.96	4.39
6/29/2010	12.69	34.59	8.27	684.41	718.27	626.26	4.66
6/30/2010	12.73	33.74	8.56	668.80	698.23	606.13	4.55
7/1/2010	12.76	32.40	8.48	638.67	657.52	564.63	4.30
7/2/2010	12.78	31.14	8.15	594.60	602.32	549.13	4.20
7/3/2010	12.71	33.53	8.06	641.03	665.16	600.23	4.39
7/4/2010	12.71	34.78	8.00	694.50	714.40	634.22	4.39

Table 5-A continued

Date	Battery Volts	Panel Temperature (^{0}C)	Solar Panel Volts	Current Sensor #1 (watt-hrs)	Current Sensor #2 (watt-hrs)	Current Sensor #3 (watt-hrs)	Sampler Temp. (^{0}C)
7/5/2010	12.69	35.83	8.10	710.33	735.67	666.32	4.42
7/6/2010	12.68	36.42	8.21	742.98	769.18	677.42	4.33
7/7/2010	12.68	37.19	8.69	760.99	784.58	716.84	4.40
7/8/2010	12.83	36.14	8.56	591.87	609.47	309.28	16.97
7/9/2010	12.67	34.27	8.22	540.02	569.41	673.15	5.24
7/10/2010	12.66	35.00	8.33	718.32	755.66	655.47	4.73
7/11/2010	12.73	34.99	8.35	703.56	726.59	633.13	4.10
7/12/2010	12.41	31.41	8.21	374.75	417.63	545.91	4.31
7/13/2010	12.45	33.60	8.13	596.23	644.65	617.73	4.64
7/14/2010	12.58	35.72	8.68	839.93	885.12	673.65	4.68
7/15/2010	12.70	36.16	7.85	784.25	816.80	673.88	4.20
7/16/2010	12.67	37.95	7.92	769.44	807.10	724.80	4.10
7/17/2010	12.51	36.01	8.25	578.80	633.01	660.54	3.99
7/18/2010	12.54	35.56	7.50	719.74	760.35	671.88	4.48
7/19/2010	12.56	33.37	7.67	654.67	696.73	603.63	3.74
7/20/2010	12.64	34.73	7.85	711.63	735.72	615.43	3.80
7/21/2010	12.60	34.15	8.02	625.69	668.69	613.91	3.95
7/22/2010	12.82	32.80	7.89	525.77	537.31	259.61	15.94
7/23/2010	12.72	36.95	7.64	682.36	702.13	739.11	5.27
7/24/2010	12.65	38.62	7.73	784.31	822.30	734.70	4.36
7/25/2010	12.63	39.38	7.46	824.90	862.23	763.48	4.45
7/26/2010	12.54	38.21	7.97	751.46	798.84	757.98	4.84
7/27/2010	12.45	35.73	7.73	607.93	661.91	678.03	4.58

Table 5-A continued

Date	Battery Volts	Panel Temperature (^{0}C)	Solar Panel Volts	Current Sensor #1 (watt-hrs)	Current Sensor #2 (watt-hrs)	Current Sensor #3 (watt-hrs)	Sampler Temp. (^{0}C)
7/28/2010	12.47	37.65	8.66	763.23	818.27	727.03	4.58
7/29/2010	12.46	36.23	8.19	649.22	702.11	670.86	4.04
7/30/2010	12.50	34.49	7.90	788.68	831.87	629.55	3.85
7/31/2010	12.34	30.05	7.79	358.53	405.80	526.02	3.79
8/1/2010	12.43	32.80	7.61	687.82	740.05	592.00	3.74
8/2/2010	12.58	34.89	7.55	806.54	847.04	657.18	3.91
8/3/2010	12.55	36.13	7.47	770.19	818.36	712.73	4.12
8/4/2010	12.55	36.37	7.50	784.16	825.26	720.29	4.21
8/5/2010	12.58	33.78	7.64	621.01	665.58	415.19	11.70
8/6/2010	12.59	32.25	7.30	589.90	631.89	616.47	4.86
8/7/2010	12.65	33.14	7.49	703.02	727.54	584.04	4.08
8/8/2010	12.67	32.20	7.61	668.24	688.13	578.29	4.18
8/9/2010	12.62	33.53	7.56	672.32	712.10	610.87	4.13
8/10/2010	12.59	35.71	7.63	775.82	811.61	697.84	4.55
8/11/2010	12.58	36.68	7.46	815.39	858.05	731.21	4.73
8/12/2010	12.53	35.65	7.54	731.94	778.33	711.29	4.69
8/13/2010	12.57	36.48	8.04	807.98	850.48	725.15	4.44
8/14/2010	12.55	35.90	8.05	741.64	790.27	684.86	4.06
8/15/2010	12.55	36.14	7.72	766.49	811.55	710.00	4.33
8/16/2010	12.43	34.92	7.57	637.86	689.53	667.60	4.23
8/17/2010	12.36	32.38	7.52	544.82	593.87	586.58	3.90
8/18/2010	12.15	30.24	7.36	336.89	389.73	532.62	3.90
8/19/2010	12.18	29.87	7.56	294.03	343.59	316.14	14.65

Table 5-A continued

Date	Battery Volts	Panel Temperature (^{0}C)	Solar Panel Volts	Current Sensor #1 (watt-hrs)	Current Sensor #2 (watt-hrs)	Current Sensor #3 (watt-hrs)	Sampler Temp. (^{0}C)
8/20/2010	12.25	36.63	7.32	864.14	929.27	844.53	2.02
8/21/2010	11.93	33.17	7.42	290.13	347.79	714.94	1.22
8/22/2010	12.02	35.77	7.27	755.49	835.88	720.12	0.87
8/23/2010	12.12	33.79	7.09	791.45	867.28	642.05	0.84
8/24/2010	12.22	32.39	6.93	765.62	837.89	620.95	0.65
8/25/2010	12.28	33.68	6.82	815.25	881.26	664.26	0.39
8/26/2010	12.39	33.36	7.07	834.79	893.30	667.14	0.22
8/27/2010	12.50	34.13	6.73	894.99	943.00	670.27	-0.32
8/28/2010	12.57	34.91	6.89	842.62	874.53	707.88	-0.51
8/29/2010	12.55	34.64	7.01	759.22	794.18	692.29	-0.55
8/30/2010	12.56	35.08	7.03	810.16	842.00	691.59	-0.57
8/31/2010	12.61	34.02	7.06	758.27	784.37	656.00	-0.59
9/1/2010	12.61	33.63	7.12	739.90	769.00	652.98	-0.60
9/2/2010	12.75	32.22	7.20	591.82	601.30	300.18	9.90
9/3/2010	12.55	32.34	7.37	604.26	640.23	751.46	1.86
9/4/2010	12.67	28.02	7.30	661.45	679.50	496.54	0.67
9/5/2010	12.75	25.73	7.43	545.90	551.53	462.56	0.70
9/6/2010	12.70	28.03	7.55	570.37	586.65	538.45	0.68
9/7/2010	12.65	31.04	7.56	649.42	672.26	607.98	0.61
9/8/2010	12.24	29.56	7.90	324.85	376.85	562.71	0.61
9/9/2010	12.36	31.19	7.06	651.62	710.22	583.43	0.57
9/10/2010	12.27	29.52	7.87	421.34	473.65	562.93	0.61
9/11/2010	12.05	27.80	8.05	308.31	359.59	524.08	0.60

Table 5-A continued

Date	Battery Volts	Panel Temperature (^{0}C)	Solar Panel Volts	Current Sensor #1 (watt-hrs)	Current Sensor #2 (watt-hrs)	Current Sensor #3 (watt-hrs)	Sampler Temp. (^{0}C)
9/12/2010	12.16	31.36	7.83	628.26	694.10	585.08	0.39
9/13/2010	12.44	28.31	7.52	861.94	913.46	514.56	0.46
9/14/2010	12.60	29.98	6.46	746.20	777.78	605.10	0.60
9/15/2010	12.61	31.31	6.79	702.96	731.63	615.09	0.46
9/16/2010	12.70	28.31	6.62	506.26	533.57	259.19	10.07
9/17/2010	12.53	32.92	6.24	627.62	660.89	720.46	1.68
9/18/2010	12.60	31.35	6.62	698.19	710.10	633.01	0.81
9/19/2010	12.60	31.92	6.86	701.41	722.41	631.51	0.80
9/20/2010	12.59	32.95	7.06	741.53	760.82	683.52	0.97
9/21/2010	12.57	34.06	7.11	780.82	799.48	722.66	1.07
9/22/2010	12.51	33.92	7.12	739.99	775.42	675.94	1.01
9/23/2010	12.52	34.59	6.68	780.96	818.13	742.29	1.24
9/24/2010	12.55	33.83	7.36	768.63	801.43	663.02	1.06
9/25/2010	12.23	29.64	7.33	331.80	386.37	563.37	0.90
9/26/2010	11.93	25.11	7.26	136.82	182.30	465.68	0.96
9/27/2010	11.91	24.34	7.13	280.16	335.93	446.11	0.92
9/28/2010	12.12	24.25	6.87	649.51	714.21	434.60	0.89
9/29/2010	12.42	25.76	6.93	791.93	843.16	470.70	0.82
9/30/2010	12.23	24.57	7.01	279.45	332.19	450.27	0.91
10/1/2010	12.59	23.92	6.26	721.47	739.64	237.51	6.75
10/2/2010	12.72	22.39	5.89	500.10	505.02	457.72	1.24
10/3/2010	12.27	15.60	5.92	140.96	187.15	308.97	0.36
10/4/2010	12.36	14.75	6.24	320.75	374.52	308.10	0.28

Table 5-A continued

Date	Battery Volts	Panel Temperature (^{0}C)	Solar Panel Volts	Current Sensor #1 (watt-hrs)	Current Sensor #2 (watt-hrs)	Current Sensor #3 (watt-hrs)	Sampler Temp. (^{0}C)
10/5/2010	12.61	15.89	6.54	498.59	518.92	314.93	0.30
10/6/2010	12.73	17.72	6.12	420.84	434.55	343.06	0.34
10/7/2010	12.70	20.61	7.27	438.64	457.81	395.87	0.30
10/8/2010	12.66	23.84	7.74	509.13	522.42	431.39	0.35
10/9/2010	12.66	23.79	6.14	502.74	514.91	440.53	0.36
10/10/2010	12.65	25.04	6.26	527.17	533.77	461.39	0.35
10/11/2010	12.63	25.68	6.85	547.43	578.70	496.20	0.47
10/12/2010	12.56	23.35	7.90	471.15	501.95	430.66	0.40
10/13/2010	12.59	26.58	7.68	562.06	581.90	480.91	0.33
10/14/2010	12.66	22.41	7.45	442.18	458.86	258.88	5.45
10/15/2010	12.70	16.92	7.46	361.36	374.89	381.18	1.12
10/16/2010	12.72	17.43	7.31	376.81	383.30	333.39	0.46
10/17/2010	12.70	18.63	7.23	400.38	408.20	361.72	0.47
10/18/2010	12.66	20.07	6.61	424.68	443.96	387.73	0.43
10/19/2010	12.65	21.57	6.99	461.22	474.44	417.91	0.53
10/20/2010	12.52	22.79	7.06	464.85	494.25	416.74	0.60
10/21/2010	12.69	18.65	7.58	409.32	426.68	353.64	0.45
10/22/2010	12.69	17.79	7.72	386.26	402.60	336.27	0.44
10/23/2010	12.69	18.47	7.53	388.73	402.07	358.74	0.45
10/24/2010	12.63	22.29	7.31	450.31	470.55	420.21	0.46
10/25/2010	12.40	23.28	7.22	403.81	453.63	439.31	0.58
10/26/2010	12.44	26.49	6.35	477.26	527.17	523.92	0.57
10/27/2010	12.12	22.99	7.51	179.78	232.13	416.07	0.77

Table 5-A continued

Date	Battery Volts	Panel Temperature (^{0}C)	Solar Panel Volts	Current Sensor #1 (watt-hrs)	Current Sensor #2 (watt-hrs)	Current Sensor #3 (watt-hrs)	Sampler Temp. (^{0}C)
10/28/2010	12.52	23.72	7.51	706.74	732.89	277.10	.
10/29/2010	12.70	16.86	7.41	377.94	385.72	364.80	.
10/30/2010	12.74	14.13	7.13	331.17	337.37	291.64	.
10/31/2010	12.69	15.73	5.68	354.11	370.88	317.09	.
11/1/2010	12.68	16.77	5.93	370.86	391.42	331.18	.
11/2/2010	12.66	19.24	5.62	410.12	420.96	357.90	.
11/3/2010	12.51	17.26	6.40	311.44	359.07	337.96	.
11/4/2010	12.43	15.28	7.25	312.23	353.45	312.13	.
11/5/2010	12.42	9.39	7.50	224.60	268.14	240.98	.
11/6/2010	12.62	7.44	7.27	273.39	314.45	221.05	.
11/7/2010	12.72	7.19	7.09	229.03	251.66	205.73	.
11/8/2010	12.67	9.99	7.02	270.35	279.12	249.86	.
11/9/2010	12.64	12.70	5.71	297.06	305.77	278.21	.
11/10/2010	12.64	14.28	5.73	339.02	350.58	295.48	0.71
11/11/2010	12.73	14.70	5.71	301.33	315.28	179.13	11.90
11/12/2010	12.63	15.07	5.97	322.34	322.02	349.16	1.13
11/13/2010	12.61	14.86	7.60	341.14	357.86	303.96	0.57
11/14/2010	12.50	13.07	7.39	279.98	319.18	281.60	0.47
11/15/2010	12.16	14.19	7.18	114.53	161.66	302.69	0.35
11/16/2010	12.26	16.39	6.99	298.06	343.38	328.51	0.40
11/17/2010	12.53	14.95	7.10	546.34	562.74	300.41	0.44
11/18/2010	12.65	10.50	6.99	280.14	309.33	255.00	0.48
11/19/2010	12.64	14.65	6.90	346.11	363.49	305.78	0.46

Table 5-A continued

Date	Battery Volts	Panel Temperature (^{0}C)	Solar Panel Volts	Current Sensor #1 (watt-hrs)	Current Sensor #2 (watt-hrs)	Current Sensor #3 (watt-hrs)	Sampler Temp. (^{0}C)
11/20/2010	12.64	11.49	5.74	290.92	319.23	261.20	0.54
11/21/2010	12.55	15.11	5.28	319.84	357.19	314.57	0.51
11/22/2010	12.60	16.43	5.53	368.40	379.00	325.15	0.63
11/23/2010	12.38	13.17	6.29	143.54	190.00	176.22	4.17
11/24/2010	12.56	16.97	6.39	440.34	459.18	379.05	0.93
11/25/2010	12.56	20.93	6.88	417.01	434.24	384.49	0.62
11/26/2010	12.38	13.90	6.45	213.02	263.51	244.23	2.28
11/27/2010	12.67	5.08	6.16	256.15	268.61	154.21	1.61
11/28/2010	12.72	5.08	6.71	183.71	193.92	160.00	0.99
11/29/2010	12.70	8.83	5.51	214.38	234.90	200.92	1.97
11/30/2010	12.18	15.87	6.39	87.78	132.88	282.40	2.31
12/1/2010	12.41	7.24	6.29	273.15	320.41	172.57	2.24
12/2/2010	12.76	1.81	5.31	221.92	250.95	126.75	0.55
12/3/2010	12.77	5.75	7.14	191.92	209.51	166.18	1.61
12/4/2010	12.33	3.17	7.29	59.28	102.53	133.96	1.95
12/5/2010	12.51	2.85	6.88	156.50	199.94	126.26	2.00
12/6/2010	12.75	0.22	4.86	163.64	194.55	128.03	0.00
12/7/2010	12.70	-2.24	5.44	134.92	165.36	127.91	-0.54
12/8/2010	12.76	-2.88	6.61	146.63	169.55	127.66	-1.62
12/9/2010	12.77	-0.74	7.31	151.51	170.37	117.67	-1.09
12/10/2010	12.68	2.97	5.02	161.95	179.32	154.90	0.11
12/11/2010	12.61	6.16	5.31	193.88	222.18	203.56	0.26
12/12/2010	12.22	4.88	6.54	81.11	127.81	182.33	0.31

Table 5-A continued

Date	Battery Volts	Panel Temperature (^{0}C)	Solar Panel Volts	Current Sensor #1 (watt-hrs)	Current Sensor #2 (watt-hrs)	Current Sensor #3 (watt-hrs)	Sampler Temp. (^{0}C)
12/13/2010	12.28	-2.69	6.44	103.41	151.44	138.63	-0.87
12/14/2010	12.57	-3.82	7.48	267.65	293.36	142.46	-2.53
12/15/2010	12.75	-4.78	7.35	184.36	204.82	140.70	-3.71
12/16/2010	12.34	0.78	7.03	57.04	99.56	114.53	-0.76
12/17/2010	12.54	2.73	6.34	146.38	188.48	115.18	-0.06
12/18/2010	12.67	3.83	5.00	153.07	185.54	118.04	0.27
12/19/2010	12.67	1.72	5.19	139.10	170.55	120.23	0.20
12/20/2010	12.72	-0.05	6.68	143.99	164.40	122.40	-0.23
12/21/2010	12.30	3.03	6.99	73.75	117.39	114.32	0.30
12/22/2010	12.58	6.33	4.89	158.32	196.86	115.48	3.54
12/23/2010	12.78	3.41	5.33	133.25	156.60	100.52	1.67
12/24/2010	12.79	1.80	6.20	131.25	143.80	100.48	-0.43
12/25/2010	12.46	2.56	6.34	82.65	125.76	97.09	0.84
12/26/2010	12.34	0.36	7.01	66.65	110.86	97.28	-1.06
12/27/2010	12.54	-0.54	5.05	147.37	183.65	136.06	-1.54
12/28/2010	12.69	-2.01	5.43	158.80	183.48	136.29	-0.75
12/29/2010	12.74	-1.77	7.08	157.94	187.00	135.72	-2.05
12/30/2010	12.63	3.10	7.65	143.80	175.96	142.05	-0.12
12/31/2010	12.58	11.10	5.18	261.66	284.24	263.00	0.41
1/1/2011	12.11	15.62	5.01	82.96	127.28	318.27	0.28
1/2/2011	12.33	10.09	5.99	316.45	357.51	219.43	0.34
1/3/2011	12.67	1.84	7.18	303.59	315.74	134.71	-0.17
1/4/2011	12.73	1.72	6.66	191.77	219.83	143.43	-0.03

Table 5-A continued

Date	Battery Volts	Panel Temperature (^{0}C)	Solar Panel Volts	Current Sensor #1 (watt-hrs)	Current Sensor #2 (watt-hrs)	Current Sensor #3 (watt-hrs)	Sampler Temp. (^{0}C)
1/5/2011	12.71	0.53	6.14	157.29	193.05	130.12	-0.12
1/6/2011	12.70	3.75	6.52	184.73	212.40	159.67	0.29
1/7/2011	12.37	3.97	5.03	110.76	153.66	185.16	0.28
1/8/2011	12.62	1.01	5.33	214.11	244.13	128.28	0.22
1/9/2011	12.79	-4.47	6.71	175.40	188.16	138.36	-1.06
1/10/2011	12.37	-0.74	6.17	78.57	122.04	130.11	-0.53
1/11/2011	12.45	1.22	5.73	137.47	179.90	125.76	-0.11
1/12/2011	12.69	-0.75	6.23	181.08	212.91	131.68	-0.22
1/13/2011	12.79	-1.77	5.12	160.80	184.82	122.95	-0.87
1/14/2011	12.80	-3.04	6.30	167.14	186.01	142.75	-5.14
1/15/2011	12.80	1.02	7.81	163.12	169.53	125.73	-1.72
1/16/2011	12.77	4.10	5.12	159.03	169.34	123.92	0.83
1/17/2011	12.56	3.47	5.36	122.20	157.45	153.73	1.10
1/18/2011	12.58	6.51	6.14	186.34	219.30	175.93	2.08
1/19/2011	12.26	8.13	7.20	110.61	155.42	198.56	1.97
1/20/2011	12.56	4.17	7.81	231.76	249.91	103.24	1.86

Table 6-A. Battery volts, panel temperature, solar panel volts, energy readings and sampler temperature from Lick Creek.

Table 6-A continued

Date	Battery Volts	Panel Temperature (^{0}C)	Solar Panel Volts	Current Sensor #1 (watt-hrs)	Current Sensor #2 (watt-hrs)	Current Sensor #3 (watt-hrs)	Sampler Temp. (^{0}C)
3/18/2010	13.05	18.57	6.73	.	.	.	17.11
3/19/2010	13.03	16.45	8.97	379.82	338.28	295.55	15.49
3/20/2010	13.06	16.40	9.19	270.64	230.16	85.06	13.73
3/21/2010	13.14	14.54	8.59	158.22	149.73	46.19	12.29
3/22/2010	13.07	9.23	7.97	174.63	170.36	125.23	7.63
3/23/2010	12.97	12.14	8.90	319.99	281.47	233.62	11.33
3/24/2010	12.98	16.99	8.66	393.31	365.61	310.23	16.01
3/25/2010	12.64	13.73	6.76	189.95	205.96	250.45	13.33
3/26/2010	12.56	11.92	6.70	184.45	199.79	223.07	11.25
3/27/2010	12.95	12.66	8.97	524.60	487.00	217.57	10.86
3/28/2010	12.82	15.28	6.87	301.67	305.16	269.77	14.94
3/29/2010	12.70	14.06	6.83	254.96	270.92	247.94	13.77
3/30/2010	12.91	15.64	8.45	459.83	435.39	266.70	7.96
3/31/2010	13.16	17.34	9.05	490.17	426.24	297.90	1.72
4/1/2010	12.98	22.58	8.70	529.11	493.00	427.39	0.62
4/2/2010	12.93	25.03	8.35	572.47	540.32	463.88	0.06
4/3/2010	12.90	22.81	8.01	531.61	526.19	397.01	-0.02
4/4/2010	12.94	25.53	8.43	593.96	553.93	455.93	-0.03
4/5/2010	12.94	25.35	8.41	606.91	580.12	487.67	0.05
4/6/2010	12.91	27.95	8.41	675.66	649.82	528.03	0.04

Table 6-A continued

Date	Battery Volts	Panel Temperature (^{0}C)	Solar Panel Volts	Current Sensor #1 (watt-hrs)	Current Sensor #2 (watt-hrs)	Current Sensor #3 (watt-hrs)	Sampler Temp. (^{0}C)
4/7/2010	12.94	26.31	8.38	617.60	590.72	486.58	0.33
4/8/2010	12.52	19.54	6.96	186.96	206.16	354.93	0.24
4/9/2010	12.96	17.20	8.86	635.45	604.82	269.52	0.25
4/10/2010	13.08	17.60	9.51	394.84	362.55	288.51	0.19
4/11/2010	13.01	20.95	9.12	481.34	441.97	371.43	0.04
4/12/2010	12.99	21.70	9.03	494.36	465.99	383.38	0.15
4/13/2010	12.99	23.41	9.03	494.81	452.03	353.04	0.54
4/14/2010	12.99	25.51	8.91	496.30	469.03	370.92	0.61
4/15/2010	13.03	24.89	9.15	393.79	369.42	194.70	8.09
4/16/2010	13.01	25.34	8.96	487.32	452.63	418.44	2.09
4/17/2010	12.97	24.06	8.85	481.82	454.24	348.84	1.34
4/18/2010	13.04	18.86	9.54	379.49	349.56	276.24	1.03
4/19/2010	13.03	17.59	9.32	369.68	339.25	269.41	0.99
4/20/2010	12.86	16.87	7.38	288.60	299.31	264.52	1.00
4/21/2010	12.97	18.63	8.72	420.53	400.73	284.20	1.03
4/22/2010	13.04	19.03	9.43	401.74	377.39	297.21	1.04
4/23/2010	12.98	25.39	9.02	486.24	456.13	388.53	1.28
4/24/2010	12.81	24.67	7.30	393.01	399.11	371.94	1.40
4/25/2010	12.94	24.77	9.01	570.86	531.86	367.79	1.40
4/26/2010	12.82	18.99	7.55	328.16	337.25	293.66	1.09
4/27/2010	12.89	15.99	8.44	375.45	364.30	256.13	0.75
4/28/2010	13.04	15.88	9.74	354.95	324.24	242.46	0.69

Table 6-A continued

Date	Battery Volts	Panel Temperature (^{0}C)	Solar Panel Volts	Current Sensor #1 (watt-hrs)	Current Sensor #2 (watt-hrs)	Current Sensor #3 (watt-hrs)	Sampler Temp. (^{0}C)
4/29/2010	12.99	20.06	9.40	421.28	395.26	326.47	1.14
4/30/2010	12.96	24.94	9.17	490.72	469.59	390.86	1.23
5/1/2010	12.91	27.75	8.52	509.14	489.90	449.41	1.40
5/2/2010	12.85	31.22	8.04	621.17	609.88	525.79	1.62
5/3/2010	13.01	31.71	8.06	778.66	753.22	519.72	1.66
5/4/2010	12.98	31.54	8.87	629.99	597.96	490.61	1.61
5/5/2010	12.98	29.60	8.92	589.50	560.63	477.53	1.53
5/6/2010	12.96	31.53	8.83	648.16	616.05	526.75	1.65
5/7/2010	12.94	31.25	8.72	648.07	622.80	530.04	1.62
5/8/2010	12.97	26.63	9.34	576.21	548.73	398.70	1.56
5/9/2010	13.05	20.51	9.75	411.34	369.29	298.36	1.14
5/10/2010	13.02	18.32	9.06	359.23	345.46	287.81	1.00
5/11/2010	13.04	24.32	8.63	468.83	457.80	373.74	1.18
5/12/2010	12.88	28.19	8.33	516.76	517.19	429.93	1.22
5/13/2010	12.95	30.43	8.85	610.43	591.92	516.51	2.58
5/14/2010	12.89	31.91	8.33	647.08	633.80	547.21	2.89
5/15/2010	12.86	31.13	8.18	606.61	601.97	541.89	2.90
5/16/2010	12.80	28.91	7.86	540.86	548.38	452.91	2.63
5/17/2010	12.93	28.10	8.66	630.94	613.85	453.38	2.58
5/18/2010	13.01	25.95	8.70	516.65	500.23	394.95	2.43
5/19/2010	12.97	24.37	8.71	449.79	438.25	354.92	2.23
5/20/2010	12.98	26.76	9.28	529.31	502.55	415.67	2.21

Table 6-A continued

Date	Battery Volts	Panel Temperature (^{0}C)	Solar Panel Volts	Current Sensor #1 (watt-hrs)	Current Sensor #2 (watt-hrs)	Current Sensor #3 (watt-hrs)	Sampler Temp. (^{0}C)
5/21/2010	12.90	28.33	8.21	537.68	534.35	439.18	2.46
5/22/2010	12.94	30.16	8.75	602.09	584.54	502.80	2.53
5/23/2010	12.92	33.76	8.78	681.31	665.94	568.01	2.63
5/24/2010	12.94	31.35	8.81	651.39	631.65	506.30	2.52
5/25/2010	12.92	32.59	8.72	647.62	627.51	531.85	2.55
5/26/2010	12.91	29.51	8.23	540.76	545.31	452.79	2.53
5/27/2010	12.91	31.32	8.36	619.94	611.05	530.11	2.68
5/28/2010	12.69	29.37	7.98	469.09	481.38	499.44	1.63
5/29/2010	12.88	31.53	8.55	748.98	732.95	545.66	1.49
5/30/2010	12.90	33.17	8.48	672.01	658.01	576.23	1.58
5/31/2010	12.91	32.05	8.47	679.28	674.60	547.15	1.56
6/1/2010	12.90	31.35	8.44	626.85	621.15	537.91	1.53
6/2/2010	12.89	33.92	8.38	724.40	726.94	612.93	1.75
6/3/2010	12.89	34.68	8.61	777.01	756.92	635.96	1.58
6/4/2010	12.77	33.11	8.09	668.00	691.06	599.72	1.67
6/5/2010	13.00	32.67	8.54	832.62	808.34	614.73	1.85
6/6/2010	12.75	30.32	8.11	529.12	547.75	541.64	1.69
6/7/2010	12.88	29.84	8.69	683.76	668.25	471.98	1.16
6/8/2010	12.96	31.49	8.89	643.78	632.75	540.99	1.60
6/9/2010	12.63	27.82	7.87	346.84	366.43	463.65	1.30
6/10/2010	12.89	29.37	8.38	596.44	594.18	232.58	11.56
6/11/2010	12.94	36.13	8.59	738.59	734.13	776.64	2.59

Table 6-A continued

Date	Battery Volts	Panel Temperature (^{0}C)	Solar Panel Volts	Current Sensor #1 (watt-hrs)	Current Sensor #2 (watt-hrs)	Current Sensor #3 (watt-hrs)	Sampler Temp. (^{0}C)
6/12/2010	12.82	34.04	8.26	750.00	757.88	623.03	1.44
6/13/2010	12.84	35.79	8.21	737.47	747.09	646.45	1.59
6/14/2010	12.85	35.38	8.35	738.61	736.08	622.36	1.56
6/15/2010	12.78	33.22	8.14	634.50	648.19	556.41	1.51
6/16/2010	12.85	34.40	8.49	724.66	726.44	595.82	1.56
6/17/2010	12.87	36.66	8.57	792.55	784.82	636.08	1.54
6/18/2010	12.87	35.58	8.68	720.98	716.46	628.93	1.53
6/19/2010	12.64	33.38	8.13	534.50	560.66	600.11	1.40
6/20/2010	12.73	37.40	8.25	891.52	908.93	734.89	1.46
6/21/2010	12.79	36.93	8.28	836.43	849.20	713.80	1.42
6/22/2010	12.87	36.52	8.47	798.99	798.46	690.64	1.37
6/23/2010	12.76	37.76	8.26	822.61	836.84	748.27	1.29
6/24/2010	12.90	33.76	8.55	592.29	584.85	261.59	13.21
6/25/2010	12.84	37.91	8.33	792.15	806.42	856.22	2.99
6/26/2010	12.72	37.79	8.19	814.56	834.27	769.69	1.76
6/27/2010	12.66	37.74	8.17	803.87	827.69	763.44	1.80
6/28/2010	12.65	35.76	8.01	816.86	840.54	747.39	1.90
6/29/2010	12.73	36.16	8.15	832.49	851.97	688.59	1.73
6/30/2010	12.82	35.19	8.29	771.04	780.27	621.29	1.73
7/1/2010	12.82	33.33	8.68	755.95	751.27	575.09	1.61
7/2/2010	12.85	33.36	8.62	751.52	744.01	667.44	1.81
7/3/2010	12.80	35.49	8.33	811.63	822.44	696.96	1.99

Table 6-A continued

Date	Battery Volts	Panel Temperature (^{0}C)	Solar Panel Volts	Current Sensor #1 (watt-hrs)	Current Sensor #2 (watt-hrs)	Current Sensor #3 (watt-hrs)	Sampler Temp. (^{0}C)
7/4/2010	12.74	36.14	8.23	805.65	820.42	723.46	2.11
7/5/2010	12.77	36.99	8.29	844.78	854.15	741.50	2.11
7/6/2010	12.71	37.68	8.20	831.69	848.28	759.44	2.02
7/7/2010	12.62	37.71	8.07	749.89	777.30	754.79	1.82
7/8/2010	12.83	36.89	8.66	700.28	696.86	292.70	13.35
7/9/2010	12.69	34.07	7.97	530.87	548.24	688.58	2.99
7/10/2010	12.61	36.54	8.04	791.25	817.22	733.17	1.76
7/11/2010	12.74	37.02	8.12	864.97	877.62	695.41	1.56
7/12/2010	12.50	32.81	7.75	488.95	515.53	608.69	1.58
7/13/2010	12.45	32.44	7.84	539.42	568.00	577.59	1.45
7/14/2010	12.50	36.97	7.96	828.50	860.73	714.58	1.70
7/15/2010	12.58	37.85	7.98	875.73	904.75	729.11	1.60
7/16/2010	12.50	39.27	7.89	783.11	816.77	807.52	1.60
7/17/2010	12.43	36.33	7.79	695.34	736.21	676.40	1.36
7/18/2010	12.41	34.59	7.77	665.61	697.90	637.56	1.43
7/19/2010	12.48	34.25	7.55	813.62	842.51	629.45	1.52
7/20/2010	12.45	34.72	7.81	728.41	760.27	687.77	2.22
7/21/2010	12.38	35.03	7.70	680.85	719.77	686.89	1.87
7/22/2010	12.59	33.91	7.99	763.88	785.93	269.65	12.38
7/23/2010	12.62	39.16	7.92	844.39	869.78	906.54	3.64
7/24/2010	12.38	41.32	7.72	848.06	898.80	925.60	4.44
7/25/2010	12.41	38.62	7.74	814.82	860.50	715.02	12.49

Table 6-A continued

Date	Battery Volts	Panel Temperature (^{0}C)	Solar Panel Volts	Current Sensor #1 (watt-hrs)	Current Sensor #2 (watt-hrs)	Current Sensor #3 (watt-hrs)	Sampler Temp. (^{0}C)
7/26/2010	12.31	39.19	7.59	775.13	825.33	883.95	7.92
7/27/2010	12.28	36.83	7.61	699.36	752.37	633.89	8.10
7/28/2010	12.33	36.70	7.54	848.73	898.84	790.81	9.42
7/29/2010	12.23	28.75	5.82	188.81	210.13	159.11	13.19
7/30/2010	12.53	41.84	9.54	721.05	747.79	477.50	3.64
7/31/2010	12.10	31.44	7.36	425.40	461.14	559.92	1.95
8/1/2010	12.11	34.05	7.45	730.72	782.05	671.69	2.99
8/2/2010	12.14	35.92	7.44	861.35	922.22	649.16	3.77
8/3/2010	12.34	34.85	7.59	844.96	894.77	570.18	10.82
8/4/2010	12.23	36.56	7.44	768.64	819.34	760.39	7.51
8/5/2010	12.16	33.45	7.32	544.01	579.41	381.81	13.41
8/6/2010	12.09	34.48	7.35	674.43	713.64	716.40	2.56
8/7/2010	12.16	34.63	7.46	874.16	914.48	605.22	1.21
8/8/2010	12.31	33.97	7.54	936.63	969.64	614.51	1.26
8/9/2010	12.33	34.93	7.46	829.34	859.61	640.90	1.16
8/10/2010	12.24	36.75	7.35	797.47	835.32	728.02	1.36
8/11/2010	12.18	37.06	7.31	802.88	843.49	694.26	1.19
8/12/2010	12.06	36.97	7.17	705.70	751.11	784.98	1.69
8/13/2010	11.99	37.13	7.24	778.39	828.73	758.06	2.16
8/14/2010	11.86	35.95	7.01	650.92	701.47	701.28	2.03
8/15/2010	11.89	37.40	7.16	894.20	955.20	754.84	2.18
8/16/2010	11.75	34.69	7.00	573.07	627.02	656.95	2.19

Table 6-A continued

Date	Battery Volts	Panel Temperature (^{0}C)	Solar Panel Volts	Current Sensor #1 (watt-hrs)	Current Sensor #2 (watt-hrs)	Current Sensor #3 (watt-hrs)	Sampler Temp. (^{0}C)
8/17/2010	11.60	32.51	6.81	517.89	564.54	617.98	1.95
8/18/2010	11.18	30.37	6.53	348.11	393.19	447.02	1.86
8/19/2010	11.62	28.17	5.16	216.16	234.12	76.19	16.00
8/20/2010	12.30	35.66	7.25	895.96	925.33	629.01	5.04
8/21/2010	12.11	32.25	6.97	369.64	394.37	501.36	3.98
8/22/2010	12.18	35.75	7.15	831.93	867.05	588.91	4.11
8/23/2010	12.32	34.08	7.28	805.26	827.75	533.10	3.89
8/24/2010	12.37	31.23	7.25	622.63	638.72	470.84	3.75
8/25/2010	12.45	32.30	7.32	719.43	729.11	493.08	3.79
8/26/2010	12.58	32.78	7.53	799.67	790.39	511.53	3.77
8/27/2010	12.67	33.75	7.62	795.53	780.04	526.73	3.71
8/28/2010	12.72	33.64	7.62	758.36	740.85	545.85	3.72
8/29/2010	12.72	33.19	7.56	682.68	664.29	517.11	3.66
8/30/2010	12.74	33.25	7.49	713.34	697.68	532.41	3.54
8/31/2010	12.77	32.80	7.85	685.94	664.24	523.15	3.45
9/1/2010	12.77	32.58	7.85	655.81	635.97	495.46	3.44
9/2/2010	12.84	31.24	8.12	498.50	470.07	216.19	11.90
9/3/2010	12.78	29.41	7.39	519.41	508.15	487.88	4.19
9/4/2010	12.80	27.02	8.39	560.42	520.86	382.07	2.78
9/5/2010	12.84	25.50	8.40	491.27	450.28	365.19	2.51
9/6/2010	12.81	27.22	8.18	533.00	500.13	402.15	2.92
9/7/2010	12.77	29.32	7.90	559.17	528.70	442.16	3.92

Table 6-A continued

Date	Battery Volts	Panel Temperature (^{0}C)	Solar Panel Volts	Current Sensor #1 (watt-hrs)	Current Sensor #2 (watt-hrs)	Current Sensor #3 (watt-hrs)	Sampler Temp. (^{0}C)
9/8/2010	12.65	28.96	6.97	519.03	519.20	432.14	4.23
9/9/2010	12.78	29.76	7.94	579.82	558.65	420.77	4.03
9/10/2010	12.63	27.58	6.99	419.62	425.42	411.97	3.81
9/11/2010	12.55	27.52	6.68	482.72	475.92	405.08	3.85
9/12/2010	12.74	30.74	7.73	651.99	616.88	459.49	4.11
9/13/2010	12.79	27.17	8.04	516.97	482.18	390.07	3.58
9/14/2010	12.78	28.10	7.84	529.45	503.72	403.34	3.68
9/15/2010	12.76	29.99	7.71	575.82	547.89	438.60	3.91
9/16/2010	12.82	27.76	7.52	398.38	383.77	182.79	11.63
9/17/2010	12.78	31.97	7.55	588.07	561.63	528.10	4.25
9/18/2010	12.79	29.45	7.80	566.91	537.95	419.30	3.02
9/19/2010	12.78	29.82	7.78	570.18	541.47	442.32	3.03
9/20/2010	12.78	30.78	7.67	590.46	556.44	452.90	3.09
9/21/2010	12.77	31.18	7.63	599.50	573.24	470.76	3.13
9/22/2010	12.77	31.73	7.43	613.79	591.68	483.10	3.20
9/23/2010	12.77	31.53	7.36	594.11	570.80	480.81	3.15
9/24/2010	12.78	30.38	7.62	597.41	570.08	451.44	3.12
9/25/2010	12.58	28.44	6.57	382.96	391.45	420.35	3.09
9/26/2010	12.29	23.68	6.23	128.74	134.54	334.04	2.79
9/27/2010	12.36	22.96	6.32	323.23	330.72	340.66	2.68
9/28/2010	12.68	22.97	6.71	796.08	784.72	321.84	2.56
9/29/2010	12.87	23.27	7.44	482.20	457.03	333.86	2.62

Table 6-A continued

Date	Battery Volts	Panel Temperature (^{0}C)	Solar Panel Volts	Current Sensor #1 (watt-hrs)	Current Sensor #2 (watt-hrs)	Current Sensor #3 (watt-hrs)	Sampler Temp. (^{0}C)
9/30/2010	12.73	24.30	6.69	410.07	402.48	340.39	2.77
10/1/2010	12.88	23.12	8.10	390.65	350.64	156.18	8.12
10/2/2010	12.89	20.42	8.18	382.77	343.39	332.99	2.55
10/3/2010	12.49	15.37	6.33	139.24	143.71	224.91	1.57
10/4/2010	12.69	14.88	6.68	380.60	380.47	224.72	1.45
10/5/2010	12.87	14.86	7.32	350.52	332.97	223.75	1.42
10/6/2010	12.87	16.25	8.21	367.70	328.71	239.67	1.51
10/7/2010	12.85	19.25	8.01	390.05	352.11	281.25	1.72
10/8/2010	12.82	22.09	7.79	435.57	405.10	315.66	1.90
10/9/2010	12.82	21.75	7.74	417.76	380.01	300.39	1.87
10/10/2010	12.81	22.63	7.68	432.19	396.80	326.47	1.92
10/11/2010	12.80	23.03	7.64	451.62	414.11	327.12	1.92
10/12/2010	12.75	21.02	6.84	369.61	356.84	301.65	1.87
10/13/2010	12.78	24.71	7.32	487.00	452.81	351.53	2.00
10/14/2010	12.85	22.19	7.89	396.90	358.09	183.38	7.06
10/15/2010	12.90	16.41	8.25	344.24	306.39	270.70	2.49
10/16/2010	12.87	15.98	8.11	341.11	297.61	229.67	1.93
10/17/2010	12.86	16.79	7.94	339.58	304.43	242.69	1.97
10/18/2010	12.85	18.54	7.84	375.69	342.39	271.59	2.09
10/19/2010	12.83	19.40	7.69	373.47	345.13	277.76	2.16
10/20/2010	12.79	22.05	7.26	437.02	413.51	292.54	2.35
10/21/2010	12.87	17.30	8.05	369.36	334.71	252.47	1.99

Table 6-A continued

Date	Battery Volts	Panel Temperature (^{0}C)	Solar Panel Volts	Current Sensor #1 (watt-hrs)	Current Sensor #2 (watt-hrs)	Current Sensor #3 (watt-hrs)	Sampler Temp. (^{0}C)
10/22/2010	12.86	16.51	7.98	358.71	312.81	233.21	1.92
10/23/2010	12.84	16.36	7.70	323.69	294.93	241.66	1.89
10/24/2010	12.82	20.45	7.58	406.38	367.89	292.94	2.13
10/25/2010	12.71	21.83	6.20	390.27	379.92	307.60	2.26
10/26/2010	12.82	24.28	6.53	457.45	438.71	360.98	2.41
10/27/2010	12.46	22.45	5.95	240.00	248.73	321.28	2.60
10/28/2010	12.82	22.80	7.58	548.30	508.40	163.80	.
10/29/2010	12.95	15.20	8.07	337.13	287.87	256.32	.
10/30/2010	12.94	12.80	8.18	300.69	259.35	194.79	.
10/31/2010	12.90	14.51	8.02	323.26	280.54	216.14	.
11/1/2010	12.88	15.50	7.83	321.81	284.20	227.32	.
11/2/2010	12.86	17.97	7.65	362.01	328.50	246.30	.
11/3/2010	12.82	16.24	6.26	288.43	281.51	235.67	.
11/4/2010	12.79	14.16	6.41	318.33	301.62	202.00	.
11/5/2010	12.80	9.55	6.40	238.96	224.46	169.44	.
11/6/2010	12.86	8.11	6.91	246.20	230.96	148.35	.
11/7/2010	12.93	6.49	8.31	228.03	175.16	123.30	.
11/8/2010	12.90	9.24	8.16	247.48	208.37	164.22	.
11/9/2010	12.87	12.06	7.92	266.39	242.25	185.07	.
11/10/2010	12.85	13.37	7.66	305.13	273.14	197.32	.
11/11/2010	12.90	14.14	7.81	271.56	243.08	124.94	12.95
11/12/2010	12.89	14.04	7.77	293.60	257.40	237.91	0.75

Table 6-A continued

Date	Battery Volts	Panel Temperature (^{0}C)	Solar Panel Volts	Current Sensor #1 (watt-hrs)	Current Sensor #2 (watt-hrs)	Current Sensor #3 (watt-hrs)	Sampler Temp. (^{0}C)
11/13/2010	12.85	14.07	7.67	321.90	280.00	207.70	0.37
11/14/2010	12.77	12.26	6.10	246.98	234.68	191.49	0.32
11/15/2010	12.40	14.03	5.53	107.84	111.67	204.37	0.28
11/16/2010	12.71	16.79	6.08	483.78	464.50	238.53	0.28
11/17/2010	12.88	13.63	7.63	345.00	312.45	191.95	0.35
11/18/2010	12.87	10.56	7.28	256.64	227.27	182.84	0.38
11/19/2010	12.87	14.23	7.68	327.39	288.18	205.62	0.31
11/20/2010	12.89	11.53	7.41	282.22	255.69	184.27	0.40
11/21/2010	12.81	14.96	6.91	315.11	290.83	226.97	0.29
11/22/2010	12.85	15.78	7.48	341.96	308.84	231.70	0.33
11/23/2010	12.64	13.56	5.78	156.53	160.57	105.63	4.33
11/24/2010	12.80	15.67	7.18	351.63	332.54	259.13	-0.19
11/25/2010	12.82	20.05	7.21	395.51	359.18	273.43	-0.85
11/26/2010	12.74	13.61	5.76	267.58	262.07	172.70	1.70
11/27/2010	12.95	5.15	8.27	200.29	161.76	89.55	1.21
11/28/2010	12.93	4.80	8.16	177.20	146.88	88.47	0.59
11/29/2010	12.85	8.99	7.35	181.59	164.58	135.79	1.27
11/30/2010	12.36	16.26	5.08	72.25	75.14	209.16	1.41
12/1/2010	12.78	7.11	6.48	401.59	369.86	97.56	2.08
12/2/2010	12.96	2.35	7.48	152.14	129.17	67.04	0.26
12/3/2010	12.92	5.69	7.67	173.84	151.92	98.33	1.46
12/4/2010	12.53	3.88	5.23	51.73	55.92	68.77	1.75

Table 6-A continued

Date	Battery Volts	Panel Temperature (^{0}C)	Solar Panel Volts	Current Sensor #1 (watt-hrs)	Current Sensor #2 (watt-hrs)	Current Sensor #3 (watt-hrs)	Sampler Temp. (^{0}C)
12/5/2010	12.82	3.59	5.90	185.61	180.07	66.20	1.72
12/6/2010	12.94	0.69	7.50	140.77	126.20	64.16	-0.56
12/7/2010	12.85	-1.38	7.48	146.10	118.11	65.60	-1.20
12/8/2010	12.89	-2.36	8.17	145.63	117.61	66.61	-2.85
12/9/2010	12.90	-0.91	8.24	149.16	113.31	59.48	-2.57
12/10/2010	12.88	3.74	7.93	191.93	153.85	104.81	-0.07
12/11/2010	12.77	6.66	6.86	197.14	173.17	145.77	0.27
12/12/2010	12.51	4.85	5.28	117.18	123.71	124.30	0.27
12/13/2010	12.83	-3.08	6.58	219.68	206.84	91.52	-2.25
12/14/2010	12.92	-3.63	8.39	200.52	147.61	95.83	-3.19
12/15/2010	12.88	-5.22	7.65	159.55	135.93	84.58	-4.18
12/16/2010	12.46	1.31	5.11	49.35	51.52	55.86	-1.05
12/17/2010	12.75	3.83	5.63	167.82	164.32	55.90	-0.23
12/18/2010	12.84	4.50	6.79	138.83	124.08	57.94	0.30
12/19/2010	12.86	2.79	7.36	144.36	121.79	59.66	0.05
12/20/2010	12.85	0.84	7.46	145.27	117.28	63.63	-0.62
12/21/2010	12.50	3.75	5.28	70.57	72.72	56.76	0.28
12/22/2010	12.76	7.18	6.36	169.88	153.65	54.95	3.61
12/23/2010	12.91	4.10	7.60	130.78	107.25	41.80	2.10
12/24/2010	12.92	2.15	8.30	129.81	98.09	43.07	-0.22
12/25/2010	12.77	3.41	5.56	92.35	90.50	40.27	1.29
12/26/2010	12.57	0.88	5.30	75.49	78.18	41.77	-1.21

Table 6-A continued

Date	Battery Volts	Panel Temperature (^{0}C)	Solar Panel Volts	Current Sensor #1 (watt-hrs)	Current Sensor #2 (watt-hrs)	Current Sensor #3 (watt-hrs)	Sampler Temp. (^{0}C)
12/27/2010	12.77	0.16	7.37	172.46	143.09	89.76	0.03
12/28/2010	12.86	-1.21	8.09	167.21	137.48	91.06	-2.23
12/29/2010	12.85	-1.04	6.77	152.99	141.92	90.20	-2.12
12/30/2010	12.72	4.91	6.34	153.53	143.66	115.88	0.71
12/31/2010	12.78	11.92	7.20	288.47	262.10	197.99	0.80
1/1/2011	12.33	14.92	5.23	78.03	84.93	220.76	0.37
1/2/2011	12.70	10.25	6.80	492.46	451.72	161.53	0.14
1/3/2011	12.94	1.75	8.12	188.07	151.87	89.46	-0.98
1/4/2011	12.92	2.80	7.56	166.26	146.98	93.30	-0.75
1/5/2011	12.84	1.28	6.14	138.34	131.32	81.44	-0.67
1/6/2011	12.82	4.02	6.99	179.88	162.63	106.31	-0.10
1/7/2011	12.55	4.48	5.42	125.34	129.17	135.22	0.02
1/8/2011	12.84	1.29	7.64	234.12	194.95	84.67	-0.39
1/9/2011	12.92	-4.73	8.31	169.78	133.21	86.77	-3.32
1/10/2011	12.79	-0.28	5.81	115.03	111.69	58.13	-1.59
1/11/2011	12.85	1.85	6.46	128.10	118.25	56.62	-0.73
1/12/2011	12.87	-0.80	7.56	135.13	119.14	60.76	-1.48
1/13/2011	12.89	-0.04	8.31	146.77	118.00	54.44	-1.79
1/14/2011	12.87	-1.94	8.36	168.38	134.91	95.27	-4.41
1/15/2011	12.87	1.51	8.20	176.23	141.67	83.26	-1.06
1/16/2011	12.83	5.65	7.53	201.71	173.48	122.26	0.81
1/17/2011	12.63	4.58	5.77	139.53	138.71	124.38	1.01

Table 6-A continued

Date	Battery Volts	Panel Temperature (^{0}C)	Solar Panel Volts	Current Sensor #1 (watt-hrs)	Current Sensor #2 (watt-hrs)	Current Sensor #3 (watt-hrs)	Sampler Temp. (^{0}C)
1/18/2011	12.72	6.88	5.95	219.31	212.71	145.42	0.98
1/19/2011	12.41	8.29	5.47	115.55	120.56	170.59	0.63
1/20/2011	12.72	6.77	6.61	332.28	315.16	142.68	0.59
1/21/2011	12.92	2.30	8.14	211.91	174.40	85.65	0.19
1/22/2011	12.91	1.09	8.48	178.22	139.96	84.32	-0.53
1/23/2011	12.90	1.43	8.43	173.78	141.86	84.20	-1.07
1/24/2011	12.84	6.70	7.74	207.00	179.38	139.15	0.40
1/25/2011	12.44	4.80	3.24	35.54	43.45	59.95	0.67

Table 7-A. Current sensor calibration.

Table 7-A continued						
Current (amps)	**Sensor 1**	**Sensor 2**	**Sensor 3**	**Sensor 4**	**Sensor 5**	**Sensor 6**
0.00	2.4978	2.4958	2.4958	2.4983	2.4963	2.4977
0.25	2.5143	2.5124	2.5124	2.5146	2.5125	2.514
0.50	2.5307	2.5287	2.5289	2.531	2.5289	2.5303
0.75	2.5471	2.5450	2.5454	2.5473	2.5469	2.5466
1.00	2.5636	2.5612	2.5619	2.5637	2.5631	2.5629
1.25	2.5797	2.5774	2.5784	2.5801	2.5795	2.5793
1.50	2.5962	2.5936	2.5948	2.5964	2.5958	2.5955
1.75	2.6125	2.6099	2.6112	2.6127	2.6122	2.6118
2.00	2.629	2.6261	2.6276	2.629	2.6285	2.6282
2.25	2.6454	2.6423	2.6442	2.6454	2.6448	2.6444
2.50	2.6615	2.6583	2.6605	2.6618	2.6611	2.6607
2.75	2.6779	2.6745	2.6770	2.6782	2.6773	2.677
3.00	2.6945	2.6907	2.6933	2.6945	2.6936	2.6933
3.25	2.7105	2.7069	2.7099	2.7108	2.71	2.7095
3.50	2.7268	2.7231	2.7262	2.7272	2.726	2.7258
3.75	2.743	2.7393	2.7426	2.7435	2.7424	2.7421
4.00	2.7593	2.7555	2.7591	2.7599	2.7587	2.7584
4.25	2.7756	2.7716	2.7755	2.7762	2.775	2.7746
4.50	2.7921	2.7878	2.7918	2.7926	2.7912	2.7909
4.75	2.8084	2.8040	2.8083	2.8088	2.8076	2.8072
5.00	2.8246	2.8208	2.8245	2.8251	2.8237	2.8234
5.25	2.8409	2.8364	2.8406	2.8415	2.84	2.8398
5.50	2.8572	2.8526	2.8571	2.8578	2.8563	2.856
5.75	2.8738	2.8687	2.8733	2.8741	2.8725	2.8722
6.00	2.8898	2.8849	2.8899	2.8904	2.8888	2.8884
6.25	2.9061	2.9011	2.9061	2.9066	2.905	2.9045
6.50	2.9226	2.9172	2.9224	2.9231	2.9213	2.9208
6.75	2.9387	2.9333	2.9387	2.9393	2.9376	2.9374
7.00	2.9547	2.9495	2.9548	2.9557	2.9538	2.9534
7.25	2.9712	2.9657	2.9712	2.972	2.97	2.9698
7.50	2.9876	2.9818	2.9875	2.9882	2.9862	2.9861
7.75	3.0038	2.9979	3.0037	3.0041	3.0025	3.002
8.00	3.0201	3.0139	3.0200	3.0205	3.0188	3.0183

Table 7-A continued						
Current (amps)	**Sensor 1**	**Sensor 2**	**Sensor 3**	**Sensor 4**	**Sensor 5**	**Sensor 6**
8.25	3.0362	3.0301	3.0362	3.0366	3.035	3.0343
8.50	3.0524	3.0462	3.0525	3.053	3.0513	3.0508
8.75	3.0687	3.0623	3.0685	3.0694	3.0675	3.0671
9.00	3.0851	3.0785	3.0850	3.0856	3.0838	3.0831
9.25	3.1012	3.0946	3.1006	3.102	3.1	3.0994
9.50	3.1172	3.1107	3.1174	3.1184	3.1163	3.1156
9.75	3.1337	3.1267	3.1335	3.1346	3.1324	3.1317
10.00	3.1500	3.1429	3.1497	3.1508	3.1488	3.1482
10.25	3.1661	3.1592	3.1662	3.1673	3.1651	3.1645
10.50	3.1823	3.1754	3.1825	3.1832	3.1815	3.1804
10.75	3.1988	3.1914	3.1986	3.199	3.1978	3.1968
11.00	3.2149	3.2075	3.2139	3.2153	3.214	3.2131
11.25	3.2311	3.2238	3.2303	3.2313	3.2302	3.2292
11.50	3.2470	3.2398	3.2465	3.2474	3.2463	3.2455
11.75	3.2635	3.2560	3.2627	3.2636	3.2623	3.2616
12.00	3.2799	3.2713	3.2790	3.2797	3.2788	3.2771
12.25	3.2959	3.2873	3.2953	3.296	3.2953	3.2935
12.50	3.3122	3.3034	3.3115	3.3124	3.3115	3.3096
12.75	3.3287	3.3196	3.3274	3.3283	3.3281	3.3256
13.00	3.3448	3.3356	3.3436	3.3445	3.344	3.3419
13.25	3.3611	3.3518	3.3603	3.3606	3.3603	3.3582
13.50	3.3772	3.3680	3.3763	3.3767	3.3766	3.3741
13.75	3.3933	3.3841	3.3920	3.3928	3.393	3.3907
14.00	3.4096	3.4001	3.4082	3.4089	3.4084	3.4066
14.25	3.4255	3.4161	3.4242	3.4252	3.4245	3.4231
14.50	3.4416	3.4323	3.4403	3.4414	3.4408	3.4391
14.75	3.4585	3.4486	3.4563	3.4576	3.4571	3.4554
15.00	3.4747	3.4647	3.4727	3.4737	3.4736	3.4711
15.25	3.4911	3.4809	3.4886	3.49	3.4896	3.4877
15.50	3.5061	3.4966	3.5045	3.5062	3.5061	3.5037
15.75	3.5223	3.5126	3.5206	3.521	3.522	3.5198
16.00	3.5385	3.5289	3.5367	3.539	3.5387	3.5357
16.25	3.5536	3.5446	3.5530	3.5547	3.5551	3.552
16.50	3.5693	3.5608	3.5681	3.5707	3.5714	3.5682
16.75	3.5857	3.5766	3.5840	3.5867	3.5871	3.584

Table 7-A continued						
Current (amps)	**Sensor 1**	**Sensor 2**	**Sensor 3**	**Sensor 4**	**Sensor 5**	**Sensor 6**
17.00	3.6025	3.5928	3.6003	3.6028	3.6037	3.6001
17.25	3.6192	3.6087	3.6160	3.6186	3.62	3.6166
17.50	3.6347	3.6250	3.6321	3.6347	3.6362	3.6324
17.75	3.6508	3.6412	3.6484	3.6507	3.6523	3.6486
18.00	3.6672	3.6572	3.6630	3.6667	3.6686	3.6646
18.25	3.6833	3.6733	3.6786	3.682	3.6847	3.6807
18.50	3.6999	3.6893	3.6941	3.698	3.7011	3.6966
18.75	3.7161	3.7055	3.7103	3.7142	3.7175	3.7121
19.00	3.7321	3.7215	3.7262	3.7303	3.7338	3.728
19.25	3.7481	3.7378	3.7422	3.7463	3.7499	3.7436
19.50	3.7642	3.7531	3.7579	3.7617	3.7662	3.7598
19.75	3.7804	3.7691	3.7739	3.7776	3.7826	3.776
20.00	3.7963	3.7853	3.7901	3.7935	3.7982	3.7925

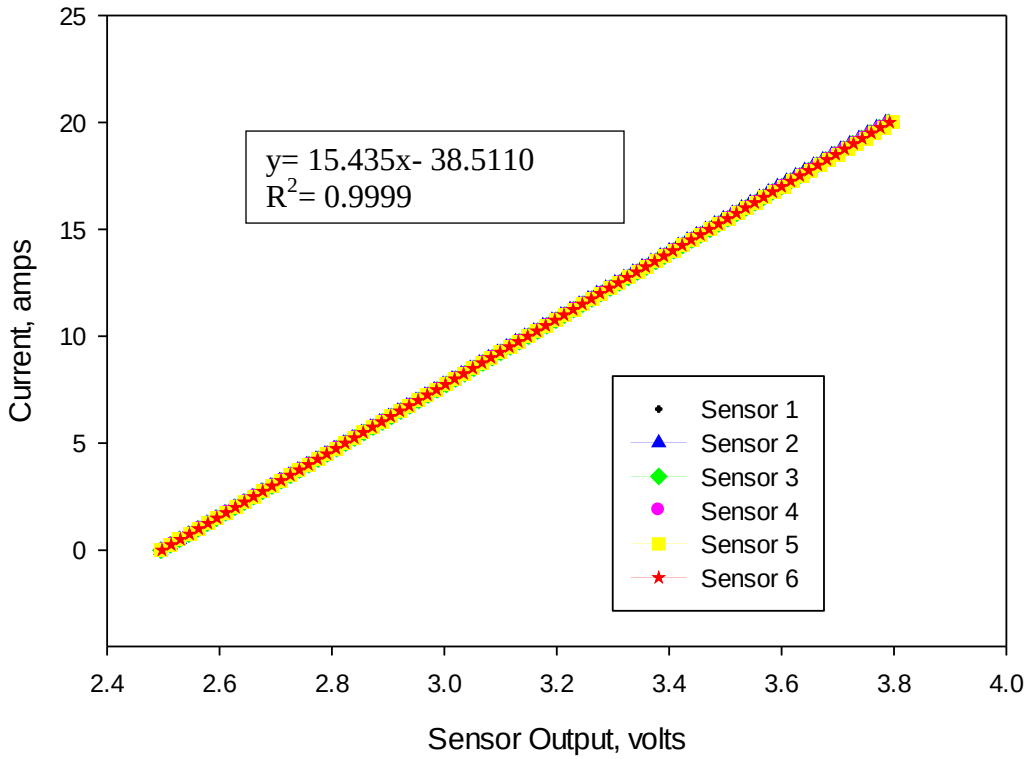


Figure 1-A. Current sensor calibration with equation and R^2 where y is current in amps and x is sensor output in volts.

VITA

Hannah Marie Armstrong is from the small middle Tennessee community of Coble in Hickman County. She graduated from Hickman County High School in May of 2004 and began her undergraduate studies at the University of Tennessee at Martin. While at UTM, she was a member of the Student Cattleman's Association, collegiate FFA, and received the Outstanding Ag Engineering Technology Student award from the department of Agriculture and Applied Sciences. In December of 2008, she graduated summa cum laude with a Bachelor of Science degree in Agricultural Engineering Technology. The following year she began as a Graduate Research Assistant at the University of Tennessee at Knoxville under the supervision of Dr. Shawn Hawkins in the Biosystems Engineering and Soil Science department. While at UTK, she was awarded membership into Gamma Sigma Delta Honor Society of Agriculture and the Graduate Student with Professional Promise award. Her Master of Science degree in Biosystems Engineering Technology was conferred in August of 2011.