

Report as of FY2006 for 2005IA81B: "Sensors for CyberEngineering: Monitoring and Modeling the Iowa River for Nutrients and Sediments"

Publications

Project 2005IA81B has resulted in no reported publications as of FY2006.

Report Follows

Problem Statement and Research Objectives

The flux of nutrients and sediments into Iowa's lakes and rivers can have severe impacts on health of these systems, and the way which these resources are utilized. Delivery of nutrients such as nitrogen and phosphorus to water bodies via surface runoff can increase the total mass of those constituents in surface waters, creating eutrophic conditions. These conditions can spur the growth of harmful algal blooms which can lead to aesthetically displeasing water. Consumption of dissolved oxygen by algal populations may inhibit the ability of an ecosystem to sustain fish populations. Nutrients and sediments are also transported downstream to the Gulf of Mexico causing large scale hypoxic episodes and harmful bloom events. Sensors used to track nutrients, sediments and other water quality parameters have traditionally been deployed in a passive manner; meaning that data is collected and analyzed after the fact. However, increasing capabilities in sensor technology, telemetry hardware, and cyberinfrastructure allow for the real-time integration of sensors and water quality models. This fusion of real-time water quality data with water quality models can potentially provide regulators with a tool to predict environmental events. This knowledge can be used to implement management actions to remedy deleterious events before they happen.

The aim of this research project was to construct an operational water quality node to provide near real-time measurements at an environmental observatory on Clear Creek, Iowa River Basin, near South Amana, Iowa. Specifically, the main goal of this project was to use sensors and wireless communications to gather high frequency data on water quality which is assimilated in modeling efforts. This required the purchase, assembly and configuration of hardware such as water quality sensors, dataloggers, power sources, and modems. Once these components were purchased, they were assembled and deployed at Clear Creek.

The ability to measure water quality parameters, transmit them in near real-time, download them into a data base, and model them in real-time represented an ambitious goal for a two-year project. This was made possible using cellular technology to transmit information to a database in the Environmental Engineering Laboratories at the University of Iowa. Although the information flow from the database to our water quality model has not yet been made permanent, preliminary model results have been generated. Results from this project have provided the first step to creating a fully functioning environmental observatory at Clear Creek which can be used to predict downstream water quality.

Method Development

System Components

Development of the water quality node required the assembly and configuration of several key pieces of hardware and cyberinfrastructure (Figure 1). This includes sensors, dataloggers, cellular telemetry hardware, and water quality models. To detect water quality constituents, we have purchased and configured water quality sensors. Data from

these units can be collected and transmitted to a database in the Environmental Engineering Laboratories at the University of Iowa using the remote data collection platforms purchased from Campbell Scientific.

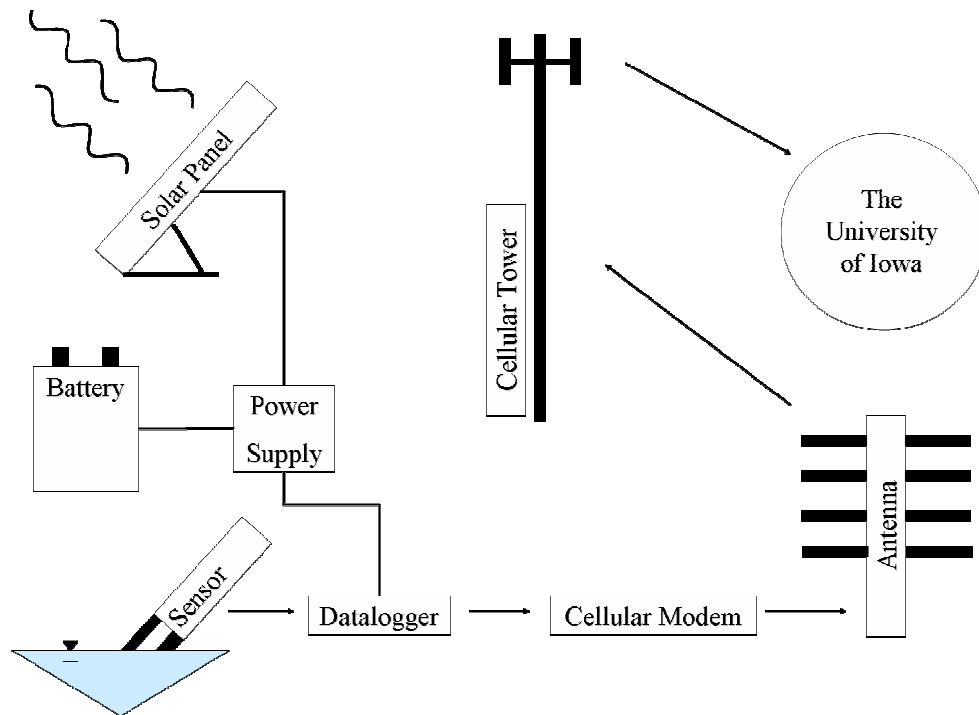


Figure 1. Schematic of the water quality node installed at the environmental observatory on Clear Creek.

Water quality measurements have been recorded and are currently monitored using two different models of water probes: the Hydrolab DS5X data sonde and the MicroLAB Nutrient Analyzer. The Hydrolab DS5X Water Quality Multiprobe (Hach, Loveland, Colorado) can measure chlorophyll *a*, conductivity, dissolved oxygen, pH, temperature and turbidity. It also contains a sweeper that removes biomass from several of the sensors. The MicroLAB Nutrient Analyzer (EnviroTech LLC, Chesapeake, VA) can be used to measure ammonia, nitrate, and phosphate.

Water quality measurements have been successfully downloaded and transferred using a remote data collection platform purchased from Campbell Scientific, Inc. The datalogger used in this system is the CR1000 Measurement and Control System (Campbell Scientific Inc., Logan, Utah). This unit receives and stores sensor measurements until they are uploaded into a database in the Environmental Engineering Laboratories. Measurements were transmitted from the remote data collection platform using cellular technology. Specifically, data was transferred through a Redwing 100 CMDA Modem (Airlink Communications, Hayward, California) and through the Verizon Cellular Network (Verizon, Elgin, Illinois) by way of a YA Series Yagi Directional Antenna (Radial/Larsen Antenna Technologies, Vancouver, Washington). The cellular plan used was an America's Choice II for Business 450 Plan which includes 450 minutes.

The remote data collection platform and sensors were powered by a NP12 Rechargeable 12-Volt Lead Battery (Campbell Scientific Inc., Logan, Utah) and a BP SX20U Solar Cell (British Petroleum, London, United Kingdom) via a CH100 12 Volt Charger/Regulator (Campbell Scientific Inc., Logan, Utah). All components of the remote data collection platform except the antenna, solar panel and data sondes were enclosed in a RJ Series Junction Enclosure (Stahlin Non-Metallic Enclosures, Belding, Michigan, Model No. RJ1816HPL). The enclosure protected the components from rain and moisture. Locks were placed on the enclosure latches to discourage vandalism. Desiccant bags were placed in the enclosure to help remove moisture inside the Stahlin enclosure.

Water Quality Node Configuration

Before water quality data could be collected, transmitted and input into water quality models, hardware components of the water quality node were configured and integrated. Formatting of the Hydrolab DS5X data sondes was performed using software supplied by Hach. The MicroLAB Nutrient Sensors were assembled and supplied with the necessary reagents to take measurements. Finally, components in the remote data collection platform were wired and programmed to seamlessly collect and transmit water quality data in real-time.

Configuration of the Hydrolab DS5X data sondes was performed using the Hydras 3LT software supplied by Hach. Using this software, settings on the data sonde such as the internal clock, output configuration, and deployment settings were programmed. Calibration of the individual sensors was performed by connecting the Hydras 3LT software with a DS5X data sonde. This was done by selecting the calibration tab on the software and clicking a sub-tab for each individual sensor. The calibration cup for the data sondes was then filled with the required standard to a level which covered the sensor, and the value of the standard was entered into Hydras 3LT. Standards used include the following: 0.100 mS/cm Conductivity Standard Solution (Hydrolab cat. No. 013610HY), 1.1412 mS/cm Conductivity Standard Solution (Hydrolab cat. No. 013620HY), 100 NTU StablCal Turbidity Standard (Hydrolab cat no. 007308), 1000 NTU StablCal Turbidity Standard (Hydrolab cat no. 007309.), pH 7.00 buffer solution (Acros, New Jersey, USA, cat no. 61106-0040), and pH 10.00 buffer solution (Fisher Fair Lawn, New Jersey cat no. SB115-4). Between the calibration of the sensors to each solution, the calibration cup used to hold the standard was rinsed out three times with deionized water. A full description on this procedure can be found in the Hydrolab DS5X User Manual (Hach Company, 2005).

The MicroLAB Nutrient Sensors were configured and assembled to sense fluxes of ammonia, nitrate and phosphorus. The first step in assembling these sensors was to construct the chemical reagent bag system. Next, the required chemical reagents were created as per the instructions in the MicroLAB Operating Manual (EnviroTech LLC, 2006). The instruments were readied for operation by filling the reagent bags. The MicroLAB Nutrient Sensors can only be configured to measure the concentration of one nutrient at a time. This is due to the fact that the analysis for each nutrient requires a

unique set of chemical reagents and a detector specific for the specified nutrient. Currently these sensors are configured to measure for nitrate.

In addition to the configuration of the Hydrolab DS5X data sondes and the MicroLAB Nutrient Sensors, effort also went into the assembly and operation of the remote data collection platform. This platform was essential for the collection and near real-time transmission of water quality measurements, as well as supplying power to the data sondes. Configuration of the platform began with the CR1000 datalogger using the Loggernet 3.1.5 Software. This software was used to download water quality measurement schedules onto the datalogger. The Loggernet software itself was also programmed to download measurements collected at the water quality node to the database in the Environmental Engineering Laboratories at the University of Iowa. Configuration of the cellular modem was completed to link the Loggernet Software to with the datalogger in the field. This was performed using the Cellset program available for download from Campbell Scientific Website (Campbell Scientific, Inc, 2006). Cellset allowed the system ID number and telephone number to be programmed into the cellular modem. Further detail on the full configuration of the remote data collection platform can be found in the 2005 Annual Report.

Water Quality Models

The ability to predict deleterious water quality events required the use of models. Models selected for this project include the BASINS (Better Assessment Science Integrating Point and Nonpoint Sources), the Watershed Analysis Risk Management Framework (WARMF) and the QUAL2K Stream and Water Quality Model. Before conducting analyses using these models, basic knowledge about the operation of these models was required.

BASINS is a model used to perform watershed and water quality-based studies which enable the integration of point and nonpoint source analysis for a variety of pollutants. This model was developed by the USEPA to assist state regulatory agencies in identifying and analyzing water quality issues. BASINS is driven by a graphical user interface which combines environmental data, fate and transport models, and geographical information systems (GIS) to facilitate the development of watershed management alternatives. BASINS includes an automatic delineation tool which breaks a watershed into smaller hydrologically connected subwatersheds. The delineated watershed can then be imported into a model of choice. For this project the HUC 8 watershed of the Lower Iowa River watershed, of which the Clear Creek is located in the north-central section, was delineated.

BASINS provides several tools which were used to download data for the Lower Iowa River HUC 8 from several sources including USGS, EPA, and local-sources. Data downloaded includes the Digital Elevation Model (DEM), National Hydrography Dataset (NHD), and the National Landcover Database (NLCD) for the Lower Iowa River HUC 8. Once all necessary data was extracted the automatic delineation tool was used to divide the Lower Iowa River watershed into multiple subwatersheds. The subwatershed that defined the Clear Creek watershed was then selected as the focus area. The delineated

Clear Creek digital watershed was then imported into both the QUAL2K and WARMF models. Figure 2 shows the BASINS delineation of the Clear Creek watershed.

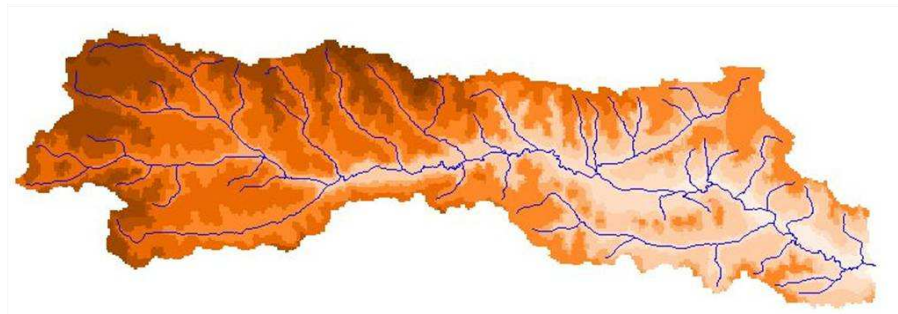


Figure 2. BASINS delineation of the Clear Creek watershed.

The ability to predict water quality throughout Clear Creek in real-time required the integration of real-time water quality data into a model. Several different water quality models were analyzed to determine their compatibility with the project goals. We originally planned to integrate the AVSWAT Model with data streaming from the water quality node. However, AVSWAT was found to be too cumbersome for this application. Specifically, the model requires too much spatially detailed information and requires a significant amount of time to run each simulation. An alternative model we have chosen to develop is the QUAL2K Stream Water Quality Model.

The QUAL2K model is a one-dimensional model (longitudinal direction) based on assumptions that the channel is well mixed in the vertical and lateral directions. It has the ability to simulate a system comprised of a main branch and several tributaries. All hydraulics are simulated as steady state with non-uniform flow. The model can capture diurnal variations in certain water quality parameters (like pH, dissolved oxygen, and carbon dioxide), and the heat budget is determined on a diel time scale. This allows the integration of highly resolved water quality data which the Hydrolab DS5X data sondes collect.

To set up the model, data from several resources were used. Output from the BASINS model was used to transform the physical creek network into the digital model. This output included information such as the location of branching tributaries and the length of those tributaries. Diurnal water quality data collected from the water quality node were input into the model as initial conditions for model trials. Constituents modeled by QUAL2K are shown in Table 1 (Chapra et al., 2006). Hydraulic data input into the QUAL2K Model was estimated using data from the USGS stream gage located in Coralville, IA (USGS, 2007). Although further work is needed to better define non-point source inputs into the creek, preliminary trials runs of the QUAL2K have modeled water quality constituents throughout the main stem of Clear Creek and its tributaries.

Table 1. Water quality parameters simulated in the QUAL2K model (from Chapra et al., 2006.).

Variable	Symbol	Units	Variable	Symbol	Units
Conductivity	s	μmhos	Inorganic phosphorus	p_i	$\mu\text{gP/L}$
Inorganic suspended solids	m_i	mgD/L	Total inorganic carbon	c_T	mole/L
Dissolved oxygen	o	mgO_2/L	Bottom algae biomass	a_b	mgA/m^2
Slowly reacting CBOD	c_s	mgO_2/L	Bottom algae nitrogen	IN_b	mgN/m^2
Fast reacting CBOD	c_f	mgO_2/L	Bottom algae phosphorus	IP_b	mgP/m^2
Organic nitrogen	n_o	$\mu\text{gN/L}$	Phytoplankton	a_p	$\mu\text{gA/L}$
Ammonia nitrogen	n_a	$\mu\text{gN/L}$	Detritus	m_o	mgD/L
Nitrate nitrogen	n_n	$\mu\text{gN/L}$	Pathogen	X	$\text{cfu}/100 \text{ mL}$
Organic phosphorus	p_o	$\mu\text{gP/L}$	Alkalinity	Alk	mgCaCO_3/L

System Installation

Following the configuration of the sensors and remote data collection platforms, the water quality node was installed in the upper reaches of the Clear Creek catchment (Figure 3). The site selected for deployment was one which the Iowa Institute of Hydraulic Research (IIHR) had already developed with rain gauges, and a plot to study erosion processes. The existing partnership between the IIHR and the land owner made this an attractive site to install the water quality node. Highly erodable soil in the area also makes this site well qualified to study the “hot spots” and “hot moments” of nutrient and sediment delivery to Clear Creek.

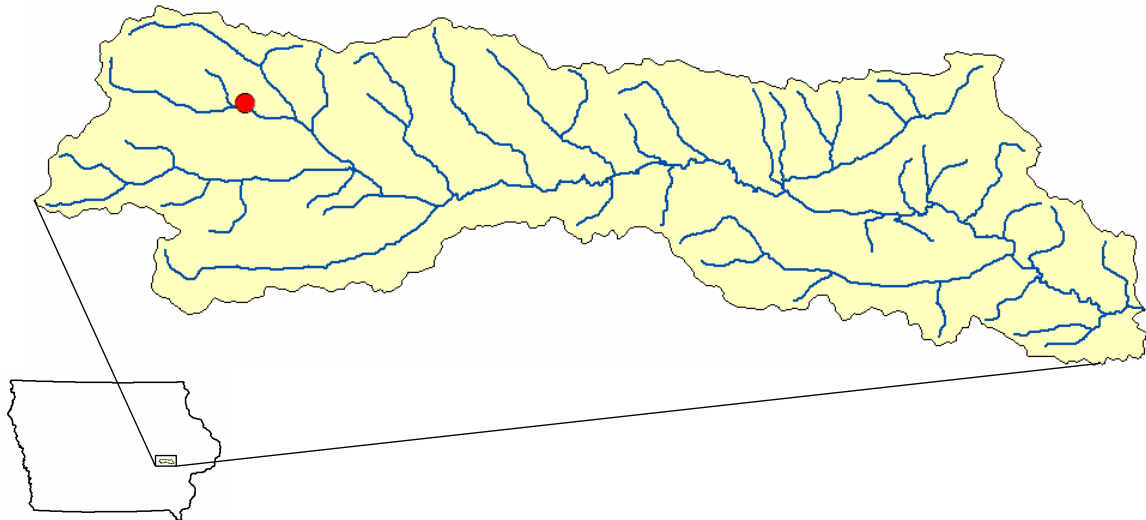


Figure 3. The University of Iowa water quality node (red dot) at the environmental observatory in the Clear Creek HUC 10 watershed.

The water quality node was installed in Clear Creek on March, 2006 (Figure 4). Both the solar panel and the remote data collection platform were each attached to their own set of two studded T-posts on the bank of the creek. The directional antenna was also attached to a studded T-post on the bank. An additional post was driven into the creek bed with a Hydrolab DS5X data sonde secured to it using a section of aircraft cable. Desiccant bags were placed in the enclosure for the remote data collection platform to reduce the humidity inside the enclosure. This was done to prevent any unnecessary damage that might occur due to moisture.



Figure 4. Water quality node installed in Clear Creek, Iowa.

Bi-Monthly Site Visits

Data sondes deployed at the water quality node are subject to biofouling; thus, bi-monthly site visits were performed to clean or replace a data sonde which showed a significant amount of biofouling. Although the data sondes were equipped with sweeper brushes, they did not remove all of the biofouling (Figure 5). Maintenance on the water quality node was also performed during bi-monthly site visits. This included the removal of debris from any of the T-posts, cleaning of the glass on the solar panel, and replacement of the desiccant in the remote data collection platform (if required).

Grab samples were also collected on site visits. This was done to validate measurements collected from the data sonde. Samples were taken from the middle part of the channel approximately half way below the surface of the water. These samples were then tested for dissolved oxygen, pH, and turbidity. Results were then compared to measurements taken by the data sondes. Measurements of dissolved oxygen, pH, specific conductivity, and temperature were also taken using a Hach Hydrolab Quanta G data sonde for further comparison.



Figure 5. Biofouling on the Hydrolab DS5X data sonde after a two week deployment.

Diurnal Study

Validation of trends seen in data from the summer of 2006 was performed during a diurnal study from 10:00 AM on August, 3rd to 12:00 PM on August 4th, 2006. During this time three Hydrolab DS5X data sondes were deployed and collected measurements once every twenty minutes. Grab samples and Hydrolab Quanta G measurements were also collected once every hour except at 3:00 AM and 5:00 AM on August 4th. Grab samples were analyzed for pH and turbidity and also for dissolved oxygen using a Hach HQ-10 portable dissolved oxygen meter. Variability between sensor measurements was assessed using data from this study. Before this study Hydrolab DS5X data sondes #1 and #2 were cleaned and calibrated. Hydrolab DS5X data sonde #3 had been deployed on seventeen days earlier to observe the effects of biofouling on sensor measurements.

Results and Discussion

The water quality node has allowed for measurement and collection of several water quality parameters for a large portion of the spring, summer and fall of 2006. These water quality parameters include dissolved oxygen, pH, specific conductivity, temperature, and turbidity. This data was collected using three Hydrolab DS5X data sondes, a Hydrolab Quanta G data sonde and grab samples. Three gaps in the data occurred during the deployment period. This was due operational error in deploying individual data sondes at those times. The water quality node was removed on September 12th, 2006 due low flows in Clear Creek and vandalism concerns from the onset of the fall hunting season.

Temperature

Temperature data collected in Clear Creek throughout the entire deployment is shown in Figure 6. This data shows a distinct seasonal trend as the water temperature generally increased during the warm summer months, and declined for the cooler periods in August

and September. The vertical “smearing” of the data points which occurs in Figure 6 can be attributed diurnal variations in the water temperature. Figure 7 shows a section of this data from July 20th to August 4th. Trends in this figure highlight the existence of multi-day phenomenon. For example, stable temperatures and during a frontal convective storm can be seen on July 25th through the 27th. The subsequent movement of a warm front through the study area from July 28th to July 31st can be seen by the increasing minimum and maximum daily temperatures. Daily fluctuations in water temperature were captured during the diurnal study (Figure 8). Water temperatures were shown to increase during the day, and fall at night time, a process driven by the rising and setting of the sun. A lack of variability between data sonde measurements in the diurnal study indicates that temperature measurements taken by the DS5X data sondes are reliable and the effects of biofouling on temperature measurements are negligible.

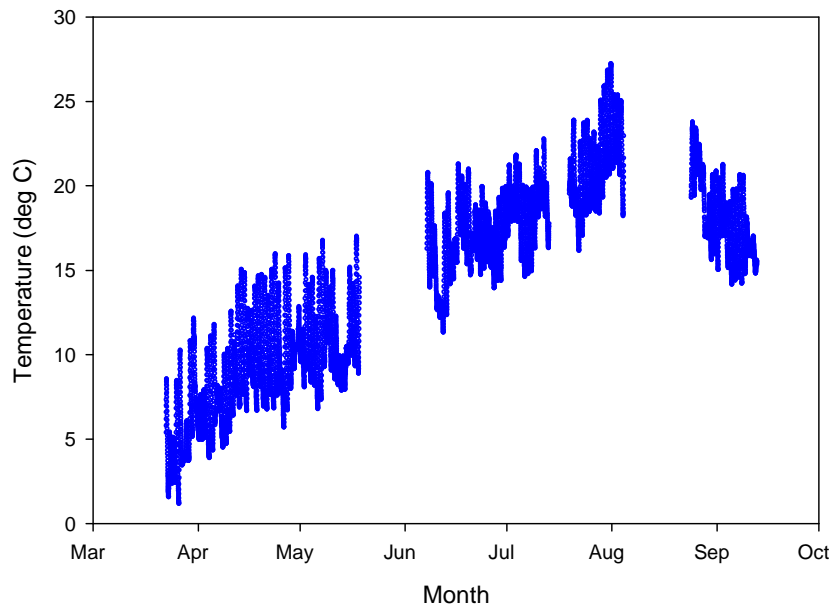


Figure 6. Seasonal variations in Clear Creek water temperature.

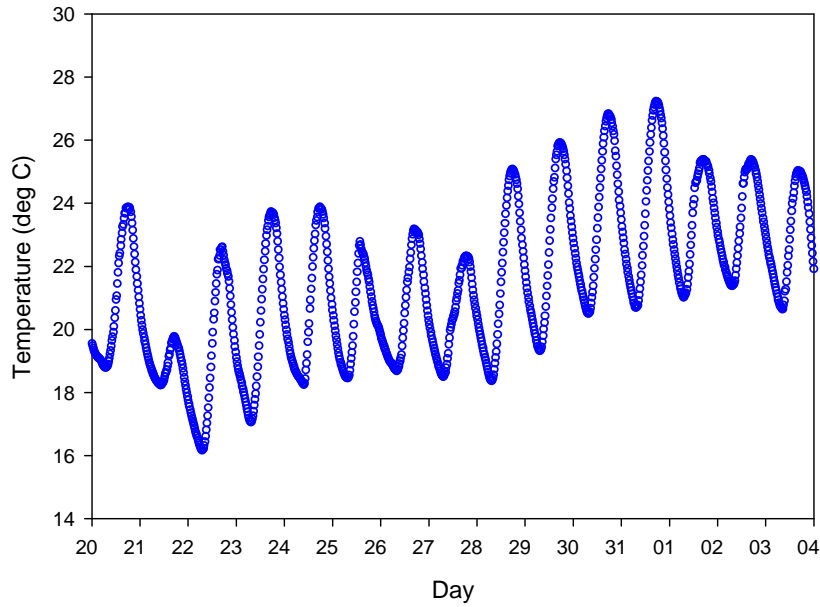


Figure 7. Multi-day variations in Clear Creek water temperature from July 20th to August 4th.

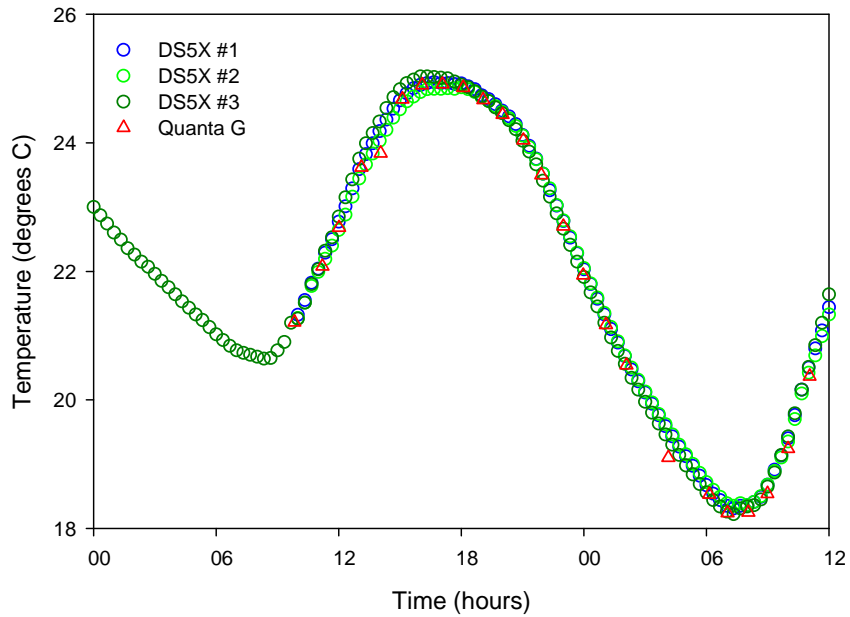


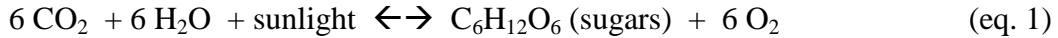
Figure 8. Temperature measurements from Clear Creek taken during the diurnal study.

pH

Measurements of pH were collected for a majority of the time from March to September, 2006. Data from the second half of April collected by two different DS5X data sondes is presented in Figure 9. This data shows the presence of a diurnal trend in pH. The data also shows some discontinuity between deployments of the two sensors. For example, on April 20th when DS5X #2 was replaced by DS5X #1, the pH measurements dropped from 8.3 to 7.7. A similar drop in pH measurement also occurred on April 27th. Possible

explanations for this phenomenon include calibration error, loss of calibration by the sensor, and biofouling.

Measurements collected during the diurnal study indicated the presence of a distinct daily cycle (Figure 10). In this cycle the pH increases during the daytime, and decreases during the nighttime. This trend is due to the consumption of carbon dioxide, a weak acid, via photosynthesis during the daytime (forward reaction, equation 1), and the creation of carbon dioxide at nighttime from the respiration by periphyton (back reaction, equation 1). Measurements taken by both DS5X data sondes, the Quanta G data sonde and grab samples during the diurnal study all show a low amount of variability between sensors throughout the daily cycle.



The diurnal trend in pH is also due to the role of dissolved carbon dioxide as a weak acid. When $\text{CO}_2(\text{aq})$ increases during nighttime respiration, the pH decreases; and when $\text{CO}_2(\text{aq})$ decreases during daytime photosynthesis due to uptake by algae, the pH increases. The first acidity constant (ionization) of carbonic acid can be used to illustrate the cause of the diurnal cycle of pH. As $\text{CO}_2(\text{aq})$ is respired, it results in formation of a strong acid H^+ , which lowers the pH.

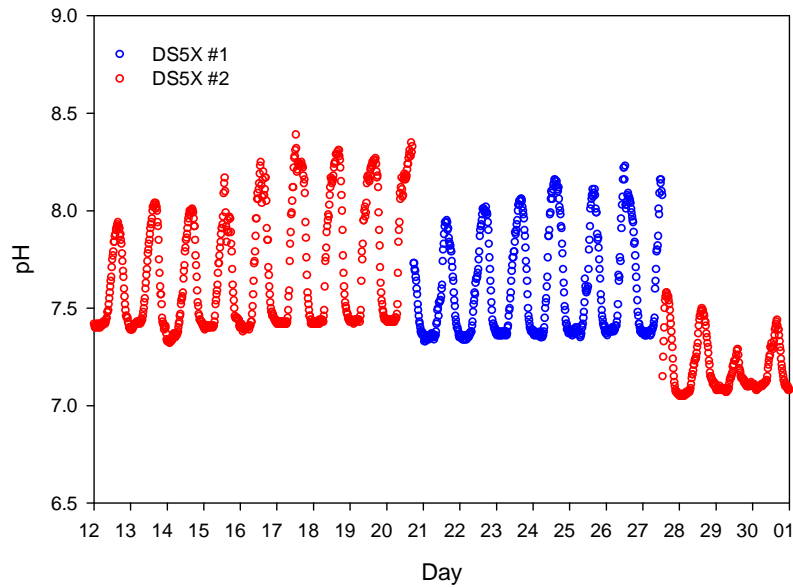
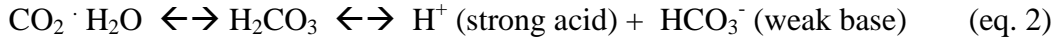


Figure 9. Clear Creek pH measurements from April 20th to May 1st, 2006.

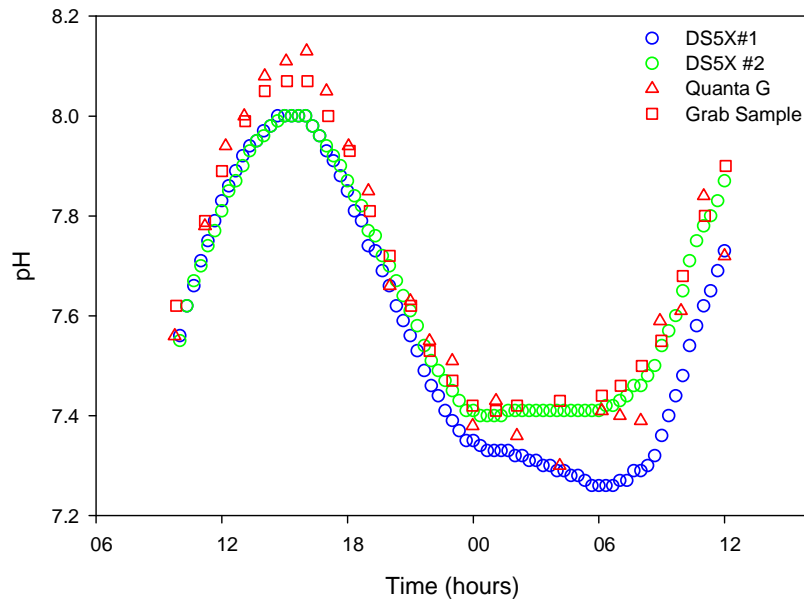


Figure 10. Clear Creek pH measurements during the diurnal study.

Dissolved Oxygen

Dissolved oxygen measurements collected during the entire summer are shown in Figure 11. The figure shows a decreasing trend from March to September. This may be due to the accumulation, death and decay of algal plant biomass in the creek. Increasing decay of this biomass would create an increasing oxygen demand, thus, reducing dissolved oxygen levels throughout the summer. Also shown on Figure 11 is the saturation concentration for dissolved oxygen which is based on temperature readings taken by the data sondes. A significant portion of the measurements were actually higher than the saturation values further indicating the presence of photosynthetic organisms. The diurnal trend of dissolved oxygen observed during the diurnal study is shown on Figure 12. This trend shows an increase of dissolved oxygen during the day which is again due to photosynthesis by periphyton (see eq. 1 above), and a decrease in dissolved oxygen concentration during the night time due to the respiration by phytoplankton. One point of particular interest in Figure 11 is the decrease of dissolved oxygen concentration below the EPA daily minimum of 5 mg/L for parts of July, August and September. This highlights the need of continuous sampling as traditional grab samples may have missed these critical events occurring largely during nighttime. The two events of low dissolved oxygen during March and April are actually due to sensor error and are not accurate measurements. Although the source of this error is unknown, it was remedied by reinstalling the drivers on the sensor.

All measurements recorded by the DS5X data sondes and the Hydrolab HQ-10 Dissolved Oxygen Meter during the diurnal study showed only a small amount of variation. There was a distinct difference between measurements taken by these sensors and the Hydrolab Quanta G sensor as measurements from the Quanta G were consistently lower. This was also observed in data presented in the 2005 Annual Report. Effects from biofouling of the dissolved oxygen sensor appear to be minimal.

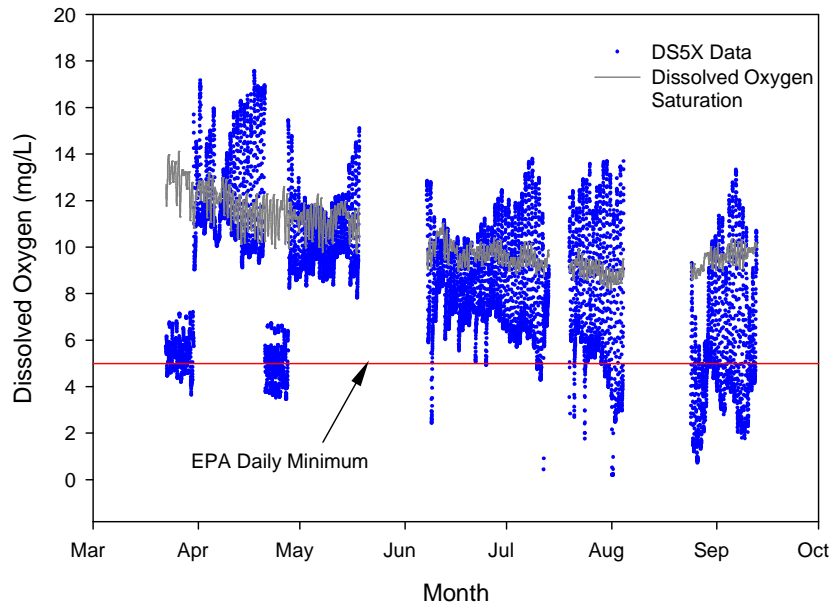


Figure 11. Dissolved oxygen measurements from Clear Creek during the summer of 2006.

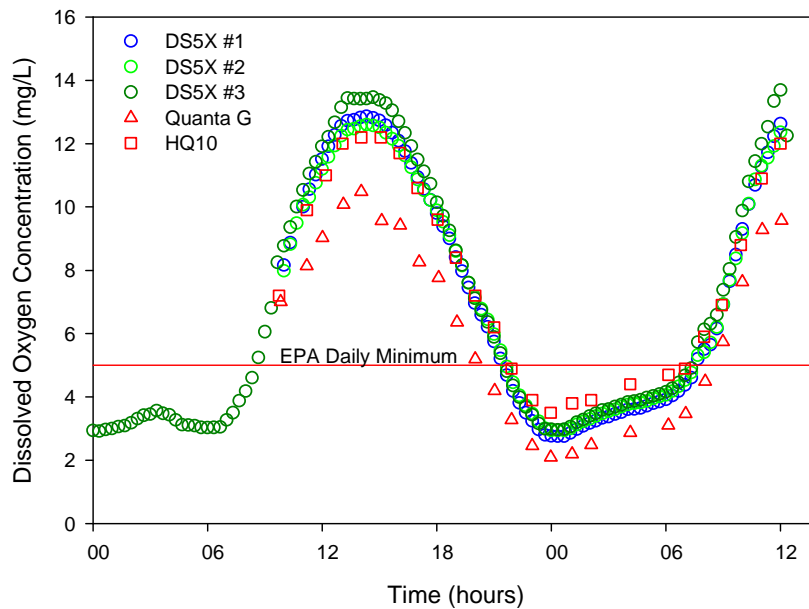


Figure 12. Dissolved oxygen measurements from Clear Creek during the diurnal study.

Turbidity

Figure 13 shows turbidity data from the summer of 2006. While most of the measurements were below 100 NTUs, there were a few events which reached the sensor's maximum limit of 3000 NTU. Some events with higher measurements (>100 NTU) are not believed to be representative of the actual water quality in the creek. This is supported by evidence shown in Figure 14. Data in this figure are from the continuous

deployment of one DS5X data sonde. Grab samples were collected and measured on March 30th and April 11th and are shown as red squares. The data sonde was calibrated and cleaned at the time of its installation on March 30th. During the April 11th site visit, the data sonde was observed to have significant amounts of biomass on it. The data sonde was cleaned and placed back into the creek without recalibration. The measurements taken before and after the cleaning of the data sonde were 299 NTU and 5.1 NTU respectively. The 5.1 NTU data sonde measurement corresponds well with the 4.3 NTU grab sample taken. Thus, it would be reasonable to conclude that the period of high turbidity measurements (>100 NTU) taken during the previous week were inaccurate due to biofouling of the turbidity sensor. Despite these problems with the turbidity sensors, measurements taken by the DS5X data sondes during the diurnal study seemed to indicate a minimal amount of variability (Figure 15). No measurement was recorded above 30 NTU which was consistent with the lack of particles observed in the water. Data points collected using the DS5X data sondes match values recorded from the grab samples. The lack of variability in measurements indicates that the effects of biofouling at this period of time were minimal.

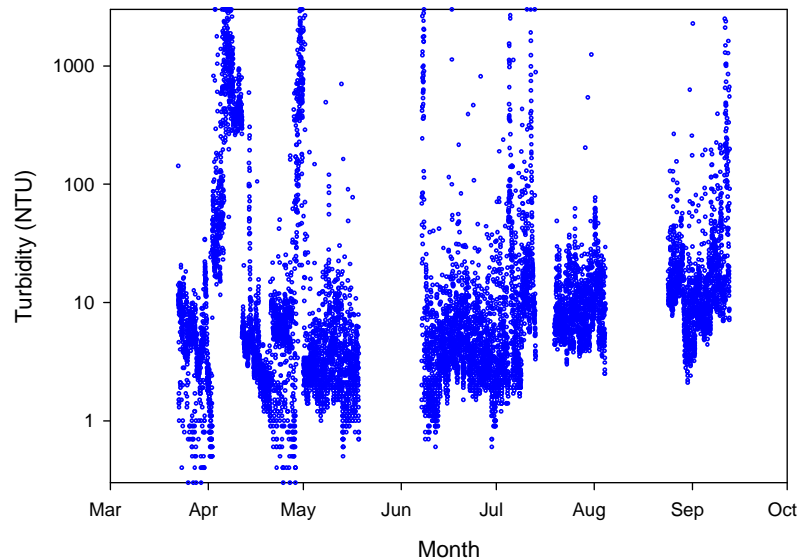


Figure 13. Clear Creek turbidity measurements during the summer of 2006.

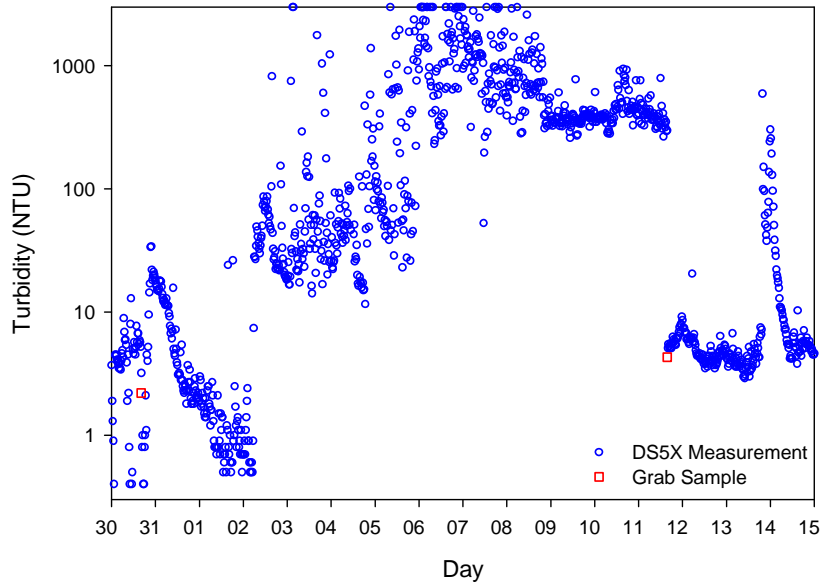


Figure 14. Clear Creek turbidity measurements taken between March 30th and April 15th.

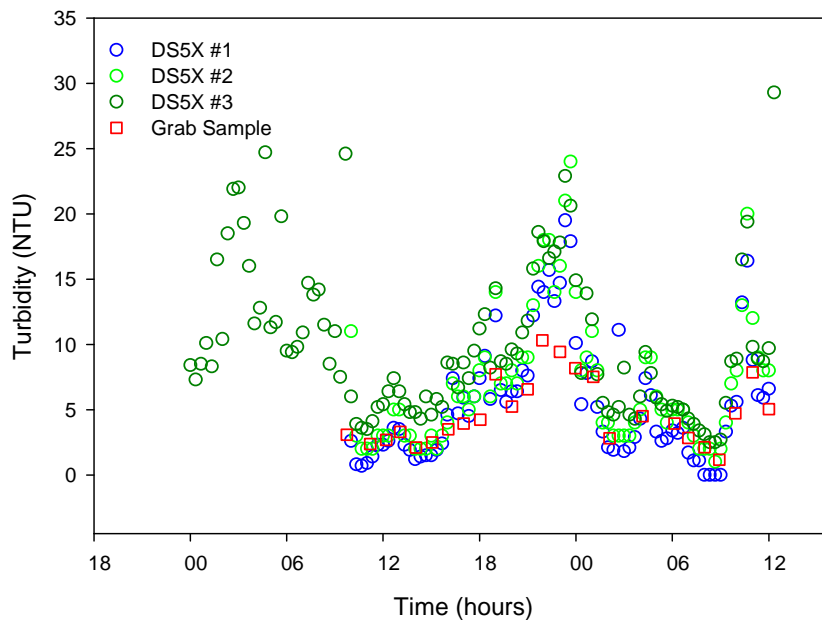


Figure 15. Clear Creek turbidity measurements taken during the diurnal study.

Specific Conductivity

Specific Conductivity measurements taken during the summer of 2006 are shown in Figure 16. Measurements stayed relatively constant throughout the entire summer with a few notable exceptions. The reason for the occurrence of the peaks is unknown and will be investigated the upcoming summer. Measurements taken from April 20th to April 27th appear to contain a bias compared to those collected before and after this period. These measurements were collected using a different data sonde. As a result, this bias may be due to an error when this data sonde was calibrated. A diurnal trend in specific conductivity can be seen in data collected during the diurnal study (Figure 17). This data

showed an increase in specific conductivity during the evening and a decrease in specific conductivity during the morning. The diurnal trend observed may be due to the dissolution and precipitation of calcium carbonate. Differences in the measurements between DS5X #3 and the Quanta G data may have again been due to calibration differences as the DS5X #3 data sonde was calibrated and deployed seventeen days prior to the Quanta G data sonde.

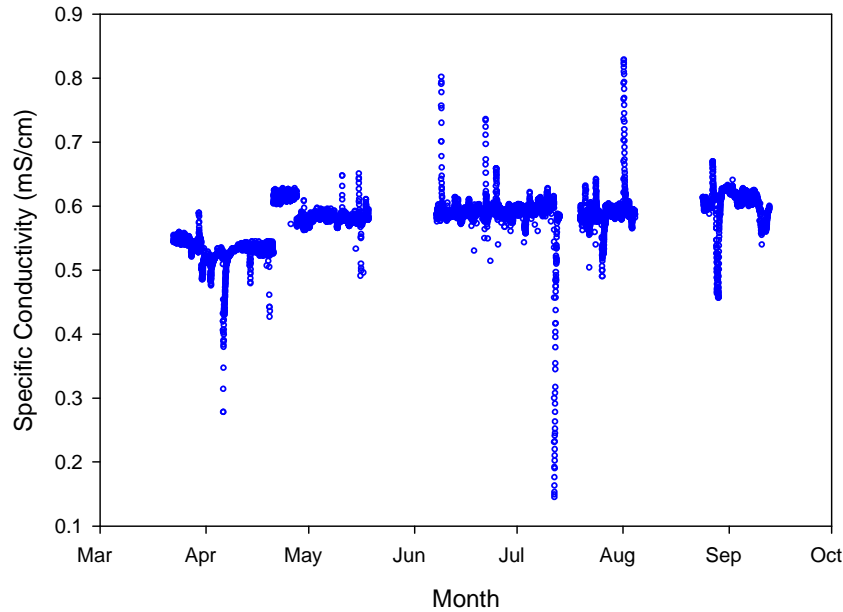


Figure 16. Specific conductivity measurements from Clear Creek during the summer of 2006.

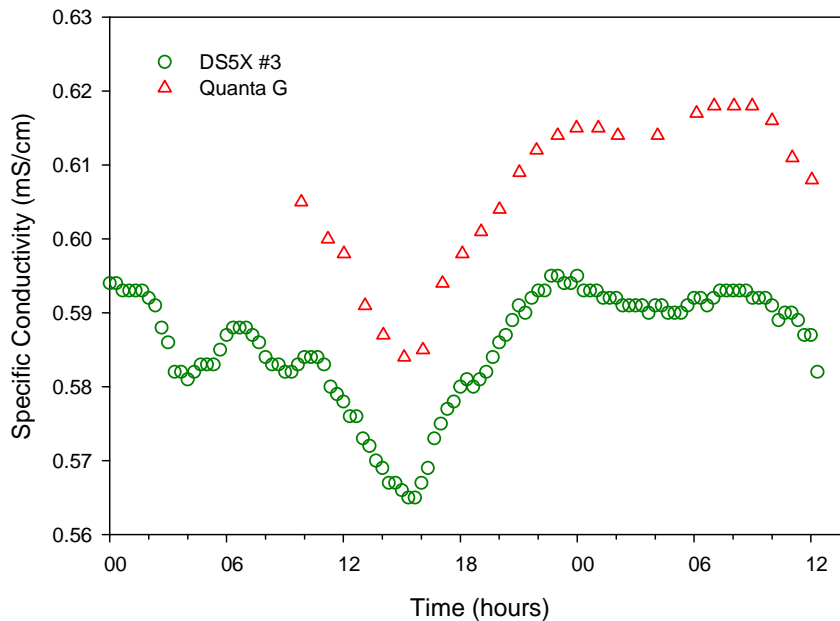


Figure 17. Clear Creek specific conductivity measurements collected during the diurnal study.

System Analysis

The integrated use of sensors, communication hardware, and cyberinfrastructure is essential in the real-time transmission of environmental measurements. Analysis of our system is therefore necessary to determine what improvements can be made to enhance the performance of the water quality node. Figure 18 shows the potential difference in the battery powering the remote data collection platform. This data illustrates the diurnal trend in potential difference in the battery as it is recharged during the daytime, and drawn down during the nighttime. Throughout the entire operation of the water quality node, the potential difference never dropped below twelve volts. This indicates that the powering system on the station is sufficient to meet current power requirements.

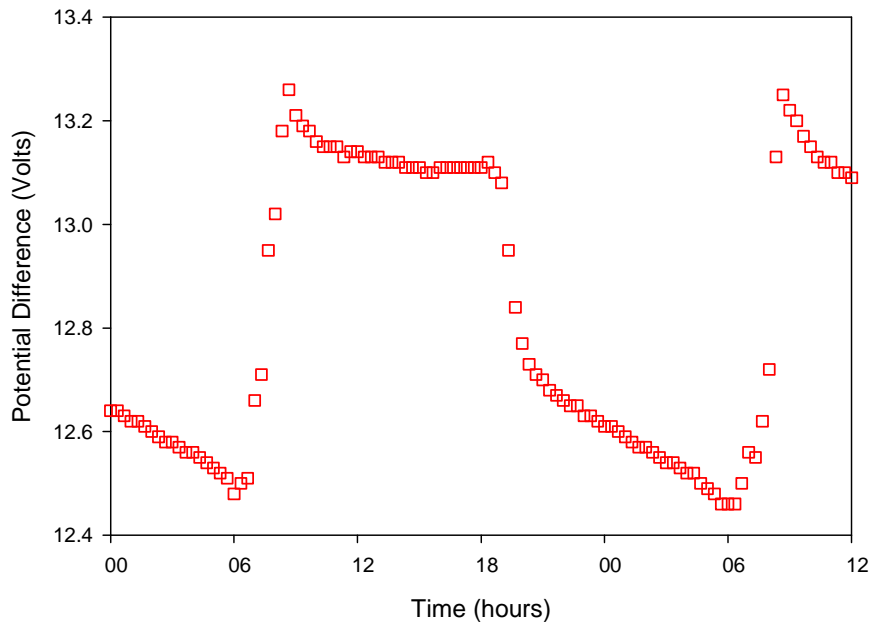


Figure 18. Potential difference in the remote data collection platform battery during the diurnal study.

This system has also been successful in transmitting near real-time water quality measurements to the database in the Environmental Engineering Laboratories. Measurements are downloaded into a database file and are readily accessible for analysis. Due to the remote location of the water quality node, communication with the cellular modem was difficult during poor weather. Although no data was lost during communication errors, data was not always downloaded in a timely manner. This can have implications if this system is used to make timely management decisions. A problem using cellular connections is that locations of individual stations are limited to where cellular coverage is provided by the carrier. Another problem with using cellular connections is that the number of minutes in the voice plan limits the frequency which data can be downloaded. In order to avoid charges for using too many minutes, communication with the water quality node can only occur once every hour. Thus, water quality measurements taken at a twenty minute interval can only be downloaded in a one hour time interval.

The CR1000 has allowed for the collection and transmission of water quality measurements, however, there are some disadvantages with using this datalogger. In order to update the frequency with which water quality measurements are collected, a new monitoring program must be manually programmed and sent to the datalogger. If real-time data is needed to make regulatory decisions on a large scale, the current water quality node would not be adequate. An automated process is needed to continually update dataloggers with the necessary frequency for data collection. This automated process should also be able to identify an event from the incoming data and increase the sampling frequency as needed, such as during a rain event.

Conclusions

Sensors, telemetry hardware, cyberinfrastructure, and models can be used to create real-time measurements and (eventually) predictions of water quality events. Funds from this grant were used to successfully create a water quality node to collect and process data in a real-time manner. This node is able to measure and transmit high temporal resolution data to a database in the Environmental Engineering Laboratories for input to the QUAL2K model. This high temporal resolution data has also shed light on the fundamental processes which are occurring in the watershed, as well as provided warning for violations of federal water quality standards. Experience with the maintenance of the water quality node has provided valuable experience by highlighting potential problems which may inhibit the large scale installation of these environmental observatories. Experiences from this project can be incorporated into future designs to create more robust system which seamlessly integrate real-time water quality data with model to forecast the health of Iowa's water.

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