INTEGRATING FIELD RESEARCH INTO UNDERGRADUATE EDUCATION: DEER CREEK RESERVOIR CASE STUDY

By

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A project submitted to the faculty of

Brigham Young University

in partial fulfillment of the requirements for the degree of

Master of Science

Department of Civil and Environmental Engineering

Brigham Young University

August 2009

BRIGHAM YOUNG UNIVERSITY

GRADUATE COMMITTEE APPROVAL

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ABSTRACT

INTEGRATING FIELD RESEARCH INTO UNDERGRADUATE EDUCATION:

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For my project, I developed materials and tools to integrate field research data into our environmental engineering undergraduate education. The goal of this effort is to expose students to current research efforts, methods, and data to make them more aware of research issues and to provide different learning methods in undergraduate civil and environmental engineering classes. The work involved developing classroom laboratory exercises that use current field data collection activities and newly developed geographic information system (GIS) extensions and computer tools to analyze these data. The work targets the introductory environmental engineering class, CEEn 351, at Brigham Young University (BYU). The first laboratory module allows students to collect field data at the research study site to become familiar with some current field methods, the second module has the students study the physical and chemical parameters affecting water

quality in Deer Creek Reservoir and find relationships between these parameters. The third module requires students to perform a phosphorus budget on the reservoir to calculate the in-lake phosphorus concentration. The last module is a case study that has students work with field-collected data and familiarizes them with a GIS system for visualizing these data using tools specially developed for this project. In addition to exposing students to field methods and analysis using actual data, these exercises provide the students with an introduction to using GIS and other common visualization tools used in engineering practice. Working through these exercises provide students with an introduction to the issues involved with field data collection and analysis and exposes them to specialized tools and advanced programs for visualizing these data. The laboratory exercises also require the students to become familiar with and understand different basic environmental aspects.

The GIS Laboratory module was tested on approximately 50 students in class laboratory sessions and I collected feedback on the results. The results were positive in terms of correlation of the laboratory with the material taught in the classroom. At least 70% of the students agreed that the laboratory exercise instructions were easy to follow and the instructions were clear and sufficiently detailed. Less than 16% of the students disagreed with the statement that the laboratory relates to the environmental class to some extent or to the general engineering principal applied to a real problem.

ACKNOWLEDGMENTS

I wish to thank Dr. Gustavious P. Williams for his frequent advice and guidance. I am also very grateful for my committee members: Dr E. James Nelson and Dr M. Brett Borup for their help along the way. Many thanks to our Deer Creek Group who helped in collecting data that went into my project. Also to Caleb Buahin who developed the GIS tools that I based one of the laboratory exercises on.

I would also like to thank Dr. Erlend Peterson, the International Affairs Vice President, for his financial and mental support. Last but not least, a special thanks to my parents who encouraged me and supported me financially and spiritually from the beginning; I would not have done all this without them.

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1. Introduction

According to National Science Foundation, there is an increasing concern that what is being taught at universities on the undergraduate level does not prepare students for real world challenges upon graduating (Sabatini 1997). In general, engineering homework and assignments given in the classroom tend to be very limited in scope compared to open ended work-related problems faced in real life (Sabatini 1997). For students to be competitive in the engineering market, they will not only need basic knowledge in engineering studies but also the technical skills that come from doing research and solving hands-on real life problems (Sabatini 1997). To provide this experience for undergraduates at Brigham Young University (BYU), I created educational laboratory modules related to different on-going research issues at Deer Creek Reservoir in Utah. They focus on understanding the processes related to the water quality of the reservoir and are designed to get students involved in the research being done in the area. These laboratory modules are being integrated in the BYU undergraduate introductory environmental engineering course, CEEn 351.

BYU's environmental engineering undergraduate students are taught the basic principles of material balance in water streams and the effects of water property changes to the overall reservoir quality. This is done using textbook developed problems and solutions. In general, the data presented in these problems directly show the process under study and do not have accuracy or precision issues. I developed these laboratory modules to extend this learning experience to include field data and also provide students with an introduction to engineering research issues and methods.

In most field research projects, field data collection is usually done by graduate students with assistance from a limited number of undergraduates (Sabatini 1997). This is also true at BYU. The Deer Creek project supports a number of graduate students doing independent, but related research. These graduate students are supported by some undergraduates: a range of 1 to 4 undergraduate students have worked with the team mostly performing data collection and preliminary laboratory analysis. For the Deer Creek research projects, most of the data collection activities are shared, as multiple projects use the data. Including undergraduates in this research is done to support specific research goals, not to directly support undergraduate education. However, I think the data collected for this research with its associated problems (uncertainties, errors, etc.) can provide undergraduates in CEEn 351 with an exposure to real data and an introduction to more open ended problems of the type that might be expected in actual projects after graduation (Sabatini 1997). Creating these laboratory exercises, I hope, will aid in undergraduate students comprehension and better understanding of natural processes to provide a more complete learning environment.

Research has shown that field trips and computer modeling activities associated with a class increase the learning opportunities [(Feisel and Rosa 2005); (Bell and Fogler 1995); (Sabatini 1997)]. (2005) state that an educational field trip or using computer-aided modeling to support material studied in class can be an integral part of an instructional program. Good field trips provide the participants with firsthand experience related to the topic or concept being discussed (Sabatini 1997). Laboratory sections associated with courses provide unique opportunities for learning that are not available in a regular classroom setting (Feisel and Rosa 2005). The integration of computer-aided tools in education gets students more deeply immersed in the computer simulation and educational experience in ways that are often not possible using traditional in-class teaching (Bell and Fogler 1995). Numerous research studies in science education have documented the importance of having inclusive labs associated with their undergraduate courses (Feisel and Rosa 2005). My development of the laboratory exercises is based on this research, which includes both field trips to gather data and computer exercises to visualize and analyze these data.

Deer Creek Reservoir was the study area for the exercises I created. Data were collected from the reservoir as part of the class laboratory exercise and augmented with other data from the on-going research projects. These data were put into a laboratory format for students to work with, reducing the amount of time required for simple data formatting and translations. The main focus of the modules I developed is using field data to understand the water quality of the reservoir. The modules approach this goal in several different ways introducing the students to field data collection and different methods for analysis including methods such visualizing data, analyzing specific data sets, and by performing a mass balance on the reservoir. The outcome of the laboratory exercises is designed to emphasize how water quality issues can be identified using field measurements to understand basic reservoir processes. The students are required to develop ways to address these issues, learning how the processes might be managed to maintain high water quality in the reservoir.

Understanding short-term changes in water quality in different lakes and reservoirs requires high temporal monitoring of the area (Yang, Merry et al. 1999). Advanced research tools and the availability of high technology equipment make it easy to collect numerous water quality parameters at high spatial and temporal resolutions (Buahin 2009). To identify, characterize, and understand these rapidly changing processes, frequent monitoring is performed at Deer Creek Reservoir. This monitoring is based on research requirements but could cover a range of parameters from meteorology, to physical, to chemical characteristics (Hamilton and Schladow 1997). Most often, the primary or secondary water use determines what parameters are monitored and collected. Studying the water quality and physical processes of a specific reservoir can be done to help understand processes and develop management plans to support the intended purpose for the water (Hamilton and Schladow 1997). BYU is studying Deer Creek to determine how reservoir management practices affect the water quality since it is used as a major water supply source.

In general, our field research data are collected with electronic equipment, though some data are developed from field samples that are analyzed in the laboratory. There are many different programs that can be used for managing and storing these data. The basic tasks involve entering, visualizing, and analyzing the data. In most environmental management programs, GIS is considered a key component for successful management as this software allows analysis of the data in a spatial context (Abbott and Argentati 1995). GIS software is capable of storing, retrieving, mapping, and analyzing geographic data referring to a certain location and doing various spatially based analyses (Abbott and Argentati 1995). However, GIS systems are not necessarily designed to analyze reservoir water quality data. Adding extra tools to a GIS system for viewing the data along with the accuracy and functionality of GIS makes it easy to organize data collected in the field (Buahin 2009)

The Deer Creek Research Project has developed a number of tools to store, analyze, and visualize the collected and generated data (Buahin 2009). These tools are integrated into the ESRI ArcInfo GIS tools. I used these tools and the associated data in developing the laboratory exercises that are the topic of this case study.

2. Study Area

Data were collected From Deer Creek Reservoir, Utah. Deer Creek Reservoir lies in the southwest corner of Heber Valley. The watershed study area, which drains into Deer Creek Reservoir, has an area of 171,663 acres (Psomas 2002) and the reservoir holds up to about 150,000 acre-foot of water (Robinette 1966). Figure 2-1 shows the study area.

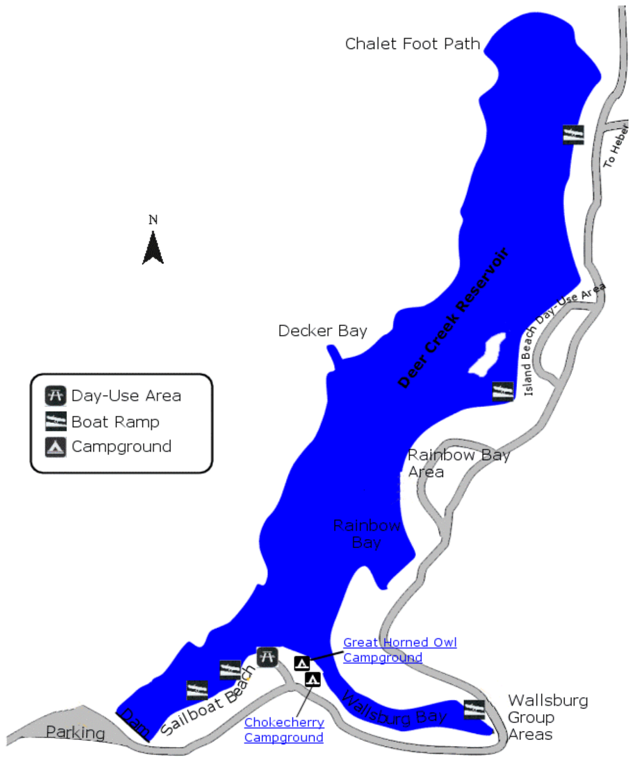

Figure 2-1 Deer Creek Reservoir

3. Water Quality Modules

BYU received funding to study nutrient cycling processes in Deer Creek Reservoir. Part of this research included monitoring the water quality in the reservoir by choosing specific monitoring points, using various field techniques to acquire data, and using these data to identify changes over time. My work was to use these data and techniques and develop laboratory exercises for an undergraduate class, CEEn 351, to get students involved in the research and to expose them to a more realistic working environment as seen in Figure 3-1.

Figure 3-0-1 Hach multisensor Probe used for data collection at Deer Creek Reservoir

The laboratory modules I developed include four separate study areas or fields, with each module presenting a single area. The first module is a field exercise designed to familiarize students with some basic field data acquisition methods, the second has the students evaluate the different water quality parameters that they measured; the third is a requires the students to compute a phosphorus budget on Deer Creek Reservoir; and the fourth is assigns the students with a data analysis task using GIS tools specifically developed for the on-going research program.

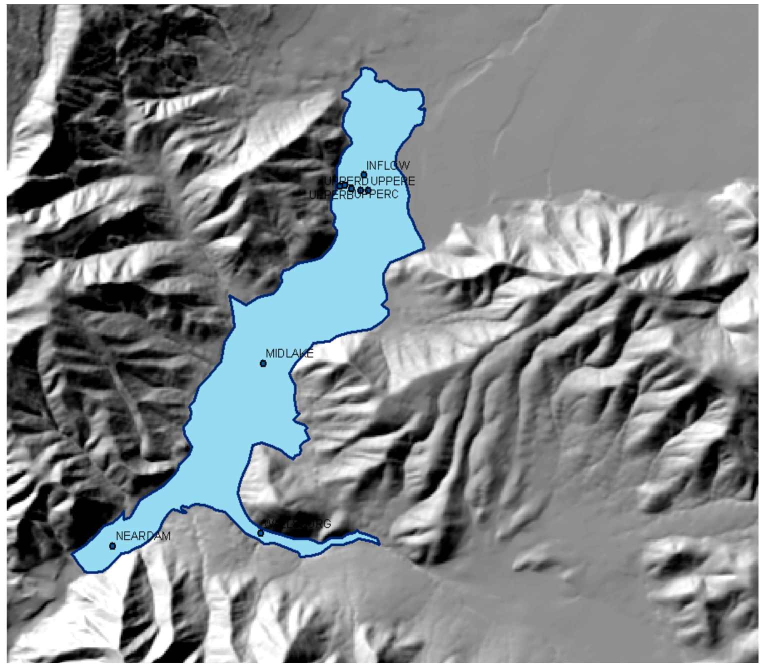

Figure 3-0-2 Monitoring points locations

3.1 Field Data Collection

The field data collection module requires a field trip to Deer Creek Reservoir to collect data at the monitoring points shown in Figure 3-2. At the reservoir, the students collect vertical profile data using Hach electronic probes. In a later module, they use these data (along with data previously collected as part of the research program) to perform an assessment of the current state of the reservoir. The main equipment used for this exercise is a Hach multisensor Hydroprobe shown in Figure 3-1 (Buahin 2009). This exercise requires the students to go to Deer Creek Reservoir and collect data using the multi-probe in the same locations and using the same methods as the on-going research project. The students are assisted by the researcher assistants who work on the project, and the data collected by the students are included in the research database. This exercise not only provides a field trip to allow sophomore and junior students to become familiar with current field data acquisition techniques, it also provides them with a brief introduction to the field research project and how it operates.

As part of this laboratory module, I developed presentation and briefing materials for the Teaching Assistants (TAs) to use with the students. Before the trip, the students are given a brief description on what kind of data they will be collecting with a demonstration of how to use the probe and associated collection apparatus. Since the monitoring points are scattered across the reservoir, the University boat is used to travel to the different locations. Safety instructions are also provided prior to the trip. Figure 3-2 illustrates the monitoring points at which students will collect data at Deer Creek Reservoir.

As part of the field data collection laboratory, the students process the data collected from the field. They are required to identify problem measurements, interpolate the vertical profile information to 1-foot increments, and format the data to be imported into the GIS program. The outline and support information for this laboratory are included in the Appendix A in the Field Data Collection Laboratory Module.

3.2 Classroom Laboratory Modules

In addition to the Field Data Collection laboratory exercise, three indoor laboratory modules were developed. Each of these laboratory exercises use the data the students collect as part of their field trip, augmented with data collected during the research project. Each Laboratory has its own concept and purpose. The three laboratory exercises are described individually in the following sections.

3.2.1 Water Quality Laboratory Module

Environmental engineers determine water quality by testing for specific chemicals (Mackay and MacLeod 2002). Most often, the type of water or water use determines what parameter the analyst tests for in the study. Studying the water quality of a reservoir is very important to determine if the water is applicable for the intended use (Mackay and MacLeod 2002). While some parameters are specific to certain uses, other parameters are more universal are used to determine the overall quality of the water and determine how the water can be used. I used these general water quality parameters in this laboratory module.

The students are asked to analyze the following parameters. They are provided with a brief explanation of what each parameter is used for and what should be known about each one. This information is included in the laboratory handout in the appendix. The parameters the students are required to analyze are:

- Temperature
- Turbidity
- Conductivity
- Dissolved Oxygen (DO)
- Phosphorus
- Nitrate
- Chlorophyll

This laboratory module introduces the undergraduate students to water quality assessment and familiarizes them with commonly measured water parameters. They are asked to use these data to evaluate the state of the reservoir. As noted above, the laboratory module includes a handout I created that has a brief summary on the parameters measured by the students at Deer Creek reservoir. The students are asked to read through the laboratory handout to obtain a general knowledge about water quality monitoring, then use data they previously collected from the reservoir to analyze the water quality. They are also asked to find and identify any relationships between parameters; both chemical and physical. A copy of the lab handout is found in Appendix B.

3.2.2 Phosphorus Budget Laboratory Module

A nutrient budget model for reservoirs is essential in monitoring the overall water quality of the water body (Bennett, Reed-Andersen et al. 1999). The change in nutrient concentration affects other parameters, such as algae growth, that directly impact water quality (Wetzel 2001). Nutrient budgets are developed to study the intermediate concentration of nutrients in the water environment (Mukhopadhyay and Smith 2000). For Deer Creek reservoir, phosphorus budget has been calculated and showed that phosphorus is the fundamental driver of lake primary production. Excessive phosphorus can degrade the lake through eutrophication (Bennett, Reed-Andersen et al. 1999). In addition, for Deer Creek Reservoir, phosphorus is considered a more controllable pollutant than nitrogen (Psomas 2002) and is the focus of current management practices to improve the water quality of the reservoir.

For this laboratory module, a mass balance approach is used by the students to calculate change in storage of phosphorus in the reservoir based on reservoir inputs and outflows. There are four major input streams to Deer Creek Reservoir (Provo River, Snake Creek, Main Creek and Daniels Creek) with the Provo River contributing 69% of the input phosphorus loads (Psomas 2002). There are also non point sources contributing to phosphorus input such as urban and agriculture sources (Psomas 2002).

I made some assumptions made to simplify the calculations for the students. For the laboratory assignment, the reservoir is treated as a black-box system assuming a uniform concentration of material throughout the reservoir. The reservoir is also assumed to have constant loading with time. The students are directed to use a first-order settling coefficient for phosphorus settling in the reservoir. With these assumptions, the students use the following equation to calculate the phosphorus budget.

$$V\left(\frac{dp}{dt}\right) = W - Qp - k_s Vp \tag{3-1}$$

where

p = Reservoir Total Phosphorus Concentration (mg/ m^3)

Q = Flow (m^3/yr)

V = Reservoir Volume (m^3)

k_s = 1^{st} order settling constant (yr^{-1})

The students are given the flow, volume, input phosphorus concentration and the settling coefficient. They are asked to find the in-lake phosphorus concentration for each given year using equation 1. The students are then asked to analyze these results and write a paragraph explaining the reason of getting a different concentration each year.

The goal of this laboratory exercise is to familiarize undergraduates with performing mass balance on a reservoir using real data. In the process, students will broaden their knowledge in phosphorus dynamics and explore options of the reservoir being a net source or a sink net for phosphorus. A copy of the laboratory handout is found in Appendix C.

3.2.3 GIS Visualization Laboratory Module

An undergraduate civil engineering student at Brigham Young University, Caleb Buahin, developed a spatial toolbox in GIS that allows data visualization of these vertical profile data collected by the Hach (Buahin 2009). The tool includes methods to look at the data as a function of time, depth, or space. The data collected in the field by the students are entered in the database,(Buahin 2009) ,which supports these tools. The database stores the information as data tables, which allow the database to connect with GIS for analysis (Buahin 2009). The following sections provide a description of the capability of these tools. The toolbox includes four processes that are used for data management and visualization. A copy of the manual is found in appendix D. The students are required to use the GIS system with these tools to complete this laboratory module.

3.2.3.1 Creating monitoring points

This tool is used to create and plot the monitoring points available in the project's database. GIS retrieve the stored points with their associated coordinates and plots them on the DEM of the reservoir. The software gives the option to label the points created. The goal for creating the monitoring points is to show the location where field measurements were taken and provide a graphical way to access these data.

3.2.3.2 Plot Profile

This tool allows the user to plot a vertical profile for a selected parameter with depth. Engineers are typically interested in viewing changes of water quality parameters as a function of depth to compare any changes that may occur as water gets deeper away from the surface and closer to the sediment in the reservoir. Basic reservoir processes are a function of depth and this tool can clearly show thermoclines and other features associated with reservoir limnology. Plot profile allows the user to choose up to two different parameters to plot on the same graph. This way, the effect of one parameter can be studied compared to another as depth changes. The graph will show depth on the y-axis and the parameters on the x-axis. The plot includes the values taken from data already present in the database.

3.2.3.3 Time series

Time series is a useful tool for analyzing the change in a parameter at a certain location with time. The water quality in any water body can change dramatically with time, depending on the season or even the time of the day (Psomas 2002). For each monitoring point, data were collected at different times and dates year round. To compare changes with time, the user could use the time series function to show the changes with time by a line or a bar graph. More than one parameter can be chosen but due to different value ranges in data, user must be careful with parameters picked in order to see difference with time. These tools plot complete profiles and allow the engineer to understand how these profiles change over time.

3.2.3.4 Correlation

Correlation allows the user to get correlation equations and regression coefficients between parameters. This function helps in data comparison and prediction for future use. This statistical tool also helps students explore relationships among the various data sets

3.2.3.5 Animation

Animation is the most preferable way to view temporal changes over a spatial area. In many cases relationships and trends that are not obvious in a series of static plots can be identified through viewing animations. It helps the engineer understand the results of an analysis of the data. This tool allows the data to be animated in two different ways; vertical profile or time series. As described above, vertical profile and time series are used for different data visualizations. The animation tool creates a different raster image for each depth or time step and shows a smooth transition between raster layers in animation. The vertical plot animation will show the changes in a parameter across the area as depth changes. Since the data provided represent certain points across the reservoir, the GIS tool interpolates the values between these points when creating the raster. This gives a rough estimate of the values between points.

The time series animation combines rasters for a parameter at one depth then animates the change at different times based on available dates in the database. The purpose of this application is to compare the changes in water quality with time, depending on the date at which the data were collected. The overall quality of the reservoir highly depends on the time and the temperature in the area it is measured; any drop in temperature in the area will result in water quality change (Psomas 2002). Also during spring season, runoff is higher due to snow melting so more water will flow to the reservoir carrying water of different quality (Wetzel 2001). The water from the runoff gets mixed with reservoir water changing the overall quality of the water body (Wetzel 2001). Time series animation allows users to view such changes and compare the overall water quality with time.

4. Laboratory Module Application Results

The GIS laboratory module was tested on a CEEn 351 environmental engineering class with approximately 50 students at BYU. In order to evaluate the impact of the laboratory exercise, I distributed a short electronic survey to the students enrolled in the class who participated in the exercise. The survey focused on the manual the students used to complete the exercise and how the exercise helped them understand the various water quality issues. Students enrolled in the class were undergraduate civil engineering students and the majority had not taken a GIS class before. A copy of the survey and the results are provided in appendix E.

The survey findings indicated that the manual provided a good outline and guidance for first time users although extra help from the professor or the teaching assistant would have been preferred by the students. The timing for the laboratory is convenient for a college lecture as the majority of the students finished in less than an hour.

At least 70% of the students agreed that the laboratory exercise instructions were easy to follow and the instructions were clear and sufficiently detailed. Less than 16% of the students disagreed with the statement that the laboratory relates to the environmental class or to the general engineering principal applied to a real problem. This shows that involving students in a different learning process was well received by students in the class.

Since this was the first use of the instructional materials, including the manual, the students faced some difficulties following the manual and identified some problems. Most of the problems faced were systematic problems with the computer system setup. GIS, being sensitive software, was not consistently configured on all computers in the computer lab. This resulted in some of the students having problems with following the exercise. For example, the 3D analyst extension was not activated for all computers and is required for the animation tools, so the animation portion of the laboratory did not work form some of the students. Based on these results, I realized that some basic GIS instructions should be added to the laboratory instructional materials to avoid systematic inconsistencies.

In order to get a full vision on the student's opinion of the laboratory exercise, I added an open-ended question for comments and suggestions of possible improvement. Table 1 below shows some of the comments I received from the survey.

Table 4-1 Comments from students for GIS manual improvement

Text Response
It is neat
it was hard to get started, but after that things were better
The manual was good however the arc gis had an issue with the animation button on the tool bar so we were unable to complete this part of the manual.
It was great
The lab manual instructions were clear and easy to follow, but the program wasn't responding correctly.
We had trouble with the animation, but other than that everything worked. The manual didn't include what to do if we ran into problems.
The instructions were clear but the program did not work.
The instructions were clear and easy to follow. It would have been even easier if the TA were to demonstrate the process before turning the students loose.
The manual was very effective as a roadmap to accomplish the things we needed to. The program on the lab computers in 234 did not allow most students to operate the program though.
The manual seemed sufficient. The problem was either due to a lack of explanation or computer errors that were not foreseen. I thought that using GIS could be interesting.
It was a pretty good manual and fairly easy to use. We just had several VBA run time errors, so we couldn't do any of the animation parts. Also, we couldn't export anything, there was some problem there. Maybe you could include a troubleshooting section with things that possibly go wrong.
I wish we had more opportunities to use GIS.
It was a good lab I'm always interested in that kind of stuff
If the file is properly extracted, then the program works great and the process is efficient.

The survey gave a good feedback overall and the laboratory exercise was effective based on the post-exercise survey and evaluation despite the technical errors. The evaluation indicates that involving students in research expose them to a different experience required for critical thinking and that the students appreciate and support these types of activities. Based on the survey results, most students are willing to try new techniques as part of their education and look forward to these efforts. I think undergraduate students prefer problem solving, getting exposed to real life problem and the opportunity to provide input.

5. Conclusion

The paper discusses laboratory exercises I developed for undergraduate classes in an introductory environmental engineering class. The main goal of this effort is to introduce the undergraduates to research methods and expose them to actual field data and methods to provide a more complete learning experience. Obtaining feedback from students after performing the laboratory exercises was very important to determine if I met these goals. For that reason I distributed a survey to the student. The findings indicated that students accepted the concept of including a laboratory exercise in the curriculum and that, in fact, it is effective in giving them a more professional experience.

Including laboratory exercises in educational courses, even if they do not provide the expected benefits, should not interfere with tradition education techniques. Implementing real life problems into the curriculum expands the knowledge and extent of thinking for students. Interaction between students working in groups in the field present a real life situation to better prepares them for future work.

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Appendix A Field Data Collection Laboratory Module

Objectives

- Getting exposed to field research projects
- Getting familiar with field data acquisition techniques
- Collecting vertical profile data using Hach electronic probes

Assignment

For this lab, you will be going out to Deer Creek Reservoir to collect water quality parameters using Hach electronic probes. You will be traveling through points by BYU's Boat. Please note the following:

1. Go through the safety instructions before getting on the boat.
2. Follow the instructions to get a vertical profile for *"Midlake"* and *"NearDam"* points.
3. Learn how to export data from the sonde to an excel sheet.

Preparing the DO probe

1) Connect the DO probe to the laptop using the long cable.
2) Start "*Hydras3LT*" on the laptop.
3) Wait until the program detects the probe (COM1) and select "*operate sonde"*.

4) Before start taking reading, the probe must be calibrated for depth. Lower the probe until it barely touches the surface of the water.
5) Click on *"Calibration"* tab.
6) Enter **0** for the depth and hit *"Calibrate"*.
7) Click on "*online monitoring*" tab.
8) Choose the following parameters: Temp (c), Temp (F), pH, Spcond (ms), SpCond (us), TDS, Depth (ft), Depth (m), Turbidity, LDO, Chlorophyll
9) Now the probe is ready to take measurement. Click on "*Start*" and start lowering probe at a speed of approximately 1ft/s.
10) Once you have reached the bottom click "*Stop*" and pull the probe up using the downrigger (See below for details).
11) Click on "*Export to excel*" and save the file on the computer.

Preparing the Nitrate probe

1) Connect the nitrate probe to the surveyor.
2) Turn the surveyor on.
3) Select *"file"*.
4) Select *"Surv4"*.
5) Choose *"Create"* then *"Select"*.
6) Choose *"Manual"*.
7) Type the name of the monitoring point and click *"Done"*
8) The parameters should be already saved on the surveyor.
9) Select *"Done"*.

10) Exit to the main menu.

11) Select *"Store"*

12) Choose the file you just created.

13) Now the probe is ready to take measurements. Unlike the DO probe, you will have to manually select store every second to record the data.

NOTE: Do not lower the nitrate probe deeper than 40 feet.

14) One you have reached the bottom, or 40 ft, stop storing the data and pull the probe up using the downrigger.

15) The file is automatically saved.

Downrigger

1) Connect probe on hooks
2) Lower to water depth
3) Start recording of measurements
4) Lower downrigger by hand
    a. Pull handle back
    b. Move wheel forward
5) To raise the sonde after completion of recording, turn knob to 'on' setting. The machine will automatically stop when it reaches the top.

Boat Step by Step Procedures

1) To be done one week before trip.

A) Plan the date, time and location of trip.

B) Designate Group Leader

C) Have the Group Leader reserve the truck or get the secretaries to rent a truck if needed.

D) List all of the individuals going on the trip on the Boat Trip Plan Authorization form.

E) Designate the Driver of the Truck on the Boat Trip Plan Authorization form.

F) Designate the Driver/Drivers of the Boat on the Boat Trip Plan Authorization form.

G) Designate two Traffic Directors on the Boat Trip Plan Authorization form.

H) Make sure that the weather is good enough be on the water. Check the forecast.

I) Ensure that all safety and maintenance items listed on the Boat Trip Plan Authorization form are on the boat.

J) Specify on the Boat Trip Plan Authorization form any special or extra equipment needed.

K) Turn in Boat Trip Plan Authorization form to the Safety Officer.

2) To be done the day of the trip before getting to the Lake.

A) Before leaving on the trip make sure there is enough gas and oil in the Truck/Boat/Generator. Fill the oil tank on the boat each time you fill up with gas.

B) Make sure that the State Park Pass is in the truck that you are driving.

C) Make sure that you have two copies of keys-one for truck driver and one for boat driver.

D) Pick up the boat. Hook up the trailer and trailer lights ensuring that the safety chains are attached properly and that the ball is locked in place with a pin.

E) Check to see that the trailer lights are working properly.

F) Ensure that Traffic Directors guide the truck driver while hooking up the trailer and while pulling out of parking stall.

G) Drive with the canopy down and its cover on. (Warning, if the boat is being transported the canopy of the boat must be lowered).

3) To be done before unloading the boat.

A) Unhook straps on the back of the boat

B) Take off canvas cover and store in the truck.

C) Fill out the items Left on Boat form listing what is currently on the boat.

D) Put up all tables, canopy and downrigger that will be used during the trip.

E) Back the boat into the water ensuring that the motor is sufficiently in the water.

  i) Make sure that the Traffic Directors are guiding the driver back into the water.

  ii) Make sure that the Boat Driver is in the boat before backing the boat into the water.

  iii) Do not unhook the boat from the trailer until the motor is running.

F) Prime the motor by squeezing the bulb until tight.

G) Start the motor, if motor does not start, refer to Boat Troubleshooting sheet found in the compartment next to the captains seat.

  i) Let the motor idle for a couple of minutes before trying to back the boat off of the trailer.

4) Unloading the boat

A) Unhook the boat from the trailer.

B) Back the boat off of the trailer and pull up to the dock

i) Make sure that someone is there to catch the boat at the dock.

ii) Use buoys to protect the edge of the boat from rubbing on the dock.

iii) Tie off onto the dock then have everyone get onto the boat.

iv) Have the last person push off of the dock while the driver pulls away.

C) Drive the boat with caution following all boating safety guidelines.

5) Loading the boat

A) Follow docking procedures as outlined above and drop off truck driver and the two traffic directors and any others who need to get off of the boat.

B) Back trailer into water following procedures outlined above using traffic directors.

C) With trailer in place slowly drive boat onto the trailer ensuring proper alignment.

i) Traffic directors are responsible to let the boat driver know which direction to go and to ensure that no damage is done to the trailer by misalignment.

ii) One of the traffic directors if responsible to hook up the boat to the trailer and tighten it up, making sure it is locked in place.

D) Turn the key off and take the key out of the ignition (Ensure that all switches and the radio are in the off position. ***All Switches should be in the down position except the Nav/Anch switch should be in the middle position.

E) Pull the boat out of the water

F) Hook the straps onto the back of the boat.

G) While driving, ensure that the canopy is down with its cover on.

H) Put the canvas cover back onto the boat (make sure to take out all of the items that will not be stored in the boat)

I) Fill out Items left on boat sheet and sing and date it.

J) Check trailer lights.

K) Drive back safely

6) Parking the boat

A) Be aware of other vehicles and obstacles

B) Ensure that the traffic directors direct the truck driver to position the boat in its proper parking stall.

C) Return keys

Appendix B Water Quality

This lab is due ______ at ________

In this lab, you will study the different water parameters that control the quality of a certain water body.

Objectives

- Study the parameters controlling water quality.
- Find relationships and connections between parameters.
- Understand the effect of change in reservoir's physical or chemical properties.

Assignment

You will be interpolating the data given by finding relationships between different water quality parameters.

Environmentalists determine water quality by testing for specific chemicals. Most often, the type of water being tested determines what parameter the analyst looks for. Studying the water quality of a certain reservoir is very important for whatever purpose the water will be used for. Certain parameters affect the overall quality of the water and determine how the water can be used. For this lab, we will be studying the water quality of Deer Creek water. Certain parameters are collected from different points at the reservoir using Hach multisensor Hydroprobe.

The probes are highly tech devices that measure many parameters of water in seconds just by dipping them in water. The data for this lab was collected using these probes. As a demonstration, we will be using the probe to get different parameters by dipping the probe in a small bucket filled with water from Utah Lake.

This section lists common water quality parameters important in drinking water, wastewater, and natural water. Many parameter listings include descriptions of the effects of levels on living organisms.

1. Temperature.

Water temperature is affected by many factors such as depth, air temperature, time of the year, and latitude of reservoir along with many others. The variation of water temperature mainly affects the behavior of water organisms. Fish and most aquatic organisms are cold-blooded. Consequently, their metabolism increases as the water warms and decreases as it cools. Each species of aquatic organism has its own optimum (best) water temperature. If the water temperature shifts too far from the optimum, the organism suffers. In addition to that, warm water makes toxic substances, such as zinc, more toxic for organisms.

2. Turbidity.

Turbidity is the optical property of a water sample that causes light to be scattered and absorbed rather than transmitted in straight lines through the sample. In other word, how cloudy the water is. Lights ability to pass through the water depends on the amount of suspended material in the water. Water can get turbid from microorganisms, plants and mostly from silt. Aside from the muddy color it gives the water, high turbidity interferes with light penetration for fish and plants leading to their death.

3. Phosphate and Nitrate.

Nitrates and phosphate are major components of farm fertilizer and are necessary for crop production. When it rains, varying nitrate and phosphate amounts wash from farmland into nearby rivers. These components can also get into water from lawn fertilizer run-off, leaking septic tanks and cesspools, or from farm livestock, animal wastes

Nitrates and phosphate stimulate the growth of algea and water plants that provide food for fish. This may increase the fish population. However, if algae grow too wildly, eutrophication occurs blocking sunlight from reaching fish and decreasing oxygen levels. This will not only kill fish, but cause bad odors and taste of the water.

Nitrates can be reduced to toxic nitrites in the human intestine, and high levels of nitrate-nitrogen can seriously poison babies. On the other hand, Phosphates won't hurt people or animals unless they are present in very high concentrations. Even then, they will probably do little more than interfere with digestion.

4. Ammonia

Pure ammonia is a strong-smelling, colorless gas. It is manufactured from nitrogen and hydrogen or is produced from coal gas. In nature, ammonia is formed by the action of bacteria on proteins and human waste. Ammonia is toxic to fish and aquatic organisms, even in very low concentrations. The danger ammonia poses for fish depends on the water's temperature and pH, along with the dissolved oxygen and carbon dioxide levels. The higher the pH and the warmer the temperature, the more toxic the ammonia in the water is.

5. Dissolved Oxygen (DO)

DO is oxygen that is dissolved in water. It gets there by diffusion from the surrounding air; aeration of water that has tumbled over falls and rapids; and as a waste product of photosynthesis. If water is too warm, there may not be enough oxygen in it. When there are too many bacteria or aquatic animal in the area, they may overpopulate, using DO in great amounts. The level of oxygen in the water can change by increasing the concentration of phosphate and nitrate. Under these conditions, the number and size of water plants increase dramatically causing eutrophication. Then, if the weather becomes cloudy for several days, respiring plants will use much of the available DO. When these plants die, they become food for bacteria, which in turn multiply and use large amounts of oxygen.

6. pH

The balance of positive hydrogen ions (H^+) and negative hydroxide ions (OH^-) in water determines how acidic or basic the water is. The pH scale ranges from 0 (high concentration of positive hydrogen ions, strongly acidic) to 14 (high concentration of negative hydroxide ions, strongly basic). In pure water, the pH measures to 7 but in most cases, natural water is basic due to all the minerals present.

What to Do

For this lab you will be asked to interpolate data (copy is attached to the lab) already collected from Deer Creek Reservoir by the probes. You will be given a set of data containing the reading for different parameters at different locations in the reservoir. Use your judgment to see any relationship in the data.

Write a short paragraph (2-3 lines) describing the effect each of the following parameters has on the overall water quality of a certain reservoir:

1. Temperature.
2. Turbidity
3. Conductivity.
4. Dissolved Oxygen (DO).
5. Phosphorus.
6. Nitrate.
7. Chlorophyll.

Hints:

1. Try finding relationships between parameters (e.g DO and chlorophyll).
2. Pay attention to how one parameter can change with depth and explain why.

Table B-1 Raw data from Deer Creek Reservoir.

Date / Time	Temp [°C]	Temp [°F]	pH [Units]	SpCond [mS/cm]	SpCond [µS/cm]	Sal [ppt]	TDS [g/l]	Dep25 [meters]	Dep25 [feet]	Turbidity [NTU]	LDO% [Sat]	LDO [mg/l]	Chlorophyll [µg/l]
5/7/09 10:42	12.44	54.4	9.17	0.4	366	0.2	0.2	0.8	2.6	74.7	103.7	11.05	2.69
5/7/09 10:42	12.44	54.4	9.17	0.4	366	0.2	0.2	0.8	2.6	74.7	103.7	11.05	2.69
5/7/09 10:42	12.44	54.4	9.17	0.4	366	0.2	0.2	0.8	2.6	74.7	103.7	11.05	2.69
5/7/09 10:42	12.44	54.4	9.17	0.4	366	0.2	0.2	0.8	2.6	74.7	103.7	11.05	2.69
5/7/09 10:42	12.44	54.4	9.17	0.4	366	0.2	0.2	0.8	2.6	74.7	103.7	11.05	2.69
5/7/09 10:42	12.44	54.4	9.17	0.4	366	0.2	0.2	0.8	2.6	74.7	103.7	11.05	2.69
5/7/09 10:42	12.44	54.4	9.17	0.4	366	0.2	0.2	0.8	2.6	74.7	103.7	11.05	2.69
5/7/09 10:42	11.59	52.9	8.86	0.4	370	0.2	0.2	2.62	8.6	3000	0	0	3.67
5/7/09 10:42	11.59	52.9	8.86	0.4	370	0.2	0.2	2.62	8.6	3000	0	0	3.67
5/7/09 10:42	11.35	52.4	8.8	0.4	375	0.2	0.2	3.13	10.3	3000	128.4	14.03	4.58
5/7/09 10:42	11.34	52.4	8.74	0.4	376	0.2	0.2	3.61	11.8	4	128.5	14.05	4.58
5/7/09 10:42	11.34	52.4	8.74	0.4	376	0.2	0.2	3.61	11.8	4	128.5	14.05	4.58
5/7/09 10:42	11.29	52.3	8.71	0.4	377	0.2	0.2	4.04	13.3	2.4	128.8	14.09	4.58
5/7/09 10:42	11.29	52.3	8.71	0.4	377	0.2	0.2	4.04	13.3	2.4	128.8	14.09	4.58
5/7/09 10:42	11.13	52	8.69	0.4	380	0.2	0.2	4.31	14.2	1.9	129	14.17	4.58
5/7/09 10:42	11.13	52	8.69	0.4	380	0.2	0.2	4.31	14.2	1.9	129	14.17	4.58
5/7/09 10:42	11	51.8	8.67	0.4	381	0.2	0.2	4.6	15.1	0.9	129.2	14.23	4.58
5/7/09 10:42	10.95	51.7	8.67	0.4	382	0.2	0.2	4.91	15.1	0.9	129.2	14.25	4.58
5/7/09 10:42	10.95	51.7	8.65	0.4	382	0.2	0.2	4.91	16.1	2.1	129.2	14.25	4.58
5/7/09 10:42	10.9	51.6	8.63	0.4	383	0.2	0.2	5.32	17.4	1.7	129.2	14.26	4.58
5/7/09 10:42	10.9	51.6	8.63	0.4	383	0.2	0.2	5.32	17.4	1.7	129.2	14.26	4.58
5/7/09 10:42	10.87	51.6	8.61	0.4	379	0.2	0.2	5.63	18.5	2.2	129.2	14.27	4.58
5/7/09 10:42	10.87	51.6	8.61	0.4	379	0.2	0.2	5.63	18.5	2.2	129.2	14.27	4.58
5/7/09 10:42	10.46	50.8	8.4	0.4	368	0.2	0.2	6.88	22.6	2.3	128.5	14.33	21.04
5/7/09 10:42	10.46	50.8	8.4	0.4	368	0.2	0.2	6.88	22.6	2.3	128.5	14.33	21.04
5/7/09 10:42	10.21	50.4	8.36	0.4	362	0.2	0.2	7.63	25	2.1	127.7	14.33	16.33
5/7/09 10:42	10.21	50.4	8.36	0.4	362	0.2	0.2	7.63	25	2.1	127.7	14.33	16.33
5/7/09 10:42	9.72	49.5	8.29	0.4	380	0.2	0.2	8.04	26.4	2	127.3	14.44	14.41
5/7/09 10:42	9.72	49.5	8.29	0.4	380	0.2	0.2	8.04	26.4	2	127.3	14.44	14.41
5/7/09 10:42	9.44	49	8.27	0.4	385	0.2	0.2	8.49	27.9	1.9	115.7	13.21	13.91
5/7/09 10:42	9.44	49	8.27	0.4	385	0.2	0.2	8.49	27.9	1.9	115.7	13.21	13.91
5/7/09 10:42	9.24	48.6	8.2	0.4	389	0.2	0.2	8.85	29	1.9	114.4	13.13	13.36
5/7/09 10:42	8.77	47.8	8.2	0.4	392	0.2	0.3	9.33	29	1.9	113.4	13.17	13.36
5/7/09 10:42	8.77	47.8	8.11	0.4	392	0.2	0.3	9.33	30.6	1.9	113.4	13.17	13.48
5/7/09 10:42	8.3	46.9	8.07	0.4	396	0.2	0.3	9.79	32.1	1.8	112.6	13.21	12.95
5/7/09 10:42	8.3	46.9	8.07	0.4	396	0.2	0.3	9.79	32.1	1.8	112.6	13.21	12.95
5/7/09 10:42	7.97	46.3	8.01	0.4	398	0.2	0.3	10.09	33.1	1.7	111.4	13.18	7.33
5/7/09 10:42	7.97	46.3	8.01	0.4	398	0.2	0.3	10.09	33.1	1.7	111.4	13.18	7.33
5/7/09 10:42	7.88	46.2	7.98	0.4	399	0.2	0.3	10.42	34.2	1.6	109.9	13.03	6.97
5/7/09 10:43	7.88	46.2	7.98	0.4	399	0.2	0.3	10.42	34.2	1.6	109.9	13.03	6.97
5/7/09 10:43	7.84	46.1	7.96	0.4	401	0.2	0.3	10.47	34.4	8.3	97.4	11.57	5.71
5/7/09 10:43	7.83	46.1	7.96	0.4	400	0.2	0.3	10.47	34.4	8.3	97.4	11.57	5.71
5/7/09 10:43	7.83	46.1	7.94	0.4	400	0.2	0.3	10.47	34.4	1.3	96.7	11.48	8.05
5/7/09 10:43	7.83	46.1	7.93	0.4	400	0.2	0.3	10.5	34.4	1.3	96	11.4	3.48
5/7/09 10:43	7.83	46.1	7.93	0.4	400	0.2	0.3	10.5	34.4	3	96	11.4	3.48
5/7/09 10:43	7.84	46.1	7.91	0.4	400	0.2	0.3	10.51	34.5	3	95.4	11.33	2.89
5/7/09 10:43	7.84	46.1	7.91	0.4	400	0.2	0.3	10.51	34.5	3	95.4	11.33	2.89
5/7/09 10:43	7.84	46.1	7.91	0.4	398	0.2	0.3	10.51	34.5	1	95	11.28	6.8
5/7/09 10:43	7.84	46.1	7.91	0.4	398	0.2	0.3	10.51	34.5	1	95	11.28	6.8

Appendix C Mass Balance Lab

(Section 3.2 in Textbook)

This lab is due _____ at _______

In this lab, you will perform mass balance on Deer Creek Reservoir.

Objectives

- Get familiar with the law of conservation of mass.
- Use mass balance equation on Deer Creek Reservoir
- Perform phosphorus budget on the reservoir
- Interpolate the results

Assignment

You are required to measure the concentration of phosphorus in the reservoir. For simplicity, you will assume a continuous mass balance and a steady state process. You will be studying the amount of phosphorus entering, leaving and settling in the reservoir by using a first order rate constant (ks) to estimate the amount of in-lake phosphorus.

A mass balance is an application of conservation of mass to the analysis of physical systems. Mass flows can be identified by accounting for material entering and leaving a system. The exact conservation law used in the analysis of the system depends on the problem but all revolve around mass conservation, i.e. matter cannot disappear or be created spontaneously.

Mass balances are used widely in engineering and environmental analysis. For example mass balance theory is used to design chemical reactors, analyze alternative processes to produce chemicals as well as in pollution dispersion models and other models of physical systems. In environmental monitoring the term budget calculations is used to describe mass balance equations where they are used to evaluate the monitoring data (comparing input and output, etc.)

You might wonder why it is important to do mass balance for a certain river or stream. Reliable assessment of the potential impact of chemical releases in the ecosystem is essential in fields such as ecological risk management, life-cycle impact assessment, green engineering, and pretreatment of water for potable uses. In these applications, the potential ecological impact of chemicals must be evaluated by assessing the likelihood that adverse effects may result from environmental exposure to the chemical.

Classification of mass balance Processes

Based on how the process varies with time.

a. <u>Steady-state process</u> is one that does not change with time. At a given time, all the variables have the same values.

b. <u>Unsteady-state (Transient) process</u> is one that changes with time. At a given time, many of the variables have different values than initial values.

Based on how the process was built to operate.

a. <u>Continuous process</u> where a basis of a unit time of operation is introduced, the material balance will be made on what entered or left the system during that period of time so the quantities will be given in mass/time (also called load).

b. <u>Batch process</u> where the total mass considered includes what entered or left the system at one time.

Equations

For Deer Creek reservoir the input and output have been monitored along with already existed concentrations. For this analysis

Mass accumulation rate = Input rate - Output rate - Transformation rate

$$V\left(\frac{dp}{dt}\right) = W \quad Qp \quad k_s V p$$

Where

p = Reservoir Total Phosphorus Concentration (mg/ m^3)

Q = Flow (m^3/yr)

V = Reservoir Volume (m^3)

k_s = 1^{st} order settling constant (yr^{-1})

Since no phosphorus is created or destroyed ($V\left(\frac{dp}{dt}\right) = 0$), we can rewrite the equation to find the concentration of phosphorus:

$$p = \frac{W}{(Q \cdot k_s V)}$$

Mass balance problem solving approach:

1. Determine the mass (pollutant) that you are interested in.

2. Determine system boundary (examples: river, treatment plant, Jacksonville air quality)

3. Draw representation of materials balance (black box approach)

4. Determine all inputs and outputs of the pollutant of interest.

5. Determine runoff and infiltration rates (if any).

6. Determine the time dependent state of the system (Steady-State or Dynamic)

7. Assign known values (flow, concentration, etc..)

8. Use equation to plug in known values and solve for unknown.

Black-Box Approach

This means that we take a look at a unit operation from the outside, looking at what goes into the system and what leaves, and extrapolating data about the properties of the entrance and exit streams from this. This type of analysis is important because it does not depend on the specific type of unit operation that is performed. When doing a black-box analysis, we don't care about how the unit operation is designed; only what the net result is. In our lab, we will consider the reservoir, as a whole, the black box representing the material/flow going in and out.

What you need to do

To complete this lab, you will be given a set of data for the years 1993-1999. Perform a mass balance for Deer Creek reservoir to figure out the amount of the in-lake phosphorus. An average flow rate of 3.2E8 m^3/s is used for all years. Table 1 below shows the data necessary to complete a phosphorus budget.

Table C-1 Deer Creek data for Phosphorus Budget Calculation.

Year	Volume (V), m^3	TP Load IN (W), kg/yr-P	ks, yr^{-1}
1993	1.43E+08	36142	2.787
1994	1.32E+08	11173	-0.18
1995	1.42E+08	21384	2.668
1996	1.53E+08	24052	4.649
1997	1.56E+08	19037	3.001
1998	1.68E+08	14022	1.172
1999	1.58E+08	25350	2.915

Appendix D GIS Manual

This lab is due _____ at ______

In this lab, you will be using GIS spatial tools to visualize data collected from Deer Creek reservoir.

Objectives

- Get user familiar with GIS.
- Learn how to visualize data in GIS.
- Provide easy-to-use tools in GIS interface
- Ability to readily visualize and maintain the spatial relevance of the data

Assignment

Follow the tutorial below and save a copy of the exported figures and tables. You will be asked to write a short report including any observation or explanation from the results.

Using the assigned monitoring points, you will display the data in GIS showing different graphs, relationships and even animation of changes with depth with time. The following step-by-step instructions will show you how to work with the data.

1. Getting started

1. Download the data located on the Deer Creek website
   http://www.et.byu.edu/groups/deercreek/GISTOOLS/WORKSAMPLE.zip

2. Start ArcMap (found under ArcGIS)
3. Select ***File | open.***
4. Locate the folder WORKSAMPLE.
5. Open the file named *Sample.mxd*.
6. Select *Open.*

Note: If you cannot see anything in the display window that means GIS can not find the files, so you will need to locate the files in the project explorer.

1. Switch to the *Source* tab in the project explorer.
2. Click on the red exclamation mark next to "*boundaryflat"*, and locate the shape file *boundaryflat.shp* in the boundary folder (all located in the WORKSAMPLE folder).
3. You will repeat step 2 for the DEM and the database.

Note: You will find the database of measurement, sample, and location in "*dbaseV2.3.mdb"*.

At this point, you will have the shape file for the reservoir along with the Digital Elevation Model (DEM) imported in. The DEM is a digital representation of ground surface topography or terrain. In GIS, it is a raster layer representing elevation and for our lab, the shape file and the DEM are used for site presentation.

2. Joining the tables

Now you have to join the data to connect the sample to the location and the measurements (make sure you are still under the *Source* tab)

1. Right click on *sample* and choose **Join and Relate | Join**.
2. Choose "*Join data based on pre-defined relationship class*" for "What do you want to join to this layer?".
3. Choose "*location*" for the relationship class to base the join on.
4. Click *OK*
5. Repeat steps 1 -3 but instead of "*location*", choose "*Measurements*".
6. Click *OK*

3. GIS Toolbar

For this tutorial, a specially developed toolbar created by Caleb Buahin, is used to visualize parameters collected for Deer Creek Reservoir. Take a second to locate the toolbar. Figure 1 shows the toolbar.

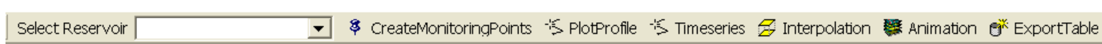


Figure D-1 Toolbar

4. Creating Monitoring points

After you have the DEM and the shape file imported, you will import the monitoring points containing the data for Deer Creek.

1. Choose "*Deer Creek*" from the "Select Reservoir" drop down menu on the left of the toolbar.
2. Choose "*CreateMonitoring Points*" from the Water Quality Monitoring toolbar.
3. Select *Yes* when asked to label them.

You will notice 9 monitoring points created in the display layout as shown in figure 2. Also, a new layer "*Monitoring points*" is created in the project explorer containing the data related to these points.

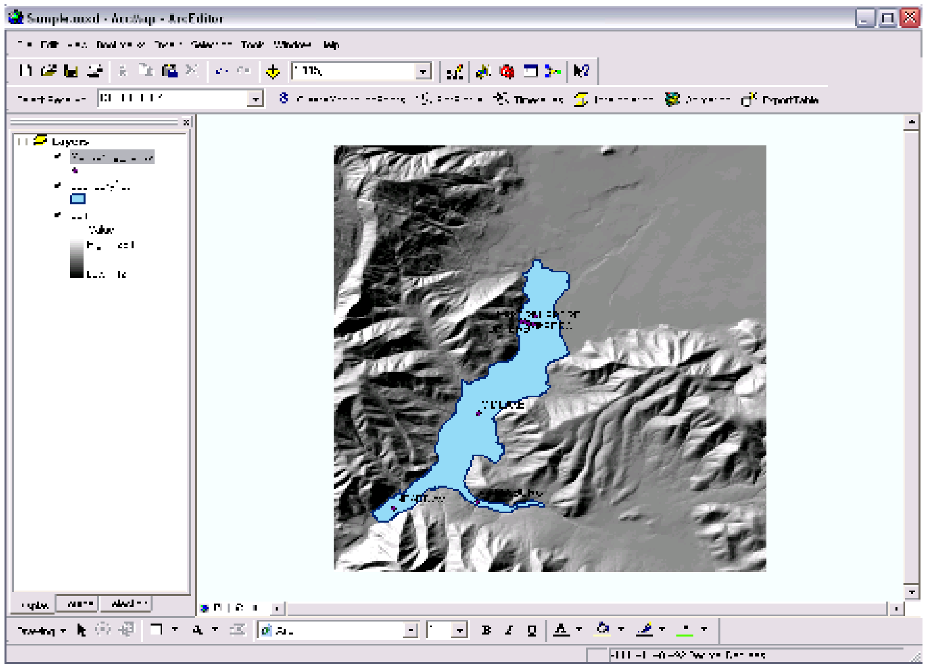


Figure D-2 Monitoring points display.

5. Exploring GIS

You should be able to see the DEM for Deer Creek Reservoir along with the Monitoring points available for the reservoir in the layout window. On the left, the project explorer includes all imported files. In here are the monitoring points and the information they carry.

1. Right click on "*sample*". Remember you are still in the source tab.
2. Select ***Open | Attribute table***.

A table will come up showing all the information associated with the file. The dialogue presents the information related to each monitoring point.

3. Close the attribute table.

6. Plot profile

In order to compare two different parameters for a certain monitoring point, plot profile allows you to plot the change in parameters with depth.

1. Select “*Plot Profile*”.
2. Choose *NEARDAM* for the location.
3. Select 2008 for the year.
4. Select *7/3/2008* for the date.
5. Next you will select the parameters you are interested in plotting. You can choose up to two parameters to be plotted on the same graph. For this lab, choose “*TEMPERATURE [^{o}F]*” and “*SPECIFIC CONDUCTIVITY*”.
6. Choose *“LINE”* for your graph type.
7. Click on *“PLOT PROFILE”*.

The profile dialog will pop up. You can see the elevation on the y axis and the parameters chosen on the x axis. You can compare the change in parameters as depth changes and look for association between the two variables. Figure 3 shows the result.

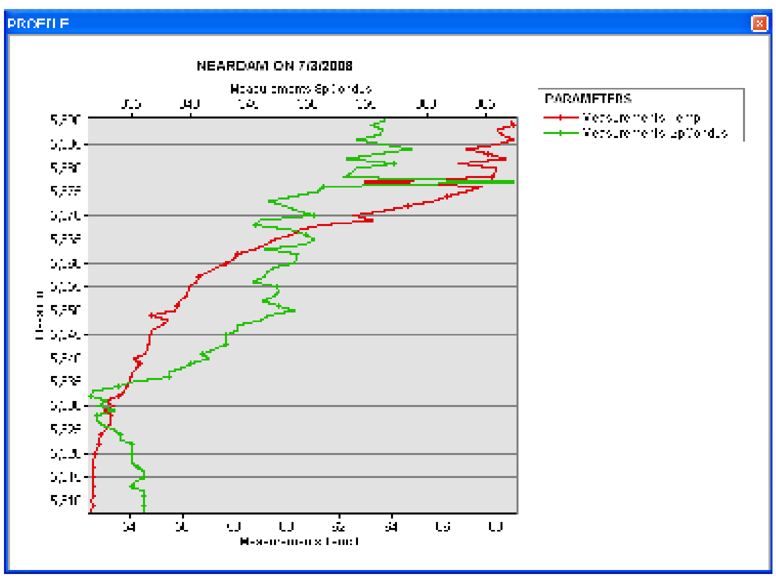


Figure D-3 Plot Profile result

It is also possible to export the data or the picture to be used outside of GIS.

8. Right click on the profile dialog and select “*Export*”.
9. Make sure you are in the *Picture* tab.

10. Choose "*As JPEG*".
11. Click on "*Save*" and specify a name and location for your file.

7. Time series

The Time series tool in GIS allows you to view changes of a certain parameter at a certain depth with time.

1. Choose "*Time series*".
2. Go to the *Point Time series* tab.
3. Specify *MIDLAKE* for the location folder.
4. Choose an elevation of *5360 ft*.
5. Start date *6/20/2008*.
6. End date *7/9/2008*.
7. You can choose as many parameters as wanted. For this lab, check "*SPECIFIC CONDUCTIVITY [mS/cm"], "SAL [ppt]" ,* and "*CHLOROPHYLL [µg/l]".*
8. Choose "*BAR*" for your graph type.
9. Click on "*PLOT PROFILE*".

The time series dialog will pop up showing a bar graph for the four parameters at different dates. Figure 4 shows the resulted plot. This helps in analyzing the change in water quality with time. Just as in profile plotting, you can export the data and picture to use in other applications outside of GIS.

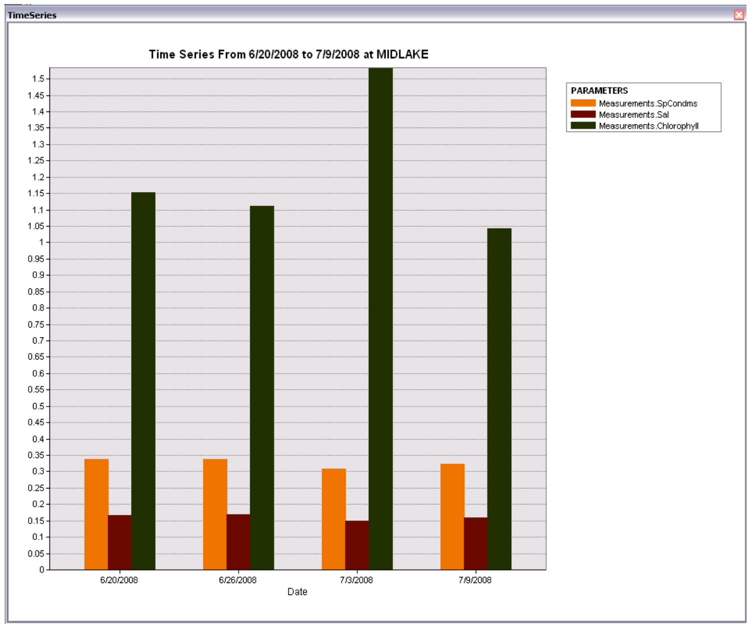


Figure D-4 Time Series result

8. **Animation**

The Animation tool creates an animation that shows the change in a certain parameter over time or with changing depth. With this tool, you can view a vertical profile showing how the concentration of material changes with depth, or an animation of a time series that shows the change in concentration at a certain depth with time.

To view a time series animation:

1. Click on "*Animation*".
2. Make sure you are on the *Time series* tab.
3. Choose an elevation of *5333 ft.*
4. Choose start date 9/12/2007.
5. End date 7/9/2008.
6. Choose "*pH*" as the parameter.
7. Click on "*ANIMATE*".

At this point, GIS will start creating a different raster for each time step. Raster is a method for the storage, processing and display of spatial data.

8. Once raster layers are created (it might take some time), the *Animation Controls* dialog will appear as shown in figure 5.

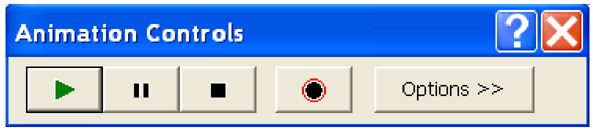
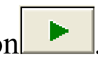


Figure D-5 Animation control dialog

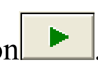
9. Click on the play button .

The animation will play, and you will see the changes in pH values for a certain depth with time. The label

To view the Vertical profile animation:

1. Choose start date 7/3/2008.
2. Choose "*TEMPERATURE [^{o}F]*" as the parameter.
3. Click on "*ANIMATE*".

A different temperature raster will be created for each depth in common between the points and will be shown as an animation. This might take some time (up to 10 minutes).

4. The *Animation Controls* dialog will appear.
5. Click on the play button .

Once you start the animation, the raster will be created for each depth. This animation shows the change in temperature as depth increases.

9. Correlation

For finding a correlation between two locations, two dates, and two parameters, *Spatial Correlation* can be used.

1. Click on *“Correlation”*.
2. Choose *“UPPERA”* for location 1 and *“UPPERB”* for location 2.
3. Choose *“7/3/2008”* for location 1 and *“7/9/2008”* for location 2.
4. Choose *“TURBIDITY”* for location 1 and *“CHLOROPHYLL”* for location 2.
5. Hit the “*COMPUTE”* button.

You should see three correlation equations (Turbidity vs. Elevation, Chlorophyll vs. Elevation, and Turbidity vs. Chlorophyll) and the R-square coefficient for each.

10. Export data

This tool is used to export data in other formats such as .dbf, .txt, or .xls.

1. Click on “*ExportTable”*.
2. Select a Begin Date and an End Date.
3. Specify a location for the file.
4. Choose the exported Format (.dbf, .txt, .xls)
5. Name the output file.
6. Click on “*EXPORT TABLE”*.

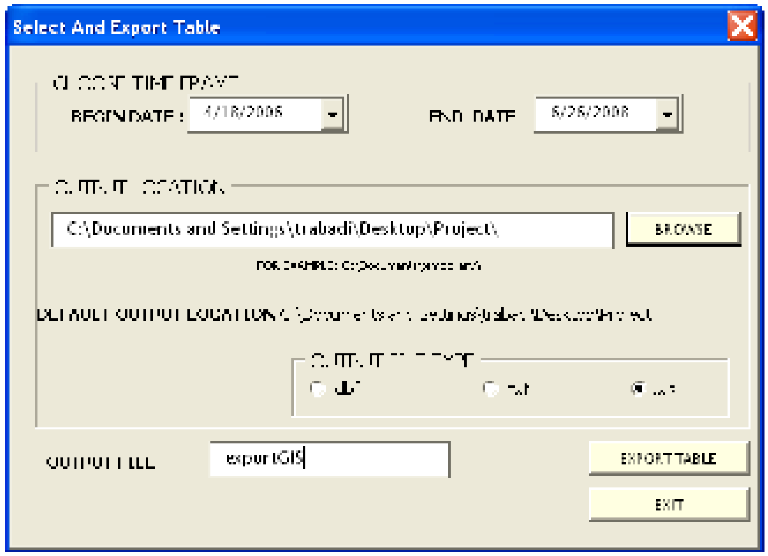


Figure D-6 Export data dialog

The data will be exported and saved in the format and location chosen.

Conclusion

By the end of this tutorial, you should be familiar with the spatial tools used in water quality management. These tools are still expanding to include more features and monitoring points that include data taken over longer periods of time.

What to hand in

After going through the tutorial, write a short report (2-3 pages) including the figures you saved. You should also include an explanation for the resulting graphs and any relationships found between parameters.

Appendix E Student Survey Instrument

Default Question Block

Thank you for taking this survey. The results of this survey will be used to evaluate the effectiveness of including the lab in the CEEN 351 course.

Please be honest and accurate in your responses as they will be completely anonymous. We will receive confirmation that you completed the survey. However, we will not be able to see how individual students responded to the survey.

This survey should not take longer than 5 minutes to complete.

To start, click on the "Next" button below. Thank you!

Have you ever used Geographic Information System (GIS) before?

- ☐ Yes
- ☐ No

As a first time user of GIS, did the manual include sufficient basic support to help you through the instructions?

- ☐ The manual included all the support I needed
- ☐ The manual included some support but I needed some extra help
- ☐ The manual did not include any support for me as a first time user of GIS

How long did it take you to finish the lab with the aid of the manual?

- ☐ Less than 30 minutes
- ☐ 30 minutes to an hour
- ☐ More than one hour

Do you agree or disagree with the following statements about the manual:

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
It was easy to use	☐	☐	☐	☐	☐
The instructions were clear to follow	☐	☐	☐	☐	☐
It had enough detailed	☐	☐	☐	☐	☐

	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
instructions					
It had enough visual aids	○	○	○	○	○
It helped me apply general engineering principles to real life problems	○	○	○	○	○
It helped me apply the principles I learned in the CEEN 351 class to real life problems	○	○	○	○	○

Please tell us about any other comments you have about the manual. These comments will be used, anonymously, to improve the quality of this manual for future use.

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1. Have you ever used Geographic Information System (GIS) before?

#	Answer		Response	%
1	Yes		11	28%
2	No		28	72%
	Total		39	100%

Statistic	Value
Mean	1.72
Variance	0.21
Standard Deviation	0.46
Total Responses	39

2. As a first time user of GIS, did the manual include sufficient basic support to help you through the instructions?

#	Answer		Response	%
1	The manual included all the support I needed		9	35%
2	The manual included some support but I needed some extra help		17	65%
3	The manual did not include any support for me as a first time user of GIS		0	0%
	Total		26	100%

Statistic	Value
Mean	1.65
Variance	0.24
Standard Deviation	0.49
Total Responses	26

3. How long did it take you to finish the lab with the aid of the manual?

#	Answer		Response	%
1	Less than 30 minutes		11	30%
2	30 minutes to an hour		23	62%
3	More than one hour		3	8%
	Total		37	100%

Statistic	Value
Mean	1.78
Variance	0.34
Standard Deviation	0.58
Total Responses	37

4. Do you agree or disagree with the following statements about the manual:

#	Question	Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree	Responses	Mean
1	It was easy to use	0	2	9	21	5	37	3.78
2	The instructions were clear to follow	0	3	4	22	8	37	3.95
3	It had enough detailed instructions	0	3	8	20	6	37	3.78
4	It had enough visual aids	1	8	4	17	7	37	3.57
5	It helped me apply general engineering principles to real life problems	0	2	16	15	4	37	3.57
6	It helped me apply the principles I learned in the CEEN 351 class to real life problems	0	6	16	13	2	37	3.30

Statistic	It was easy to use	The instructions were clear to follow	It had enough detailed instructions	It had enough visual aids	It helped me apply general engineering principles to real life problems	It helped me apply the principles I learned in the CEEN 351 class to real life problems
Mean	3.78	3.95	3.78	3.57	3.57	3.30
Variance	0.56	0.66	0.67	1.25	0.59	0.66
Standard	0.75	0.81	0.82	1.12	0.77	0.81

Deviation						
Total Responses	37	37	37	37	37	37

5. Please tell us about any other comments you have about the manual. These comments will be used, anonymously, to improve the quality of this manual for future use.

Text Response
It was awesome!!
I think the manual may be inappropriate for this system if the difficulty everyone was having was a result of poor instructions. I am more inclined, however, to believe the difficulties were due to individual computers rather than poor instructions.
it was good. A few parts were hard to understand, like the exporting part.
It would have been nice to have had additional support beyond the scope of the manual. As far as helping with the specifics, the manual was helpful
I dont have any other comments
Good. Still had a problem with the vertical profile animation. Took very long to compile.
Update the guide at the beginning of the process
ArcGIS requires you to have everything linked perfectly it wold help to have some notes about this
The program is pretty tricky if there is an error somewhere along the line... If everything worked correctly the sheet was great but there were errors and it didn't go as planned.
The manual was good, the program just needs to be consistent
It was easy to use but I do not fully understand how it applies to real life or the things we learned in the class. possibly more instruction on this topic would be helpful.
If the file is properly extracted, then the program works great and the process is efficient.
The manual was fine, but the animation button didn't work. If it could includes some trouble shooting would be great.
I think if more of the concepts were explained that would be helpful
The manual was easy to follow however i was not familar enough with the program to trouble shoot any of the issues i had with the animation.
The caedm system didn't really let me do it.
As a number of problems arose in trying to successfully use the software, it would be helpful to have a section in the manual to solve to most common difficulties.
I think I would have liked it more if I would have used it more.

Proofread instructions
maybe going through the steps on the screen would help us better understand it
I already did the survey but I wanted to make a couple other comments. I could not get the export a table or whatever function to work. There was some error. Also, this is more of an issue with the specific program. The animations do not show any units to go along with them. For example, the lake changes color but it doesn't tell you how deep it is or what date it is. So, that kind of makes it not so useful.
The instructions were clear and easy to follow, but the program wasn't responding very well.
Just the bugs were hard to work with
It was a good lab I'm always interested in that kind of stuff. And Tamara is gorgeous!! Remember this is anonymous
as long as all the bugs were worked out it would run smoothly following the instructions given
The manual should provide more detail on how to load the file, trouble shooting
.
no comments
There were a few unclear instructions
The should be more pictures of the dialog boxes. Several of the functions did not work. The source needed to be fixed for the tables, and there were no instruction on how to do so.
Make sure the bugs are worked out of the software first.
I wish we used GIS more.
The manual was easy to follow, but some errors popped up and I wasn't sure how to make it work (as with the graphing and animation)
The manual was good. It was clear and easy to follow. The functions in the software are useful to what we are and will be doing.
Nothing.
Use quotes around all buttons to be pressed
The manual was good, but i felt that it should have included more visual aids so that we could tell more easily where we were supposed to be.

Statistic	Value
Total Responses	37