Field Investigations of a Campus Pond Foster Interdisciplinary Approaches Across the Sciences

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Using Field Observations and Experiences to Teach Geoscience:

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Abstract

Bryn Mawr College, in collaboration with local authorities, built a storm water retention pond in 2001. Since its construction, the authors have devised and carried out student field exercises as lab projects in introductory, intermediate and advanced courses in the departments of Geology and Chemistry. These courses include GEOL 101: How the Earth Works, GEOL 103: Earth Systems and the Environment, CHEM 102: General Chemistry II, GEOL 205: Sedimentology, GEOL 302: Low-temperature (Aqueous) Geochemistry, and GEOL 310: Geophysics. Exercises in these courses address common themes including topographic mapping, field sampling, data processing/analysis, runoff/stream flow, biodiversity and water quality issues. The incorporation of field exercises focused on the pond has reinforced the interdisciplinary nature of our multi-department Environmental Studies program, and has catalyzed conversations on course content and learning goals.

To varying degrees, students develop an understanding of the pond as a small-scale analogue of a hydrologic and sedimentary basin, as well as a biogeochemical system involving primary productivity and nutrient cycling. In introductory courses students make and compare topographic maps with their observations of the pond basin. Introductory students also measure dissolved oxygen and temperature to calculate whether the pond is over- or undersaturated with oxygen. General chemistry students have measured the concentration of chemical constituents to evaluate whether the pond meets drinking water standards for those constituents. For some chemistry majors these exercises are their only experience with outdoor fieldwork and sampling. Sedimentology students use a small boat to measure vertical temperature and dissolved O_2 profiles to evaluate the pond as small-scale basin wherein organic carbon-rich sediments are deposited. Students have observed elevated algal growth (and oxygen supersaturation) near the surface, whereas the sinking of excess organic matter into the poorly ventilated, deepest part of the pond produces suboxic-to-anoxic conditions. In Low-temperature Geochemistry, students collect and analyze the nutrient (e.g., nitrate) content of water in various parts of the pond system and have documented reduction of nutrient concentrations, presumably by primary productivity uptake, as water passes through the system and drains to a nearby stream.

Photo 1: Measuring temperature, dissolved oxygen, pH and conductivity at varying depths and locations in pond, early fall. Note greenish water color due to a waning algal bloom. The laser reflector (on pole) was used to track sample station locations from a shore-based Total Surveying Station.

Photo 2: Students use the laser Total Surveying Station to track station positions of the research vessel (rowboat) on the pond. Water quality parameters were measured at 11 stations on the pond. See x-y coordinate map, of surveyed station locations, below left.

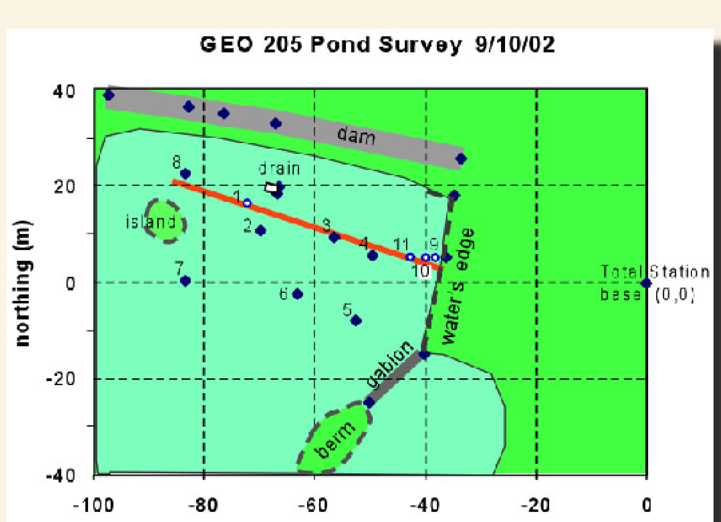


Figure 1. **X-Y plot of water quality station locations** (numbered points) **in the BMC pond.** The Total Station was set up on the hillside near a dorm (off right side of plot). **Orange line** shows sampling transect; see cross-sectional data plots, right. Stations 9 - 11 were occupied nearshore by wading. Unnumbered blue diamonds mark points surveyed to provide map reference

What's Here

Along with comments summarizing our teaching experiences in a range of courses that have conducted pond-related field activities, this poster presents specifics (or web links to info) on two activities conducted on a local pond.

The first example describes measurements of dissolved oxygen, using a portable, submersible water quality meter. The concepts necessary to understand and extrapolate the results of this activity are broadly interdisciplinary, drawing from chemistry, biology and geology. Provided access to adequate equipment, the activity can be done at many instructional levels, including pre-college.

The second activity uses ground-penetrating radar to image the pond floor. Because this activity is much more technical and requires specialized equipment, it is applicable primarily to upper-level geology and geophysics courses. Nevertheless, the concepts of survey design, mapping, data processing and visualization, and the physics of radio wave transmission all have cross-disciplinary components. For this reason the activity should resonate with the non-geology majors, including archaeology, anthropology, biology and physics students, that have taken our Sedimentology and Geophysics courses. A few field photos and data images from this activity are shown at right, but for further details the reader is invited to visit our web site:

http://www.brynmawr.edu/geology/205/bmcPondGPRfall03.html

Both of these activities have been conducted during the 3-hr afternoon lab period for our Sedimentology course. With minor modifications, the dissolved oxygen activity translates well into introductory courses in Earth Science, Biology and Chemistry, as well as upper-level courses. A simpler version of this exercise is run during the 3-hour afternoon lab for our introductory Earth Systems and the Environment course.

Field Measurements of Water Temperature and Dissolved $[O_2]$ in a Campus Pond

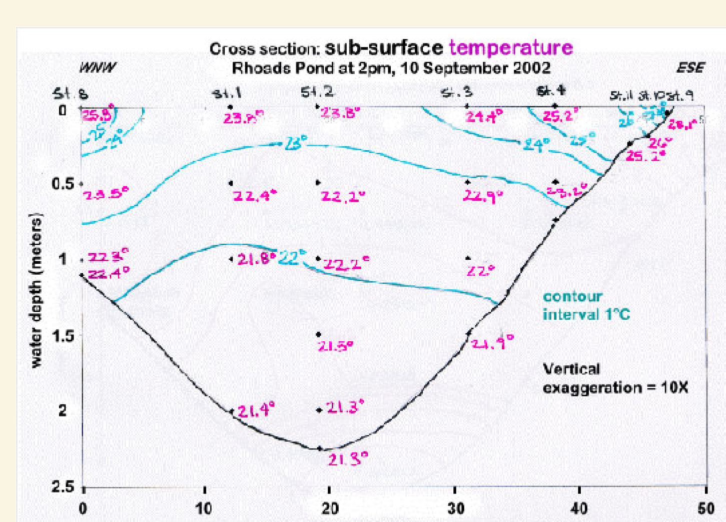


Figure 2. Cross-section (see map in Fig. 1, left) of pond showing subsurface temperatures (°C, in pink) measured by students on the afternoon of 10 September 2002. Note that this plot is vertically exaggerated, thus the pond basin appears too steep. These temperature values are needed to calculate the theoretical dissolved oxygen concentrations at equilibrium. The theoretical values are compared with observed values, and students must explain why observations are different.

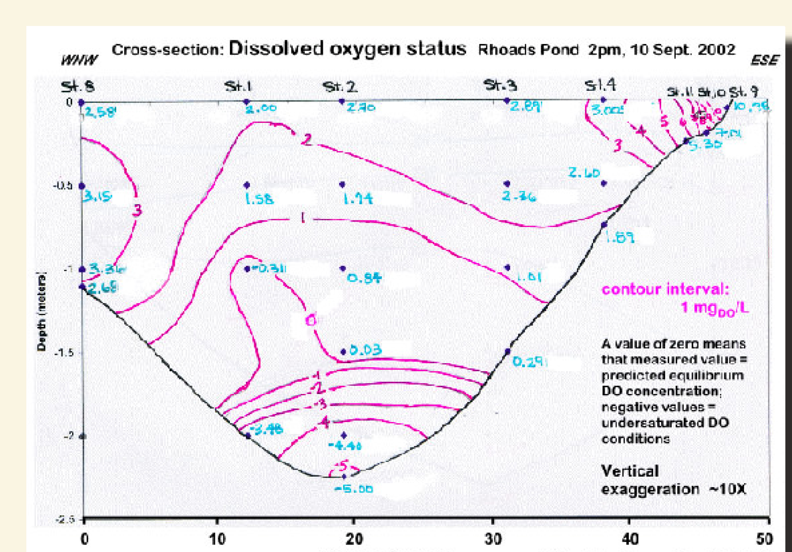


Figure 3. Dissolved oxygen conditions. Values in light blue on plot show difference between field measurements and predicted equilibrium saturation values for the measured temperature (Fig. 2, at left). This cross-section shows the amount of over- and under-saturation of dissolved oxygen in different parts of the pond. The high (supersaturated) values on the margins imply that the aquatic plants were actively photosynthesizing. The depleted oxygen levels in the bottom center of the pond probably result from decomposition of organic matter settling to the pond floor, coupled with poor mixing due to the observed temperature stratification of the pond

Learning Goals, Materials, and Assessment:

Water Temperature & $[O_2]$

Goals: This exercise aims to expose students to both general and specific science concepts, as well as specific skills. **General concepts** include practice in posing testable hypotheses, designing a sampling scheme to test them, and interpreting data. **Specific content** includes understanding physical controls on water properties in a basin, how these relate to observable sediment properties, and how biological processes (photosynthesis and respiration) influence the observable water properties (esp. dissolved oxygen). **Specific skills** include making and recording observations, mapping sample locations, entering and manipulating data in a spreadsheet (e.g., calculating equilibrium $[O_2]$ values from temperature observations), plotting a cross-section (depth vs. distance) and contouring observed and derived values.

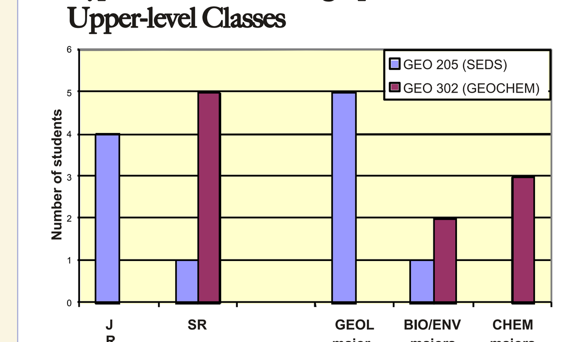
Sampling Platform: Observations are best done from a small boat or raft, but could be done from a bridge or dock structures if present. Wading is only of use for shallow, pond margin areas, and tends to stir up the water column. It is important to sample the deepest basin in the pond to see the full range of environmental values.

Measurements: We used a battery-powered, submersible water quality meter (Horiba™) on a cable, with digital handheld readout. This unit gave sufficient precision to delineate the surface-to-bottom range in temperature and dissolved oxygen concentrations.

Positioning: In our first attempt, we used a laser range-finding Total Surveying Station to track our sampling positions, but this was overkill. We employed the Total Station simply because it gave students practice for a later field surveying exercise carried out at the NJ coast, but this level of precision is unnecessary. Dead-reckoning, range-running or some other rudimentary positioning would also work, provided the boat can be moved over the deepest part of pond and held stable for sampling. In future cases, we plan to try using a newly acquired differential GPS unit for positioning, but again this probably is not necessary.

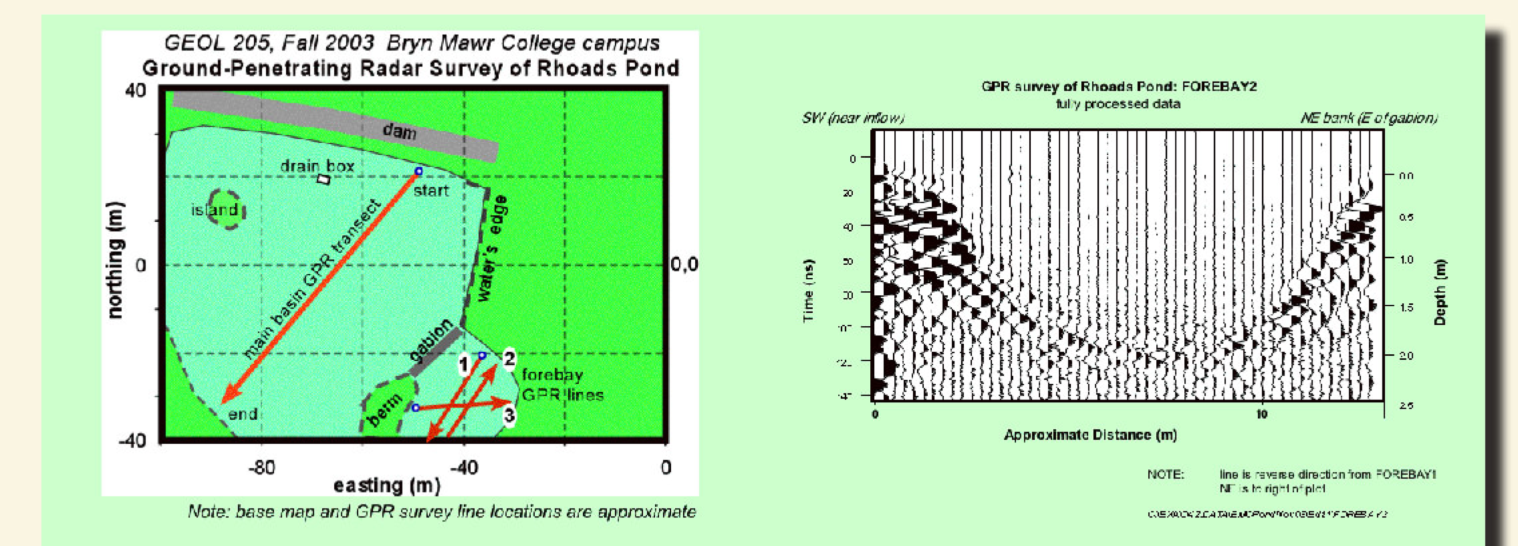
Assessment: Sedimentology lab meets for 3 hours once a week in the afternoon. Write-ups of field exercises are turned in the following week and graded by instructor. These write-ups usually involve use of computer for data processing and graphing and/or drawings of maps and profiles. Short written topical quizzes are given occasionally at the beginning of the following lab period. In the case of these two field exercises, students work in teams and turn in collaborative work that receives a group grade.

Typical Student Demographics for Two Upper-level Classes



The Aqueous Geochemistry course offered insight into the response and performance of non-Geology majors in a course focusing on field projects that investigated the campus pond.

Photos from ground-penetrating radar (GPR) pond survey during Sedimentology lab, Fall 2003. Students moved boat along a fixed rope to maintain a relatively straight and constant survey velocity.



Ground-Penetrating Radar Pond Survey: Trackline map (above left). Plot above right is a GPR data profile from survey line 2 in the shallow pond forebay (see map). Water flowing from storm sewers enter the forebasin before percolating through gabion into main pond basin. The GPR data shown above were processed to emphasize pond floor reflections. The standard freshwater radio wave velocity of 0.033 meters per nanosecond was used to assign depth (m) to the righthand side of the plot. Additional information on this activity is provided at the web URL given on this poster (to left).

Student Feedback and Instructor Insight about Interdisciplinary Field Activities

Summary of student questionnaire responses at end of courses:

1. Student comfort levels with 'open-ended' field projects were diverse. While students were generally reserved in the field, they were proud of their work at the end, once a finished group lab write-up was completed.

2. Students were surprised at how much thought they needed to put into what they initially perceived to be a simple exercise; e.g., making a depth cross-section of the pond.

3. The majority of students said that they would have liked to have spent more time on such field projects but expressed unwillingness to forgo any of the traditional Sedimentology subject material.

4. Students expressed enjoyment at being able to collaborate across disciplines by bringing their own expertise to bear: biology students help geo and chem majors understand plant life in the pond; geo students assist group in making cross sections and contouring data.

5. Chemistry students have different intellectual needs than biology or geology students. Many chemistry students are turned on by learning as many analytical techniques as possible – performing the same set of analysis repeatedly is boring! Biology and geology students are happy to use data from repeat analyses to learn about spatial and temporal variations in an environmental system.

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