ABSTRACT

SHAW ENVIRONMENTAL AND INFRASTRUCTURE INTERNSHIP

by Michael Turner

This report on the activities performed during my internship with Shaw Environmental and Infrastructure in Cincinnati, OH. The internship consisted primarily of a project to develop a research plan for a government client. This report covers the tasks that were part of the internship. The tasks completed were: Training, review project background material, laboratory setup and verification, and project communication document generation. Each task is described and illustrated as to why it was required, what it entailed, and an evaluation of the process for completing the task. A summary of the role that the education and experience provided by Miami University’s Institute of Environmental Science played in acquiring and succeeding in my internship with Shaw Environmental and Infrastructure (E&I) and obtaining a permanent position with Shaw E&I is included.
A REPORT:
ENVIRONMENTAL SCIENTIST II INTERNSHIP WITH SHAW ENVIRONMENTAL AND INFRASTRUCTURE IN CINCINNATI, OHIO

An Internship Report

Submitted to the

Faculty of Miami University

For partial fulfillment of

Master of Environmental Sciences

Institute of Environment and Sustainability

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2012

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Acknowledgement

Although there were many people that helped me, I would like to extend my most sincere gratitude to my graduate committee Dr. Hailing Dong, Dr. Jing Zhang, and Dr. Bill Renwick. I would also like to thank Dr. William Kovacik, Dr. Jurate Virkutyte, and Dr. Sandi Woy-Hazelton for their guidance during the course of my internship project, and while completing the course work for the IES program.
Introduction

The internship was tasked with evaluating the proposed experimental design for developing a quantitative polymerase chain reaction (qPCR) method for measuring the Selenate Reductase Enzyme. The goal was to use the enzyme as a biological marker for predicting the intrinsic ability of the soil to reduce water soluble selenium oxyanions (selenate and selenite) into elemental selenium, which is not water soluble and thus reducing the bioavailability of selenium to aquatic organism.

The required outcome from my six month internship is to design an experiment that will identify biological organisms that are capable of reducing selenium. This will be contained in the Quality Assurance Project Plan (QAPP); which I authored with technical assistant from the technical advisors.

In order to write the QAPP I need to complete the following tasks:

- Review the proposed research plan
- Complete training to work in the laboratory
- Setup the laboratory equipment and verify its operation
- Write the Health and safety plan (HASP)
- Write the QAPP

There were many factors that went into selecting the internship with Shaw E & I, but the most important factor was the ability to gain experience at both a government research facility and a corporate environmental services firm. The work performed in a government research facility was another reason I selected this internship. I have a background in analytical laboratory work, and I have completed many projects while complying with government regulations. I thought this would be an avenue to continue this kind of career while I transitioned from biotechnology and pharmaceutical work into environment remediation and restoration work. The research project’s goal is in the realm of applied science, and this is complementary to my area of concentration for my Masters degree.
My area of concentration is applied ecology. This concentration selection was another effort to aid with my career transition into an applied science with an environmental focus. Ecology was part of my major for my undergraduate degree, but I was not able to develop it into a career. The lack of success of obtaining a career in an applied environmental science can be attributed to my not having a graduate level degree. Therefore, I decided to return to school and pursue a similar field of study for my graduate studies, as well as select an internship that will aid in gaining experience in the environmental field.

The main benefit that this internship offered in relation to my personal interest was a research project, which was the one skill/experience that I was not able to gain at Miami University. There were many duties associated with the internship, but the main task which fit with my interest was the research project in the field of risk assessment. This project provided the opportunity to gain research experience in a professional setting, which would aid in gaining a career in the environmental remediation field, or as an environmental researcher.

I originally envisioned the internship fulfilling three long term career goals: research experience, professional project management experience, and developing professional relationships in the environmental field (both corporate and governmental). In addition to my three long-term goals the internship will also fulfill the short term goal of developing professional skills for acquiring a job after completing my Masters in Environmental Science. This internship with an environmental consulting firm, the experience and skills that I acquired are marketable, and will aid me completing both my short term and long term goals. More specifically, the project management and research experience are very marketable skills. The ability to manage all of the aspects of a research project in an effective manner will be desired by future employers. Also, the ability to design a research project that will add to the knowledge base of a scientific discipline shows creative thinking.

Company overview
The overall purpose of Shaw Environmental and Infrastructure (Shaw E & I) is to provide competitive priced high quality work for their clients, as it is related to environmental services and regulations compliance. The Shaw group is a large multi-national company with four main business units: Power, Environmental and Infrastructure, Energy and Chemical, and Fabrication and Manufacturing. The Shaw group is a fortune 500 company that employs about 27,000 people worldwide.

Shaw E & I has two main businesses, commercial and governmental. I am working as a Scientist II on the governmental side in the federal contracts portion as a contractor to the Pegasus technical services, which is the on-site contractor for a governmental research laboratory at the Center Hill research labs. The overall structure is outlined in figure 1.
More specifically, my position was a frontline employee that directly interfaced with the client and subcontractors at Center Hill research laboratory. As a frontline employee I performed the majority of the research related work independently. I received assistance with technical aspects of the project, but all of the stated tasks were completed without help, except for the review and approval of the clients controlled documents, such as the HASP and the QAAP.

The internship had an initial contract time of six months with the potential of becoming a full time position, which would continue for another year. The continuation of the project was dependent on work performance and available funding. To achieve a successful work performance and the continuation of the research project, I needed to successfully complete the following tasks:

- Perform review of former researchers proposal and pertinent work in biological reduction of selenium
- Setup or locate laboratory facilities
- Design the experiment
- Write guidance documents
  - HASP
  - QAPP

My main focus was to research and design an experiment to identify microbes that can reduce mobile water soluble selenium oxyanions (selenate and selenite) into a non-mobile form of selenium. First, I reviewed the research proposal that was made by the former researcher. The proposal was to isolate, sequence, and generate primers for the enzyme responsible selenium reduction in *Thurea selenatis* (selenate reductase). Unfortunately, selenate reductase does not appear to be the only enzyme for selenium reduction in bacteria. This proposal would not fulfill the required outcome of a biomarker that can be used to determine the potential of soil to reduce water soluble selenium oxyanions into non water soluble selenium. Therefore I proposed
utilizing portions of the experiment with *T. selenatis* as a control for selenium reduction as measured from soil microcosms.

**Reporting structure**

The reporting and the work structure were more complex than I have worked under in the past. My supervisor was Radha Krishnan (Shaw E&I), but I also had interactions with the on-site technical manager from Pegasus Technical Services who was in charge of the contract that my project was part of, and the CLIENT work assignment manager which represented the ultimate client. Therefore, I had three different individuals to report to as it related to this research project: Radha for Shaw E&I, Raghu for Pegasus Technical, and the Work Assignment Manager for the client.

The internship research project took place at Center Hill / AWBERC the research laboratory. The majority of the work was performed at Center Hill, but there were technical training and safety training that occurred at the AWBERC facility. In addition to the research project, I also performed work at the EPA Test and Evaluation (T&E) facility in Cincinnati, OH, which is operated by Shaw E&I.

**Problem definition**

The following problem definition was utilized for guidance as the project evolved to ensure that the final project experimental design will meet the client’s requirements. 

*There is currently no rapid method for determining the potential impact of anthropogenic selenium on the immediate ecosystem from mining activities.*

**Project Goal**

To contribute to the development of a rapid method for identifying selenium reducing microbes which may indicate the potential of the soil to reduce water soluble selenium species into non water soluble selenium. The complexity of the microbial interaction with its environment has led to the changing of the original goal to develop a polymerase chain reaction
method. The project will continue to generate data, which will contribute to the method development.

The following chapters describing the task which were completed for this internship are organized by subject and not in the chronological order for their completion. Many tasks were in progress simultaneously and completed at different times with respect to their initiation date.
Chapter 1

Training

The training requirement by law and by the policy to work in a laboratory environment is 24 hours of laboratory safety training (OSHA requirement 29 CFR 1910.1450) and chemical hygiene Plan (the client's Cincinnati facilities chemical hygiene plan section 5.2). I also received training on the requirements for generating safety documents for the client. To comply with those requirements set by OSHA and the client, I participated in two types of training; safety and regulatory documentation generation.

The safety training was conducted online (self guided), short presentation, and extended classroom training with exams to evaluate the comprehension of the safety regulations and procedures.

The training that I completed consisted of the following subjects

- Chemical Hygiene Plan
- Resource Conservation and Recovery Act (RCRA)
- 24 hour lab safety training
- 40 Hour HAZWOPER
- Health and Safety Plan
- Quality Assurance Project Plan

First, the self conducted training which consisted of 24 hours of training modules, which I completed by viewing the training modules from the client’s online training system. It covered basic laboratory training which is required by the client in order to work in a client laboratory. In addition, there was presentation style training which is required for all personnel working at a client facility, which covered the basics of safety for the workplace. It also informed employees of the precautions for physical and chemical hazards that they may encounter at a facility that performs research with potentially hazardous materials. Thus, the training covered general labeling, reporting a safety concern, and what to do when there is an emergency.
Furthermore, the classroom training was weeklong intense hands-on training that covered the proper procedure for assessing hazardous situations such as a chemical spill. The 40 hour HAZWOPER training covered numerous aspects for safe response to chemical spills. It also covered a systematic approach to safely recover people and material from hazardous sites, such as inside a building. The training also demonstrated how to safely contain potentially hazardous materials and prevent it from contaminating the surrounding environment.

Lastly, the training for generating regulated documentation was self guided with the exception of the QAPP, which was an hour presentation that outlined the type of information that must be included in the document. There was a written example of a previous QAPP to illustrate the style that the document needed to utilize.

Evaluation:

The training provided me with a lot of information for working in an environment with numerous government regulations. The training that was directly connected to handling hazardous material or working in an environment where hazardous materials were present was very useful. It educated me on the proper and safe method for working with environmental contaminates. I utilized what I learned from this training on a daily basis while performing my laboratory work.

The training on environmental regulations such as RCRA was less applicable to the job functions that I performed. The RCRA training had a lot of overlap with the regulation portion of the 40 hour HAZWOPER training that I completed. Unlike the HAZWOPER training which required the training participates to apply the information to problems that were taken from actual real life situations, the RCRA training presented a lot of information and then ended. The ability to apply the training to a situation in a class room setting aided in my understanding and retention of the information that I learned from the training.

The training program would be greatly improved if it could be refined to include examples that the trainees will encounter in their job. For example, discus how to ship samples
from the field to the lab. Field samples may contain hazardous material and will need to have the RCRA (and other) regulations applied to its handling. The training only covered safe handling of hazardous material in the laboratory, and not hazardous materials in the field.
Chapter 2

Selenium Project Background review

I took over the selenium reduction research project from another researcher that was moving to a different work location; therefore, I needed to review the work that he had completed and evaluate if I would continue on the same plan or if I needed to make changes. In order to determine if the proposed project could be performed at Center Hill, it would need to meet the goal of contributing to the developing of a rapid analytical method that would use biomarkers to predict the potential of soil to sequester water soluble selenium. This dictated that a project review and literature search needed to be conducted.

After reviewing the project design and with further research into the literature I was able to make a conclusion for whether or not to keep the proposed research project. I determined that the original proposal to identify the enzyme responsible for selenium reduction and develop a quantitative polymerase chain reaction (qPCR) primer to detect it in soil samples would not meet project goal of developing a rapid method for predicting the intrinsic ability of soil to sequester water soluble selenium. I came to this conclusion due to the results from my literature review which indicated that selenium is reduced differently by different microbes. For example: *T. selenatis* uses selenate as a primary electron donor when nitrate is not available and the environment is anaerobic. Although *T. selenatis* will reduce selenate in the presence of nitrate it is at a reduced rate. There are other microbes that will not reduce selenium in the presence of other substances, such as nitrates; therefore developing a qPCR primer for the selenate reductase enzyme was terminated. This review led to the complete re-writing of the experimental design and target organism for use in the proposed analytical method. The experimental design will be discussed in more detail in chapter 4.

The new proposal was to screen different soils from areas disturbed by coal mining in West Virginia and determine if there were common microbes found in all sites. The goal is to identify two or three common microbes in the field soil microcosm experiments, and to demonstrate the soil microbes’ ability to reduce selenium oxyanions from water soluble to non-
water soluble elemental selenium. After the demonstrating the soil microbes’ ability to reduce selenium oxyanions, the development of qPCR primers would commence.

There are three major phases in the experimental design.

- Determine the concentration of *T. selenatis* (control) to use in the microcosms
- Determine the concentration of selenium oxyanions to spike into the microcosms
- To identify selenium reducing microbes from field samples

The experimental design will be discussed in detail in chapter 4’

**Evaluation:**

The experimental design went through a couple of revisions. This was due in part to the numerous stakeholders for the project. The goal of each stakeholder was different, and at times was in direct conflict with each other. The different goals led to a final project proposal that is greatly reduced in the kind of data that it will provide. Instead of developing a rapid method for microbial identification via qPCR the project will set the foundation for a method to be developed in the future. This change was due to one stakeholder’s insistence of breaking the project into numerous projects for documentation reasons.

Final thought on the process is: There is more oversight than is required for basic research, and it is counterproductive to advancing our knowledge in the environmental field. The ability to work on projects that are not guaranteed to be completed successfully allows basic research to keep advancing our knowledge. Performing research that addresses over simplified questions to ensure a good success rate should not be what drives research projects.
Chapter 3

Laboratory Setup and equipment verification

The Center Hill research facility is currently setup to perform analytical chemical measurements from contaminated soil and simulated landfill leachates. A small part of the project deals with soil and heavy metals detection and quantification. The majority of the project is working with microbiology and molecular biology techniques. To complete the project, I needed to locate equipment to perform the work at Center Hill, or laboratory facilities to complete the work that I would not be able to perform at Center Hill.

Locating the equipment that could be sent to Center Hill was fairly easy, but receiving authorization for it to be moved from the storage warehouse to Center Hill was a long process. I needed to communicate what equipment was needed to the on-site technical manager which would aid in determining if there was equipment available on a different project that he managed and then seek permission from the client person in charge of the equipment to allow for its use on the selenium project. For example, there was one piece of analytical equipment that was transferred to Center Hill from another client facility, and the paperwork to transfer of chain of custody for it took a little longer than ten weeks. There was a simpler process for obtaining some of the equipment, such as, the two pieces of equipment showed in figure 2, which are used for DNA amplification and analysis. These pieces of equipment were transferred from the warehouse and did not need to go through the same chain of custody approval, which was beneficial since they will be used to complete the majority of the DNA preparation and analysis work.

Locating laboratory facilities that could perform the work involved for the sequencing the microbes within what the budget would allow proved to be a challenge that I could not overcome. This led to all of the sequencing work except for the analysis on a sequencer to be performed by myself, and to verify that the work could be performed with the current facilities at Center Hill.
To assist with verifying that the culturing of bacteria and DNA extraction work could be performed at Center Hill I performed culturing, DNA extraction and amplification, and visualization on *T. selenatis*. The following figures show the unification of a single colony morphology and agar that demonstrates the qualitative increase in concentration from the DNA extraction from *T. Selenatis* refer to figure 3 and 4 respectively.

Figure 2 Equipment that was set up and operation verified pictured here are a PCR thermocycler and the tank for the DGGE analysis
In order to verify the ability to culture bacteria, extract and analyze DNA at Center Hill without contamination. I performed both liquid media culturing and plate cultures of *T. selenatis*. See figure 3 for the plate containing *T. selenatis*. The verification of the DNA extraction and analysis is observed in the agarose gel in figure 4.

**Evaluation:**
The identifying and locating that the equipment could work at Center Hill was a good experience in managing logistics. The coordination between the onsite technical manager, the client work assignment manager, and the authorized client personnel for the different laboratory equipment that was required for this research project posed a challenge. All of the parties have limited time available to meet; therefore, I served as an intermediate. The complex process of acquiring approval from numerous individuals delayed the approval of equipment transfer to Center Hill. The challenge was rooted in my lack of authority for when it comes to client facilities and property, and the rules that govern contract employees and federal employees’ communication. Since I had a professional level of a P2 I was not able to speak to any federal employees that were a P3 or higher without the on-site technical manager present. The on-site manager worked at a different client facility than I did and was not able to be accommodate the schedules of pertinent client employees.
Chapter 4

Due to the policy of the client I am only able to give a high level summary of the contents of the reports that I wrote. The documents (Summary reports, QAPP, and HASP) are internal documents and as such have not been included in this internship report.

Project communication

The need to communicate the project experimental design, the goal of the project, and the necessary safety and quality requirements required both verbal and written forms of communication. There were stakeholders from different government agencies that required information on the different stages of the project, as well as a brief summary of the project as a whole. This information was used to inform both scientists and non-scientists alike. I also generated documents to communicate safety and project quality procedures to inform other researcher that worked in the laboratory of potential hazards. These documents are required under the hazardous communication, which requires all workers to be informed about the chemicals that will be in their work area. The documents that I wrote were the HASP, QAPP, and project summary reports.

HASP

The HASP is the primary document for communicating the precautions for completing the laboratory task associated with the research project in a safe manner. There are four steps for this document: the step completed to generate this document included, first, determining the different the equipment and materials that will be used to complete the research. Second, the potential danger that the different chemicals and equipment posed to the human health was determined. Third, the identified safety hazarders were used to the design the required engineering and administrative modifications to mitigate for the potential detrimental effects. Finally, when there were no engineering options available, personal protective equipment was identified for the researcher.

The following is a summary of the different task I performed to complete the HASP:
• Describe the project and background
• Describe the laboratory activities
  o List all the equipment that will be utilized
  o List and describe the analytical methods that will be utilized
• Analyze the physical and chemical hazards that the laboratory work will encounter while performing the work
• Describe the engineering controls that will mitigate both the physical and chemical hazards
• When there is no engineering control available identify the personal protective equipment and training the laboratory worker will need to ensure they are working in a safe environment
• Describe the safe use, storage, and disposal of all the chemicals that will be used for the research project
• Describe the spill response for the laboratory chemicals

**QAPP**

The QAPP serves two main purposes: to ensure that the required elements for generating high quality results are included in the experiments, and to describe the overall plan, as well as to describe the required analytical methods that will be used for the research project.

The following summarizes the activities detailed by the QAPP:

• The initial DNA extraction from *T. selenatis* using a general primer (16s) and analysis by gel electrophoresis will generate a baseline molecular banding pattern and intensity of each band for future reference. This experiment will also help determine the required concentration of PCR reaction to perform DGGE analysis.
• The extraction of DNA in the presence of sand is being conducted to determine what concentration of *T. selenatis* to use as a control in the field samples.
• Laboratory samples will be used to determine the concentration of selenium to add to the field samples.
• The field sample microcosm experiment will analyze for a correlation between the composition of the microbial community in a particular field sample and the reduction of selenium.

Summary Reports

The project was funded by a different client region (region 3) and the region needed to be informed of the current status of the project. Therefore, I generated several summary reports, and a power point presentation to inform the region of the new proposal, and the progress of the research project. The summary reports were also used to inform potential collaborators of the goal and approach that was being employed for the research project. I also generated a monthly report for the client work assignment manager that included the current status of the project.

Monthly report

Every month, I generated a report for the client’s Work Assignment Manager; the progress made for the past month and described the expected activities for the next month. The monthly report was the official record for tracking the progress on the research project.

The monthly reports contained the following minimum information:

• Documents currently being generated and where they were in the approval process
• Meeting conducted for the project (both external and internal)
• All data that was generated
• The future planned activities for the next month

Evaluation:

Although writing the HASP and the QAPP was a long process where many compromises were made to gain approval from the different stakeholders; it was an excellent experience. I was able to gain a deeper understanding of the requirements for a client’s document. Although writing the documentations was challenging, it was great experience in identifying what all the stakeholders’ requirements for the project were, and create a document that successfully
incorporated them. The experience I gained with generating and presenting the project through reports and a power point presentation is valuable experience that will aid my career.

Although the experience with writing documents and reports was valuable, the ability to work with a diverse group of stakeholders that had different goals and produced a project proposal that was approved by all will be the success that I will value the most from my internship.
Chapter 5

**Additional work performed assisting other projects**

I performed work at the Test and Evaluation facility for two weeks, and on federal holidays that were not Shaw E&I holidays. The two week assignment was due to the delay of the approval of the next option year for the research project that I was working on. The work was in an assisting role for other researchers on projects, and assisting with facility reorganization.

I spent two weeks at the T&E where I aided with the metal digestion for a different client’s research project. I also assisted with monitoring water contaminant detection equipment and a commercial product, which was being tested at the facility. In addition to assisting with scientific projects I also assisted with the completion of facility modifications to comply with safety and fire regulations. The last project that I performed was an inventory of expired chemicals that were going to be disposed of.

**Evaluation:**

I found the many different technologies very interesting. I enjoyed the time I spent at the T&E facility. The culture at the T&E facility was very positive, and the researchers were very free with their knowledge. This combination made for an excellent experience that I value. The ability to be exposed to the current technology and thinking in how it is being implemented was also appreciated. I left my two week assignment at the T&E with a more in-depth understanding of current issues in water quality, and the ways we are trying to address them.
Reflection for the internship:

I experienced an affirmation about working at a highly regulated facility, which was with the increased size and complexity of the institution came a lot of oversight. I know that oversight is there to ensure that the funds are used wisely, but I found that the many extra layers of control challenging. I am not able to place a specific dollar amount which the oversight added to my project, but I am confident that it is a greatly increased the labor costs to the project. This is due to the extended period of time I spent explaining and rewriting the project to oversight authorities that were not scientist. Due to their lack of understanding of the project as a whole more of the funds were utilized to have additional reviews performed by outside contractors.

Although it took longer than expected to accomplish the task, the experience was beneficial; I learned how to conduct a research project as I adhered to the client’s rules that govern it. I learned so much with the help of the other researchers, especially Dr. Jurate Virkutyte and Dr. Kovacik. The help from Dr. Virkutyte and Dr. Kovacik provided with the process of developing and writing a research plan was invaluable, and I will benefit from it for many years to come.

Another benefit I will take away from this internship is the confidence to defend my work and my ideas, not to just accept requested changes without some valid reasons, supported by published work or experimental results.

The organization gained insight from my many years in the Biotech and Quality Control, in addition to my experience biological analysis methodology. I was the only biologist working at Center Hill.

I brought a regulated approach to data recording for experiments and the reagents that are used in the experiments, which I believe increased, the quality of the research project. This improvement is observed when experimental results are not as expected. The additional information allows for increased support of the data being valid and not due to researcher error.
The skill set I developed working with cellular biological methods helps in resolving issues with other researchers’ projects. Although there are differences between cell and tissue culture techniques and microbiology techniques, there is enough cross over that I was able to help an environmental engineer trouble shoot unexpected results with an experimental reactor that utilized sulfur reducing bacteria. I was able to analyze the effluent and show that the sulphur reducing bacteria were not only present, but were increasing their population. This allowed for the trouble shooting to move on to other media which was being used in the reactor and to eventually determine that it was a design flaw in how the reactor column was packed that was causing the unexpected results.

IES REFLECTION:

The most valuable portion of the IES program was the one year of Statistics and Environmental Modeling. The ability to analyze data and determine if the results are statistically significant is very important. The modeling class was also very important; it helped me with the design portion of the experiment. This allowed me to ensure that I would have enough data points to determine significant, which allowed for the selection of the number of replicate samples to be generated.

Having six years of progressively more responsibilities in the biotech and pharmaceutical industry allowed me to develop many skills that are required to be successful in this internship, but I believe that the IES programs use of the public service project is an good way for IES students to begin gaining experience with environmental problem solving, and allows the students to start developing skills that will aid them in the professional world.

The specific skills that can be obtained from the public service projects are: proposal generation and presentation, research, and report writing. There are also the skills and personal attributes that are required to complete an environmental project, such as time management and
development of organization skills for generating and recording the information that clients have requested.

Future Benefits from Internship

The internship will help me achieve my future career goal by providing research experience, and applying the knowledge to risk assessment and remediation work. Specifically the three topics below.

- Research experience continue working as a research in environmental science
- Continue work in the remediation field with Shaw E&I on future research projects
- Professional project management

Currently I am not sure exactly what I plan to do in the future as it pertains to my career. I see this internship fitting into the different paths that I may take. I have been able to gain experience in the preparing and proposing of environmental research, which would serve as a good initial base for developing a career as a researcher. I have also gained experience in the laboratory with methods that can be applied to analysis of environmental sample, which would also be very useful if I decided that I would like to return to an analytical laboratory career.

The experience I gained in leading the work assignment for this research project will benefit me in numerous careers: both in science research and management of environmental projects.

I see my professional experience and the IES program as making a strong contribution to forming a solid base to launch my environmental career, in many directions. My time in the IES program has contributed greatly to the development of a professional network, which will be valuable as I continue my career in the environmental science field. This network will allow for the exchanging of ideas as the field evolves as well as serve as a source for potential candidates to join the research team.