

OUTDOOR EDUCATION AND CITIZEN SCIENCE IN A HIGH SCHOOL  
FRESHWATER ECOLOGY SCIENCE CLASSROOM

by

Sarah Martina Tierney

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of the requirements for the degree

of

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in

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## ABSTRACT

Outdoor education and citizen science practices were implemented into a high school freshwater ecology curriculum to assess student motivation, attitude, and in general their connection with the outside world. In this study students were exposed to various outdoor learning opportunities and citizen science activities. Pre and post treatment student surveys were conducted, student interviews, student journaling, and student engagement tally sheets were all recorded to assess student engagement. As a result of this study, a majority of students reported a benefit from lessons outside the classroom as well as indicating an increase of energy, pleasantness, and engagement.

## INTRODUCTION AND BACKGROUND

Students in my classroom are academically driven, both for grades and knowledge. Developing a robust curriculum and yet also providing a real-world approach has been a goal of mine to continue to engage students in the quest for learning. I have continued to design a curriculum that allows students to get outside of the walls of their classroom and to partner in the local community through citizen science.

I teach seniors and post-graduates at Brewster Academy, a private boarding school located right on the shores of Lake Winnepesaukee in Wolfeboro, New Hampshire. Brewster has a mastery-based approach, meaning it is required that all students aim to earn an 80% or higher on any major assessment. If they do not, students retake the assessment and the scores are averaged. Twenty-one countries are represented by the student body and 74 different classes are offered.

At Brewster, I am required to level each student in the class appropriately: Accelerated, Standard, or Foundational. Leveling determines the pace and amount of material students are expected to learn and is tied in with different assessments and GPA. I decide what level material students should master to be considered Accelerated, the highest level, versus Foundational, the lowest level (D. Davis, personal communication, September 22<sup>nd</sup>, 2017).

I completed the study with my three freshwater ecology students containing 42 Juniors, Seniors, and postgraduate students. Students learn in small classroom sizes, 14 students each. Sixty-four percent of my students have learning differences. I have four students with attention deficit hyperactivity disorder (ADHD), two students with foreign

language waivers due to dyslexia, two students who have a learning disability in regard to a weakness in math, and four students who are English as a Second Language (ESL).

The ethnic breakdown of the classes is 36 Americans, 2 from Canada, 3 students from China, and 1 student from Spain. The four ESL students Test of English as a Foreign Language (TOEFL) scores are considered high, but do require me to adjust my curriculum to fit their learning needs (D. Davis, personal communication, September 22<sup>nd</sup>, 2017). There are also three races represented in all three classes: Caucasian, African American, and Asian ( $N=42$ ).

In my teaching experience, I have seen students lack some of the skills to apply what they know outside of the classroom by purely memorizing information for assessments instead of seeing the bigger picture. I have also witnessed a deficiency in my student's connection with their local community. Therefore, I decided to do an action research model to guide my capstone project that encouraged my students to engage in the outdoors and apply what they've learned in the form of citizen science.

In this action research-based class project, one of the goals is to incorporate a curriculum that allows student learning to occur in order to demonstrate real-world application and provide students with a unique educational experience that they could use outside of the classroom. Experience with my freshwater ecology science students this year led me to my primary action research model question to investigate: How will citizen science and outdoor education impact student learning in freshwater ecology science classroom in high school? The research also addressed the following sub questions:

1. Will using hands-on field activities increase student interest and engagement in freshwater ecology?
2. Will the use of citizen science help students make connections to their own lives, community, and understand the importance of their own environment?

### CONCEPTUAL FRAMEWORK

Citizen science is a partnership between the public and non-scientists in scientific research and education within the community. It has become a key tool in helping to collect, monitor, and analyze environmental change on both the local and global scale (Johnson, et al., 2014). Citizen science has been incorporated with outdoor education, the organization of outdoor activities increases experiential learning (Martin, 2003).

A benefit to citizen science is that it increases student's awareness and attitude towards the environment. It encourages a curiosity within students and prompts participants to engage in their natural surroundings. The *Global Environmental Change* journal elaborates upon the importance of monitoring climate change on the local and global scale and has been using citizen science. This journal looks at the use of citizen science and how it has increased environmental awareness in the general public. Citizen involvement has been used to help collect data and encourage more ecologically friendly changes. It also increases inclusiveness within the community (Toomey & Domroese, 2013). Citizen science is best used when it compliments scientific research and is an effective tool that impacts quantitative approaches in the science community (Dickinson, et al., 2010). A three-step process where motivated individuals seek environmental science opportunities and gain experience through citizen science outreach was

implemented in Bangalore, India. This led to more citizens being involved in active environmental outreach programs throughout the area (Toomey & Domroese, 2013).

Citizen science projects help scientists collect data, but also help participant's attitude. Researchers investigated what participants specifically learned and took away from the citizen science partnerships as well as why they participated. The Ajzen's Theory of Planned Behavior, a theoretical model of human behavior, was used to better understand influences and attitudes. The results indicated that most individuals participating in the study were highly educated, previously participated in citizen science projects, and were reoccurring citizen-science participants that showed an increased interest in environmental issues (Toomey & Domroese, 2013).

Citizen involvement has been used to help collect data and encourage more environmentally friendly changes to occur as well as to create an inclusiveness within the community (Johnson et al., 2014). In addition, citizen science is growing as more citizens become involved in their community. Educators are beginning to collaborate more effectively with the community to spark interest and investment. The idea of shared responsibility for one's environment is trending. Citizen science work has increased, and a structure has been put in place to promote the necessary skills for participants of citizen science to be successful both on the local and global scale (Mueller & Tippins, 2012).

Citizen science, linked with outdoor education, can encourage a greater connection between students and their environment. Outdoor education is also a way for students to apply knowledge and understanding in real-world scenarios (Jordan & Nadelson, 2012). Today, children struggle to know their own backyard woods but have a

better global perspective of the world due to social media and networking. Students may be aware of global issues, but they are detached from nature (Louv, 2007). Utilizing outdoor research with citizen science has led to unique benefits within the scientific community due to volunteers. This has allowed the involvement of researchers to increase and community building to occur moving away from traditional research models (Dickinson, et al., 2010).

Often, citizen science is applied to informal science education (ISE) as well as incorporated in formal science education (FSE). Both informal and formal science education have clear benefits for middle and high school student learners. A logic model was developed and implemented in Acadia Learning Project that showed how classroom-based citizen science activities can be applied in and out of the classroom (Zoellick, 2012).

Jordan and Nadelson (2012) measured student's attitude and retention in outdoor settings. Outdoor field trips were taken and students were measured on their attitude on being outside. Results indicated a higher positive attitude among all students. Students in this study were also assessed post field trips and one month later on retention. Students were able to recall the most information with hands-on activities (Jordan & Nadelson, 2012).

Testimony before the Interior and Environmental Subcommittee regarding human relationships with the environment found that only six percent of students play outside. A study by the California Department of Education, done in 2005, discovered that science test scores increased 27% percent with outdoor science curriculums. The physical

location of students, such as urban environmental settings, indicated a higher number of students inside compared to outside. However, students in outdoor education programs have increased motivation to learn, self-esteem and problem-solving abilities. Results indicated that under the right circumstances cultural and political change could occur quickly. The government could increase parks and outdoor public areas. At the federal and state levels Connecticut's "No Child Left Inside" policy could be adapted and implemented which would result in increased numbers of outdoor education programs (Louv, 2007).

A report conducted by the National Foundation for Education Research at Kings College in London and the University of Bath showed that outdoor learning opportunities are in decline. The study focused on planning and implementing effective outdoor classroom experiences. Three separate outdoor learning environments were studied to better understand the process, impacts, and evaluation of outdoor learning. Effective ways to increase student learning in outdoor classes was discussed and the findings signified education outside of the classroom significantly benefits students. In addition, findings indicated that outdoor activities provided a way to include students in social settings which can result in increased student levels of self-confidence (Dillion, 2005).

An article in the *Journal of Science Teacher Education* discussed ways to support teachers in reflective practices in outdoor education settings. Teacher interviews and in-services were utilized to help prepare middle and elementary teachers for teaching outside for their middle and elementary school students. Teachers were encouraged and supported to teach outdoor lessons followed by group reflections. Both teachers and

students expressed having positive experiences in this situation. Recommendations were made to continue to hold outdoor field activities that supported teachers by offering them outdoor teaching strategies to set them up for success. Outdoor education training sessions resulted in greater student learning (Tal, 2009).

Providing opportunities for teachers to have space and time to create effective outdoor lessons is crucial. There can be challenges with creating outdoor lessons such as funding, class scheduling, and preparation time. Acknowledging barriers and findings creative solutions to overcome them is important for the success of the teacher and students learning environment which will lead to greater student success (Rogers & Smith, 2012).

Offering the time for students in and out of the classroom requires strategic planning and it's recommended that teachers maximize student's experiences through outdoor classroom settings. The teacher needs to provide key learning targets and opportunities for students to ask questions to better understand the natural world. Preparing to teach outside requires teachers to understand that some parts of the lesson are out of their control, weather for example. Providing students with outdoor learning opportunities allow students to connect and reinforce lessons previously taught indoors (Lakin, 2006). Furthermore, finding the necessary time for citizen science projects has allowed for greater contributions to the scientific community overtime through education by volunteer participants. It has provided answers to key ecological questions about conservation and management of one's habitat. Including resources to collect accurate

data, provide time for volunteer feedback, and general feedback on citizen science projects will help propel future projects to be more successful (Kobori, et al., 2016).

Allowing occasions for students to be outside requires the teacher to observe and reflect upon the lesson. Acknowledging that outdoor classes should pull from students' knowledge not just from one topic, but many topics learned, is a key part of making connections to the real world. Students can learn in an outdoor setting or a classroom setting, but having an outdoor classroom allows students to have greater insight into ecological relationships. Four key variables were looked at, environmental attitudes, knowledge, attitudes, behaviors, and comfort level in the greater outdoors. These components can help determine how effective an outdoor classroom environment is for students and will be adopted into my own outdoor classroom as students work within the community to take on citizen science projects (Martin, 2003).

## METHODOLOGY

In this study, junior, senior and post graduate students in freshwater ecology were given opportunities to experience outdoor education settings as well as citizen science projects ( $N=42$ ). The research methodology for this project received an exemption by Montana State University Institutional Review Board and compliance for working with human subjects was maintained (Appendix A).

Six main modules were investigated during the time of the study which included lake Winnepesaukee's watershed, water quality testing, drinking water, freshwater fish, ecological cycles, and water laws, policies, and regulations. A full module description along with learning targets can be found in Appendix B.

Students completed six modules from September 2017 to May 2018 (Table 1). In Module one, Winnepesaukee's watershed, students investigated general statistics and facts, the lake as a resource, environmental issues associated with the lake, water quality, and general history. Students became an expert in one particular area and presented it to the class in the form of an iMovie presentation. The second module, students took a deep dive into water quality testing. They participated in deep-water testing sites on Lake Winnepesaukee's Wolfeboro Bay, they partnered with the Lake Association, and wrote a persuasive essay about if they believed the Lake Winnepesaukee to have good or poor water quality. The third module students learned about drinking water by taking a drinking water tour, participating in a water debate, and a blind water taste test. The fourth module students started raising brook trout, toured the fish hatchery, and became an expert in a particular freshwater fish species. The fifth module students learned about ecological cycles such as water, nitrogen, phosphorus, etc. In the final module, module six, students explored environment laws, policies, and regulations. Students took a closer look at the US political system and shared lake management plans with the Lake Association.

Table 1  
*Freshwater Ecology Module Timeline*

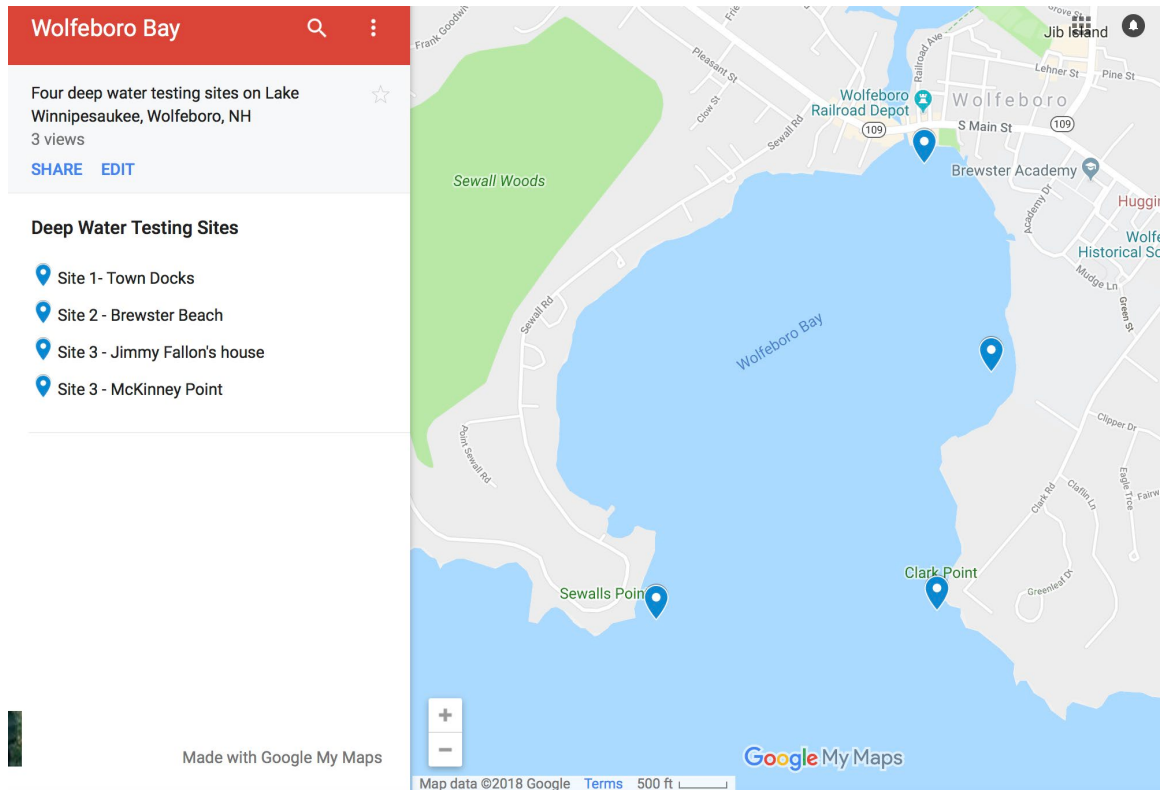
| Module | Topic                                 | Dates (2017-2018)              | Activities                                                                                                                                                                                                                                                                                                                           |
|--------|---------------------------------------|--------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1      | Lake Winnepesaukee's Watershed        | September to early October     | Watershed Project: 1. General Facts & Stats on the watershed 2. History of the watershed 3. Water quality of the watershed 4. The lake as a resource 5. Environmental issues in the watershed                                                                                                                                        |
| 2      | Water Quality Testing                 | Early October to end of May    | 1. Deep-water quality testing on four sites on Lake Winnepesaukee, in Wolfeboro Bay, NH. Data used in partnership with Lake Winnepesaukee's Lake Association. 2. Water quality videos for students and other people to test water quality. 3. Water Quality Essay 4. Water quality testing within the watershed at site descriptions |
| 3      | Drinking Water                        | Early November to mid-December | 1. Drinking Water Facility tour - Wolfeboro drinking water. 2. Water Taste test 3. Water debate. 4. Tapped Documentary 5. A book on Drinking Water                                                                                                                                                                                   |
| 4      | Freshwater Fish                       | Early January to mid-February  | 1. Freshwater Fish expert 2. Powder Mills Fish Hatchery 3. Trout in the Classroom                                                                                                                                                                                                                                                    |
| 5      | Ecological Cycles                     | Mid-February to early March    | 1. Ecological Cycles 2. Ecological Cycles expert - water, oxygen, sulfur, phosphorous, nitrogen                                                                                                                                                                                                                                      |
| 6      | Water Policies, Laws, and Regulations | End of March to early May      | 1. Case study and Fact sheet 2. Water quality regulations 3. Water law 4. Water conflict 5. Water solutions                                                                                                                                                                                                                          |

Six citizen science activities were conducted throughout the study period to allow students to have a real word, authentic experiences (Table 2). Water quality testing was conducted with the Wolfeboro Lakes Association on four different bodies of water. In each citizen science activity, pre and post treatment student surveys were conducted, student interviews, student journaling, and student engagement tally sheets were all recorded to assess student engagement further.

Table 2  
*Citizen Science Activities, 2017-2018*

|   | Citizen Science Activity                                            |
|---|---------------------------------------------------------------------|
| 1 | Water quality testing with Wolfeboro Lakes Association              |
| 2 | Water quality testing for NH Fish & Game                            |
| 3 | Drinking water books with Carpenter Elementary School, Wolfeboro NH |
| 4 | Water quality testing with Crescent Lake School, Wolfeboro NH       |
| 5 | Trout in the Classroom                                              |
| 6 | Canoeing activity with Milfoil removal                              |

Water quality testing was conducted in leeway with the Wolfeboro Lakes Association. Six main water tests were conducted, which included nitrate, phosphate, dissolved oxygen, temperature, pH, and turbidity. These tests were conducted on four deep-water sites located in Wolfeboro Bay (Figure 1). Students became experts in one particular water quality test and were responsible for collecting water quality data as well as upholding water quality testing state standards.



*Figure 1.* Deep-water testing sites on Wolfeboro Bay.

The water quality testing for New Hampshire Fish and Game was done at 13 site descriptions (Figure 2). At each site, the six main water quality tests were completed in the same steps and protocols as the water quality testing done for the Wolfeboro Lakes Association deep-water sites in Wolfeboro Bay.

In addition to collecting water samples, students created drinking water books about the importance of drinking water, where water comes from, and tap water over bottled water, and read these books to Carpenter Elementary School's 1<sup>st</sup>, 2<sup>nd</sup>, and 3<sup>rd</sup> grade classes (Appendix C). Freshwater students were split into groups of threes or fours and attended the school's story time period as well as answered questions the elementary students had about the town's water.

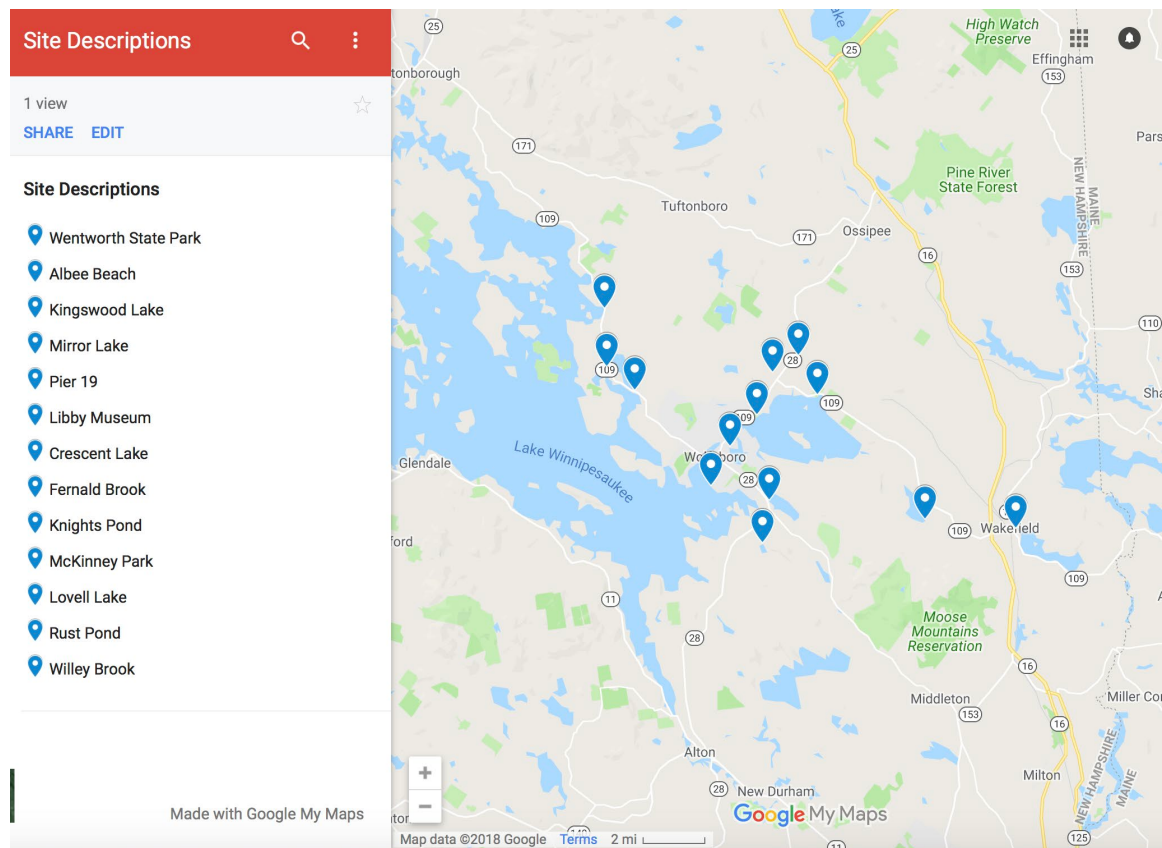
Freshwater students attended Crescent Lake School, the public upper elementary school in Wolfeboro, NH where they worked with the 5<sup>th</sup> grade students and demonstrated how to conduct water quality tests. Freshwater students had the 5<sup>th</sup> graders rotate through stations and learn about each water quality test. The six water quality tests which were done previously in Wolfeboro Bay and the site description locations were also conducted with the 5<sup>th</sup> graders.

Trout in the Classroom (TIC) program was participated in during the study period, from January to May. 200 Brook Trout (*Salvelinus fontinalis*) eggs were picked up from the Powder Mills Fish Hatchery in New Durham, NH in late January. Students were tasked with learning how to care and raise Brook Trout. Water quality testing was done on the tank to ensure proper care, as well as site descriptions, were used as a way to access possible trout release sites. In early May, when the brook trout had used up their yolk sac, swam up, and had been feeding for roughly a month the students released them in Mountain Lake, in Brookfield, NH. This site was determined by the students to be the most ideal habitat environment for trout compared to the other site descriptions and sites visited in the area.

Students also had the opportunity to participate in the removal of Eurasian Milfoil (*Myriophyllum spicatum*), an invasive species located in Lake Winnepesaukee's Back Bay (Appendix D). Students canoed during lab time, canoeing instruction and water safety were given prior to canoeing, to Back Bay on Lake Winnepesaukee where they wore gloves, identified Eurasian Milfoil, and removed the plant via pulling up from the roots. The plants were then bagged and disposed of properly. New Hampshire Weed

Watchers, Volunteer Monitoring for Aquatic Invasive Plants protocol and plant identification was followed for proper collection and removal techniques (Appendix E).

In addition to citizen science activities, outdoor education took place in the form of site descriptions (Appendix F). Thirteen site descriptions occurred throughout the study period. At each site description students recorded the site name, body of water, date, time, weather conditions, plant species, general characteristics, general observations/interpretations, and conducted six main water quality tests as a class (nitrate, phosphate, dissolved oxygen, temperature, pH, and turbidity).



*Figure 2.* Site description location map.

In each module, a number of surveys were done to assess student attitude and interest level in the topic (Appendix G). These surveys were done in the form of a Pear

Deck during the regular class time and took about 10 to 15 minutes to complete (Deck, 2017).

Students completed a pre and post, six-question survey, at the start and end of each module. Students had the option of picking strongly disagree, disagree, agree, or strongly agree. Students also earned recognition grades, six total for the year following Brewster Academy's recognition system. Students had the opportunity to score themselves on each of the ten items. The scale was recorded as a one to four, with a one meaning a student does not meet expectations, a two meaning a student completes expectations with the teachers support, a three meaning a student meets expectations independently, and a four meaning a student goes above and beyond and the behavior is a habit of mind.

In addition, students also had the opportunity to complete student surveys on me, the instructor, in regards to the classroom environment and classroom practices. Both surveys were on a one to four scale of never, sometimes, mostly, and always. Students completed these surveys twice during the study period, once at the midway mark and again at the end of the study period.

The Yale Emotional Literacy program (mood meter) was used as well as student sit spots were used to assess students' attitude towards citizen science projects (Figure 3). The mood meter and sit spots were used to see if students were having a better attitude towards citizen science projects. This was a quick check for students before and after our activity where they plotted their mood on the mood meter. I was also able to read and assess their sit spot entries after the activity (Figure 4) (Appendix H).

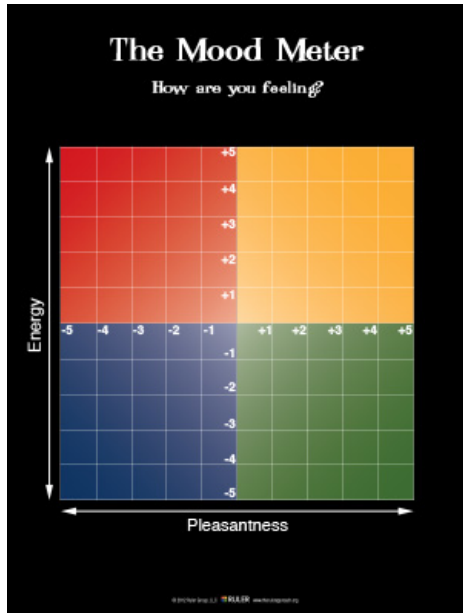


Figure 3. Mood meter.

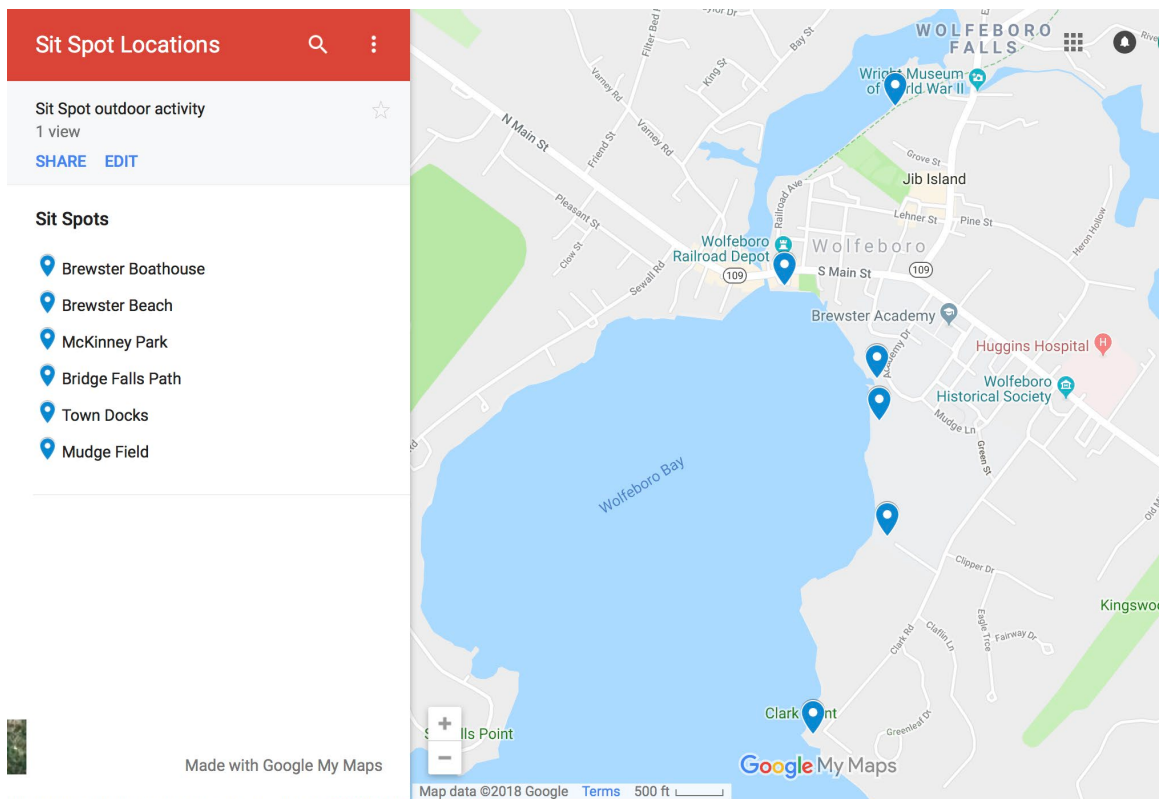


Figure 4. Sit spot site location map.

Student interviews were also conducted at the end of each main module with six random students across all three freshwater classes (Appendix I). Interviews were conducted during team study, an afternoon extra help period built into the school day or during evening study hall. Interviews lasted roughly 10 minutes and were used as a tool to better see if students were making connections with their own lives and communities. This also helped to determine if students were able to understand the importance of citizen science projects.

Class observations were conducted by Brewster Academy's science department head and other science faculty members in the form of tally sheets to assess student engagement. This was completed once in each one of the modules covered to get an outside perspective on how engaged students were during hands-on activities. Tally sheets of students that were off-task were documented (Appendix J).

Throughout the study period, students were asked to keep a student journal in the form of an online portfolio via Google Sites (Appendix K). They were asked to reflect in each module on how they felt towards citizen science and outdoor classroom activities. Students were asked to reflect upon the impact they were making in the community and how that was changing their own day-to-day life. These journal entries were completed at the end of each module. These were then analyzed for common trends and themes as a way to support other data.

Students attended four guest speakers to complement citizen science opportunities (Table 3). At each guest speaker presentation, students were asked to complete a reflection sheet about the guest speaker and how it related to the big picture (Appendix

L). Abi Bradford, an expert from NexGen Climate Change, was brought in to discuss climate change and add to the ecological cycles module. Judy Tumosa, New Hampshire Fish and Game education specialist was brought in to discuss freshwater systems and educate students about the Trout in the Classroom program (Appendix M). Dave Burdick, a natural resources professor at the University of New Hampshire, presented to the class about buffers, habitat, and wetland areas to help assist students in having a more well-rounded understanding of the site descriptions they had conducted throughout the year. And lastly, Andrea LaMoreaux, vice president of New Hampshire Lake Association came and presented to the students about invasive species to help aid students in being prepared for the Eurasian Milfoil removal on Lake Winnepesaukee, Back Bay.

Table 3  
*Guest Speakers, 2017-2018*

|   | Guest Speakers                                                               |
|---|------------------------------------------------------------------------------|
| 1 | Abi Bradford, NexGen Climate Change                                          |
| 4 | Judy Tumosa, New Hampshire Fish and Game Education specialist                |
| 2 | Dave Burdick, professor at the University of New Hampshire Natural Resources |
| 3 | Andrea LaMoreaux, vice president of New Hampshire Lakes Association          |

In addition to guest speakers, students attended two tours to add to their overall experience outside of the classroom setting. At each tour, students completed a brief assignment associated with the tour (Appendix N). The first being, the Drinking water facility tour of Wolfeboro New Hampshire's water supply. The tour was taken to help aid students in their understanding of their drinking water module and to help them have an outside of the classroom experience. The tour lasted roughly 45 minutes long and students specifically learned about how Wolfeboro's town water gets treated.

The second one was the Powder Mills Fish Hatchery which was a tour taken to help support students in their understanding of the Trout in the Classroom program to raise Brook Trout as well as to help them in their freshwater fish module. Like the drinking water tour, the fish hatchery tour, was also taken to help students have a classroom experience outside. The tour lasted roughly 45 minutes and was located in New Durham, NH (Table 4) (Appendix O).

Table 4  
*Freshwater Ecology Class Tours, 2017-2018*

|   | Tours                      | Location                                  | Tour guide                            |
|---|----------------------------|-------------------------------------------|---------------------------------------|
| 1 | Drinking Water Facility    | North line road, Wolfeboro, NH 03894      | Janine Gillum, primary operator       |
| 2 | Powder Mills Fish Hatchery | 288 Merrymeeting Rd, New Durham, NH 03855 | Chad Miller, Fish Hatchery Supervisor |

*Note.* All data sources used in this study can be found in Table 5.

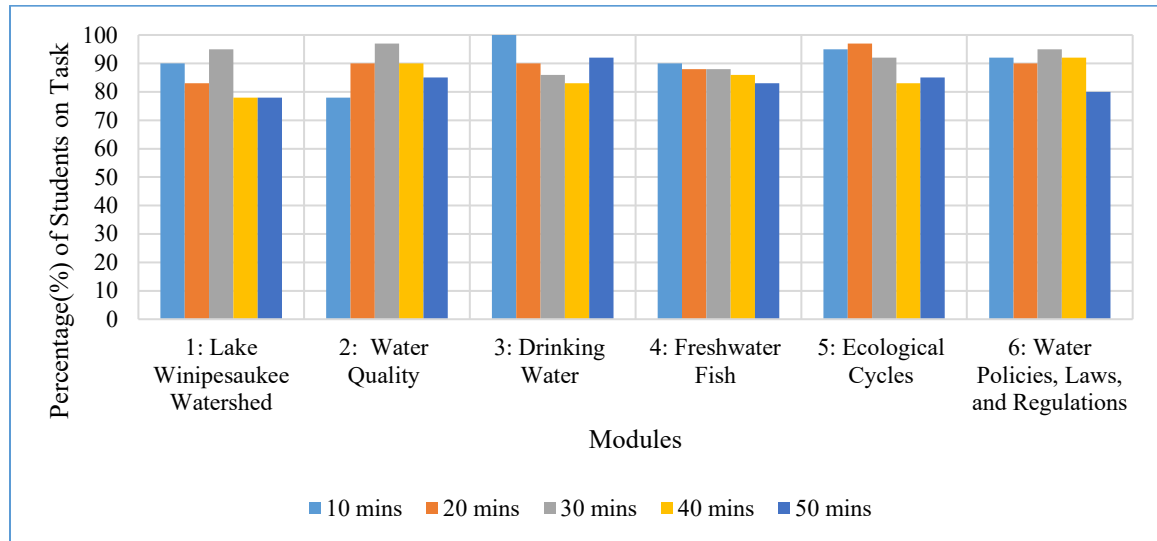
Table 5  
*Data Triangulation Matrix*

| Focus Question                                                                                                                                        | Source 1                        | Source 2                                       | Source 3           | Source 4               | Source 5                        | Source 6                        |
|-------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|------------------------------------------------|--------------------|------------------------|---------------------------------|---------------------------------|
| How will citizen science and outdoor education impact student learning in freshwater ecology science classroom in high school?                        | Pre and post Student Interviews | Pre and Post Student Surveys & Teacher Surveys | Pear Deck Surveys  | Student Journals       | Guest Speakers & Tours          | Pre and Post Student Interviews |
| Will using hands-on field activities increase student interest and engagement in freshwater ecology?                                                  | Student Recognition Scores      | Mood Meter & Sit Spots                         | Class Observations | Trout in the Classroom | Milfoil Removal                 | Water Quality Tests             |
| Will the use of citizen science help students make connections to their own lives, community, and understand the importance of their own environment? | Site Descriptions               | Mood Meter & Sit Spots                         | Student Websites   | Student Journals       | Pre and post Student Interviews | Pre and Post Student Surveys    |

### DATA ANALYSIS

The results from this study conducted on the effects of outdoor education and citizen science on student learning in a high school freshwater ecology classroom indicated that students were on task 90% of the time throughout outdoor setting lessons during module three and five. Module three was drinking water while module five was ecological cycle and each had strong outdoor component. Eighty four percent of the class was on task behaviors during module one, Lake Winnepesaukee's watershed ( $N=42$ ). Module one did not have an outdoor component. Students were on task on average during the 30-minute mark across all six modules at 92% compared to the lowest percentage of students being on task at 84% at the 50-minute mark of an outdoor lesson. One student in

their student journal wrote, ““Being on the boat helps me learn, its nice just to get out of the classroom and apply what we are learning about” (Figure 5).



*Figure 5.* Tally sheets: percentage of students modeling on task behavior in 10-minute intervals, ( $N=42$ ).

Ninety-eight percent of students strongly agreed that they benefit from having class outside in a pre and post study conducted at the start and end of each module in freshwater ecology class. One student said, "It was so cool feeding the brook trout at the fish hatchery. I can't wait to have our trout get that big and let them go in the river."

Ninety-six percent of student in their post survey said that they enjoy having opportunities to do citizen science projects while only five percent of students in their post survey said that they disagree with the survey question that stated, "I like having guest speakers in the classroom and think they add to my learning experience." Another student wrote on their online website, "I like it when we have professionals come and talk to our class. The lake association talk made me feel like all the water quality data we have been doing was helpful to the people and town around Lake Winnepesaukee"

(Figure 6).

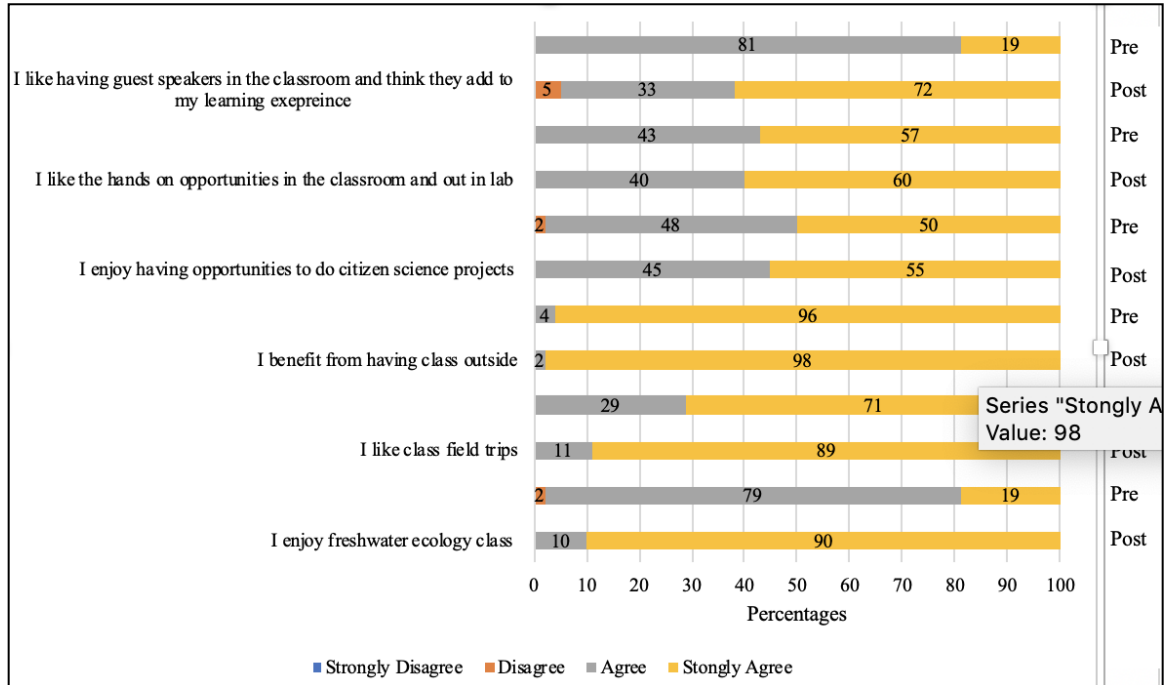
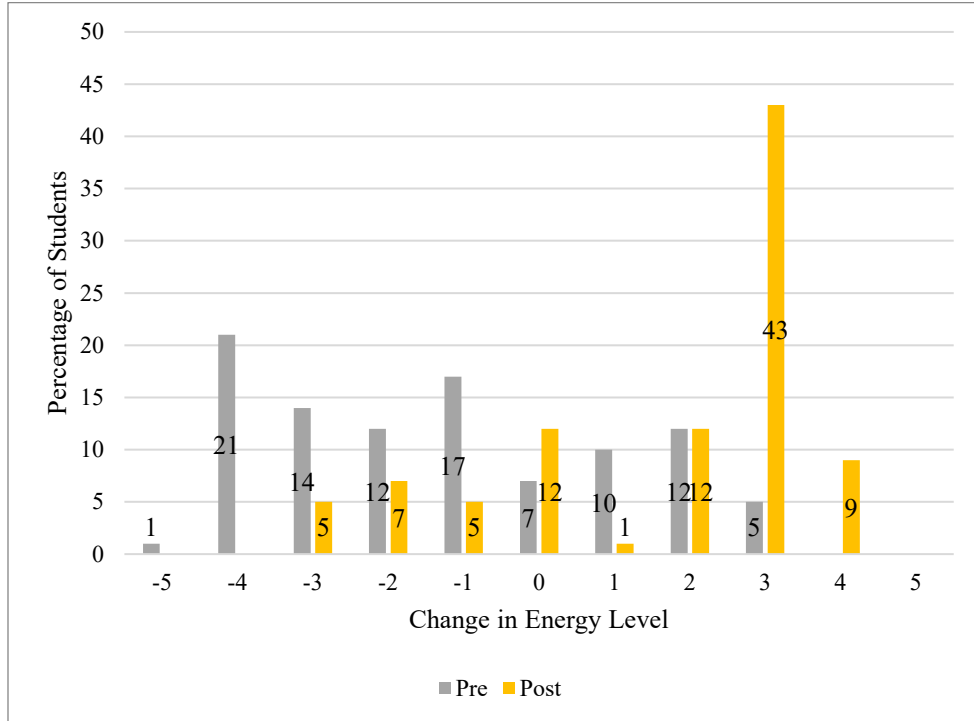


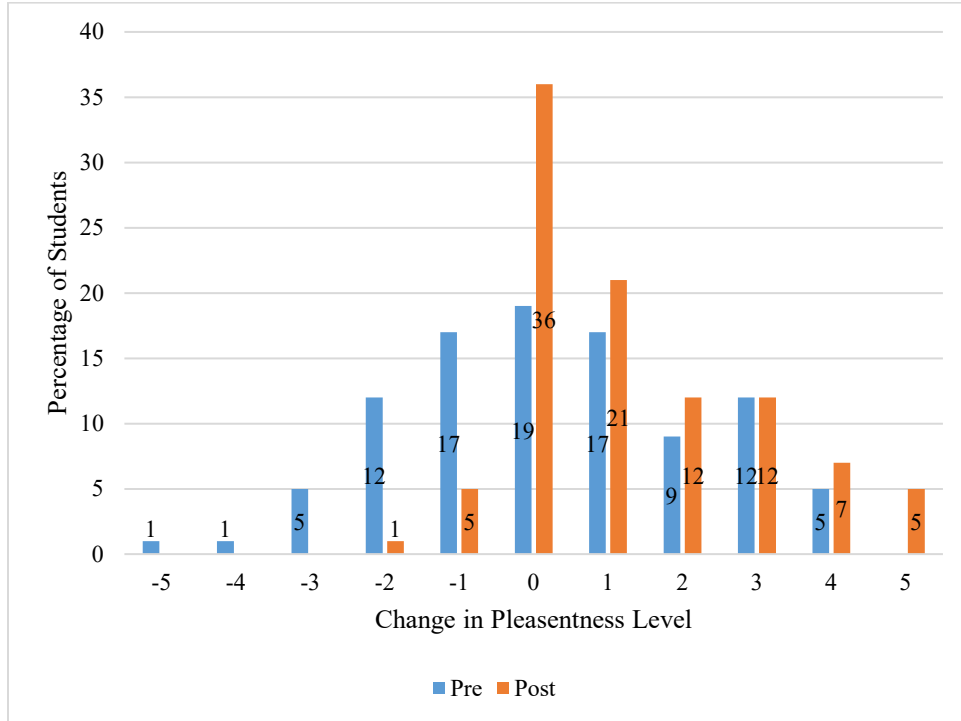
Figure 6. Pre and post student module check-ins via Pear Deck Surveys, (N=42).

In the Emotional Literacy Mood Meter plotting pre and post major outdoor activities and citizen science opportunities in regard to energy level 64% of students felt low energy levels in the pre-activity compared to only 17% of students feeling low energy post activity. Sixty-five percent of students felt their energy levels increase while only 27 percent of student started out with higher levels of energy. One student after an outdoor activity, visiting the drinking water facility, said, “I feel like I didn't quite get how our drinking water worked and the main differences between tap and bottled until we went to the drinking water facility. I liked that we got to see it step by step. It made it all make sense to me seeing it run” (Figure 7).



*Figure 7. Mood meter: pre and post surveys, percentage of students versus change in energy level, (N=42).*

In the Emotional Literacy Mood Meter plotting pre and post major outdoor activities and citizen science opportunities in regard to pleasantness level 57% of students felt an increase in their pleasantness level post activity compared to the 6% that still felt low levels of pleasantness. While 36% stated that they felt no change in their level of pleasantness. One student said, “My favorite part was when we got to go to the 2nd and 3rd grade elementary classes. Reading my drinking water storybook was so much fun and I felt like the kids liked having us there too.” Another student wrote on their website after returning from our class field trip to the elementary school to teach them water quality, “explaining to the 5th graders about the DO [dissolved oxygen water quality test] test made me feel like a teacher myself. I liked that we were able to demonstrate how to use our tests with them outside” (Figure 8).



*Figure 8.* Mood meter: pre and post surveys, percentage of students versus change in pleasantness level, ( $N=42$ ).

Every five to six weeks recognition scores were reevaluated for each individual student in the classroom. An average was taken of these scores indicating that the highest scoring recognition item was students being on time with 74% earning above average, habit of mind. The most challenging recognition item for students to earn was, dresses appropriately, with 5% of students meeting expectations only with teacher support, such as reminders, and only 12% of students meeting the standard above and beyond, habitat of mind. Another standard that students did well on was cooperation and collaboration with 50% of students going above and beyond this standard, habit of mind, and 50% of students meeting this standard independently (Figure 9).

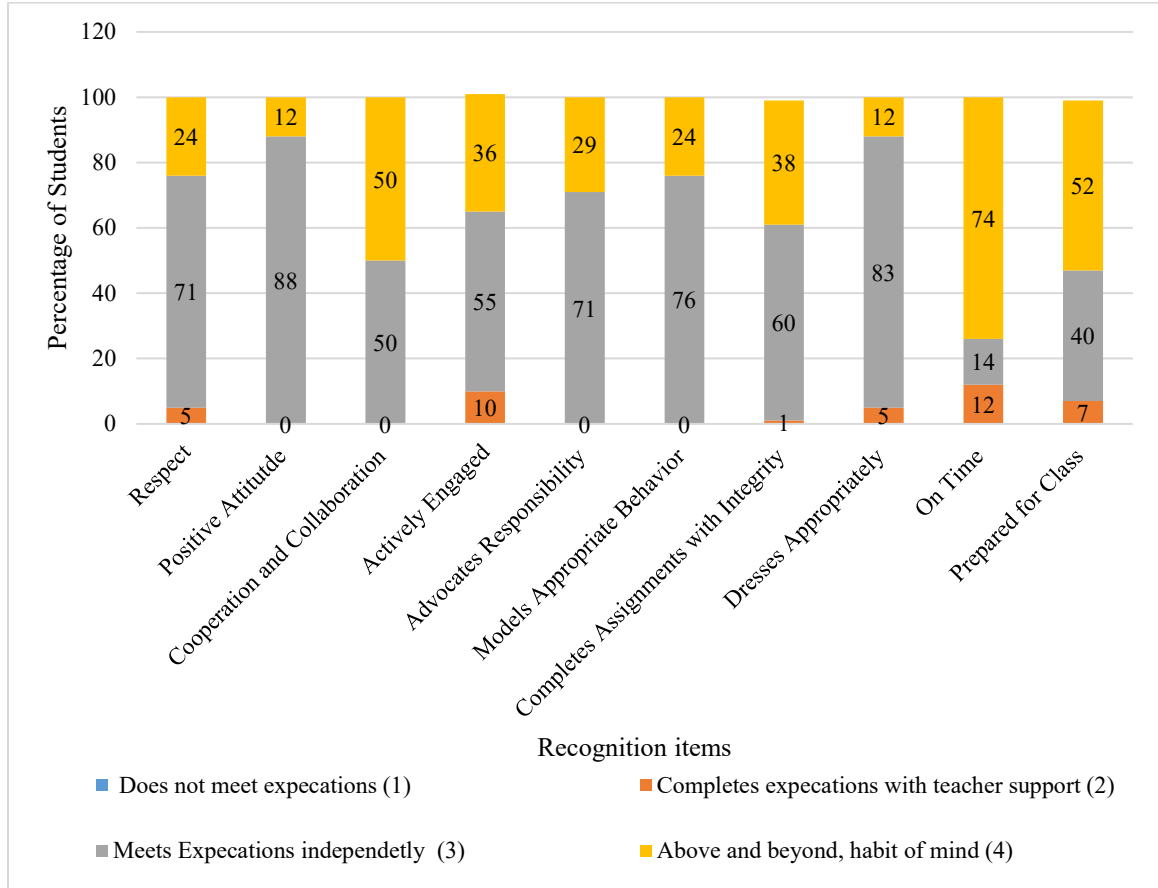


Figure 9. Percentage of students and their average recognition scores, (N=42).

## INTERPRETATION AND CONCLUSION

In my classroom I wanted to engage my students with the outside world by taking them out into the field and participating in citizen science projects. Building a curriculum around outdoor activities and integrating citizen science opportunities such as bringing in guest speakers or working with the lake association allowed my students to connect to their community and become more excited about science. Allowing students the opportunity to be outside worked well for my students as it gave them a better idea of what they valued during hands on activities. It also provided my students to feel part of the community by allowing them to collect real live data, such as the information

collected at deep-water testing sites. It also gave me a better understanding of what my students felt was important in their daily lives. I was pleased with how the field trips went, such as the fish hatchery and the drinking water tour, as it seemed to be an effective way to have students collaborate with each other and learn a real-world application (Figure 10).



*Figure 10. Canoeing in action.*

In regards to the percentage of students modeling on task behavior the data showed a clear trend in students being more on task during modules that had a greater percentage of outdoor activities. In Module 1, I had little to no major components of outdoor work and it was clear in the tally sheet data that students were more off task during this module compared to my other modules which were heavier with outdoor experiences.

I noticed that my students that had lab with me first thing in the morning, 7:45am for two hours, were more tired and lethargic to begin with compared to my afternoon lab

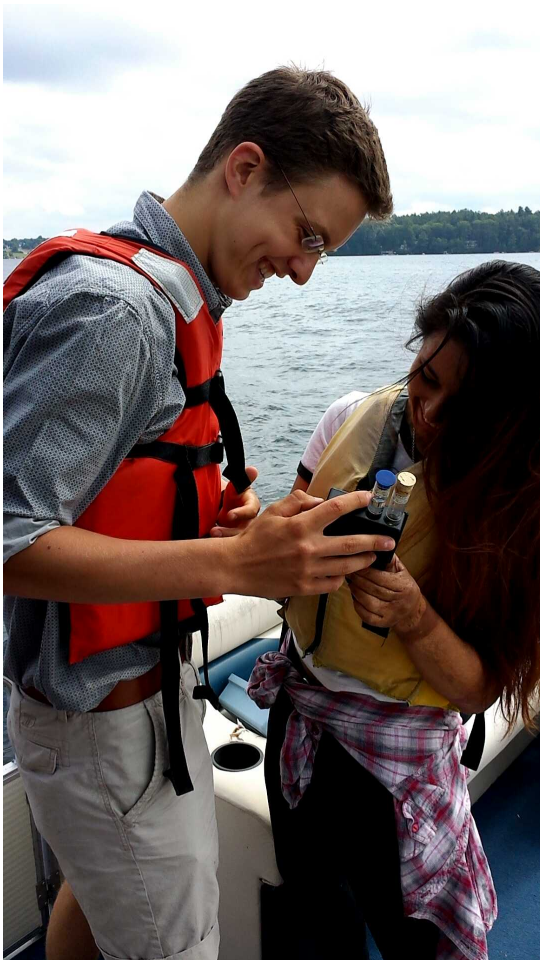
class which started at 2pm where students typically came already excited to be outside and happy that the school day was ending (Figure 11). This made the mood meter check ins, change in pleasantness and energy level, more difficult to interoperate on days when students were outside with me on the boat during these structured times. The scheduled sit spots and site descriptions helped to add to this data and paint a broader picture for me though allowed me to see that the data still trended positively with an increase in energy level and pleasantness level post outdoor or citizen science activities.



*Figure 11.* Deep water testing map reading.

I really enjoyed doing the pre and post module check ins with my students. I did them via Pear Deck surveys which allowed students to see where the whole class was feeling, while remaining anonymous to their peers. It was great to do a quick check in

with students about how they were feeling and allowed me to get a better idea of what was and was not working in my classroom (Figure 12). I also am really glad that I stuck to having students create an online website which acted as their portfolio for the class. It allowed them to be able to keep track of their work throughout the class and also provided an effective way to share the work with their parents. It made it easy for me to grade and to evaluate how students were feeling with our outdoor and citizen science components.



*Figure 12. Nitrate water quality testing.*

I wasn't very surprised with the recognition data that I received from my freshwater classes. Most of my students struggled with coming prepared to class with the appropriate gear. From forgetting gloves or good shoes to wear during our snowshoeing activity to not having enough layers for ice drilling. This impacted student recognition scores and altered what I was able to do out in the field based on how prepared students were for the elements. The rest of the recognition items I felt accurately reflected my students' progression over the course of the school year. Students in general want to earn status, and because I taught mostly seniors most students are very familiar by this time in their high school career with how the system works.

I was surprised however with how many students said they enjoyed the class and took ownership over the activities. Seeing seniors and post graduates working on their drinking water book and reading it to elementary students was incredibly rewarding for me as a teacher to see. I also loved having students passionately debate with one another about what strategies we can take as a school and a town to help protect our water. Students truly did become experts in their water quality testing and I felt reassured that students were taking their tests seriously when we went out to test our sites and reported it back to NH Fish and Game. I also loved that students didn't mind getting dirty with removing milfoil from Back Bay or patiently cleaning, monitoring, and raising our brook trout (Figure 13). Creating opportunities for students to have ownership over their own work and providing them with opportunities to do something outside of the classroom added to their overall experience of their education.



*Figure 13.* Macroinvertebrate sampling with kick nets.

#### VALUE

Citizen science increases student's awareness and attitude towards the environment while also encouraging curiosity within students. It also prompts participants to engage in their natural surroundings (Johnson, et al., 2014). At the foundation of outdoor education is this idea that students learn best when they are in an environment that allows them to investigate their natural world. Providing students with opportunities to get outside of their own classroom and partner with real scientist allows them to think bigger than themselves and engrosses them in a desire to learn.

In this study I hoped to be able to grow and learn as a teacher to provide my students with an educational experience that they would benefit from outside of my classroom. I wanted to be able to connect my students with their community. Working with international and a majority of boarder students allowed me to ground my students in their own campus by taking them outside on the boat, providing them with local experts to discuss with, and encouraging them to explore with a scientist perspective.

I fully enjoyed our class discussions and found that I liked being able to listen to my students work together as a whole class. The most meaningful part of this study was watching students that didn't fit the typical educational mold excel in my classroom in outdoor settings. I particularly liked that students felt comfortable enough to share how they were feeling in my class and with their peers. Students took it upon themselves to use their time effectively and wanted to be a part of the water quality data collection for the state of New Hampshire. I was surprised that my students were able to take such ownership over the material and teach others such as the 5th graders during our water quality testing module. The study went better than I would have expected it to go given that freshwater ecology is the only class at Brewster Academy currently designed this way and is the only class with a double lab block period associated with it.

If I was to conduct this study again I would build in more ways to collect quantitative data on my students. I would also involve other science classes in my study to see how outdoor education and citizen science opportunities could be applied in other science classrooms with other teachers.

Implementing this study into my classroom has allowed me to see how I can incorporate professional input from scientists into my curriculum and establish partnerships within my own community. I was astounded by the generosity of my guest speakers, the access to waterways to collect water quality data, the willingness of people to give my students tours, and the generosity of the Fish and Game and the lake association to work with my students. It enabled me to take a look at how I can teach this with this mindset of outdoor education and citizen science in the future and what type of

topics I may want to cover with my students next. In particular it helped shape my teaching this year at my new school, Miss Porter's School, where I have worked to establish partnerships with local public schools, Trout Unlimited, Farmington River Association, and the Kensington Fish Hatchery to allow my students to get outside and experience working with real scientific data. I hope to continue this type of technique throughout my teaching career and bring it to other teachers and new schools.

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## APPENDICES

APPENDIX A  
MONTANA STATE UNIVERSITY INSTITUTIONAL REVIEW BOARD RESEARCH  
EXEMPTION FORM



**INSTITUTIONAL REVIEW BOARD**  
**For the Protection of Human Subjects**  
**FWA 00000165**

960 Technology Blvd. Room 127  
 c/o Microbiology & Immunology  
 Montana State University  
 Bozeman, MT 59718  
 Telephone: 406-994-6783  
 FAX: 406-994-4303  
 E-mail: cherylj@montana.edu

**Chair:** Mark Quinn  
 406-994-4707  
 mquinn@montana.edu

**Administrator:**  
 Cheryl Johnson  
 406-994-4706  
 cherylj@montana.edu

**MEMORANDUM**

**TO:** Sarah Tierney and John Graves

**FROM:** Mark Quinn *Mark Quinn*  
 Chair, Institutional Review Board for the Protection of Human Subjects

**DATE:** April 2, 2019

**RE:** "The Effects of Outdoor Education and Citizen Science and Their Impacts on Student Learning in a High School Freshwater Ecology Course" [ST040219-EX]

The above research, described in your submission of April 2, 2019, is exempt from the requirement of review by the Institutional Review Board in accordance with the Code of Federal regulations, Part 46, section 101. The specific paragraph which applies to your research is:

- X   (b) (1) Research conducted in established or commonly accepted educational settings, involving normal educational practices such as (i) research on regular and special education instructional strategies, or (ii) research on the effectiveness of or the comparison among instructional techniques, curricula, or classroom management methods.
- X   (b) (2) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures or observation of public behavior, unless: (i) information obtained is recorded in such a manner that human subjects can be identified, directly or through identifiers linked to the subjects; and (ii) any disclosure of the human subjects' responses outside the research could reasonably place the subjects at risk of criminal or civil liability, or be damaging to the subjects' financial standing, employability, or reputation.
- \_\_\_\_\_ (b) (3) Research involving the use of educational tests (cognitive, diagnostic, aptitude, achievement), survey procedures, interview procedures, or observation of public behavior that is not exempt under paragraph (b)(2) of this section, if: (i) the human subjects are elected or appointed public officials or candidates for public office; or (ii) federal statute(s) without exception that the confidentiality of the personally identifiable information will be maintained throughout the research and thereafter.
- \_\_\_\_\_ (b) (4) Research involving the collection or study of existing data, documents, records, pathological specimens, or diagnostic specimens, if these sources are publicly available, or if the information is recorded by the investigator in such a manner that the subjects cannot be identified, directly or through identifiers linked to the subjects.
- \_\_\_\_\_ (b) (5) Research and demonstration projects, which are conducted by or subject to the approval of department or agency heads, and which are designed to study, evaluate, or otherwise examine: (i) public benefit or service programs; (ii) procedures for obtaining benefits or services under those programs; (iii) possible changes in or alternatives to those programs or procedures; or (iv) possible changes in methods or levels of payment for benefits or services under those programs.
- \_\_\_\_\_ (b) (6) Taste and food quality evaluation and consumer acceptance studies, (i) if wholesome foods without additives are consumed, or (ii) if a food is consumed that contains a food ingredient at or below the level and for a use found to be safe, or agricultural chemical or environmental contaminant at or below the level found to be safe, by the FDA, or approved by the EPA, or the Food Safety and Inspection Service of the USDA.

Although review by the Institutional Review Board is not required for the above research, the Committee will be glad to review it. If you wish a review and committee approval, please submit 3 copies of the usual application form and it will be processed by expedited review.

## APPENDIX B

### FRESHWATER ECOLOGY MODULE DESCRIPTIONS: SCOPE AND SEQUENCE

### Freshwater Ecology Scope and Sequence

|                                                  | <b>Module 1: Lake Winnepesaukee Watershed:</b>                                                                                                                                                                                                                                                                                                                                                                                                                       |
|--------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Module Description<br>(one paragraph)            | In this module the main focus will be for students to investigate Lake Winnepesaukee Watershed. Students will be investigating general statistics and facts, history of the watershed, general water quality parameters, environmental issues, and how the lake can be used as a resource. Students will be developing their understanding of our natural environment through hands on activities that require students to develop research and presentation skills. |
| Central or Essential Question for the Module     | Investigate Lake Winnepesaukee's Watershed                                                                                                                                                                                                                                                                                                                                                                                                                           |
| Discipline Specific Content Objectives           | <ul style="list-style-type: none"> <li>● Watershed Project investigation one of the following five topics:</li> <li>● 1. General Facts/Stats about the watershed</li> <li>● 2. History of the watershed</li> <li>● 3. Water quality of the watershed</li> <li>● 4. The lake as a resource</li> <li>● 5. Environmental issues in the watershed</li> </ul>                                                                                                             |
| Skills (Science skills, technology skills, etc.) | <ul style="list-style-type: none"> <li>● Google Website</li> <li>● Imovie</li> <li>● Lab Safety</li> <li>● Graphing</li> <li>● Data Collection</li> <li>● Research techniques</li> </ul>                                                                                                                                                                                                                                                                             |

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| Essential Abilities (list of abilities students will demonstrate in this module) | <ul style="list-style-type: none"> <li>Analyze information by breaking it down to its parts</li> <li>Be skilled at gathering information from a variety of sources including books, journal articles, periodicals, internet, etc.</li> <li>Effectively use search engines on the internet</li> <li>Acquire information from charts and graphs</li> <li>Acquire information from video, audio, web pages, etc.</li> <li>Introduce the topic by establishing the purpose (or thesis) of their presentation</li> <li>support their point of view with logical, organized arguments throughout</li> <li>conclude presentation by summarizing main points and how they support their purpose</li> <li>use verbal and nonverbal elements of delivery (e.g., eye contact, stance, movement) to maintain audience focus</li> <li>provide appropriate visual representations to support their presentation</li> <li>respond appropriately to audience comments or questions</li> <li>understand and apply the elements of a scoring rubric to improve and evaluate oral presentations</li> </ul> |
|----------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

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|----------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                              | <b>Module 2: Water Quality Testing:</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| Module Description (one paragraph)           | In this module the main focus will be for students to become an expert in one of the seven main water quality tests that we conduct. Students will learn how to do one test and then rotate through a jigsaw to conduct the other six tests that were looked at. Students will be required to conduct all tests, understand what results they're getting, and be able to apply how all tests are related to one another. All data that is being collected will be stored and sent out to New Hampshire Fish and Game as well as used in the Lake Winnepesaukee's watershed management plan. |
| Central or Essential Question for the Module | Learn how to properly conduct water quality parameter tests                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| Discipline Specific Content Objectives       | <ul style="list-style-type: none"> <li>Water Quality Tests: Becoming an expert in one of the following seven tests: pH, Temp, Turbidity/secchi disk, DO, N, P, Salinity</li> <li>Water Quality Basics: Introduction and inorganic contaminants, pollutants, DO and BOD</li> <li>Water Quality Essay: Does Lake Winnepesaukee have good or bad water quality?</li> <li>Guest Speaker - Nextgenclimate - Ryan Carney</li> <li>Guest Speaker Don Ketchmer</li> </ul>                                                                                                                           |

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| Skills (Science skills, technology skills, etc.)                                 | <ul style="list-style-type: none"> <li>● Google Website</li> <li>● Imovie</li> <li>● Graphing</li> <li>● Data Collection</li> <li>● Research techniques</li> <li>● Oral Skills</li> <li>● Observation Skills</li> <li>● Lab safety procedures</li> <li>● Lab write ups: Introduction, data, results, conclusion</li> <li>● Collaboration and Cooperation Skills</li> <li>● Presentation Skills</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| Essential Abilities (list of abilities students will demonstrate in this module) | <ul style="list-style-type: none"> <li>● Define the research question or problem sufficiently</li> <li>● be skilled at gathering information from a variety of sources including books, journal articles, periodicals, internet, etc.</li> <li>● Engage meaningfully in the process of inquiry</li> <li>● Draw connections within and across learning experiences</li> <li>● create spreadsheets for data that is provided or collected</li> <li>● use digital software to create graphs</li> <li>● create visual presentations using software (i.e. PowerPoint or keynote)</li> <li>● create and edit videos that demonstrate their learning</li> <li>● create web pages that demonstrate their learning employ web 2.0 technologies to collaborate with others</li> <li>● Establish a clear and appropriate purpose in their writing</li> <li>● maintain focus in their writing and support ideas with details and reasoning</li> <li>● use clear and varied sentence structure to create interest</li> <li>● use precise and varied word choice to create interest</li> <li>● write using standard grammar and usage</li> <li>● use the MLA method to cite sources accurately in written work</li> </ul> |

|                                    | <b>Module 3: Drinking Water</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Module Description (one paragraph) | In the Drinking Water module students will debate the use of bottled water compared to tap water. A tour will be given at the Drinking Water facility of Wolfeboro and students will be able to see firsthand how our drinking water gets treated. Students will complete a taste test so as to see for themselves the differences or similarities between different types of water. The movie Tapped will be watched and discussed followed by an in-depth project where students will write a story book where it will be shared with the local 5th grade class at Crescent Lake Elementary school. |
| Central or Essential               | Investigate drinking water and determine the threats to our natural                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |

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| Question for the Module                                                          | resource                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| Discipline Specific Content Objectives                                           | <ul style="list-style-type: none"> <li>● Drinking water Debate</li> <li>● Water Taste Test Tapped</li> <li>● Drinking Water Book</li> <li>● Tour of Drinking Water Facility</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
| Skills (Science skills, technology skills, etc.)                                 | <ul style="list-style-type: none"> <li>● Collaboration and Cooperation Skills</li> <li>● Presentation Skills</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| Essential Abilities (list of abilities students will demonstrate in this module) | <ul style="list-style-type: none"> <li>● maintain eye contact with person being spoken to</li> <li>● reference what is heard from others and formulates ideas that respond appropriately to those ideas</li> <li>● comments are relative to the topic at hand</li> <li>● Engage meaningfully in the process of inquiry</li> <li>● Draw connections within and across learning experiences</li> <li>● Technology Skills: create visual presentations using software (i.e. PowerPoint or keynote). create web pages that demonstrate their learning. employ web 2.0 technologies to collaborate with others</li> <li>● Apply acquired knowledge to novel settings</li> <li>● Employ convergent and divergent thinking skills to resolve problems or issues</li> <li>● Draw inferences and reach conclusions independently</li> <li>● Engage meaningfully in the process of inquiry</li> <li>● Draw connections within and across learning experiences</li> </ul> |

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|                                              | <b>Module 4: Freshwater Fish</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| Module Description (one paragraph)           | In Freshwater Fish students will investigate a freshwater fish species of their choosing and present their findings to the class. Students will be expected to understand what type of habitat their fish prefers, what their fish likes to eat, and most importantly what type of water quality their fish can tolerate. Students will also be raising Brook Trout, with a program called Trout in the Classroom. Students will be expected to check their progress of their Brook Trout daily, count eggs, watch hatching stages, and predict when the swimming up stage will be. Students will tour the Powder Mills Fish Hatchery and pick a release spot for their Brook Trout. Two guest speakers will come in one a fish ecologist and the other a Fish and Game specialist who will share freshwater ecosystems with the students. |
| Central or Essential Question for the Module | Learn about freshwater fish and determine where they live, what they eat, what type of habitat they need to survive in, and what type of water quality they need to thrive in. As well as raise and care for Brook Trout.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
| Discipline Specific                          | <ul style="list-style-type: none"> <li>● Powder Mills Fish Hatchery Tour</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |

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|----------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Content Objectives                                                               | <ul style="list-style-type: none"> <li>● Guest Speaker - Todd Gem</li> <li>● Trout in the Classroom</li> <li>● New England Fish Species Project</li> <li>● Guest speaker - Janine Gillum</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| Skills (Science skills, technology skills, etc.)                                 | <ul style="list-style-type: none"> <li>● Collaboration and Cooperation Skills</li> <li>● Presentation Skills</li> </ul>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| Essential Abilities (list of abilities students will demonstrate in this module) | <ul style="list-style-type: none"> <li>● Engage meaningfully in the process of inquiry</li> <li>● Draw connections within and across learning experiences</li> <li>● create visual presentations using software (i.e. PowerPoint or keynote)</li> <li>● create and edit videos that demonstrate their learning</li> <li>● create podcasts that demonstrate their learning</li> <li>● create web pages that demonstrate their learning</li> <li>● employ web 2.0 technologies to collaborate with others</li> <li>● Apply acquired knowledge to novel settings</li> <li>● Employ convergent and divergent thinking skills to resolve problems or issues</li> <li>● Draw inferences and reach conclusions independently</li> <li>● Engage meaningfully in the process of inquiry</li> <li>● Draw connections within and across learning experiences</li> </ul> |

|                                                  |                                                                                                                                                                                                                                         |
|--------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                  | <b>Module 5: Ecological Cycles</b>                                                                                                                                                                                                      |
| Module Description (one paragraph)               | In the Cycles module students will gain knowledge about five main cycles: Carbon, Phosphorus, Nitrogen, Water, and Oxygen. Students will present their findings to the class and discuss how each one impacts our freshwater ecosystem. |
| Central or Essential Question for the Module     | Investigate and understand our cycles (Carbon, Phosphorus, Nitrogen, Water, Oxygen) and how they impact our freshwater ecosystem                                                                                                        |
| Discipline Specific Content Objectives           | <ul style="list-style-type: none"> <li>● Cycles: Carbon, Phosphorus, Nitrogen, Water, Oxygen</li> </ul>                                                                                                                                 |
| Skills (Science skills, technology skills, etc.) | <ul style="list-style-type: none"> <li>● Collaboration and Cooperation Skills</li> <li>● Presentation Skills</li> </ul>                                                                                                                 |

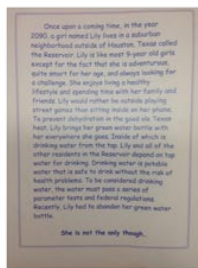
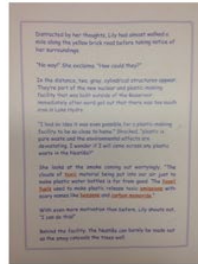
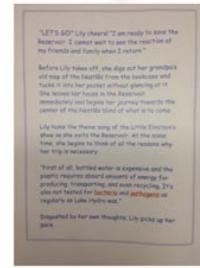
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|----------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Essential Abilities (list of abilities students will demonstrate in this module) | <ul style="list-style-type: none"> <li>• Oral Abilities – maintain eye contact with person being spoken to, reference what is heard from others and formulates ideas that respond appropriately to those ideas, comments are relative to the topic at hand</li> <li>• Engage meaningfully in the process of inquiry</li> <li>• Draw connections within and across learning experiences</li> <li>• Conduct self in manner consistent with Brewster Principle</li> <li>• demonstrate a global awareness and respect for other cultures</li> <li>• evaluate information and circumstances in order to make ethical decisions</li> <li>• work as a member of a team</li> <li>• use critical feedback to improve one's work</li> <li>• create visual presentations using software (i.e. PowerPoint or keynote)</li> <li>• create and edit videos that demonstrate their learning</li> <li>• create podcasts that demonstrate their learning</li> <li>• create web pages that demonstrate their learning</li> <li>• employ web 2.0 technologies to collaborate with others</li> <li>• Apply acquired knowledge to novel settings</li> <li>• Employ convergent and divergent thinking skills to resolve problems or issues</li> <li>• Learn new vocabulary through curriculum materials that introduce new words as part of the curriculum</li> <li>• Draw inferences and reach conclusions independently</li> <li>• Engage meaningfully in the process of inquiry</li> <li>• Draw connections within and across learning experiences</li> </ul> |
|----------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|

|                                              | <b>Module 6:Water Policies, Law, and Regulations</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|----------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Module Description (one paragraph)           | In module 6: Water Policies Laws and Regulations, students are learning the ins and outs of our freshwater policies, laws, and regulations. Students investigate and discuss the pros and cons of water law. Current events such as major conflicts and potential solutions are discussed. How water can be reused or shared is provided for students. Once students have a background they investigate one particular case study and research about how it ties into one of the various laws/policies. |
| Central or Essential Question for the Module | <ul style="list-style-type: none"> <li>• In the water policies, laws, and regulations module students learn about major water policies and laws work while investigating a particular case study of their choice.</li> </ul>                                                                                                                                                                                                                                                                            |
| Discipline Specific Content Objectives       | <ul style="list-style-type: none"> <li>• Federal Laws and regulations with water quality</li> <li>• Case Study</li> <li>• Water Law</li> </ul>                                                                                                                                                                                                                                                                                                                                                          |

|                                                  |                                                                                                                                                                                                                                                                                                      |
|--------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                  | <ul style="list-style-type: none"> <li>● Water Quality Regulations</li> <li>● Water Conflict</li> <li>● Water Solutions</li> <li>● Water Re-use</li> <li>● Guest Speaker Andrea LaMoreaux</li> </ul>                                                                                                 |
| Skills (Science skills, technology skills, etc.) | <ul style="list-style-type: none"> <li>● Case Study research skills</li> <li>● Interpreting case law/policy</li> <li>● Investigating skills</li> <li>● Debate strategies</li> <li>● Developing conclusions</li> <li>● Collaboration and Cooperation Skills</li> <li>● Presentation Skills</li> </ul> |

## APPENDIX C

### DRINKING WATER STORYBOOK EXAMPLE





So the time came for Lily—to save the Reservoir from an expensive, unhealthy habit, Lily must travel into the doomed Nestlé forest. From the outside, the forest reminds many of a foggy graveyard. Some reports say the tree change positions and sometimes it feels like you are being watched. The forest is dark and filled with inexplicable sounds. Unlike most places in Texas, there is nothing colorful or inviting about the Nestlé. It is no surprise that no one has ever dared to step one foot near the tree line. But if Lily does not succeed on her journey to the center, climate change will progress in the Reservoir indefinitely.



Finally, on December 12, an anti-corporate rally took place in front of the American Trade and Development Center building.



The tap water that *Life* and other residents of the Reservoir depend on for drinking comes from Lake Hyde. This lake contains some of the world's usable drinking water which only makes up 1% of all water on Earth. The Reservoir is lucky to have this lake practically in their backyard.

Unfortunately, three months ago, the entire southern region of Texas suffered an extreme drought. When the rain finally returned, large amounts of iron were measured in the water. The Houston Water Facility deemed the water not potable. As a result, hundreds of cases of plastic water bottles to be trucked into the Reservoir for people to drink. Over the course of just three months, every resident in the Reservoir turned their taps on and off to be disappointed. In short, people were waiting for bottled water without realizing the consequences.



"If everyone carried their own water bottle around like me, things like the Dunes of Plastic would not exist. Besides, tap water is an unlimited resource. It is natural and not processed like bottled water. Iron levels in Lake Hydroxide, tap water is readily available at all times somewhere else," Lily pointed.

*"People enjoy convenience too much..."*

...If I was to ask any water treatment engineer, they would surely say they trust

In the midst of her daydream, Lily is unaware of the fact that she crossed the tree line and is walking straight into the depths of the Nazhills.

THOUGHTS  
TO PONDER

- What are some of the benefits mentioned earlier in this story of tapped water?
- Do you think Lily is a hero?
- Why are the residents of the Reservoir so excited? Think of some reasons why.

## Glossary

**Sulfate**—sulfuric acid compound. Not an acid disease.

**Griffith's discovery** - a substance, which was later identified as DNA, was formed by incomplete combustion of carbon.

**Excretion** - the production and discharge of something, especially of waste or excrement

*Pygospio* = amphipod

acidified) - 100% at 100% of load that increases with a change in different metal, base, or acid  
 gas - potential of hydrogen is figure expressing the acidity or basicity of a solution on a logarithmic scale on which 7 is neutral, lower values are more acid, and higher values more basic

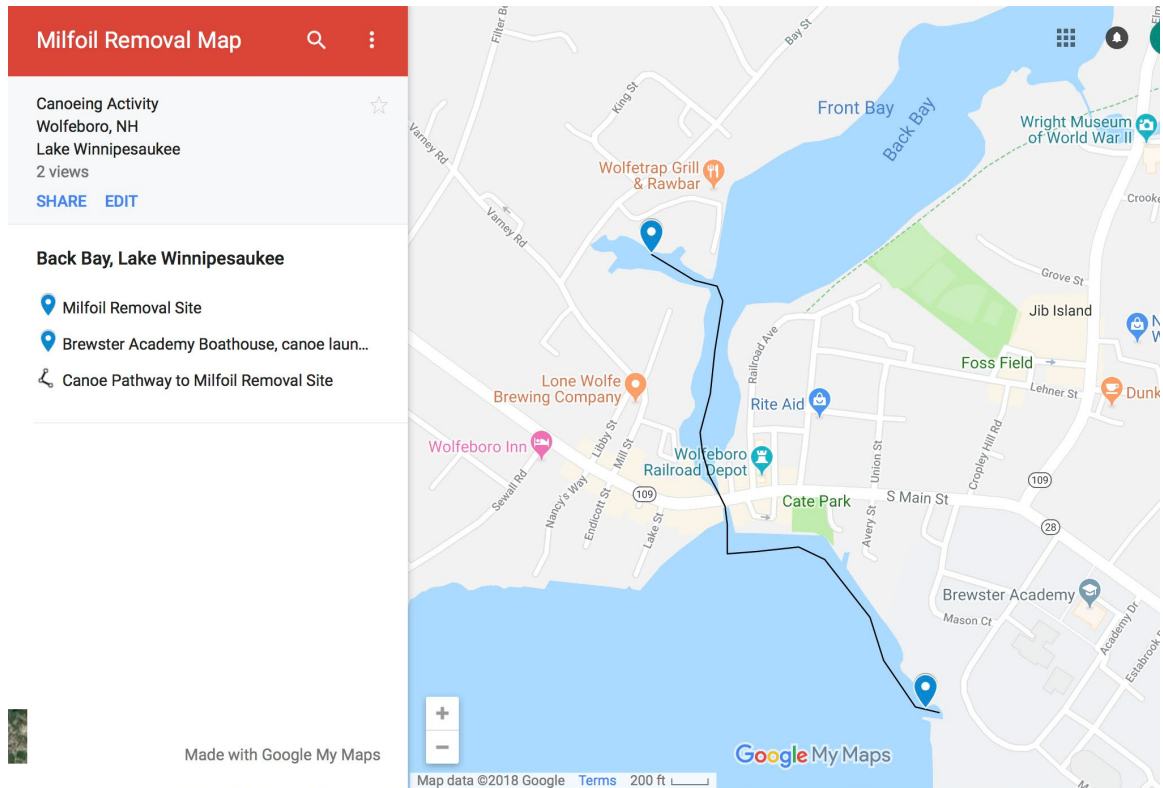
### Works Cited

[illegible]

The Day Day People: *Indigenous Communities, Multiculturalism and Spirituality* by Philip Barbour, ed. 1996. 254 pp. \$19.95.

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APPENDIX D  
MILFOIL REMOVAL SITE MAP



APPENDIX E  
WEED WATCHERS

# ENVIRONMENTAL Fact Sheet



29 Hazen Drive, Concord, New Hampshire 03301 • (603) 271-3503 • [www.des.nh.gov](http://www.des.nh.gov)

BB-4

2018

## Weed Watchers

### Volunteer Monitoring for Aquatic Invasive Plants

Freshwater aquatic invasive plants are those that are not naturally found in New Hampshire's lakes, ponds, and rivers. Because they are not native, they have no predators or diseases, which allows them to grow quickly and dominate freshwater systems and native plants, fish and aquatic insects already present. Aquatic invasive plants can lead to reduced shorefront property values, water quality impairments and problems with the aesthetic and recreational values of waterbodies. New Hampshire now has nearly 90 infested waterbodies, including 11 infested river systems and dozens of lakes and ponds, most containing variable milfoil (*Myriophyllum heterophyllum*) as the primary invasive plant, while others have fanwort, Eurasian water milfoil and water chestnut, among other common species. Dense stands of these plants inhabit shoreline areas frequented by water-based recreationalists. Exotic plants can create the following problems:

- Displacing of beneficial wildlife.
- Reducing the aesthetic quality of lakes.
- Littering of beaches with plant fragments.
- Creating difficult or dangerous swimming areas
- Snagging fish lines and stunting fish life.
- Becoming tangled in outboard motor propellers.
- Choking boat traffic lanes.
- Requiring substantial funds for managing.

The spread of these plants to other uninfected waterbodies often occurs by transient boat traffic. If accidentally introduced into a waterbody, they grow at explosive rates, some between an inch to as many as six inches a day! Many times, new infestations are not discovered until the plants become a nuisance requiring expensive control methods. Once fully established, they are virtually impossible to eradicate. Therefore, education, vigilance and early detection are key components in keeping these non-native nuisance plants in check.

"**Weed Watchers**," a volunteer program dedicated to monitoring the lakes and ponds for the presence of aquatic invasive plants, was formed by the NHDES in 1988. Volunteers are given a special "**Weed Watchers Kit**," which contains the following:

- Photographs of exotic plants.
- Detailed drawings of the plants.
- An information bulletin on exotics.
- A list of lakes known to have exotic plants, including a map.

- Recommendations on how to conduct a plant survey.
- A complete set of fact sheets and pamphlets on exotics in New Hampshire.

The Weed Watchers Kit can be sent to you at no expense. Any individual wishing to participate in the "Weed Watchers" program should contact the Exotic Species Coordinator at:

[NHDES](#)  
 29 Hazen Drive, PO Box 95  
 Concord, New Hampshire 03302-0095  
 (603) 271-2248

#### **What does a Weed Watcher do?**

All that weed watching involves is a small amount of time during the summer months. Volunteers survey their waterbody once a month from May through September. To survey, volunteers slowly boat around the perimeter of that waterbody and any islands it may contain. NHDES encourages larger waterbodies to have a team of volunteers, who can divvy up the shoreline into segments that volunteers commit to surveying, so one individual is not responsible for an entire waterbody. Using the materials provided in the Weed Watchers Kit, volunteers will then look for any species of concern, and have voucher specimens of those species verified by state biologists. After a trip or two around the waterbody, volunteers will have a good knowledge of its plant community and will immediately notice even the most subtle changes.

#### **What happens if a Weed Watcher finds an exotic plant in a waterbody?**

In most cases, volunteers will be instructed to deliver a plant specimen via mail or in person, or email photos of the species in question. Volunteers are encouraged to collect a portion of the suspect plant when it is in flower, but any part of the plant will do if there are no flowers. This may be the only way to precisely identify the plant. If the plant is a state-listed invasive, a biologist will visit the site to determine the extent of the problem and to formulate a plan of action to control the nuisance infestation.



APPENDIX F  
SITE DESCRIPTION WORKSHEET

### **Site Descriptions**

You are required to write a site description for each site that is visited throughout the year.

***The following items must be included in the site description -----***

- Site name (general location)
- Body of water name
- Date
- Time
- Weather
- Plant species (include scientific names)
- General characteristics (exs: sandy soil, rocky bottom, little plant vegetation, rough shoreline, adjacent wetland, etc.) This section should be at **least 5 sentences!**
- Water Quality Data – six total
  - Nitrate
  - Phosphate
  - Dissolved Oxygen
  - Temperature
  - pH
  - Turbidity
- General observations/interpretations – (ex: The DO level was 12mg/L indicating high oxygen levels.)
- Picture(s) – **BONUS**

***Things to be aware of----***

- Remember to include all that is listed above
- Use descriptive words
- Make sure the reader, me, can picture the area that you are describing
- Your water quality data should have the correct units

These will be due after -----

We will be handing these in as well as posting these on our websites. Do not post these on your website until they have been reviewed by Ms. Tierney.

Sarah Tierney  
Freshwater Ecology  
Site Description

- McKinney Point
- Lake Winnepesaukee
- November 22<sup>nd</sup>, 2015
- 11:30am
- 43 degrees. There were strong winds, but few clouds making it an overall sunny day.
- Dominant plant species included white pine (*Pinus strobus*), eastern hemlocks (*Tsuga Canadensis*), highbush blueberries (*Vaccinium corymbosum*)
- General characteristics included very sandy soils exposing rocks along the shoreline. The rocks seemed to be primary jagged and granite rocks. The shoreline had a solid buffer with highbush blueberries and large white pines surrounding the area. Where the shore touches the water there were an abundance of rocks. The area was sheltered from the strong winds due to all the mature trees in the area. The water was very wavy from the strong winds. Rocks could be shown about 10 to 15 feet out. The depth of the water was hard to tell, but having been to the site previously and swam there is a drop off about 20 feet out. The overall site area was littered with small pinecones, pine needles, and various rocks. There was little grass or young vegetation.
- Water Quality Data
  - Nitrate: 5 mg/L
  - Phosphate: 2mg/L
  - Dissolved Oxygen: 8 mg/L
  - Temperature: 11.2 C
  - pH: 6.2
  - Turbidity: 19 ntu
- After visiting this site I noticed that we had relatively cold water, 11.2 C, indicating that there must be good levels of oxygen as colder water tends to hold more oxygen. I also can infer that because there was a natural buffer of highbush blueberries and other tree species along the edge that there must not be as much runoff in the forms of Nitrate and Phosphate as these are both nutrient pollutants. The pH levels, 6.2, indicated good levels of acidity in the water. The ideal range to support aquatic species is a pH of 6.5 to 8, however because Lake Winnepesaukee is in New Hampshire which can be known as the tailpipe of America it is common for our bodies of water to be more on the acidic side.
- Below is a map of the site area as well as a photo showing the shoreline



APPENDIX G

PEAR DECK SURVEYS PRE/POST

| Survey Questions |                                                                                                  |                      |          |       |                   |
|------------------|--------------------------------------------------------------------------------------------------|----------------------|----------|-------|-------------------|
|                  |                                                                                                  | Strongly<br>Disagree | Disagree | Agree | Strongly<br>Agree |
| 1                | I enjoy freshwater ecology class                                                                 |                      |          |       |                   |
| 2                | I like class field trips                                                                         |                      |          |       |                   |
| 3                | I benefit from having class<br>outside                                                           |                      |          |       |                   |
| 4                | I enjoy having opportunities to<br>do citizen science projects                                   |                      |          |       |                   |
| 5                | I like the hands on opportunities<br>in the classroom and out in lab                             |                      |          |       |                   |
| 6                | I like having guest speakers in<br>the classroom and think they<br>add to my learning experience |                      |          |       |                   |

|    | Reconition Item                         | Does not<br>meet<br>expectations<br>(1) | Completes<br>expectations<br>with teacher<br>support (2) | Meets<br>Expectations<br>independently<br>(3) | Above and<br>beyond,<br>habit of<br>mind (4) |
|----|-----------------------------------------|-----------------------------------------|----------------------------------------------------------|-----------------------------------------------|----------------------------------------------|
| 1  | Respect                                 |                                         |                                                          |                                               |                                              |
| 2  | Positive Attitude                       |                                         |                                                          |                                               |                                              |
| 3  | Cooperation and Collaboration           |                                         |                                                          |                                               |                                              |
| 4  | Actively Engaged                        |                                         |                                                          |                                               |                                              |
| 5  | Advocates Responsibility                |                                         |                                                          |                                               |                                              |
| 6  | Models Appropriate Behavior             |                                         |                                                          |                                               |                                              |
| 7  | Completes Assignments with<br>Integrity |                                         |                                                          |                                               |                                              |
| 8  | Dresses Appropriately                   |                                         |                                                          |                                               |                                              |
| 9  | On Time                                 |                                         |                                                          |                                               |                                              |
| 10 | Prepared for Class                      |                                         |                                                          |                                               |                                              |

| Student Surveys       |                                                                                   |           |               |            |            |
|-----------------------|-----------------------------------------------------------------------------------|-----------|---------------|------------|------------|
| Classroom Environment |                                                                                   | Never (1) | Sometimes (2) | Mostly (3) | Always (4) |
| 1                     | My teacher manages behavior in the classroom effectively                          |           |               |            |            |
| 2                     | My teacher creates a positive learning environment                                |           |               |            |            |
| 3                     | My teacher creates an interesting learning environment                            |           |               |            |            |
| 4                     | My teacher makes class rules clear to me                                          |           |               |            |            |
| 5                     | My teacher enforces rules fairly                                                  |           |               |            |            |
| 6                     | My teacher frequently shows me how my behavior translates into Recognition scores |           |               |            |            |

| Student Surveys     |                                                                                        |           |               |            |            |
|---------------------|----------------------------------------------------------------------------------------|-----------|---------------|------------|------------|
| Classroom Practices |                                                                                        | Never (1) | Sometimes (2) | Mostly (3) | Always (4) |
| 1                   | My teacher uses teaching methods and materials that help me learn                      |           |               |            |            |
| 2                   | My teacher is knowledgeable about the subject matter                                   |           |               |            |            |
| 3                   | My teacher explains things clearly in a way that I understand                          |           |               |            |            |
| 4                   | My teacher sets realistic, yet high, expectations for me                               |           |               |            |            |
| 5                   | My teacher provides me with appropriate opportunities to practice what has been taught |           |               |            |            |
| 6                   | My teacher provides enough opportunities to participate in each lesson                 |           |               |            |            |
| 7                   | My teacher provides me with frequent opportunities to participate in each lesson       |           |               |            |            |
| 8                   | My teacher makes homework assignments clear to me                                      |           |               |            |            |
| 9                   | My teacher prepares me to do my homework successfully                                  |           |               |            |            |
| 10                  | My teacher gives me feedback in a timely fashion                                       |           |               |            |            |
| 11                  | My teacher makes grading criteria clear to me                                          |           |               |            |            |
| 12                  | My teacher helps me understand why I am placed in my instructional groupings           |           |               |            |            |
| 13                  | My teacher helps me understand how I can advance my instructional grouping             |           |               |            |            |
| 14                  | My teacher makes it clear what I need to do in a module of study                       |           |               |            |            |

APPENDIX H  
SIT SPOT ACTIVITY

### **Sit Spot**

You are required to do a sit spot – A sit spot is normally 20 minutes where you do just that sit and observe your surroundings. This means that you are take it all in. be reflective. What are you observing?

***The following items must be included in the sit spot -----***

- ☐ Site name (general location)
- ☐ Body of water name
- ☐ Date
- ☐ Time
- ☐ Weather
- ☐ Plant species (do you recognize any? If not you can draw)
- ☐ General characteristics (exs: sandy soil, rocky bottom, little plant vegetation, rough shoreline, adjacent wetland, etc.) This section should be at **least 5 sentences!**
- ☐ General observations/interpretations – (ex: the ground is sandy here therefore there must be a lot of water runoff)
- ☐ Picture(s) – Get out that artistic side! You should draw at least something that you see in detail!

***Things to be aware of----***

- ☐ Remember to include all that is listed above
- ☐ Use description words
- ☐ Make sure the reader, me, can picture the area that you are describing
- ☐ Your water quality data should have the correct units

These will be due after -----

We will be handing these in as well as posting these on our websites. Do not post these on your website until they have been reviewed by Ms. Tierney.

APPENDIX I  
STUDENT INTERVIEW QUESTIONS

**Student interview Questions**

1. What has been your favorite part or activity in this module?
2. How do you think you learned best in this module and why?
3. Describe a time when you felt most connected with your peers and the outside world in this module.
4. What do you think was the main takeaway from this module?
5. How do the topics covered in freshwater ecology connect to other classes?
6. How do you think this module relates to the big picture that is outside of our own classroom and even Brewster Academy?
7. If you could change a component about this module what would it be and why?
8. Do you have any comments or questions for me?

APPENDIX J

TALLY SHEETS OF STUDENT ENGAGEMENT

| Write in number of students displaying engaged behaviors in class at 10 minute intervals |    |    |    |    |    |
|------------------------------------------------------------------------------------------|----|----|----|----|----|
| Name                                                                                     | 10 | 20 | 30 | 40 | 50 |
| 1                                                                                        |    |    |    |    |    |
| 2                                                                                        |    |    |    |    |    |
| 3                                                                                        |    |    |    |    |    |
| 4                                                                                        |    |    |    |    |    |
| 5                                                                                        |    |    |    |    |    |
| 6                                                                                        |    |    |    |    |    |
| 7                                                                                        |    |    |    |    |    |
| 8                                                                                        |    |    |    |    |    |
| 9                                                                                        |    |    |    |    |    |
| 10                                                                                       |    |    |    |    |    |
| 11                                                                                       |    |    |    |    |    |
| 12                                                                                       |    |    |    |    |    |
| 13                                                                                       |    |    |    |    |    |
| 14                                                                                       |    |    |    |    |    |

|                                     |                                                      |
|-------------------------------------|------------------------------------------------------|
| Behavior Codes                      |                                                      |
| On task:                            | Off task:                                            |
| writing                             | starring off into space                              |
| raising hand                        | conversations not about class topics                 |
| reading aloud                       | drawing/writing that is not relivent to class topics |
| reading silently                    | motor activies not related to the class              |
| talking (in regards to class topic) | sitting quetiety and not engaged in group work       |
| asnwering questions                 | distracting others                                   |
| activley listening to classmates    |                                                      |
| activley listening to teacher       |                                                      |

## APPENDIX K

### STUDENT PORTFOLIO, GOOGLE SITES, EXAMPLE

## Online Websites

### Journal Prompt Questions

- What did you like about this lesson?
- What did you not like?
- What do you think the main takeaway was?
- How engaged do you think you were during this lesson?
- How does this lesson or unit relate to the overall module that we are studying?
- How does this lesson or unit relate to the bigger picture?
- What type of citizen science activity or outside environmental activity did you find most useful in learning about this topic?

In your journal reflection response please be specific and use concrete examples.

### Example Website:

The screenshot shows the website for Brewster Freshwater Ecology - AMF. The header includes the site name and a search bar. A left sidebar lists various navigation links such as HOME, ACCELERATED JOURNAL, ALL ABOUT ME, DRINKING WATER, CHILDREN'S BOOK "LILY THE ADVENTURER", FACT SHEET, FRESHWATER ACCELERATED PRESENTATIONS, FRESHWATER FISH PROJECT, GOOGLE CLASSROOM PAGE, GOOGLE DOC NOTES, GUEST SPEAKER REFLECTION, HATCHERY REFLECTION, PEAR DECK, PHOSPHOROUS CYCLE PROJECT, SITE DESCRIPTIONS, STAD REVIEWS, TAPPED REFLECTION, TASTE TEST/DEBATE, MODIFIED REFLECTIONS (ABSENT), VIDEO PROJECT ON MY WATER TEST (PH), WATER QUALITY ESSAY, WATER TREATMENT FACILITY REFLECTION, WATERSHED PRESENTATION - THE HISTORY OF THE WATERSHED, and SITEMAP.

The main content area is titled "Accelerated Journal" and "Year-Long Journal Entries". It displays a specific entry titled "FE - ANGIE'S JOURNAL". The entry content includes:

**"Time the Government woke up to its own advice on freshwater"**  
<http://www.scoop.co.nz/stories/PO1704/S00292/time-the-government-woke-up-to-its-own-advice-on-freshwater.htm>  
 April 26, 2017

Why did the article, "Time the Government woke up to its own advice on freshwater" catch my eye? Well, because of the pure sarcasm in the title. The article was published by Greenpeace today so it is really recent. Greenpeace's motto is, "Greenpeace exists because this fragile earth deserves a voice." Their goal is to change attitudes and behaviors in order to "protect and conserve the environment and to promote peace".

After reading the article it seems that Prime Minister Bill English has a bad reputation with environmental activists. Apparently he is pretending to care about New Zealand's rivers; yet, he is putting money towards agricultural irrigation which disrupts freshwater life by causing more pollution.

Greenpeace's purpose in writing this article specifically is to retell what the most recent report from the Ministry for the Environment states. In summary, the report reveals how nitrogen pollution has become problematic in New Zealand. The waterways of the country have deteriorated tremendously between 1990 and 2012. The circumstances are unfortunate because New Zealand is known for pristine freshwater bodies.

**The article answer a question any reader might pose--what is the**

The above is an accelerated freshwater ecology journal. There will be weekly article response entries on topics pertaining to freshwater information. The responses will be about 6-10 sentences in length and contain opinions, facts, studies, etc.. This will be maintained for the entire year.

APPENDIX L  
GUEST SPEAKER WORKSHEETS

**Guest Speaker**  
**Abi Bradford**  
NexGen Climate Change

**NAME:** \_\_\_\_\_

**B LOCK:** \_\_\_\_\_

**Part 1**

- ☐ Describe three main factors of climate change
  
- ☐ What threats do we have specifically in NH?
  
- ☐ What could we be doing as a school to help?
  
- ☐ Why is climate change still a controversial word to be discussed?
  
- ☐ List two facts that are a major threat to our waterways

**Part 2**

**Reflection**

Now, that you have had time to process our guest speaker's presentation please provide a short reflection about your overall impression and experience. How does Ms. Bradford's talk on climate change relate to what we have been learning in freshwater ecology class so far? How does this guest speaker's presentation relate to the big picture?

**Guest Speaker**  
**Judy Tumosa**  
New Hampshire Fish and Game  
Educationalist Specialist

**NAME:** \_\_\_\_\_

**B LOCK:** \_\_\_\_\_

**Part 1**

- ☐ What is New Hampshire Fish and Game?
- ☐ What is an aquatic ecosystems?
- ☐ Explain the water cycle?
- ☐ What is a habitat?
- ☐ What percentage of water is drinkable?
- ☐ What is a watershed?
- ☐ What are the 5 major watershed?
- ☐ Which watershed do we live in in Wolfeboro?
- ☐ How do we classify aquatic ecosystems?

- ☐ What is Palustrine?
- ☐ What is Lacustrine?
- ☐ What is Riverine?
- ☐ Explain Lake Succession?
- ☐ Explain the River Continuum Theory?
- ☐ Explain stream order?

**Part 2****Reflection**

Now, that you have had time to process our guest speaker's presentation please provide a short reflection about your overall impression and experience. How does Ms. Tumosa's talk on freshwater ecosystems relate to what we have been learning in freshwater ecology class so far? How does this guest speaker's presentation relate to the big picture?

**Guest Speaker**  
**Dave Burdick**  
Interim Director, Jackson Estuarine Laboratory  
Associate Research Professor

**NAME:** \_\_\_\_\_

**B LOCK:** \_\_\_\_\_

**Part 1**

- 1) What does Mr. Burdick do specifically at the Jackson Laboratory? Explain.
- 2) What are estuaries?
- 3) How are students involved at the Jackson Laboratory?
- 4) Explain what a wetland is and the properties associated with it?
- 5) Why are buffers so important? Define
- 6) What is the NH minimum requirement for buffers?
- 7) Explain what buffer bypasses are
- 8) What are riparian forest buffers?
- 9) Name two of the benefits of riparian forest buffers?
- 10) Tell me on unique fact you learned today?

**Part 2****Reflection**

Now, that you have had time to process our guest speaker's presentation please provide a short reflection about your overall impression and experience. How does Mr. Burdick's talk on buffers and wetlands relate to what we have been learning in freshwater ecology class so far? How does this guest speaker's presentation relate to the big picture?

**Guest Speaker**  
**Andrea LaMoreaux**  
**Vice President of New Hampshire Lakes Association (NH Lakes)**

**NAME:** \_\_\_\_\_

**B LOCK:** \_\_\_\_\_

**Part 1**

- 1) When was the New Hampshire Lake Association established?
- 2) List two reasons why NH lakes and ponds are important
- 3) What are aquatic invasive species?
- 4) How do aquatic invasive species spread?
- 5) How many waterbodies in New Hampshire are “infested” with invasive species?
- 6) List two invasive species
- 7) How can you prevent the spread of invasive species?
- 8) What is the NH Lake Host Program?
- 9) What is Weed Watchers?
- 10) Explain the long-term management plan

**Part 2****Reflection**

Now, that you have had time to process our guest speaker's presentation please provide a short reflection about your overall impression and experience. How does Ms. LaMoreaux's talk on invasive species relate to what we have been learning in freshwater ecology class so far? How does this guest speaker's presentation relate to the big picture?

APPENDIX M  
TROUT IN THE CLASSROOM

# TROUT

by  
Linda  
Saucerman

## in the Classroom

If you've heard the old proverb once, you've heard it a hundred times: "Give a person a fish, and they'll eat for a day. Teach a person to fish, and they'll eat for a lifetime." Now imagine what could happen if you teach a child to hatch fish from eggs, raise them into bug-eyed "fingerlings," and eventually release the fish into a cool, clear river!

That's what schools across the Granite State, in partnership with New Hampshire Fish and Game, Trout Unlimited and various other conservation-minded organizations, are doing — through an exciting program called "Trout in the Classroom."

During the 2010-11 academic year, thirty New Hampshire schools took part in the program, with students and their teachers raising Eastern brook trout, fish that can be found in New Hampshire's rivers and are a "species of conservation concern" recognized in the Wildlife Action Plan. Trout in the Classroom is just one part of N.H. Fish and Game's Watershed Education Program, supported by Sport Fish and Wildlife Restoration Funds and local grants. N.H. Fish and Game hatcheries supply the schools with fish eggs. Trout Unlimited chapters help out with donations of chillers and tank supplies. Many volunteers assist as classroom liaisons, delivering eggs and helping to address tank problems. With dedicated supporters and numerous helping hands, more than a thousand New Hampshire school children each year are learning about aquatic ecosystems in the most effective possible way — by *doing*.

### SMALL FRY, BIG IDEAS

"We got our fish on Valentine's Day," said Mackenzie Rittenhouse, a seventh grader at Dover Middle School, as she sprinkled krill into a tank for fish that were now a little over a month old.

"I like your feeding technique, but just remember not to overfeed them," advised Judy Tumosa, an aquatic resources educator for Fish and Game.

Tumosa provides the training and curriculum materials for the program and gets the needed permits, but her involvement doesn't end there. She periodically checks in on each classroom to help ensure that students and teachers have the materials and know-how they need to raise healthy fish. On this particular day, she was visiting all of the participating schools in Dover. At Garrison Elementary School, students were eager to ask Tumosa questions, show her their own version of a "fish face," or describe what they see when peeking inside the tank.

"The fry stage is when they are little. They're small trout and they're squiggly when they swim," explained Sofie Demaray of Sue Schlapak's third grade class at Garrison.

Down the hall in Elaine Marhefka's fourth grade class, the students were studying the warmwater species of fish from the river as a comparison to the life cycle of the coldwater trout species. Brianna Surawski talked about how some fish in their classroom tank survived, while others weren't so lucky. "The



pickere! tried to eat the bass, but it spit him out," she said. "The bass then got this white fuzz on its skin and then he died."

But students in the program are learning about much more than just the strange circle of life that happens between a "mean" pickere! and a "big mouth" bass and how to raise trout eggs; they're also learning about the importance of good water quality and land conservation.

"The students study water quality by taking pH levels and measuring water temperatures. For instance, brook trout don't like water above 65 degrees. They need cold water because it holds more oxygen," explained Tumosa. "And in warmer weather, we take field trips to rivers, and the students will turn over rocks to look for certain insects that cannot tolerate pollution. If you have a river that has those insects, such as the Cocheco River in Dover, then you have a river that's clean."



Clockwise from top left: Third graders from Garrison Elementary in Dover show off school projects made in the Trout in the Classroom program. Trout "fingerlings" on view at the Children's Museum of N.H. in Dover. Regan Hartley, Miss New Hampshire 2011, checks out insects collected from the Cocheco River by aquatic resources educator Judy Tumosa (right) of N.H. Fish and Game. Garrison students Michael Willett (right) and Heather Caruso release "wicked squirmy" fish into the Cocheco River during a field day.

APPENDIX N  
TOUR WORKSHEETS

**Powder Mills Fish Hatchery  
Reflection**

Please reflect upon your time at the Powder Mills Fish Hatchery.  
Here are some questions to help guide your response.

- ☐ What did you learn?
- ☐ What did you take away from the tour?
- ☐ How did this tour tie into our freshwater fish module?
- ☐ What was interesting about the tour? How did this tour tie into our freshwater fish module?
- ☐ How did this experience aid your overall understanding of our Trout in the Classroom program?
- ☐ How are you feeling about our freshwater fish module now?

**Drinking Water Facility Tour  
Reflection**

**Part 1:** Answer the questions below while you are on the tour.

- 1) Where does Wolfeboro get their drinking water from?
- 2) What is the name of our tour guide today?
- 3) How many days a year is the water treatment plant open?
- 4) Name two chemicals that are put in the water to make it safe for drinking
- 5) Name something that has to be taken out of the water to make it safe for drinking
- 6) Explain what disinfecting the water means? What is a key part of how this occurs?
- 7) What does state and federal standards mean? Why does the drinking water facility have to meet both of them?
- 8) Name TWO MAJOR steps that are required to do to make it safe to drink the water
- 9) Name ONE fact you learned
- 10) What is the flow rate per day?
- 11) Is the plant powered by electricity or gravity?
- 12) How often is the water tested?

**Part 2:**

Now that you have finished the tour please write a short summary about your experience on the tour. Please reflect upon your time at the drinking water facility.

Here are some questions to help guide your response.

- ☐ What did you learn?
- ☐ What did you take away from the tour?
- ☐ How did this tour tie into our drinking water module?
- ☐ What was interesting about the tour?
- ☐ How did this experience aid your overall understanding of how drinking water is treated?
- ☐ How are you feeling about our drinking water module now?

APPENDIX O  
TOUR SITE MAP

