Clean Water Initiative 2015

Post-Trip Report

Choluteca, Honduras

Monica Mueller
Andrea Paul
Alan Renner
Brandon Renner

June 4, 2015
# Table of Contents

A. Project Title.................................................................................................................2
B. Project Dates................................................................................................................2
C. Preamble.........................................................................................................................2
   a. Project Team............................................................................................................2
   b. Project Location.....................................................................................................2
   c. Definitions..............................................................................................................2
D. Executive Summary.....................................................................................................3
E. Background....................................................................................................................3
F. Scope of Work..............................................................................................................4
   a. Problem Statement/Needs Assessment.................................................................5
   b. Customer................................................................................................................5
   c. Challenges/Goals of Project..................................................................................5
   d. Deliverables..........................................................................................................6
   e. Plan for End User Involvement/Training/Education.............................................6
   f. Plan for Sustainability and Ownership.................................................................6
G. Research/Design/Prototype/Testing............................................................................7
   a. Participant roles/responsibilities.........................................................................7
   b. Project Schedule (Gantt chart).............................................................................7
   c. Narrative................................................................................................................
      i. Background research..........................................................................................8-10
      ii. Selectivity Process.............................................................................................10
      iii. Sketches, drawings, photos, tables.................................................................10-12
      iv. Prototyping details...........................................................................................12
      v. Testing and results.............................................................................................12
      vi. List of materials/sources..................................................................................13
      vii. Tools/materials/equipment brought from Columbus......................................13
      viii. Materials/equipment obtained in Honduras..................................................13
H. In-Country Implementation.........................................................................................14
   a. Implementation.......................................................................................................16
   b. Issues Encountered.................................................................................................21
   c. Testing....................................................................................................................22
   d. Material given to Customer...................................................................................26
I. Post-Trip Results.........................................................................................................26
   a. Objectives Achieved...............................................................................................27
   b. Sustainability and Ownership.................................................................................26
   c. Cost Analysis..........................................................................................................27
   d. Conclusions............................................................................................................28
   f. Recommendations...................................................................................................29
H. Works Cited..................................................................................................................30
I. Acknowledgements.......................................................................................................31
J. Appendix......................................................................................................................32
Project Title Clean Water Initiative (CWI)
Project Dates May 9th-23rd, 2015

Preamble

Members:
Monica Mueller
   mueller.347@osu.edu
   Environmental Engineering Major
   Team Leader

Andrea Paul
   paul.147@osu.edu
   Environmental Engineering Major
   CFO

Alan Renner
   renner.131@osu.edu
   Chemical Engineering Major
   CCO

Brandon Renner
   renner.132@osu.edu
   Chemical Engineering Major
   Document Coordinator

Location of Project:
Choluteca, Honduras and the surrounding area, especially Siete de Mayo. The water testing laboratory will be set up Angie Overholt’s clinic.

Definition of terms used in the proposal:
- SOW – Scope of work
- Nonpoint source pollution: these are sources of pollution that come from a variety of factors (i.e.: runoff)[4]
- Point source pollution: these are sources that are able to be pinpointed to a specific factor [5]
- Escherichia Coli: a bacterium that is found in the lower intestine of warm-blooded organisms. Most strands are harmless, but some serotypes can cause serious health complications.[2]
- Vibrio Cholerae: a gram-negative bacterium that can cause cholera, a small intestine infection.[3]
- CFO- Chief Financial Officer
- CCO- Chief Communications Officer
- GIS- Geographic Information System
Executive Summary

A large percentage of the world does not have access to clean water, and Honduras is no exception to this trend. According to our partners in Honduras, Choluteca’s water is not sanitary. The main problem in this area is water contaminated with *Escherichia Coli*. This is a microorganism found in water that is contaminated with human or animal feces. Consuming water contaminated with *E.coli* can cause gastrointestinal problems, diarrhea, and dehydration.\(^2\)[3]

Another problem that Choluteca faces is the lack of ability to test the water for *E.coli*. The current system is highly flawed, and the company that is currently doing the testing has questionable methods and results. With this information, the 2015 CWI team has taken on the task of starting a lab in Choluteca to test for *E.coli*. Along with setting up the lab, GIS mapping will be conducted of the local water sources, and sanitation surveys and water education brochures will be given to the local Hondurans.

To help set up the lab, an incubator has been purchased, and this will be delivered to Angie’s clinic to aid in the *E.coli* testing. After much research, a test called CHROMagar™ *E.coli* was selected to test for *E.coli*. This test was selected because it is a relatively cheap quantitative coliform test. This test will allow the team to count the number of *E.coli* colonies of each water sample; it is not just a presence or absence test. This test makes *E.coli* specifically turn blue, so it can be distinguished from other coliforms\(^7\). For the GIS/GPS mapping, an app called Endomondo was selected because it was free and fulfilled the team’s needs.

This project is sustainable because there is a company very close to Choluteca that sells CHROMagar™ products, so it should be relatively easy to purchase them without the help of OSU students. The company is called CAM International\(^8\). Also, the incubator should last for 5-10 years, and this is something that can be used year around. There is a plan for ownership as well. A local microbiologist, Maribel, will be taught how to use the lab, and after the team leaves, Maribel and Angie will truly own the lab; they can use it however they see fit. They will also be responsible for its maintenance and repair. This could create jobs opportunities for other Hondurans in the community to help with these tasks. This project will create a sustainable lab that will be owned and operated by local members of the community to help benefit the community.

A team of women known as the Health Promoters will also be trained on how to collect water safely and how to conduct sanitation surveys. This will allow the entire project to sustainable. The Health Promoters will collect the samples; then, the samples will be taken to Maribel for testing. The results will then be relayed to the villagers via the Health Promoters.

The cost analysis shows that the total cost of materials for this project is $1143.74. However, replication would only cost $3.47 per test. There would be an additional expense every couple of months to replace the pipets, but this could be an infrequent expense depending on testing frequency. The pipets cost $45.55 for 250.

The in-country results showed that the CHROMagar™ tests mirrored the professional tests that were purchased while in Honduras. The CHROMagar™ tests were able to show which wells were cleaner than others, and this was backed by the professional tests. However, there were some problems with the CHROMagar™ tests. One problem is that the CHROMagar™ tests may pass water sources that are almost clean but slightly contaminated. Also, there was a problem with sterilization, so some clean sources had colony growth with the CHROMagar™ tests. It is recommended that conclusions to these problems are researched. At just $3.47 per CHROMagar™ test, this option is much more affordable than $41.13 per professional test. This is an important option because it is much more affordable.
Background

According to water.org, it is estimated that 954 thousand out of the 8.1 million people living in Honduras do not have access to clean drinking water.[1] Drinking unclean drinking water can have very serious health effects. The main health risk with drinking contaminated water, especially water contaminated with human or animal feces, is the risk of gastrointestinal infection. Infections of this nature can cause severe diarrhea, and this can lead to dehydration and many other serious health concerns. Some of the most common microorganisms that cause infection are *Escherichia Coli* and *Vibrio Cholerae*. Both of these bacteria are found in fecal contaminated water, and they can be indicators of areas where people are consuming or washing with fecal contaminated water. Some other factors that can pollute water and cause humans to become sick are parasites and chemicals.[2][3] There is a dire need for accurate water testing, GIS mapping of water sources, and hygiene education in the country of Honduras. If these tasks can be completed in a sustainable fashion, then the quality of life for the local people of Honduras can be greatly improved.

Scope of Work

Specified Itemized SOW:

Completed:
- Create Gantt chart
- Research different GPS applications
- Test GPS application
- Research the essentials components of a water testing laboratory
- Research possible testing kits, focusing on *E.coli* tests
- From the research, pick test/test kits that will be quantitative and effective
- Create educational literature on water safety
- Research water collection and petri dish streaking methods
- Purchase/research incubators
- Purchase accessory glassware, tools, and gloves

To do:
- Acquire the test
- Extensively test the technology for functionality and sustainability
- Implement water test in Honduras
- Test the finished product for functionality
- Assist in setting up a permanent water testing laboratory while in Choluteca
- Locate, GIS map, test and conduct a sanitation surveys at identified water sources and points of use (e.g. wells, homes) in the villages
- Educate Hondurans on water safety
- Train Maribel and the Health Promoters
- Assess the incidence of water-borne disease near the water sources
- Create final Excel spreadsheet

Narrative form of SOW:

Completed Tasks:

There were a multitude of tasks that had to be completed for this project, and some of these tasks are still be in the process of completion. To begin, a Gantt chart was constructed to lay the foundation of the
semester and create deadlines. Then, the rigorous task of researching water tests and kits was undergone. There are many different parameters that can be tested in water, and the price to test each parameter can vary. Usually qualitative tests are cheaper, and quantitative tests are more expensive. The group mainly focused on researching tests that tested for \textit{E. coli} because our partners in Honduras stated that this is their biggest problem. What made this task more difficult was the fact that a quantitative test was preferred, and this can cause the price to increase drastically. After weeks of research, a coliform test was finally found, \textsc{CHROMagar™}. This test grows coliform bacteria colonies on agar in a petri dish treated with the water sample. This test is special, however, because \textit{E. coli} colonies specifically turn blue on this agar. This will allow the group to make some real quantitative assumptions about the water source, not just know whether \textit{E. coli} is present or absent.

Other research has also been conducted. Incubators were researched because this test, like any coliform test, requires an incubation period. Several incubators were selected, and one was purchased based on its weight and price. GPS applications also were explored. This is because every water source that is tested will be also be mapped. This will allow Larry and Angie see which water sources have a high \textit{E. coli} count. A free app called Endomondo was selected, and it will give the coordinates of any water source. Additional research has been done to learn about proper water collection and petri dish streaking techniques. The manuals that were found for these topics are included in the appendix.

There are a couple other smaller tasks that have been completed. These tasks included buying the appropriate glassware needed to use \textsc{CHROMagar™} and constructing the water survey and educational brochure. \textsc{CHROMagar™} does not require expensive, special equipment, but common glassware like test tubes and pipets are required.

To do:

As mentioned, there are tasks that still need to be completed. Premade \textsc{CHROMagar™} only has shelf life of 6 weeks, so it had to be ordered just prior to the trip. The order is currently being processed, so it the tests have not arrived. Once they arrive, water from the Olentangy River will be tested. This is the last item that can be completed in the United States.

Once the group arrives in Honduras, the setup of the water testing lab in Angie’s clinic will begin. After this, the group will travel to the water sources, take samples, GIS map, and conduct sanitation surveys. Educational brochures will also be distributed at this time. Then, the samples will be taken back to the lab, incubated, and the results will be put into a spreadsheet using Microsoft Excel.

\textbf{Problem Statement:}

According to Ohio State’s correspondents in Choluteca, Honduras, the water quality in Choluteca and the area that surrounds it is poor. There is an above average amount of people that live in this area that report diarrhea and gastrointestinal illness. Another very significant problem is that there is no way to test the water and get accurate results. The current third party water testing facility is both slow and costly. Without a true way to test the water, it is difficult to isolate the specific problem or contaminant. There are efforts by the local people to clean and sanitize their water with chemicals, but these methods often don’t provide great results. With these problems in mind, it is clear that there is a paramount necessity for a hygiene education, water testing, and GIS mapping in Choluteca and the areas that surround it.

\textbf{Customer:}

Inhabitants of surrounding areas of Choluteca along with Larry and Angie Overholt
Challenges/goals of the project:

The main goals of the clean water initiative are: identify potentially harmful water sources in the Choluteca area through GIS mapping, educate the community on water safety, and assist in the startup of a water testing laboratory for use by Larry and Angie Overholt. By completing these goals, we will educate the community on how to obtain safe drinking water, provide a reliable method of water testing, and lay the foundation for a new, permanent water testing facility. There are multiple challenges associated with this project which include: developing a cost effective testing kit, overcoming the cultural/language barrier, creating a testing kit with the parts available in Choluteca, and building a water testing facility for the first time in the Choluteca area. The biggest challenge, however, was finding a cost reasonable quantitative *E.coli* test.

Deliverables:

There will be several products delivered during the project. An incubator will be delivered to Angie Overholt, and it will be placed in her clinic. An incubator is essential in growing bacteria for the *E.coli* testing. The incubator was purchased from The Lab Depot, Inc[6]. There will also be 60 CHROMagar™ *E.coli* units delivered. These are the tests that will be used to test for *E.coli*. Each unit is a petri dish filled with premade agar that the distributor creates. *E.coli* shows up blue once the incubation period is finished; other gram negative bacteria show up colorless. Premade CHROMagar™ *E.coli* petri dishes must be refrigerated and have a shelf life of four to six weeks. However, it is possible to buy the powder and make the agar on demand[7]. Please refer to the user manual in the appendix for CHROMagar™ *E.coli*. There will also be a sanitation survey and water education pamphlet delivered to the inhabitants of La Bonanza. The survey will ask about the health of the individual; it will also ask where the individual or family gets their water. The pamphlet will give some tips/information on how to keep water safe and sanitary. The last deliverable will be an Excel spreadsheet that can be used to store the data collected from the different water sources.

Plan for end user involvement/training/education:

The user will need to understand how the water testing process works in order to continue testing after group implementation. Locals should be involved in the set-up of the laboratory to learn how to fix a part of the testing procedure in the future. A local microbiologist, Maribel, will help during the set up, and she will be taught the process. Training will be provided to the user to ensure accurate results following water testing. The user should receive clear instructions and basic education on the procedure and its purpose. Locals will also receive education on the importance of clean/sanitary water. This education should teach them the basics of clean water and encourage them to use the water quality testing laboratory implemented by the group.

Plan for sustainability and ownership:

Locals should be involved in building and implementing the testing laboratory in Honduras. The procedure will be explained and any repairs will be done by local Hondurans once the team has departed. As mentioned, Maribel will be using the lab after the project is over. The incubator will, if maintained with proper care, last for about 5 to years, and it can be used by Maribel or Angie for whatever purpose they see fit. There is no need for OSU students to be present for its use. The most sustainable part of this project is the fact that CHROMagar™ products are easily accessible in Choluteca. There is a company called CAM International that is just two hours away from Choluteca. This company is located in
Nicaragua, but it is still very close\textsuperscript{[8]}. This makes it easy for the product to be obtained during the entire year.

Once the project is done, the lab will truly be owned and used by Angie and Maribel. They will be in charge of its upkeep and use. This could create jobs opportunities for other Hondurans in the community to help with these tasks. They will be able to use the lab whenever they want to help the community because they own it.

**Research/Design/Prototype/Testing**

**Roles and Responsibilities:**

Monica Mueller is the team leader, and she sets up weekly meetings when necessary and leads meetings. Andrea Paul is the chief financial officer, CFO, and she is charge of budgeting and recording purchases. Alan Renner is the chief communications officer, CCO, and he manages correspondence and communicates with project contacts. Brandon Renner is the document coordinator, and he documents meetings and makes available all documentation to members.

**Project Schedule (Gantt Chart):**

The following Gantt Chart kept the group on task, and allowed us to better budget our time. All tasks accomplished, in progress, and scheduled to be completed are listed along with estimated start dates and time duration.
**Figure 1. Pre-trip Gantt Chart**

<table>
<thead>
<tr>
<th>ACTIVITY</th>
<th>PLAN START</th>
<th>PLAN DURATION</th>
<th>ACTUAL START</th>
<th>ACTUAL DURATION</th>
<th>PERCENT COMPLETE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Team Agreement</td>
<td>3</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>100%</td>
</tr>
<tr>
<td>Project Proposal</td>
<td>4</td>
<td>2</td>
<td>4</td>
<td>2</td>
<td>100%</td>
</tr>
<tr>
<td>Initial Research</td>
<td>4</td>
<td>3</td>
<td>4</td>
<td>3</td>
<td>100%</td>
</tr>
<tr>
<td>Define the problem</td>
<td>4</td>
<td>1</td>
<td>4</td>
<td>1</td>
<td>100%</td>
</tr>
<tr>
<td>Research Testing</td>
<td>5</td>
<td>5</td>
<td>5</td>
<td>10</td>
<td>100%</td>
</tr>
<tr>
<td>Contact Connections</td>
<td>5</td>
<td>10</td>
<td>5</td>
<td>10</td>
<td>100%</td>
</tr>
<tr>
<td>Find Water Test</td>
<td>5</td>
<td>4</td>
<td>5</td>
<td>4</td>
<td>100%</td>
</tr>
<tr>
<td>Research iPad Attainment</td>
<td>5</td>
<td>4</td>
<td>5</td>
<td>2</td>
<td>100%</td>
</tr>
<tr>
<td>Write Justification</td>
<td>8</td>
<td>1.5</td>
<td>8</td>
<td>1.5</td>
<td>100%</td>
</tr>
<tr>
<td>Research Prices</td>
<td>8</td>
<td>1</td>
<td>8</td>
<td>1</td>
<td>100%</td>
</tr>
<tr>
<td>Email Dan Vehr</td>
<td>8</td>
<td>1</td>
<td>8</td>
<td>1</td>
<td>100%</td>
</tr>
<tr>
<td>Find GPS App</td>
<td>11</td>
<td>1</td>
<td>11</td>
<td>1</td>
<td>100%</td>
</tr>
<tr>
<td>Sanitation Survey</td>
<td>5</td>
<td>1</td>
<td>5</td>
<td>1</td>
<td>100%</td>
</tr>
<tr>
<td>Write Educational Brochure</td>
<td>12</td>
<td>2</td>
<td>12</td>
<td>2</td>
<td>100%</td>
</tr>
<tr>
<td>Print Brochure</td>
<td>14</td>
<td>1</td>
<td>14</td>
<td>1</td>
<td>100%</td>
</tr>
<tr>
<td>Order Water Test</td>
<td>10</td>
<td>1</td>
<td>12</td>
<td>3</td>
<td>100%</td>
</tr>
<tr>
<td>Field Test Olentangy</td>
<td>12</td>
<td>1</td>
<td>2</td>
<td>13</td>
<td>100%</td>
</tr>
<tr>
<td>Make Adjustments</td>
<td>14</td>
<td>2</td>
<td>13</td>
<td>1</td>
<td>100%</td>
</tr>
<tr>
<td>Test GPS App</td>
<td>12</td>
<td>2</td>
<td>11</td>
<td>1</td>
<td>100%</td>
</tr>
<tr>
<td>Input Data from GPS</td>
<td>14</td>
<td>2</td>
<td>11</td>
<td>3</td>
<td>80%</td>
</tr>
<tr>
<td>Document Progress</td>
<td>2</td>
<td>13</td>
<td>2</td>
<td>13</td>
<td>75%</td>
</tr>
<tr>
<td>Pre-trip Documentation</td>
<td>14</td>
<td>2</td>
<td>14</td>
<td>2</td>
<td>70%</td>
</tr>
<tr>
<td>Pre-trip presentation</td>
<td>14</td>
<td>2</td>
<td>14</td>
<td>2</td>
<td>0%</td>
</tr>
<tr>
<td>Arrive in Honduras</td>
<td>17</td>
<td>1</td>
<td>17</td>
<td>1</td>
<td>0%</td>
</tr>
<tr>
<td>Set up Lab</td>
<td>18</td>
<td>0.5</td>
<td>18</td>
<td>0.5</td>
<td>0%</td>
</tr>
<tr>
<td>Survey</td>
<td>18</td>
<td>0.5</td>
<td>18</td>
<td>0.5</td>
<td>0%</td>
</tr>
<tr>
<td>Water Education</td>
<td>18</td>
<td>0.5</td>
<td>18</td>
<td>0.5</td>
<td>0%</td>
</tr>
<tr>
<td>Test Water</td>
<td>19</td>
<td>0.5</td>
<td>19</td>
<td>0.5</td>
<td>0%</td>
</tr>
<tr>
<td>GPS map</td>
<td>19</td>
<td>0.5</td>
<td>19</td>
<td>0.5</td>
<td>0%</td>
</tr>
<tr>
<td>Show how to use tests</td>
<td>19</td>
<td>0.5</td>
<td>19</td>
<td>0.5</td>
<td>0%</td>
</tr>
<tr>
<td>Input test data in to GIS app</td>
<td>19</td>
<td>0.5</td>
<td>19</td>
<td>0.5</td>
<td>0%</td>
</tr>
<tr>
<td>Post-trip documentation</td>
<td>20</td>
<td>1</td>
<td>20</td>
<td>1</td>
<td>0%</td>
</tr>
<tr>
<td>Post-trip presentation</td>
<td>20</td>
<td>1</td>
<td>20</td>
<td>1</td>
<td>0%</td>
</tr>
</tbody>
</table>

*Figure 1. Pre-trip Gantt Chart*
Figure 1a. In country Gantt chart

Narrative:

Water Tests:

A majority of the research effort was dedicated to water testing. To determine if a water source is safe to drink from, there are many tests that need to be conducted. Some of the water’s physical parameters should be tested (pH, alkalinity, turbidity). Also, the source should be tested for Escherichia Coli, heavy metal, organic, phosphorus, nitrogen, ammonia, and disinfectant contamination.

Escherichia Coli is a common source of contamination in drinking water. Escherichia coli is a member of the coliform bacterial family, and it is found in the feces of warm blooded animals. There are many health concerns that can arise for humans drinking fecal contaminated water which include: “gastrointestinal illness, skin, ear, respiratory, eye, neurologic, and wound infections. The most commonly reported symptoms are stomach cramps, diarrhea, nausea, vomiting, and low-grade fever”[13]. There are three quantitative tests for Escherichia Coli: membrane filtration, colony count, and most probable number.
Phosphorus, nitrogen, and ammonia are classified as nutrient contaminates. Nutrients enter water sources most commonly from farming runoff. High concentrations of nitrogen and phosphorus can cause eutrophication which can harm wildlife\textsuperscript{[14]}. There are three different methods for nutrient testing: strip (similar to pH strips), visual comparator, and photometer kits\textsuperscript{[15]}.

Organic compounds are another source of contamination. Common organic contaminants are benzene, dichloromethane, toluene, and many others. Drinking water with organic contamination can cause organs to fail, cardiovascular complications, an increase risk of cancer\textsuperscript{[14]}. To test for organic contamination, a biochemical oxygen demand test must be conducted. This test shows the amount of dissolved oxygen needed by biological organisms to break down the organic materials in the water\textsuperscript{[16]}.

Heavy metals are another common source of contamination. Common heavy metal contaminates are copper, zinc, cadmium, chromium, lead, arsenic and mercury\textsuperscript{[14]}. Some medical complications caused by drinking water containing heavy metals include: kidney damage, various types of cancer, gastrointestinal damage, and nervous system damage\textsuperscript{[17]}. Metal strips (similar to pH strips) are used to test the concentration of heavy metals.

Disinfectants, such as chlorine, are sometimes unregulated. If water is treated with improper amount of chlorine, it can be harmful for humans. Potential health risks are eyes/nose irritation and stomach discomfort\textsuperscript{[14]}. Chlorine strips can be used to test the amount of chlorine in the water.

Finally, physical parameters of the water must be measured. Important parameters to test are turbidity, pH, and alkalinity. Turbidity is the cloudiness in water caused by suspended particles\textsuperscript{[18]}. Turbidity can be first be tested by sight. If a water source is very cloudy or discolored, it is not safe to drink. Large amounts of cloudiness can be seen by eye. For more accurate results, turbidity meters should be used. pH is the amount of hydronium ion present in the water, and can it be measured using pH strips. Alkalinity is the ability for the water to neutralize in acid\textsuperscript{[19]}. Alkalinity is an important test to conduct because it illustrates how well a body of water can neutralize acidic pollution from acid rain and runoff\textsuperscript{[19]}. A chemical titration can be conducted to determine alkalinity.

**GPS:**

GPS mapping will be used to accurately identify which sources of water have been tested. To do this, the team researched several phone applications. The application that will meet our needs is called Endomondo. Endomondo is an application meant to map recreational runs. The team use the application when walking to the water sources. Endomondo will use our GPS signal to create a map of where we have walked. After visiting the water sources, the map created by Endomondo will then be exported to Google Earth. From Google Earth, the longitude, latitude, and elevation of the water sources can be determined.

**Sample Testing:**

For the testing procedure for the laboratory, the group decided to perform a serial dilution of the sample followed by quadrant streaking on the CHROMagar\textsuperscript{TM} plates. These methods, combined, allow any present \textit{E.coli} in the water sample to be diluted to a point where the group can count the number of colonies grown after incubation - with a target of 30 to 300 colonies on a plate\textsuperscript{[20]}. After the colonies are in this range, the colony forming units per milliliter can be calculated, giving the user a quantitative result for the \textit{E. coli} content in the water\textsuperscript{[20]}. The serial dilution test will consist of diluting the sample with purified water in increments of 0.1. For example, the first dilution will be considered a $10^{-1}$ dilution, the next a $10^{-2}$, and so on. The quadrant streaking method adds one inoculating loop of the diluted water sample to the agar plate, and then pulls from that to spread the water sample across the area of the plate.
These methods will effectively diluted the E. coli in the water samples from millions of bacterial cells in the sample to a quantifiable amount. Specific, step-by-step instructions for both the dilution and streaking methods can be referred to in the Appendix at the end of this documentation.

Collecting Water Samples:

A sterile and closable container is required to hold the collected water sample. The container should be labeled with the location, time, and date. Just before sampling, open the container, ensuring that the inside of it is left untouched. When collecting from a river or a stream, carefully go to the middle to avoid the main current. When wading to the middle, try not to disturb sediment. Collect the sample upstream, by turning the container underwater to face towards the current and away from your body. Fill the container up to about an inch from the top so that the sample can be shaken before it is analyzed.

Incubator:

In order to grow bacteria, an incubator must be able to reach a temperature of 55 degrees Celsius. The compact Incubator from The Lab Depot Inc. can reach 92 degrees Celsius. The compact incubator also weighs 25.5 pounds and has a diameter in inches of 13 by 15 by 11. American Airlines allows one baggage check for free so long as it is under 51 pounds.

Healthy Water Brochure:

The following can contaminate water: human and animal feces, trash and litter, uncovered water containers, and dirty hands. Also, rain water becomes contaminated after running along unclean roofs. In order to maintain healthy families, hands must be washed before cooking or eating, and after using the bathroom. Bathrooms must also be kept clean, and clean water sources must be protected from animals that carry diseases. Water should be kept in a container with a spout. Bathrooms should be at least 60 meters from water wells, and a canal should be dug to divert waste water from latrines from contaminating clean water.

Water can be disinfected with chlorine or by boiling it. Only 5 to 6 milliliters of chlorine should be used for every 5 gallons of water, and after treatment 30 minutes should pass before using the water. When boiling water, it should be brought to a rolling boil for one minute, and then the pot should be covered while the water cools. Hands should be washed before cleaning the water container, and the container should be scrubbed thoroughly with clean water and soap. The container used to store water should be clean, durable, and have a stable foundation.

Selectivity Process:

There were multiple steps taken to select which test would be used in Honduras. Firstly, our customers, Larry, Angie, and Maribel, expressed that Escherichia coli was their biggest concern. Because of this, the team’s research was focused on finding an appropriate coliform bacteria test. During the selection process, there were a few factors that were kept in mind. The first factor effecting the group’s decision was sustainability. Our goal is to provide a reliable method that can be continued by our customers after we leave Honduras. Secondly, the price of the test had to be reasonable. Thirdly, the test had to give quantitative results. With these factors in mind, CHROMagar™ was selected for testing. Firstly, it was selected because there is a distributor of the product in Nicaragua. The company is called CAM International, and it located two hours away from Choluteca. The group would have liked the distribution site to be in Honduras, but despite our best efforts, a distributor that meet our needs could not be identified in Honduras. Secondly, CHROMagar™ is reasonably priced. CHROMagar™ is considered a
“plate count” method of testing and requires no special equipment. The alternative methods, membrane filtration and most probable number, require special equipment and are far more expensive. Finally, this product will allow the team to quantify the amount of Escherichia coli in the water. CHROMagar\textsuperscript{TM} was the best product to fulfill the needs of the team and customer.

**Sketches, Drawings, Photos, Tables:**

**Water Survey:**

Hola. Somos estudiantes de ingeniería de la Universidad del Estado de Ohio. Estamos aquí para ayudar mejorar la calidad de agua. Podemos hacerles unas preguntas a ustedes sobre tu agua?

1. What is the main source of drinking water for members of your household?
¿Cuál es la fuente principal de tu agua potable para las personas que viven en su casa?

2. How much do you pay for bottled water and how often do you buy it?
¿Cuánto paga por su agua embotellada y con qué frecuencia lo compra?

3. What is the main source of water used by your household for other purposes?
¿Cuál es la fuente principal de agua para otros propósitos?

4. How long does it take to go there get water and come back?
¿Cuánto tiempo usa aproximadamente para ir allá, buscar agua y regresar?

5. Who usually goes to get the water?
Normalmente, ¿quién sale a buscar el agua?

6. Do you treat you water in any way to make it safer to drink?
¿Trata su agua con algún método para hacerla más segura para beber?

7. What do usually do to make the water safer to drink?
Normalmente, ¿qué hace para hacer el agua más segura beber?

8. What kind of toilet facility do members of your household usually use?
¿Qué tipo de baño están usando las personas que viven en su casa familiar?

9. Do you share the facility with other households?
¿Comparte su baño con otras familias?

   If yes, how many other households use this facility?
   Si es así, ¿cuantas otras casas familiares usan este baño?

10. How many people in the household use this facility?
¿Cuántas personas en esta casa familiar usan este baño?

11. The last time [name of the youngest child] passed stools, what was done to dispose of the stools?
El tiempo más reciente [nombre del niño menor] defeco, ¿qué hizo para deshacerse de las heces?

12. How often are you sick?
¿Con qué frecuencia se enferma?
13. Do you know what makes you sick?
Usted sabe ¿qué le hace enfermar?

14. How often do you wash your hands?
¿Con qué frecuencia se lava sus manos?

15. How clean do you think your drinking water is?
¿Qué tan limpia piensa usted está su agua potable?

Clean Water Brochure:
Prototyping Details:

In order to properly complete the dilution of the sample and avoid contamination of the samples, measures will need to be taken to ensure that all equipment is sterile. For sterilization, a flame is needed to heat the inoculating loop and test tube rim. Alcohol lamps are simple jars with a wick and alcohol to keep the wick burning, and are used to create a sterile space for microbiological use\(^\text{[22]}\). The team wanted to create sustainability in this part of the design, so an alcohol lamp will be constructed in-country using easily accessible materials purchased from either the hardware store or Maxi Despensa. The materials needed for the project are: a small glass jar, such as a baby food jar; ethyl alcohol; and a 100% cotton wick, preferably braided\(^\text{[22]}\). While the team has not been able to create a prototype for the alcohol lamp, it will be constructed and tested with the water samples before departure to Honduras in an out-of-class meeting. This fairly simple design has been proven to work many times in home microbiology experiments, so the team should not encounter many problems while constructing the prototype.

Testing and Results:

Testing was done before the group went to country to make sure that the tests were functional. A sample from the Olentangy River was collected using proper collection techniques, which will be explained in more detail in the in-country portion of this document. An unopened, clean water bottle purchased at a grocery store was also tested. Both samples came back negative for E.coli or any other coliform.
<table>
<thead>
<tr>
<th>Item</th>
<th>Manufacturer/ Source</th>
<th>Catalog Number</th>
<th>Cost:</th>
<th>Item</th>
<th>Manufacturer/ Source</th>
<th>Cost:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incubator</td>
<td>The Lab Depot Inc.</td>
<td>10-180</td>
<td>$403.50</td>
<td>Pure ethanol</td>
<td>Superstore</td>
<td>$19.97</td>
</tr>
<tr>
<td>E-Coli Tests</td>
<td>CHROMagar™</td>
<td>Pack of 10:</td>
<td>$34.70</td>
<td>Water Bottles</td>
<td>Superstore</td>
<td>$10.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$34.70</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>60 ordered:</td>
<td>$208.20</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Metal</td>
<td></td>
<td></td>
<td></td>
<td>Scotch Tape</td>
<td>Superstore</td>
<td>$2.99</td>
</tr>
<tr>
<td>Inoculator</td>
<td>Walmart</td>
<td></td>
<td>$12.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cooler</td>
<td>Walmart</td>
<td></td>
<td>$17.97</td>
<td>Cooler for</td>
<td>Superstore</td>
<td>$13.97</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Water Transport</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ice pack</td>
<td>Walmart</td>
<td></td>
<td>$7.99</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baby Food Jar</td>
<td>Walmart</td>
<td></td>
<td>$6.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100% Cotton</td>
<td>Walmart</td>
<td></td>
<td>$12.04</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rope</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10 mL</td>
<td>FisherScientific™</td>
<td>S63455</td>
<td>$14.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Graduated</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cylinder</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>125 Erlenmeyer Flask</td>
<td>Corning™</td>
<td>S63270</td>
<td>12 Pack:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pyrex™</td>
<td></td>
<td>$64.75</td>
<td>1 used:</td>
<td></td>
<td>$5.39</td>
</tr>
<tr>
<td></td>
<td>Purchased from Fisher</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.75 in</td>
<td>FisherScientific™</td>
<td>13-678-6A</td>
<td>Pack of</td>
<td></td>
<td></td>
<td>$45.55</td>
</tr>
<tr>
<td>Disposable</td>
<td></td>
<td></td>
<td>250:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soda-Lime Glass Pasteur Pipets</td>
<td></td>
<td></td>
<td>$45.55</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Glass</td>
<td>FisherScientific™</td>
<td>14-955-500</td>
<td>144 (12</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Droppers, 2 mL, Straight Pipet</td>
<td></td>
<td></td>
<td>bags of 12</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Pack:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>$106.00</td>
<td>2 bags used:</td>
<td></td>
<td>$17.66</td>
</tr>
<tr>
<td>25 mL</td>
<td>FisherScientific™</td>
<td>14-961-31</td>
<td>1000</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Disposable</td>
<td></td>
<td></td>
<td>Pack:</td>
<td></td>
<td></td>
<td>$98.46</td>
</tr>
<tr>
<td>Borosilicate Glass Tubes</td>
<td></td>
<td></td>
<td>$98.46</td>
<td>10 used:</td>
<td></td>
<td>$.98</td>
</tr>
<tr>
<td>Test Tube</td>
<td>FisherScientific™</td>
<td>14-765</td>
<td>$40.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rack</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Table 1. Pre-Trip Purchases*
In-Country Implementation

Implementation/Installation

I. Initial Setup

Upon arriving in Honduras, the team’s first objective was to set up the lab. The clinic was organized in a way to accommodate our testing. The CHROMagar dishes were placed in the refrigerator for preservation. The incubator was unpacked and placed into the clinic. The glassware, gloves, and additional tools were brought into the clinic. Also, the alcohol lamp was constructed. The supplies was gathered from the local convenient store. A hole was drilled into the lid of a baby’s food jar, and the jar was filled with isopropyl alcohol. A strip from a 100% cotton t-shirt was threaded through the hole. This allowed the strip of t-shirt to rest in the alcohol while the portion outside could be lit. An image of the alcohol lamp is shown below.

![Figure 3. Alcohol Lamp](image)
II. Water Collection

After the lab setup was complete, samples from nearby villages had to be collected. The team travelled to the nearby village of Siete de Mayo to collect the water. The team, with the aid of local villagers, collected water from local wells, rivers, and other water sources that are used. The specific locations will be shown in the results. The team was careful not to containment the samples while acquiring them. A clean water bottle was emptied, and usually, the clean water was given to the Hondurans. Next, the team member put on gloves and dipped the clean water bottle into the water source. The bottle was removed, labeled, and placed into a book bag until it reached the lab. During this process, the team was careful not to make any skin or mouth contact with the top or inside of the bottle. A picture of the collection process is shown below.

![Monica collecting water](image)

*Figure 4. Monica Collecting Water*

The team was also concerned with mapping the water sources. To do this, an application called Endomondo was used. Endomondo is a recreational running app which doesn’t require internet connection while in the field. The team would run the application during the collection trip. After the trip was complete, the map Endomondo created could be exported to Google Earth. From Google Earth, the longitude, latitude, and elevation of the water sources could be obtained. A map of the water sources from Siete de Mayo is shown below.
III. Water Testing (Method 1)

After the water was collected, it was taken for the lab for testing. The procedure for the first round of the lab test was as follows: the inoculation loop was sterilized using the alcohol lamp, the loop was dipped into the water sample, and one inoculation loop of water was spread onto the CHROMagar plate. The water sample was spread using an isolation method. An image of the streaking method is shown below.

After the plate was streaked with sample, it would be placed in the incubator and set to 97 degrees Fahrenheit. The samples would sit for 24 hours and then be taken out for inspection. The results of these tests will be discussed later.

During the first round of testing, the samples were also taken to a professional lab. This was done so the team could compare results. The comparison between the team’s results and the professional results will be discussed later.
IV. *Water Testing (Method 2)*

After the first round of testing, the team was concerned that not enough sample was being used to streak the plates. The procedure for the second round of the lab test was as follows: the inoculation loop was sterilized using the alcohol lamp, .5 milliliters of sample was pipetted out into a graduated cylinder, the .5 milliliters of the sample was dropped onto the plate using a medicine dropper, and the liquid was then spread throughout the plate using the inoculation loop. The method of collection remained the same for the second round of testing. This method gave the team more useful results. The comparison between method 1 and 2 will be discussed later.

During the second round of testing, Maribel, a local microbiologist, was brought into the lab. She was taught the second method of testing. This would allow for the water testing to continue even after the team left the country. Maribel successfully completed testing with and without the team’s help. A picture of the team instructing Maribel is below.

![Figure 7. Maribel Learning in the Lab](image)

V. *Water Surveys/Education*

The team’s next objective was to train the Health Promoters about surveying the villages about their water. The team meet with the Health Promoters in Siete de Mayo. With the aid Mariant, the team explained the importance of asking the locals about how they collect and use their water. Once the meeting was over, the team assisted the health promoters in conducting several surveys. A copy of the sanitation survey will be in the appendix. A picture of the team assisting the health promoters is shown below.
Along with surveys, the team educated the health promoters on water sanitation. To do this, the team gave the promoters healthy water brochures. This brochure included information on how people can clean, collect, and maintain water safely. A copy of this brochure will be in the appendix.

Finally, the team taught the promoters how to collect water samples from the villages. The team explained the collection process and stressed the importance wearing gloves, not touching the bottles with hands/mouth, and being sure not to contaminate waters sources during the collection process. A picture of the team explaining the collection process is shown below.
Issues Encountered

i. As stated in the results section, sterilization of the lab equipment became an issue towards the end of the stay in Honduras. During the blank water bottle test, there was growth on the agar plate. This shows that there was cross contamination during the tests.

ii. Another issue was encountered during the sanitation surveys. During the survey process, the Honduran people were not always honest with their answers. They gave answers which seemed to be embellished in order to make themselves look good. For example, when the team asked the Hondurans how often they washed their hands, they would respond by saying they wash their hands about 20 times a day. This is difficult to believe. Doctors in America probably don’t wash their hands 20 times a day. The team encountered two issues while giving the surveys. The first was an Ego issue. The Honduran people did not want to give answers that would make themselves look like they live an unsanitary life. The second issue was a cultural difference. The people of Siete de Mayo had no prior relationship with the CWI team. With the lack of trust and common ground, there was no way the villagers were going to be honest. Larry stated that it takes a lot of time and effort for the villagers to become comfortable with a stranger. The team concluded that the health promoters could get more honest answers from the villagers.

iii. The final issue the team encountered was disposing the CHROMagar plates. The team was not completely sure how to dispose of biohazard material in country. During the experiments, the team poured antibacterial soap into the plates and used duct tape to seal them. Even with these measures, more could be done to ensure proper disposal.
While in Honduras, many different water sources were tested for E.coli and other coliforms. The goal was to test wells and rivers that people were using for drinking or cleaning purposes. Both source and point-of-use samples were taken to make that the source of contamination could be pinpointed if possible. The tables below summarize all the test results that were collected. There is one table for method 1 and another table for method 2, which were explained earlier.

### Method One Results

<table>
<thead>
<tr>
<th>Source Name</th>
<th>E. coli Coliforms</th>
<th>Unknown Coliforms</th>
<th>Official Lab Results Total Coliform NMP/ml</th>
<th>Official Lab Results Escherichia Coli</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maribel's Kitchen</td>
<td>0</td>
<td>0</td>
<td>&lt;3</td>
<td>&lt;3</td>
</tr>
<tr>
<td>L&amp;A Kitchen</td>
<td>0</td>
<td>0</td>
<td>&lt;3</td>
<td>&lt;3</td>
</tr>
<tr>
<td>L&amp;A Bedroom</td>
<td>0</td>
<td>0</td>
<td>&lt;3</td>
<td>&lt;3</td>
</tr>
<tr>
<td>Siete house 1 outside</td>
<td>0</td>
<td>3</td>
<td>&gt;2400</td>
<td>&lt;3</td>
</tr>
<tr>
<td>Siete House 1 Fridge</td>
<td>0</td>
<td>0</td>
<td>1100</td>
<td>&lt;3</td>
</tr>
<tr>
<td>Siete Public Well 1</td>
<td>0</td>
<td>0</td>
<td>43</td>
<td>4</td>
</tr>
<tr>
<td>Siete Public Well 2</td>
<td>0</td>
<td>5</td>
<td>&gt;2400</td>
<td>150</td>
</tr>
<tr>
<td>Siete River</td>
<td>1</td>
<td>2</td>
<td>&gt;2400</td>
<td>&gt;2400</td>
</tr>
<tr>
<td>LB Well 1</td>
<td>0</td>
<td>13</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>LB Well 2</td>
<td>0</td>
<td>0</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>LB Well 3</td>
<td>0</td>
<td>2</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>LB House 1</td>
<td>0</td>
<td>7</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>LB House 2</td>
<td>0</td>
<td>14</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>LB Washing Hole</td>
<td>2</td>
<td>1</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>VS Girls' Bathroom</td>
<td>0</td>
<td>0</td>
<td>1100</td>
<td>23</td>
</tr>
<tr>
<td>VS Source Well</td>
<td>0</td>
<td>0</td>
<td>23</td>
<td>9</td>
</tr>
</tbody>
</table>

*Table 2. Method 1 Results.*
### Table 3. Method 2 Results

<table>
<thead>
<tr>
<th>Source Name</th>
<th>E. coli Coliforms</th>
<th>Unknown Coliforms</th>
<th>Official Lab Results Total Coliform NMP/ml</th>
<th>Official Lab Results Escherichia Coli</th>
</tr>
</thead>
<tbody>
<tr>
<td>Siete House 1 Outside</td>
<td>0</td>
<td>47</td>
<td>&gt;2400</td>
<td>&lt;3</td>
</tr>
<tr>
<td>Siete House 1 Fridge</td>
<td>0</td>
<td>11</td>
<td>1100</td>
<td>&lt;3</td>
</tr>
<tr>
<td>Siete Public Well 1</td>
<td>0</td>
<td>0</td>
<td>43</td>
<td>4</td>
</tr>
<tr>
<td>Siete Public Well 2</td>
<td>0</td>
<td>70</td>
<td>&gt;2400</td>
<td>150</td>
</tr>
<tr>
<td>Siete Public Well 3</td>
<td>1</td>
<td>100</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Siete Public Well 3 W/ Leaves</td>
<td>0</td>
<td>Uncountable (not individual)</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Siete River (Where main source goes)</td>
<td>0</td>
<td>35</td>
<td>&gt;2400</td>
<td>&gt;2400</td>
</tr>
<tr>
<td>Siete Ultimate</td>
<td>0</td>
<td>7</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Siete Mega Ultimate 1 (Main Source)</td>
<td>0</td>
<td>10</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Siete Mega Ultimate 2 (Main Source)</td>
<td>0</td>
<td>20</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>VS Girls' Bathroom</td>
<td>0</td>
<td>9</td>
<td>1100</td>
<td>23</td>
</tr>
<tr>
<td>VS Source Well</td>
<td>1</td>
<td>27</td>
<td>23</td>
<td>9</td>
</tr>
<tr>
<td>Ice 1</td>
<td>0</td>
<td>44</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Ice 2</td>
<td>0</td>
<td>0</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Ice 3</td>
<td>0</td>
<td>4</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Ice 4</td>
<td>0</td>
<td>16</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Blank 1</td>
<td>0</td>
<td>20</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Blank 2</td>
<td>0</td>
<td>0</td>
<td>N/A</td>
<td>N/A</td>
</tr>
</tbody>
</table>

**Analysis/Interpretation:**

These charts show how the second method was a superior testing method. This is can be observed in the vocational school girls’ bathroom result. The first method results gave no coliform growth for this location; however, the professional testing that was done on the same sample showed that there were 1100 NMP/ml for total coliforms, which is not safe for drinking based on the drinking standards of
Honduras. The first method cleared a contaminated drinking source, which is not satisfactory. However, the second method did show coliform growth for the girls’ bathroom at the vocational school. This shows the second method can detect a smaller amount of contamination and therefore is the safer method to use.

Based on the results, the tests administered by the CWI team were comparable to the professional tests. For example, the CHROMagar™ tests showed that the refrigerated water inside the house in Siete de Mayo was cleaner than the source outside of the house. This pattern was reflected in the professional results. A similar trend can be observed for public well 1 and 2 in Siete de Mayo. Public well 1 was considerably cleaner based on both tests; however, the CHROMagar™ results showed that public well 1 had no coliform growth with both methods, but there were coliforms present as shown by the professional testing. This could be one short fall of using the CHROMagar™ tests. The CHROMagar™ tests may pass water that is not entirely clean. Both methods tested by the CWI team showed well 1 as clean, but it was not perfectly clean. Using the CHROMagar™ tests did successfully show that well 1 was much cleaner than well 2, however.

Sterilization is another problem that is reflected in the results. The last two tests conducted in country were “blank” tests. The “blank” tests were clean, unopened water bottles. There were two samples taken from two different water bottles. “Blank 2” showed no growth, but “blank 1” had some coliform growth. Since the bottles were unopened before testing, it can be concluded that there were some issues with the sterilization methods. Some of the glassware or the inoculation loop may have been contaminated with previous samples, and this gave a false indication that the clean water was contaminated. Knowing this, new methods of sterilization methods should be researched to make sure that the results obtained are accurate as possible.

Based on the results, overall, the CHROMagar™ tests have proven to be a good alternative to professional testing. The results obtained by the CHROMagar™ tests are comparable to the professional tests, and it is easy to conclude which water sources are better than others. At just $3.47 per CHROMagar™ test, this option is much more affordable than $41.13 per professional test. No one that needs their water tested would be able to afford professional testing, so this is an important option to be available.

Full PDF scans of the professional tests will be included in the appendix. There will also be a description for each location tested in the appendix. The lab the conducted the professional tests is called the Laboratorio de Patología Acuática y Calidad de Agua, and the doctor in charge is Dr. Gabino E. Zúñiga. Based on the results, this lab seems to be a credible lab for water testing.

The sanitation survey results are summarized in the following table:

<table>
<thead>
<tr>
<th>SIETE DE MAYO</th>
</tr>
</thead>
<tbody>
<tr>
<td>Note: Sixteen surveys conducted</td>
</tr>
<tr>
<td>1) What is the main source of drinking water for members of your household?</td>
</tr>
<tr>
<td>- Spicket (Llave): 14</td>
</tr>
<tr>
<td>- Well #1: 1</td>
</tr>
<tr>
<td>- Well #2: 1</td>
</tr>
</tbody>
</table>
2) How much do you pay for bottled water/how often do you have to buy it?
   - Do not buy: 15
   - Buy bags for 2 Lempira

3) What is the main source of water used by your household for other purposes?
   - Spicket (Llave): 15 (River when spicket breaks: 1)
   - Well #1: 1

4) How long does it take to go there, get water, and come back?
   - Under 5 minutes: 5
   - 1 hour: 1

5) Who regularly retrieves the water?
   - The wife: 8

6) Do you treat your water in any way to make it safer to drink?
   - No: 11 (all that don’t use a cloth to filter)
   - Yes: 4

7) What do you usually do to the water to make it safer to drink?
   - Add chlorine: 4

8) What kind of toilet facility do members of your household usually use?
   - Latrine: 14
   - Wild: 1

9) Do you share this facility with other households?
   - No: 14

10) How many persons in the household use this toilet facility?
    - 2: 1
    - 3: 2
    - 4: 3
    - 5: 4
    - 7: 1

11) The last time your youngest child passed stools, what was done with the stools?
    - Do not have young children: 7
    - Throw away from house: 1

12) How often are you sick?
    - All of a sudden in mornings: 2
    - Once a month: 1
    - Often: 2
    - Once a year/rarely: 3

13) Do you know what makes you sick?
    - Colds: 8
    - Stomach problems: 5
    - Diabetes: 1
    - Blood Pressure: 1

14) How often do you wash your hands?
    - After bathroom/before cooking or eating: 12

15) How clean do you think your drinking water is?
    - Clean: 10
    - Not clean: 1
    - Did not know: 1

There are some concerns with these results, however. The people of Honduras are not very open to strangers they have not met, and this may cause these results to be less than accurate. However, it is the
hope that once the Health Promoters start to conduct these surveys themselves, the results will be more accurate because the Health Promoter women are trusted, know individuals.

Materials Given to Customer

- Incubator
- Glassware:
  - Test tubes
  - Graduated cylinders
  - Medicine droppers
- Inoculation loops
- Gloves
- CHROMagar plates for E. coli testing
- Excel spreadsheet for Siete de Mayo (See Appendix)
- Excel spreadsheet for La Bonanza (See Appendix)
- Sanitation Survey & Education Pamphlet
- Maps of water sources tested in Siete de Mayo and La Bonanza

Post-Trip Results

Sustainability and Ownership

As mentioned before, Maribel was successfully trained during the time in-country. She was able to complete the entire process by herself, and she even had people from her church asking her to test their water. This shows how the project is sustainable without the help of OSU students. Maribel now owns and operates the lab by herself.

Cam International, the company in Nicaragua that sells CHROMagar™ products, was also contacted while in-country. The representative stated that it would be no problem to ship products to Choluteca, and it would take about 3 days.

Health Promoters is a program started by Angie, and this program is comprised of groups of women that promote health in their respective villages. These women are trusted and well known in the community, and they already spend a lot of time in the community doing health related tasks. The CWI team decided that the Health Promoters would be perfect for the implementation of the sanitation surveys and the collection water samples. With the help of Mariant, the CWI team and the Health Promoters had a meeting; during this meeting, proper water collection methods were explained. In addition, the clean water brochures and sanitation surveys were given to the Health Promoters. The importance of the sanitation survey was explained to the Health Promoters, and then, water cleaning techniques were explained. These techniques include boiling water and treating water with chlorine. After the meeting was done, the CWI team and the Health Promoters went out into the village and conducted some sanitation surveys together.

With this training, the entire project is sustainable. The Health Promoters could now go out into the villages to collect water samples and conduct sanitation surveys. These samples could then be transported back to Maribel at the lab. Maribel then would then test the samples in the lab, and the results of the tests would be relayed back to the people using the Health Promoters. This would allow the people to know how clean their water is and if it is getting better or worse, which was the goal of the project.

Objectives Achieved
The entire SOW was successfully completed in country. What was completed is as follows:

**Completed:**
- Create Gantt chart
- Research different GPS applications
- Test GPS application
- Research the essentials components of a water testing laboratory
- Research possible testing kits, focusing on *E. coli* tests
- From the research, pick test/test kits that will be quantitative and effective
- Create educational literature on water safety
- Research water collection and petri dish streaking methods
- Purchase/research incubators
- Purchase accessory glassware, tools, and gloves
- Acquire the test
- Extensively test the technology for functionality and sustainability
- Implement water test in Honduras
- Test the finished product for functionality
- Assist in setting up a permanent water testing laboratory while in Choluteca
- Locate, GIS map, test and conduct a sanitation surveys at identified water sources and points of use (e.g. wells, homes) in the villages
- Educate Hondurans on water safety
- Train Maribel and the Health Promoters
- Assess the incidence of water-borne disease near the water sources
- Create final Excel spreadsheet

**Cost Analysis**

There were purchases made in country. Below is a table that summarizes all purchases for implementation.

<table>
<thead>
<tr>
<th>Item</th>
<th>Location</th>
<th>Cost</th>
</tr>
</thead>
</table>
### Water Tests

<table>
<thead>
<tr>
<th>Water Tests</th>
<th>Water Lab</th>
<th>$41.13 per test Total: $329.06</th>
</tr>
</thead>
</table>

### Bottled Water

<table>
<thead>
<tr>
<th>Bottled Water</th>
<th>Maxi Dispensa</th>
<th>$6.34 for 24 Pack 2 Packs: $12.68</th>
</tr>
</thead>
</table>

### Stickers

<table>
<thead>
<tr>
<th>Stickers</th>
<th>Maxi Dispensa</th>
<th>$1.37 per Pack 2 Packs: $2.74</th>
</tr>
</thead>
</table>

### Candles

<table>
<thead>
<tr>
<th>Candles</th>
<th>Maxi Dispensa</th>
<th>$.59</th>
</tr>
</thead>
</table>

### Ethanol

<table>
<thead>
<tr>
<th>Ethanol</th>
<th>Maxi Dispensa (Punto Farma)</th>
<th>$1.44</th>
</tr>
</thead>
</table>

### Glass Jars (Baby Food)

<table>
<thead>
<tr>
<th>Glass Jars (Baby Food)</th>
<th>Maxi Dispensa</th>
<th>$.69 per Jar 2 Jars: $1.38</th>
</tr>
</thead>
</table>

### 100% Cotton T-Shirt

<table>
<thead>
<tr>
<th>100% Cotton T-Shirt</th>
<th>Maxi Dispensa</th>
<th>$4.57</th>
</tr>
</thead>
</table>

*Table 4. In-Country Expenses*

### R&D Cost

There was no R&D cost associated with this project.

### Replication Cost

With the in-country and pre-trip purchases, the grand total for the project was $1143.74. However, replication would only cost $3.47 per test. There would be an additional expense every couple of months to replace the pipets, but this could be an infrequent expense depending on testing frequency. The pipets cost $45.55 for 250.

### Conclusions Regarding the Project and Technology

Although the three stages of the project could use some improvements like sterilization and Health Promoter involvement, the system ultimately achieves the team’s objectives. The collection was very successful. The team took every precaution to keep the water uncontaminated, and tracked and mapped the sample sites through Endomondo with success. This phone application was very useful and would be recommended for possible future projects continuing the Clean Water Initiative. The testing procedure was modified in-country to better serve the team and the customers’ needs. Although only E. coli was identified – along with other unknown bacteria – the testing procedure was, again, well suited for the customers’ needs, with E. coli being a large problem with the water quality in Honduras. The team was able to reproduce results and produce results comparable to those tested in a professional setting. When used for comparison, the system works well, has a high demand, and is sustainable. Finally, the sanitation surveys provided the team with important information as far as health and water use in the community. The method of taking the surveys could be improved, however, to include Health Promoters or locals with a goal of receiving more honest answers from the people interviewed. Brochures and procedures seemed to be understood by the Health Promoters and were received very well. Overall, the three stages of the project – collection, testing, and surveying – achieved the team’s and customers’ goals of providing an inexpensive, simple way to test water quality for use in the community of Choluteca, Honduras.
**Recommendations**

The CWI team suggests that more research be done with biohazard waste disposal in Choluteca and other sterilization techniques. Future teams should extend what the water is tested for, because while E.coli is a large problem in Honduras, it is not the only problem. The people of the surrounding villages of Choluteca would benefit from their water being tested for a wider variety of contaminants.

A simple filtration system would also be useful in Choluteca. The surveys indicated that many pour their water through a cloth as a means to filter out some of the larger particles in the water. This method, however, does not remove the microscopic contaminants. Boiling the water or treating it with chlorine would help, but the health promoters of La Bonanza reported that the people do not like these methods because they cause the water to taste strange. A filtration system that does not alter the taste of the water and simple to use would greatly improve the health of the villages.

An additional project that would improve the quality of water in Choluteca is the creation of clean, functional latrines. The proper disposal and containment of human waste is essential in order to maintain clean water. If latrines overflow, the waste could potentially flow into the water source, which could lead to serious sickness. In the interest of clean water, it is advised that functional and culturally acceptable latrines are designed and constructed for the people of Choluteca.
Works Cited:

Acknowledgements

A special thanks to:

Roger Dzwoncezyk
Mariantonieta Gutterez Soto
Angie Overholt
Larry Overholt
Maribel Estrada
Appendix:

**Serial Dilutions** [20]  
1. Begin with collected water sample  
2. Add 9 mL of purified water to a separate test tube with 1 mL of the water sample  
   - This is a $10^{-1}$ dilution  
3. Taking 1 mL from the test tube in the previous step, add it to 9 mL of purified water in a separate test tube  
   - This is a $10^{-2}$ dilution  
4. Repeat step 3 for as many dilutions as necessary

**Quadrant Streaking** [21]  
1. Divide the agar plate visually or with a marker into three of four sections  
2. Flame the inoculating loop and allow to cool  
3. Dip the loop into the water sample after re-suspending sample  
4. Streak a zig-zag pattern across one section of the plate  
5. Re-flame loop and let cool  
6. Start in section 1, crossing over part of the zig-zag, then proceed to zig-zag across section 2  
7. Repeat steps 5 & 6 until all sections have been filled with sample  

Notes:  
- Be sure to fill the entire plate, not just the outer edge  
- Be sure to just graze surface of agar, not gouging into or scraping the top of the medium  
- Visual examples:
Water Sources

5/11/2015
Siete de Mayo:

1. Public Well #1
2. House #1 (outside)
   a. Notes: excrement next to stagnant water; comes from “La Tajellada”; outhouse up hill; clothes drying near open water container
3. House #1 (fridge)
   a. Notes: Uses a cloth to filter the water into the bucket, then stores water in a closed container in the fridge
4. Public Well #2
   a. Notes: Some people who live by don’t have a big storage container so they just go to this well
5. River
   a. Notes: Low flow; people washing clothes; animal waste nearby; trash

5/12/2015
La bonanza:

1. Washing Well
   a. Notes: Stagnant water in barrel; only used for cleaning and washing
2. Well #1
   a. Notes: Stagnant water in covered well; everyone uses a different bucket from their house to scoop out water because the pump is broken
3. Well #2
   a. Notes: Covered well; pump; fenced in and locked; unlocked once every three days
4. House #1
   a. Notes: Poured from a bag that had been stored in their fridge
5. House #2
   a. Notes: Poured from cup
6. Well #3
   a. Notes: Water low; wash station and outhouse nearby

5/13/2015
Vocational School:

1. Girls Bathroom
   a. Notes: tap water; sink dirty
2. Source Well
   a. Notes: locked tank; tap open

5/15/2015
Siete de Mayo:

1. Well #3
1. Notes: Burn pit nearby; covered well; need bucket to retrieve water because the pump is broken; no one uses it since the pump is broken

2. Ultimate Source #1
   a. Notes: water constantly moving; uphill trek; add chlorine; 10,000 gallons; made 30 years ago; every 15 days 5 people empty, scrub and disinfect it

3. Mega Ultimate #1
   a. Notes: Over flows sometimes; clean it with bushes and chlorine; surrounded by barbed wire; spider webs; covered by heavy cement lid (took three people to lift it); 42 people use this source; pay 4000 limpiras for electricity to pump the water

4. Mega Ultimate #2
   a. Notes: heavy cover; goes directly to people; fills the tank; spider webs

Excel Spreadsheets left with Angie and Maribel
Clean Water Initiative 2015 Project Proposal

Date: January 29, 2015

Project title: Clean Water Initiative (CWI)

Members:

Monica Mueller
mueller.347@osu.edu
Environmental Engineering Major
Team Leader

Andrea Paul
paul.147@osu.edu
Environmental Engineering Major
CFO

Alan Renner
renner.131@osu.edu
Chemical Engineering Major
CCO

Brandon Renner
renner.132@osu.edu
Chemical Engineering Major
Document Coordinator

Customer:
Inhabitants of surrounding areas of Choluteca

Definition of terms used in the proposal:

SOW – Scope of work

Nonpoint source pollution: these are sources of pollution that come from a variety of factors (i.e.: runoff)\(^4\)

Point source pollution: these are sources that are able to be pinpointed to a specific factor\(^5\)

Escherichia Coli: a bacterium that is found in the lower intestine of warm-blooded organisms. Most strands are harmless, but some serotypes can cause serious health complications.\(^2\)

Vibrio Cholerae: a gram-negative bacterium that can cause cholera, a small intestine infection.\(^3\)

CFO- Chief Financial Officer
CCO- Chief Communications Officer
GIS- Geographic Information System

Background:
According to water.org, it is estimated that 954 thousand out of the 8.1 million people living in Honduras do not have access to clean drinking water. Drinking unclean drinking water can have very serious health effects. The main health risk with drinking contaminated water, especially water contaminated with human or animal feces, is the risk of gastrointestinal infection. Infections of this nature can cause severe diarrhea, and this can lead to dehydration and many other serious health concerns. Some of the most common microorganisms that cause infection are *Escherichia Coli* and *Vibrio Cholerae*. Both of these bacteria are found in fecal contaminated water, and they can be indicators of areas where people are consuming or washing with fecal contaminated water. Some other factors that can pollute water and cause humans to become sick are parasites and chemicals. There is a dire need for accurate water testing, GIS mapping of water sources, and hygiene education in the country of Honduras. If these tasks can be completed in a sustainable fashion, then the quality of life for the local people of Honduras can be greatly improved.

**Problem Statement:**

According to Ohio State`s correspondents in Choluteca, Honduras, the water quality in Choluteca and the area that surrounds it is poor. There is an above average amount of people that live in this area that report diarrhea and gastrointestinal illness. Another very significant problem is there is no way to test the water and get accurate results. The current third party water testing facility is both slow and costly. Without a true way to test the water, it is difficult to isolate the specific problem or contaminate. There are efforts by the local people to clean and sanitize their water with chemicals, but these methods often don’t provide great results. With these problems in mind, it’s clear that there is a paramount necessity for a hygiene education, water testing, and GIS mapping in Choluteca and the areas that surround it.

**Challenges/goals of the project:**

The main goals of the clean water initiative are: identify potentially harmful water sources in the Choluteca area (GIS mapping), educate the community on water safety, and assist in the startup of a water testing laboratory in the Choluteca area. By completing this goals, we will educate the community on how to obtain safe drinking water, provide a reliable method of water testing, and lay the foundation for a new, permanent water testing facility. There are multiple challenges associated with this project which include:
- Developing a cost effective testing kit  
- Overcoming the cultural/language barrier  
- Creating a testing kit with the parts available in Choluteca  
- Building a water testing facility for the first time in the Choluteca area

**SOW/specific objectives:**

- Research the essentials components of a water testing laboratory  
- Research possible home testing kits  
- Create educational literature on water safety  
- From the research, create multiple different testing kits and determine which is the most effective  
- Build/acquire a prototype of the most effective testing kit  
- Extensively test the technology for functionality and sustainability  
- Implement finished product in Honduras  
- Test the finished product for functionality  
- Assist in setting up a permanent water testing laboratory while in Choluteca
- Locate, GIS map, test and conduct sanitation surveys at identified water sources and points of use (e.g. wells, homes) in the villages
- Assess the incidence of water-borne disease near the water sources.

**Testing:**

- Assess common water testing methods
- Gather the most effective tests so that a test is available for each common water impurity
- Evaluate gathered tests for potential issues (i.e. cultural acceptability, availability of materials, cost, usability, and durability)
- Ensure the final set of tests is able to check for the common impurities found in the water of the surrounding areas of Choluteca
- Judge the durability of the tests in order to check how it withstands high temperatures, UV light and water
- Input sample data into chosen GIS software in order to better understand how the system operates

**Deliverables:**
The customer will be provided with a simple water testing lab to expedite the process of testing the quality of water. A short and clearly written pamphlet will be provided, which will briefly outline key concepts about water safety. GIS software will be provided to help find point and nonpoint sources of water pollution. The initial gathered data will be inputted into the system.

**Plan for end user involvement/training/education:**
The user will need to understand how the water testing process works in order to continue testing after group implementation. Locals should be involved in the set-up of the laboratory to learn how to fix a part of the testing procedure in the future. The use of local materials to build the lab will also allow for easier repairs for the user. Training will be provided to the user to ensure accurate results following water testing. The user should receive clear instructions and basic education on the procedure and its purpose. Locals will also receive education on the importance of clean/sanitary water. This education should teach them the basics of clean water and encourage them to use the water quality testing laboratory implemented by the group.

**Plan for sustainability and ownership**
Locals should be involved in building and implementing the testing laboratory in Honduras. The procedure will be explained and the materials will be purchased locally to ensure the project is accepted and is sustainable. Locals should also be able to repair part of the lab in the future should something break, again promoting sustainability and a long life of the project after implementation. The sustainability will stem from the promotion of ownership in the project. Ownership will be promoted by getting locals involved in the building of the testing lab. Purchasing materials in Honduras will also promote both ownership and sustainability in the project.
Works Cited:


Clean Water Initiative 2015: Team Agreement
January 29, 2015

1. Members:

   Monica Mueller
      mueller.347@osu.edu
      Environmental Engineering Major

   Andrea Paul
      paul.147@osu.edu
      Environmental Engineering Major

   Alan Renner
      renner.131@osu.edu
      Chemical Engineering Major

   Brandon Renner
      renner.132@osu.edu
      Chemical Engineering Major

2. Roles:

   Team Leader – Monica Mueller
      Set up weekly meetings when necessary
      Lead meetings

   CFO – Andrea Paul
      Manage budget
      Record purchases

   CCO – Alan Renner
      Manage correspondence
Communicate with project contacts

Document Coordinator – Brandon Renner
Document meetings
Make available all documentation to members

3. Decision Making Process

All major decisions will be made through a vote, where all members have an equal vote.
In the case of a tied vote, a compromise will be reached through a mediator.
Members may communicate via email, texting, phone, meetings and buckeye box.

If member realizes he/she will be late, the individual will let another group member know.

Reserved meeting time is Saturday at 1pm on the third floor of SEL.

4. Conflict Resolution

Talk with the individual.
Bring it to the group with both sides being heard.
Talk to Mariant or Roger.

Monica Mueller
Andrea Paul

Alan Renner
Brandon Renner
Clean Water Initiative 2015

Pre-Trip Report

Choluteca, Honduras

Monica Mueller
Andrea Paul
Alan Renner
Brandon Renner

April 23, 2015
# Table of Contents

A. Project Title........................................................................................................2
B. Project Dates........................................................................................................2
C. Preamble...............................................................................................................2
   a. Project Team.................................................................................................2
   b. Project Location..........................................................................................2
   c. Definitions..................................................................................................2
D. Executive Summary............................................................................................3
E. Background..........................................................................................................3
F. Scope of Work......................................................................................................4
   a. Problem Statement/Needs Assessment.........................................................5
   b. Customer.....................................................................................................5
   c. Challenges/Goals of Project.......................................................................5
   e. Deliverables...............................................................................................6
   f. Plan for End User Involvement/Training/Education.................................5
   g. Plan for Sustainability and Ownership.......................................................6
G. Research/Design/Prototype/Testing.................................................................7
   a. Participant roles/responsibilities..............................................................7
   b. Project Schedule (Gantt chart).................................................................7
   c. Narrative.....................................................................................................
      i. Background research...........................................................................8-10
      ii. Selectivity Process............................................................................10
      iii. Sketches, drawings, photos, tables.................................................10-12
      iv. Prototyping details...........................................................................12
      v. Testing and results.............................................................................12
      vi. List of materials/sources.................................................................13
      vii. Tools/materials/equipment brought from Columbus......................13
      viii. Materials/equipment obtained in Honduras..................................13
H. Works Cited.......................................................................................................14
I. Acknowledgements............................................................................................15
J. Appendix.............................................................................................................16
**Project Title** Clean Water Initiative (CWI)

**Project Dates** May 9th-23rd, 2015

**Preamble**

**Members:**

Monica Mueller  
mueller.347@osu.edu  
Environmental Engineering Major  
Team Leader

Andrea Paul  
paul.147@osu.edu  
Environmental Engineering Major  
CFO

Alan Renner  
renner.131@osu.edu  
Chemical Engineering Major  
CCO

Brandon Renner  
renner.132@osu.edu  
Chemical Engineering Major  
Document Coordinator

**Location of Project:**

Choluteca, Honduras and the surrounding area, especially La Bonanza. The water testing laboratory will be set up Angie Overholt’s clinic.

**Definition of terms used in the proposal:**

- **SOW** – Scope of work
- **Nonpoint source pollution:** these are sources of pollution that come from a variety of factors (i.e.: runoff)**[4]**
- **Point source pollution:** these are sources that are able to be pinpointed to a specific factor**[5]**
- **Escherichia Coli:** a bacterium that is found in the lower intestine of warm-blooded organisms. Most strands are harmless, but some serotypes can cause serious health complications.[2]
- **Vibrio Cholerae:** a gram-negative bacterium that can cause cholera, a small intestine infection.[3]
- **CFO:** Chief Financial Officer
- **CCO:** Chief Communications Officer
- **GIS:** Geographic Information System
Executive Summary

A large percentage of the world does not have access to clean water, and Honduras is no exception to this trend. According to our partners in Honduras, Choluteca’s water is not sanitary. The main problem in this area is water contaminated with *Escherichia Coli*. This is a microorganism found in water that is contaminated with human or animal feces. Consuming water contaminated with *E.coli* can cause gastrointestinal problems, diarrhea, and dehydration.\(^2\)[3]

Another problem that Choluteca faces is the lack of ability to test the water for *E.coli*. The current system is highly flawed, and the company that is currently doing the testing has questionable methods and results. With this information, the 2015 CWI team has taken on the task of starting a lab in Choluteca to test for *E.coli*. Along with setting up the lab, GIS mapping will be conducted of the local water sources, and sanitation surveys and water education brochures will be given to the local Hondurans.

To help set up the lab, an incubator has been purchased, and this will be delivered to Angie’s clinic to aid in the *E.coli* testing. After much research, a test called CHROMagar™ *E.coli* was selected to test for *E.coli*. This test was selected because it is a relatively cheap quantitative coliform test. This test will allow the team to count the number of *E.coli* colonies of each water sample; it is not just a presence or absence test. This test makes *E.coli* specifically turn blue, so it can be distinguished from other coliforms\(^7\). For the GIS/GPS mapping, an app called Endomondo was selected because it was free and fulfilled the team’s needs.

This project is sustainable because there is a company very close to Choluteca that sells CHROMagar™ products, so it should be relatively easy to purchase them without the help of OSU students. The company is called CAM International\(^8\). Also, the incubator should last for 5-10 years, and this is something that can be used year around. There is a plan for ownership as well. A local microbiologist, Maribel, will be taught how to use the lab, and after the team leaves, Maribel and Angie will truly own the lab; they can use it however they see fit. They will also be responsible for its maintenance and repair. This could create jobs opportunities for other Hondurans in the community to help with these tasks. This project will create a sustainable lab that will be owned and operated by local members of the community to help benefit the community.

The cost analysis shows that the total cost of materials for this project is $848.21.

Unfortunately, the CHROMagar™ tests have not arrived yet, so no testing has been conducted with them, but the GPS app has been tested. However, once they arrive test will be conducted of the Olentangy River. Once the team arrives in Honduras, the testing and mapping of the sources will begin. All the data will be compiled onto one final Excel spreadsheet, and this will be given to Larry and Angie for their use.

Background

According to water.org, it is estimated that 954 thousand out of the 8.1 million people living in Honduras do not have access to clean drinking water.\(^1\) Drinking unclean drinking water can have very serious health effects. The main health risk with drinking contaminated water, especially water contaminated with human or animal feces, is the risk of gastrointestinal infection. Infections of this nature can cause severe diarrhea, and this can lead to dehydration and many other serious health concerns. Some of the most common microorganisms that cause infection are *Escherichia Coli* and *Vibrio Cholerae*. Both of these bacteria are found in fecal contaminated water, and they can be indicators of areas where people are consuming or washing with fecal contaminated water. Some other factors that can pollute water and cause humans to become sick are parasites and chemicals.\(^6\)[3] There is a dire need for accurate water testing,
GIS mapping of water sources, and hygiene education in the country of Honduras. If these tasks can be completed in a sustainable fashion, then the quality of life for the local people of Honduras can be greatly improved.

**Scope of Work**

**Specified Itemized SOW:**

Completed:
- Create Gantt chart
- Research different GPS applications
- Test GPS application
- Research the essentials components of a water testing laboratory
- Research possible testing kits, focusing on *E.coli* tests
- From the research, pick test/test kits that will be quantitative and effective
- Create educational literature on water safety
- Research water collection and petri dish streaking methods
- Purchase/research incubators
- Purchase accessory glassware, tools, and gloves

Still in progress/to do:
- Acquire the test
- Extensively test the technology for functionality and sustainability
- Implement water test in Honduras
- Test the finished product for functionality
- Assist in setting up a permanent water testing laboratory while in Choluteca
- Locate, GIS map, test and conduct a sanitation surveys at identified water sources and points of use (e.g. wells, homes) in the villages
- Educate Hondurans on water safety
- Assess the incidence of water-borne disease near the water sources
- Create final Excel spreadsheet

**Narrative form of SOW:**

Completed Tasks:

There were a multitude of tasks that had to be completed for this project, and some of these tasks are still be in the process of completion. To begin, a Gantt chart was constructed to lay the foundation of the semester and create deadlines. Then, the rigorous task of researching water tests and kits was undergone. There are many different parameters that can be tested in water, and the price to test each parameter can vary. Usually qualitative tests are cheaper, and quantitative tests are more expensive. The group mainly focused on researching tests that tested for *E.coli* because our partners in Honduras stated that this is their biggest problem. What made this task more difficult was the fact that a quantitative test was preferred, and this can cause the price to increase drastically. After weeks of research, a coliform test was finally found, CHROMagar™. This test grows coliform bacteria colonies on agar in a petri dish treated with the water sample. This test is special, however, because *E.coli* colonies specifically turn blue on this agar. This will allow the group to make some real quantitative assumptions about the water source, not just know whether *E.coli* is present or absent.
Other research has also been conducted. Incubators were researched because this test, like any coliform test, requires an incubation period. Several incubators were selected, and one was purchased based on its weight and price. GPS applications also were explored. This is because every water source that is tested will be also be mapped. This will allow Larry and Angie see which water sources have a high E.coli count. A free app called Endomondo was selected, and it will give the coordinates of any water source. Additional research has been done to learn about proper water collection and petri dish streaking techniques. The manuals that were found for these topics are included in the appendix.

There are a couple other smaller tasks that have been completed. These tasks included buying the appropriate glassware needed to use CHROMagar™ and constructing the water survey and educational brochure. CHROMagar™ does not require expensive, special equipment, but common glassware like test tubes and pipets are required.

To be completed:

As mentioned, there are tasks that still need to be completed. Premade CHROMagar™ only has shelf life of 6 weeks, so it had to be ordered just prior to the trip. The order is currently being processed, so it the tests have not arrived. Once they arrive, water from the Olentangy River will be tested. This is the last item that can be completed in the United States.

Once the group arrives in Honduras, the setup of the water testing lab in Angie’s clinic will begin. After this, the group will travel to the water sources, take samples, GIS map, and conduct sanitation surveys. Educational brochures will also be distributed at this time. Then, the samples will be taken back to the lab, incubated, and the results will be put into a spreadsheet using Microsoft Excel.

Problem Statement:

According to Ohio State’s correspondents in Choluteca, Honduras, the water quality in Choluteca and the area that surrounds it is poor. There is an above average amount of people that live in this area that report diarrhea and gastrointestinal illness. Another very significant problem is that there is no way to test the water and get accurate results. The current third party water testing facility is both slow and costly. Without a true way to test the water, it is difficult to isolate the specific problem or contaminant. There are efforts by the local people to clean and sanitize their water with chemicals, but these methods often don’t provide great results. With these problems in mind, it is clear that there is a paramount necessity for a hygiene education, water testing, and GIS mapping in Choluteca and the areas that surround it.

Customer:

Inhabitants of surrounding areas of Choluteca along with Larry and Angie Overholt

Challenges/goals of the project:

The main goals of the clean water initiative are: identify potentially harmful water sources in the Choluteca area through GIS mapping, educate the community on water safety, and assist in the startup of a water testing laboratory for use by Larry and Angie Overholt. By completing these goals, we will educate the community on how to obtain safe drinking water, provide a reliable method of water testing, and lay the foundation for a new, permanent water testing facility. There are multiple challenges associated with this project which include: developing a cost effective testing kit, overcoming the cultural/language barrier, creating a testing kit with the parts available in Choluteca, and building a water
testing facility for the first time in the Choluteca area. The biggest challenge, however, was finding a cost reasonable quantitative \textit{E.coli} test.

\textbf{Deliverables:}

There will be several products delivered during the project. An incubator will be delivered to Angie Overholt, and it will be placed in her clinic. An incubator is essential in growing bacteria for the \textit{E.coli} testing. The incubator was purchased from The Lab Depot, Inc\textsuperscript{[6]}. There will also be 60 CHROMagar\textsuperscript{TM} \textit{E.coli} units delivered. These are the tests that will be used to test for \textit{E.coli}. Each unit is a petri dish filled with premade agar that the distributor creates. \textit{E.coli} shows up blue once the incubation period is finished; other gram negative bacteria show up colorless. Premade CHROMagar\textsuperscript{TM} \textit{E.coli} petri dishes must be refrigerated and have a shelf life of four to six weeks. However, it is possible to buy the powder and make the agar on demand. If this is done, the powder has a shelf life of about 4 years, and the agar can be made when needed\textsuperscript{[7]}. Please refer to the user manual in the appendix for CHROMagar\textsuperscript{TM} \textit{E.coli}. There will also be a sanitation survey and water education pamphlet delivered to the inhabitants of La Bonanza. The survey will ask about the health of the individual; it will also ask where the individual or family gets their water. The pamphlet will give some tips/information on how to keep water safe and sanitary. The last deliverable will be an Excel spreadsheet that can be used to store the data collected from the different water sources.

\textbf{Plan for end user involvement/training/education:}

The user will need to understand how the water testing process works in order to continue testing after group implementation. Locals should be involved in the set-up of the laboratory to learn how to fix a part of the testing procedure in the future. A local microbiologist, Maribel, will help during the set up, and she will be taught the process. Training will be provided to the user to ensure accurate results following water testing. The user should receive clear instructions and basic education on the procedure and its purpose. Locals will also receive education on the importance of clean/sanitary water. This education should teach them the basics of clean water and encourage them to use the water quality testing laboratory implemented by the group.

\textbf{Plan for sustainability and ownership:}

Locals should be involved in building and implementing the testing laboratory in Honduras. The procedure will be explained and any repairs will be done by local Hondurans once the team has departed. As mentioned, Maribel will be using the lab after the project is over. The incubator will, if maintained with proper care, last for about 5 to years, and it can be used by Maribel or Angie for whatever purpose they see fit. There is no need for OSU students to be present for its use. The most sustainable part of this project is the fact that CHROMagar\textsuperscript{TM} products are easily accessible in Choluteca. There is a company called CAM International that is just two hours away from Choluteca. This company is located in Nicaragua, but it is still very close\textsuperscript{[8]}. This makes it easy for the product to be obtained during the entire year.

Once the project is done, the lab will truly be owned and used by Angie and Maribel. They will be in charge of its upkeep and use. This could create jobs opportunities for other Hondurans in the community to help with these tasks. They will be able to use the lab whenever they want to help the community because they own it.
Research/Design/Prototype/Testing

Roles and Responsibilities:

Monica Mueller is the team leader, and she sets up weekly meetings when necessary and leads meetings. Andrea Paul is the chief financial officer, CFO, and she is charge of budgeting and recording purchases. Alan Renner is the chief communications officer, CCO, and he manages correspondence and communicates with project contacts. Brandon Renner is the document coordinator, and he documents meetings and makes available all documentation to members.

Project Schedule (Gantt Chart):

The following Gantt Chart kept the group on task, and allowed us to better budget our time. All tasks accomplished, in progress, and scheduled to be completed are listed along with estimated start dates and time duration.
Narrative:

Water Tests:

A majority of the research effort was dedicated to water testing. To determine if a water source is safe to drink from, there are many tests that need to be conducted. Some of the water’s physical parameters should be tested (pH, alkalinity, turbidity). Also, the source should be tested for Escherichia Coli, heavy metal, organic, phosphorus, nitrogen, ammonia, and disinfectant contamination.

Escherichia Coli is a common source of contamination in drinking water. Escherichia coli is a member of the coliform bacterial family, and it is found in the feces of warm blooded animals. There are many health concerns that can arise for humans drinking fecal contaminated water which include: “gastrointestinal illness, skin, ear, respiratory, eye, neurologic, and wound infections. The most commonly reported symptoms are stomach cramps, diarrhea, nausea, vomiting, and low-grade fever” [13]. There are three quantitative tests for Escherichia Coli: membrane filtration, colony count, and most probable number.

Phosphorus, nitrogen, and ammonia are classified as nutrient contaminants. Nutrients enter water sources most commonly from farming runoff. High concentrations of nitrogen and phosphorus can cause eutrophication which can harm wildlife [14]. There are three different methods for nutrient testing: strip (similar to pH strips), visual comparator, and photometer kits [15].

Organic compounds are another source of contamination. Common organic contaminants are benzene, dichloromethane, toluene, and many others. Drinking water with organic contamination can cause organs to fail, cardiovascular complications, an increase risk of cancer [14]. To test for organic contamination, a biochemical oxygen demand test must be conducted. This test shows the amount of dissolved oxygen needed by biological organisms to break down the organic materials in the water [16].

Heavy metals are another common source of contamination. Common heavy metal contaminants are copper, zinc, cadmium, chromium, lead, arsenic and mercury [14]. Some medical complications caused by drinking water containing heavy metals include: kidney damage, various types of cancer, gastrointestinal damage, and nervous system damage [17]. Metal strips (similar to pH strips) are used to test the concentration of heavy metals.

Disinfectants, such as chlorine, are sometimes unregulated. If water is treated with improper amount of chlorine, it can be harmful for humans. Potential health risks are eyes/nose irritation and stomach discomfort [14]. Chlorine strips can be used to test the amount of chlorine in the water.

Finally, physical parameters of the water must be measured. Important parameters to test are turbidity, pH, and alkalinity. Turbidity is the cloudiness in water caused by suspended particles [18]. Turbidity can be first be tested by sight. If a water source is very cloudy or discolored, it is not safe to drink. Large amounts of cloudiness can be seen by eye. For more accurate results, turbidity meters should be used. pH is the amount of hydronium ion present in the water, and can be measured using pH strips. Alkalinity is the ability for the water to neutralize in acid [19]. Alkalinity is an important test to conduct because it illustrates how well a body of water can neutralize acidic pollution from acid rain and runoff [19]. A chemical titration can be conducted to determine alkalinity.

GPS:

GPS mapping will be used to accurately identify which sources of water have been tested. To do this, the team researched several phone applications. The application that will meet our needs is called Endomondo. Endomondo is an application meant to map recreational runs. The team use the application
when walking to the water sources. Endomondo will use our GPS signal to create a map of where we have walked. After visiting the water sources, the map created by Endomondo will then be exported to Google Earth. From Google Earth, the longitude, latitude, and elevation of the water sources can be determined.

Sample Testing:

For the testing procedure for the laboratory, the group decided to perform a serial dilution of the sample followed by quadrant streaking on the CHROMagar\textsuperscript{TM} plates. These methods, combined, allow any present \textit{E}.\textit{coli} in the water sample to be diluted to a point where the group can count the number of colonies grown after incubation - with a target of 30 to 300 colonies on a plate\textsuperscript{20}. After the colonies are in this range, the colony forming units per milliliter can be calculated, giving the user a quantitative result for the \textit{E}.\textit{coli} content in the water\textsuperscript{20}. The serial dilution test will consist of diluting the sample with purified water in increments of 0.1. For example, the first dilution will be considered a $10^{-1}$ dilution, the next a $10^{-2}$, and so on. The quadrant streaking method adds one inoculating loop of the diluted water sample to the agar plate, and then pulls from that to spread the water sample across the area of the plate \textsuperscript{21}. These methods will effectively diluted the \textit{E}.\textit{coli} in the water samples from millions of bacterial cells in the sample to a quantifiable amount \textsuperscript{20}. Specific, step-by-step instructions for both the dilution and streaking methods can be referred to in the Appendix at the end of this documentation.

Collecting Water Samples:

A sterile and closable container is required to hold the collected water sample. The container should be labeled with the location, time, and date. Just before sampling, open the container, ensuring that the inside of it is left untouched. When collecting from a river or a stream, carefully go to the middle to avoid the main current. When wading to the middle, try not to disturb sediment. Collect the sample upstream, by turning the container underwater to face towards the current and away from your body. Fill the container up to about an inch from the top so that the sample can be shaken before it is analyzed\textsuperscript{9}.

Incubator:

In order to grow bacteria, an incubator must be able to reach a temperature of 55 degrees Celsius\textsuperscript{11}. The compact Incubator from The Lab Depot Inc. can reach 92 degrees Celsius. The compact incubator also weighs 25.5 pounds and has a diameter in inches of 13 by 15 by 11\textsuperscript{10}. American Airlines allows one baggage check for free so long as it is under 51 pounds.

Healthy Water Brochure:

The following can contaminate water: human and animal feces, trash and litter, uncovered water containers, and dirty hands. Also, rain water becomes contaminated after running along unclean roofs. In order to maintain healthy families, hands must be washed before cooking or eating, and after using the bathroom. Bathrooms must also be kept clean, and clean water sources must be protected from animals that carry diseases. Water should be kept in a container with a spout. Bathrooms should be at least 60 meters from water wells, and a canal should be dug to divert waste water from latrines from contaminating clean water\textsuperscript{12}.

Water can be disinfected with chlorine or by boiling it. Only 5 to 6 milliliters of chlorine should be used for every 5 gallons of water, and after treatment 30 minutes should pass before using the water. When boiling water, it should be brought to a rolling boil for one minute, and then the pot should be covered while the water cools. Hands should be washed before cleaning the water container, and the container
should be scrubbed thoroughly with clean water and soap. The container used to store water should be clean, durable, and have a stable foundation.[12]

**Selectivity Process:**

There were multiple steps taken to select which test would be used in Honduras. Firstly, our customers, Larry, Angie, and Maribel, expressed that Escherichia coli was their biggest concern. Because of this, the team’s research was focused on finding an appropriate coliform bacteria test. During the selection process, there were a few factors that were kept in mind. The first factor effecting the group’s decision was sustainability. Our goal is to provide a reliable method that can be continued by our customers after we leave Honduras. Secondly, the price of the test had to be reasonable. Thirdly, the test had to give quantitative results. With these factors in mind, CHROMagar™ was selected for testing. Firstly, it was selected because there is a distributor of the product in Nicaragua. The company is called CAM International, and it located two hours away from Choluteca. The group would have liked the distribution site to be in Honduras, but despite our best efforts, a distributor that meet our needs could not be identified in Honduras. Secondly, CHROMagar™ is reasonably priced. CHROMagar™ is considered a “plate count” method of testing and requires no special equipment. The alternative methods, membrane filtration and most probable number, require special equipment and are far more expensive. Finally, this product will allow the team to quantify the amount of Escherichia coli in the water. CHROMagar™ was the best product to fulfill the needs of the team and customer.

**Sketches, Drawings, Photos, Tables:**

**Water Survey:**

Hola. Somos estudiantes de ingeniería de la Universidad del Estado de Ohio. Estamos aquí para ayudar mejorar la calidad de agua. Podemos hacerles unas preguntas a ustedes sobre tu agua?

1. What is the main source of drinking water for members of your household?
   ¿Cuál es la fuente principal de tu agua potable para las personas que viven en su casa?

2. How much do you pay for bottled water and how often do you buy it?
   ¿Cuánto paga por su agua embotellada y con qué frecuencia lo compra?

3. What is the main source of water used by your household for other purposes?
   ¿Cuál es la fuente principal de agua para otros propósitos?

4. How long does it take to go there get water and come back?
   ¿Cuánto tiempo usa aproximadamente para ir allá, buscar agua y regresar?

5. Who usually goes to get the water?
   Normalmente, ¿quién sale a buscar el agua?

6. Do you treat you water in any way to make it safer to drink?
   ¿Trata su agua con algún método para hacerla más segura para beber?

7. What do usually do to make the water safer to drink?
   Normalmente, ¿qué hace para hacer el agua más segura beber?
8. What kind of toilet facility do members of your household usually use?
¿Qué tipo de baño están usando las personas que viven en su casa familiar?

9. Do you share the facility with other households?
¿Comparte su baño con otras familias?

   If yes, how many other households use this facility?
   Si es así, ¿cuantas otras casas familiares usan este baño?

10. How many people in the household use this facility?
¿Cuántas personas en esta casa familiar usan este baño?

11. The last time [name of the youngest child] passed stools, what was done to dispose of the stools?
El tiempo más reciente [nombre del niño menor] defecó, ¿qué hizo para deshacerse de las heces?

12. How often are you sick?
¿Con qué frecuencia se enferma?

13. Do you know what makes you sick?
Usted sabe ¿qué le hace enfermar?

14. How often do you wash your hands?
¿Con qué frecuencia se lava sus manos?

15. How clean do you think your drinking water is?
¿Qué tan limpia piensa usted está su agua potable?

Clean Water Brochure:
Prototyping Details:

In order to properly complete the dilution of the sample and avoid contamination of the samples, measures will need to be taken to ensure that all equipment is sterile. For sterilization, a flame is needed to heat the inoculating loop and test tube rim. Alcohol lamps are simple jars with a wick and alcohol to keep the wick burning, and are used to create a sterile space for microbiological use. The team wanted to create sustainability in this part of the design, so an alcohol lamp will be constructed in-country using easily accessible materials purchased from either the hardware store or Maxi Despensa. The materials needed for the project are: a small glass jar, such as a baby food jar; ethyl alcohol; and a 100% cotton wick, preferably braided. While the team has not been able to create a prototype for the alcohol lamp, it will be constructed and tested with the water samples before departure to Honduras in an out-of-class meeting. This fairly simple design has been proven to work many times in home microbiology experiments, so the team should not encounter many problems while constructing the prototype.

Testing and Results:

As of now, no testing has been done. As mentioned, CHROMagar™ has a short shelf life, so the product could not be ordered in extreme advance. Once the tests arrive, testing will be conducted on the Olentangy River.
List of Materials/Sources:

<table>
<thead>
<tr>
<th>Item:</th>
<th>Manufacturer/ Source</th>
<th>Catalog Number</th>
<th>Cost:</th>
<th>Item:</th>
<th>Manufacturer/ Source</th>
<th>Catalog Number</th>
<th>Cost:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Incubator</td>
<td>The Lab Depot Inc.</td>
<td>10-180</td>
<td>$403.50</td>
<td>Pure ethanol</td>
<td>Superstore</td>
<td></td>
<td>$19.97</td>
</tr>
<tr>
<td>E-Coli Tests</td>
<td>CHROMagar™</td>
<td></td>
<td></td>
<td>Water Bottles</td>
<td>Superstore</td>
<td></td>
<td>$10.00</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Metal Inoculator</td>
<td></td>
<td></td>
<td>$12.00</td>
<td>Scotch Tape</td>
<td>Superstore</td>
<td></td>
<td>$2.99</td>
</tr>
<tr>
<td>Cooler</td>
<td>Walmart</td>
<td></td>
<td>$17.97</td>
<td>Cooler for Water Transport</td>
<td>Superstore</td>
<td></td>
<td>$13.97</td>
</tr>
<tr>
<td>Ice pack</td>
<td>Walmart</td>
<td></td>
<td>$7.99</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Baby Food Jar</td>
<td>Walmart</td>
<td></td>
<td>$6.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>100% Cotton Rope</td>
<td></td>
<td></td>
<td>$12.04</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10 mL Graduated Cylinder</td>
<td>FisherScientific™</td>
<td>S63455</td>
<td>$14.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>125 Erlenmeyer Flask</td>
<td>Corning™ Pyrex™</td>
<td>S63270</td>
<td>12 Pack: $64.75</td>
<td>1 used: $5.39</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.75 in Disposable Soda-Lime Glass Pasteur Pipets</td>
<td>FisherScientific™</td>
<td>13-678-6A</td>
<td>Pack of 250: $45.55</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Glass Droppers, 2 mL, Straight Pipet</td>
<td>FisherScientific™</td>
<td>14-955-500</td>
<td>144 (12 bags of 12) Pack: $106.00</td>
<td>2 bags used: $17.66</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25 mL Disposable Borosilicate Glass Tubes</td>
<td>FisherScientific™</td>
<td>14-961-31</td>
<td>1000 Pack: $98.46</td>
<td>10 used: $.98</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Test Tube Rack</td>
<td>FisherScientific™</td>
<td>14-765</td>
<td>$40.00</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Works Cited:

Acknowledgements

A special thanks to:

Roger Dzwoneczyk
Mariantonieta Gutierrez Soto
Angie Overholt
Larry Overholt
Maribel Estrada