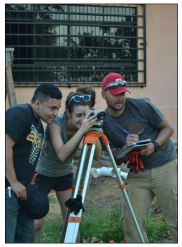
New Drinking Water and Sewer System for an Elementary School for Orphans
Bilwi, Nicaragua

Project Description:

An elementary school located in Bilwi, Nicaragua contacted our team of 40 student engineers to request assistance in providing a drinking water system, sewer system, and bathroom facilities for nearly 400 of the school's orphaned children. At the time of the request, the school's only toilet and cesspool were on the verge of overflow, and water being supplied to the school, via a shallow well, was found to be highly contaminated with E-coli, cryptosporidium and trash. The project's scope of work included assessments, planning, detailed design, and construction of a new, reliable water and sewer system. The duration for this project was two years and included over 2,500 engineering labor hours. Approximately $28,000 dollars was required for materials and travel to fund the mission and was provided by the students who spent two years coordinating fundraising events to raise money. **The student engineers, and the professionals who accompanied them, have been so impacted by this endeavor that, if successful in obtaining the NCEES award, pledge to apply 100% of the earnings towards the construction of our May 2017 Nicaraguan Orphanage Water Project, which is currently being designed.**

Knowledge and Skills Gained:

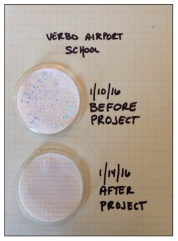


Although it wasn't recognized at the time, some of the most important skills gained were the interactions shared with the professional engineers during this experience. Working side-by-side with professionals in this type of environment while receiving hands-on experience has proven invaluable to the students. Learning the art of compromise to achieve the best value for the client was another lesson learned, as well as persistence and patience. The students, who experienced an unlimited amount of compassion during this trip, also learned what it means to truly make a difference in the lives of those who suffer from extreme poverty, and are now stronger engineers and better human beings because of it.

Collaboration of Faculty, Students, and Licensed Professional Engineers:

Since the start of this project in 2014, the students have worked on this project alongside licensed professional engineers, faculty members and staff. Since the inception of the organization, the students have been under the guidance of practicing, licensed professional civil engineers. The students have held biweekly project meetings for over two years where licensed professional engineers and/or engineering interns are in attendance. During the assessment and implementation trips, the students are always accompanied by a professional engineer. The photos to the right show a professional engineer working side-by-side with engineering students.

Protection of Health, Safety, and/or Welfare of the Public:



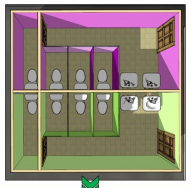
Prior to the implementation trip in 2016, the young school children were drinking contaminated water that contained harmful E-coli and cryptosporidium. After a few days from drinking the dirty water, most children can recover on their own, however, those with compromised immune systems are unable to fight off bacteria. This problem prompted the students to learn how to correctly use laboratory equipment to determine the presence of harmful bacteria. The sample on the top right shows blue dots that indicate there is E-coli and cryptosporidium. The sample on the bottom right represents safe, healthy water that is ready to drink. The school now encourages children to take bottled water home from the school to share with their family members (est. to be 2,000), drastically improving the overall public health of Bilwi.

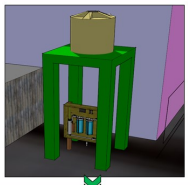
Multidiscipline and/or Allied Profession Participation:

Environmental Engineering – Working with a professional environmental engineer, the students designed a water treatment system, an eight stall bathroom facility and septic system. The water system included a 1 micron filter with an ultraviolet disinfection system. The bathroom included eight toilets and four sinks. The septic system was sized to accommodate 300 gpd.

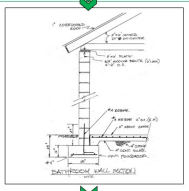
Structural Engineering – The students worked closely with a Professional engineer and a University Professor to design multiple structures. The structures included an eight stall CMU block bathroom, a septic tank, a wooden control cabinet, and a 14-foot high concrete water tower.

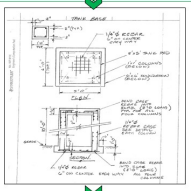
3-D Concept And Preliminary Design Phase

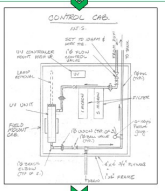




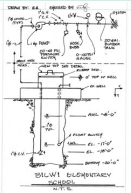
Detailed Design Phase







Construction Phase



Electrical and Control Systems Engineering – The students worked closely with a professional electrical engineer to develop a fully automatic control strategy for the entire water treatment system. They controlled the newly installed well pump by float switches while the UV disinfection unit was triggered by a pump start and the flow for the filters was controlled by a flow regulating valve. Design considerations included head loss, start/stop levels, pressure drops, flow element sizing, response timing, rangeability, accuracy and repeatability. The photo to the left represents an early Process and Instrumentation Diagram (P&ID) of the water system.

Agricultural and Biological Engineering: The students collected and analyzed water samples onsite. Samples were taken for turbidity, bacteria, and pH. Water samples were also taken back to the US where the students worked with laboratory technicians at their local water municipality to compare the data against the US EPA's maximum contaminate levels.

Principles and Practice of Surveying: During the assessment trip the students collected conventional topographical information of the salient features of the school. During the construction surveying was used to determine lines and grades. Surveying was also used to develop as-built documents for the owner. The photo to the right shows a student behind the level while being mentored by a civil engineering professor. They are laying out the gravity sewer pipe from the new bathroom to the new septic tank.

NEW DRINKING WATER AND SEWER SYSTEM FOR AN ELEMENTARY SCHOOL FOR ORPHANS – BILWI, NICARAGUA

Abstract

The lack of potable drinking sources poses as the number one priority in global risk based on the impact to society as announced by the World Economic Forum in January 2015. Regrettably, many less-privileged rural communities are unable to afford adequate sustainable systems to address this complication, negatively impacting the welfare of hundreds of communities worldwide. Our student-directed organization, is associated with our University and aims to fundraise, design, and develop stable and innovative engineering systems to alleviate such critical issues revolving around the safety, and health of other humans and the natural environment. This document summarizes the contributions and activities conducted by approximately 40 engineering students of multidisciplinary backgrounds, university faculty members, multiple licensed professional engineers, several technical advisors, and various members and leaders of the local community to establish a sustainable water disinfection, water distribution, and septic system at a school of more than 400 orphaned children. Consequently, a project of this magnitude demanded practices of various technical fields such as surveying, water resources engineering, geotechnical engineering, structural engineering, mechanical and control systems engineering, and electrical engineering.

Findings from an initial assessment trip to the community in January 2015 reported that (a) the current single well being used for the school was a shallow, exposed hole which posed serious health and safety concerns for the community, (b) the water in use contained numerous contaminants and harmful bacteria and viruses, (c) the community did not have a reliable method of storage and distributing water and (d) the school's septic tank and bathrooms had failed to provide adequate sanitation. In response, to each of the documented problems, the project team proposed (a) the construction of a concrete lid for the well in use to improve the safety of the school children and prevent future contamination, (b) the installation of a chlorine and ultraviolet ray disinfection system, (c) the construction of a sustainable storage and distribution system for the disinfected water and (d) the drawings and calculations for a new bathroom and septic system. Throughout the course of the project, we, with the collaboration of licensed faculty members and practicing professional engineers, employed a myriad of solutions through significant planning, engineering, constructing, analyzing logistics, and fundraising to propose a new system which resolves the various risks stemming from the unsafe source of water. With the support of the organization members, the university, and various professionals in multidisciplinary technical industries, the project came to a successful completion in January 2016 with an implementation trip spanning over seven days with over 700 man-hours. The efforts of the team resulted in fulfillment of the school's critical needs and provided opportunities for the engineering students to collaborate with professionals and gain technical field experience.

NEW DRINKING WATER AND SEWER SYSTEM FOR AN ELEMENTARY SCHOOL FOR ORPHANS – BILWI, NICARAGUA

From January 2015 through January 2016, engineering students from our student organization participated in an international development project to establish a water distribution system and a sanitation system for an elementary school serving nearly 400 orphaned children in Bilwi, Nicaragua. The students who attend the school daily, lacked accessibility to clean drinking water on the premises, which posed a major health risk. Upon assessment, the water was found to contain various bacteria, E. coli, cryptosporidium, and other contaminants in addition to the visible trash floating in the open well. It was also discovered that the existing sewage system was creating hazardous runoff and an unsanitary environment for the children. The students, along with professional engineers, worked to plan, fund, and execute a water and wastewater system to provide clean, drinkable water to the elementary school and to properly remove waste through a septic system.

ASSESSMENT PHASE

The project was split into an Assessment Phase and an Implementation Phase. The Assessment Phase, which was a major focus of a May 2015 trip, prioritized the safety of the children around the existing well and provided the opportunity to use engineering knowledge to deliver a practical, temporary fix until the second phase could be executed. During this phase, a heavy, concrete lid for the well was constructed to prevent the children from discarding trash into the open well and to ensure that an elementary-aged child could not open the well and climb or fall into it. Students also installed a preliminary water distribution system, including a 1 horsepower pump supplying 35 GPM of water from the well, a bladder tank, and 500 linear feet of 1 inch PVC pipe. This system provided the children with water for washing hands and flushing existing toilets.

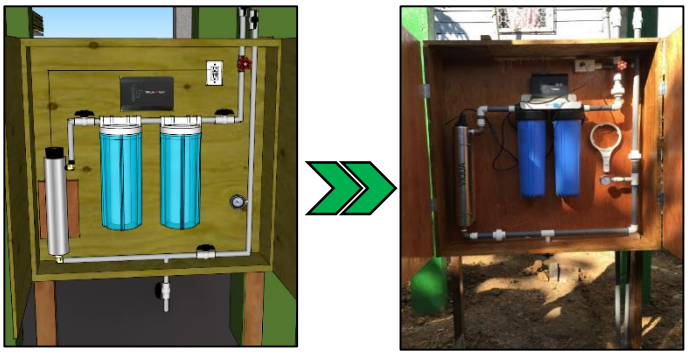
IMPLEMENTATION PHASE

The Implementation Phase was completed in January 2016 by a team of eight students, one faculty advisor and two professional engineers. The primary objectives of the implementation phase were to create a double-barrier disinfected water source, to provide clean water storage capability, and to construct an appropriate water distribution system. In doing so, our students worked with professional engineers to develop a reliable and efficient water supply and disinfection system which could provide potable water to the children. In addition, the students were given the opportunity to learn practical plumbing knowledge to strategically design an eight toilet bathroom facility that would safely dispose of waste into a septic system.

The team members were split into four teams to delegate the tasks effectively and were labeled as the distribution team, electrical team, logistics team, and control panel team. The water distribution team was responsible for digging all the trenches for the water and electrical lines and for the placement and connection of the PVC pipes.

The electrical team worked with a professional electrical engineer to run power to and properly install the 1.0 hp water pump. The team utilized a float switch, which was placed inside the tank to automatically shut the pump off when the water level drops below the intake pipe. Float switches were also installed in the storage tank, which can cut power to the pump when the tank fills to approximately 90 percent of its capacity and restores power to the pump when the water level falls below 10 percent full. This ensures the tank is refilled throughout the day while water is being used at the school. Furthermore, the automation of the pump activity reduces any human error that could occur as a result of manually turning the pump on and off throughout the day. The overall system was checked to make sure the rate of outflow was not greater than the inflow from the pump to the tank in order to prevent the pump from constantly being toggled on and off.

Given the complexity of the project and the number of students involved, the logistics team was tasked with managing the overall construction and completion of the project, to make sure it was completed on time and within budget. To gauge progress, the logistics team would track the tasks assigned to teams according to the day of the week and monitored the critical path closely. Where possible, the team would help others so that the overall project could remain on schedule. The critical path identified consisted of the construction and installation of the control panel, which was the final task completed before the water tank could be hoisted and filled.



The control panel was designed by students and faculty during numerous design meetings and ultimately constructed on-site at the school. Its purpose was to provide housing for the filtration and UV disinfection system and to allow for a centralized location to control the water system's main components. The overall structure consisted of a wooden frame attached to two wooden posts. The posts were placed 4 feet into the ground and secured with concrete. Two doors, a latch, and a lock were placed on the front of the frame, in order to prevent unauthorized access. An ultraviolet disinfection and 1.0 micron filtration system and associated piping and power components were placed within the cabinet. A pressure gauge was installed in order to regulate the water coming into the filter and to make sure there's enough pressure for the filtered water to reach the tank. Separate from the designated teams, students also collaborated with another non-profit organization to properly design a new bathroom facility with eight flushing toilets that discharge to a septic system. The total implementation took five days to complete with over 700 man-hours and zero time lost due to injury.

Throughout the course of the project, the quality of the water was assessed with field water testing kits, and after five days of construction, the entire planned system was completely installed with clean, running water and the new bathroom structure had a functioning septic

system. The partnership between the community members, our students, and the professional engineers resulted in a significant improvement in the quality of life of the Bilwi community. Throughout this period, our students were instructed and guided by a licensed professional engineer, serving as their mentor, about the installation of the system and safe practices associated with all the work.

COLLABORATION OF FACULTY, STUDENTS, AND LICENSED PROFESSIONAL ENGINEERS

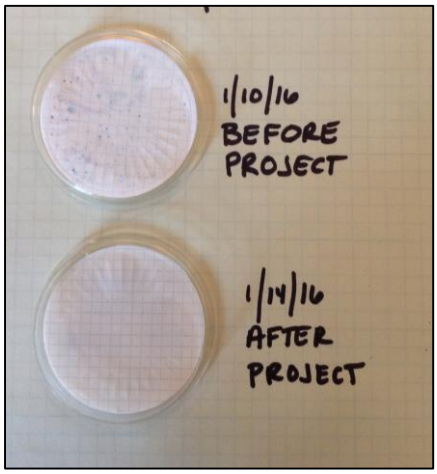
Since the first assessment trip in 2015, as many as 40 students and multiple licensed professional engineers and faculty have contributed to this project. Our organization has been under the guidance of a practicing licensed professional in civil engineering since the establishment of the organization in 2010. The students hold weekly project meetings that typically include the attendance of the professional engineers (PE) or engineers in training (EIT).

Our members conducted extensive research with professional engineers during the assessment trip to further enhance their design for the school. The data consisted of GPS coordinates, water quality tests, and soil properties from sample excavation sites, knowledge of local construction practices and associated safety measures, and community survey analysis to understand daily water consumption. Based on the data collected, students and faculty designed the system for future development and water demand growth. As part of the research and planning process, professional engineers, faculty, and students exhaustively simulated the system and began testing to avoid delays in the field. With forward thinking by the engineers, the project at the elementary school for orphans was completed within seven days.

PROTECTION OF HEALTH, SAFETY, AND/OR WELFARE OF THE PUBLIC

Prior to the implementation trip in 2015, the well at the Elementary school for orphans posed serious safety and health risks to those attending the school. The shallow well had no cover and was left exposed to surface water contamination and debris. During the day, children would use buckets supported by string to obtain water from this well that was regularly used for cleaning purposes (mops and tools) and to wash hands. Addressing health and safety concerns in two phases, our students first focused on the immediate safety risks of falling into the open hole and then addressed the disinfection of the water and installation of a septic tank. It took significant planning, engineering, construction, logistics, and funds to resolve the health and safety risks presented by this source of water. As a result of these efforts, the students and professional engineers who took part in this endeavor are proud that vast improvements have been made in the health, safety, and welfare of so many lives.

MULTIDISCIPLINE AND/OR ALLIED PROFESSION PARTICIPATION



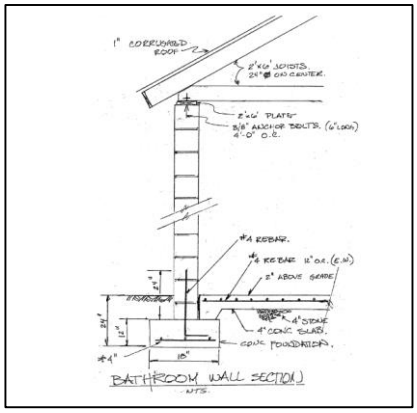
Environmental Engineering: During the assessment trip, water samples were collected and analyzed on site. Samples were taken for turbidity, bacteria, and ph. Using a bacteria testing kit, bacteria were counted within 24 hours of obtaining the sample in order to estimate the amount of bacteria within the water. Performing these tests on-site allowed the students to make any adjustments to the disinfection system while still in the country. For more specific water quality analysis, samples of water were collected and taken to the US where the students worked together with lab technicians at local municipalities to compare the data against the US EPA's maximum contaminate levels.

Surveying: The students collected conventional, topographical information of the salient features of the community. This data was reduced and plotted for the use of building and mapping the water distribution system. After each construction phase, GPS equipment was used to create an as-built plan of the facility.

Water Resources Engineering: While working with multiple civil engineers, the students developed both schematics and detailed design of the entire new water system. The professionals taught the concepts of hydraulics and instructed students on how to use EPANet to design the new water system. Students were guided on how to design a water distribution system and its many components. Strategies to design an efficient system that increased flow and maintained pressurized water were practiced.

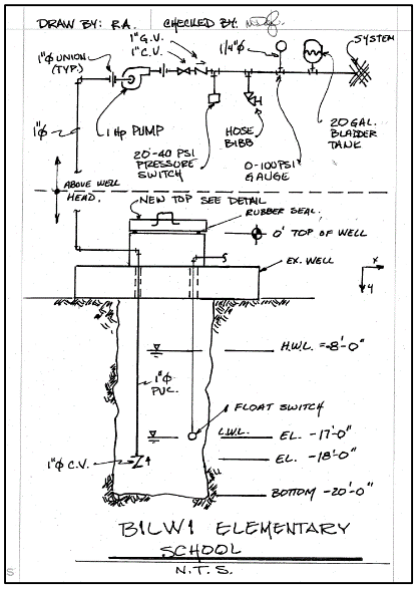
Geotechnical Engineering: Using the existing land features, the highest point on the property was selected to construct the 12-foot tall tank base. Before construction, the earth was surcharged by placing several CMU blocks where the columns were to be built. Completed about 2 weeks in advance, this applied weight before the actual construction of the towers allowed for the ground to properly compact.

Structural Engineering: Our students worked closely together with professional engineers to design multiple structures. Those structures included:



- 24’ x 24’ CMU eight stall bathroom
- 14 foot high cast in place water tower
- 20’ x 10’ x 8’ Septic tank
- 8’ x 8’ x 8’ CMU Well House
- 2 ’x 2’ x 0.5’ Concrete Well Cap
- Post mounted 4’ x 4’ Wooden Control cabinet

Mechanical and Control System Engineering: Working together with a professional engineer, the students designed and installed a control system. The system included a pump controller, pressure switch, pressure gauge, a flow meter, and a bladder tank.



Electrical Engineering: The students worked with a professional electrical engineer to design and install the control panel that powers the distribution components. All of the electrical components were installed underground or 12 ft. above ground in a manner to prevent the children from accidental contact with any wiring, both ensuring their personal safety and preventing tampering with the system.

KNOWLEDGE OR SKILLS GAINED

The knowledge gained through this incredible experience ranges from field experience in engineering to cultural learning for everyone involved. The students improved their understanding of surveying while working alongside professional engineers who taught them beyond a classroom curriculum. The students also gained knowledge in water resources engineering by understanding the fundamental importance of having the correct design for both a water treatment and septic systems.

The significance of relations with the community positively impacted the students and facilitated the understanding that although a perfect design may be constructed, if it does not meet the community's needs, it is a worthless effort. There was no better feeling than when members of the community thanked our team for their hard work in taking the time to improve their quality of life. The lessons these students learned from this project and the Bilwi community is something they will carry with them and appreciate for a long time to come; in doing so, they will continue to realize that, as engineers, they have a responsibility to society to never overlook a community's declining public welfare.