Water and Sanitation Project – Children's Feeding Center
Puerto Cabezas, Nicaragua

Project Description:

THE PROBLEM:

The Children's Feeding Center in Puerto Cabezas, Nicaragua, supplies one, nutritious meal to nearly 700 impoverished children daily. Built in 2009, the Feeding Center receives a majority of its food through an organization in Raleigh, North Carolina called Stop-Hunger-Now. Unfortunately, the Feeding Center lacked both a reliable water and sewer system. Prior to our involvement, the center's primary water source originated from a failing well, and ended with wastewater seeping across the ground to the nearest ditch, often where the children played. Our student organization was contacted by a non-governmental organization who requested us to solve the problem. In doing so, we finished on schedule and were under the original cost estimate. The project took 12 months to complete with an investment of nearly $20,000, obtained by our own fundraising.

THE SOLUTION:

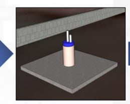
Answering the Call and Making a Difference:

- 1,000 (+/-) design labor hours
- 700 construction labor hours
- 0.0 labor hours lost due to injuries
- Re-instated the old well
- Installed a hand washing station
- Installed a new 12 -foot high concrete water tower
- Installed a new 300 gallon water tank and piping
- Installed a new 1,000 gallon septic tank system
- Installed a new sanitary drain field
- Installed a new booster pump, bladder tank, and pressure switch to maintain 40 psi
- Reinstated a 0.5 micron water filter
- Trained end-users how to operate and maintain the system

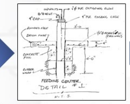
Protection of Health, Safety, and/or Welfare of the Public:

Having access to clean water opens up a world of opportunities for community growth. Public sanitation and hygiene, combined with a source of clean drinking water, creates lasting community health and sustained human growth and development. As a child, disease from lack of clean water and sanitation carries over into education. A child's education is affected by an increase in truancy, decrease in intellectual potential, and increased attention deficits. With the benefits of clean water, adequate sanitation, and good hygiene, educated individuals grow up to be enterprising adults, who become the owners of businesses, as well as corporate, community and national leaders. From the early years of life, throughout childhood and into adulthood, water is the common beneficial factor determining the quality of life and the possibilities of the future. (Below is only one example of our betterment to the welfare of the public.)

The original well was influenced by surface water and other activities.



Working with a Professional Engineer we developed a 3-D preliminary design



A detailed design was developed and Checked by a Professional Engineer

Constructed in 2015 along side a Professional Engineer

Knowledge and Skills Gained:

An engineer's primary focus is often on the math and science aspect of a project, and it can be easy to forget other skills necessary for successful project completion. Some important skills learned for this mission include the following:

Leadership: During the entire project we found that we were ultimately in charge of the entire project. We directly affected the lives of others.

Critical Thinking: Throughout construction we faced many unknown conditions and several complex problems. We had to identify the most reasonable approach in dealing with difficult situations.

Visualization: During the life of the project we had to visualize how complex components came together and ultimately work as a system. The use of 3-D models assisted in visualization (bottom right).

Clear Communication: Since we had to interact with many different types of people, we had to communicate effectively in English, Spanish and Miskito.

Master Plan

Water and Sanitation Project
Children's Feeding Center

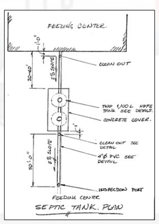
Introduction:

Collaboration of Faculty, Students, and Licensed Professional Engineers:

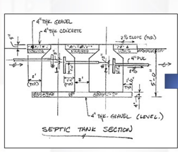
Since the start of this project in 2014, we have had as many as 20 students work on this project alongside licensed professional engineers, faculty and staff. We have been under the guidance of practicing, licensed professional civil engineers since the inception of the organization. The team has been holding bi-weekly project meetings for 12 months with licensed professional engineers and/or engineers in training (EITs) in attendance. During the assessment and implementation trips, the team always had a professional engineer accompanying the students.

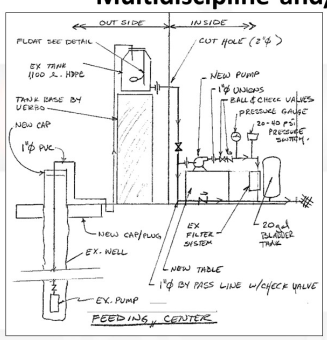
Multidiscipline and/or Allied Profession Participation:

Principles and Practice of Surveying: A few weeks before the construction phase, our professionals insisted we learn how to set up the surveyor's level. It became our primary tool in constructing the drain field for the septic system

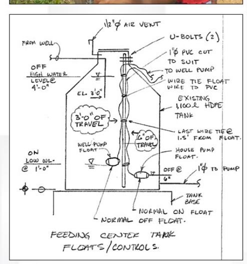


Environmental Engineering: A sanitary engineer from our local Public Works assisted us in determining the best solution for a septic tank system. Multiple alternatives were reviewed and analyzed. The final recommendation was to use two 500 gallon HDPE tanks.

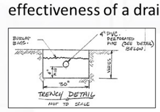


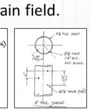


Control Systems Engineering: A professional electrical engineer worked closely with us to layout the control strategy. The client wanted the system to be fully automated. Sensor technologies were selected and checked by the professional engineer. The Process and Instrumentation Diagram was our road map for the detailed design.

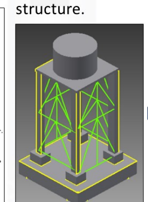


Civil Geotechnical: Working with a professional civil engineer, we performed a perk-test on the Nicaragua soil to understand the effectiveness of a drain field.



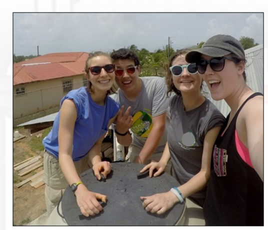


Civil - Structural: We worked with a professional civil engineer to design and build a 12-foot high concrete water tower. Design calculations included dead and live loads, deflection, beams, columns slab, and footings. MASTAN software was used to develop a force analysis of the structure.



Civil - Construction: Prior to the construction, we developed a critical path method construction schedule. We routinely updated cost estimates during the life of the project. A professional was continuously checking our work. Due to optimal construction management, we finished on time and under the budget.

Electrical Engineering: A professional electrical engineer was recruited to provide QA/QC on the electrical design and to help re-construct the power system for the entire feeding center. The electrical design included load analysis, pump and pump controls, safety grounding and lighting.



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Abstract

The Puerto Cabezas Feeding Center, located along the northeastern shore of Nicaragua, is a non-profit facility whose primary mission is to provide one nutritious meal per weekday to nearly 700 impoverished children in the community. The feeding center provides for these hungry children, as many parents of the region have various physical and economical restraints making them unable to afford sufficient meals for their families. Unfortunately, the water systems that were in use at the premises were found to be extremely inefficient and to have critical health risks due to a non-operational water and wastewater systems. The lack of these systems resulted in large delays during meal preparation and poor wastewater management. The members of the feeding center, already overwhelmed with the dependence of many children for their only source of food, did not have the financial capacity to rehabilitate the established systems to their full potential, which as a result, negatively impacts hundreds of local members of the community.

This report discusses the details of the findings, collaboration, lessons, and results of the assessment and implementation of two systems designed and constructed by a team of engineering students, practicing professional engineers, and university faculty. The project sought to improve the lives of these approximately 700 children and countless adults by increasing efficiency in water distribution and decreasing the risks associated with consumption of bacteria ridden water. The project encompassed various multidisciplinary aspects of engineering such as structural analysis, electrical engineering, mechanical engineering, and hydraulics as well as humanitarian factors such as health, safety, and welfare of the public.

An initial field-assessment in late 2014 revealed that the feeding center had abandoned its distribution system due to inadequate water pressure and was collecting the needed water directly from an open hole in the ground. During implementation, a new water distribution system was constructed to address this issue in the kitchen, garden, and at various hand-washing stations. The assessment also exposed a collapsed septic tank that resulted in improper disposal of sewage. In response, the team installed a new septic system to allow biological treatment and storage of sludge from the generated waste. The contribution of 40 engineering students of various concentrations and 10 technical advisors and practicing professional engineers made it possible for a large improvement in the protection of public health, safety, and welfare. Furthermore, working as part of the larger project team created a collaborative experience for students and industry leaders alike. The group was pleased to work with local community leaders and facility managers during the construction of the water distribution and wastewater management system, which came to a rewarding finish in 2015.

Water and Sanitation Project – Children's Feeding Center
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PROJECT DESCRIPTION

Poverty runs high in the fishing region of Puerto Cabezas, Nicaragua. Many adults are at risk of developing paralysis due to deep sea fishing without proper equipment. Once the adults have injured themselves permanently or reached the age where they can no longer work at the docks, their children feel the burden.

Orphan Network built a feeding center to provide these children with at least one substantial meal five days a week. They teamed up with Stop Hunger Now, who provides monthly shipments of food for 700 children in need. Although the feeding center is extremely beneficial to the community, there was limited access to water for the kitchen. Each meal had to be prepared with water supplied through a nearby hand dug hole in the ground, where the kitchen staff used small buckets to retrieve water. This created huge delays in cooking the meals, and often led to making smaller portions for the children.

Our nonprofit student organization, arrived to Puerto Cabezas in December of 2014. It was the first trip where many of the students were able to go into the field and apply the curriculum they have been learning, allowing them a better understanding of how engineering is done in practice. With this assessment trip, engineering students collected elevation points, surveyed, generated questions for the community, took water samples, and wrote technical memorandums. These memorandums were their base information for design when they arrived back in the United States. Because their client and job site were not easily accessible once they left Nicaragua, the students learned the importance of collecting accurate and detailed information. In response to the feeding center's collapsed septic tank, the students decided to make a new sanitary sewer system part of their scope of work. The purpose of choosing a new septic system was to remove solids from liquids, provide biological treatment and store scum/sludge for all the waste generated in the feeding center kitchen. The system emanates from a 4-inch PVC inlet, which runs from the kitchen to the septic tanks. Both, the primary and secondary, tanks have a capacity of 500 gallons and are installed underground in series at a slope of 2% with the lids flush to ground surface. Solids are retained in the tanks while the liquid fluid flows out the top of the septic tanks into a single line drain field made up of a 4-inch perforated

PVC pipe. The team started the project by surveying the area and setting up controls and reference points. Then, they staked out the layout and location of the system's components. The trenches for inlet pipe (40 linear feet), tanks (10 linear feet), and drain field (50 linear feet) were hand dug. The trenches' depth varied between 2 – 3 feet for the inlet pipe and drain field and 5 – 5.5 feet for the tanks. The depth was calculated based on the ground elevation and the 2% designed slope. Once the trenches were completed, a 6 inch gravel bedding was placed for the entire system. After the pipe connections were installed, a 12 inch layer of gravel backfill was placed, followed by filter fabric (burlap) and a 3 inch layer of sand. The trenches were capped with a layer of soil to match the existing grade. Finalizing the construction of the sanitation project.

The intention for the water distribution system was to improve the quality of water and provide enough pressure to the kitchen, garden, and children's hand washing stations; while taking precautions to ensure the distribution would not dry up the well. The system was created with PVC piping, a bladder tank, one 300 gallon HDPE tank, a 13 foot tank base, pressure gauge, 1

horsepower pump, and various check valves. The water is initially pumped from the existing well to the 300 gallon storage tank which sits atop the 13 foot concrete tank base. The storage tank is then gravity fed to a 1 hp pump that begins to fill up the bladder tank which directly supplies pressure to the kitchen faucets. The water being pumped to the kitchen goes through a 0.5 micron filter before entering the sinks. This allows for the children to have access to clean water, and for the kitchen to be able to efficiently do their work. The bladder tank provides water to the garden and hand washing stations. There is a check valve and pressure gauge attached between the pump and bladder tank to control the amount of pressure entering the system. In addition, the 300 gallon tank is monitored by a float switch that signals back to the pump to when to shut off.

SUCCESSFUL COLLABORATION OF FACULTY, STUDENTS, AND LICENSED PROFESSIONAL ENGINEERS

Were licensed professional engineers (P.E.s) involved?

Professional civil engineers and professional electrical engineers were involved during the entire project. They mentored the students on how to think through the challenges faced when working abroad. Some of the areas that needed to be focused on were substitution of materials and alternative ways to design when obstructions occur in the field.

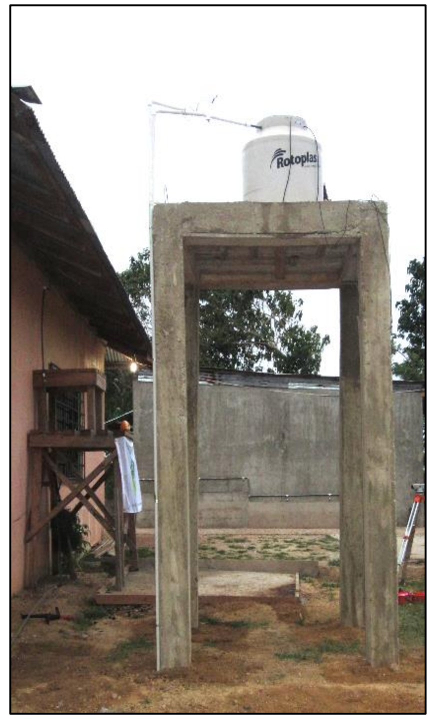
How did the students, faculty, and P.E.s interact?

Since the students working on the design ranged from freshman to seniors, a primary focus for the faculty and professional engineers was to mentor the students so each could begin discerning which field of engineering he or she is most interested in pursuing. Faculty are able to help the students better their understanding of the engineering curriculum and to demonstrate the importance of learned concepts and equations in real-world projects. Having the students work with professional engineers enables them to take their academic knowledge and be able to express and format their work in a professional manner. The collaboration of a professional engineering and student shown in the picture demonstrates how they were able to mentor the organizations students throughout the entire project.

Students were separated into various teams, each representing a necessary task within the project: water distribution, structural, wastewater, and electrical systems. The students coordinated with faculty and professional engineers to conduct biweekly meetings. These meetings updated everyone on the status of the project and created a forum to discuss problems and reach proactive solutions.

What did the students learn through the collaboration that would not have been learned in the classroom?

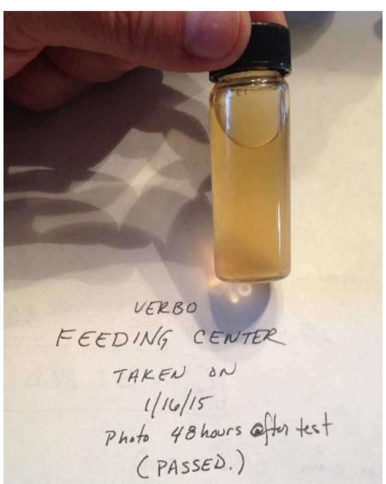
In the field, students learned how to construct a water distribution system in a hands-on environment with the collaboration of P.E.'s. By allowing students to physically construct these components, they are able to identify potential problems before they occur, which will only improve their work as a designer. An engineer's work is only good if constructed properly.



Additionally, students learned the importance of providing a design that is formatted to the needs of the client, the Puerto Cabezas community. With the experience from the professional engineers, students were able to open their minds to not just designing a functional water distribution system as you would for a class assignment, but also learn how to manage all aspects of the project. For instance, all materials within the system needed to be readily accessible, cheap, and durable so the community can fix the system if any problems arise in the future.

<u>PROTECTION OF PUBLIC HEALTH, SAFETY, AND/OR WELFARE OF THE PUBLIC</u>

Did the project include aspects that affect the health, safety, and/or welfare of the public?



To protect the health of the community, it was necessary for students to take water samples to make sure the existing well was not contaminated. Water tests were performed for iron, nitrate, pH, dissolved oxygen (DO), and hardness. Iron and nitrate are very important test results as they can affect the development of the children in the feeding center. The iron in the water was 0.3 mg/L, and nitrate was 10 mg/L, which both meet allowable limits for drinking water determined by the U.S. Environmental Protection Agency. Sampling the water for pH is to ensure that is not acidic or has any chemical infiltrating the groundwater. The results indicated the water was safe to drink, as long as it was stored properly.

Lastly, when implementing the system, all the pumps were installed in a lockable storage room. This protects the welfare of the community to ensure no one will try and steal the pump or bladder tank.

How was public protection addressed?

Public protection was firstly addressed by implementing an on-site system which allows the children and volunteers of the feeding center access to a potable water source. In addition, the team improved the public's protection by creating a septic system in place of raw sewage running across the ground where the children played. Our students also created a cover to the existing well that prevents any animal feces or trash from inadvertently entering the well head.

Which project features raised students' awareness about the impact of engineering decisions? How did the project highlight how engineering can help solve problems faced by communities nationally or worldwide?

When the team had finished the project, they could see a direct improvement within the community. The children would rush to the hand washing station, excited that there was running water. The impact the system had on the kitchen made the entire feeding center run smoothly where 700 children could get a hot, nutritious meal.

The project accentuated the desire of the community to have clean water, but also the absence of proper infrastructure and knowledge for the feeding center to improve their own situation. The students learned how difficult it is to accomplish simple tasks without running water; something many of us take for granted. Their engineering background helped a community thrive due to the hard work and commitment they were able to dedicate in designing these two systems. Students were not only aware of the impact the updated infrastructure has on a community but they were able to see directly how it improved the lives of those at the feeding center.

Did the project foster student self-reliance, cooperation, or responsibility?

During construction of the project, students were given the tools to become more self-reliant. It was up to the student-led team to find a solution based on the knowledge and mentoring that occurred leading up to the implementation. They cooperatively found solutions to issues that were not visible until they were on site and the project began. When working internationally, the students are forced to be more self-reliant and cooperative because they cannot simply look up a solution in a textbook or use a Google search to help them. They have to work as a team to ensure the project is safe and operational.

Was more than one engineering discipline involved? Was more than one branch of a particular engineering discipline involved?

Engineering is the practice of understanding the fundamentals of the project which could not be done without the help of multiple disciplines and their subsets. The independently run, student organization was ecstatic to be able to work with a variety of disciplines including electrical, civil and infrastructure, and mechanical engineering. Within each discipline there were a variety of concentrations that were a fundamental part of this project; including geotechnical, surveying, electrical, controls, structural, hydraulic and hydrology, wastewater, systems, environmental, and construction management. For students to be successful in international projects it is vital to work as a team to arrive at the best solution.

Did the project include other professions?

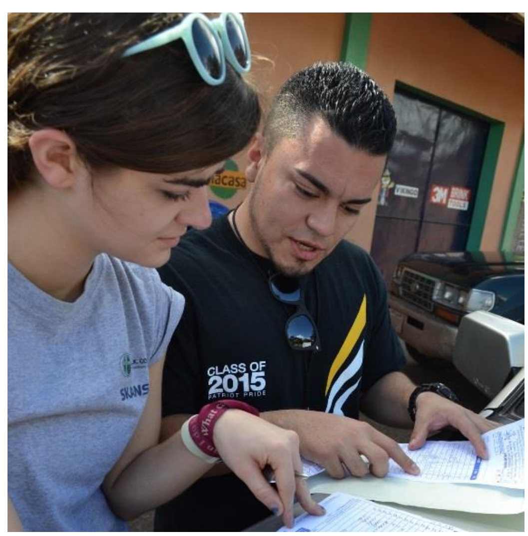
We routinely required other professions to support this project. The most important outside profession was scientists. We wanted to know specific details on the quality of the water so we engaged our local water authority laboratory professionals. We worked with them to identify sample procedures and testing procedures. We brought back water samples from the assessment trip where we worked together to find out what elements and organisms were in the Nicaraguan water.

KNOWLEDGE OR SKILLS GAINED

What knowledge/skills did the students gain? How were the knowledge/skills gained important to professional practice?

To successfully execute this project, students' communication skills were monitored by faculty and professionals. This taught the students to respond in a courteous and professional nature as it would be done in a professional setting.

Throughout the design process of the feeding center, our students were continuously improving their presentation skills as memorandums and updates were provided to the organizational member and the University leadership teams. Members of the board, professional engineers, and faculty, who are able to attend, asked questions as if they were the students' future employer. The emphasis on communication refines the students' skills, and prepares them for when they enter the professional world.



Every student involved was able to better their engineering skills and knowledge by having small group learning sessions with professional engineers. In this manner, they were able to expand their level of thinking and ask questions that were more focused on the engineering practice outside the classroom setting. The process of design was new to many students and they learned the difference of including feasibility, cost, and clients' needs.

Did the project include consideration of professional practice concepts such as project management, ethics, contracts, or law?

The student organization ensures all engineers follow a certain code of ethics just as they would once they become professional engineers. 1. Engineers shall hold paramount the safety, health and welfare of the public and shall strive to comply with the principles of sustainable development in the performance of their professional duties. 2. Engineers shall perform services only in areas of their competence. 3. Engineers shall build their reputation on the merit of their services and shall not compete unfairly with others.

Project management and leadership was particularly observed amongst the junior and senior students. Alongside working professionals, the older students were able to step up to teach and delegate the smaller tasks to the newer students. With the project containing multiple disciplines and designs, a project manager was always appointed. For this project there was a water distribution, structural, and wastewater project manager. Through these roles, the students were able to gain critical professional skills in leadership and management.