Our School Logo

EfID

Water Supply, Distribution and Storage
Sabana Grande, Nicaragua

Our School Logo

UNIVERSITY

Project Description:

Sabana Grande, Nicaragua reached out to our team of forty student engineers to provide a new water supply, distribution and storage system for their community. Their existing water system failed and they had no access to clean drinking water. The scope of work for the project included the assessment, planning, design, and construction of a new reliable water system for the 150 people who live in Sabana Grande, Nicaragua. Besides the pictures of happy community, concrete and steel, this project took 2.5 years in the making, over 3,000 engineering labor hours and funding in the approximate amount of $40,000 dollars to design and construct. The $40,000 worth of funding came from 2.5 years worth of student fundraising events. What also isn't shown in these pictures is how this project has changed 40+ student engineers and 14 professionals for the rest of their lives. If we are successful with this NCEES award, we will pledge 100% of the award money to our 2016 Nicaraguan Orphanage project.

Knowledge or skills gained

The most important skill we learned was the obligation of an engineer. After our first assessment trip we knew we had the engineering knowhow relevant to fix the immediate social need of the community. Morally as future Engineers we couldn't just turn our backs to the community's declining public welfare. In the early stages of the project (2013) we would regularly get negative reports from the community about public welfare.

Our obligation only got stronger with each report. As we proceeded with each phase (year after year) these negative reports stop coming and we began getting positive reports. At that point, we as a student organization collectively recognized we had begun to fulfill our obligations as Engineers, by serving the majority.

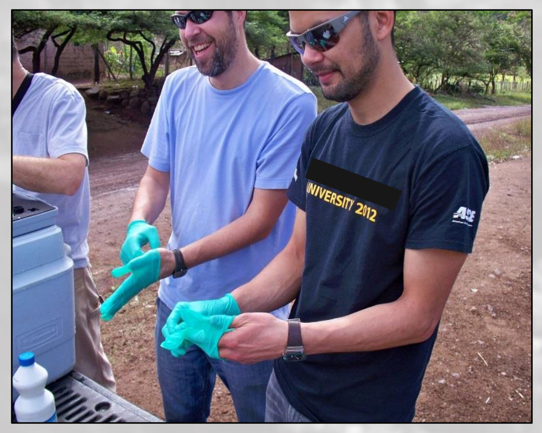
Collaboration of faculty, students, and licensed professional engineers

Since the start of this project in 2013, we have had as many as 40 students work on this project and as many as 14 licensed professional engineers, several faculty and staff. Since the inception of the organization, we have been under the guidance of a practicing licensed professional Civil Engineers. The students have been holding weekly project meetings for over two years at which Licensed Professional Engineers and/or Engineering Interns (FE) are in attendance. During the assessment trips and implementation trips the teams are small in size, and always have a Professional Engineer accompanying the students.

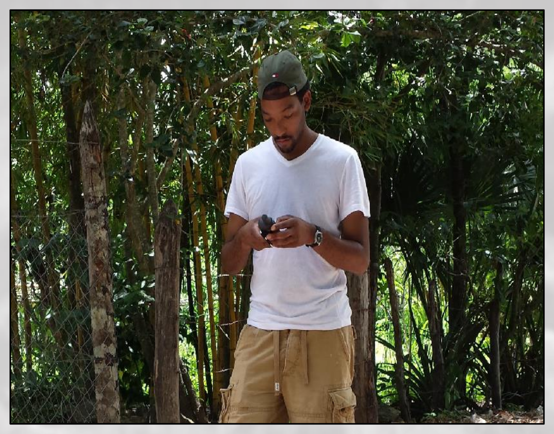
Protection of health, safety, and/or welfare of the public

Prior to our implementation trip in 2013, many of the community members needed to walk ¼ mile to get drinking water which was contaminated with bacteria. The community's crops were under producing and their livestock were malnourished. The lack of a consistent water supply was a negative impact on the quality of life, community production and public welfare. Without a consistent water supply, the community members were spending a significant amount of their time finding and collecting water rather than tending to the public welfare.

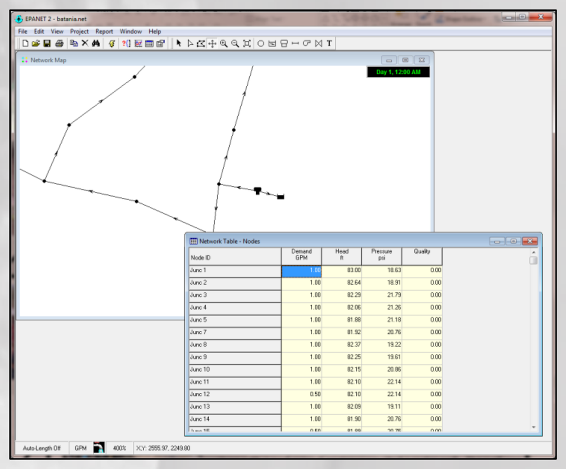
Multidiscipline and/or allied profession participation

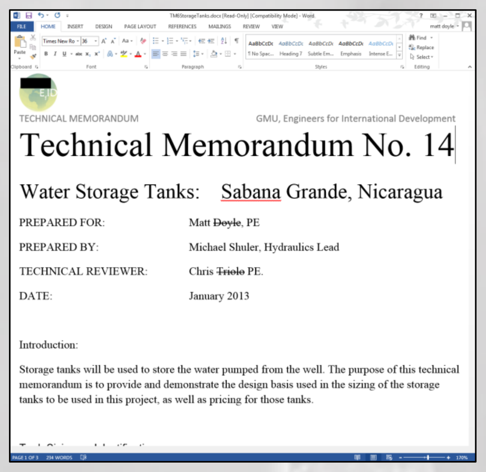


Environmental Engineering: During the assessment trip we collected and analyzed water samples on site. We took samples for turbidity, bacteria, and pH. We also brought back water samples back to the US where we worked together with our local municipality to compare the data against the US EPA's maximum contaminate levels.



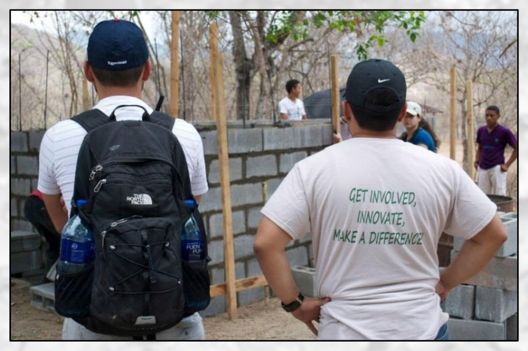
Principles and Practice of Surveying: During the assessment trip we collected conventional topographical information of the salient features of the community. This data was reduced and plotted for the use of building the water distribution system. After each construction phase GPS equipment was used to As-Built the facility.

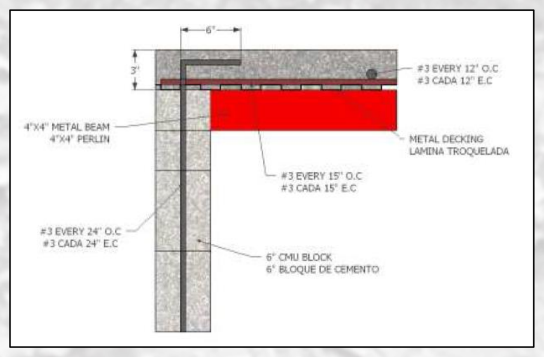


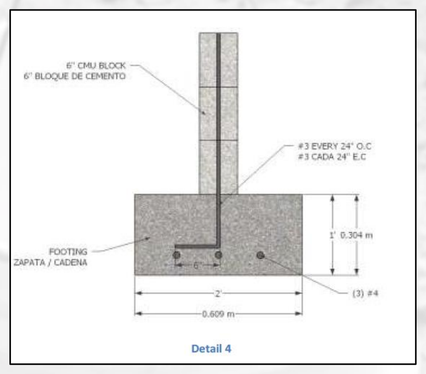


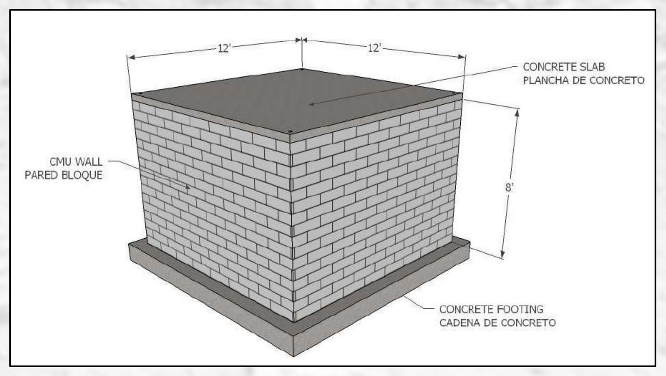
Civil: Water Resources Engineering: While working with multiple Civil Engineers we developed both schematics and detailed design of the entire new water system. The system included service connections, several miles of water lines, water storage, well and a well pump. The design included fifteen technical memorandums which detailed every existing and proposed water feature.

Geotechnical Engineering: Using existing land features we sited the 200 foot deep well. As expected, water was found at 80 feet below the surface. Data from the well draw down showed the water production was approximately 140 gpm. Well cuttings were collected and analyzed to be Volcanic black basalt.

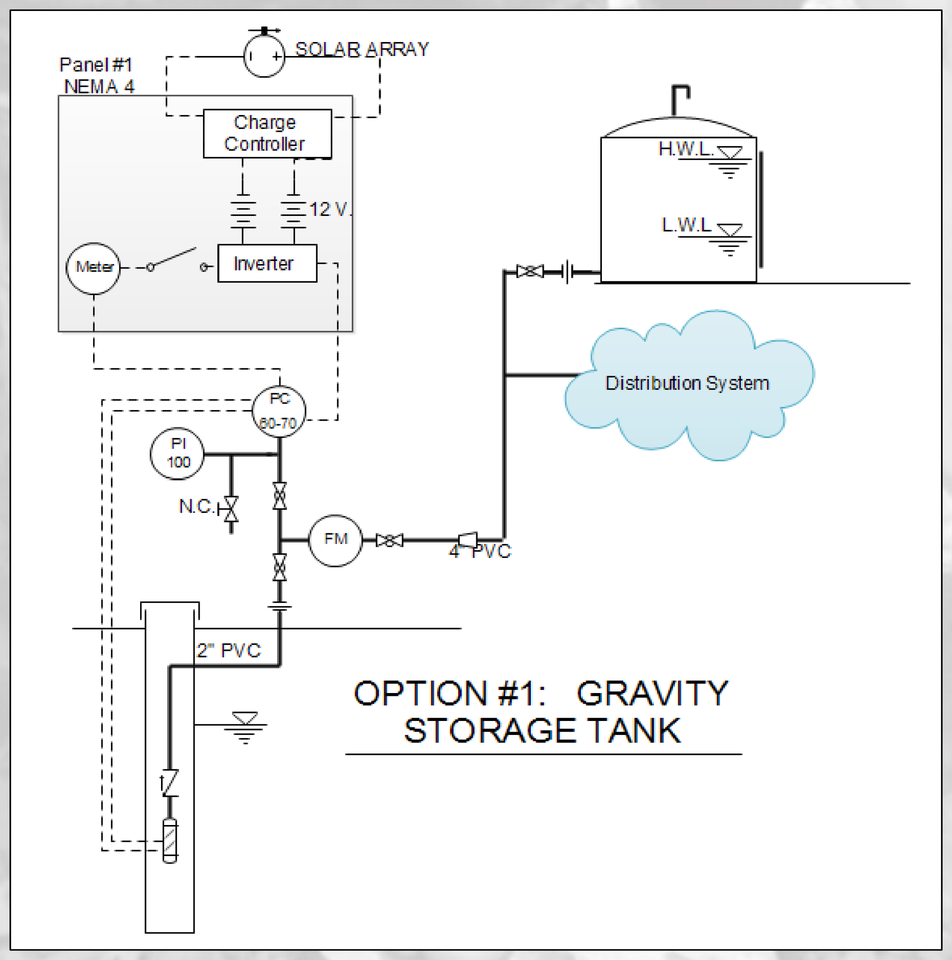








Structural Engineering: During the entire life of the project we had many structural features to design and install. These features included, concrete pads, solar array mounting devices and foundation, and an eight foot high water tower that needed to support 11 tons of water. After Students worked together with Professional Engineers to design all the structural features within the project.



Mechanical and Control System Engineering: Working together with a professional engineers we design and installed a control system. The system included a pump controller, pressure switch, pressure gauge, a flow meter, and a bladder tank.

Electrical Engineering: We worked with a professional engineer to design and install a 12 volt and 800 watt PV solar array, electrical meter, conduits, and charge controller.

WATER SUPPLY, DISTRIBUTION AND STORAGE
SABANA GRANDE, NICARAGUA

ABSTRACT

Engineers for International Development (EfID) is a rapidly growing student-directed, non-profit organization that fundraises, designs, and constructs innovative systems for communities with critical infrastructure needs. It is an organization with a foundation based on the support of student volunteers, faculty, and allied licensed professionals.

The project described herein, is EfID's largest project to date, took place in Sabana Grande, Nicaragua and was completed in two separate phases in 2013 and 2014, respectively. Phase I required installation of a 200 foot-deep well for drinking water, a water pump, a pressure tank and switch, an 800 watt, 12-volt solar powered array, and 1,500 linear feet of PVC piping and fittings. Multiple water stations or kiosks were installed at strategic locations, as well as a security fence which ensured the safety of the community and equipment. Phase II involved the extension of a water distribution system to each individual house in the community and installation of a 10,000-liter water storage tank. Students worked side by side with the faculty and volunteer professional engineers throughout each phase to ensure all design calculations were correct.

The Sabana Grande community was selected to receive EfID support after three students and one licensed professional engineer (P.E.) conducted a trip that would give them the opportunity to interact with the community and its leaders, with the goal of establishing a needs assessment. Sabana Grande is one of many communities that lacks infrastructure to distribute or store clean water. During the assessment trip, the team tested the two wells that served as the primary source for water in the community, to include drinking, cooking, and cleaning. Testing revealed that the water contained pathogens such as, bacteria, viruses, and protozoans. In addition to the poor quality of water, many members of the community consisting of about 30 homes, 150 people, and a local elementary school were located more than 1-2 kilometers from the wells, requiring significant time to gather water and haul it back to homes and the school for consumption. As a result of this assessment trip, EfID identified a critical need for a water distribution system to protect the health, safety, and welfare of the members in the community.

Since the first assessment trip in January 2013, as many as 40 students and 14 licensed engineers (*P.E, R.A, and EIT*) and faculty have contributed to this project, and as promoted by EfID, have been under the guidance of a practicing licensed professional in Civil Engineering. The students have held weekly project meetings lasting several hours with licensed professional engineers or engineering interns (*E.I.T*) in attendance. During the assessment and implementation trips to the field communities, the teams are small in size and include a professional engineer as a member of the team.

With the help of community members, undergraduate students, and licensed engineers, the Sabana Grande project was successfully completed in two separate implementation trips. This achievement required years of planning and design time and a total of 20 travel days in Nicaragua.

WATER SUPPLY, DISTRIBUTION AND STORAGE
SABANA GRANDE, NICARAGUA

PROJECT DESCRIPTION

This project took three years in the making, over 3,000 engineering labor hours, and funding in the approximate amount of $40,000 to design and construct; the result of three years' worth of student fundraising events. However, it is also worthwhile to note how this project changed nearly 40 student engineers and 14 professionals for the rest of their lives. If successful with this NCEES award, 100% of the award monies will be allocated back to our next water project in Nicaragua.

2013 Completed Water Well and Solar Power Station

PROJECT DESCRIPTION:
Sabana Grande is one of many communities in Nicaragua without infrastructure to distribute or store clean water. This particular community was selected to receive EfID support after three students and one licensed professional engineer conducted a trip in which they interacted with the community and its leaders in order to establish a needs assessment. During the initial visit to the community in January 2013, the EfID team met with leaders in the community including the mayor and the government that has jurisdiction in the community. These initial meetings were critical to the success of the project because they enabled the engineering team to better understand the community's needs and resources, allowing them to establish a foundation for a partnership with the community and support for infrastructure.

During the assessment trip, the team tested the two wells that served as the primary source for water in the community, to include drinking, cooking, and cleaning. Testing revealed that the water contained pathogens such as, bacteria, viruses, and protozoans. In addition to the poor quality of water, many members of the community consisting of about 30 homes, 150 people, and a local elementary school. Many community members, usually the children, were required to travel more than 1-2 kilometers to the wells, in order to gather water and carry it back to homes and school for consumption. As a result of this assessment trip, EfID identified a critical need for a water distribution system to protect the health, safety, and welfare of the members in this community.

PHASE I:

The goal for Phase I of the Sabana Grande project was to provide a sustainable water supply and distribution system for the community. From January until August 2013, EfID students worked beside faculty and professional engineers to design a plan to install a water distribution system in Sabana Grande. Some of the equipment required for the design had to be acquired in the United States and brought to Nicaragua. As a result, the project team had to coordinate the staging of the project with the Nicaraguan consulate and embassy in Washington, D.C. and verify that the installed system would not result in a tax burden to the community. Also, since the impoverished community does not have the resources to support electricity, the team had to design a system that did not require electricity, but instead relied on solar power.

The final design for Phase I of the project required installation of a 200 foot-deep drinking water well, a water pump, a pressure tank and switch, an 800 watt, 12-volt solar powered array, 1,500 linear feet of water distribution piping and fittings, multiple water stations, and a security fence. In August 2013, five students and one licensed professional (P.E) travelled to Sabana Grande for six days to work with the community to install the equipment and system. The success of the implementation trip relied on a tight critical path schedule.

On the first day of the trip, the team split into two separate teams to focus on different aspects of the project. Team one's primary focus was to establish a new well location away from livestock pens and wastewater facilities. During this process, the team analyzed five well sites based on water quality, security, drill rig access, and elevation. The drilling rig could not reach the original well location; therefore, EfID members and the certified well drillers had to work side by side to identify an appropriate location. The certified well drillers were based in Nicaragua, but had been trained in drilling in Norfolk, Virginia as well as Canada. One interesting aspect of working with the Nicaraguan water drillers is that they employed the old techniques of water witching to identify a suitable place to drill the well. The EfID team supplemented this method with their knowledge of topography and land formations to site the well location 100

yards away from the main well in the community. Once the well was drilled, it was fully functional within two days.

As the work on installation of the well progressed, team two strategized on the locations for six, easily accessible, water stations closer to homes and the school. These stations would serve as convenient sources of running water. The team marked all six locations and the most accessible paths to install pipeline to reach the new well. Community members took it upon themselves to dig the trench so the students could use their time to efficiently install the 1,500 linear feet of 2 1/2”-1” of PVC piping needed. There were several areas where the terrain consisted of rock leading EfID to propose running the line above ground to avoid having the community cut through solid rock. However, the community took it upon themselves and managed to separate the rock without hesitation. Several of these areas have heavy livestock traffic and some vehicular traffic, which presented a threat to the integrity of the PVC pipe should a heavy load pass over the pipeline forcing rock to pierce the PVC. The students and professional engineers evaluated the problem and together determined that in order to protect the water line, galvanized metal casing must be used to prevent the puncture of the PVC pipe.

The remaining days of the trip involved installation of the solar panel, pump, pressure switch, the base structure supporting the solar panel, and a 20-gallon storage tank used to protect the pump from overuse. EfID designed and installed three Solar Photovoltaic (PV) panels mounted high atop a 4-inch steel pole to prevent theft of the equipment. The PV panels run on a 12-volt system that provides 800 watts of electricity on a sunny day. On a cloudy or slightly overcast day the wattage drops to 200 watts, which equates to lower water flow.

The quality of the water was assessed and validated with field water testing kits, and after six days, the entire planned system was installed with clean, running water available to the community for the first time. The partnership between the community members, the students, and professional engineers resulted in a significant improvement in the quality of life of the Sabana Grande community. Throughout this period, students were instructed and guided by the licensed professional engineer, serving as their mentor, about the installation of the system and safe practices associated with electrical work.

PHASE II:

The key objective of the Phase II portion of the Sabana Grande project was to expand on the existing system previously installed during Phase I. Phase II improvements consisted of installation of a base platform and a 10,000-liter tank, which would afford the community the capability to continue receiving running water after dark when the pump no longer has solar energy to draw upon. Additionally, this phase would also allow for the expansion of water distribution beyond the six water stations, in order to reach individual homes and the school. From September 2013 until May 2014, the EfID team of 40 students and more than a dozen faculty and professional engineers developed the extensive distribution network and project design while raising funds for Phase II.

On May 2014, ten students and two licensed professional civil engineers (P.E) traveled back to Sabana Grande, Nicaragua for ten days. To

guarantee project completion within the short time frame, two teams were created; a water distribution team and tank installation team. The water distribution team’s objective was to remove all water stations installed in Phase I, locate the original piping, and create 30 new water stations at homes and the school. Their task consisted of removal of old stations, while protecting the existing pipeline and capping the six now open ends of the pipeline. The team then installed additional PVC pipe to extend the lines to the community members’ homes and the school.

Members of the community assisted by digging over 900 feet of trench for the extended water distribution system, allowing the team to install an additional 1,500 feet of PVC pipe, and thereby, doubling the original design size from Phase I. Galvanized steel pipe was used as a casing for the PVC to account for truck and bus loading at each road crossing. When it was feasible, EfID would snake a galvanized steel pipe across a gully and place the PVC pipe inside to prevent it from breaking if a collapse were to occur. Each faucet was approximately four feet above ground and constructed of ½’’ PVC piping with a 90 degree bend connector and a reducer to fit the faucet head. EfID students created about 30 of these faucets, one for every household and two for the elementary school.

As the water distribution team expanded the distribution network, the tank team installed an 8-foot high concrete block base to hold the 10,000-liter tank that had been imported from a city several hours away. After the base was constructed, the tank was rolled up the mountain and put into place. With research, EfID and professional engineers deducted that the tank must be made of polyethylene because of its reliability.

In coordination with a structural engineer, the students designed the base of the tank to be concrete masonry units (CMU). The CMU blocks were placed on an 18” thick concrete foundation. To add additional stability for the 11 tons of water, the CMU blocks were filled with concrete and vertical reinforcement. The upper deck of the tank base was designed to be a composite structure and included structural members, metal decking and a concrete floor.

The placement of the tank on the highest mountain and on the 8-foot high tank base, provided for a water distribution system with about 40-60 pounds per square inch. (psi). Due to the pre-planning and logistics, the construction of the concrete base and installation of the 10,000-liter tank was accomplished within the tight 10-day frame.

The results of Phase II provided the community of Sabana Grande access to fresh clean drinking water for 24 hours per day. The establishment of this secure and sustainable infrastructure has resulted in significant improvements in the quality of life of the 150 members of the Sabana Grande community.

2. COLLABORATION OF FACULTY, STUDENTS, AND LICENSED PROFESSIONAL ENGINEERS

Since the first assessment trip in January 2013, as many as 40 students and 14 licensed professional engineers and faculty have contributed to this project. Since the establishment of the organization, EfID has been under the guidance of a practicing licensed professional in Civil Engineering. The students have held weekly project meetings lasting several hours and include the attendance of licensed professional engineers or engineering interns.

EfID members conducted extensive research with professional engineers during the assessment trip to further enhance their design for the Sabana Grande community. The data consisted of GPS and elevation coordinates, as well as survey analysis for every household regarding daily water consumption. Based on the data collected, students and faculty designed for future development of homes in the community, as well as water demand growth. As part of the research and planning process, professional engineers, faculty, and students assembled a replica of the system and began testing to avoid delays in the field. With the forward thinking by the engineers, the Sabana Grande project was completed and improved in 20 short travel days.

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

Prior to the Phase I implementation trip in 2013, many community members had to walk over a ¼ mile for their supply of polluted water, which was having a growing, negative impact on their quality of life and public welfare. Without a running water supply, community members were spending a significant amount of time collecting and transporting water rather than tending to business or school. Unsurprisingly, the most critical concern is the health of the community members due to the unavailability to clean drinking water. Many community members utilized a trash bin full of water for cooking, cleaning, and drinking at night. This water is open to animal feces, mosquitoes caring diseases, and due to becoming stagnant, allows for the growth of algae and bacteria. EfID students clearly understood that clean running water would reduce the amount of diseases transmitted between community members and improve overall community welfare.

When the solar panel and pump were installed, a barb wired fence was created to surround the equipment for protection of theft and vandalism. Although it is a safe community, EfID realized that protecting the equipment that makes clean water feasible, would increase the duration of the water distribution system.

It took significant planning, engineering, construction, logistics, and funds to assist the community. As a result of their 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.

4. MULTIDISCIPLINE AND/OR ALLIED PROFESSION PARTICIPATION

The students were able to work with an assortment of allied professional participants who were vital to the success of the project. With the 3,000 labor hours of design and planning they were able to reach out into many engineering disciplines. Below are just a few examples of multidiscipline participation:

Environmental Engineering: During the assessment trip, water samples were collected and analyzed onsite. Samples were taken for turbidity, bacteria, and pH. Samples of back water were collected and taken to the US where the students worked together with lab techs at local municipalities to compare the data against the US EPA's maximum contaminate levels.

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

Civil: 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 students how to use EPANet to model the entire water system. The system included service connections, several miles of water lines, water storage, well, and a well pump. The design included fifteen technical memorandums which detailed every existing and proposed water feature. The technical memorandums were written by the students and quality control checked by a practicing civil engineer.

Geotechnical Engineering: Using existing land features, the students sited the 200-foot deep well. As expected, water was found at 80 feet below the surface. Data from the well draw down showed the water production was approximately 140 gpm. Well cuttings were collected and analyzed to be volcanic black basalt.

Structural Engineering: During the entire life of the project, the students had many structural features to design and install. These features included concrete pads, solar mounting devices and foundation, and an eight-foot high water tower that needed to support 11 tons of water. Afterwards, the students worked together with professional engineers to design all the structural features within the project.

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 engineer to design and install a 12 volt and 800 watt PV solar array, electrical meter, conduits, and charge controller.

5. KNOWLEDGE OR SKILLS GAINED

The knowledge gained through this incredible experience ranges from field experience to cultural learning for not only the students, but the professionals as well. The students improved their understanding of surveying while working alongside professional engineers who taught them beyond what the classroom could offer. The students also gained knowledge in water resource engineering by understanding the fundamental importance of having the correct pressure set for a water distribution system.

As the students' knowledge increased, their skills to improvise improved as well. While working in a foreign country, there are always obstacles that cannot be accounted for until they have happened. The students and professionals made a design with certain materials, but unfortunately, the only hardware store was located in a small remote town of Condega, Nicaragua. The store contained only commonly used items. Regrettably, some parts required for the water distribution system were irregular to the store and needed to be transported in from the next largest city, Esteli, Nicaragua. The team learned to improvise their design with the materials the store contained rather than to postpone building and fall behind schedule. The skills to improvise and make decisions were a vital part of working in a field that most students had not experienced.

The student volunteers and professional engineer's knowledge did not stop with engineering skills, but also expanded to cultural knowledge. Everyone realized the importance of having a strong unified community. The 150 members in the community taught all the travelers that it is the basic fundamental to a happy life when people are able to come together and help one another. To keep the water system healthy, a water committee and community members were trained on how to take care of the system. The committee came to an agreement to incorporate a savings system of 50 Cordobas (1 USD) a month to provide maintenance funds for the system. Should the equipment require repair, the community would have the money to sustain the water distribution system that will continue to improve the health and welfare of the entire community. It is evident how important a sense of community is to survive in underprivileged countries.

The significance of communication 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 the EfID 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 Sabana Grande 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, and even into the future, will be unable to overlook a community's declining public welfare.