Assessment – Post-Trip Report

Community:	El Cacao
Country:	Nicaragua
Chapter:	University of Maryland
Submittal Date:	
Dates Traveled:	January 14, 2018-January 22, 2018
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Scope of Assessment (100 words)	To determine needs of the community; to map out houses, latrines, and all existing infrastructure; to test soil and water quality; and to assess the barriers (or lack of) created by local governmental agencies.

Privacy: EWB-USA may release this report in its entirety to other EWB-USA chapters or interested parties.

Purpose: To archive, present, and summarize the information gathered during the assessment for review. This includes notes, photographs, sketches, survey information, interview notes, measurements and any other pertinent data.

Instructions:
When completing this report, the chapter should

- Provide all the technical information about the project that was gathered during the assessment.
- Modify the outline of the report if necessary to present the information more clearly. It is your chapter's responsibility to clearly and thoroughly present your project and the results of your completed assessment trip.
- Include additional information relevant to the specific project.
- Provide pertinent figures, tables, and photographs with figure numbers, table numbers and photograph numbers in the section where discussed. Full drawing sets, complete lab reports, and any information larger than 2 pages should be included at the end of the report as an appendix.

Section 1.0:

- Provide a concise description of the assessment sufficient for anyone who had not participated on the trip to understand what happened.

Section 2.0:

- Provide a review and go/no go decision based on the criteria established in the *Assessment – Pre-Trip Plan*. The chapter may decide that the originally proposed project is inappropriate but that another project is feasible. The chapter may also decide that there are no feasible projects in the community.

Section 3.0:

- Please provide a coherent, brief summary of the information that you collected while at the site. Many times it is useful to display this information in a drawing or in tabular form. You should include all the useful information collected at the site in one or more appendices. Please be sure that the data are annotated for clarity and presented in a coherent fashion.
- Establish subsections for data collection to help organize your report. Please provide maps, tables and photographs where most relevant to the understanding of the report.

Section 4.0:

- Label each photo with a photo number and give a full description.
- Provide a few photos of relevant parts of the project along with a photo number and description. Photos are not limited to this section, please include photos where appropriate. Additional photos taken during the project along with a photo log can be included in an appendix.

List of Attachments:

List all attachments included as separate files, including:

- Signed Final Project Partnership Agreement

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1.0 Assessment Description

The University of Maryland, College Park chapter of EWB-USA travelled to Nicaragua from January 14th to January 22nd, 2018 for an assessment trip, the team's first trip with the project. Before departing for Nicaragua, the project team identified several goals to address in country: community context, community identified needs, observed needs, gain technical data on water quality, soil quality, and infrastructure, and determine the government agencies and companies that would either help or hinder our work. To get information, both quantitative and qualitative assessments were completed. The insight gained from all meeting and measurement will provide the baseline for the design moving forward.

In Managua, the team met with the professional well drilling company AquaTech. While the representatives from Aquatech gave valuable information regarding the steps to drilling and maintenance, the cost estimate they gave was much higher than we were expecting (see

Pricing Data Table). After hearing the price, the team was skeptical if the community would be able to pay for a new well in both initial cost and maintenance.

Figure 1: The team after informational meeting with AquaTech

During the first day at the community, the team met with the NGO partner Tierra y Vida who gave us a detailed rundown about the Department of Carazo and the overarching water patterns. Additionally, they outlined their vision for mitigating the water issue. They saw a two-part system, using rainwater catchment for greywater and a well for potable water. In addition, they stressed educating the community on water usage and conservation. Other useful information included getting the names of a reference community, El Sol, and being taken to a private farm with a large water storage capacity (see below).

Figure 2: NGO Tierra y Vida office in Santa Teresa

After meeting with Tierra y Vida, the team met with a representative from the Alcaldía (a local governmental organization) named Leda Gloria Cruz Coroloze. She showed us the governing documents over CAPS, explained regulations surrounding new piping for the project, mentioned the 4% growth rate for the municipality, and claimed the existing 2-inch pipeline and well is insufficient for El Cacao. We also met the newly elected Mayor who proclaimed that "water is a human right," which indicates the Mayor's office may be willing to provide assistance in some form.

The team also met with the El Cacao community for a community meeting, and were later told that the people at the meeting were fairly representative of the community as a whole. The community identified their main concerns: water, latrines / sanitation, and deforestation. We learned that the community was not only concerned about water quantity, but also concerned that the water was bad for their health, because they see particles in it, it tastes off even when filtered through cloth, and people have had stomach issues which could potentially be due to the water quality. Community members revealed that they retrieve their water from the river, wells within the community, and water piped from Santa Teresa. The Santa Teresa system was inconsistent; one woman went without water for 22 days. The wells also often dry up.


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Figure 3: First community meeting with El Cacao and EWB-UMD

Team members met with ENACAL, Nicaragua's national water company. We set up for them to send us all the forms we will have to fill out, and discovered that they do not have any current plans to improve El Cacao's sanitation system. The organization also informed us that they are looking to cut off a community from the Santa Teresa pipeline system. They welcome us taking over their distribution pipe system, but would immediately cut off the community from Santa Teresa once we tap into their pipes.

Figure 4: ENACAL office in Santa Teresa

Another organization the team met with was the Ministry of Education, the group who oversees the school in El Cacao and the well that is there. The well was put in by the Southern Reserve from the United States. The well was solar powered, but was decommissioned several years ago after the panels and battery were either tampered with or stolen. Despite this, the community suggested that the well could be renovated and used as a source. To get permission, three team members met with the principal of the school Leonardo, who was incredibly willing to help out. He gave us permission to use the school well for the entire community, whereas before it was only for school use.

In addition to these organization meetings, we also visited nearby communities to see how they have implemented their water systems. We visited a private farm outside of Santa Teresa, where we looked at a 12m deep well that has been there for 80 years. The owner uses a rainwater roof catchment using bent sheet metal and PVC to run off to a tank during the dry season. He pumps the water to a smaller reservoir using his electricity for drip-irrigation. We also visited Cruz Verde, a similar though slightly more compact community, and talked with their CAPS president and took a look at their pump site and storage tank. Cruz Verde uses a pay based on income system, and people get water pumped to their house to store in tanks every fourth day.

Figure 5: Rainwater roof catchment system at the farm

Within the community, the team performed personal interviews, water testing, soil testing, and community mapping. For the interviews, the goal was to identify the pressing water needs the community faces as well as the overall context. The results of these interviews and other tasks are discussed below.

Some unexpected problems we encountered included not being able to use the TopCon in country. We were unaware of a four month long process required for allowing items over $2,000 into Nicaragua, so had to use a surveying scope to record the precise elevation change between the highest point of the community and the probable location of the water source for the future distribution system. It was necessary to use this method of data collection due to the previously mentioned confiscation of the Topcon system and the inaccuracy present in the GPS's elevation readings, which is up to 15-20 meters at points. The methodology involved situating a philly rod in a position viewable with the scope, and then subtracting the height of the instrument from the measurement recorded on the rod to find the elevation change between the two points. This process proved to be an imperfect solution, however, as the elevation decline in the community is steep enough so that the rod could only travel a relatively small distance away before it was outside of the scope's vertical range, resulting in a process that took an unexpected amount of man-hours to complete.

2.0 Go/No Go Decision

2.1 Community Health Survey - Go

A conversation with a nurse working in a local treatment center showed that diarrheal diseases were a prominent issue facing the community and others surrounding it. However, the community surveys contradicted this fact, as noone in the community identified diarrhea as a pressing issue. Despite the community's report, the overall data suggests waterborne illnesses are present and must be addressed.

2.2 Community Feedback of Water Treatment Systems - Go

The community agreed that water treatment was necessary in the system because of the non-potable quality of the sources in El Cacao. Many houses in the community rely on ENACAL, which sends treated water, for potable water or self-chlorinate their greywater to drink. Since there is a notion that any project implemented in the community would cut the community from ENACAL, a water treatment system is a must.

2.3 Community Feedback of Distribution Expansion - Go

The community has a stark inequality in their water accessibility, much of which derives from distribution issues. The majority of the community believed that an improved distribution system would help nearly everybody in the community.

3.0 Data Collection and Analysis

3.1 Community Context

3.1.1 Social, Political, Economic, Demographic

El Cacao is a highly cohesive small community of 90 households. It was founded over six generations ago, and includes some (immediate) extended family clustering, and households nuclear family. Most community members interviewed expressed that every family in the community is related to some degree. Income from work comes primarily from remittance construction work in Costa Rica, Santa Teresa, and Managua, and there is an apparent income disparity. The community has an elementary school, but for further education people go to Santa Teresa, and Jinotepe or Managua. The community was very welcoming and excited for us to be there to help them. They are a very conservative and religious, both Catholic and Christian, community.

Figure 6: Travel team with community members

3.1.2 Needs

The community's self identified needs are water quantity, including potable and non-potable, latrines, work, and reforestation. Some potential problems that we see include diarrheal disease, respiratory disease, cancers, and diabetes. The main complexities to implementing a water system in the community deal with disparity of water access (some had water on demand, others were without water for weeks) due to the distribution system. There is a challenge to reach everyone due to large geographic spread of community. Geographically, the community has two branches. The main road holds the majority of houses, west road holds roughly 20 houses, and each branch is roughly 2.5 kilometers. There is also a challenge to implement equal access to water, because of many changes in water pressure throughout the community's current systems. There is also a potentially high operations and maintenance cost of the project.

3.2 Water Sources and Use

3.2.1 Overview & Community layout

El Cacao is divided geographically into two roads (main and western branch). The main road contains three service areas created by ENACAL, north, central, and south. The central service area is further divided into north-central and south-central at the school by EWB-UMD. The western branch clusters into northern and southern sets of houses.

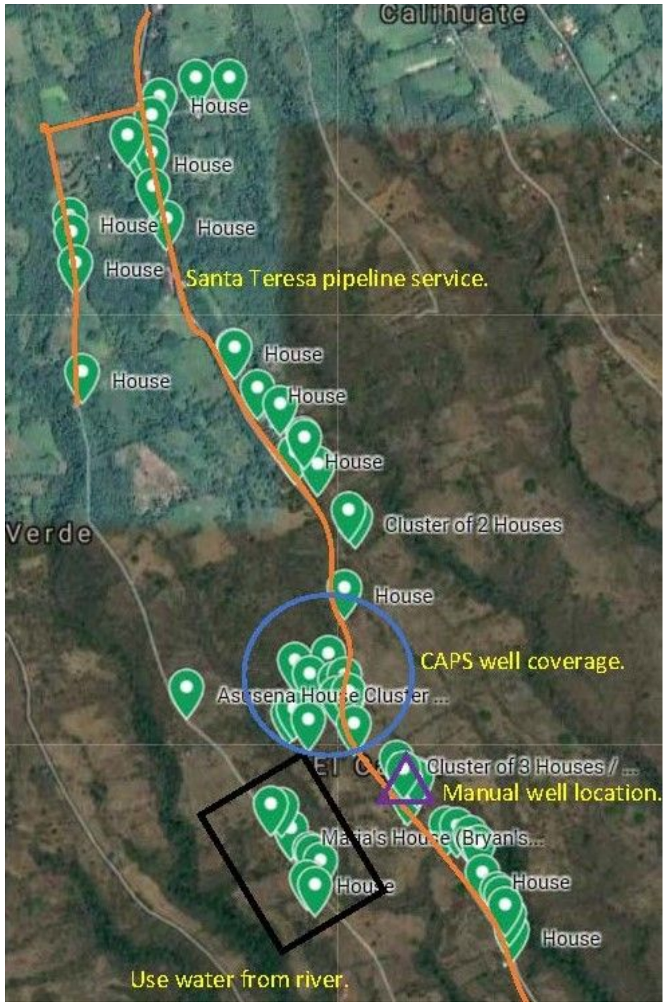

Figure 7: A map of El Cacao showing the water sources who it services.

The residents of El Cacao use a de-facto mixed-source water supply system. Potable water is supplied to parts of the community from the Santa Teresa municipal system and the CAPS well by an ENACAL-controlled piped distribution network. Water from this system is stored separately and used for drinking and cooking.

Residents utilize non-potable water from rainwater collection, superficial wells, and a nearby spring-fed river. Water from these sources are used at the source, transported to homes, and/or stored within homes. This water is used for all other uses including hygiene, clothes washing, and gardening. These sources are subject to seasonal variability, including weeks of drought.

3.2.2 Sources

3.2.2.1 Piped Water

Piped water is supplied to el Cacao from Santa Teresa and the CAPS well. *Aqua potable* managed by ENACAL is piped to the rural communities of El Cacao and El Sol from Santa Teresa. Due to water scarcity, both communities receive water from this system once or twice every eight days, on rotation. ENACAL controls a set of valves which are opened for half an hour to an hour at arbitrary times to provide water to the communities. The community of Cruz Verde once received water from this utility until USAID implemented a water system for the community.

Figure 8: An exposed portion of the water line.

Water is transported via a piped distribution system to each community. In El Cacao, this system consists of a 2" diameter main line which follows the main road (Figure 7). This line branches to include houses along [name] road. Water is piped to the 60-65 houses in the community which receive this service. Water is accessed at each house through an outdoor spigot. It was noted that several of these spigots have been removed due to low water pressure (Figure 9). ENACAL partially maintains this system by infrequently repairing damages to the line. A walk of the system revealed several leaks and major failures (See Appendix E). Claudia reports that the majority of repairs are conducted by community members.

Figure 9: Water pipe access through a hose instead of spigot due to lack of pressure.

When ENACAL opens a valve to supply water to El Cacao, community members must collect piped water for weekly consumption. Some households must have family members present to manually collect water in buckets or pay for the service. Other families have connected these lines to HDPE storage tanks or *pilas*. Many families utilize this water exclusively for human consumption.

All users are charged 130 Cordoba per month for the service regardless of consumption. Several households are reported to not pay the fee for various reasons, including poor service. It appears that some households that may be able to pay and receive adequate service do not pay.

Access to this service is primarily stratified by infrastructure. The river cluster of houses is not on the piped distribution system. Although a family once funded the construction of a branch to provide water to these houses, the section of pipe has been abandoned. Additionally, houses at the beginning and center of distribution system service areas do not receive adequate water. It is hypothesized that as there is insufficient water to cause the pipe to flow full, houses at the end of each service area receive more water for a longer period of time. Houses at the beginning and center of service areas only receive water once the pipe has been filled. Alternatively, a section of pipe is broken, clogger, or has had a valve left open.

3.2.2.2 Rainwater

Rainwater catchment is common in Cacao. Most households have simple rainwater collection systems. These systems are typically folded corrugated metal which channels water off of roofs into open drums, pilas, or shallow ponds. These systems are used in the rainy season to provide water for hygiene, clothes washing, gardening, and for household animals. Rainwater is rarely used for drinking, only during severe shortage. When rainwater is used, community members report treating it with chlorine bleach.

A 40,000L catchment system was seen on one property in the community. A 4” pipe leads from rooftop collection to a 40,000L concrete pila. This system is reported by a property staffer to sustain the family of four throughout the dry season. The system had been drained prior to our arrival due to several instances of dengue rumored to originate from the open pila. The family who owns the system raises cattle and appears to be relatively wealthy. Water from the system is presumably used to water their 32 cows and support their household.

3.2.2.3 Rio

The river is accessed at a head spring on the southwest boundary of the community. Most community members utilize the spring in dry months for bathing, washing clothes, and recreation. People typically collect water close the spring and conduct other activities downstread. The river is accessed by a descending trail for about 15-20 m, composed of primarily packed earth. Several families clustered near the river (Western-branch, south) utilize the spring as their primary water source. One family conducts 12, thirty-minute round trips, with 2 jerry cans per trip, per day to collect water.

Figure 10: The spring in the Southwest corner of the map. The sandbagged area is the primary collection site.

When asked about utilizing the river as a water source, several community members were concerned about tampering. Youth from neighboring cities often party at the river in dry months. Community members were concerned about damage to potential implementations and increasing activity due to improved access.

3.2.2.4 Superficial Wells

The majority of wells in el Cacao are hand dug wells into the water table or near-surface aquifers. These wells range in depth from 12m to 54 m. These wells are typically private or shared between neighbors or within a family. These are dug collaboratively, with the cooperation of multiple families. Superficial wells visited were finished with concrete and masonry and were primarily open. Water use from these are mixed. Families who receive water from ENACAL primarily use superficial well water for household and agricultural use (non-potable). One family was noted to collect all potable and non-potable water from their family well. This family was concerned about the taste and quality of water from the well. Another family, clustered into 5 households, shared a submersible pump to a shallow well. While the well was publically available via a manual pump, electrically pumped water was shared within the cluster of households until the system broke.

3.2.2.5 CAPS

The CAPS well is also a superficial well. It has been finished and sealed with concrete and outfitted with a submersible pump. Originally, the well had been hand dug by the community but ran dry. Community members contributed to deepening the well until it provided water once again. An organization called the Fundacion Cristianos Nicaraguenses por los Pobres aided the community in mechanizing the well with a pump connected to the electric community line. A report received from the EWB field office said the well was hand dug to a depth of 45 meters and the water level fluctuates between 2-3 meters. The pump powering the system was a 1.5 hp pump with an estimated flow rate of 5.5 gpm was included. A 5000 L plastic tank is used as a peaking tank.

3.2.3 Users

Water use in El Cacao can be described as household, small-scale agriculture, and industrial agriculture. Most families utilize water for their household. Household use includes drinking, cooking, hygiene, clothes washing, gardening, and an animal (eg. a cow, pigs, chickens, or dogs). Households typically store drinking water in closed ceramic pots or closed 20L buckets. Water for all other purposes are stored in pilas, 55-gal drums, shallow ponds, trash cans, HDPE tanks, or any other vessel. The sophistication of storage systems is a function of income. Most households describe some degree of water rationing in the dry season. These behaviors include foregoing bathing, bathing and washing clothes exclusively at the river, selling cattle, and ceasing garden watering. The amount of water stored, degree of rationing, and hardship experienced was stratified by access to piped water. One women ostensibly on the ENACAL system reported traveling on horseback biweekly to El Sol to collect water from a relative. Another women down the street reported no major issues with the same piped water supply and requested more frequent service.

One small-scale agricultural user was interviewed. The man reports that he earns an income by selling crops in nearby markets. He utilizes water from the CAPS well and a rainwater collection system stored in a 100-400 L pila to water his crops. The scale of agriculture in the community ranges from families with individual small gardens to farmers with commercial agriculture. From the water storage containers that we viewed, there was a range in amounts of water that each of the families are using.

Figure 11: Two concrete pilas next to each other for water storage.

One industrial agricultural user was identified. The family owns a large property on which they keep 32 cows. The cows are watered at the river during the day. However upon return to the property, water is used to maintain them. Water is collected from ENACAL into a 10,000 L pila. This house is the site of the 40,000L rainwater collection system previously described.

3.3 **Identified Needs**

Through a community meeting, semi-structured interviews, and informal discussions with community members, EWB-UMD identified several water-related needs in El Cacao. The community expressed that there were other needs such as renovation of latrines, reforestation and job need. These are addressed in the baseline study. The described needs and their relative priorities varied between clusters of houses, primarily by access to piped water.

3.3.1 Quantity

Several community members report concerns with shortages of potable and nonpotable water. These concerns were primarily voiced by households at the beginning of valved service areas and entirely unserved by the ENACAL distribution system. Households on the northern part of the western branch and the center of the main line service areas reported poor water flow for short durations during service hours. One woman reported that she did not receive water for 22 days during the dry season. Otherwise, her household receives as little as 4L of water, twice a week. These issues are exacerbated during the dry season, resulting in water rationing behavior to conserve potable water. Other families who are not serviced by the system rely on suboptimal water sources, such as a spring which feeds a neighboring river.

3.4 Site Mapping

Our assessment team mapped the community of El Cacao via the use of a surveying scope, the ‘GPStracks’ app, and the ‘Elevation’ app. The community is distributed across two separate roads of roughly 2.5 kilometers each, with the vast majority (~70 of the ~90 households in the community) of the population living directly off of the main road, and the remainder off of the significantly more inaccessible side road. The community is situated on a large hill with a relatively constant elevation decline, dropping 50-60 meters over its entire span according to the average of the elevations recorded by the ‘GPStracks’ and ‘Elevation’ apps. The surveying scope used, a much more accurate instrument than the GPS apps, recorded the elevation drop between the highest point in the community and the community school, where the most probable water source is located, as over 100 feet, corroborating these findings. The map of the community we created can be viewed in Appendix C.

3.5 Technical Data Collection

3.5.1 Water Data

The team conducted field water testing to identify the quality of potable and non potable water sources that the community currently uses. The team’s aim was to assess the quality of every source of water that had any potential of being a viable source for the project, and that would be distributed to the whole community. In-country, the team tested for bacterial contamination (H2S producing coliforms), temperature, pH, turbidity, conductivity, hardness, nitrate/nitrite concentration, ammoniacal-nitrogen, pesticides (presence/absence of atrazine or simazine), arsenic, free chlorine, and chlorine demand using a set of meters, dip strips, and colorimetric analysis kits.

Table 1: Source Descriptions

River/Spring	Coordinates: 11.74381,-86.14587 Elevation: 216.2 meters (Average) General Description: The community calls it a river but it is actually a spring that comes out of the ground. There are sandbags around the spring to collect water for members to fill their buckets. The water very shallow in the area and flows on a flat surface with large rocks. There is also a mini waterfall that might be man made. Many who use the river for water get all of their supply from it. On average, a single family will take 40-60 gallons per day from the river and use it for potable and non-potable uses. Other members throughout the community use the river use it to wash clothes, bathe, and, in situations where their primary source fails, drink. The river is available year round, but flows higher in the rainy season. Community members

	identified that the water level has gone down in recent years, but did not provided a reason for it. Potential Sources of Contamination: Members bathe around the spring but since members fill up water right out of the source, their water does not have too much potential to get contaminated.
Santa Teresa	Coordinates: 11.75605,-86.14519 Elevation: 251.5 meters (Average) General Description: Santa Teresa water is put into a tank and is distributed through the existing distribution system. This sample was taken from a hole in the ground where community members attached a hose into the pipeline and access the water. The source is accessed by a majority of the people on the system through spigots, others feed directly into storage tanks or concrete storage basins (pilas). The water is used for both potable and non-potable uses. The time of water availability is unknown, but generally the schedule is twice every eight days. In addition, the quantity is unequal; some families will be have water flow for 30 minutes while others have 1 to 2 hours of water. Potential Sources of Contamination: Community members fill up buckets with this water in a hole in the ground around 1.5 meters deep. Sand and dirt from the wind or from people standing near the edge of the hole can fall into the buckets or the hose. The hose is not properly sealed to the pipe which creates gaps for potential contamination. The buckets they use are also used to wash clothes and other uses, which could lead to dirty water residue in the bucket mixed with the sources water.
CAPS Well	Coordinates: 11.74939,-86.14361 Elevation: 215.2 meters (Average) General Description: CAPS water comes from a closed well and goes to community members through a distribution system. It comes out of spigots and collected in buckets. This sample was taken from the spigot at Claudia's house. The system includes roughly 20 families in the middle of main street. The system goes both above and below the well with seperate piping for each side. The system is manually altered daily by turning valves on and off, creating an every-other-day schedule for the north and south branches. Those who are on the system use the CAPS well for both potable and non-potable uses, but the well gets very low in the dry season.

	Potential Sources of Contamination: The buckets they use are also used to wash clothes and other uses, which could lead to dirty water residue in the bucket mixed with the sources water. There isn't much potential for contamination at the source.
Manual Well	Coordinates: 11.74780,-86.14198 Elevation: 244.2 meters (Average) General Description: The manual well has two ways to extract water. One is an electric pump that distributes water through piping to a few houses. The other way is to manually turn a wheel that brings up water. The electric pump is out of commission at the moment so the only access is through the hand pump. The well is used by a cluster of 6 houses who use it solely for greywater due to the poor quality of the water. The demand on the well is not great enough to dry the well up. Potential Sources of Contamination: The well does not have a cap and has several open spots. This means that anything from the range of dirty water to leaves to insects can go into the well.
Rainwater	General Description: Throughout the community, there are rudimentary rainwater collection system made out of corrugated steel on the roofs. Throughout the 6 month rainy season, the community collects rainwater for greywater purposes and watering livestock. Possible Sources of Contamination; The system does not have a filter, allowing debris from the roofs to get in the water supply. However, since the water is not for drinking, this is not a huge issue.

Table 2: Field testing water quality data

A summary of water testing results are shown below. Tests with a "-" were not conducted due to a shortage of test strips. Data highlighted in yellow are above the acceptable range for that test.

Test Type	Acceptable Range	River/Spring (from the Source)	Santa Teresa Water (Hose connected to pipeline)	CAPS Well (Claudia's House Spigot)	Manual Well (from the Source)
Temperature (deg C)		28.05	27.4	28.0	27.6

pH meter	6.5 - 8.5	6.76	7.5	7.2	7.3
pH dip strip	6.5 - 8.5	6.83	7.3	7.15	7.0
Turbidity meter (FTU)	< 5	0	0	0.04	0
Conductivity mS/cm	< 1	0.33	0.30	0.33	0.31
Total Hardness dip strip (ppm)	- 60-120 moderately hard - 120-180 Hard	130	180	150	180
Nitrate - Colorimetric (ppm)	< 50	0	0	2	4
Nitrite - Colorimetric (ppm)	< 1	0	0	0	0
Ammonia - Colorimetric (ppm)	< 0.02	0	0	0	0
Pesticides dip strip	< 3 atrazine or < 4 simazine	Negative	-	Negative	-
Arsenic (ppb)	< 10	3	0	0.7	0
Iron dip strip (ppm)	< 0.3	0.02	0	0.02	0.02
Free Chlorine DPD - Raw (mg/L)		0.2	0	0	0
Phosphate dip strip (ppb)	< 100	400	200	250	300
Coliform Test: HACH Pathoscreen	Negative	Negative - 2	Positive - 1 Negative - 2	Negative - 3	Positive - 3
Chlorine Demand - Raw: 30 min demand (mg/L)		0.1	0.1	0.1 - 0.15	0.2

A few of the tests results came out to be above the accepted safe level for potable water. Although hard water has no adverse health impacts, it's only harmful characteristic is that it can decrease the lifespan of the distribution system by having particles stick to pipes and create spots on surfaces. Moreover, all the sources have high levels of phosphates in the water which can lead to serious environmental impacts since they cause the water level to decrease over time, but it does not pose any health concerns. Furthermore, the Santa Teresa water source had one positive test result and two negative test results for E.coli coliform, which makes it uncertain whether there is fecal matter in the water. If this is a real problem, it can pose as a serious health hazard. However, there is a large probability that bacteria was externally introduced into the sample before/during the test was performed.

Table 3: Official Lab water quality data

A summary of lab water testing results are shown below. Tests with a "-" were not conducted since they were not deemed necessary to get tested in the lab. Data highlighted in yellow are above the acceptable range for that test.

Test Type	**Acceptable Range**	**Santa Teresa Water (Hose connected to pipeline)**	**CAPS Well (Claudia's House Spigot)**	**Manual Well (from the Source)**
pH	6.5 - 8.5	-	7.22	7.19
Appearance		Clear	Clear	Clear
Cadmium (mg/L)	< 0.05	<0.01	<0.01	-
Total Hardness dip strip (mg/L)	< 400	114.24	126.72	133.52
Nitrate - Colorimetric (mg/L)	< 50	-	5.82	5.1
Nitrite - Colorimetric (mg/L)	< 0.1	-	< 0.009	< 0.009
Fluoride (mg/L)	< 0.7	0.319	-	-
Arsenic (mg/L)	< 0.01	< 0.001	< 0.001	-
Cyanide (mg/L)	< 0.05	-	< 0.001	< 0.001
Chloride (mg/L)	< 250	12.3	9.66	10

Bromine (mg/L)		0.263	< 0.002	-
Total Chrome (mg/L)	< 0.05	0.0203	0.0186	-
Mercury (mg/L)	< 0.001	< 0.001	< 0.001	-
Phosphorus (mg/L)		-	1.36	0.573
Total Coliform (NMP/100ml)	Negative	2.2*10	2.2*10	7.0*10
Fecal Coliform (NMP/100ml)	Negative	1.3*10	1.4*10	1.3*10
Magnesium (mg/L)	< 50	-	12.21	12.09

All three of the source samples that were sent to the lab for water quality testing came out with positive results for bacterial and fecal matter being present in the water. This is a health hazard and makes it a risk as a potable water source. Water treatment options include shock chlorination and drip chlorination systems, but the team will implement a treatment system within the distribution design process to address this issue.

3.5.2 Soil Data

One of the host families whose property is on the northern border of the community, offered to let us build any structures on her property. Since the family's property is the highest point in the community, it would be easier to gravity feed water to the whole community. Therefore, this would be a potential area to implement a water storage tank, so the team conducted soil tests here. These tests included visual analysis of the soil, penetrometer test and drop test.

Table 3: Soil testing data (Tested by Bryan Croce on 01/20/18)

Descriptive Tests	
Angularity	Angular
Shape	Flat and Elongated
Odor	Normal
Moisture Content	Moist
Consistency	Hard

Cementation	Moderate - Strong, Some break & some don't
Hardness	It fractured
Structure	Homogenous
Coarse Grained Soil Tests	
Clean Test	Dirty
Gradation	Well graded
Shear	5.5 revolutions, 5.5 kg/cm^2
Drop Test	
Height of Drop	4 ft
Soil Depth	2 ft
Diameter of Impression	1.5 cm
Pocket Penetrometer	
Soil Depth	2 ft
Reading on Penetrometer	4.25 tons/sq.ft or kg/sq.meter

3.6 Neighboring Community Data

3.6.1 Santa Teresa Private Farm

We visited a private farm outside of Santa Teresa, where we looked at a 12m deep well that has been there for 80 years. The owner uses a rainwater roof catchment using bent sheet metal and PVC to run off to a tank during the dry season. He placed concrete on the slight incline next to his tank so that when it rains, the water doesn't soak into the ground and instead goes into his tank. He pumps the water to a smaller reservoir using his electricity for drip-irrigation. He also has a biogas system using cow and horse waste to generate gas that he uses in his kitchen. It also generates manure to be used in his fields.

Figure 12: Santa Teresa Farm Well

Figures 12 and 14: Santa Teresa Farm Drip Irrigation Tube and Farm

Figures 15 and 16: Santa Teresa Farm Biogas System

3.6.2 Cruz Verde Water System

We visited Cruz Verde, a similar community with about 60 households, and talked with their CAPS president and took a look at their pump site and storage tank. Cruz Verde uses a pay based on income system, paying between 80-200 cordoba, averaging to about 150 cordoba per household. This equates to collecting 9000 cordoba per month as a community, paying 8000 cordoba for electricity per month and keeping 1000 cordoba for maintenance. They pay Ignacio Lopez 3000 cordoba to maintain their system every 6 months. Some community members use ceramic filters from San Marco, which cost $12 and are replaced every two years. Their well cost around $30,000, put in by USAID. The distribution reaches every household, which is simpler for Cruz Verde than El Cacao because it is a more compact community. People get water pumped to their house to store in tanks every fourth day.

Figure 17: Cruz Verde Tank


Figures 18 and 19: Cruz Verde Water System

4.0 Photo Documentation

4.1 Water Use

4.1.1 Sources

4.1.1.1 Agua Potable: Piped water from Santa Teresa for drinking and cooking, also sometimes trucked in from the local town to fill up their containers.

Figure 20: An example of the taps used to deliver water to the individual homes.

Figure 21: From left to right clay pots, a pila and plastic 20 gallon water containers. The 20 gallon water containers are often also used to carry water from the tap location or the stream (if water is collected from there for that household).

4.1.1.2 CAPS well: mostly non-potable uses, some drinking and cooking uses

Figure 22: The cover of the valves used to direct water to the different areas of the community from the CAPS well.

Figure 23: The site of the CAPS well and peaking tank.

Figure 21: The CAPS well finished and covered by Fundacion Cristianos Nicaraguenses por los Pobres.

4.1.1.3 Rio: Bathing, clothes washing, drinking for west houses, farm animals, agriculture

Figure 22: The area of the stream where the clean spring comes out from the rock.

Figure 23: The area downstream of the spring that is used for washing in the community.

4.1.1.4 Private wells

Figure 24: A private well on the southern end of the community that has fallen into slight disrepair. Our on-site tests confirmed the presence of coliform in the well, which the households had already stopped using as a source of drinking water because it had made them ill.

4.1.1.5 Rainwater

Figure 25: An example of the method of roof rainwater collection in substitute of plastic gutters.

Figure 26: A plastic 50-gallon storage container that can be used to hold rainwater.

Figure 27: Another example of the storage containers used to store rainwater or other rain sources.

4.1.1.6 School Well

Figure 28: The site of the tower where the old peaking tank for the school well built by the US Southern command used to rest.

Figure 29: The features of the current above-ground water system at the El Cacao school that used to function with the well.

Figure 30: The plaque from US Southern command to denote the building of the well. Behind the plaque is the cage which contains the above-ground water system in Figure 29.

5.0 List of Attachments

5.1 Appendix A: Signed Final Project Partnership Agreement
5.2 Appendix B: In Country Community Contact Information
5.3 Appendix C: Map of Community
5.4 Appendix D: Interviews
5.5 Appendix E: List of Locally Available Material Costs
5.6 Appendix F: Results of Well test completed- NOT DONE YET