Developing Sustainable Water Distribution Systems in Rural Panama

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iDesign 2011

TEAM CANDELA iDesign 2011

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Acknowledgements: Candela Community members, Panama Peace Corps Volunteers, Team Mentor Ashley Maes, Dr. Brian Barkdoll

Project Background

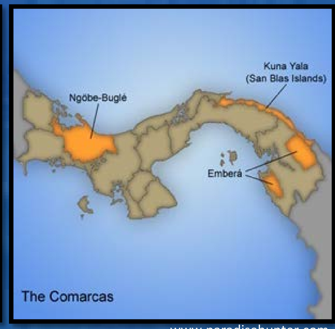
Team Candela is comprised of Jordan Huffman (P.M., construction management), Natalie Minott (environmental engineering), Steve Rutkowski (civil engineering), and Stephanie Tulk (civil engineering), and was part of Michigan Technological University's International Senior Design, 2011. For this project, students traveled to rural Panama to help communities find sustainable solutions to improve the quality of life. In August, Team Candela was welcomed into the Candela Community to find design solutions to improve their existing water supply and distribution system. Throughout the Fall 2011 semester, the team has designed recommendations for the community, ***"To improve the health and sanitation of the Candela community through sustainable water system design" (Team Mission Statement).***

The project goal has been to provide access to clean water for each home in the Candela community continually throughout the year. These recommendations also focus on staying cost effective, environmentally benign, and simple to implement and maintain.

Community Background

The people of Candela are part of the indigenous Ngöbe-Bugle tribe in Panama. They inhabit the Comarca Ngöbe-Bugle (Figure 2), similar to an Indian Reservation in the United States. The village of Candela (Figure 3) is home to approximately 250 Ngöbe-Bugle people. These families rely on subsistence farming and government support. Most Candela residents dwell in homes built with bamboo walls, corrugated metal roofs, and dirt floors (Figure 1). Most of the families live in three isolated sub communities, each served by a separate water system.

Photo Credit: Huffman



www.paradisehunter.com

Photo Credit: Huffman

Figure 1: (Left) Typical home constructed with bamboo walls, mud floor, and corrugated tin roof.
Figure 2: (Middle) Distribution of Comarcas across Panama.
Figure 3: (Right) Candela Community map drawn by community member Marco

Current Problems With the Existing Water Systems

Community Interviews resulted in the following needs for improved water systems (described below) and provided goals for design:

- Year round access to water (most water is only reliable from the systems during the wet season)
- Water treatment (illness noted at the beginning of the rainy season, likely water related)
- System protection from being contaminated with animal life (snakes, frogs, crabs, etc.)

Figure 4: Typical water spigot to a home. This water flows constantly to the latrine and to the home for cooking, bathing and laundry needs.

Figure 5: Community members helping to collect data on flow rate for further analysis. The community was very motivated by the project

System 1

- 1999 World Bank funded
- Spring box to collect water for storage in a holding tank
- Many leaks along the pipeline
- Tank is contaminated with crabs and other wildlife
- Spring box is open to contamination due to structural collapse (Figure 6)

System 2

- Created from salvaged pipe
- No water storage tank
- Spring box (Figure 7) no longer collects water, so it is gathered from an open collection pool down stream of the spring, which allows contamination

System 3

- Five houses never successfully received water from System 1
- Utilize a nearby surface runoff source (contaminated) to supply their water, but only flows six months out of the year (Figure 8)
- During the dry, season water is collected from the nearby river

Photo Credit: Minott
Figure 6: System 1 Spring box

Photo Credit: Tulk
Figure 7: System 2 Spring box

Photo Credit: Minott
Figure 8: System 3 collection

Problem Analysis

1. Will Available Water Sources Meet Community Demand?

Analysis needed to be done to see if available water sources on System 1 could provide adequate water to meet the community demand. Flow rate measurements were collected and compared to estimated community demand (below).

System 1- Supply and Demand By Season					
System 1- Minimum Demand			*System 1-Supply By Season*		
Current (50 People)	1787	(G/D)	Spring 1	41317 (Wet G/D)	5707 (Dry G/D)
With Expansion of System 3 (90 People)	3217	(G/D)	Spring 2	23968 (Wet G/D)	2283 (Dry G/D)

Even in the dry season, there should be a surplus of water to System 1. Unfortunately, water did run out in the dry season, which could be attributed to losses in the system and consumption being higher than estimated.

2. Can Water Reach System Three?

Data analysis using EPANET® hydraulic system modeling software (Figure 9) was performed, verifying that it would be impossible to gravity feed water from the tank on System 1 to System 3, so another method would have to be used.

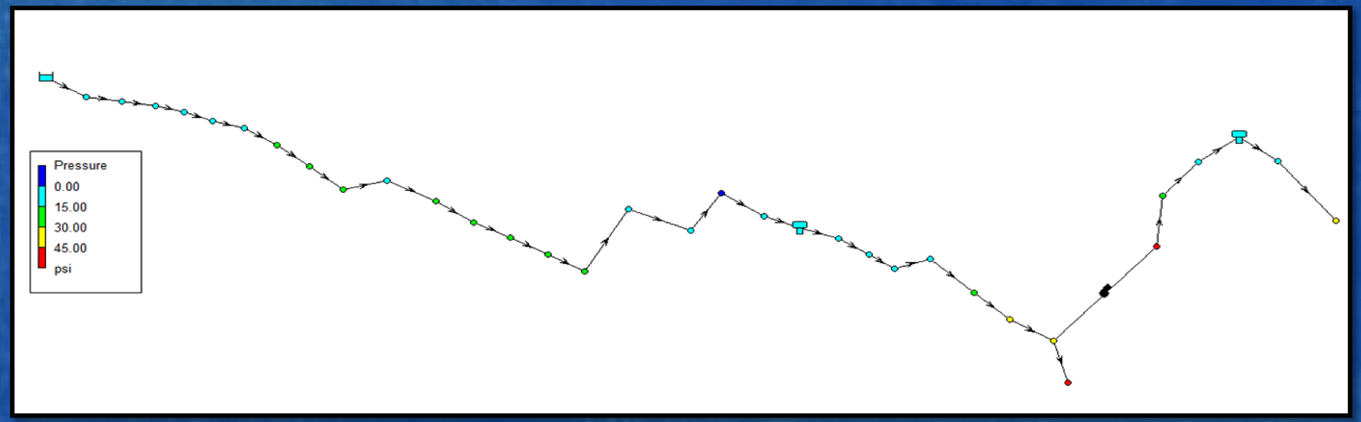


Figure 9: EPANET® software model showing the spring box on System 1 on the far left, the existing tank in the middle, and the pump (black) and other tank (both proposed in the design) ending with the homes on System 3 on the far right.

Basis for Design

While in Panama, Team Candela collected as much data as possible. The methods used for planning the design included:

- **Abney Level Surveying**: used to generate the land elevation profile, which allowed us to calculate the feasibility of a totally gravity-fed system (along with the EPANET model, above)
- **GPS point collection at survey points and at homes**: used to generate Google map (Figure 10) to give a visual representation of the community
- **3M Petrifilm water quality testing** (Figure 11): used to determine the need for water treatment because of contamination (such as Coliform presence)
- **Community Interviews**: used to determine community needs and water demand
- **Flow rate measurements**: used to determine water supply from the natural spring sources and then compare with water demand from community

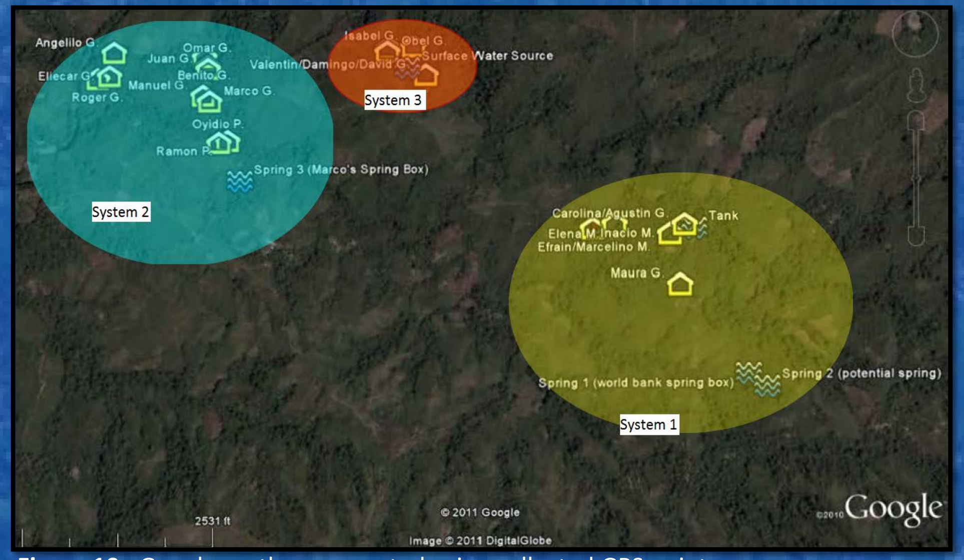


Figure 10: Google earth map created using collected GPS points

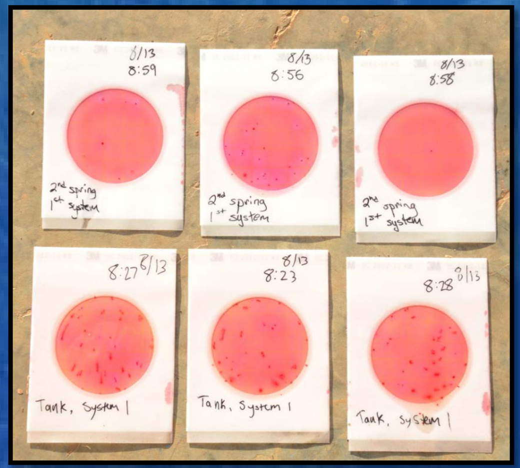


Figure 11: Results of water quality testing showing only coliform

Design Solutions

Short Term Recommendations

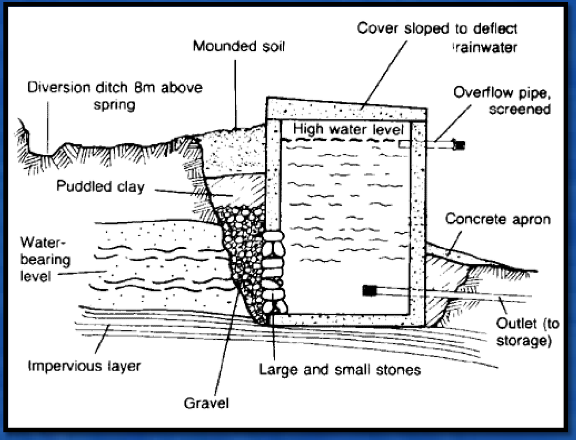
Improvements to PVC piping

- fix leaking sections/joints (countless leaks in the system from the spring box, to the tank, to homes need replaced to alleviate pressure and water losses)
- Bury exposed pipe (protection from UV radiation and damage by traffic (people and horses) on trails) (Figure 12)
- Reinforce suspended pipe where it crosses ravines (Figure 13)

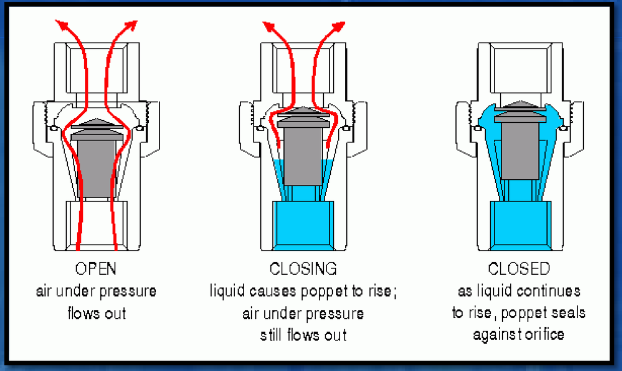
Long Term Recommendations

1. *Renovation and Addition of Spring Boxes (Figure 14)*
   - Two spring boxes on System 1: replace existing and construct at second spring source
   - One spring box on System 2: replace existing built by community

Figure 12 (top left): PVC damage from UV exposure
Figure 13 (top right): Suspended PVC pipe in Candela
Figure 14 (right): Basic composition of spring box components (1)



2. *Solar Pumping System to Supply System 3*
   - Homes currently serviced by System 3 need a reliable spring source year-round to replace current seasonal surface water runoff they rely on. Headlosses prevent the use of gravity to feed from the closest spring sources (System 1).
   - The team has recommended a basic direct solar powered pump, with the energy from the solar panels traveling directly to the pump without requiring battery storage.



https://huskymail.mtu.edu/service/home/~/air_release_3_views.gif?auth=co&loc=en_US&id=5834pa

Figure 15: Air release valves

3. *Addition of Air Release Valves along Major Pipe Segments*
   - Excess air builds up in the PVC and prohibits water to flow in the pipe as needed
   - Candela community members drilled periodic holes along the length of the pipe to release the air which somewhat relieved the air, but caused significant water losses throughout the system. Team Candela proposes air release valves (Figure 15).

4. *Water Storage Tanks*
   - Construction of two water storage tanks: one on System 2, and another for System 3 after solar pumping (connected to System 1).

Figure 16: Inline water Chlorinator apparatus

http://www.waterresearch.net/watertreatment/chlorination.htm

5. *Installation of Inline Water Chlorinators*
   - Installation before the water tanks on each
   - system to kill any unwanted bacteria (Figure 16)

In addition to the designs, Team Candela formulated a Cost Estimate and Construction Schedules for a completed project plan.

Total Project Estimates	
Total Project Length	*Total Project Cost*
6 months	$12,400

(1) A Handbook of Gravity-Flow Water Systems. Thomas D. Jordan Jr., UNICEF, 1980. Reprinted by Intermediate Technology Publications, London, 1992, 1996.