

# PLANNING AND BUILDING A WATER SUPPLY PROJECT NEAR LEOGANE, HAITI: EXPERIENCES OF UCF-EWB CHAPTER

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## ABSTRACT

Haiti is primarily an agrarian society, and up to seventy-five percent of Haitians live off the land by way of small-scale subsistence farming. Traditional farming practices are inefficient and provide low yields. One problem is the seasonality of rainfall and the lack of irrigation. The Lakoline Village near Leogane is working with Tevel b'Tzedek, an NGO to implement modern agricultural practices, such as drip irrigation. However, without a reliable source of irrigation water, the modern agricultural practices may not succeed. A team, consisting of a professional engineer and a group of engineering students from the University of Central Florida (UCF) chapter of Engineers Without Borders (EWB) conducted a site assessment to collect information on the needs and potential water sources in the project area. The team then performed an evaluation of three identified water supply options, including groundwater development, a surface water reservoir, and hauling water from a nearby river. This paper will describe the planning of the water supply project and the process of options evaluation by the UCF EWB team with respect to the challenges and limitation common in some low-income developing countries and rural areas such as the lack of access to electrical power, information, transportation infrastructure, construction equipment, mechanical repair facilities and other modern conveniences that are often taken for granted in developed countries.

## 1. INTRODUCTION

Haiti is the poorest country in the western hemisphere (Human Development Report Office, 2011). The severely depressed economic conditions in Haiti are further exacerbated by natural disasters. On January 12, 2010 Haiti experienced an earthquake with a measured intensity of 7.0 on the Richter scale and an epicenter approximately 2 kilometers south of the village of Lakoline, near Leogane. Most concrete structures in the provincial capital of Leogane and the national capital city Port au Prince were destroyed by the earthquake. Streets and highways were damaged by subsurface displacement and debris from the damaged buildings. Government institutions were shut down for an extended period of time due to the destruction of most government buildings. Figure 1 shows the central market in Leogane two years after the earthquake. The earthquake destroyed many

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residences and the population of Port-au-Prince and other areas moved into hastily constructed shanty villages. In many cases the only roof over people's heads consisted of tarps provided by international aid agencies. As a result of this concentration of the population, sanitation was impacted and a cholera epidemic ensued.



Figure 1 Central Market, Leogane, Haiti. Two years after 2010 earthquake.

In addition to the earthquake, Haiti is at a location which is subject to periodic tropical storms and hurricanes. On average, Haiti has been subject to a tropical storm every other year (Klose, 2011). With much of the population now living in hastily constructed shanty villages, tropical rainfall events pose significant flooding threats. Currently, drinking water is often obtained from untreated sources, such as the well with a hand pump shown in Figure 2.



Figure 2 Existing hand pumped well in Lakoline Village

Haiti is primarily an agrarian society. Due to the practice of dividing land holdings evenly among heirs, farm plots have become smaller from generation to generation. Today up to seventy-five percent of Haitians live off the land by way of small-scale subsistence farming, with individual farmers land holdings averaging less than 1 hectare. Commonly grown crops include plantains, corn, rice, beans, tomato, melon, and peppers, depending upon the season and the availability of irrigation water. Traditional farming practices utilized in Haiti are inefficient, providing low yields and very low income. The Haitian Agriculture Ministry is working with Tevel b'Tzedek (TbT), a non-governmental aid organization (NGO), to implement modern agricultural practices in the village of Lakoline near Leogane. TbT is recommending modern agricultural practices such as drip irrigation. However, although drip irrigation is very efficient, it requires a reliable source of irrigation water. TbT contacted the University of Central Florida chapter of Engineers Without Borders (UCF-EWB) to request technical assistance to plan a water supply project.

TbT wanted to investigate the potential development of a surface water reservoir at the village. TbT specified a water demand of 2.5 cubic meters per day for a 90-day period for each of up to 150 farmers in and around the Lakoline village. TbT is providing training to the farmers in Lakoline on methods to improve crop yields and also introducing new crops and marketing techniques. It is projected by TbT that these practices can increase the farmer's annual income from \$120-\$1,000 to as much as \$2,000-\$8,000 (Liberzon, 2011). A pilot plot using these advanced agricultural practices is shown in Figure 3.



Figure 3 Existing TbT agricultural test plot. Lakoline Village, Haiti

This paper explores the challenges that can be encountered when planning and implementing a water supply project in a low-income developing country and how the UCF-EWB project team addressed these challenges.

## **2. PROJECT PLANNING**

After being contacted by TbT, UCF-EWB appointed a project manager to lead the project team. Other team members consisted of student volunteers. A professional engineer working for the university agreed to be the professional mentor for the project team.

### **2.1 Information for Project Planning**

The first major challenge in planning a project in a developing nation is obtaining quality information. Prior to the advent of the internet, this would have meant traveling to several government agencies and libraries to review written records, databases and reports. Today the internet provides a great degree of connectedness regarding resource information. However, in a developing country such as Haiti, there is limited availability to the kinds of information needed to plan a water resource project. The information needed for a water supply planning project can vary from one site to another. Dixon (1964) lists a number of items to consider in planning a water resource project, including the following factors relevant to the Haiti project:

- Project area considerations such as geography, settlement, development, economic conditions and existing investigations and reports;
- Hydrologic data such as hydrologic records, hydrometeorological data, surface water data and groundwater data;
- Water supply including sources of supply, variation of supply, quality of water and legal rights; and
- General considerations for design and planning including
  - Geology
  - Design problems
  - Construction problems
  - Alternative plans
  - Estimates of Costs
  - Political/legal problems
  - Organizations to be involved in the project

The team's first task was to collect information that could be used to plan a water supply project. When TbT initially contacted UCF-EWB in January, 2012, the only information provided was an unintelligible map and an explanation of the anticipated water needs. Further enquiries with TbT resulted in a latitude and longitude for the project site and a computer map file that the team could not open. However, with a project location the UCF-EWB team could begin to search for information to plan the project. Internet searches uncovered several pieces of relevant information including a 1999 water resources assessment of Haiti by the U.S. Army Corps of Engineers and rainfall information for Haiti. The team also located hydrologic information for Puerto Rico, including evaporation and probable maximum precipitation information published by the National Oceanic and Atmospheric Administration (NOAA), U.S. Department of Commerce. This information was useful and relevant, in that Puerto Rico is also a mountainous Caribbean island at the same latitude as Haiti. A professional friend of the team's mentor provided a map of Haiti containing geologic information that was prepared by the World Bank. One of the students discovered a computer data file with geographic information for Haiti developed by the World Bank and within this computer file was a digital elevation model for a small area in Haiti near the city of Leogane. The project site is within this area.

The team obtained assistance from an expert in geographic information systems to open the digital elevation model and manipulate this information. This provided the team with topographic

maps of the project site. In addition, the project team utilized Google Maps to familiarize themselves with the project area. With these resources the team was able to identify watersheds and potential reservoir sites for further investigation of the surface water supply option sought by TbT.

One study discovered by the team reported that there is a gaging station in the nearby Momance River. The data from this monitoring site could not be found on the internet. The team followed up with a letter to the Minister of the Environment for Haiti, but this data was not obtained. Note that many government buildings in Haiti were destroyed in the 2010 earthquake and many records were lost.

In March, 2012, a team consisting of the professional engineer mentor, the project manager and two other UCF-EWB engineering students conducted a site assessment. Several potential reservoir sites were inspected and many of the villagers were interviewed about hydrologic conditions. The team also conducted percolation tests and collected soil samples for testing as shown in Figure 4. The TbT staff were interviewed regarding the resources that they had available for construction and financing of projects. The UCF-EWB team also provided TbT with a list of questions for a local well driller who could not be interviewed in person. The professional mentor provided TbT a written procedure for a pump test of a well that was to be drilled in the area.



Figure 4 Conducting percolation tests and collecting soil samples.

During the site assessment trip, the UCF-EWB team identified three potential water supply options for further evaluation. The first option was a surface water reservoir in a gully that drained a mountainous area south of the village. The second option was hauling water from the Momance River, located approximately 1 kilometer to the east of the project site. The third option was use of groundwater. The UCF-EWB team met with the village project committee to discuss the options and obtain feedback regarding the project, shown in Figure 5.



Figure 5 Meeting with the village committee

## 2.2 Construction and Operation Limitations

The next major challenges often encountered when planning a water project in a low-income developing nation are technological and economic. The village of Lakoline does not have electricity. The only access road serves as the village drainage canal in the rainy season. Construction equipment and other mechanized equipment has limited availability and are very expensive, and any solution requiring significant or complex maintenance is not likely to succeed. These and other limitations apply both in Haiti and in many of the extremely poor developing countries around the world. Therefore it is necessary to consider these limitations in determining the feasibility of a project.

Initially, TbT requested a surface water reservoir. The advantage of locating a reservoir in one of the mountain gullies was that the reservoir could be at a higher elevation than the farm fields and water could be delivered by gravity, obviating the need for a pump. With no electrical service and difficulty obtaining and maintaining mechanical systems, this option appeared quite attractive.

## 2.3 Evaluating Project Options

The project team visited several potential reservoir sites identified from Google Earth and the topographic maps. Based upon the visual inspections all but one of these sites were determined to be infeasible because of limited water storage potential, as these sites were in narrow and steep ravines. Analysis of the digital elevation data also showed that the potential mountain reservoir site did not have sufficient storage and the percolation test performed by the team showed that there would be a substantial loss of water stored at this site. During the site inspection an additional reservoir site located in the valley was evaluated. The team interviewed several villagers and these villagers reported that during the rainy season runoff from the mountain ravines would collect in the eastern portion of the valley (the upstream portion of the valley). Visual inspection of the valley

indicated that there is no surface water drainage outlet from this area. However, the percolation test at this site established that water could not be stored at this location for the three-month dry season irrigation period specified by TbT. This was further corroborated by statements by the villagers that this area would dry up within a period of weeks after experiencing depths of 1 to 1.5 meters.

The second option, hauling the water from the nearby river, appeared to be viable at first. The Momance River is perennial and was observed near the end of the dry season to have substantial flow. This river is already used for irrigation by downstream users via a diversion structure located about 0.5 kilometers downstream. The volume of water needed per field is small for the drip irrigation system. A tractor used to till fields could be fitted with a PTO powered pump to fill a tank on a wagon. However, based upon the interview of TbT staff, it was determined that the sole tractor in the village did not have sufficient power to pull a water wagon up the steep escarpment from the river. Also, fuel costs could be high for this option and fuel must be trucked in from Leogane. This option was therefore deemed to be infeasible. The project team also discussed the possibility of pumping water directly from the Momance River to the Lakoline project area. The east end of the valley is approximately 60 meters above the river and the distance from the river bank to the top of the escarpment is approximately 0.5 kilometers. TbT staff reported that another NGO had put in a pump on the east shore of the Momance River, but that project had not been successful because of issues with both operation and maintenance problems. Problems for a pump on the west side of the river would include poor security of the pump and fuel system which would be located 1 kilometer from the village, poor access to the site for delivery of fuel due to the quality of the dirt road down the escarpment from the village and concerns about operation and maintenance of a surface water pump by the villagers. Based upon these concerns, both pumping and transport of water from the Momance River were not considered feasible by the project team and TbT sponsors.

The next option to be evaluated was a groundwater supply. The national geologic survey obtained by the project team indicated that the valley is underlain by an alluvial aquifer. Local well drillers report that this aquifer has a depth of 45 to 50 meters. A number of villagers stated that storm water runoff from the mountains would collect and be ponded in the eastern end of the valley. Interviews of villagers indicated that storm runoff from the mountains would be impounded to a depth of up to 1.5 meters in the eastern portion of the valley during the rainy season for periods of days to weeks. Site inspections and interviews of villagers established that drainage into the eastern portion of the project area flows into a depression which does not have a surface water outlet. During the rainy season water ponds for periods of several days to weeks in this depression and then infiltrates into the unconfined alluvial aquifer. The UCF-EWB team estimated that this recharge volume exceeds the volume of water specified by TbT as needed for irrigation. This information and the well log and pump test information obtained from the well driller will ensure that wells constructed for agricultural irrigation will not interfere with existing water supply wells or each other. Solar powered pumps (with backup generator) were specified in order to reduce maintenance and fuel costs. With the financial assistance of a Canadian NGO charity, TbT is in the process of putting in the first well, which will serve up to ten farmers as well as meet the potable water needs of many of the villagers.

### **2.3 Financing of Project Implementation**

The implementation of the irrigation system will greatly improve the profitability of the local farms. The UCF-EWB team discussed with TbT financing options for additional wells. TbT is working with an NGO that provides micro loans for small business development. Another option is to have the farmers that benefit from the first well (and subsequent wells) pay a water use fee to support the installation of additional wells for the remaining farmers in the village and also to generate funds for maintenance of the wells and water distribution system. This funding decision will be up to the village committee.

### **3. DISCUSSION**

The UCF-EWB team encountered many challenges planning a water supply project for the village of Lakoline, Haiti. Many of these challenges are typical for low-income developing countries. Haiti is very poor and as a result has limited ability to finance infrastructure improvements. Availability of technology such as electricity, construction equipment, construction materials, and competent maintenance is very limited. These limitations must be considered when designing a project in Haiti and many other developing countries.

It is also very important to have active participation by the local population. In the Lakoline village, TbT had been working with a community committee that had been organized for many years. This local committee had elected leadership and worked for the betterment of the community. The UCF-EWB team met with the committee (shown in Figure 5) and also interviewed a number of the committee members and local farmers individually in order to obtain feedback on the project options being evaluated and also to obtain information on local hydrologic conditions. For example, several of the farmers reported that during the rainy season water from the mountains would collect and be impounded in a portion of the valley for periods of weeks to months. Such anecdotal information can be useful, when corroborated by multiple sources independently.

To be successful, the UCF-EWB team and TbT agreed that the water supply project must be simple to operate and maintain, due to the lack of mechanical expertise of the villagers. The alternative of pumping water from the Momance River, located approximately one kilometer from the east end of the village was ruled out as involving equipment that would be too difficult to maintain and to secure. Hauling water from the river was ruled out because the village tractor does not have enough power to haul a water tank up the escarpment from the river and the dirt road may not be passable during portions of the year. The selected alternative of a groundwater supply with solar powered pumps with diesel generator backup was considered feasible, as the pumps have a very long service life and maintenance service for a generator is available in Leogane.

### **4. CONCLUSIONS**

Development projects in countries as poor as Haiti have significant challenges that require careful consideration. The lack of information, local access to technology, transportation infrastructure, maintenance capability, and funding can increase the time it takes to plan and build a project and constrain the potential solutions. Many projects in developing countries fail because inadequate consideration is given to these limitations.

The UCF-EWB's successful experience in Haiti suggests that in order to succeed project teams need to:

- consult the locals, not just the government and non-governmental organizations
- make sure there is a local organization to implement the project
- search for adequate, relevant information and be open to unusual sources of information
- consider technical capability of locals to construct, maintain and operate a project when formulating the design
- keep in mind local economic limitations for both construction and operation
- consider other local limitations, such as the lack of electrical power, good road access and lack of availability of construction equipment

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