THE DESIGN, CONSTRUCTION, AND MAINTENANCE OF A GRAVITY-FED WATER SYSTEM IN THE DOMINICAN REPUBLIC

By

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A REPORT

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This report 'The Design, Construction and Maintenance of a Gravity-Fed Water System in the Dominican Republic,' is hereby approved in partial fulfillment of the requirements for the Degree of MASTERS OF SCIENCE IN CIVIL ENGINEERING.

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Preface

This project was conducted during my Peace Corps service in the village of Los Arroyos in the Dominican Republic, where I served as a volunteer in the Water/Sanitation sector from 2001-2003.

This report was submitted to complete my Master's Degree in Civil Engineering from the Master's International Program in Civil and Environmental Engineering at Michigan Technological University. This program combined Peace Corps service with a master's degree. As a Michigan Tech sophomore, I heard one of the first presentations about the Master's International program on campus and immediately knew that was what I was going to do. I was the second student to graduate from this program, and the first student to graduate from the program in Civil Engineering.

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I would like to first thank the villages of Los Campeches, Los Arroyos, and Los Botados. Without the friendship and open hearts of these communities, this project would not have been possible. Many thanks to Amable Montero, my Dominican host father, who without his caring and guidance during my "adjustment period" in my new community, it would have been much more difficult. Dominicans are some of the most kind and warmhearted people I have ever had the fortune to live and work with and I will cherish the time I had with them.

Second, thank you so much to Father John Cervini, my Peace Corps project partner, who supported me throughout the project. Also thank you to Christopher and Letzbia Lang-Martinez. Those Sunday night movies helped me keep my sanity. Thank you to all my Peace Corps friends, who started this great journey with me.

Thanks to Mr. Elvin Beach, who without his continuous editing of this report, would not have been completed so smoothly. Also, thanks to my advisor Dr. James Mihelcic, who supported me during the abrupt ending to my Peace Corps service, and who helped me complete this report.

Finally, thank you to all my family and friends who have supported me during the ending of my Peace Corps service and during the writing of this report. Muchas Gracias!

Abstract

This report was conceived during my year as a Peace Corps Volunteer in the villages of Los Arroyos and Los Botados. This project was built together with the Peace Corps/Dominican Republic and the Catholic Mission Church of El Cercado. I lived in the community and contributed the technical and organizational assistance on-site.

This project is a gravity-fed water system. The water used is from a natural occurring mountain spring. A spring box was constructed to collect the water. Schedule 40 PVC pipes were used to transmit the water to the communities. A break-pressure box was constructed half-way down the mountain to reduce water pressure in the pipeline. The water exits into a 10,000 Gallon water storage tank above the community. Seventy-five homes participated in the project and each worked for a private tap in their home.

Over 600 PVC pipes were used and installed in over 4.8 Kilometers (3 miles) of hand-dug trench. The final cost of the water system was US$10,175. A water committee was formed among the community leaders to manage the usage and maintenance of the project. Health talks were offered during and after the project to help promote clean and healthy living practices. This report covers all the procedure from the organizational period to the final product.

1.0 Introduction

One billion people in the developing world still lack access to clean water, and two billion lack adequate sanitation (Banker, 1999). The availability of an adequate clean drinking water supply is a fundamental need in daily life and in this day and age should be considered a human right. Access to a potable water supply also provides considerable health and economic benefits to households and individuals. Access to water also means that the considerable amount of time women and children spend retrieving fresh water could be spent more effectively on other tasks, improving their economic productivity, a key component in the alleviation of poverty (UNICEF, 2000).

It is easier to construct a water system than to leave in place a local organization capable of managing it technically and financially. For a rural water project to succeed, those involved must be fully committed to the project and prepared to take over operation and maintenance of the new and/or improved facilities. Time and effort must be spent helping local groups until they can manage water systems on their own (World Bank, 2002).

The objective of this report is to illustrate the construction of a gravity fed water system from beginning to end in a rural region of Southwestern Dominican Republic. This project was initiated by the Catholic Church (Non-Governmental Organization), the Peace Corps, and the local communities of Los Arroyos and Los Botados, Dominican Republic. The project was constructed over the period of a year and a half, during which I served as a Peace Corps Volunteer Water/Sanitation Engineer.

In this report, Chapter 2 provides background information on the Dominican Republic, including geography, climate, history, government and politics, economy, and demographics of the country. Next, the present water supply coverage and current water problems in the Dominican Republic are presented. The goals and objectives of Peace Corps Dominican Republic's Water/Sanitation Sector are briefly explained.

Chapter 3 provides an overview of the project site for the water system. First it describes the Project Partner whom I was assigned to as a Peace Corps Volunteer. Next it presents the communities who would be participating in the water system projects. My housing and living standards are explained, followed by a short discussion on the average standard of living in these communities. Finally, the community's attitude towards Americans is described.

Chapter 4 presents the water system procedures, first describing the formation of water committee, feasibility study, on-site research with the community, and the land survey. The design, budget, construction, education, and maintenance are covered extensively. The inauguration of the project, feasibility study repeated, overall support until end of service, and final report to Peace Corps Dominican Republic are discussed.

Chapter 5 discusses recommendations for future work. It provides insight into oversights made during the project and describes some potential solutions for future projects. Chapter 6 summarizes the project and briefly lists the final benefits of the project.

2.0 Background

This chapter provides geographic, demographic, historical, political and economic background information on the Dominican Republic. The Peace Corps Dominican Republic's (PCDR) water/sanitation sector is also introduced including the history, goals and objectives of the PCDR in this developing nation.

2.1 Geography & Climate

The Dominican Republic is located on the island of Hispaniola, which is located west of Puerto Rico and East of Cuba in the Caribbean Sea. It occupies the eastern two-thirds of the island, with the Republic of Haiti occupying the western third (Figure 2.1 a & b).

http://www.hispaniola.com/DR/maps/
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http://www.lib.utexas.edu/maps/americas/dominican_republic.gif
(Courtesy of The General Libraries, The University of Texas, Austin)

(a) (b)

Figure 2.1. (a) Map of Dominican Republic and surrounding islands
(b) Dominican Republic with major cities.

The total area of the Dominican Republic is 48,730 km^2 (~18,815 mi^2), which is slightly more than double the size of New Hampshire. The Dominican Republic boasts the highest elevations in the Antilles in Pico Duarte at 3,175 m (~10417 ft.), as well as one of the lowest elevations in its saltwater lake below sea level named Lago Enriquillo -46 m, (~151 ft) (CIA 2002). (The Antilles consist of all islands between North and South America, sometimes called the West Indies.) The Capital of the Dominican Republic is the District of Santo Domingo. The Dominican Republic is divided into twenty-nine provinces and one district. Each province has its own provincial capital and its own government.

The climate in the Dominican Republic is primarily tropical, with more local than seasonal variations in temperature, and seasonal variability in the abundance of rainfall. Typically seasons vary more as a function of rainfall than of temperature. The average annual temperature is 25° C (77?F), ranging from 18° C (64.4?F) at an elevation of more than 1,200 meters to 28° C (82.4?F) at an elevation of ten meters. Highs of 40° C (104?F) are common in protected valleys, as are lows of 0° C (32?F) in mountainous areas. In general, August is the hottest month and January and February, the coldest (Chapin Metz 2001).

The country is susceptible to tropical cyclones, such as tropical depressions, tropical storms, and hurricanes. These hazards occur on an average of once every two years (Chapin Metz 2001). This is because the country lies in the middle of the hurricane belt (CIA 2002). Hurricane George, the most recent storm, passed over on September 22, 1998. It was a category three hurricane, with winds reaching 209 km/hr (130 mi/hr). It affected at least seventy percent of the national territory and killed an estimated 235 people. The estimated cost of Hurricane George was US$ 1.3 billion (World Bank 1999).

2.2 History, Government and Politics

The island of Hispaniola was originally occupied by Tainos who were an Arawak-speaking people. The Arawak tribe originated in South America, moved north and inhabited the Antilles islands. Taino was the unique name given to the tribe on the island of Hispaniola. The indigenous Tainos welcomed Christopher Columbus during his first voyage in 1492. However, subsequent colonizers were brutal, reducing the Taino population from approximately one million to only 500 in 50 years. To ensure adequate labor for plantations, the Spanish brought African slaves to the island beginning in 1503 (U.S. Department of State 2000).

In the following century, French settlers occupied the western end of the island, which Spain ceded to France in 1697. In 1804 this French territory became the Republic of Haiti. From 1822 until 1844, the Haitians conquered and ruled the Dominican Republic. On February 27, 1844 the hero of Dominican independence, Juan Pablo Duarte, drove the Haitians out and established the Dominican Republic as an independent state (U.S. Department of State 2000).

Economic difficulties led to U.S. President Theodore Roosevelt sending U.S. Marines to occupy the country from 1916 until they were withdrawn in 1924, with the start of a democratically elected Dominican government. American occupation helped enact programs in education, health, sanitation, agriculture, and communications; highways were built; and other public works were created (Chapin Metz 2001). In 1930, this government was overthrown and Rafael Trujillo Molina became dictator. Border clashes with Haiti occurred and in 1937 Dominican troops massacred thousands of immigrant Haitians. War was narrowly averted but Trujillo continued to suppress domestic opposition to his rule. His regime gradually turned the country into a private dominance. Material improvements in roads, agriculture, sanitation, and education contributed to the duration of the regime. Feuds with other Caribbean nations, mainly Cuba and Haiti, developed over land ownership. In 1961, Trujillo was assassinated by unknown conspirators. Joaquin Balaguer, Trujillo's puppet, who had been named president by Trujillo in 1960 initiated democratic elections and withstood attempts of the Trujillo family to regain power (Encyclopedia.com 2003).

On December 20, 1962 the scholar and poet Juan Bosch Gavino was elected president in the first free elections held in the Dominican Republic in decades. He served a four-year term and lost in the 1966 elections to Joaquin Balaguer. Balaguer served three, four-year terms until he was defeated in 1978, by wealthy cattle rancher Silvestre Antonio Guzman, despite trying to fix the election. Guzman spent one corruption-filled term in office and lost in 1982 to Salvador Jorge Blanco. During Blanco's term he attempted to undue the economic damages his predecessors had caused, by borrowing money from foreign lenders. Meanwhile, Mexico suspended all payments to creditors, so thereafter, no foreign banks would extend credit to the Dominican Republic unless it came to an agreement with the International Monetary Fund (IMF). An agreement was never reached, so with an unsuccessful term, Blanco disappeared from the political scene on May 16, 1986.   He was defeated by Joaquin Balaguer, now 80 years old, blind with glaucoma and in poor health, beginning his fifth term. For two terms Balaguer ran his government like a dictatorship. After rigging the 1990 and 1994 elections, the military threatened to step in. In turn, Balaguer, agreed to shorten his sixth term and hold new elections 18 months later. Good to his word, on June 31, 1996, Leonel Fernandez, a lawyer who grew up in New York City, became president (Lonely Planet 1999). Since 2000, the presidency has been held by Rafael Hipolito Mejia Dominguez (CIA 2002).

Like the U.S., since 1966, the Dominican Republic has been a representative democracy whose national powers are divided among independent executive, legislative, and judicial branches. The President appoints the Cabinet, executes laws passed by the legislative branch, and is Commander in Chief of the armed forces. The President and Vice President run for office on the same ticket and are elected by direct vote for four-year terms (U.S. Department of State 2000).

Although there are more then 20 political parties, there are three major parties that dominate the popular vote. They are the Dominican Liberation Party (PLD), the Dominican Revolutionary Party (PRD), and the Social Christian Reformist Party (PRSC), led by Balaguer (CIA 2002).   Balaguer recently died on July 14, 2002 at the age of 95.

2.3 Economy

The Dominican Republic is a middle-income developing country primarily dependent on services, especially tourism, remittances from the US trade, construction, and agriculture. Although the service sector has recently overtaken agriculture as the leading employer of Dominicans (due principally to growth in tourism and Free Trade Zones), agriculture remains the most important sector in terms of domestic consumption and is second behind mining of gold, silver, and nickel, in terms of export earnings. Rice, beans, plantains, cassava, and citrus fruits are primarily produced for domestic consumption. Sugar cane, coffee, cocoa, and various tropical fruits and vegetables are exported in large quantities, in addition to covering the local market (Peace Corps Information Packet 2000).

With over one million foreign tourists visiting each year, tourism accounts for more then one billion dollars in annual earnings. Remittances from Dominicans living in the United States (there are approximately one million residing in the U.S. currently) are estimated to be about $1.5 billion per year (U.S. Department of State 2000).

Drugs also play a large role in the country's economy. Women as well as men have turned to trafficking and/or selling drugs as a means to escape their financial situations. While there are no hard statistics on the illegal trade, US law enforcement officials in late 1998 estimated that Dominican drug traffickers were transporting as much as one-third of the approximately 300 metric tons of cocaine that enter the U.S. each year (Lonely Planet 1999).

As of 2001, the gross domestic product (GDP) per capita purchasing power parity is $5,800 U.S. (CIA 2002) and the gross national income (GNI) per capita is $2,230 U.S. (World Development Indicators 2001). The current inflation rate is 5%, which is evident in the devaluation of the Dominican Peso to the dollar. The exchange rate in 2001 was $RD16.95 to the dollar. As of March 2003, the exchange rate was $RD24.09 (www.DR1.com 2003) and still rising. As of 1999, 25% of the country's population was below the national poverty line (CIA 2002). In 2002, 16% of the population was earning less then US$2 a day (World Bank 2002).

2.3 Demographics

The Dominican Republic has a population of over 8.7 million people according to July 2002 estimates (CIA 2002). As of 2001, the population consists of approximately 75 percent Mulatto (offspring of a Black (African) and White (Spanish) parents, 10 percent White (Spanish), and 15 percent Black (African) (Chapin Metz 2001). Spanish is the official language, but Dominicans have adopted numerous English and indigenous words from their Taino ancestors. The Dominican people are a blend of three races or ethnic groups: Spanish, African, and indigenous Arawak Indians. Over the years, Whites and Blacks intermarried, and the Dominican Republic is probably the only country in the world with a majority Mulatto population. In this century there has been an influx of small but substantial numbers of Japanese, Chinese, European Jews, Arabs, and Spanish, in addition to expatriate North Americans and Europeans who accompany foreign business investments and international trade operations (Peace Corps Information Packet). Ninety-five percent of the population is Roman Catholic (CIA 2002).

About 40% of the population lives in rural areas in small scattered communities that consist of 10 to 200 families. The other 60% of the population lives in the urban areas of Santo Domingo, Santiago, and the other 28 provincial capitals. The annual population growth rate is 1.7%, with a total fertility rate of 2.8 children born to each mother (WHO 2001). As of July 2002, the average life expectancy for both males and females at birth was 73 years old (CIA 2002). The infant mortality rate was 42 deaths per 1,000 live births, and the adult literacy rate was 84% (UNICEF 2002).

In terms of economic class, fewer than 5% of Dominicans are member of the wealthy elite, about 35% belong to the middle sector and more than 60% are poverty stricken people without regular employment or prospects of a better life (Lonely Planet 1999). Color plays a strong role in the socioeconomic picture, with the wealthy elite consisting mostly of light-skinned people and the poor sector consisting almost exclusively of dark-skinned people (Lonely Planet 1999). Generally, darker skin usually correlates to a lower class, lower income, less educated and poorer housing.

The Dominican culture reflects these same racial and ethnic groups. From the Spanish, the Dominicans have inherited their language, food styles, Catholicism, and extended family united by a patriarch, *machismo* (the repudiation of all things feminine, or to act macho), and a somewhat fatalistic view of human destiny. From the African and indigenous Indian cultures, the Dominicans have inherited their music (meringue) folklore, social activities, handicrafts, cuisine, and many of the names given to children (often in commemoration of Indian chiefs and queens who lived and governed the island centuries ago) (Peace Corps Information Packet 2000).

2.8 Water Supply

Historically, endemic and epidemic waterborne disease has been of major consequence in the overall national health status. One of the major public health problems the Dominican Republic is confronting is a high infant mortality rate. One of the principal direct causes of this mortality rate is the diarrheal diseases transmitted by contaminated water. Diarrhea is one of the principal killers of children under five years of age. Other water borne diseases include cholera and typhoid (Curtis 2000).

The biggest reason water borne disease is so prevalent is insufficient access to potable water and sanitary facilities. Twenty-one percent of the Dominican population still does not have access to improved water sources (World Bank 2001). In the Dominican Republic the access to potable water is lower in rural areas then in urban areas; 90% of the urban population and 78% of the rural population has access to potable water, and 70% of the urban population and 60% of the rural population has access to adequate sanitation (UNICEF 2002).

Women and children are the main beneficiaries of improvements in water supply and sanitation. Women benefit because they are responsible for the collection, transportation and storage of water in the Dominican Republic. Children benefit because the heaviest burden in morbidity and mortality from water-related diseases falls on them (Curtis 2000). Figures 2.2 and 2.3 show methods of water collection used in the Dominican Republic.

Figure 2.2 Local women collecting water.

Figure 2.3 Local Children collecting water in home-made wheelbarrow

2.9 Peace Corps Dominican Republic (PCDR)

In July 1962, twenty-two Peace Corps Volunteers (PCV) arrived in the Dominican Republic to work in community development projects throughout the country. To date, 3,630 volunteers have served in the Dominican Republic. The average number of volunteers at any given time is about 125. PCDR has volunteers serving in agriculture, urban and rural development, environment, information technology (computers), small business development, youth development, health and education (Peace Corps Web Site 2003).

The Water/Sanitation sector of PCDR is a subset of the health initiative. Since 1962, PCV's in the Water/Sanitation sector have been working at the poorest economic level with small rural villages, building drinking water systems and latrines, giving health talks, and various secondary projects.

In 2001, the goals and objectives were restructured and a 6-year project plan was established. This project would span over three separate two-year terms. Table 2.1 shows the six objectives to the new plan pertaining to each volunteer group (two-year time period).

Table 2.1 Peace Corps/Dominican Republic Water/Sanitation Goals and Objectives

PCDR Goals and Objectives
1. Training of local leaders to facilitate the construction of 6 aqueducts to increase the access of 500 rural families to drinkable water and 150 to adequate excreta disposal systems.
2. Training of 24 local leaders to properly maintain, manage and operate the water systems and latrines constructed.
3. Training of 36 local leaders to be sanitation promoters.
4. 500 families reached with messages of improved sanitation practices.
5. Training of 36 local leaders to organize 6 water committees to respond to the water and sanitation needs of rural communities.
6. Training of 36 water committee leaders to identify funding sources, articulate proposals and set operational procedures to manage sanitation projects.

Source: Peace Corps/Dominican Republic 2001

In fall 2001, the entering Peace Corps training group consisted of 6 water/sanitation volunteers. Each volunteer was responsible for one-sixth of the desired results in Table 2.1. Unfortunately two volunteers decided to leave the country during the first two months of training, so the goals and objectives had to be adjusted. We were requested to work on water systems as first priority and excreta disposal systems second.

3.0 Site Overview

This chapter provides information on the project partner I worked with while in the Dominican Republic. The communities I lived in, the people I lived with, living conditions, standard of living in the community, and the general attitude towards Americans will also be discussed.

3.1 Project Partners

Upon completion of the twelve-week Peace Corps training period, each volunteer is assigned a project site with a coinciding project partner. Project partners can be as large as an active non-governmental organization (NGO), or small as a local community group, such as a local agricultural cooperative. The responsibility of the project partner is to support the volunteer in all aspects of their service. This could involve introduction into the community, support in soliciting for projects, financing for projects, and basic moral support during their two years of service.

There is a solicitation process for any institution that desires the assistance of a Peace Corps Volunteer. This process is executed up to a year ahead of time of when the next group of volunteers is scheduled to arrive in country. Soliciting institutions must show an explicit need for a Peace Corps Volunteer, with a thorough description of planned activities, project goals, and benefits to the institution and volunteer. The Assistant Peace Corps Director (APCD) is then responsible to match the number of incoming volunteers with suitable project partners. Due to the limited number of incoming volunteers, all qualified institutions do not receive a volunteer each year, however, they are given priority the following year.

My project partner was the Catholic Church of St. Peter, located in El Cercado, San Juan de La Maguana. It is a Mission Church under the supervision and direction of Father John Cervini. The mission is supported by the Diocese of Rockville Center, Long Island, New York. The Diocese of Rockville Center also supports two other Mission Churches in the area. The church of El Cercado has already had great successes with four Peace Corps Volunteers in the past. Working from the words of the previous priest of El Cercado, Father Andrew Connelly, whose only dream was for all communities in the parish to have water, the four volunteers built four gravity-fed water systems, supplying water for 12 communities in the area.

Historically, Water/Sanitation Peace Corps Volunteers, as part of their first six to eight months, were forced to spend their time soliciting other project donors for financial support for water systems and latrine projects. Recently, approximately half of the volunteer solicitations from institutions have predetermined avenues of financial support or already have the support available.

I was one of the lucky volunteers to be assigned a project partner which had already collected sufficient funding to start a water project. Part of the funds were provided to Father John as a gift from a past parish he worked at on Long Island, and the other half was donated by a Catholic nun from the United States, who worked locally with the other church in the area, run by the same Diocese.

Since the project partner had previously secured funding, I was able to begin my project much more quickly and not spend valuable time searching for funds. The solicitation of funding is a largely inefficient process that many Water/Sanitation Peace Corps Volunteers spend a majority of their time doing in order to initiate a project in their community.

3.2 Communities

During Peace Corps training, all trainees go through a series of interviews. These interviews are conducted in attempts to match each person with the ideal community and type of project. During my interviews, I conveyed that I really liked to keep busy and would like to be involved in a large project. I also explained that I had no preference on site placement.

On December 2001, I was assigned to five small villages outside the town of El Cercado, Province of San Juan de La Maguana. The town is located approximately four and a half hours away from the capital, and less than an hour away from the Haitian border. Figure 3.1 is a hand-made parish map of El Cercado and all the surrounding villages. My communities were located south west of El Cercado, the last five communities in the parish; Los Botados, Los Arroyos, Pinar del Cuellos, Los Campeches, and Guayabo Dulce .

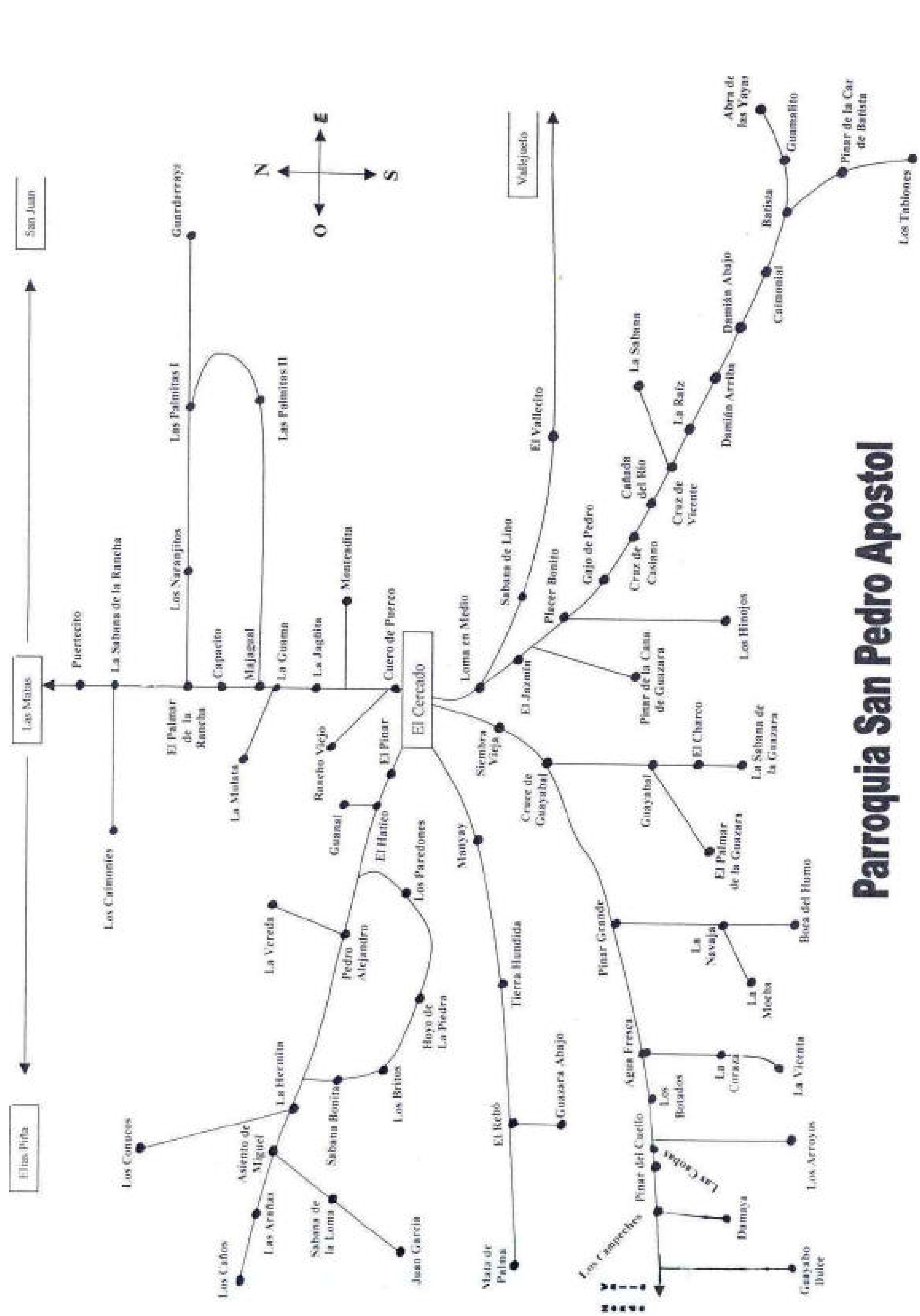


Figure 3.1 Map of El Cercado and the surrounding area.

I lived with the local Church Coordinator, Amable Montero, a resident of the community of Los Campeches. Upon arrival it was discovered that a few of the villages had many more homes and were spread over larger distances than was reported to Peace Corps. After 2 weeks of hiking and touring each community, it was evident that two separate water systems would have to be built.

The community of Los Campeches is 771 m (2,530 ft) above sea level, located in a valley. The community had access to various mountain springs, but was currently retrieving water in the local rivers. Electricity was available; however, due to inconsistent (or non-existent) payments by the local citizens, it was not very dependable.

The majority of the population supported themselves through farming. The principle crops in the community are; coffee, corn, chick peas, red and black beans, and onions. These crops are typically easier to grow with varying rainfall. Others supported themselves by owning small stores, or had politically appointed positions.

3.3 People

The population of Los Arroyos and Los Botados, the two villages where one of the water systems was to be constructed, has a total of 75 families. These communities are covered in this report. Refer to Appendix H to learn more about the second water system project started during my Peace Corps service.

Due to the proximity to the Haitian border and the large number of Haitians present in the area (both legally and illegally) the people are darker complected than one sees in other areas of the country. The Haitian culture is influential in the local Dominican culture. It is an interesting mix of cultures which produces unique traditions and customs not found anywhere else in the country.

3.4 Housing & Living Conditions

Typical living conditions consist of a two or three-room house made with palm board siding. All homes are painted a variety of bright colors. About ten percent of the community has concrete floors, while the remaining houses have earthen floors which over the years have been packed down sometimes seemingly as strong as concrete. Almost all houses have roofs made of four-foot pieces of galvanized corrugated sheet metal constructed in an overlapping manner. The poorer families overlap dried banana leaves which render the home almost rain-free. All homes use separate buildings as their kitchens. These small buildings are not given as much importance as the main home and consist of old unpainted palm board and banana leaf roofs. Three of the five communities have latrines that have been built by development organizations in the past. (see Figure 3.2)

Figure 3.2 Typical latrine seen in the Southwest region of the Dominican Republic

After living with a local Dominican family for three months, I began to rent a small house up the road. The house consisted of two rooms, with an extension of three rooms in back, which the owner of the house used herself when she came to visit during the holidays (see Figure 3.3).

Figure 3.3 Photograph of the house where PCV Matthew Niskanen resided in the village of Los Campeches.

The house had a typical kitchen and a deluxe latrine that was built by the owner. It had two small rooms each with their own door. One side had the hole (toilet), and the other side was a concrete slab which was used for bathing. (See Figure 3.4)

Figure 3.4 Photograph of my latrine (at left) in the village of Los Campeches.

3.5 Standard of Living

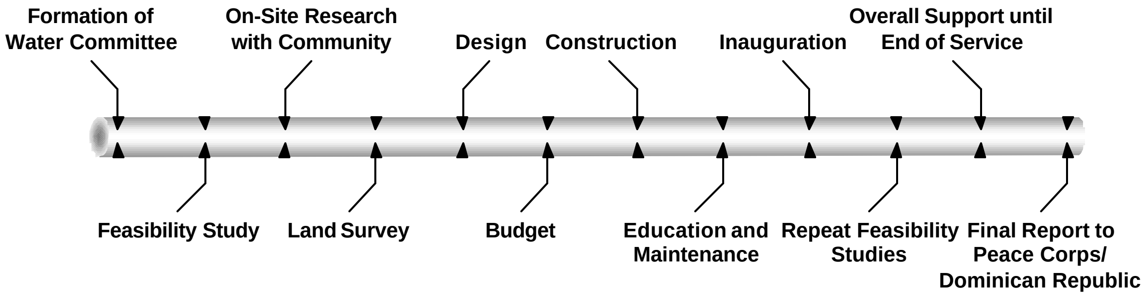
This area of the Dominican Republic is the poorest in the whole country. This is evident in the people's housing, dress, meals, and earnings. My estimates are that during four months, the average family can earn from US$200 to US$400 from their harvests. During the other eight months, without any harvestable crops, the average family earns less then US$35 total. For the sake of comparison, as a Peace Corps Volunteer with the goal of volunteers living like the people, I earned approximately US$250 per month. This was more then enough to live in my village. Financial problems only arose when taking trips to the capital where it was not uncommon to spend over US$50 in one weekend.

A large problem with uneducated Dominicans is money management. Almost all of the families in these communities could live comfortably year round if they could learn how to manage the money they earn. Money management and financial responsibility is another area where the Peace Corps is establishing programs to help the people of the Dominican Republic.

3.6 Attitude towards Americans

As a whole, Dominicans, through their elders, have learned about the U.S. Marine occupation of the Dominican Republic from 1916 to 1924. There are a variety of opinions, with the more negative ones coming from the elders and the positive and indifferent opinions coming from the younger generation. With over 40 years of development organizations working in the Dominican Republic, the overall sentiment toward Americans (and Caucasians in general) is positive. Over the years, many good and bad development organizations have come and gone, leaving a sense of dependability on the "white man." So, in the beginning, I was looked at as the "American who is going to give us water." Then they realized I was there to organize and help construct a water project with their help. Over a matter of a few months, I was viewed as a community member because I really was not there to provide free handouts. Respect had to be earned, and this is what differentiates the Peace Corps from many other development institutions.

4.0 Project Steps and Procedures



This chapter covers the required steps and procedures for a gravity-fed water system in the Dominican Republic(See figure above). This chapter is based on my Peace Corps experience from September 11, 2001 through February 7, 2002. Many of the preceding methods were adapted from various Peace Corps discussions, teachings, and observations. In the first four sections, formation of water committee, feasibility study, on-site research, and the land survey are presented. Next, design, budget, construction, education, and maintenance are covered. Finally, the inauguration, feasibility study revisited, final support, and final report to Peace Corps are discussed.

4.1 Formation of Water Committee

Within the first month of arriving to the community, it was very important to help the community form a water committee. This committee is responsible for all project activities. The community already had one existing organization, the asociación agricultures (Farmer's Cooperative). Attending these meetings was important to observe who the community leaders were. It should not be assumed that the leaders of the other organizations will by default become the leaders of the new water committee. A fundamental principle of development work is the equal access of power. For this reason, it is important that elections are held by the entire community (Curtis 2000).

The basic water committee typically consists of at least five members: the president, vice-president, treasurer, secretary, and any additional members to act as vocals (hold right to vote). Once these positions were filled, the first order of business was to create committee statutes, a constitution. The statutes establish rules such as the frequency of elections, the roles of every member, and responsibilities of the committee (Curtis 2000).

Election of the water committee was scheduled for the third meeting with the community. All thirty families of the initial project site were invited to participate in the elections. Unexpectedly the neighboring village, which did not have water either and had heard that the community was meeting that day to discuss a new water project, attended this meeting. When the meeting started, a spokesperson for the other community began by showing their communities' concern for the lack of water in their village, and asked the community and myself if we would consider including their community in the project. Due to the potential change in the project size and scope, all plans to elect a water committee were postponed.

The neighboring community members left the meeting, and the remainder of time was spent discussing the advantages and disadvantages of including the second community.

My main concern was to make sure the church had sufficient funding to support more then twice as many homes as originally planned. It was decided by show of hands that they would be allowed to participate, because the work would be finished much more quickly with more workers. After discussing the issue with the project partner, Father John Cervini, it was decided that money was available for both communities.

The next meeting was held with both communities present. The goal of the meeting was to elect water committee representatives and to establish a constitution. The larger community (Los Botados) explained that geographically they were divided into two regions. They suggested electing three members from each side, with an additional three members from the original community in the mountains (Los Arroyos). Elections were held, the true leaders of the community were elected, and we had a nine member water committee. Community members did not suggest which office each should hold, neither did any of the newly elected members request one. However, the treasurer was elected unanimously. I later discovered that he was elected because he was the only one who could both read and write.

I proceeded to hand out the example of a constitution that I copied from a Peace Corps Supplement, "Rural Aqueducts and Community Development in the Dominican Republic." (See Appendix A) Only a small number of copies were made, and nobody was interested in reading it. The papers were continually passed on to the next person, until they ran out of people to pass it on to. I then asked who would be interested in reading out loud some of the proposed rules. I explained, once we read them, we would discuss them as a group, and decide which ones we like and dislike, and could add any additional rules we saw fit. These rules would then be voted on by the committee and made legal. Minutes passed by and no one volunteered to read. I was nervous at this point with my intermediate level of Spanish, because a small murmur of conversation started, that I could not comprehend. Finally a few community members suggested that since I was the boss, I read the rules and they could discuss them afterwards. I then realized that I had given out a written document to a group of people who could not read. I was as embarrassed as they were, but proceeded to read the statutes, and initiated some great discussions. A constitution was completed and the excitement of the community was ignited.

It was also important to talk about the word “El Jefe,” which means the boss. This was what I was referred to. While it made me feel important, I had to explain that I was not the boss, but the engineer. My purpose was to enable the project through guidance and management; however, all decisions and activities were to be controlled by the water committee. My role as a Peace Corps Volunteer was to act as an advisor. I reminded them that I would only be around for two years, and the committee was responsible for all activities thereafter, so in two years when I was gone, things could continue to run smoothly.

Responsibilities of the water committee were discussed for the remainder of the meeting. There are three different phases: pre-construction, construction, and post-construction. In all these phases, the water committee should meet regularly in order to make meetings a “good habit” of the community (Curtis 2000). The decision was made during this meeting that the committee would meet every Saturday at 3 PM. Figure 4.1 shows the water committee structure and responsibilities in relation to the three phases.

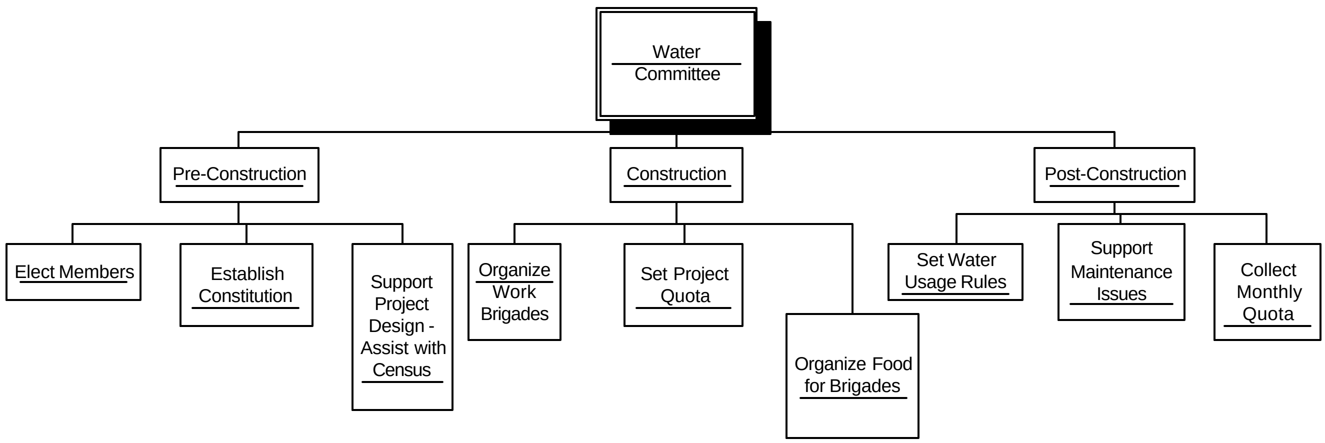


Figure 4.1 Water Committee Structure and Responsibilities

The water committee had several responsibilities during the pre-construction period. The first was to support the project design. The water committee was needed to support me during the administration of the initial feasibility study. The committee had to decide who would accompany me while I conducted the census/study of all the homes in the communities. In general, the water committee was committed to guiding the project and my activities during the first three months of the project.

To begin the construction phase, the water committee had to establish three key elements of the project: work brigades, quota, and food. The formation of the work brigades was simple. Since there were seventy-five homes, it was decided to have three brigades of twenty-five persons each. Furthermore, Los Arroyos had approximately twenty-five homes so they became one brigade, and Los Botados was already divided geographically into two groups of about twenty-five. Each Brigade was assigned a brigade leader who was a member of the water committee. I was working on two projects in the beginning, so we decided that we would work every Monday and Tuesday. With two days of work per week, and three work brigades, workers would have a hard time thinking in advance to which day would be their next day of work. It was a constant question to each brigade leader. It was also decided that each day of work missed would cost 50 pesos.

The next issue was to decide on a quota. After much debate, a twenty peso quota per month was recommended. This fund would go directly to purchasing food for the men on work days. The committee also suggested the remainder of the money left over once the project was finished should be saved for any unexpected maintenance work. On termination of the project, a monthly quota of five pesos was tentatively put into effect to support the maintenance of the water system.

Finally, food for the work brigades was organized. Of the elected water committee, there was one woman from each brigade. This woman became responsible to organize the cooking for her brigade. This did not mean she had to cook; rather she had to recruit the women to cook. It was decided that a day of cooking was not equal to a day of work of a man, unless the woman had no one in her home to work for her. Most often, widowed women or young women without any men in their homes did the cooking.

Initially, the excitement of starting the project united the community in a euphoric frenzy, with work brigades at full capacity. These feelings dwindled as the days turned into weeks, and the community members realized the amount of work involved in the project. The committee needed to keep a positive attitude in the community and motivate them when necessary. During construction, interest fell toward the middle of the project, but when the finish was in sight, full participation reappeared.

The final phase of the water committee is post-construction. This is the most important phase of the entire project. The sustainability of the water system is at risk during this phase without the complete participation of the water committee. Rules on maintenance, repairs, quota debt, vandalism, and watershed conservation need to be regularly covered.

4.2 Feasibility

The feasibility study for the water system was performed during the first three months of the project with strong support from the water committee. Some basic questions to be answered were: Does the community need water? What does the community do now to retrieve water? Is there general interest to work and contribute time to a water project? These questions were investigated by observing the community during the initial water committee meetings. By inserting oneself into the community socially as well as professionally, many questions can be answered by observation only.

Introduction into the community is a very important aspect of the volunteer's life. Besides informal introductions in the community by different community leaders, it is important to have a large community meeting in the first week to introduce oneself to the people as a whole. Important aspects to cover when introducing oneself to the community include why the volunteer is here, what the volunteer intends to accomplish, where the volunteer will be living, and resulting goals and benefits to the project. This meeting is typically carried out by the Water/Sanitation Assistant Peace Corps Director (APCD), who, depending on the volunteer's language level, can easily explain all the aforementioned topics to the community clearly.

It is very important to use the word "we," instead of "I." This will show that the volunteer is not there to work alone, but to work with the people. During the first few meetings it is important to primarily be the observer, rather than an active participant. The final goal of the first meeting is to decide as a community when to meet for a second time and discuss more in-depth plans to come. The community decided we would meet every Saturday afternoon at 3 P.M. for the first few months to organize the project better. I explained that a water committee was going to be elected in the near future and to start thinking about the leaders or interested people in the community to elect to these positions.

Once need was evident within the community, the next step was a home health survey. Tables 4.1 and 4.2 present the questions and results of the home health survey. The survey is an aid in the introduction of the volunteer into the community. The survey is carried out with various leaders of the community, members of the water committee, or elders who are comfortable visiting the entire community. The survey forces the volunteer to meet all heads of household. Dominican men would consider themselves head of household, but for survey purposes, since women ran the home, women were asked the questions from the survey. During my survey, I carried a small notebook which I recorded responses to all of the health survey questions, as well as names of family members in each house. This small effort to learn everyone's name, demonstrated to the community my eagerness to know each and every one of them, however, with seventy five extended families, it is almost impossible.

Table 4.1: Home Health Survey and Results Los Arroyos,

Sample Size of 30 Families

Home Health Study	
1. Where do you get water from for your home?	
Faucet	29%
River	71%
2. How far is any type of water supply from your home?	
Less then 1 Km	100%
3. How many hours are dedicated to finding water each week?	
Less then 5 hours	5%
5-10 hours	23%
10-15 hours	54%
More then 15 hours	15%
4. What do you use to carry your water in?	
Oil Cans (4 gallons)	8%
Gallon Jugs	31%
5 Gallon Buckets	61%
5. Who gets the water in your family?	
Children	31%
Wife	23%
Wife and Children	46%
6. Have you had any accidents while retrieving water?	
Yes	0%
No	100%
7. What do you store your water in?	
Same as question 4	100%
8. What do you do to the water before drinking?	
Nothing	54%
Boil	8%
Bleach	38%
9. When do you wash your hands?	
Never	31%
When Necessary	23%
Before eating	8%
Always	38%
10. Do you have a concrete floor?	
Concrete	15%
Dirt	85%
11. Do you have a latrine?	
Yes	23%
No	77%

Due to the large number of homes, Table 4.1 is only a partial sampling of the communities. Approximately half of the homes were surveyed. The poorer of the two communities had the larger population of children; therefore, the majority of the surveys were carried out in Los Arroyos. Typically, homes with young children were targeted, since they would become the major beneficiaries on the completion of the project.

A few of the questions were found to be skewed because of uncontrollable factors. First, question one, which asks, where do you get water, says that 29% retrieve their water from a faucet. To clarify, this faucet is about a one kilometer walk down the road to the neighboring community which has a water system in place. Question six, asks if any accidents have occurred while gathering water. Not one family answered yes. I believe this is because retrieving water is such a normal daily chore that it is not differentiated between any other normal daily activity, therefore when an accident does occur, the fact that they were in the act of fetching water is not accounted for. Questions eight and nine received puzzled looks and mothers responded with what would make them look good and make me happy. The lack of hand washing was evident throughout the community (along with the lack of soap). Finally, the last question (number 11) is not a good representation of latrine presence. The actual distribution of latrines is about 67% with, and 33% are without. This is because the forty-five homes not surveyed, typically owned a latrine.

Table 4.2: Cases of Diarrhea in last few months (January 2002)

Age	yes	no
0-5 years	51%	49%
6-10 years	25%	75%

Table 4.2 shows the percentage of reoccurring diarrhea in children in two different age groups. It is evident that the 0-5 age group is much more affected by the sickness. Water-borne diarrheal sickness is one of the top priorities to decrease with the addition of cleaner water, as previously discussed in Section 2.8.

Tables 4.1 and 4.2 have shown definite difficulties in the community. These results clearly show evidence of the need for a potable water system. Three months after the completion of the project, the above surveys will be conducted with the same families, to show the benefits of potable water and an improvement in their quality of life.

4.3 On-Site Research with Community

Researching all known water sources in or around the communities is the next step, which was done simultaneously with the health surveys. A small group of men from each community accompanied me into the fields and up in the mountains to show me the two sources of water available. Discussions of who would accompany me to the sources were a major topic of our first two community meetings. I had to wait two weeks before I could see the water sources, because that was the earliest date where both communities would be free to show me.

Both water sources ended up being the same mountain spring, just that the spring had two exits on each side of a large overhang. After further investigation, the men explained how both springs were presently being used for two other water systems, coincidentally built by Peace Corps Volunteers. The villagers had seen that there was an abundance of overflowing water from one of the existing systems. The catchment basin presently had two 4 inch PVC tubes that were overflowing at a rapid rate. This water was overflowing into a small concrete basin which was being used for animal drinking water. Their idea was to use some of this overflow water to supply their water system. We measured the supply of water using a bucket of known volume and a digital watch. It was determined that there was 140 gallons per minute being wasted. I suggested that we use only one of the 4 inch tubes for our system and leave the other tube for animals. The community concurred. All equations and methods used will be further discussed in Section 4.5.

With the help of the community health surveys, and a few new Dominican friends, a community map was drawn. The maps were drawn with corresponding heads of household, number of persons per home, and whether they were planning on participating in the project recorded in a small notebook. The community map is very important. This helps in getting to know the community better, and aides in designing the direction of the pipeline. It will also help to foresee land ownership problems, whether the line crosses a plowed field, or the front yard of someone who is not participating in the project (See Figure 4.2).

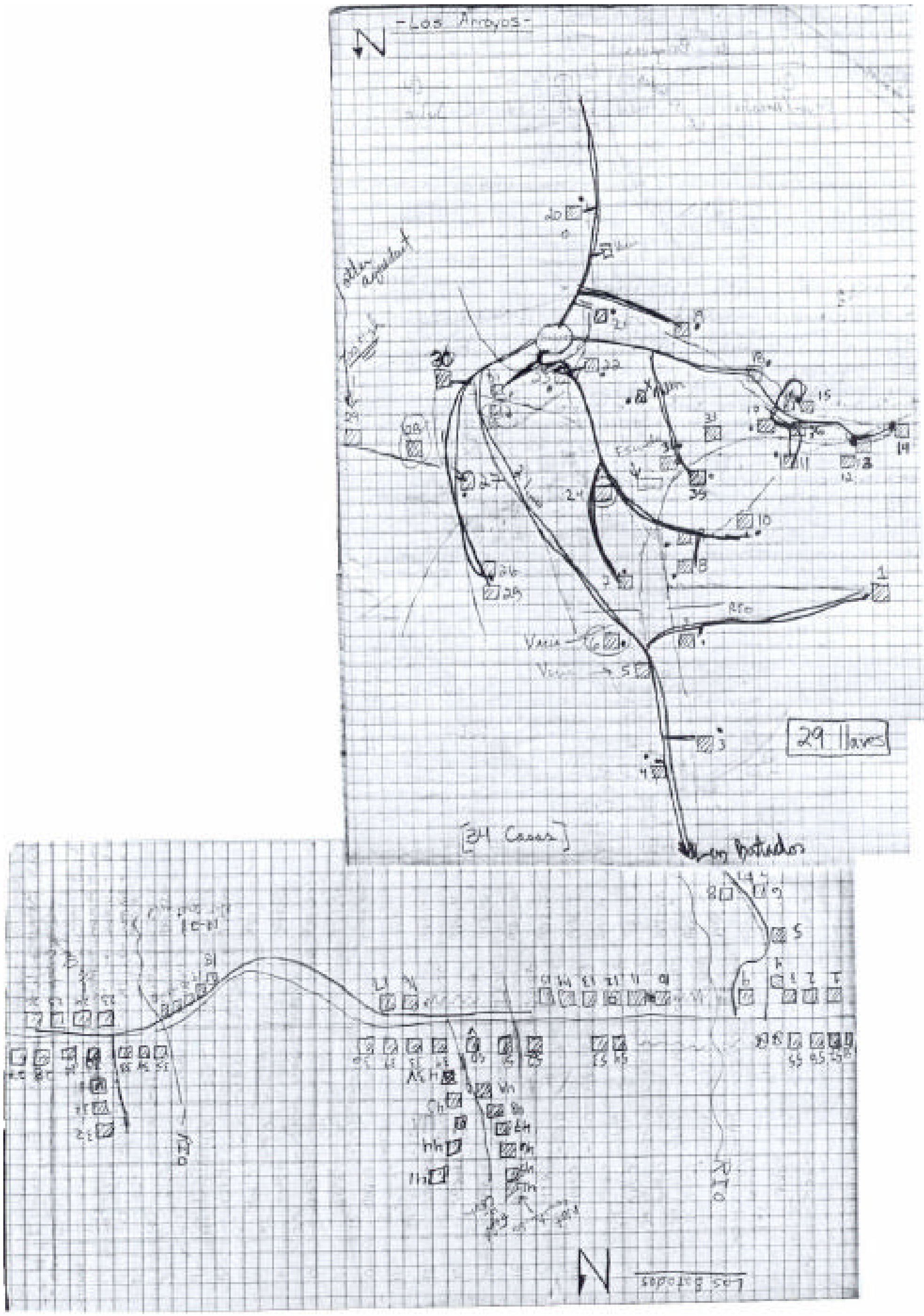


Figure 4.2 Original Community Field Map Los Arroyos/Los Botados

Once the map is completed, small meetings with the community were scheduled. The purposes of these meetings were to get different opinions from different focus groups in the community. There were three main focus groups interviewed: men, women, and landowners near the main transmission line.

At the men's meeting, they were interested in walking the entire line, from water source to holding tank. Besides a few differences of opinion, the main line was mapped out in our heads, and attitudes of each landowner were discussed. There was only one occasion where we had to reroute the transmission line, as not to upset someone. The direction of the main transmission line that I had in my head was totally different from what the men mapped out. This was because the people knew the terrain much better then I did.

The women were more interested in knowing if they would each receive a private faucet next to their home. Their main concern was that they did not have to walk to the river anymore. They wanted to know when we were starting and when we would be finished. I also used this time to discuss with them the advantages of having clean water to use for cooking, bathing and drinking. They listened politely, but kept returning to the question of whether each house was going to get a private faucet and how they would never have to carry buckets full of water on their heads anymore. One great piece of advice I took from the women was the human dynamics in the community (i.e. family feuds, drunks, respected elders, leaders, etc.).

The landowners only wanted to know if we planned on leaving them a faucet from the transmission line as it passed each field. Met with great objections, I had to explain to the men that this project was a health project and not agriculture. Additionally, I told them that the church (the project partner) was supporting the project for health and personal use purposes only and would not provide funding for agricultural usage of the water system.

After finishing meetings with the focus groups, it was evident that without taking all opinions into account, this project would not be possible because all aspects of the project would have been designed how I saw fit, and possibly not compatible with the community. These meetings were held unofficially so as not to alert the entire community. In the women's case, it had the added benefit of letting them speak freely, without the presence of their husbands.

4.4 Land Survey

The purpose of the land survey is to gather data for the design of the water system. The survey was conducted from the spring, downhill, until we reached the proposed water storage tank site. From the tank site, multiple surveys were carried out to each of the homes in the communities. The survey would help me design the pipe sizes, break-pressure box placement, water tank placement, as well as where we were going to need stronger pipes for gorge crossings, or areas of higher pressure, if applicable.

Before the survey could be done, permission to cross each landowner's piece of property had to be granted. This was done by a few water committee representatives and me making a personal visit to each landowner's home. We met with approximately eleven men. Eight of these men were members of the participating communities and had no problems with it. The other three asked if they could obtain a water faucet in their respective fields. We explained that this was not possible, and they eventually accepted the proposed idea. Later, these three men would change their minds and demand a water faucet.

The equipment used for the land survey consisted of an Abney Hand Level, since transits or Total Stations were not available. The Peace Corps had Abney Hand Levels available for our use. Abney Hand Levels typically consist of a tube (dimensions of about 16 x 1.5 x 1.5 cm) with an eyepiece at the observer's end and horizontal cross-hair at the objective end (see Figure 4.3).

Figure 4.3 Typical Abney Level

Near the center of the tube is a 45° mirror, which reflects half of the line-of-sight upwards through an aperture in the tube. Mounted above the aperture is a bubble level with an index mark arm, which adjusts against half degree graduations on a nickel-silver arc (Jordan 1980). The other piece of equipment is a 100-meter tape measure. We did not have access to a proper metal survey tape; therefore, a cloth tape was used.

From the initial meetings with the water committee, small groups of people were organized for approximately two weeks of surveying. I explained the method we would be using to each group. I would always be at the uphill end of the tape measure ("the dummy end"). Each day I would appoint the seemingly most intelligent young man to be in charge of reading the tape measure. It was easiest to teach him to read the large blue numbers at every whole meter, to decrease any possibility for error. Later, some men learned how to call out tenths of a meter. The second man elected for surveying duty was to be my target. Since we were using the Abney Level, I had to have a target approximately the same height as me. His job was to stand on the spot we measured and do nothing. The third man stood next to me and held the opposite end of the tape measure. The remainder of the group was on machete patrol. They were in charge of clearing a good line of site from me to the next survey point. Dominicans are very skilled with their machetes, so it was obvious that even these men took pride in their "chopping" alongside me. Angle and distance were recorded in a field notebook that my five-year old sidekick, Hennessy, carried down the hill for me. Figure 4.4 shows a drawing of the basic survey method and trigonometric calculations to find elevation change.

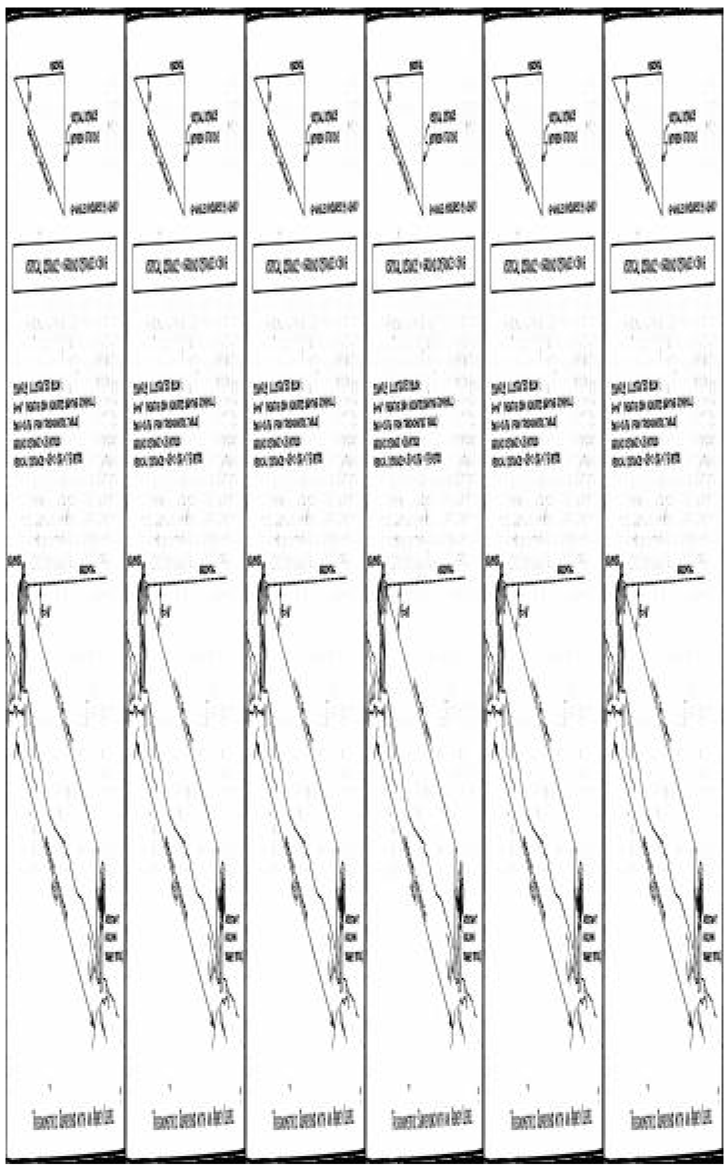


Figure 4.4 Survey Technique (Source: Jordan, 1980)

Each survey point was marked with a prepared stake marked with a corresponding number and tied with a brightly colored piece of fabric. Thorough notes were recorded during the survey in case of damage to stakes by animals or by small children. This paid off in the end, after six consecutive stakes disappeared.

It is important to note that the surveying process was not easy and not without problems. The first problem that was encountered was the explanation of the Abney Level to each group. The majority of the group had no idea what a set of binoculars were, so to explain the idea of a monocular with a level attached to it was a difficult concept for the Dominicans to understand. They just accepted it and looked at me as if I were crazy every time I used it. The next problem was yelling downhill to explain what branches needed to be chopped, or what path to follow. It took some explaining to show how one route would be easier because it was softer soil. I asked them if they wanted to dig up large rocks as an example, and they immediately understood. Since my language skills were only sufficient for basic communication at the time, yelling to people down hill did not always translate correctly. They had a habit of chopping down an entire tree, to get one small twig out of the way. After trying to explain that it was not necessary to cut the whole tree down, with no response, I gave up and made a mental note to cover deforestation topics in our next meeting.

Another consistent problem was the "target" man not doing his job. Sometimes they would switch, and since I had not been there for very long, I would not realize it was a different person. Unfortunately I realized this problem on the last day. We had tried marking a long piece of wood at the level of my eyes, but it was either hard to see through the Abney Level, or someone would forget it at the last stake. The last consistent problem was the reading of the tape measure. The tape measure was marked on both sides, English and Metric. It wasn't uncommon to call out incorrect measurements up to three times a day. These mistakes were usually caught right away, but on occasion, a small piece of the survey had to be measured again the following day.

Due to previously mentioned problems and mistakes, there were a few sections of the survey that had to be re-surveyed. Some of these areas were because there was a large elevation change or U-profile. It is very important to re-measure in both of these instances and check the difference of the two surveys. One section, I had recorded very odd looking numbers, and after a new measurement, realized that the measurement was misheard. The last re-survey was because of the opposition of one local farmer to use his land. Instead of fighting with him, we found an alternate route which was an insignificant change in distance.

Jordan, (1980) states that a 6% error for every one kilometer of ground distance is acceptable. Due to time constraints the entire survey could not be reworked. Instead, elevations were checked against a handheld GPS unit. The results compared to the original numbers within 4% accuracy.

4.5 Design

4.5.1 Water Supply and Demand

Water supply and demand are calculated to start the overall design of the system. Water supply is most conveniently measured for spring flows using a wide-mouthed container, such as a five-gallon bucket available in the village. Flow is calculated by using a container of known volume, divided by the time (seconds) it takes to fill it up. An average of at least three tests is used. Using the five-gallon bucket, we concluded the water supply from one pipe in the mountain spring to be approximately 70 gallons per minute. This test was carried out during the dry season, so it was assumed this was the minimum supply. Figure 4.5 shows the calculations.

Water Supply Calculations

Time to fill up 5 gallon bucket

$T1 := \mathbf{4.5} \cdot sec \qquad T2 := \mathbf{4} \cdot sec \qquad T3 := \mathbf{4.5} \cdot sec \qquad Vol := \mathbf{5} \cdot gal \qquad Q := \frac{Vol}{sec}$

$Q1 := \frac{Vol}{T1} \qquad Q2 := \frac{Vol}{T2} \qquad Q3 := \frac{Vol}{T3}$

$Q1 = \mathbf{66.67}\,\frac{gal}{min} \qquad Q2 = \mathbf{75}\,\frac{gal}{min} \qquad Q3 = \mathbf{66.67}\,\frac{gal}{min}$

$Supply := \frac{Q1 + Q2 + Q3}{\mathbf{3}}$

Supply ~ 70 gal/min

Figure 4.5 Water Supply Equations and Results

Next, the water demand was determined. Water demand is calculated (Figure 4.6) by using the total population plus a factor of safety.

Water Demand Calculations

$\text{persons} ?? \mathbf{1}$ $\text{Design} ?? \mathbf{50} ? \frac{\frac{\text{liter}}{\text{persons}}}{\text{day}}$ $\text{Supply} ? \mathbf{69.44} \frac{\text{gal}}{\text{min}}$ $\text{P} ?? \mathbf{500} ? \text{persons}$

ADD = Average Daily Demand

$\text{ADD} ?? \text{Design} ? \text{P}$

$\text{ADD} ? \mathbf{25000} \frac{\text{liter}}{\text{day}}$

ADF = Average Daily Flow(L/s)

$\text{ADF} ?? \text{Design} ? \text{P}$

$\text{ADF} ? \mathbf{0.29} \frac{\text{liter}}{\text{sec}}$

PD = Peak Demand

$\text{PD} ?? \mathbf{4} ? \text{ADF}$

$\text{PD} ? \mathbf{1.16} \frac{\text{liter}}{\text{sec}}$

SF = Source Flow

$\text{SF} ?? \text{Supply}$

$\text{SF} ? \mathbf{4.38} \frac{\text{liter}}{\text{sec}}$

Figure 4.6 Water Demand Equations and Results

There were 430 inhabitants in the two communities. I decided to use 500 for ease of calculations which resulted in a sixteen percent factor of safety, due to the ample supply of water. Per capita demand of forty-five liters per person per day is the present design standard. Per capita demand is the water required per person of the projected village population. This figure was determined from World Health Organization (WHO) studies, and includes allowances for personal washing, drinking, cooking, and a portion of domestic animal needs (Jordan 1983). I chose to use fifty liters per person per day, for ease of calculations.

Average Daily Demand (ADD) is calculated by multiplying the design standard of 50 liters per person per day by the total population of 500 persons. With this result, the

Average Daily Flow (ADF) is calculated by changing units to a per second basis. The Peak Demand (PF) at any given moment is calculated by multiplying the ADF by four.

The PF is compared to the Source Flow (SF) and if the peak demand is less than the source flow, the design is finished. Furthermore, Tank Storage (TV) volume and Tank Dimensions (r_1, r_2) can be estimated. This method of calculations is taken from Faiia (1982). Figure 4.7 shows tank dimension estimates for the system.

Tank Size and Dimension Estimation
- SqaureTank Design

TV = Tank Size

$$TV ?? .75 ? ADD ? 1 \frac{m^3}{1000 ? liter} ? 1 ? day$$

TV ? ▮

Assume h = height
r = side

$$h ?? 1.5m \qquad h1 ?? 2.0m$$

$$r ?? \sqrt{\frac{TV}{h}} \qquad r1 ?? \sqrt{\frac{TV}{h1}}$$

r ? ▮ r1 ? ▮

Figure 4.7 Tank Dimension Equations

4.5.2 Survey Calculations and Pipe Sizing

Previously discussed survey notes, the stake numbers, distance between each stake, angle from each stake, and cumulating distances are entered into the spreadsheet. Using a spreadsheet, the sine of the angle, vertical elevation change, and total change in elevation are calculated. The last column in the spreadsheet was for observations copied from the original notes. Table 4.1 shows the survey data and calculations for the first twenty survey points. All survey tables and graphs from initial survey are provided in Appendix C.

Table 4.1 - Example Survey Spreadsheet – First twenty survey points from spring

Survey Data for the Aqueduct of Los Arroyos and Los Botados

Stake #	Distance (m)	Total Dist. (m)	Angle ?	Sine ?	Vert. Distance (m)	Elevation (m)	Observations
Fuente		0				1000	Overflow of existing system
	5.7		0	0.000	0.00		
1		5.7				1000.0	
	50		-10.5	-0.182	-9.11		
2		55.7				990.9	
	40		-14	-0.242	-9.68		
3		95.7				981.2	
	42		-20	-0.342	-14.36		
4		137.7				966.8	
	41		-14.5	-0.250	-10.27		
5		178.7				956.6	
	23		-10.5	-0.182	-4.19		
6		201.7				952.4	
	33		-14	-0.242	-7.98		
7		234.7				944.4	
	25		-19	-0.326	-8.14		
8		259.7				936.3	
	8		-10	-0.174	-1.39		
9		267.7				934.9	
	15		-20	-0.342	-5.13		
10		282.7				929.7	
	18		-13	-0.225	-4.05		
11		300.7				925.7	
	24		-13	-0.225	-5.40		
12		324.7				920.3	
	16		-14	-0.242	-3.87		
13		340.7				916.4	
	25		-8	-0.139	-3.48		
14		365.7				913.0	
	41		-11	-0.191	-7.82		
15		406.7				905.1	
	20		-9	-0.156	-3.13		
16		426.7				902.0	Crossing Foot Path
	17		-20	-0.342	-5.81		
17		443.7				896.2	
	23		-15	-0.259	-5.95		
18		466.7				890.2	Open Field
	47		-11	-0.191	-8.97		
19		513.7				881.3	Cerca de Mata de Mango
	35		-15	-0.259	-9.06		
20		548.7				872.2	Good place for a break tank

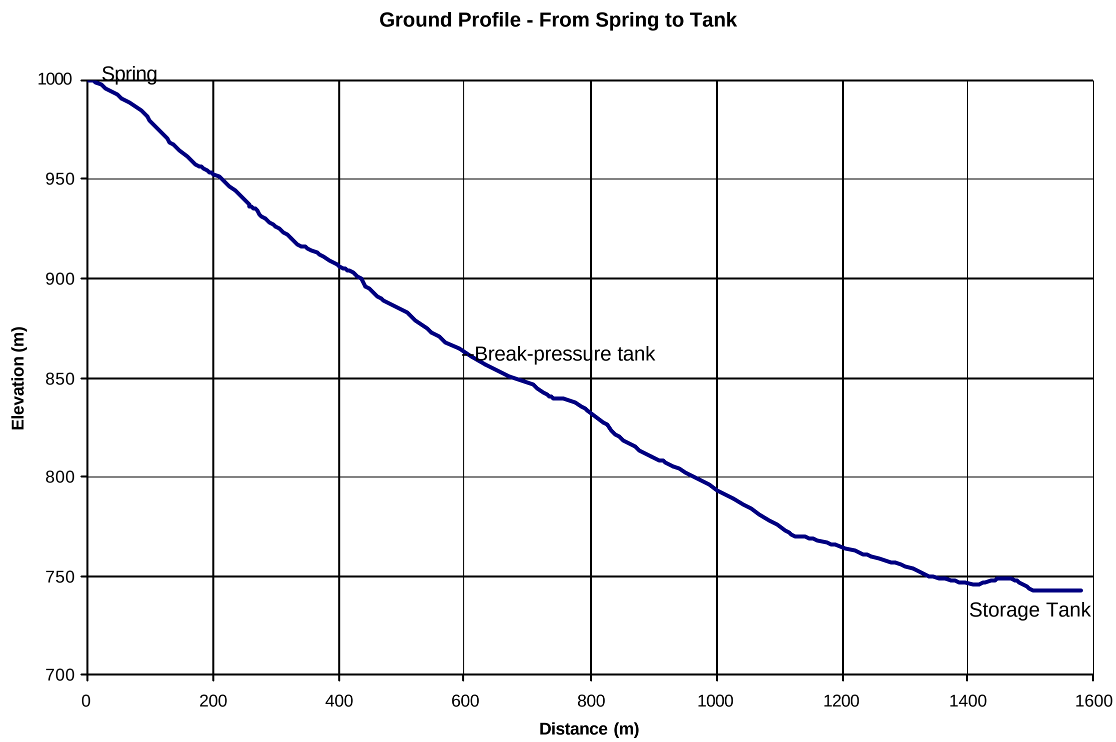


Figure 4.8 Main Transmission Line Ground Profile from Spring to Tank

From the spreadsheets, graphs are produced showing the ground profile of the proposed main transmission line(See Figure 4.8). After completion of the transmission line table and graph, the next step was to size the pipes. Pipe sizing was based on a number of factors; ground profile, static and dynamic head, flow, and frictional losses. A trial and error type method using the "Rigid PVC Frictional Head Loss Factors" table and design methods (Faiia, 1982), was used (Appendix D).

Previously discussed peak flow was calculated to be 1.16 liters per second. The corresponding flow of 1.15 was used from the frictional loss table. The smallest tube which transports water without outstanding friction losses is a 1-inch PVC pipe. As the diameter increases, the friction losses decrease. Trials are performed by hand, plotting out each headloss factor in m/100m of each proposed pipe diameter on the previously plotted ground profile. These plotted lines are referred to as the Hydraulic Grade Line (HGL). This is illustrated in Figure 4.9.

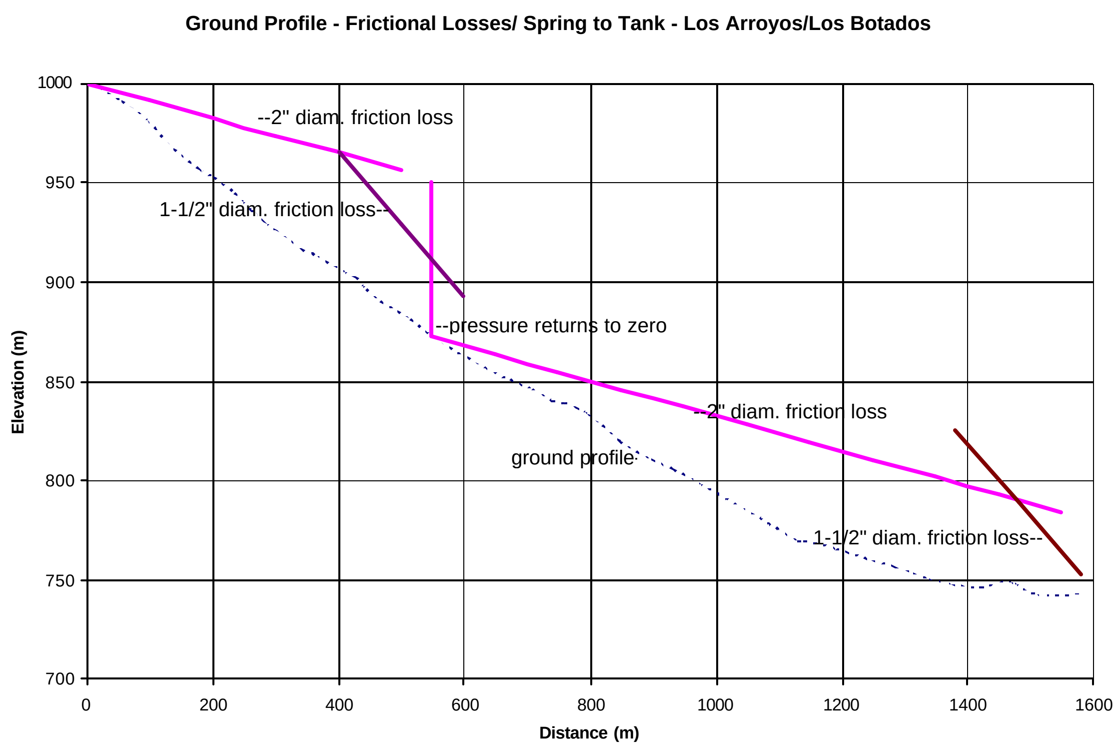


Figure 4.9 Representative Hydraulic Grade Line plotted against Ground Profile.

The objective of the plotted frictional losses of the chosen pipe diameter is to keep the profile as close to the ground profile as possible, limiting the dynamic head at any given point. Dynamic head is the difference between the ground profile elevation and the HGL elevation at any chosen point. Dynamic head is minimized by reducing the pipe diameter. Static head is also an important factor. The static head is the difference between the original spring elevation and ground profile elevation at any chosen point. A general rule of thumb is that static head at any given point with a good factor of safety should not exceed 100 meters (328 ft) of head (Peace Corps Personal Training Notes, 2001). The difference in head from the spring to tank is 260 m (853 ft), therefore one or two break-pressure tanks are needed. The function of a break-pressure tank is to allow the flow to discharge into the atmosphere, thereby reducing its hydrostatic pressure to zero, and establishing a new static level (Jordan 1982). I decided that one break-pressure tank would be installed at the midpoint of the elevation change due to land issues and to save money on the project. The static head at that point is 130 m (426.5 ft). This was above the recommended allowable static head, however, the actual maximum allowable head pressure for a Schedule 40 PVC pipe is 183.4 meters (400 psi).

The first 520 meters (1705 feet) of the transmission line was designed using 90 two-inch diameter, 19 foot long pipes. (PVC pipes are referred to in feet. As of June 2000 the nominal length of PVC pipes in the Dominican Republic was changed from 20 feet to 19 feet. Although no reason for the change was reported, the typical flatbed truck available in the country can carry materials with a length of up to 19 feet.) The final 60 meters (197 feet) to the break-pressure tank was designed with one and a half inch pipe. The line exits the break-pressure tank in two-inch pipes for the next 880 meters (2,887 feet). To slow down the flow before it arrived at the storage tank, the last 100 meters (328 feet) was designed to be one and a half-inch diameter pipe.

Figure 4.10 shows the ground profile of the three branch lines that leave the tank. Two of the lines are supplying the community right at the tank.

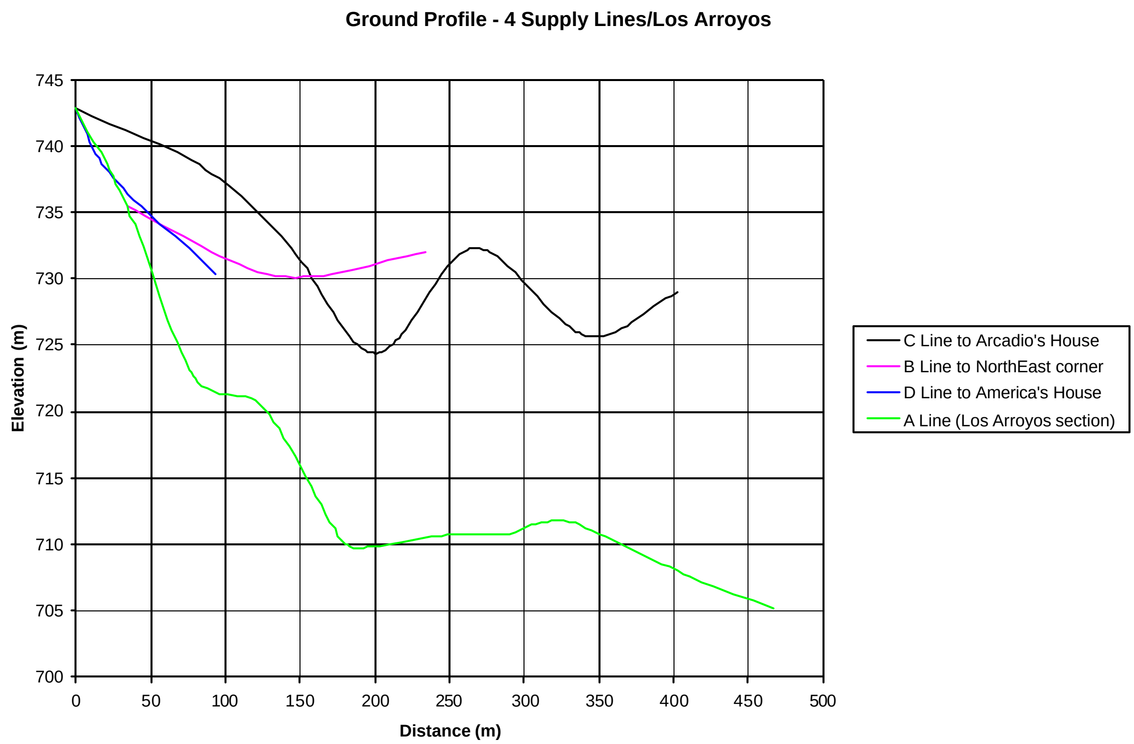


Figure 4.10 Ground Profile of Four Branch Lines

Line A is 400 meters (1,312 feet) long, which eventually continues as the supply line to the other community of Los Botados. Line B is 94 meters (308 feet) long and branches off of Line A. Each line begins in one and a half-inch pipe and gradually decreases to half-inch pipe. These designs were done without calculations or plotting of HGL for simplicity (water flows down hill). With more elevation changes, Line C consists of a greater amount of larger diameter tubes gradually decreasing much later in the profile.

Line A, which proceeds 1.1 kilometers (3,608 feet) further down hill, is designed for one and a half-inch pipe. This pipeline connects to existing pipes from a ten-year old water system that was built by the government and never maintained. The idea to use these existing tubes was to save money, since the second community was added. The existing water system will be covered more in Section 4.7.

An interesting fact about the community's impression of pipe size was that they didn't understand why we needed to change the diameter of the pipes as we came closer to the community. They wanted to use two-inch pipe on the entire system. In fact, when I first explained to them that we would not be using two-inch pipe the entire way, I got many looks of disbelief. Most of the community thought that one and a half-inch pipe was way too small for the entire community and that it would never bring enough water to them. They showed me the difference in size of the diameters of the two pipes with their thumb and finger, and how two-inch pipe would bring them so much more water. I realized they were looking at the amount of water in a 2-dimensional fashion, instead of thinking about the volume each size carries. Granted, the larger the pipe, the more water can fit in the tube and bigger is better, but the community leaders were not taking into account all aspects, such as needed water supply, water pipe flow and cost. I had to explain to them to just trust my engineering opinion, and eventually I gained that trust.

4.5.3 Water Storage Tank Design

As previously discussed in section 4.5.1, the estimated tank volume was 4,953 gallons (18,749 liters). These results were based on the average daily demand of the communities. After sharing these numbers with the community, they were not happy. They thought the size was very small and they wanted a tank as big as one of their neighboring villages had. Seeing that this was a battle that I was not going to win, and without their total participation, the project would not have been possible, I agreed that we should have a larger tank. To justify a larger tank, I explained that if there ever was need for a repair on the main line of the tube, there would be enough storage in the tank for almost two days.

The second tank was designed to hold approximately 10,000 gallons (37,854 liters) of water. It was designed 14 foot (4.3 meters) square, outside dimensions, with a height of 8 feet (3.44 meters). It is designed of concrete block and poured reinforced concrete. The finished and original tank designs are provided in Appendix E.

4.5.4 Break-Pressure Tank Design

There is no minimum required capacity for a break-pressure tank, as long as water is able to drain from it as fast as it is discharged. The dimensions of the tank are influenced more by the size of the fittings (such as control valves, float valves, etc) which must fit inside of it (and size of the pipe wrenches which must be able to swing around inside as well) (Jordan 1982). The break-pressure tank was designed arbitrarily to make it the most comfortable to construct for the masons.

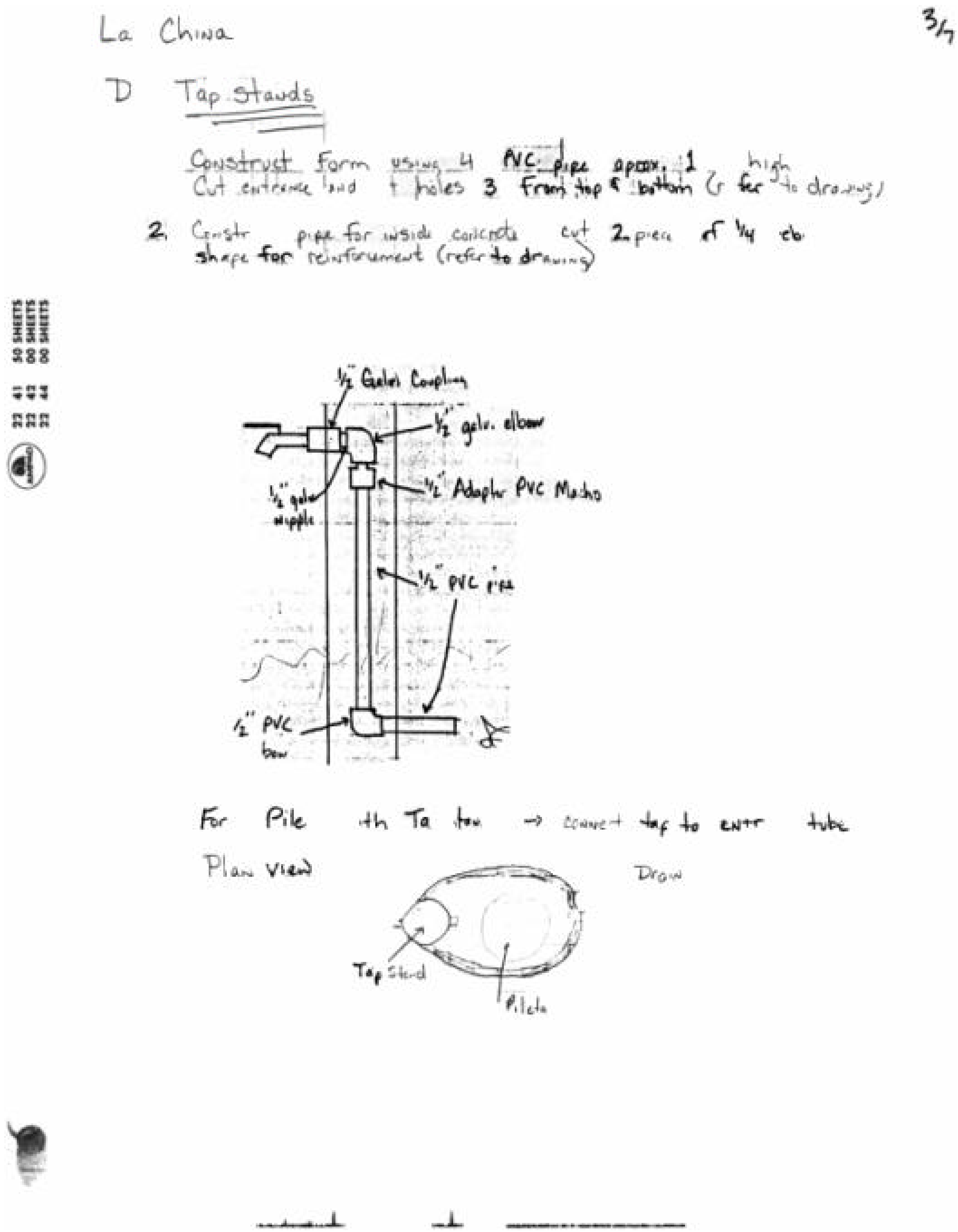
Since their was no form of sedimentation at the head of the water source, the break-pressure tank was designed with two small compartments. The water enters on one side, and rises until it then overflows into the second compartment. The first compartment acts as a sedimentation basin, allowing any solids to fall to the bottom. Located slightly above the second compartments floor, is the exit pipe. There are no fittings inside the tank, so there was no need to allow space for wrenches. The tank was designed with an overflow pipe, in case of a blockage in the pipe downstream. A half-inch galvanized nipple was also installed in the first compartment in an exterior wall as a public faucet. It was installed to satisfy the landowners, so they would have a place to get water, closer to their fields. The original and final break-pressure tank designs are provided in Appendix E.

4.5.6 Spring Box Design

The spring box is actually a small transmission box, because we are using an existing water system. The existing water system had two, four-inch PVC overflow pipes. To direct one of these flows into our system, a small tank had to be constructed. This tank was built to accommodate the rocky terrain and only large enough to mount a sheet metal trap door on the roof for maintenance purposes. An additional animal trough was discussed and designed, but was never installed because I had to leave the Dominican Republic earlier then planned, due to uncontrollable circumstances. See Appendix E for the original and final spring box designs.

4.5.7 Tapstand Design

Design of tapstands (water faucets), was adapted from Peace Corps Technical Training, taught by Eric Zalkin (Peace Corps Dominican Republic 1995-1997), country director for Hermandad, a NGO building water systems at the community level in the Dominican Republic. Design was based on notes taken from training classes and examples shown in training manual. Figure 4.11 shows the design of the tapstand from field notes. Figure 4.12 shows an additional design of a typical tapstand from Jordan (1980).



La China 3/7

D Tap stands

Construct Form using 4 PVC pipe apprx. 1 high
Cut entrance land + holes 3 From top & bottom (refer to drawing)

2. Constr pipe for inside concrete cut 2 piece of 1/4 el
shape for reinforcement (refer to drawing)

For Pile th Ta ton → connect tap to entr tube

Plan view Draw

Figure 4.11 Tapstand Design from Peace Corps Field Notes

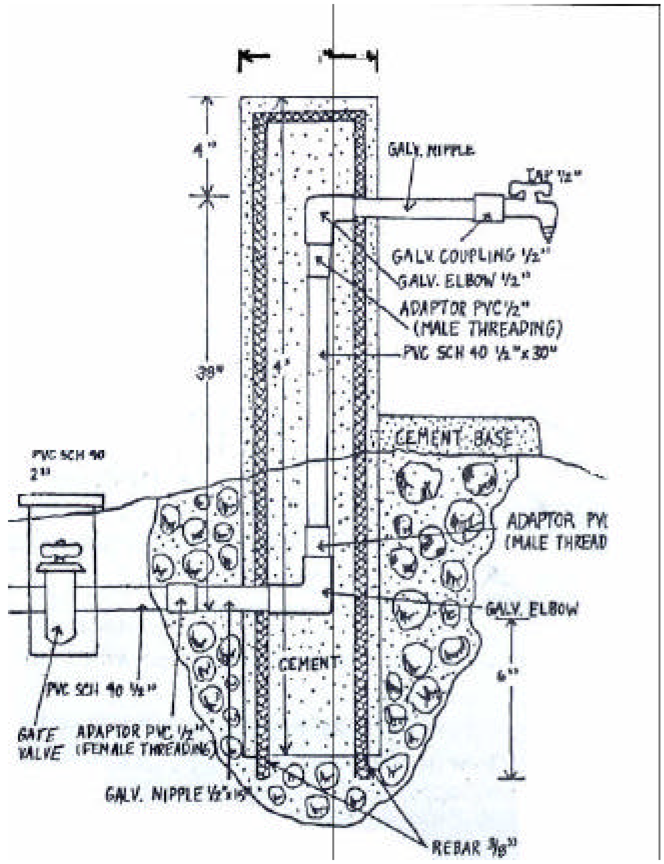


Figure 4.12 Typical Tapstand Design in the Dominican Republic

(From Curtis 2000)

4.6 Budget and Materials

4.6.1 Budget

As previously mentioned in Section 3.1, funds were available for this water system on arrival to the project site. The project partner, the Catholic Church, received a donation from one of the priest's congregations in Long Island, New York, in the amount of US$22,500 to be used only for water projects. Due to the availability of this money, solicitation for funding was not relevant.

Upon completion of the basic designs of the system, the budget was calculated. The purpose of the budget was to make sure that the entire water project would be covered by the donated monies. The budget included all materials, skilled labor (masons), delivery fees, and any other miscellaneous items. Miscellaneous items constituted things such as lunch for church staff while delivering materials, extra materials not accounted for in original design, and/or new materials needed due to special circumstances.

The project was completed under budget. The estimated cost to build the water system in Los Arroyos and Los Botados was US$8,457 based on January 2002 exchange rates. (18 Dominican Pesos to One US Dollar) Original budget and final cost provided in Appendix F.

The estimated budget turned out to be lower then the final cost. The final cost was US$10,175, a difference of US$1,718. This was due to the constant rise in cost of construction materials, from the time the budget was established until the end of the project. The difference was also due to low estimations of mason costs. The final cost consists of all monetary costs only. The cost breakdown is shown in Figure 4.13.

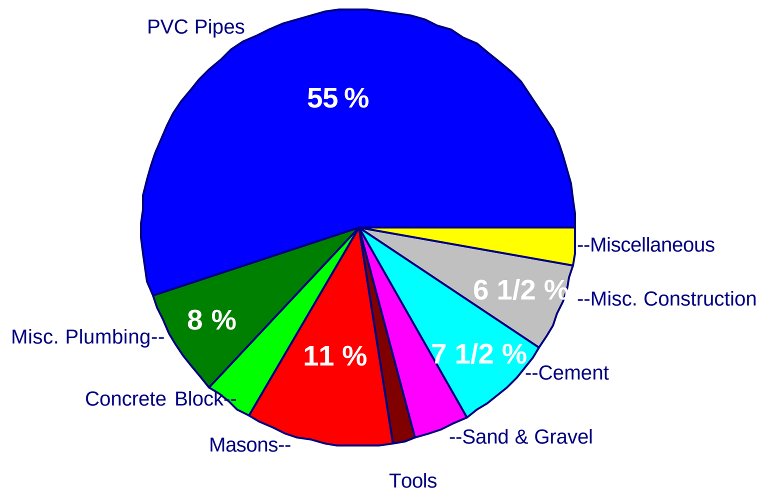


Figure 4.13 Cost Breakdown of Project Materials ~ US$10,175

The price of labor from the community is not included. This cost is important to show the community, with their time and effort, their labor was more then half of the total cost of the project. The labor cost is theoretical and wages are not actually paid to the workers. Labor costs were calculated using eighty work days, ten-man average crews, working an average of six hours per day. A work day was worth fifty Dominican Pesos. The final labor cost was RD$240,000. Of the overall cost, the labor represented 57% of the total cost. The final itemized cost is shown in Appendix F. Figure 4.14 shows the communities' portion of the total cost compared to the contribution by the NGO.

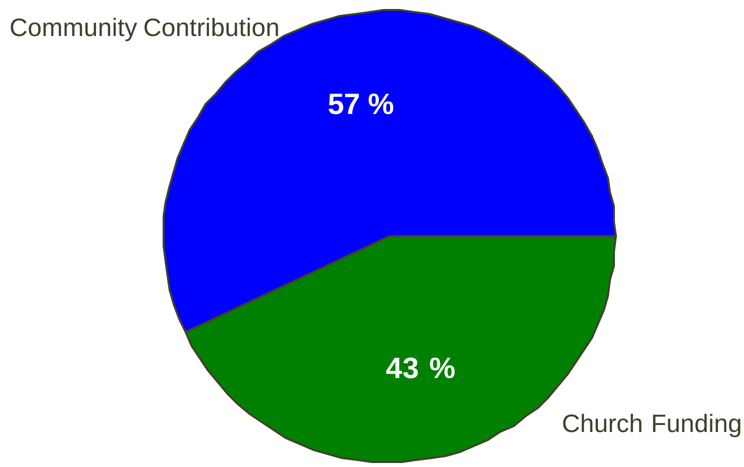


Figure 4.14 Total Project Contributions-Total Church Funds was US$10,175

It should be noted that even though the final cost was still below the initial donation, work on another, much larger project was initiated during the same time. However, during the design stages of the projects, the Catholic Church of El Cercado received another donation of US$20,000 to help continue both projects. With the new donation and remainder of the previous one, money was available for both water systems.

4.6.2 Material Availability

Almost all materials were available in the local town of El Cercado. Unfortunately since the town was located an hour away from the provincial capital and almost five hours away from the capital, the prices were considerably much higher. The church owned a medium sized Daihatsu dump truck and several Toyota pick-up trucks. With the help of these vehicles, transport of sand, gravel, and many other construction materials, made it possible to save money.

Considerable money was saved by taking two trips to the capital city of Santo Domingo. The first trip was to the major hardware store. All tubing connections (PVC and Galvanized Iron), water spigots, check valves, necessary tools (shovels, axes, hammer, screws, etc.), gate valves, access doors and anything that could fit in the back of the truck were purchased. Two committee members accompanied us to learn how to ask for parts and get a chance to see the large selections available in the capital. Typically, prices in the capital were one-fourth of the purchase price from the local towns.

The other important item obtained in the capital city was all of the PVC tubes. The company provided Peace Corps Volunteers a discount, and since the order was rather large each time, free delivery. Between three separate orders, 950 PVC tubes were bought from the manufacturer. The manufacturer, INCA Inc., is a Dominican company which fabricates its own product in accordance with ASTM Standards, locally in Santo Domingo. Buying large amounts of tubes straight from the manufacturer saved approximately US$500 compared to purchasing the tubing in El Cercado.

The next location of larger selections was in the provincial capital of San Juan. Typically, hardware stores in San Juan carried just about everything, but in short supply. When unexpected items that were not available in the local town were needed, they could typically be bought in San Juan. Raw materials were all bought from the local mine. This included gravel, rough sand, and sieved sand for final coatings. We also used the dump truck to hall a large quantity of rebar and all galvanized pipes for both projects.

The final location was in the local town of El Cercado. The town has three local hardware stores which all stock the same materials. It was important to have a good relationship with the owner of one of them. Subsequently, because of our relationship, it was possible to borrow tools and obtain materials on credit when time was of the essence. Materials bought in town were time-dependent items. These included bags of cement and concrete block for tank construction, all wood used for forms, nails, screws and any other miscellaneous items not purchased in the capital. The hardware store in El Cercado was frequented at least once a week looking for additional parts which we did not account for.

4.7 Construction

There are four basic phases to the construction of a gravity fed water system which are listed below.

1. Connect and bury the entire main transmission line from spring to storage tank.
2. Construct spring box, storage tank, and necessary break-pressure tanks.
3. Complete installation of all the supply lines to each house.
4. Construct tap stands and install spigots.

Ninety-nine percent of the transportation of materials, food and tools during the work day was all done by horse, mule or donkey. This also includes heavy materials dropped off in large trucks, such as cement, blocks, sand or gravel. Figure 4.15 shows my mode of transportation while working.

Figure 4.15 My mule (transpo rtation), Fulana (Jane Doe).

4.7.1 Phase 1 – Transmission line

The main transmission line extends 1 mile (1.6 kilometers) from the spring to the storage tank. While the designs of the tanks and supply lines were in progress, the main line was begun. Every work day, each man was responsible for his pick or shovel, and one nineteen-foot length of PVC tube. On an average work day, because of the very compact, rocky soil, each brigade would dig a trench, connect and bury sixteen tubes. At the beginning of the work day, a thin red rope was tied from stake to stake to establish a straight line guide for the trench. This phase of the project was very non-technical. Each brigade had a few men that would get trained to properly clean each connection, apply PVC cement to both tubes and connect in the proper fashion. The brigade followed behind covering up the pipes an hour later. This phase lasted four months. As more tubes were installed, the distance to the worksite shortened, leaving more time during the work day, therefore, a few more pipes per day were installed on average.

The community's prior knowledge of PVC connections was sufficient. Many men knew how to connect tubes by force but never had the availability of PVC cement. They also knew how to mold the male end of the tube into a female end, achieved by heating the male end over an open fire and forcing another male piece of tube of the same size into the heated end, creating a custom fit. I had no previous field experience with this method, so by demonstrating it to me, the men felt like more of an equal.

The constant problem involved in this phase of the project was making sure the trenches were dug deep enough. From day one, it was explained that the ideal depth to put the tubes was one-meter deep. This measurement was recommended in Peace Corps training for maximum protection of pipeline. After a few hours of digging, it was evident that because of the rocky soil, two feet would have to be sufficient. Still, the men would ask if their area was deep enough, after digging less then a foot deep. The knee was used as a reference point. However, even though each man understood this, they still wanted approval for their work. This was never resolved; I was constantly instructing the brigades if their trench was deep enough. During the first month, I worked with the brigades on every work day. During the following months, I would work one of the two days, leaving one of the brigade leaders with instructions. Figure 4.16 shows a brigade admiring the trench they dug through one of the many fields that were crossed.

Figure 4.16 Work brigade digging pipeline trench

4.7.2 Phase 2 - Construction of Tanks

4.7.2.1 Storage Tank Construction

In preparation for the tank, a large square hole was dug, approximately three-feet deep and twenty feet square. The location for the tank sat directly above the community in a central area. Unlike the previous trench work, the soil was free of rocks. It took approximately three days for the brigades to complete the excavation.

The footings were measured and squared off by the two masons who were hired labor from a neighboring community, who had some similar experience. With the foundation dimensions, another brigade had to dig another half-meter deep to prepare for the concrete footings. Figure 4.17 shows the completed footing trenches, and the masons preparing the rebar for the footing and corner columns.

Figure 4.17 Footing trench

Figure 4.17 also shows the prepared rebar for the columns. The columns were designed for the corners of the tank. They were constructed of 4-3/8-inch (no. 3 bar) rebar tied together with rebar "hooks" located every 12-inches. These rebar columns were tied into the foundation rebar with tie wire.

The next step was to place the foundation concrete. No forms were used because of cost and the stability of the ground was good, i.e. shifting of the foundation was not a concern. The method of mixing the concrete was the first major problem. We did not have electricity, nor access to a concrete mixer. I had planned to mix the concrete on a couple of pieces of plywood to keep the mix clean. The masons suggested we mix up one batch and once it hardened, we would have a hard surface to mix on. Since the plywood was in short supply, and needed for other uses, the dry concrete pad was prepared with the first mix.

I explained the idea of ratios to them, using the example of one part gravel can mean one bucket, one shovel full, or one wheelbarrow. Ratios to Dominicans were understood that one part cement was always one bag and never measured differently. So, when I first explained six wheelbarrows of cement, to twelve wheelbarrows of sand to twelve wheelbarrows of gravel, they understood the cement as six bags, only half of the required amount. Thereafter, the measuring out of materials was monitored closely on a daily basis. It was quickly realized that this was a fight that I could not win, so I let them do it the way they always had. It was difficult to argue with the methods they had used all their lives and I did not want to offend anyone.

Typical methods used in the US of measuring out the cement, gravel, sand and water were not used by the Dominicans. Dominicans are taught to prepare the dry mix as large as thought needed. The water is not measured. It is added to one side of the large pile and mixed until the mason's desired consistency is reached. The consistency depends on what part of the tank is being worked on. A thicker mix is desired for the foundation and thinner mixes for the columns and bond beams for ease of filling in around all rebar. The desired foundation mix was one part cement to two parts sand, and two parts gravel. Typical mortar mixes for placing block are negligible, as long as the mix is thick enough to adhere to each block. Figure 4.18 shows a prepared dry mix, as workers prepare one side with water. Unfortunately no one bucket of concrete had the same ratio of cement to sand, water or gravel. It was not uncommon to find small amounts of dirt, or small clumps of dried concrete or sand that never got mixed thoroughly. Since the concrete consistency could not be controlled, additional rebar was used throughout each tank.

Figure 4.18 Mixing concrete

Water was obtained from the local river. Animals were used to retrieve the water, which was located downhill of the tank, but on days when no animals were available, water had to be retrieved by the work brigade. This was the hardest job of the entire tank construction.

Once the foundation was cured for 24 hours, six lines of block were laid. Existing rebar which had been tied into the foundation rebar, were extended up through each block cavity. Every cavity had a piece of rebar and was filled with an even concrete mixture of sand and gravel, and half cement. Water was added until it was a soupy mixture. Figure 4.19 shows the masons and community members filling in blocks.

Figure 4.19 Filling in Block Cavities.

The plan was to train the masons to build the different tanks involved in the system, so when time came to build the same structures on the other water system, they would already know all the construction methods, and be able to work without my presence at all times. The mason's are shown in Figure 4.19; one on the extreme left and the other on the extreme right. They both had years of experience in and around the community and discussing with them different construction methods, it was obvious they understood the skill and were open to adjusting some of their bad habits to what I desired. Another important request was to allow interested community members, learn some of the masonry skills during construction. Figure 4.19 shows two young men learning the art of laying block.

The following step was to construct a bond beam and complete the lower part of the columns. A "ladder" of rebar was constructed for the bond beam, similar to the rebar that was constructed for the columns. Bond beam rebar was tied into the column rebar. American pine (1-inch thick by 14-foot long planks) was used for all formwork. American pine lumber was significantly more expensive then native lumber, but since we planned to reuse the wood four times, it was worth the investment. With formwork in place for the bond beam and lower half of the columns, the concrete was prepared and placed.

A concrete mixture of two parts sand and two parts gravel, to one part cement was desired. The masons complained that the larger amount of gravel was not necessary and that it was much harder to mix with so much gravel. I explained to them why this amount of gravel was required and in the end they agreed to work with the high gravel content mixture I required.

The forms were removed after the bond beam and columns were allowed to cure for 24 hours. Five lines of block were laid, following the same procedure as mentioned with the first six lines of block. Rebar was extended, and all cavities were filled in with a soupy concrete mix and the walls were left to cure for 24 hours. Figure 4.20 shows the interior of the completed rough wall. The mason is standing on level ground by the outside of the tank. The comparison of the depth of tank to ground level is shown.

Figure 4.20 Rough interior walls

Figure 4.20 shows the three holes that were made for the tank exit. The cavities in the block were not filled with any concrete mixture to make it easier to make the holes. The following day, the tops of the columns were formed and cast.

The next step was to coat the interior walls with three impermeable coats of a cement/sand mixture. The first coat to be applied was three parts sand, one part cement, with water being added to desired consistency. The purpose of the first coat was to fill in any holes and create a level finish for the next two coats. It was spread as thin as possible.

The second coat was two parts sand, one part cement. This mixture was put on very thin to create the first waterproof layer. Later in the afternoon, on the same day, the final coat of pure cement and water was placed. At the same time, threaded galvanized iron nipples were installed for the exits and one galvanized nipple was installed to serve as the cleanout.

Rebar was then tied for the tank floor. 3/8-inch diameter (No. 3 bar) rebar was used, placed at 12-inch intervals. The biggest mistake pertaining to the storage tank occurred in the construction of the floor. The day the floor was to be placed, I was needed to work up in the mountains at the spring to instruct the brigade how to prepare the spring box for construction. By mistake, I forgot to tell the masons the desired concrete ratio for the floor. It had rained all day, so in the afternoon when I arrived, they were just finishing the floor. It had required them to tie a huge plastic tarp over the top of the tank to shelter the floor from the rain and finish working. The problem was that the crew did not use any gravel in the concrete mixture. Three-fourths of the floor was finished when I arrived. After I voiced my disappointment, the masons apologized and offered to add gravel to the present batch, but I let them finish the floor with the sand, cement, water mixture. It was not worth the time and effort to start over and I was in no mood to keep working that day. Even if the floor cracked, it would have minimal effect on loss of water through the tank floor. Unlike concrete floors in the area, the tank floor had rebar reinforcement to help prevent any shifting and was cured for over a month under 100% humidity (floor was covered in water on a daily basis).

It is important to note that this is normal practice for Dominican masons. They install all floors with a sand-cement, and sometime small gravel mixtures. All of the floors in my community were severely cracked. The owners reported that they cracked within the first three months after construction. They never caught on to the trend that the floors were cracking due to the abundance of water in the mix as well as lack of course aggregate to bond the cement/sand mixture to.

The next step was to prepare the final bond beam and construct the false roof for placement of the final roof. Again, a rebar "ladder" was constructed at a slightly larger dimension to tie into the roof. A false floor was built using small diameter trees that had been cut down in nearby fields. Lumber (2x4-inch) was placed on two foot centers, with four poles supporting it from below. This lumber was then nailed into the bond beam frame already in place. Additional lumber was nailed under the 2x4's to give it stability in both directions. The final step was to cut 2-foot strips of plywood and nail them down. The plywood had to be cut in 2-foot strips because the access door we were installing on the top of the tank was 2-foot square, and all lumber had to be removed, through the access door, once the roof was allowed to cure for several days. Figure 4.21 shows the bond beam rebar and the crew preparing the false roof.

Figure 4.21 Bond beam and false floor construction

Once all forms were installed the final preparation before casting the bond beam and roof was to prepare the rebar and access door. 3/8-inch (No. 3 bar) rebar was used on 10-inch centers (Jordan 1980). For additional support, three ½-inch pieces of rebar were tied in the center running in each direction. The access door was tied into the rebar, positioned at the elevation of finished concrete. Figure 4.22 shows rebar in place and ready for concrete.

Figure 4.22 Roof rebar preparation

The bond beam and roof were cast monolithically and left to cure for ten days. After the ten days, the interior and exterior forms were removed. (It is interesting to note that the community was surprised that the interior forms would be removed. They could not understand what would prevent the roof from caving in.) A slurry coat of cement, sand and water was applied to the outside of the tank to give it an aesthetically pleasing finish.

At the tank exit, a small box was built with blocks, which reached ground level and supported an additional access door. This door provided security for the three gate valves already in place for the three supply lines. Without locking up access to these gate valves, children in the community could continually play with, and potentially abuse anything they could get their hands on. Figure 4.23 shows the top of the security box with three respiration pipes originating from the box located on the right.

Figure 4.23 Security valve box/respiration tubes

The final step for the water storage tank was to connect the main transmission tube to the tank. Additionally, an HG pipe was installed for the cleanout with the opposite end exiting the side of the hill. HG elbows were installed on the two cleanout nipples. The final product can be seen in Figure 4.24, and a picture of the overflow tubes can be seen in Figure 4.25. When the system was finally put into service, it turned out that the supply was much greater then the demand, so the storage tank, constantly overflowed. This caused major panic within the community because the water eroded away a significant amount of earth. The community had to stack a large amount of rocks in the eroded area, as well as dried banana leaves in attempt to redirect the force of the overflowing water. (see figure 4.25) Additionally a small trench had to be dug to direct the overflowing water back to the local river. The community had no water, and now they had too much.

Figure 4.24 Water storage tank

Figure 4.25 Overflow

4.7.2.2 Spring Box Construction

As mentioned previously, the spring that was used as the source of my gravity fed water system was in-use by another community who had constructed their water system with a previous Peace Corps Volunteer. Our decision was to use one of the overflow tubes from the existing catchment. Since no catchment was needed, all we needed to build was a transmission tank. This tank would serve the exact same purpose as a break-pressure tank. The tank would receive water and exit into the main transmission line. Figure 4.26 shows existing water system on the left, with the newly built transmission box on the right.

Figure 4.26 New and existing spring construction

As shown in Figure 4.27, the overflowing trough provides water for animals. There are two 4-inch PVC pipes coming out of the ground that act as overflows. The closest to the new tank was used as the supply for the new water system. A 4-inch PVC elbow was connected. In addition, 4-inch PVC pipes were used to make the connection to the new tank.

Figure 4.27 Connection to transmission tank

An overflow was installed in the new tank. It is pictured above, and although it is at a bad angle, it still served its purpose. Pieces of screen were installed in between the connections of the overflow pipes, to keep out any unwanted animals and debris.

Construction of the transmission tank was mimicked from the storage tank construction. The main difference was that a foundation was not cast. Due to the small size, the tank floor was cast, followed by four lines of block. The last step was to cast the roof and install the access door.

Difficulties arose with the ground preparation of the site, and delivery of materials. Preparing the site was made difficult by the very wet and rocky conditions. The brigade would pick and shovel with a constant flow of water from the trough seeping into the hole. Small drainage trenches were made, which made digging a little easier. A depth of a foot was all the brigade could reach due to the abundance of rocks.

Materials had to be carried the mile up hill on animals. It was very difficult to estimate how much of each material would be needed for this first tank built, so there was a constant convoy of men with animals, carrying cement, sand, gravel, and blocks up to the work site.

The work site was located on one of the well-traveled paths in the area. Men brought their animals from great distances to drink water. To protect from the weight of the many animals, the exit pipes had to be galvanized pipe. The pipe exits and immediately is connected to a galvanized elbow. With another short galvanized nipple and galvanized elbow, the line proceeded to cross the path about two feet underground in 2-inch galvanized pipe. (See Figure 4.28)

Figure 4.28 Transmission tank exit piping

4.7.2.3 Break-pressure tank

The purpose of a break pressure tank is to return the pressure of the water to zero, or atmospheric pressure. The tank was constructed using the same methods as the water storage tank. A small footing was initially cast, followed by five courses of block. An internal wall was also constructed of four courses of block. This would serve as a small sedimentation basin as the water entered.

The entrance and exit piping was changed to galvanized pipe as it came out of the ground and went back into the ground to protect the pipeline from animals or humans damaging it. An overflow pipe was also installed in case of any blockage in the pipes below the tank. A small ½-inch HG nipple was installed in the first compartment to be used as a public water spigot. Figure 4.29 shows the tank under construction and Figure 4.30 shows the finished tank.

Figure 4.29 Break-Pressure Tank under Construction

Figure 4.30 Completed Break-Pressure Tank

4.7.3 Installation and completion of all supply lines

The next phase of construction was to continue digging trenches and installing pipes on all of the supply lines. This was no different then the first phase of construction except special attention was paid to insure that reduction to a smaller pipe diameter was done at the proper points along the supply line.

During the entire project, there were only three instances that required using galvanized pipe. The first location was at a twenty-foot river crossing. It was traversed with two galvanized pipes (1-1/2" diameter) with the connection in the middle of the crossing to divide the amount of buried pipe evenly. There was no additional support needed. It was decided that the span crossed did not warrant any additional support. The other two locations were very narrow river crossings of approximately twelve feet. For these crossings, only one galvanized pipe was required for the exposed, elevated crossing. Figure 4.31 shows an example of how a galvanized pipe would be installed in a gulley crossing. GI pipe in the figure refers to galvanized.

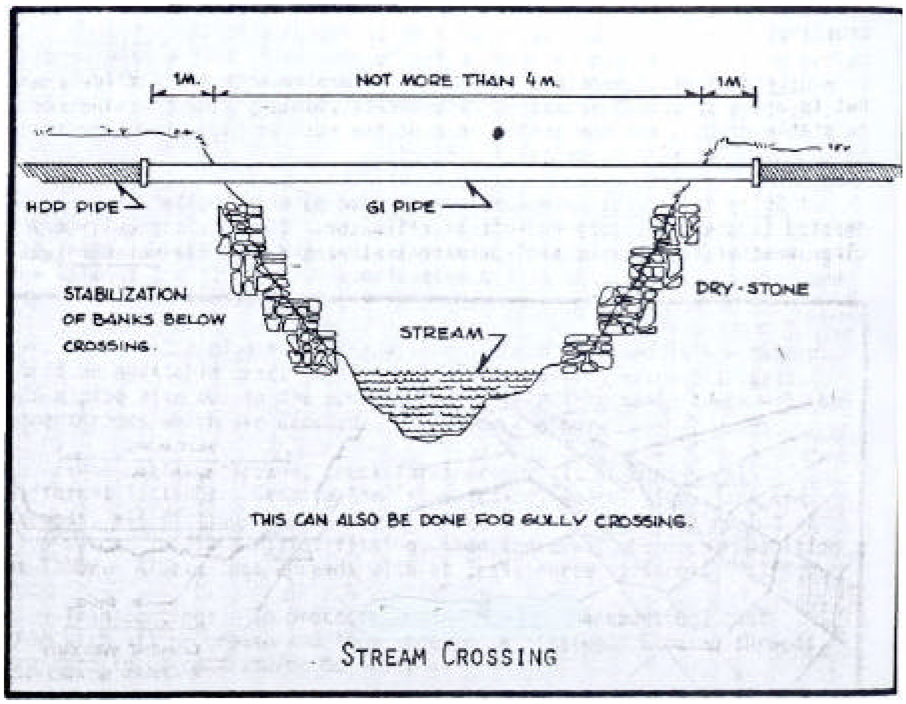


Figure 4.31 Galvanized pipe gulley crossing (Source: Jordan, 1980)

While working near the community, the brigades realized that by using two of their bulls and plowing the trench a few times, work was made much less laborious. There were three days that the land permitted enough area to use the plow and animals, the brigades installed three times as many pipes.

The supply lines in the community of Los Arroyos, right in the vicinity of the water tank, were finished within a month. This was because during the water tank construction there were always men not needed at the tank, which allowed them to continue digging the trenches right in the community. So the next large line of tubes to install was the long supply line that led to the next community. Once the trench was made to the community it had to be connected to the existing water lines from an old aqueduct.

The existing water lines were unproven. There were several visible areas where the pipeline had eroded and was exposed. The old system had dried up over the prior seven years. Needless to say, all of the old tap stands were broken, stolen, or non-existent. So, the initial plan during the design stage was to use existing pipes where possible and extend the system where necessary. It was also planned to supply each home with a brand new tap stand, so no family was better then the next.

The first priority was to obtain permission to use the existing pipeline. The existing water system was constructed about ten years ago by the government water agency, INAPA (Instituto de Agua Potable Y Alcantarillados). Translated to English, INAPA is the National Water Supply and Sewage Institute. They are responsible for all potable water supply other than in the capital city and a handful of the largest cities. Although technically a sub-entity of the Secretary of Public Health, the agency in practice functions independently, with its chief officer in direct contact with the president of the country (Johnson, 2002). The community claimed that the main reason for the failure of the previous water system was that INAPA never paid any of its hired plumbers to maintain the system. Eventually, so many tubes and tap stands needed repair, leaks increased, the pressure decreased, and the community lost all pressure.

Several visits to the local INAPA office were carried out. Each time I was redirected to talk with another person. After four visits I finally talked to the correct person and a visit to the community was planned. The visit was very short and permission was granted with the understanding that a detailed drawing of where connections were made was supplied to INAPA on completion of the project. The engineer also informed me that the reason for the short life of the water system was the community's failure to pay the required monthly water fee, which would have paid for the plumbers to maintain the system. (The official letter of permission is provided in Appendix G.)

The existing pipeline was cut and connected to the community's supply line shortly after permission was granted. During pipeline construction in the second community of Los Botados, many problems with the existing system became apparent. Among them, one woman thought that a twenty-foot stretch was all blocked up with debris. (This was later found to be untrue.) A large problem that was not voiced when the design was created was that there were several locations where a branch of the pipeline crossed the road, and the divisions were located below the asphalt. Since some of these connections were said to have leaked in the past, it was necessary to break up the road and drainage ditches to find the existing connections and repair them. Figure 4.32 is an example of breaking through the asphalt and locating an existing connection.

Figure 4.32 Searching for existing connections

The majority of the work in Los Botados was to find the existing pipeline that branched off to each home, clean it up, and install new pipes to the location of the new tap stand. Additional work was required when the system was pressure tested. These problems were located and repaired as needed.

4.7.4 Tapstand construction

Tapstands are the final phase in the construction process. Tapstands are best constructed using reusable molds. Typically PVC drainage tubes are used. We used Schedule 40 – 4-inch pressure PVC tubes because they were more readily available at the time. Each tube was cut into one-meter sections. Three tubes were used to have a total of fifteen molds. These molds were then cut lengthwise on both sides. Holes were cut using a heated piece of rebar, three inches from the top and three inches from the bottom, on opposite sides of each mold. The molds were held together with 4-inch hose clamps.

Using a one part gravel, two parts sand to one part cement mix, fifteen tapstands were built each day. After twenty-four hours in the mold, each tap stand was removed and submerged in water to cure for 7 days at 100% humidity. Seventy-five tap stands were constructed in five days. Figure 4.33 shows the method used to reproduce the tapstands.

Figure 4.33 Tapstand construction

Each tapstand was connected to the supply line going to each house. Once the pipes were connected a small splash area was made. This splash area was constructed with a concrete mixture and small rocks found in the area to take up space. The purpose of the splash area was to keep the surrounding area free of mud, and to serve as structural support for the tapstand. A small piece of ½-inch pipe was installed for drainage. The final step was to install the water spigot. Figure 4.34 shows a picture of an installed tapstand.

Figure 4.34 Installed tap stand

4.8 Education and Maintenance

Once the project is near completion, a critical part of the project begins. This phase of the project does not have a definitive ending. The education on how to benefit from the clean water and maintenance of the newly built water system is dependent on the support of the participating communities. Without proactive concern and participation from the community, the life-span of the project is decreased substantially.

4.8.1 Education

When the finish date of the project is closing in, it is important to continue holding water committee meetings and encourage the community to continue meeting after the project is complete, for the life of the system. Near the completion of the project, there were people that did not fulfill the requirements. As previously noted, the two requirements were to pay the twenty peso quota and work every day with your brigade. Approximately twenty percent of the community had not fulfilled their obligations. In one of the final meetings, during the construction phase, names of every community member were read aloud, so it was publicly known who had earned water and who had to wait. The water committee had decided to install plugs in all tapstands of families who did not comply with the agreed requirements. This inspired half of the incomplete families to immediately pay their debts, out of fear of future embarrassment.

During completion of the project, weekly meetings, called charlas, were held for all women in the community. These charlas would focus on the different health concerns the new water system would bring to the family. Women were the focus group because they were responsible for the children in the home. Water treatment for infants was discussed initially. It was explained that it was not enough that clean water was available now. To an infant, the stomach is not accustomed to anything foreign in his/her stomach early on in life, so even the smallest trace of bacteria could affect the health and well-being of the child. Suggestions were made to boil the water before giving to infants and small children. The importance to keep water containers clean was reiterated. Without a clean container, boiled water is contaminated immediately on contact. Filtering water was discussed, but due to the high price of filters, not emphasized.

Another important charla was to reiterate the importance of hand washing. A recent article from The Economist, referring to diarrhea, stated that now it seems that the best solution may also be the simplest: persuading people to wash their hands with soap (Economist, 2002). The article claims that this simple action would save one million children in the world per year. Emphasis was put on the importance of washing hands before and after eating and after using the latrine.

Finally, cleaning of the water storage tank was planned. It was explained why it was best to clean the tank once a month. Monthly cleanings at the beginning of operation was most important because many pipes were installed dirty, and all the sediment would wash directly into the tank in the first few months. Water could be emptied through the cleanout pipe. A small amount of soap and bleach would be used to sanitize the walls. If a small group of women did this together, water could be restored within four hours. I explained that water would have to be run through the tank and run out the cleanout to eliminate the soap and bleach. The women would have to inform the community not to drink the water until the evening to protect against soapy or over bleached water.

Taking advantage of the women being all together, we also discussed the importance of having the small children wear clothes whenever possible. I explained that many different sicknesses can be contracted through contact with the ground. One of the most common diseases that is contracted is worms. Naked children were a very common occurrence, reasons typically were that the child did not want to wear pants, the pants were in the wash, or they could not afford to buy more then one pair.

4.8.2 Maintenance

Maintenance of the water system started on the first day of construction. Community members learned how to connect PVC pipes in the correct way, how deep to bury the pipes and how to correctly cover the trench to protect from future erosion. Maintenance was a continual process throughout construction.

The idea was to teach interested men every aspect of the construction process. Explanations from connecting tubes, to how the water gets to each tapstand were provided. Procedures had to be repeated several times, but as the project moved along, the goal was for the community members to do more of the day to day technical work, as I slowly did less and less, until I became the observer.

During this time, more specific training was provided to three young men that expressed interest in learning to act as the plumbers of the system. Specific operations, such as threading galvanized pipes, the use of Teflon tape to help against water leaks, and why a break-pressure tank was required were taught.

Near the end of the project, many community members had problems with the newly trained "plumbers." They said that I had trained the "dumb guys" of the community and that they had not learned anything and could not be trusted. I told the community that they had learned everything I had taught them, and by doing those things during construction had demonstrated their knowledge. I challenged the community by saying that of the numerous persons of the community, these three men were the only ones that wanted to learn.

Small meetings were scheduled with the plumbers and water committee, to explain the responsibilities of the plumbers. These men, supported by the maintenance fund, could repair any problem that may occur with the water system. All problems were to be discussed with these men, before anyone is sent to talk with the church in El Cercado.

The final meeting before the system was put into service was to discuss spring protection and to distribute the keys to the access doors. To their advantage, the spring was very populated with large trees. Currently no threat of deforestation was apparent, but we discussed the issue of deforestation and the importance of keeping it well forested to keep the quantity of water the same. It was also discussed that barbed wire was purchased for the landowner of the spring, to protect the newly constructed transmission tank from animals. Finally, keys to all padlocks were distributed to the three main representatives of the water committee.

4.9 Inauguration

The inauguration of the final water system is very important to Dominicans. There are two reasons to hold inauguration ceremonies. The first, since ninety-five percent of the culture is Catholic; a religious ceremony to the saints is required, along with special praises to the saint or god of water, a Haitian tradition adopted by the Dominican culture (this was later explained to me by some Dominican elders). This event is typically at the spring in the mountains. Food and drink are consumed while three large drums, called palos, are played, with people singing and dancing along with them. This celebration typically lasts late into the night.

The second reason for an inauguration was to have a good excuse to have a great big party. The community would come together at a central location. They would prepare goat, cow, chicken, and pig to be eaten with corn, rice, beans and anything else in season at the time. It was an expensive event, but the communities had prepared for this, and took up a collection during construction to fund it.

The celebration was also an opportunity for me to invite fellow Peace Corps Volunteers and Staff, as well as the church staff to share in what we accomplished. A small award ceremony would be held to present the newly trained plumbers with small certificates of achievement, and to recognize the leaders of the community that made the project all possible. Without these leaders to animate, organize and lead the community, no water system would exist.

4.10 Feasibility survey repeated

Three months after project completion, initial families surveyed before the project started, should be re-surveyed. This method is used to show effects of the cleaner water. It is important to note that there is no concrete proof that changes are directly related to the cleaner water, but there is an assumed correlation in most cases.

Unfortunately, surveys could not be reissued. Due to circumstances out of my control, I was not able to continue my service in the Dominican Republic and was medically separated from the Peace Corps directly after completion of the project.

4.11 Continued maintenance and water committee support until end of service

From the completion date of the project, continual support for the maintenance of the system as well as for the water committee is vital to the sustainability of the project. This does not mean the volunteer doing the maintenance work, or running the committee meetings. It means to show your presence and concern during all project activities until the end of your service.

During the first six months after a project is complete, maintenance issues will arise. The job of the volunteer is not to go and fix these problems, though the community may think so. The volunteer is present for all maintenance issues, helps to explain what happened and guides the plumbers to a final resolution. Usually, the fix is to replace a pipe, which is obvious when a geyser of water is found exploding from the ground.

Water committee support is also important. It is important to be an observer and only offer occasional guidance when needed. The community needs to feel like they have complete control over the project. If total control is not felt, the committee will fall apart on the volunteer's exit from the community.   This is a proven fact, which is evident in neighboring community's water committees, who at first sight of problems, immediately sends someone to complain at the church and ask for assistance. That is not sustainability. The subject of sustainability is taken for granted too much in development projects all the time.

4.12 Final report to Peace Corps/Dominican Republic

Upon completion of Peace Corps service, the APCD (Assistant Peace Corps Director) asks that all water/sanitation volunteers submit a short report on the project or projects that were completed during the two-years of service. These reports are used for the only official description of Peace Corps service which gets filed at Peace Corps Headquarters in Washington D.C.   The report is also copied and made available to future volunteers working in the Dominican Republic for their future projects. This is the most useful aspect of the reports. Personally, I had the opportunity to review two reports from the last ten years when I began my project, and they both offered different methods of construction and different technologies, as my report will do the same.

5.0 Recommendations for future work

This chapter offers recommendations for future work, based on the entire experience with the gravity-fed water system discussed in this report.

I recommend that more time be spent strengthening the water committee. During the start of the project, the entire committee naturally is excited to be involved. It is important to attend all meetings in the beginning stages. In this project, I missed various meetings for different reasons. Sometimes the water committee would not meet because I was not in attendance. During the construction of the project this did not have a great impact on the work. Lack of strength in a water committee shows up in the post-construction phase when water is available. Interest to participate goes down, and the committee eventually stops meeting. My mistake for this project was not forcing the communities to meet on a regular basis. Their biggest complaint was that it was too far to walk to the other community. During important moments, we had to hold two committee meetings, one in each community.

I would also have handled training of plumbers differently. I trained interested men on the job. A few of these men, although intelligent, were not well-respected members of the community, and the committee initially did not want to entrust responsibility to the men. I recommend that interested men are elected to be the plumbers for the water system during community meetings so the entire community is happy.

I also recommend that talks about clean water, health issues, and reasons why we need the water system being held more often during the construction and not put off until after project is finished. Audiences will tend to be more attentive before the project is finished, out of excitement alone. Additionally, by starting earlier, more time is available to repeat the talks.

The remainder of the recommendations covers design and construction.

The decision on the break-pressure tank placement was to construct only one at the elevation midpoint of the system. In retrospect, it would have been better protection, to install a second break-pressure tank, dividing the elevation changes by three, instead of two. One of the private water spigots exploded due to high water pressure on the main line. This water spigot along with one other, were located before the storage tank, directly on the main line. These two spigots had a gate valve to regulate flow to them, reducing the pressure from the main line. I repeatedly explained to the families that the gate valve could not be played with.   It was protected by a cover, but without a lock. I explained that adjusting the gate valve would increase the flow and pressure above the maximum tolerance of the water spigots they had, with the possibility to rupture any of the pipe connections. Within the first month, someone opened the gate valve full blast and twelve hours later, the concrete cracked on the tapstand, a connection cracked, and water shot forty feet in the air. Another reason for the connection failure was that I accidentally ignored the static pressure on the valve and spigots that were extremely high.

Currently, a Peace Corps Volunteer friend is correcting this problem by constructing an additional break-pressure tank to lower the pressure to about forty meters of head.

Another mistake was using PVC drainage connections in some areas, instead of pressure connections. The system is designed with all pressure fittings. Due to lack of availability of pressure connections, drainage constructions were used instead, attempting to compensate for the weaker fittings by using extra amounts of PVC cement and burying the connection with caution. Certain pressure fittings were only available in the capital. Purchased pressure fittings were used until supply ran out. The quantity necessary was underestimated, therefore having to use drainage fittings. Two months after the system was in operation there was only one problem with any of the drainage connections. This connection was replaced with a pressure fitting and has had no further problems. Drainage connections are typically the first to fail.

While building the water storage tank, allowance for height of the upper bond beam and roof were not accounted for. Therefore, the overflow pipes were installed in the last level of block, before the bond beam was prepared. After the roof and bond beam were finished, it was obvious that we lost a good amount of volume of the tank above the overflow pipes, which were useless. Figure 5.1 shows overflow pipes and the space lost above them. Approximately 1,000 gallons were wasted. Since the supply already appeared to be much higher then the demand, nothing more was done to address this problem.

Figure 5.1 Water storage tank overflow – Unutilized volume above overflow.

Another change I recommend is to have been present to supervise the tank floor construction. As discussed in the previous chapter, the floor was cast without any gravel in the mixture. A significant amount of sand and cement were wasted in the process as well as no presence of large aggregate for the cement paste and sand to bond to. The potential hazard is the possibility of the floor cracking or shrinking and leaking through the openings formed between the floor and walls. I also recommend looking at ways to tie the floor and the walls together to help prevent any additional problems.

Finally, during this construction project, I was also working on a second project. That project was much larger and involved three times as many homes. I regret that I decided to help with both projects at the same time. It would have been better to manage one project, and on its completion, start the next project. There was some confusion where I was to be working, what budget I was planning, and if I was keeping track of the expenses for each project correctly. If done over again, I would have finished the project discussed in this report first, and moved to the next project thereafter.

6.0 Summary and Conclusion

The organization and construction of this gravity-fed water system in the Dominican Republic was a learning experience for me, as well as the two communities who constructed it. The rules and regulations of traditional education on management and construction had to be set aside in many cases and methods agreeable to the Dominican culture and Dominican way of building had to be learned. In the same respect, the Dominicans adjusted to some of my teachings and deserted some traditional practices. Together, we built a gravity-fed water system, which consisted of over 950 pipes, 600 concrete blocks, 140 bags of cement, and 4.8 Kilometers (3 miles) of trenches dug into compact, rocky soil. This system benefits seventy-five families who previously had no access to clean water.

This project educated over thirty women in proper practices of water preparation for infants and small children. In addition, the project educated the communities on proper hand washing techniques and the importance of washing after using the latrine and before and after eating.

Five men from the community were trained in operation and maintenance of the water system. Three of these men, the plumbers, were extensively trained to repair any part of the water system.

A water committee was organized and left in charge of collecting quotas and leading any repair efforts necessary. The water committee was trained to act as the authority on any problems, mechanical or social, having to do with the water system or with proper use of the water system.

Based on my Peace Corps experience, it was observed that this project was only made possible through outside financial and technical assistance. It is important to conduct these projects with equal responsibility from the donor institution as well as the benefiting community. Without shared responsibility, the sustainability of the project is questionable. In this project, the equal participation of the Catholic Church (donor), myself (technical and organizational assistance), and the community (organization and labor), resulted in a working gravity fed water system that delivers clean water, and an improved quality of life, to 75 families.

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Appendices

Appendix A – Example Water Committee Constitution

Appendix B – Home Health Survey Results – Sample Size of 30 Families

Appendix C – Final Survey Tables and Graphs

Appendix D – Water Supply and Demand Methods - Frictional Headloss Table used for Pipe Design

Appendix E – Original and Final System Designs

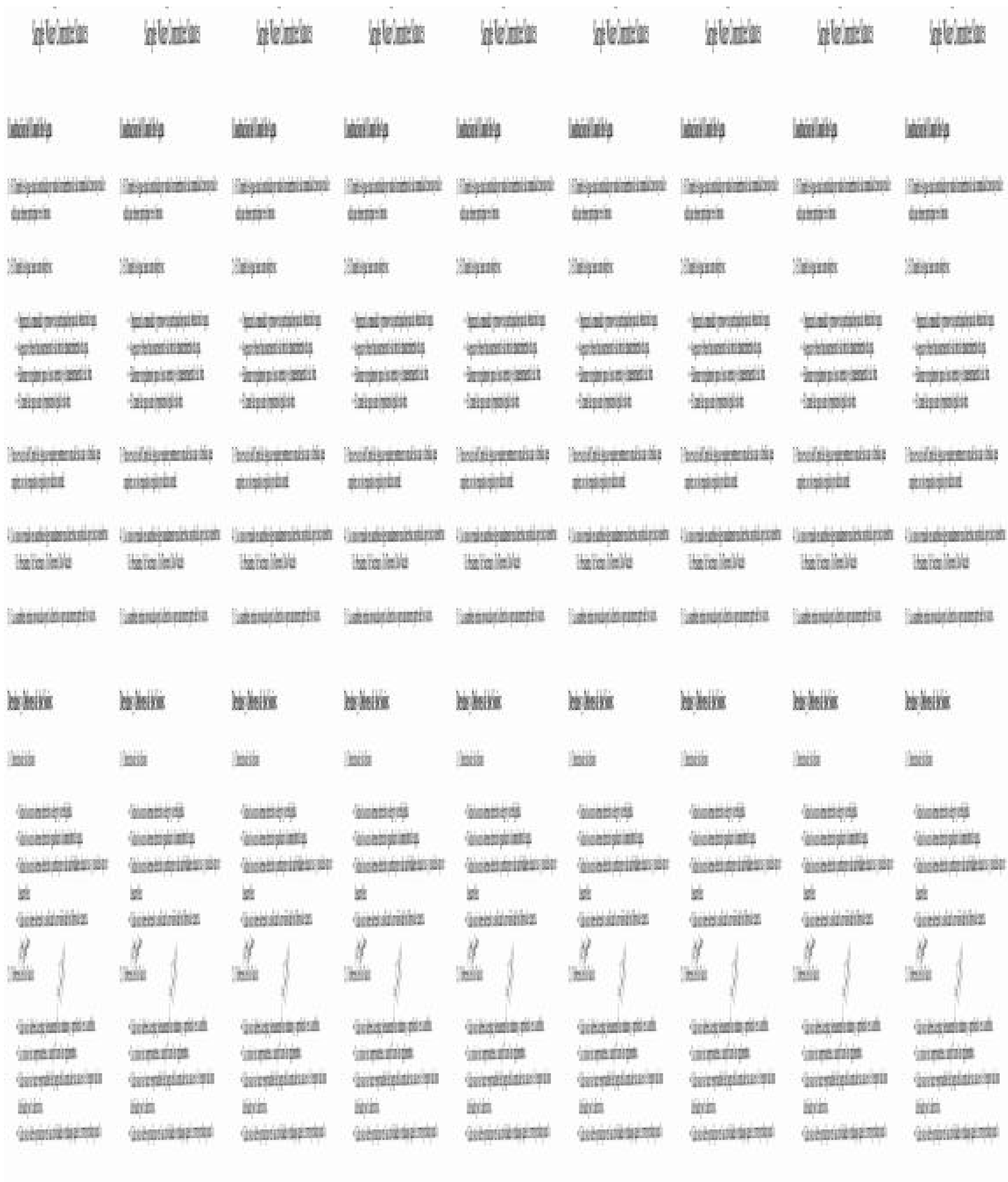
Appendix F – Original Project Budget and Final Cost

Appendix G – INAPA Permission Letter

Appendix H – Description of Second Water System

Appendix A

Example Water Committee Constitution



realización y el mantenimiento de la obra.

- Los socios tendrán que afrontar los problemas que se presenten en la obra en construcción o ya en funcionamiento.

Objetivos de la Directiva

- Asegurar el buen funcionamiento de la obra y el suministro igualitaria del agua a todos los socios.
- Cumplir y hacer cumplir los estatutos y el reglamento.
- Elaborar los planes de trabajo para la construcción y el mantenimiento de la obra.
- Cobrar una cuota para el mantenimiento de la obra y recabar fondos extraordinarios cuando sea necesario.
- Llevar la contabilidad y administrar los fondos.
- Planificar y coordinar los trabajos de reparación y mantenimiento de la obra.

Funciones de los Miembros de la Directiva

1) Funciones del Presidente

- Organizar, coordinar y animar las actividades del Comité.
- Conducir las asambleas del Comité de Agua, dando participación a todos.
- Representar el Comité de Agua frente a otras instituciones o en las negociaciones.
- Supervisar el manejo de los fondos.
- Tomar decisiones de manera democrática.

2) Funciones del Secretario asistentes

- Llevar las actas de las reuniones y asambleas.
- Recoger las cuotas de cada casa en el tiempo establecido por la directiva y anotarlas en el cuaderno.
- Entregar al tesorero el dinero recaudado en la fecha establecida.
- Sustituir al Presidente interinamente.

3) Funciones del Tesorero

- Recibir el dinero de mano del Secretario.
- Llevar la contabilidad.
- Cubrir los gastos autorizados por la directiva.
- Entregar un informe de su contabilidad de manera regular.

4) Funciones de los vocales

- Informar a los socios de las actividades del comité.
- Ayudar al secretario y sustituir los otros directivos interinamente.

Appendix B

Home Health Survey Results

Table 4.1: Home Health Survey and Results from 2 Communities,

Sample Size of 30 Families

Home Health Study	
1. Where do you get water from for your home?	
Faucet	29%
River	71%
2. How far is any type of water supply from your home?	
Less then 1 Km	100%
3. How many hours are dedicated to finding water each week?	
Less then 5 hours	5%
5-10 hours	23%
10-15 hours	54%
More then 15 hours	15%
4. What do you use to carry your water in?	
Oil Cans (4 gallons)	8%
Gallon Jugs	31%
5 Gallon Buckets	61%
5. Who gets the water in your family?	
Children	31%
Wife	23%
Wife and Children	46%
6. Have you had any accidents while retrieving water?	
Yes	0%
No	100%
7. What do you store your water in?	
Same as question 4	100%
8. What do you do to the water before drinking?	
Nothing	54%
Boil	8%
Bleach	38%
9. When do you wash your hands?	
Never	31%
When Necessary	23%
Before eating	8%
Always	38%
10. Do you have a concrete floor?	
Concrete	15%
Dirt	85%
11. Do you have a latrine?	
Yes	23%
No	77%

Table 4.2: Cases of Diarrhea in last few months (January 2002)

Age	yes	no
0-5 years	51%	49%
6-10 years	25%	75%

Appendix C

Final Survey Tables and Graphs

Survey Data for the Aqueduct of Los Arroyos and Los Botados

Stake #	Distance (m)	Total Dist. (m)	Angle ?	Sine ?	Vert. Distance (m)	Elevation (m)	Observations
Fuente		0				1000	Overflow of existing system
	5.7		0	0.000	0.00		
1		5.7				1000.0	
	50		-10.5	-0.182	-9.11		
2		55.7				990.9	
	40		-14	-0.242	-9.68		
3		95.7				981.2	
	42		-20	-0.342	-14.36		
4		137.7				966.8	
	41		-14.5	-0.250	-10.27		
5		178.7				956.6	
	23		-10.5	-0.182	-4.19		
6		201.7				952.4	
	33		-14	-0.242	-7.98		
7		234.7				944.4	
	25		-19	-0.326	-8.14		
8		259.7				936.3	
	8		-10	-0.174	-1.39		
9		267.7				934.9	
	15		-20	-0.342	-5.13		
10		282.7				929.7	
	18		-13	-0.225	-4.05		
11		300.7				925.7	
	24		-13	-0.225	-5.40		
12		324.7				920.3	
	16		-14	-0.242	-3.87		
13		340.7				916.4	
	25		-8	-0.139	-3.48		
14		365.7				913.0	
	41		-11	-0.191	-7.82		
15		406.7				905.1	
	20		-9	-0.156	-3.13		
16		426.7				902.0	Crossing Foot Path
	17		-20	-0.342	-5.81		
17		443.7				896.2	
	23		-15	-0.259	-5.95		
18		466.7				890.2	Open Field
	47		-11	-0.191	-8.97		
19		513.7				881.3	Cerca de Mata de Mango
	35		-15	-0.259	-9.06		
20		548.7				872.2	Good place for a break tank

Survey Data for the Aqueduct of Los Arroyos and Los Botados

Stake #	Distance (m)	Total Dist. (m)	Angle ?	Sine ?	Vert. Distance (m)	Elevation (m)	Observations
20		548.7				872.2	Good place for a break tank
	42		-11	-0.191	-8.01		cross path
21		590.7				864.2	
	42		-10	-0.174	-7.29		
22		632.7				856.9	
	40		-9	-0.156	-6.26		
23		672.7				850.6	
	36		-7.5	-0.131	-4.70		
24		708.7				845.9	
	30		-11	-0.191	-5.72		cross path
25		738.7				840.2	
	20		-4	-0.070	-1.40		
26		758.7				838.8	
	18		-6	-0.105	-1.88		
27		776.7				836.9	
	20		-10	-0.174	-3.47		
28		796.7				833.5	
	23		-14.5	-0.250	-5.76		
29		819.7				827.7	
	27		-17	-0.292	-7.89		
30		846.7				819.8	
	26		-11.5	-0.199	-5.18		
31		872.7				814.6	
	24		-10	-0.174	-4.17		
32		896.7				810.5	cross path
	35		-8	-0.139	-4.87		
33		931.7				805.6	
	97		-10	-0.174	-16.84		OPEN FIELDS
34		1028.7				788.7	
	100		-11	-0.191	-19.08		
35		1128.7				769.7	
	10		1	0.017	0.17		
36		1138.7				769.8	
	52		-4.5	-0.078	-4.08		
37		1190.7				765.8	
	57		-6	-0.105	-5.96		
38		1247.7				759.8	
	37		-5.5	-0.096	-3.55		
39		1284.7				756.3	
	28		-6	-0.105	-2.93		
40		1312.7				753.3	Arrive at first hous

Survey Data for the Aqueduct of Los Arroyos and Los Botados

-End of Los Arroyos main line - followed by main line to Los Botados

Stake #	Distance (m)	Total Dist. (m)	Angle ?	Sine ?	Vert. Distance (m)	Elevation (m)	Observations
40		1312.7				753.3	Arrive at first hous
	25		-7	-0.122	-3.05		
41		1337.7				750.3	
	36		-4	-0.070	-2.51		
42		1373.7				747.8	
	45		-2	-0.035	-1.57		cross path
43		1418.7				746.2	
	31		5	0.087	2.70		First Incline
44		1449.7				748.9	
	24		-1.5	-0.026	-0.63		Pass 2nd house
45		1473.7				748.3	
	35		-9	-0.156	-5.48		
46		1508.7				742.8	
	72		0	0.000	0.00		
47T		**1580.7**				742.8	Tank Placement
	34		-12.5	-0.216	-7.36		
48		34				735.4	Beginning of trench for main
	45		-16.5	-0.284	-12.78		line to Los Botados and partial
49		79				722.7	supply to some homes in
	47		-3	-0.052	-2.46		Los Arroyos
50		126	0			720.2	
	52		-11	-0.191	-9.92		
51		178				710.3	
	19		-1.5	-0.026	-0.50		
52		197	0			709.8	cross path
	28		1	0.017	0.49		
53		225				710.3	
	27		1	0.017	0.47		OPEN FIELDS
54		252				710.7	
	35		0	0.000	0.00		River Crossing (2GALV)
55		287				710.7	
	24		2	0.035	0.84		Field of Guandules
56		311				711.6	
	23		0	0.000	0.00		
57		334				711.6	
	77		-3	-0.052	-4.03		
58		411				707.5	
	56		-2.5	-0.044	-2.44		
59		467				705.1	Last Stake in Los Arroyos
	45		-8	-0.139	-6.26		
60		512				698.8	RC?

Survey Data for the Aqueduct of Los Arroyos and Los Botados
- main line to Los Botados

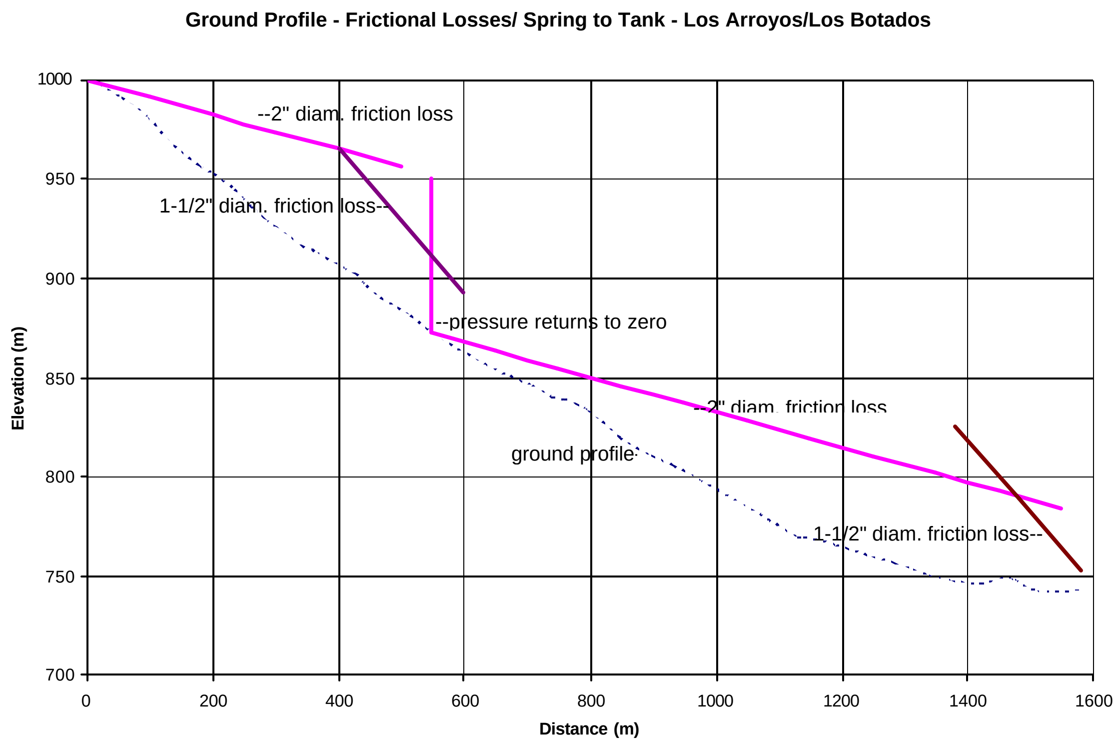
Stake #	Distance (m)	Total Dist. (m)	Angle ?	Sine ?	Vert. Distance (m)	Elevation (m)	Observations
60		512				698.8	
	28		-7.5	-0.131	-3.65		
61		540				695.2	
	17		-4	-0.070	-1.19		
62		557				694.0	
	22		-3	-0.052	-1.15		
63		579				692.9	
	26		-3.5	-0.061	-1.59		
64		605				691.3	
	30		-3.5	-0.061	-1.83		
65		635				689.4	
	28		-3.5	-0.061	-1.71		
66		663				687.7	
	20		-3.5	-0.061	-1.22		
67		**683**				686.5	
	32		-3	-0.052	-1.67		
68		715				684.8	
	19		-2	-0.035	-0.66		
69		734				684.2	
	20		-4.5	-0.078	-1.57		
70		754				682.6	
	20		-4.5	-0.078	-1.57		
71		774				681.0	
	16		-6.5	-0.113	-1.81		
72		790				679.2	
	16		0	0.000	0.00		
73		806				679.2	
	25		-2	-0.035	-0.87		
74		831				678.3	
	65		-4	-0.070	-4.53		
75		896				673.8	
	19		-4	-0.070	-1.33		
76		915				672.5	
	21		-2.5	-0.044	-0.92		
77		936				671.6	
	24		0	0.000	0.00		
78		960				671.6	
	28		1	0.017	0.49		
79		988				672.1	
	56	0	-2.5	-0.044	-2.44		
80		1044				669.6	

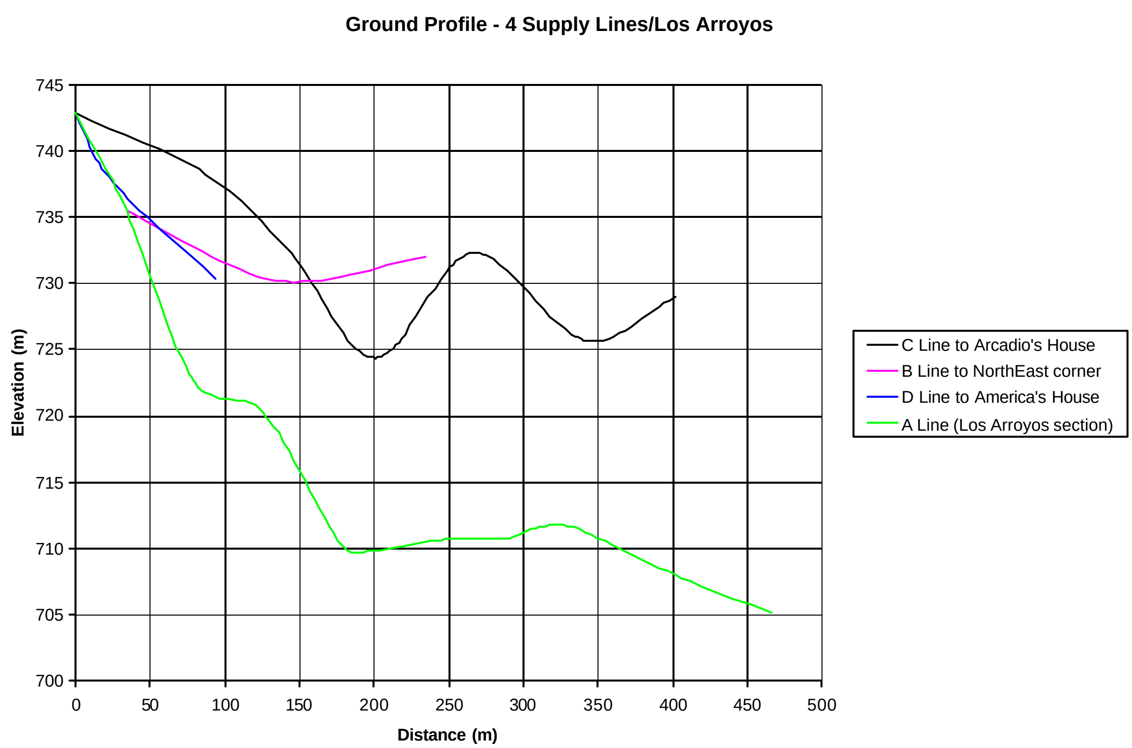
Survey Data for the Aqueduct of Los Arroyos and Los Botados
- One end of main line through Los Botados

Stake #	Distance (m)	Total Dist. (m)	Angle ?	Sine ?	Vert. Distance (m)	Elevation (m)	Observations
80		1044				669.6	
	23		-2.5	-0.044	-1.00		
81		1067				668.6	
	23		-4	-0.070	-1.60		
82		1090				667.0	
	30		-3	-0.052	-1.57		
83		1120				665.4	
	30		-3	-0.052	-1.57		
84		1150				663.9	Connect to Existing Pipes
	100		-2	-0.035	-3.49		continue in East Direction
85		1250				660.4	Old creek crossing
	46		0	0.000	0.00		1" Galv. Pipe
86		1296				660.4	
	100		1	0.017	1.75		
87		**1396**				662.1	
	64		2	0.035	2.23		
88		1460				664.4	
	23		0	0.000	0.00		
89		1483				664.4	
	82		-1	-0.017	-1.43		
90		1565				662.9	
	66		1	0.017	1.15		
91		1631				664.1	
	36		1	0.017	0.63		Leads to end of East Side
92		1667				664.7	Connects with existing
	43		2	0.035	1.50		at end (beed tubes to
93		1710				666.2	cross street) (galv.)
	38		2	0.035	1.33		
94		1748				667.5	
							West Direction
							(already have tubes)
							Just need to cap existing
							line
							Need 2" Caps….

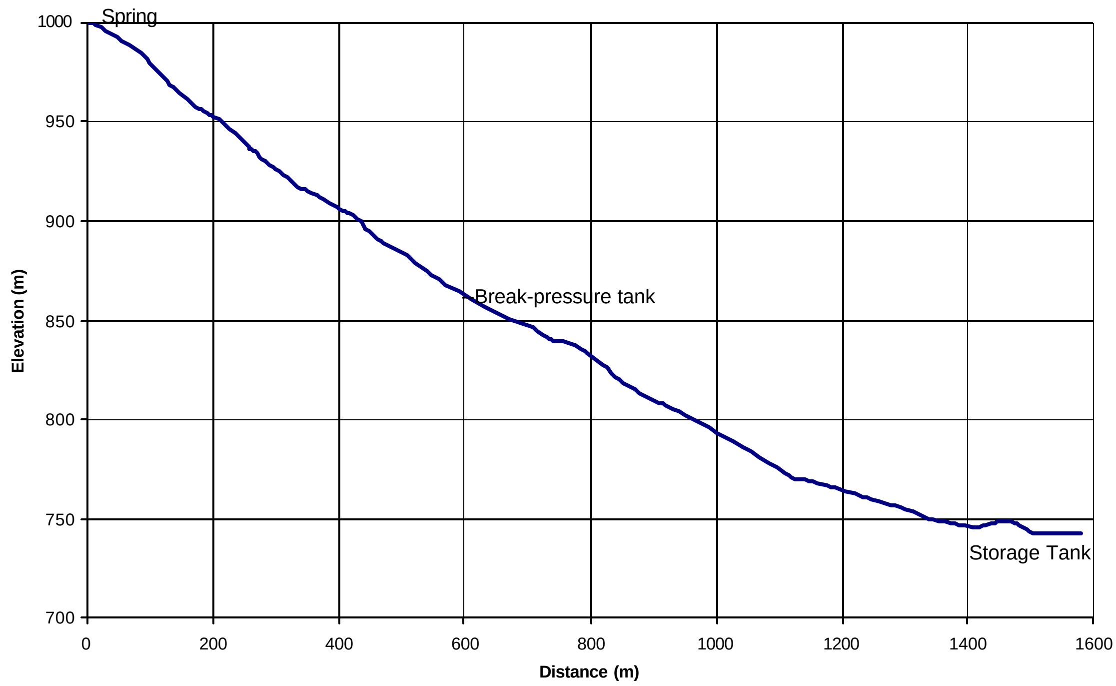
Survey Data for the Aqueduct of Los Arroyos and Los Botados
- three branch lines in Los Arroyos

Stake #	Distance (m)	Total Dist. (m)	Angle ?	Sine ?	Vert. Distance (m)	Elevation (m)	Observations
47T		0				742.8	
	87		-3	-0.052	-4.55		Line C to Arcadio's House
A		87				738.2	(I was worried about elevation
	57		-6	-0.105	-5.96		changes
B		144				732.3	
	57		-8	-0.139	-7.93		
C		201				724.4	
	65		7	0.122	7.92		
D		266				732.3	
	75		-5	-0.087	-6.54		
E		341				725.7	
	61		3	0.052	3.19		
F		**402**				728.9	
48		0				735.4	Line that branches off in
	100		-3	-0.052	-5.23		Los Botados trench to go to
G		100				730.2	one house in NorthEast
	100		1	0.017	1.75		corner
H		**200**				732.0	Line B
47T		0				742.8	Line D Branch that ends
	25		-12	-0.208	-5.20		at America's house.
I		25				737.6	
	69		-6	-0.105	-7.21		
J		**94**				730.4	


Ground Profile - Frictional Losses/ Spring to Tank - Los Arroyos/Los Botados
--2" diam. friction loss
1-1/2" diam. friction loss--
--pressure returns to zero
--2" diam. friction loss
ground profile
1-1/2" diam. friction loss--
Elevation (m)
Distance (m)
1000
950
900
850
800
750
700
0
200
400
600
800
1000
1200
1400
1600


Ground Profile - 4 Supply Lines/Los Arroyos
Elevation (m)
Distance (m)
745
740
735
730
725
720
715
710
705
700
0
50
100
150
200
250
300
350
400
450
500
C Line to Arcadio's House
B Line to NorthEast corner
D Line to America's House
A Line (Los Arroyos section)

Ground Profile - From Spring to Tank



Appendix D

Water Supply and Demand Methods

Frictional Headloss Table used for Pipe Design

Step 1. Determine design population figure ______________________

____

Step 2. Determine average daily use ______________________

____

Step 3. Determine average daily flow ______________________

____

Step 4. Determine storage size ______________________

____

Step 5. Determine peak demand ______________________

____

Step 6. Determine number of required taps ______________________

____

Step 7. Determine storage placement ______________________

____

Step 8. Determine pipe size for all reaches along the pipeline

____

Step 9. Determine exact head losses and residual head at points B, C, D and E. ______________________

____

Step 10. Plot HGL.

RIGID PVC FRICTIONAL HEADLOSS FACTORS

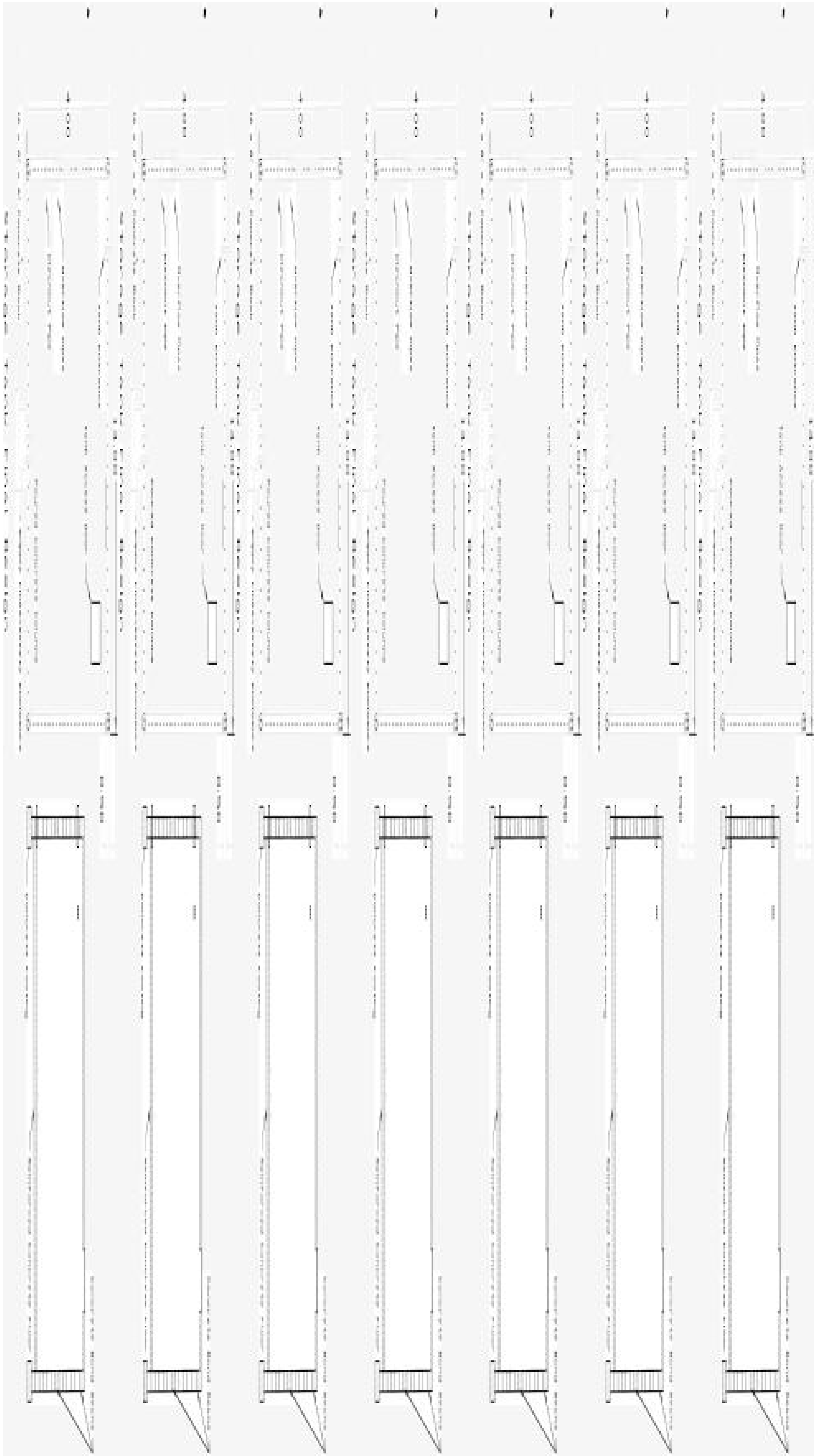
These are the approximate headloss factors, in m/100m (%), for new rigid PVC pipe. Flows are in liters/second.

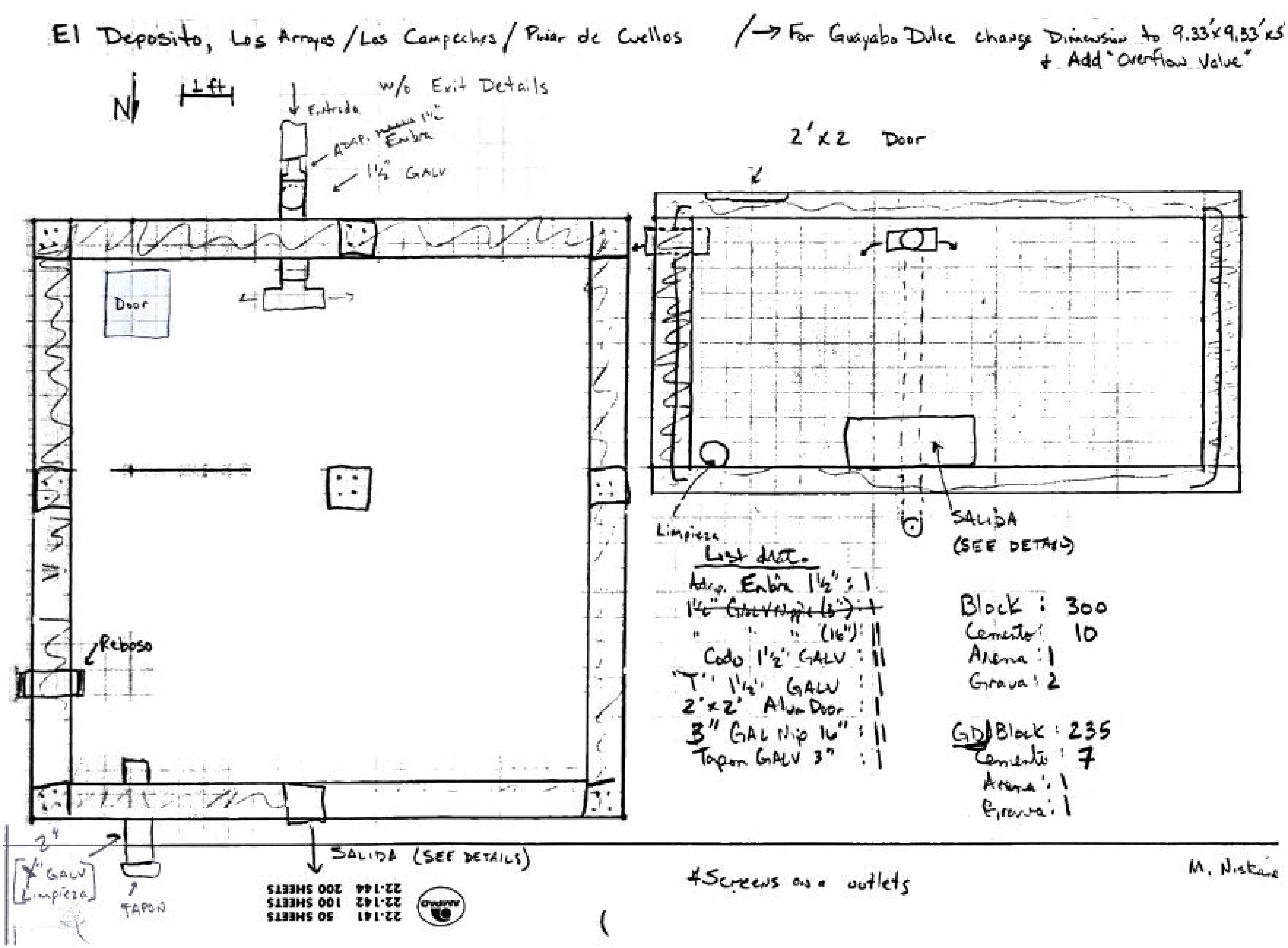
FLOW	1/2"	3/4"	1	1¼"	1½"	2"	2½"	3"	4"
0.1	4.2	1.0	0.25	0.08					
0.15	8.8	2.2	0.53	0.17	0.07				
0.2	15.0	3.7	0.9	0.28	0.12				
0.25	22.0	5.5	1.35	0.44	0.18				
0.3	31.0	7.8	1.9	0.6	0.25				
0.35	41.0	10.0	2.45	0.8	0.34				
0.4	53.0	13.0	3.1	1.0	0.43				
0.45	66.0	16.3	4.0	1.25	0.54	0.13			
0.5		19.0	4.8	1.5	0.65	0.16			
0.55		23.5	5.6	1.8	0.78	0.19			
0.6		27.5	6.6	2.1	0.9	0.22			
0.65		32.0	7.8	2.4	1.04	0.25			
0.7		36.0	8.7	2.7	1.19	0.28			
0.75		41.0	9.9	3.1	1.32	0.33	0.1		
0.8		45.0	11.0	3.5	1.5	0.37	0.12		
0.85		52.0	12.5	4.0	1.7	0.41	0.14		
0.9		57.0	14.0	4.5	1.9	0.45	0.15		
0.95		63.0	15.0	4.9	2.1	0.5	0.17		
1.0			16.5	5.4	2.25	0.55	0.18	0.08	
1.05			18.0	5.8	2.5	0.6	0.20	0.09	
1.1			19.5	6.3	2.7	0.67	0.22	0.1	
1.15			21.5	6.9	2.95	0.72	0.24	0.11	
1.2			23.0	7.3	3.2	0.78	0.26	0.12	
1.3			26.5	8.6	3.75	0.9	0.29	0.13	
1.4			30.0	10.0	4.25	1.0	0.34	0.15	
1.5			35.0	11.2	4.9	1.15	0.39	0.17	
1.6			39.0	12.5	5.5	1.3	0.43	0.19	
1.7			44.0	14.2	6.05	1.45	0.49	0.21	
1.8			49.0	15.9	6.9	1.6	0.54	0.24	
1.9			55.0	17.4	7.5	1.8	0.6	0.26	
2.0			60.0	19.0	8.0	2.0	0.66	0.28	
2.2				22.5	9.7	2.35	0.79	0.34	
2.4				26.8	11.5	2.75	0.9	0.4	
2.6				31.0	13.3	3.2	1.05	0.45	
2.8				35.1	15.2	3.7	1.2	0.52	
3.0				40.0	17.0	4.2	1.36	0.6	
3.2				45.0	19.3	4.7	1.52	0.68	
3.4				50.0	21.9	5.25	1.7	0.75	
3.6				56.0	24.0	5.8	1.9	0.84	0.2
3.8				62.0	26.0	6.3	2.1	0.9	0.22
4.0				69.0	29.0	7.0	2.3	1.0	0.24
4.5					36.0	8.8	2.8	1.2	0.3
5.0					44.0	10.5	3.5	1.5	0.37
5.5					62.0	12.5	4.2	1.75	0.44
6.0						14.7	4.9	2.1	0.52
6.5						17.0	5.6	2.4	0.6
7.0						19.5	6.5	2.8	0.7

Appendix E

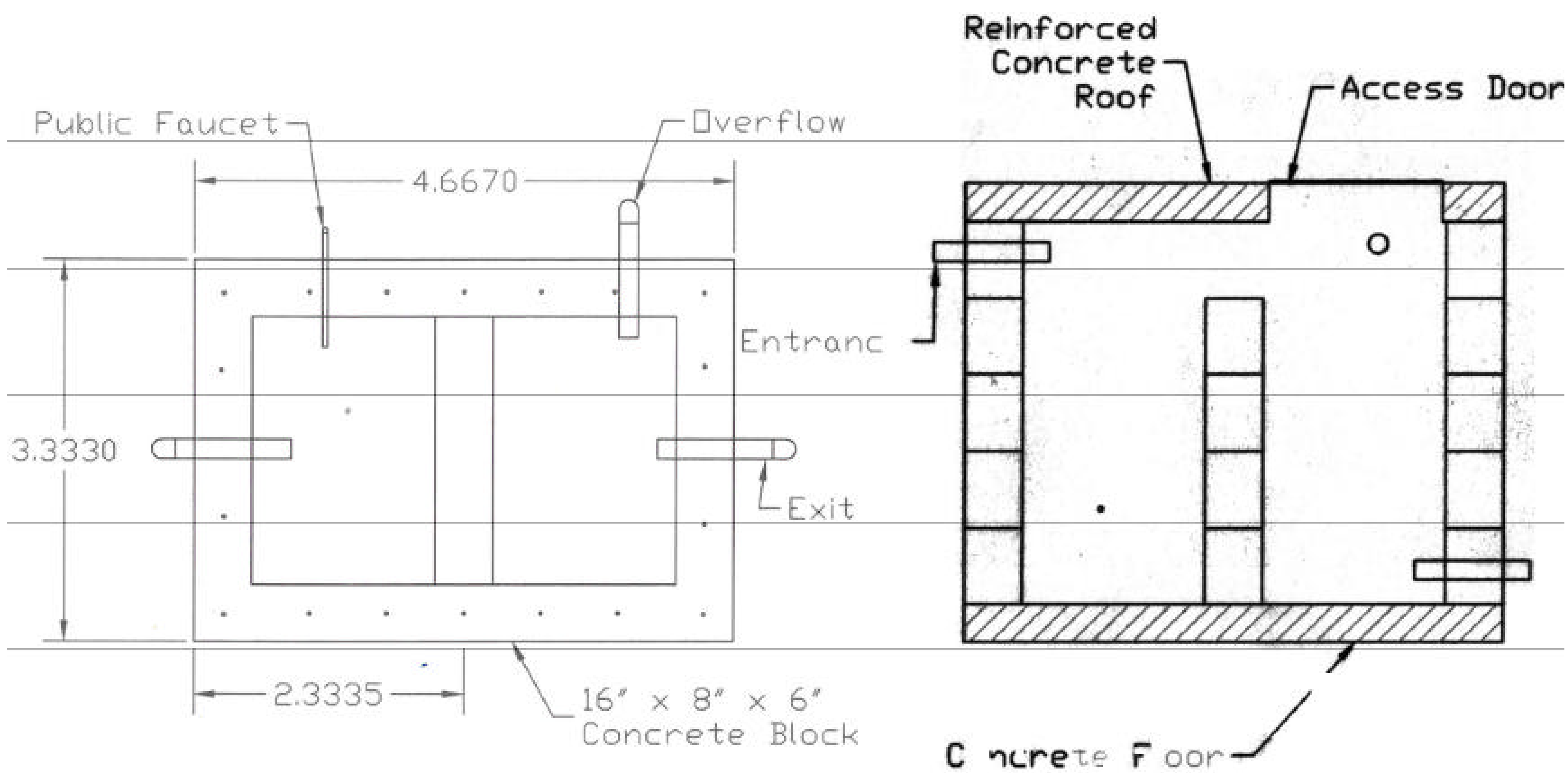
Original and Final Designs of:

Water Storage Tank
Break-Pressure Tank
Spring Box
Tapstand Design

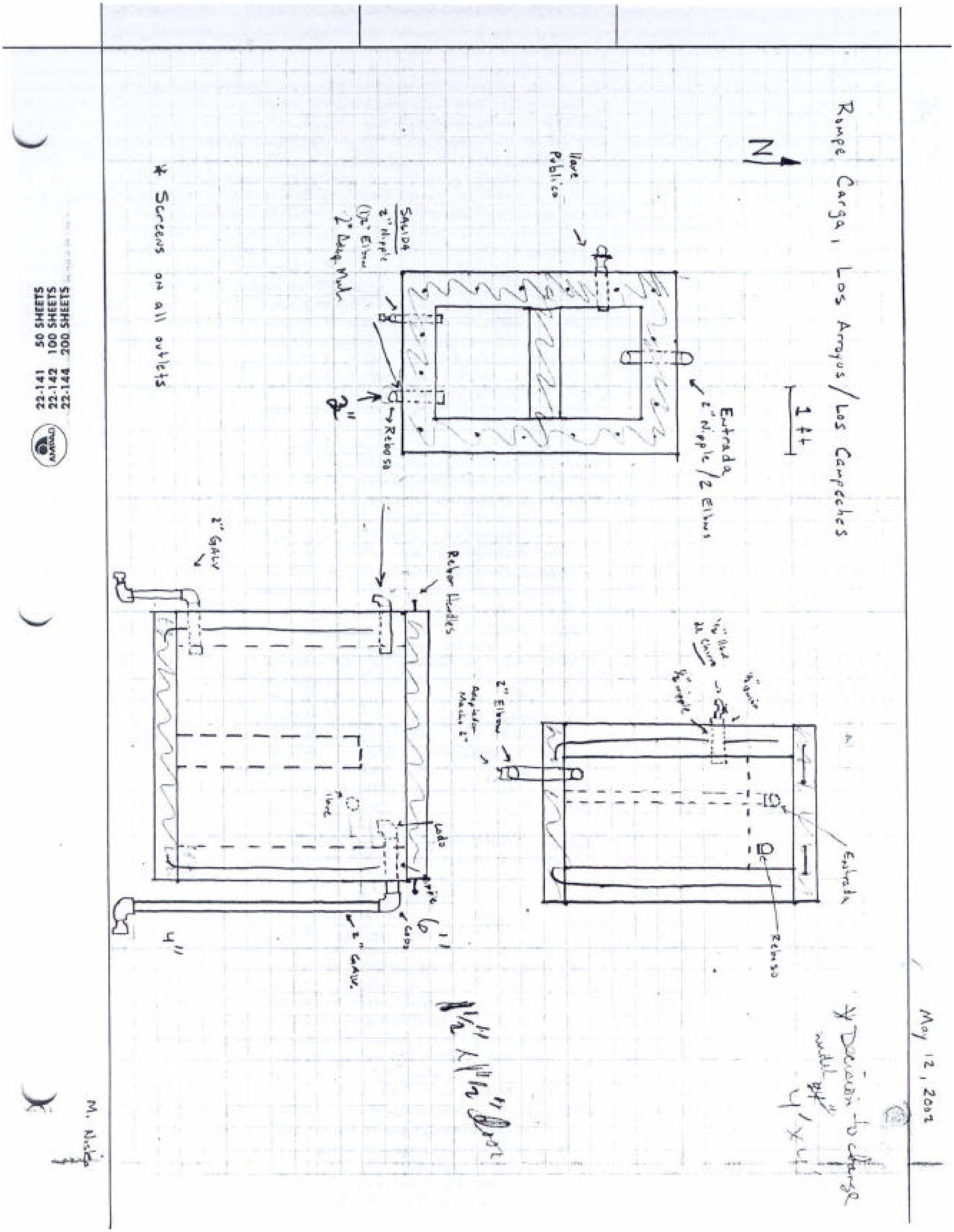


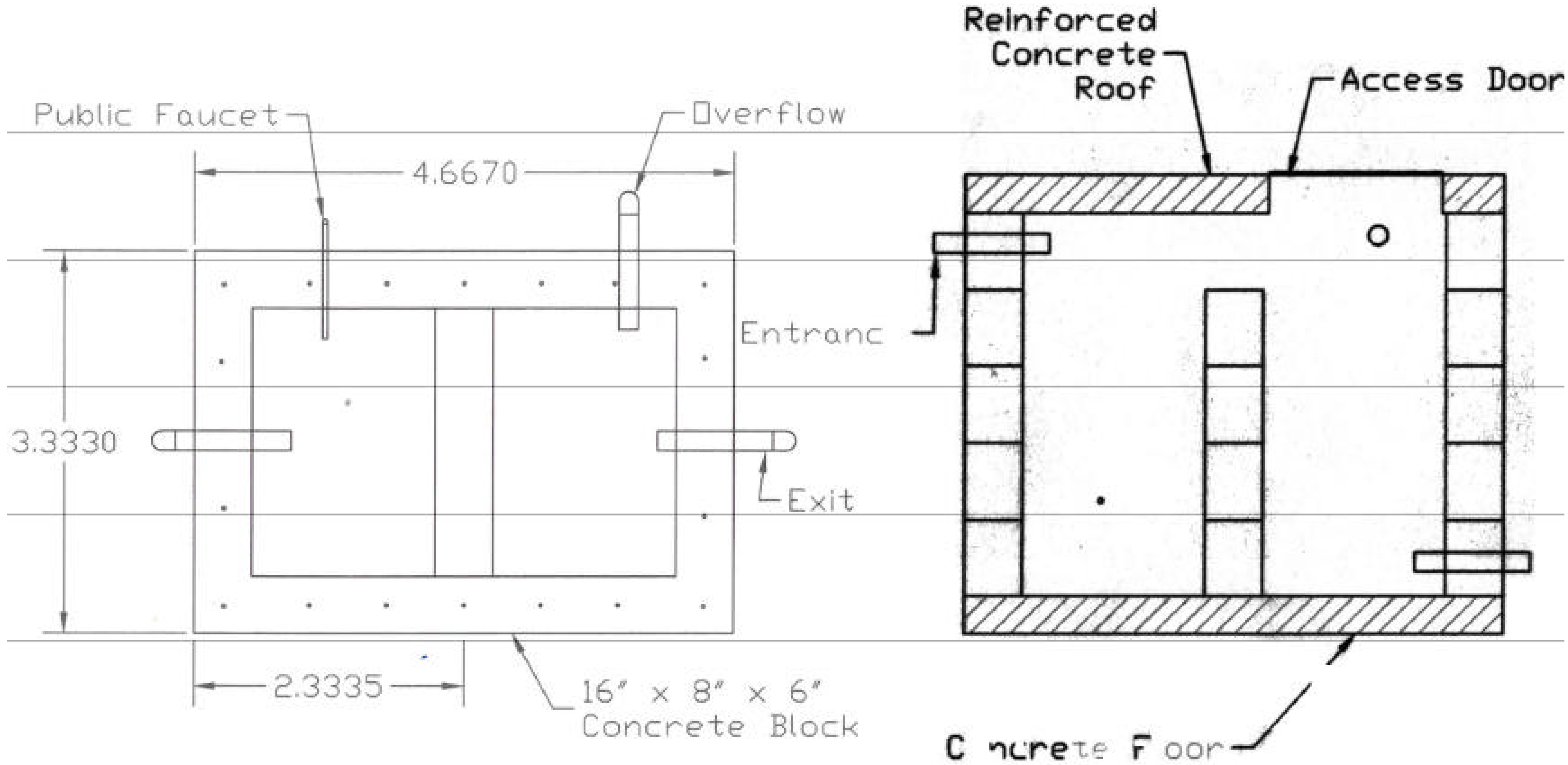


El Deposito, Los Arroyos / Los Campeches / Pinar de Cuellos
/→ For Guayabo Dulce change Dimension to 9.33'x9.33'x5'
+ Add "Overflow Valve"
N
1 ft
w/o Exit Details
Entrada
ADAP. Embra 1½"
1½" GALV
2' x 2 Door
Door
Reboso
Limpieza
SALIDA
(SEE DETAILS)
List date.
Adap. Embra 1½" : 1
1½" Galv Nipple (3") : 1
" " " (16"): ||
Codo 1½" GALV : ||
"T" 1½" GALV : 1
2'x2' Alum Door : 1
3" GAL Nip 16" : ||
Tapon GALV 3" : 1
Block : 300
Cemento : 10
Arena : 1
Grava : 2
GD Block : 235
Cemento : 7
Arena : 1
Grava : 1
2"
1" GALV
Limpieza
TAPON
SALIDA (SEE DETAILS)
22-141 50 SHEETS
22-142 100 SHEETS
22-144 200 SHEETS
Screens on outlets
M. Nistane

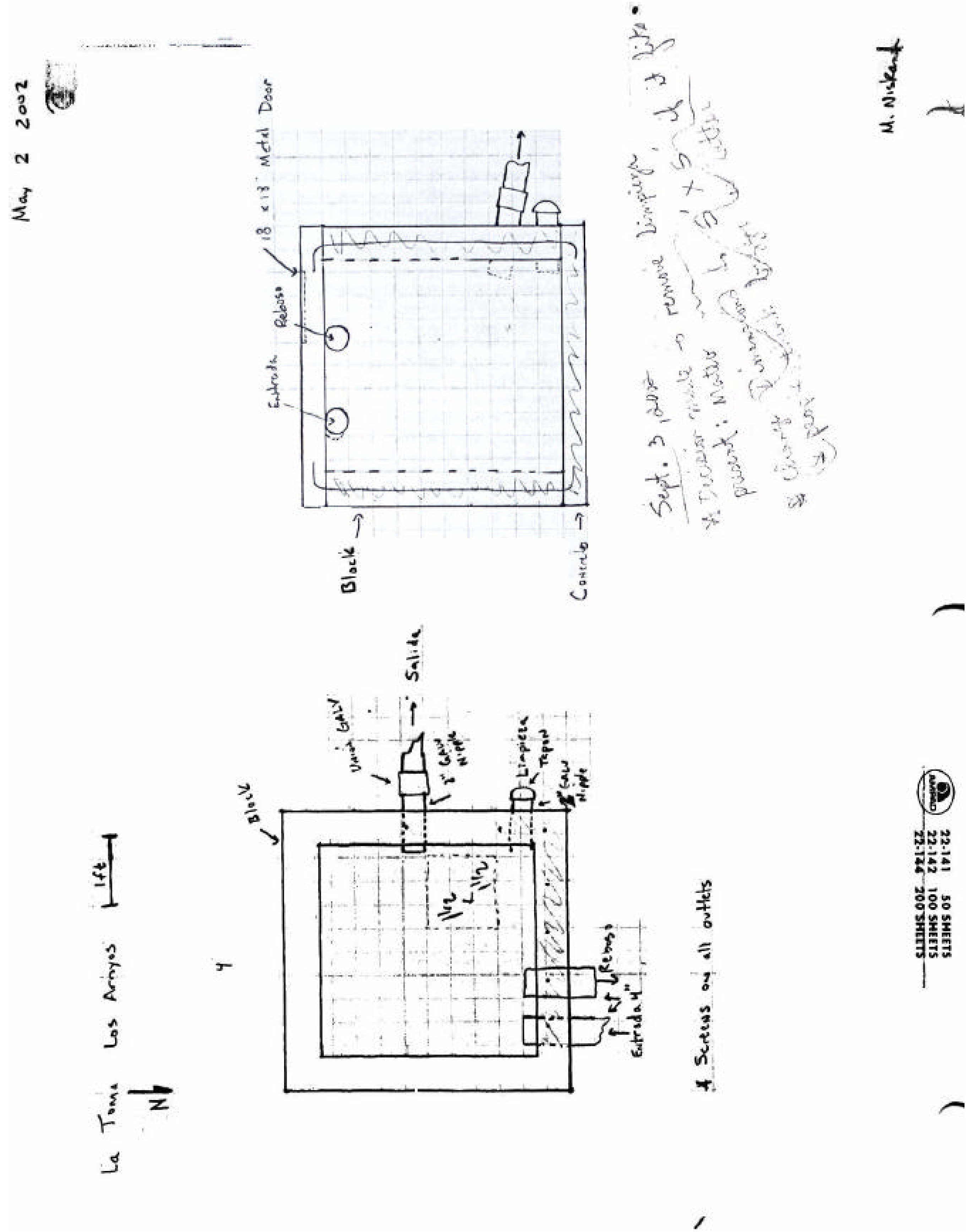


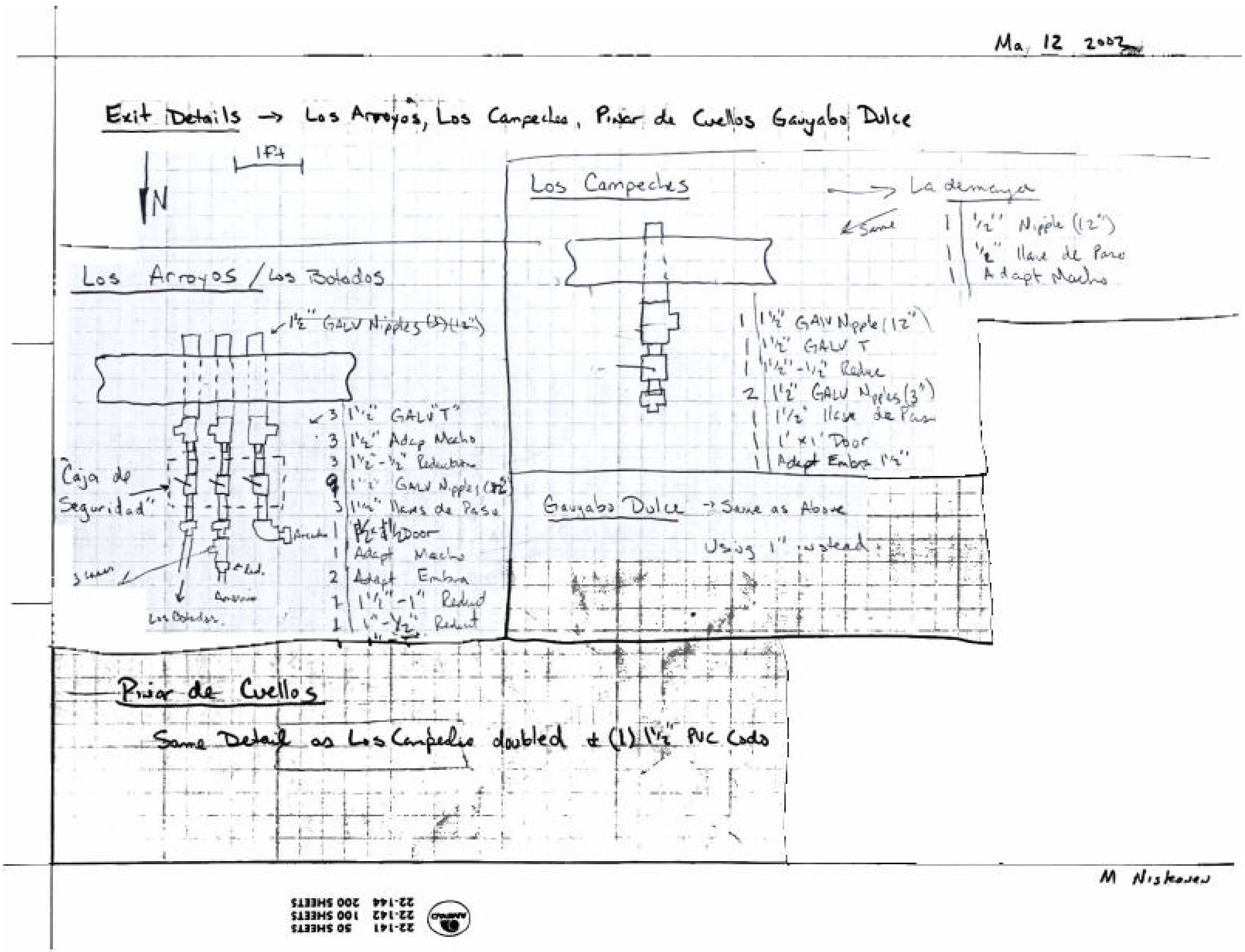
B eak Pressure Tank F na Desgn


Rompe Carga, Los Arroyos/Los Campeches
N
1 ft
llave Publico
Entrada
2" Nipple/2 Elbws
SALIDA
Rebose
2"
* Screens on all outlets
Rebar Handles
2" GALV
Lodo
2" GALV.
6"
4"
1 1/2" X 1 1/2" Door
Entrada
Rebose
2" Elbow
May 12, 2002
22-141 50 SHEETS
22-142 100 SHEETS
22-144 200 SHEETS



B eak Pressure Tank F na Des gn


May 2 2002
La Toma Los Arroyos
1ft
N
Block
Union GALV
Salida
2" GALV Nipple
Limpieza
Tapon
GALV Nipple
Reboso
Entrada 4"
* Screens on all outlets
Entrada
Reboso
18 x 18 Metal Door
Block
Concreto
Sept. 3, 2002



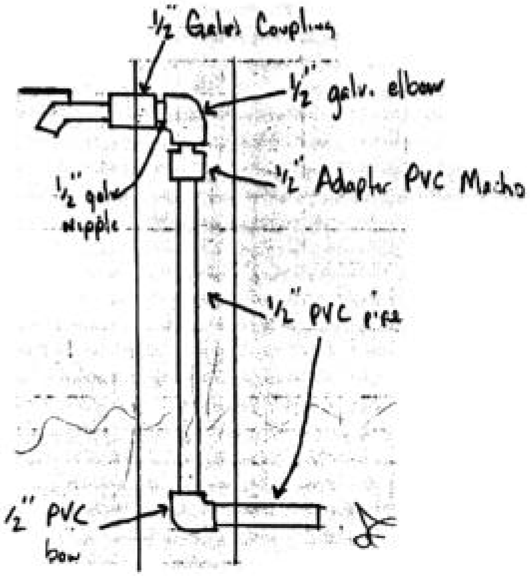
May 12 2007
Exit Details → Los Arroyos, Los Campeches, Pinar de Cuellos Gauyabo Dulce
1Ft
N
Los Arroyos / Los Botados
1½" GALV Nipples (3)(12")
3 1½" GALV T
3 1½" Adap Macho
3 1½"-½" Reduction
9 1½" GALV Nipples (3")
3 1½" llaves de Paso
1 1½"×1½" Door
1 Adapt Macho
2 Adapt Embra
1 1½"-1" Reduct
1 1"-½" Reduct
Caja de Seguridad
Los Botados
Los Campeches
→ La demanga
← Same
1 ½" Nipple (12")
1 ½" llave de Paso
1 Adapt Macho
1 1½" GALV Nipple (12")
1 1½" GALV T
1 1½"-½" Reduc
2 1½" GALV Nipples (3")
1 1½" llave de Paso
1 1"×1" Door
1 Adapt Embra 1½"
Gauyabo Dulce → Same as Above
Using 1" instead.
Pinar de Cuellos
Same Detail as Los Campeches doubled + (1) 1½" PVC Codo
M Niskanen
22-141 50 SHEETS
22-142 100 SHEETS
22-144 200 SHEETS

La China 3/7

D Tap Stands

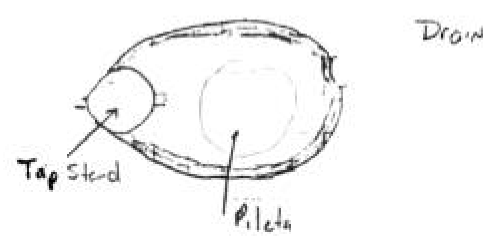
Construct Form using 4 PVC pipe aprox. 1 high
Cut entrance land + holes 3 From top & bottom (refer to drawing)

2. Constr pipe for inside concrete cut 2 piece of 1/4 eb.
shape for reinforcement (refer to drawing)



For Pile ith Ta tou → connect tap to entr tube

Plan view



Appendix F

Original Project Budget and Final Cost

Original Projected Budget

Presupuesto para Los Arroyos y Los Botados

Un Acueducto   Ingeniero: *Matthew "Mateo" Niskanen*   pg. 1

Descripcion	Cantidad	Precio ($RD)	Importe($RD)
Tubos PVC (.5")	269	37.1	9979.9
Tubos PVC (1")	62	73.49	4556.38
Tubos PVC (1.5")	333	118.52	39467.16
Tubos PVC (2")	240	158.78	38107.2
Tubos PVC (3")		327.91	0
Tubos PVC (4")	4	466.718	1866.872
Tubos Galv. (.5")		170	0
Tubos Galv. (1")	4	280	1120
Tubos Galv. (1.5")	6	460	2760
Tubos Galv. (2")	2	535	1070
Tubos Galv. (3")		860	0
Adaptador PVC .5" roscas macho	75	2	150
Adaptador PVC 1" roscas macho	4	4	16
Adaptador PVC 1.5" roscas macho	4	5	20
Adaptador PVC 2" roscas macho	2	7	14
Adaptador PVC .5" roscas hembra		2	0
Adaptador PVC 1" roscas hembra		4	0
Adaptador PVC 1.5" roscas hembra	3	5	15
Adaptador PVC 2" roscas hembra		7	0
Adaptador PVC 3" roscas hembra		10	0
Adaptador PVC 4" roscas hembra	2	15	30
PVC .5" "T"	20	5	100
PVC 1" "T"	10	7.5	75
PVC 1.5 " "T"	10	15	150
Galv. 1" "T"		20	0
Galv. 1.5" "T"	4	25	100
Coplin PVC .5"	75	3	225
Coplin PVC 1"	6		0
Coplin PVC 1.5"			0
Coplin PVC 2"			0
Coplin PVC 3"			0
Coplin PVC 4"	2	10	20
Coplin Galv. .5"	80	5	400
Coplin Galv. 1"		10	0
Coplin Galv. 1.5"		10	0
Coplin Galv. 2"	1	15	15
Coplin Galv. 3"		20	0
Niple Galv. .5" (12")	1	40	40
Niple Galv. 1" (12")		50	0
Niple Galv. 1.5" (12")	8	60	480
Niple Galv. 2" (12")	5	75	375
Niple Galv. 3" (12")	2	100	200
Niple Galv. 4" (12")	2	100	200
Niple Galv. .5" (3")	75	10	750
Niple Galv. 1.5" (3")	4	15	60
		Sub Sumacion #1	*102362.512*

Descripcion	Cantidad	Precio ($RD)	Importe($RD)
Codo PVC .5"	525	1.7	892.5
Codo PVC 1"		5	0
Codo PVC 1.5"		5	0
Codo Galv. .5"	75	15	1125
Codo Galv. 1"		15	0
Codo Galv. 1.5"	2	20	40
Codo Galv. 2"	5	20	100
Codo Galv. 3"		25	0
Reductor PVC 1.5">.5"	20	10	200
Reductor PVC 1">.5"	15	3	45
Reductor PVC 1.5">1"	5	5	25
Reductor PVC 2">1.5"	1	7	7
Tapon PVC .5"	20	5	100
Tapon PVC 1"		5	0
Tapon PVC 1.5"		5	0
Tapon PVC 2"	1	5	5
Tapon Galv. 3"		15	0
Tapon Galv. 4"	1	15	15
Block	460	8.5	3910
Cal	2	20	40
Una lata de Cemento de PVC	6	160	960
Quintal de Varilla de 3/8"	5	300	1500
Quintal de Varilla de 1/4"	2	300	600
Varilla Cuadros	40	10	400
Una Funda de Cemento Gris	91	94	8554
Madera Bruta por Pies	40	11	440
Plywood fino-Una Plancha	2	40	80
Un metro de Gravilla de 3/4"-1"	10	300	3000
Un metro de Arena Gorda Azul Lavada	10	250	2500
Un metro de Arena de Empanete	3	250	750
Alambre de Gallina(m3)	2	40	80
Puertas (aluminum)			0
1' X 1'		1000	0
1.5' X 1.5'	2	250	500
2' X 2'	2	250	500
Screen (Maya)	1	100	100
Alambre Dulce	2	10	20
Teflon(rollos)	10	4	40
Llaves de Paso .5"		200	0
Llaves de Paso 1"		250	0
Llaves de Paso 1.5"	4	300	1200
Llaves de Chorro (con candado).5"	75	60	4500
Llaves de bola .5"	2	200	400
Llaves de Cuna (1.5")			
Clampas de Manguerra(abrazaderas)	36	15	540
Herramientas	1	3000	3000
Misc.	1	5000	5000
Abinile	1	8000	8000
8" Drain pipe	1	682.82	682.82
Valvula Flota (1.5")	0	350	0
		sub sumacion #2	*49851.32*
		Total($RD):	**152213.83**
		Total($US):	**8456.32**

pg.2

Final Cost of Water System

El Costo final para Los Arroyos y Los Botados

Un Acueducto Ingeniero: *Matthew "Mateo" Niskanen* pg. 1

Descripcion	Cantidad	Precio ($RD)	Importe($RD)
Tubos PVC (.5")	330	37.1	12243
Tubos PVC (1")	62	73.49	4556.38
Tubos PVC (1.5")	333	118.52	39467.16
Tubos PVC (2")	240	158.78	38107.2
Tubos PVC (3")		327.91	0
Tubos PVC (4")	4	466.718	1866.872
Tubos Galv. (.5")		170	0
Tubos Galv. (1")	4	280	1120
Tubos Galv. (1.5")	6	460	2760
Tubos Galv. (2")	2	535	1070
Tubos Galv. (3")		860	5
Adaptador variable			750
"T"			750
Coplin			750
Niple			750
Codo PVC .5"			750
Reductor PVC 2">1.5"			750
Tapon Galv. 4"			750
		Sub Sumacion #1	*106445.612*

Descripcion	Cantidad	Precio ($RD)	Importe($RD)
Block	600	10.5	6300
Cal	2	20	40
Una lata de Cemento de PVC	8	160	1280
Quintal de Varilla	15	400	6000
Varilla Cuadros	40	10	400
Una Funda de Cemento Gris	140	100	14000
Madera Bruta por Pies	0		4296
Plywood fino-Una Plancha	2	40	80
Un metro de Gravilla de 3/4"-1"	12	300	3600
Un metro de Arena Gorda Azul Lavada	12	250	3000
Un metro de Arena de Empanete	2	250	500
Alambre de Gallina(m3)	2	40	80
Puertas (aluminum)			0
1' X 1'	0		0
1.5' X 1.5'	4	250	1000
2' X 2'	0		0
Screen (Maya)	1	100	100
Alambre Dulce	10	15	150
Teflon(rollos)	10	4	40
Llaves de Paso .5"	1	200	200
Llaves de Paso 1"	0		0
Llaves de Paso 1.5"	4	300	1200
Llaves de Chorro (con candado).5"	75	77	5775
Llaves de bola .5"	2	200	400
Llaves de Cuna (1.5")	0		0
Clampas de Manguerra(abrazaderas)	18	15	270
Herramientas	1	3000	3000
Misc.	1	5000	5000
Abinile	1	20000	20000
8" Drain pipe	0		0
Valvula Flota (1.5")	0		0
		sub sumacion #2	*76711*
		Total($RD):	**183156.61**
		Total($US):	**10175.37**

pg.2

Appendix G

INAPA permission letter

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INSTITUTO DE AGUA POTABLE Y ALCANTARILLADOS
I.N.A.P.A.
UNIDAD ADMINISTRATIVA LAS MATAS DE FARFAN.

23/ DE AGOSTO/ 2002

SR. ING. MATTHEWS NESKANIN
ENC. CONSTRUCCION AC. RURALES
LOS BOTADOS, LOS ARROYOS, EL CERCADO, R.D.

VIA PARROQUIA SAN PEDRO APOSTOL
MUNICIPIO EL CERCADO, SAN JUAN DE LA MAG

ESTA INSTITUCION TIENE A BIEN COMUNICARLES LA DESICION DE AUTORIZAR LA CONEXION DE LA TUB. Ø 1.5 " PVC." DEL AC. QUE USTED ESTA CONSTRUYENDO EN LAS COMUNIDADES DE LOS BOTADOS Y LOS ARROYOS, A TRAVES DEL CUERPO DE PAZ DE LA PARROQUIA SAN PEDRO APOSTOL DEL MINICIPIO DE EL CERCADO; CONEXION A TUB. Ø 2 pvc. PROPIEDAD DE I N A P A, CON UNA LONGITUD APROX. DE 200mts. L, EL CUAL ES UN ACUEDUCTO DE JUAN SANTIAGO Y QUE ACTUALMENTE NO CONDUCE AGUA.

TAMBIEN SE AUTORIZA CONEXION Y CONTINUACION DE ESTA LINEA DE TUB., CONEXIONES DE LA RED A DIFERENTE SECTORES DE LOS BOTADOS ETC.

LA INSTITUCION REQUIERE LA REALIZACION DE CROQUIS REFERENCIALES A ESTA CONEXIONES Y SU ENTREGA A ESTA INSTITUCION.

ATTE.

ING. SANTANA PEREZ JIMENEZ
ENC. DE OPERACIONES Y MANT.
LAS MATAS DE FARFAN

ING. MARKIN DE LA CRUZ
ENC PROVINCIAL
ELIAS PIÑA

M.L.V./S.P.J.

Appendix G

Description of Second Water System

Second Water System Description

The second water system I organized was in three nearby communities. I actually lived in one of these communities, so I felt obligated to start the water system at the same time as the Los Arroyos water system.

The second system consisted of approximately 210 homes and covered much more area. The water source was a natural occurring mountain spring approximately 1.5 miles up into the mountains.

The elevation change was large enough to require two break-pressure tanks. The second tank also served as a division tank. Since the three communities were spread apart, each one would have their own storage tank. Therefore, from the division tank, three waterlines were installed to each storage tank.

There were nine work brigades who worked three days a week. Each brigade had to work every three weeks. The large number of families made frequency of work days much longer. It was also difficult to organize the numerous families, and frequently hard to get some of them to work.

Unfortunately, since I had to leave the Dominican Republic early due to medical reasons, this system did not get finished. Fortunately, another Peace Corps volunteer and good friend of mine, volunteered to continue with the work and finish the project.