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Sustainable Water Development for the Village of Miramar, Honduras

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Sustainable Water Development for the Village of Miramar, Honduras



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***Sustainable Water Development
for the
Village of Miramar, Honduras***

by

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Executive Summary

Introduction

This report describes the 12-day trip to Miramar, Honduras, by students in the University of New Mexico's Water Resources Program, during the summer semester of 2001. The trip began on June 14 and ended on June 26. This trip was in fulfillment of WR 573, a capstone class that is tailored to fuse all of the other classes in the program into a comprehensive, practical field experience.

Miramar is a remote village of approximately 300 people, located in the coastal mountains of northwestern Honduras. A winding footpath ascending 1000 meters above sea level limits access to Miramar. Miramar sustains 47 households, two churches, a community building, and a school. Agriculture is the primary livelihood for the people of Miramar, with coffee being the primary crop.

Honduras is the second largest country in Central America and is comprised of tropical mountainous terrain and coastal plains. Because of the varying terrain throughout the country, the climate of the region depends primarily on altitude, rather than latitude. Honduras is a water-rich country, receiving the majority of its rain from May to September. Agriculture is the primary industry in Honduras, with bananas being the most important product.

Project Synopsis

Currently, the people of Miramar obtain water from cisterns and a rudimentary piping system from local springs. Because of prevalent livestock, water is often contaminated and must be boiled before human consumption. As the community grows, the need for accessible potable water has become apparent. A water project led by Alex Uriel del Cid Vásquez has been designed for Miramar and is broken down into five steps: community assessment and involvement; planning; support and funding; actual construction of the project; and long-term maintenance. The water system will ultimately result in a dam constructed at the headwaters of a stream about 3 kilometers from the village, a pipeline to carry water from the dam to a tank site located on a ridgeline above Miramar, a chlorination system to treat the water, and subsequent piping to each participating household. Upon completion of the water project, Miramar will have to maintain its water system and become aware of other considerations such as land use and population growth in order to ensure a sustainable community.

Sustainability for Miramar

Current land practices involve slash and burn methods of farming and grazing on steep hillsides, resulting in decreased fertility over time and substantial increases in erosion. Erosion control and nutrient conservation are essential to Miramar's land use sustainability. Miramar must become familiar with new techniques to improve land use efficiency, such as terracing and crop rotation.

In parallel with the implementation of a water delivery system, the maintenance of that system must be considered. Currently, the water system has been designed to sustain a population growth rate of 4.5% over the next 20 years. Within those 20 years, the system will require both labor and financially intensive maintenance. To minimize structural damage as the system ages, two primary considerations were analyzed prior to the construction of the system: the placement of the tank on a stable ridge top, and the burying of the pipeline. These are two, among several design criteria, predicted to help sustain the system over the next 20 years.

Benefits to UNM Students

UNM WRP students benefited enormously from WR 573. The trip to Honduras incorporated every aspect of the WRP that has been taught to the students. Because this was the first trip abroad for the WRP, the class has suggestions to make future trips more successful. Such suggestions include the incorporation of more rural issues into other core classes, obtaining more scientific and cultural data before and during the trip, and applying real-world problems based on this summer's trip and future trips so that students may get practical experience before embarking on future trips. Overall, the trip to Honduras was not only beneficial from an academic standpoint, but also for personal and individual development.

Project Completion

We arrived in Miramar on June 15, 2001 and departed on June 22, 2001. Alex Uriel del Cid Vásquez forecast a completion date of mid-September, 2001, assuming no problems. The project was delayed somewhat, and was finally dedicated in December 2001.

Sustainable Water Development for the Village of Miramar, Honduras

Introduction

The UNM Water Resources Program (WRP) offers the Master of Water Resources (MWR) degree, an interdisciplinary professional degree designed to prepare students for careers in water resources. The program seeks to expand and deepen students' knowledge of their primary disciplines and, at the same time, improve their capacity to think carefully and comprehensively, and develop their technical and communication skills. In order to help achieve this goal, the WRP has developed three interdisciplinary (core) courses, the last of these courses (WR 573) being designed as a capstone, representing a culmination of the student's experience in the program. This final class is an intensive field-based course in which the students work together using their previous coursework and acquired skills. A specific field project is undertaken, and students work through problem identification and definition, collect/analyze data, propose solutions, and present conclusions and recommendations in an appropriate forum.

This year, the WR 573 class spent 12 days in Honduras examining rural water issues and assisting in the construction of a gravity-flow system to provide potable water to a local village (Miramar). Our involvement was to aid in the physical construction of the system, as well as examine and critique the construct of the system itself. This paper represents a summary of our experience in Honduras, our examination and assessment of the water problems in Miramar, including both a watershed sustainability assessment and an assessment of their proposed water delivery system.

Honduras Overview

Topography

Honduras is the second largest country in Central America with an area of 112,088 square kilometers. This area contains three distinct topographical regions: an extensive interior highland area and two narrow coastal lowlands. The interior, which contains approximately 80 percent of the country's terrain, is mountainous with steep highland valleys. Large alluvial plains characterize the northern and the eastern Caribbean lowlands.

In the west, Honduras's mountains blend into the mountain ranges of Guatemala. The western mountains have the highest peaks, with the Pico Congolón at an elevation of 2,500 meters and the Cerro de Las Minas at 2,850 meters. These mountains are woodland covered with pine forests (see Appendix A, Map 1).

Climate

The entire country lies within the tropics, however, there is significant regional variation because of the mountain regions. Caribbean lowlands are generally hotter and more humid than rest of country while more temperate conditions exist at higher elevations. Rainfall also varies throughout Honduras, but is most prevalent in the Caribbean lowlands, especially in northeast where the most rainfall is received. There are distinct wet and dry seasons in Pacific lowlands and interior highlands; May to September are the wettest months.

Temperatures in the tropics vary primarily with elevation rather than with season. Land below 1,000 meters is commonly known as *tierra caliente* (hot land), between 1,000 and 2,000 meters *tierra templada* (temperate land), and above 2,000 meters *tierra fría* (cold land). Both the Caribbean and Pacific lowlands are *tierra caliente*, with daytime highs averaging between 28° C and 32° C throughout the year. April, the last month of the dry season in the Pacific lowlands, brings the warmest temperatures; the rainy season is slightly cooler, although higher humidity during the rainy season makes these months feel more uncomfortable. In the Caribbean lowlands, the only relief from the year-round heat and humidity comes during December or January when an occasional strong cold front from the north (a *norte*) brings several days of strong northwest winds and slightly cooler temperatures (see Appendix A, Map 2).

The interior highlands range from *tierra templada* to *tierra fría*. Tegucigalpa, the capital of Honduras, is in a sheltered valley and at an elevation of 1,000 meters, and has a pleasant climate, with an average high temperature ranging from 30° C in April, the warmest month, to 25° C in January, the coolest. Above 2,000 meters, temperatures can fall to near freezing at night, and frost sometimes occurs.

Rain falls year round in the Caribbean lowlands but is seasonal throughout the rest of the country. Amounts are copious along the north coast, especially in La Mosquitia, where the average rainfall is 2,400 millimeters. Near San Pedro Sula, Honduras's industrial capital, the amounts are slightly less from November to April, but each month still has considerable precipitation. The interior highlands and Pacific lowlands have a dry season, known locally as "summer," from November to April. Almost all the rain in these regions falls during the "winter," from May to September. Total yearly amounts depend on surrounding topography; Tegucigalpa, in a sheltered valley, averages only 1,000 millimeters of precipitation (see Appendix A, Map 3).

The Caribbean Lowlands

This area of river valleys and coastal plains, which most Hondurans calls "the north coast," or simply "the coast," has traditionally been Honduras's most exploited region. The central part of the Caribbean lowlands, east of La Ceiba, is a coastal plain only a few kilometers wide. To the east and west of this section, however, the Caribbean lowlands widen and in places extend inland a considerable distance along broad river valleys. The broadest river valley, along the Río Ulúa near the Guatemalan border, is Honduras's most developed area. Both Puerto Cortés, the country's largest port, and San Pedro Sula, are located here.

To the east, near the Nicaraguan border, the Caribbean lowlands broaden to an extensive area known as La Mosquitia. Unlike the western part of the Caribbean lowlands, La Mosquitia is Honduras's least-developed area. Underpopulated and culturally distinct from the rest of the country, the area consists of inland savannahs with swamps and mangroves near the coast.

Water Resources

Honduras is a water-rich country. The most important river in Honduras is the Ulúa, which flows 400 kilometers to the Caribbean through the economically important Valle de Sula. Numerous other rivers drain the interior highlands and empty north into the Caribbean. The Valle de Sula is an area that has supported settlement and economic activity, particularly around El Progreso and La Lima, two principal banana regions in the country, and San Pedro Sula. The rivers are important, not as transportation routes, but because of the broad fertile valleys they have produced (see Appendix A, Map 4).

Rivers also define about half of Honduras's international borders. The Río Goascorán, flowing to the Golfo de Fonseca, and the Río Lempa define part of the border between El Salvador and Honduras. The Río Coco marks about half of the border between Nicaragua and Honduras.

Despite an abundance of rivers, large bodies of water are rare. Lago de Yojoa, located in the west-central part of the country, is the sole natural lake in Honduras. This lake is 22 kilometers long and at its widest point measures 14 kilometers. Several large, brackish lagoons open into the Caribbean in northeast Honduras. These shallow bodies of water allow limited transportation to points along the coast.

Agriculture

The total land area of Honduras is 11.2 million hectares, of which a scant 1.7 million hectares (about 15 percent) are well suited for agriculture. Most land in Honduras is covered by mountains, giving rise to the country's nickname, "the Tibet of Central America." Nevertheless, the Honduran economy depends almost exclusively on agriculture, and in 1992 agriculture was still the largest sector of the economy, contributing 28 percent to the Gross Domestic Product (GDP). Less than half of Honduras's cultivable land was planted with crops as recently as the mid-1980s. The rest was used for pastures or was forested and owned by the government or the banana corporations. Potential for additional productivity from fallow land was questionable because much of Honduras's soil lacks the thick volcanic ash found elsewhere in Central America. In addition, by 1987 about 750,000 hectares of Honduran land had been seriously eroded as a result of misuse by cattle ranchers and slash-and-burn squatters who planted unsuitable food crops.

Scattered throughout the interior highlands are numerous valleys, 300 to 900 meters in elevation, which vary in size. The floors of the large valleys provide sufficient grass, shrubs, and dry woodland to support livestock and, in some cases, commercial agriculture. Subsistence agriculture occurs on the slopes of the valleys. However,

agriculture is limited by small-sized holdings, primitive technology, and low productivity.

Vegetation in the interior highlands is varied. Much of the western, southern, and central mountains are open woodland, supporting pine forests interspersed with some oak, scrub, and grassy clearings. The ranges toward the east are primarily continuous areas of dense, broad-leaf evergreen forest. Around the highest peaks, remnants of dense rain forest that formerly covered much of the area are still found (see Appendix A, Map 5).

Geology

The Cacaguapa Formation is among one of the formations that comprises the bedrock of the region and consists of well-foliated sericite, graphite schists, quartzites, and other metasedimentary rocks exhibiting varying degrees of metamorphism. Additionally, the area consists of dark gray claystone and shales within beds of siltstone, interstratified with beds of fine to medium sandstone and thin to thick beds of banded mudstone. There are occasional layers of pebble and cobble conglomerates shales containing Upper Triassic plants.

Miramar Overview

“View of the Sea” is the direct translation of the aptly named village of Miramar. Nestled in the coastal mountains of northwestern Honduras at exactly 1000 meters above mean sea level, the village overlooks rainforest-covered ridges with a picturesque view of the ocean, and hundreds of kilometers of coastline. The only access to Miramar is on a 7 kilometer footpath used exclusively by people and pack animals. The trail begins in the northern coastal town of Masca, and passes through rainforest and small villages on its winding path through the mountains. The clay-packed trail is narrow and rugged, consisting of steep gradients which make it treacherous after heavy rains.

Miramar itself is a community of forty-seven homes and a population of approximately 300 people. Founded some 60 years ago, the community is both motivated and highly organized and has successfully implemented several private and public projects including a new school. The new school was constructed in the late 1990s and about seventy students attend the school taught by two government-certified teachers. The community is strongly supported by a local Women’s Club, which contains a cooperative of small coffee producers and acts as a rural bank. Within the community, there are also two churches, a community house, and an old school building.

Miramar is primarily made up of subsistence farmers. While most crops are grown for local consumption, extra produce is often sold on the coast to provide a cash income. The principle cash crop in Miramar is coffee. Staples include rice, beans, and corn, but a variety of vegetables, plantains and fruits such as oranges are also grown.

Further information about the social structure and daily routine of the people of Miramar is presented in Appendix B.

Project Overview

Historically, the people of Miramar hand-carried water to their houses from nearby springs and seeps. Later, a crude delivery system was put in place that piped water to various houses from these same locations. Over the years, various improvements were made, such as creating cisterns to collect rainwater and pipe it to various locations. These sources of water are unreliable, especially during winter months when rain is less frequent. In addition, the presence of livestock and the lack of latrines have contaminated many of these sites. To provide sustainable, clean water, the village requires both a sanitation system, and a clean, reliable source of water with a well developed delivery system. The complexity of such a task requires support from the village as well as the support of outside groups, both public and private.

In any village development project, there are five important phases: community assessment and involvement; planning; support and funding; project construction; and long-term maintenance. These are discussed below.

Community Assessment and Involvement

The initial step is to find a community that desires a clean water system, and has the drive to participate and see the project through. Without local interest or participation, construction of a water system is a waste of time and money. Once a community expresses an interest, the village itself must be assessed to determine what kind of water system best suits its needs. Miramar showed great interest in the possibility of constructing a water system, and upon examining the village and surrounding area, it was decided that a small reservoir should be built at the headwaters of a stream located in the mountains southeast of the village about three kilometers away. The water would then be piped via a gravity flow system to a 5,000-gallon tank, placed just above the village, where the water would be chlorinated. From there, the water would be piped to individual houses throughout the village. In undertaking the project, the people of Miramar agreed to participate as much as they were able, providing local materials, labor, and money when possible. Throughout the life of the project they will participate in the planning and construction of the water system, and be responsible for its continued maintenance after the project is completed.

Planning

The next step is the planning of the water system itself. Technical data were gathered such as discharge of the stream, number of people in the village desiring water, projected growth rates of the village over a 20-year period, water needed per person per day, required capacity of the reservoir, and so on. Plans for construction of the reservoir were developed, diameter of pipe sized, and total pipeline length calculated. For Miramar's water system, a population growth rate of 4.5% was projected over a 20-year period. Currently, 43 houses are signed up to receive water, with an estimated usage of 35 gallons per person per day. Using these data, a supply rate from the reservoir was determined of 27 gallons per minute (gpm). A 5,000-gallon tank will be placed on a ridge at the top of the village where the water will be chlorinated and then piped to each house. While the planning phase is under way, step three will also be in process.

Support and Funding

In order for a project of this magnitude to occur, outside help, both technical and financial, is required. Most village people in the developing world have little, if any, formal education, and as a result they have few technical skills for designing or constructing a complex water system. While they can be taught many skills, the aid of various professional craftsmen is required for such aspects as masonry and plumbing. Expenses of the project will also exceed the village's financial abilities. For this reason it is necessary to raise money from outside sources such as government and non-government organizations. These monetary contributions will go towards purchasing materials and paying the wages of professional craftsmen. Miramar will soon be in need of a professional mason to help with the construction of the reservoir. In order to purchase the needed materials as well as pay the mason's wages, they have petitioned several organizations, and the government for money. Money is typically the limiting factor and is probably the biggest obstacle the people of Miramar face. Currently they have little money to work with and project construction is halted as a result.

Project Construction

Up until mid-June 2001, no physical work had been done on the water-supply project. These first three steps represent the bulk of the project in terms of time. It averages 8 months from identifying a viable village to the beginning of actual construction. The previous steps will be ongoing throughout the life of the project. As stated above, support and funding usually overlaps with project construction, as does community support, which is a continuous aspect of the project. Planning is also an ongoing step as the plans for the water system may evolve somewhat as problems arise and are solved. The building of the water system itself averages 1 to 2 months, but when money is a limiting factor, as it is here, construction may take longer.

Along with money, there are other obstacles that must be overcome. Miramar's remote location and poor access makes the transportation of materials difficult. Concrete and piping must be brought in by hand or on pack animals – a process that is both labor intensive and time consuming. Furthermore, the site of the reservoir is even more remote, with nothing but a machete-carved trail to serve as a road. Hand-carrying these heavy materials is dangerous as the trail traverses steep, unstable slopes. Storage of materials is also difficult. Carrying unused materials back to the village is time consuming; however, leaving them at the site may prove risky since rains or flash flooding may damage the concrete if it is not properly covered, or carry away piping and tools that are left near the stream banks. Although crime is not an issue in Miramar, other villages may face problems of theft or vandalism. The lack of machinery is also an obstacle. Excavation of an area that would be a simple task with the use of a backhoe, may take days to dig out by hand. Materials easily obtained in town, such as sand to mix with mortar, may have to be sifted by hand in the village, removing debris from earth, or finding and transporting sand deposits along the stream banks. Obstacles like these make determining a completion date sketchy at best – the original date of mid-September 2001 became late December 2001.

Long-term Maintenance

No matter how complex or simple a project is, it will always require maintenance in order to function long-term. This is especially true in the developing world where conditions are far from optimum. Long-term maintenance can be both costly and time consuming, and require a great deal of responsibility. This is the primary reason that the village is given ownership in both a literal as well as an emotional sense. If an outside group were to simply come and construct a water system for the village because they believed that the village would benefit from it, the local people would simply use it until it broke down and then go back to their traditional way of doing things. But when they are given the decision to build a water system, the responsibility to aid in its construction, invest their time and money, and finally, be given ultimate ownership, they will then be driven to maintain it long-term. Upon completion of the project at Miramar, certain individuals will be given responsibilities such as inspecting the reservoir for accumulation of debris, monitoring the chlorination of the water at the holding tank, and cleaning sediments that may clog the pipes. Other responsibilities will be delegated, with the village water council overseeing all aspects of the maintenance of the water system. Should problems arise beyond those that they have been trained to fix, the water council will have outside contacts who will be able to see that the necessary repairs are made.

Land Use Sustainability

Land and Agriculture

Miramar villagers recognize land ownership and most fields are delineated with barbed-wire fences. Most homesteads are adjacent to their family's fields, but some villagers involved with the water system project have land holdings away from their homes, within the same watershed. Land in Miramar is primarily used for subsistence agriculture, but a small portion of crops are also sold at local markets closer to the Honduran coastline. Crops include, but are not restricted to beans, cucumbers, carrots, coffee, bananas and pasta, a type of grass that is used to feed the villager's mules. Most of the agricultural fields exist on steep slopes ranging in grades between 40 and 60 degrees (see Figure 1). Fields are prepared using slash and burn methods, increasing the chance of massive soil loss during monsoon rainstorms prevalent in the bimodal climate.

Fig 1. *Steep slope used for growing crops.*



Felled trees mimic terrace formations but the Miramar agriculturists do not practice physical terracing of fields; however, terracing could easily be applied to slopes in this area. Coffee plants are randomly placed around the landscape, typically next to the dirt roads and paths for easy harvesting. Most households raise their own chickens, which are the dominant source of meat in the villager's diet. Most families own mules for load carrying and land tilling duties.

Vegetation around Miramar ranges from dense, native, broad leaf flora on ridge tops to barren slopes that have been historically burned by local farmers. These plots may be used for foraging, but this practice was not observed during survey. It was not apparent if timber is harvested in excess of local demand, but a declining regional economy and the possible construction of a permanent road into the village may create

and/or expand local timber production.

Agricultural fields lie on either side of a ridge that dissects Miramar with a topographic high that is utilized by the gravity-flow water distribution system. This also breaks up the village's food resources between two watersheds. A conservative soil loss estimation can be determined using the Modified Soil Loss Equation, or MSLE, with the following estimated variables and assumptions (Brooks et al., 1997):

$$A = RK(LS)(VM) = 24.1 \text{ tons/acre}$$

Where:

A = computed soil loss in tons per acre;

R = **193.12** (based on the average erosivity factor determined in southern Honduras between 1993 and 1997 by Thurow and Smith, 1998);

K = 0.25 (based on a low organic %, moderately permeable loam);
LS = 10 (based on an average case); and
VM = 0.05 (based on a 50% canopy cover and 50% cover that contacts ground is broadleaf plants and plant litter)

(Values determined from reference charts in Brooks et al., 1997)

The “highway” to Miramar

Currently, the only course to Miramar is a rugged trail that has been heavily eroded by the tropical climate and years of foot and hoof traffic (see Figure 2).

Fig 2. *An eroded portion of the road to Miramar.*



Locals generally seemed pleased with the prospect of the construction of a paved road connecting Miramar to the small town of Masca, almost 1000 meters lower in elevation and along the coastal highway. A permanent road structure would improve the transportation of supplies and commercial goods to and from Miramar, but increase other pressures related to population influx and transportation efficiency. The road may bring timber and large-scale agricultural interests to Miramar, disrupting the current equilibrium, if one is present, between the villagers’ natural resources and their population’s demand.

Physically, an impermeable surface constructed within this watershed without proper drainage and easement would multiply the runoff potential of the landscape, and possibly create turbidity problems within the main channel of this watershed resulting from increased erosion. In the short run, the villagers may enjoy the economic benefits that

increased traffic to the village could bring, but in the spectrum of sustainability, the hard surface may create less than desirable circumstances for this subsistence-based system. The introduction of outside business ventures or increased local production of natural resources for profit may attract more outsiders into the village of Miramar who are hoping to gain from the area's wealth. The more efficient travel route may also encourage local producers to increase production on local fields and shorten fallow seasons. Uncut plots may be quickly harvested for quick profit, forcing tree cutters to move deeper into virgin forests. Economic growth will beget population growth, pushing the water system and the watershed well beyond its threshold. The resulting density of domicile and agricultural spaces will increase while water quantity and quality, food production and property borders will diminish. If timber harvesting becomes a local profit venture, the possible risks are increased erosion, flushing of soil nutrients, loss of vegetation and a diminished production capacity of agricultural lands. An increasingly transient population will magnify these constraints. The Miramar community must be made aware of these risks and weigh the cost and benefits before they allow the paved road to enter both their village and their lives.

Implementing Sustainable Land Use Practices

A sustainable land use plan should complement any sustainable water use plan submitted to the village of Miramar. Slash and burn methods were not observed in practice, but charred tree trunks were seen in many fields, and burning events were planned for in the water-supply system, such as the burial of the PVC pipeline from the dam to the storage tank to prevent damage from burn events. It is vital to the population of Miramar that current slash and burn practices are replaced with more long-term methods of field preparation. Villagers should leave plant residue on the ground after harvest to serve as mulch, which will enrich the soil with nutrients and organic matter, regulate soil temperature and conserve moisture (Thurow and Smith, 1998). The exact methods of implementation and degree of success should be determined during future fieldwork. Steepland agriculture in Miramar is also void of irrigation, making crops completely dependent on rainfall. The practice of field terracing would improve the land for agricultural use in two ways: by decreasing erosion potential and increasing water retention. Fallow and production periods of plots should also be rotated for the long-term and should reflect the use, subsistence or profit, for which they are being used. Erosion control and nutrient conservation is essential to Miramar's sustainability, and it will take physical, as well as educational programs to move this village towards this goal. Also needed is the villagers' willingness to accept changes to their existing approaches to land management and the outside planner's willingness to plan around the villagers' demands.

Sustainability of Miramar's Water Delivery Project

Water Supply

To develop a community capable of growth and sustainability, a reliable supply of water must be available, among other factors. Currently, Miramar has engaged in a water project that will have to be maintained in order to sustain the village for the future. To ensure water system sustainability, a number of variables must be considered.

Alex Uriel del Cid Vásquez is the designer of Miramar's water project. His primary goal is to enable villages like Miramar to access potable water. In order to produce a sustainable water delivery system to meet the Miramar's needs well into their future, he predicted the growth of the village's population by assuming a growth rate of 4.5% per year over a 20-year life span of the project. After 20 years, the water system will need to be reassessed to support the new needs of the community. In addition to the 4.5% yearly growth rate, he used a safety factor of 50% in addition to the current population of 301 people. The projected future total user design load equation is as follows:

$$\text{Future users} = 301(1.5 + (4.5)(20)/100) = 722 \text{ persons in 20 years}$$

If each person is assumed to use 35 gallons per day (gpd), the total water needed from the designed system daily is:

$$722 \text{ persons} * 35 \text{ gpd/person} = 25,270 \text{ gpd}$$

The tank chosen for this project was a 5,000-gallon water tank constructed of masonry. Water will be delivered at a rate of 35 gallons per minute (gpm) to the dam site, of which, some water will bypass the dam to deliver the flow required by the village to the storage tank. With the dam and 2-3 kilometers of piping between the dam and the tank, there will be a delivery of 27 gpm to the tank site. Over the course of one day, this is approximately 38,880 gallons of water. The system obviously will not sustain a fast draw of the communities daily water needs, but if spread out over the course of the day, it will produce adequate storage.

This design makes logical sense, and should be sustainable for the village under relatively ideal conditions; however, there were two areas of concern expressed to Uriel del Cid during the Water Resources students' evaluation of the project's design. The first concern was the location of the tank site upslope from the village of Miramar. The site chosen was on a slope that was ranged from 30-45%, where, on steeper portions, heavy erosion was apparent. With the possibility of heavy rains in this area, in addition to the occasional anticipated overflow of the tank, there was concern from our group that the tank's foundation would not be on stable ground.

In addition to the stability of the tank's foundation our group was concerned that with such a steep slope, erosion caused from water bypassing the tank would be imminent. Uriel del Cid, in cooperation with the villagers, decided to move the tank location to the top of the ridgeline at a higher elevation from the original tank site (see Figure 3). Although the new location had been considered prior to our involvement in the project, it was initially discarded because the tank would straddle the property lines of two different landowners; however, the land issue was resolved when it was clear that ridgeline was the better of the two sites.

Fig 3. *Tank Foundation.*



The second concern Water Resources students expressed in the project's design was the proposed plan to bury the pipeline, from the dam to the tank, two feet below ground. According to Uriel del Cid, burying the pipeline minimizes ultraviolet (UV) degradation and protects the pipeline in the event of rock falls, landslides, and other occurrences above ground that could damage the pipeline. Burying the pipeline will result in a more stable pipeline. If repairs are needed however, they will be more difficult and time consuming. Additionally, the initial burial of the pipe will require a great deal of labor, which will come from the local villagers, deterring the villagers from tending to their fields and other daily activities. Weighing the advantages and disadvantages of pipe burial, it was concluded to bury the pipeline, and to include valves at regular intervals along the pipeline for testing and repairing small portions of the line at a time.

Sustainability Issues to Consider

Upon completion of the initial construction and implementation of the water system, the village of Miramar must consider future variables to ensure project sustainability. The issues that could potentially affect the sustainability of the project in the future include: increased water usage resulting from more accessible water; the need for regular maintenance on the system; and the possibility of a dramatic change in population.

The first long-term sustainability issue is the potential for an increase in water usage as clean water is more easily accessible. Water conservation is something that may be promoted through education of the community so that villagers are aware of the capabilities and limits their water system. The villagers must be taught that there is a finite amount of water that can be used and the capabilities of the water system are

limited. For example, it is not the intent of this project to provide irrigation water for crops in times of low water, but rather, to provide clean drinking water to the people of Miramar. If the potable water provided by the project is not used for its intended purpose, the success of the project in the future may be jeopardized.

Secondly, the community must be prepared to perform regular mechanical maintenance to ensure a functional water system. As with any project of this nature, there will be components of the system that may break or malfunction and will need replacing over the 20-year life of the project. It will be necessary to keep spare parts, such as those for the pipeline and the chlorination system, to ensure a functional water system. As with any project of this stature, such repairs will require both time and money. In Miramar, community involvement is apparent as the villagers perform all of the manual labor involved in constructing the system and, in addition to time, have donated both supplies and money, proving Miramar's commitment to the project. As long the villagers are aware that their maintenance responsibilities to the water system will not lessen once the project is complete, the system will enjoy a long and productive life. Regardless of how committed the village is to ensuring a functional water system, Miramar's somewhat unreliable economy may make large repairs difficult if money is not available. To ease this concern, Miramar, with the help of Alex Uriel del Cid Vásquez, may be able to obtain sustainable funding through the government of Honduras.

Lastly, there is a possibility that the village of Miramar will experience a dramatic increase in growth, due to the construction of a road or other radical change. Should this occur, the original design of the water system will not be adequate to support such an increase. Although some changes may be beyond the control of the village, for those that promote community involvement, Miramar must consider all of the potential results. One such result from increased development is a healthier economy, facilitating the construction of a larger water system.

Modeling Sustainability in Miramar

The previous sections have outlined the nature of practices, both sustainable and unsustainable, in the village of Miramar. The following section describes the development of a conceptual model for evaluating sustainability in Miramar. In addition to the production of the conceptual model, there are recommendations for future field studies. The data acquired during these trips could be used to develop a more quantitative model of sustainability.

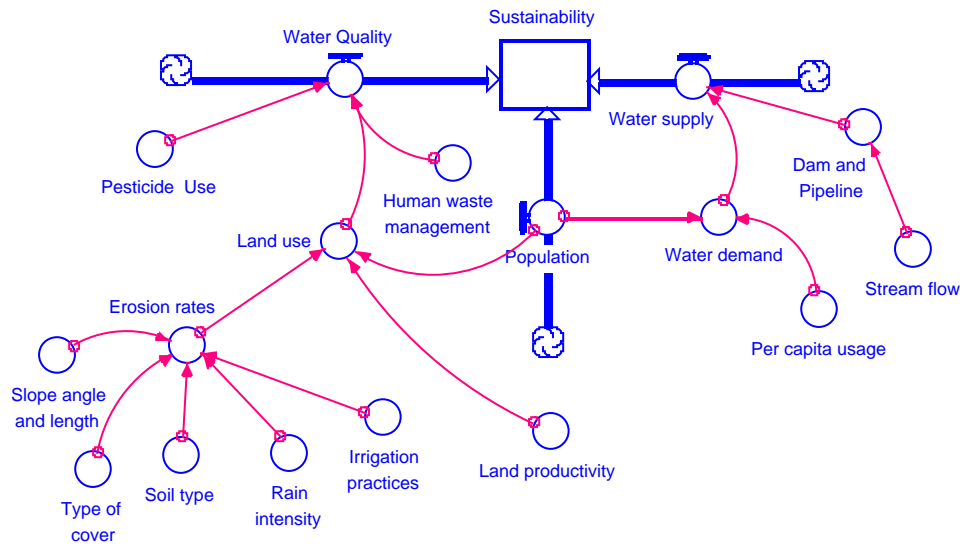
Model Foundations

While Miramar has developed a relatively secure (assuming no upstream development and limited population growth) water delivery system, numerous other resource challenges exist in the community. Issues such as soil erosion rates, human and solid waste disposal, and population growth must all be integrated into a model that attempts to evaluate the sustainability of the region. A truly sustainable system should include the land and water use recommendations discussed in the previous sections as well as ensure

that neighboring communities' water supplies are not destroyed by irresponsible practices.

Figure 4 is a schematic of a conceptual model of sustainability in the community of Miramar, based on the STELLA approach (Deaton and Winebrake, 1999). The model uses population growth, water supply and water quality as the main pillars of sustainability. The previous sections have proven the necessity for sustainable development in Miramar, and we believe this model provides an acceptable framework for guiding future efforts and evaluating their success.

Fig 4. *Conceptual Model of Sustainability*



Limits of the Model

Although the model focuses on water resources and hydrology issues, there are a multitude of variables that need to be included. For example, one would have to address not only the erosion and water quality effects resulting from the conversion of cloud forests to agricultural uses, but also the effects on biodiversity, ecological stability and local economic effects.

Future Work

Future field studies/development work should gather the following data to ensure that a more quantitative model is produced:

- geomorphic data that can be used to estimate historical stream flows;
- land use data, such as the average acreage farmed per resident of Miramar and the total area occupied by each crop type and land use type such as grazing;
- soil data such as infiltration rates, particle size distributions, and percent cover data for various land uses, so that more accurate soil loss calculations can be performed;
- turbidity and nutrient concentration data along various reaches of the local streams;
- fecal coliform counts along various reaches of the streams including at the residences of the downstream users; and
- erosion pin measurements.

A project, such as the one undertaken in Miramar, encourages these small villages to think about the sustainability of their community and how all of their systems are related into each other. For example, understanding how septic systems affect drinking water and how farming practices effect long-term erosion and production of the land will help to sustain Miramar and other communities like Miramar.

UNM Water Resources: Student Perspectives

The WR 573 class of 2001 is exceedingly grateful for the opportunity to help the community of Miramar. Although we feel that the trip was extremely successful, it is the first trip of its kind in the Water Resources Program and has room for improvement. Because this has been a new experience for all involved, the experience has allowed the class to retrospectively think of ways to improve future trips. Most importantly, it has been observed that increased preparation would be the most beneficial development to the WR 573 class.

Enhanced Course Work

Having now had this unique experience, and in planning for future such classes, there is an obvious need to begin the entire process at an earlier stage. While donating time and physical labor is a worthwhile investment both for the student and the village involved, both sides can gain more if the concepts and problems of rural water development are brought up and explored ahead of time.

From the students' perspective, this entails obtaining exposure to such issues in the classroom before even contemplating going abroad. There is consensus among the WR 573 class of 2001 that there is great opportunity for introducing these concepts into the other core courses without altering their focus. Many of the issues taught in WR 571 (the first interdisciplinary core course *Water Resources I - Contemporary Issues*) for example, have relevance in the type of work that Alex Uriel del Cid Vásquez has been conducting. It would complement the rest of the curriculum well to introduce either issues that are

currently being faced by him or someone else doing similar work, or that previous WR 573 students experienced first hand. Topics, such as identifying the needs of a community, what legal rights they possess, regulations currently in place, potential funding mechanisms, environmental impacts, and overall feasibility of a project are just some of the issues students wrestle with in WR 571. These are among the same issues faced by Alex Uriel del Cid Vásquez and others like him in their work.

Broadening the WRP Scope

UNM students may assist technical managers, such as Alex, in actual design work such that the students act as consultants to help solve real life technical issues. If the program can remain in contact with Alex and extend our network to other technical managers in other rural communities, we can act as an extension of knowledge for those people. Water project managers may contact Dr. Michael E. Campana, the Director of the WRP, to solicit a class in order to solve a technical problem or to brainstorm about an issue. This would give students practical experience in real world concerns that rural communities deal with everyday. This type of project may, at first, be integrated into the existing core of classes for the WRP, and with time, assuming increased popularity, an independent special projects course could be developed. Such a class would focus around solving one aspect of a water supply project, be it a delivery system design, watershed assessment, etc., to work on new or growing issues of a rural community.

Additionally, based on our trip to Honduras, students could use actual data collected from previous trips to recreate problems or to solve for the first time various problems that a community such as Miramar may have. Using factual data from such a village, including GPS information, a study of the economy of a village, and the resources available to them, a comprehensive water management plan may be developed and forwarded onto the respective technical manager. This would serve to solidly connect the student and his or her academic work at UNM with the real world problems experienced in Honduras and elsewhere. It would also yield continuity and provide invaluable insight into the variety of implementation issues that arise, and allows a student to actually put an academic exercise into practice. Equivalently, the benefit to a project manager like Alex Uriel del Cid Vásquez would be substantial.

Cultural and Practical Lessons

In addition to the obvious academic benefits that the WR 573 class has experienced, the class has greatly profited from the opportunity to live and work in a different culture, and witness first hand how that culture operates. There are several practical factors that can help UNM Water Resources students to be better prepared for trip such as the one described in this paper, as well as reduce the impact the we have on the people we visit.

When entering a new culture, especially one in the developing world, it is always imperative to understand that culture as best as possible. Our “invasion” of Miramar was miraculously without major incident, due mainly to the village’s hospitality and willingness to overlook *gringo* shortcomings, and also because of the sensitivity that the students themselves exercised. Unfortunately this does not always happen, and it is

always prudent to examine the place you are visiting and the people you are taking in order to ensure the least amount of negative impact to each.

Knowing the culture you are entering is imperative. Because of the melting pot America is, it has a general cultural attitude of “anything goes.” But this is not so common elsewhere in the world. Often, cultures with rich and ancient histories are bound by traditions which, when broken, can be a major affront to society. Knowing what these traditions are, such as appropriate greetings, guest/host relationships, inappropriate body language, proper male/female interaction, dress, and so on is extremely important if one is to interact positively within the status quo. A failure to recognize these, often subtle, nuances in etiquette, can cause great rifts between visitors and locals and make communication between the two difficult and icy. However, when the cultural traditions of the local community are observed, it can open otherwise difficult doors of communication, establish trust, and go a long way towards making a making both sides feel respected and valued.

As if cultural differences were not complex enough, language barriers take that complexity one step further. Student humility and flexibility are essential to ensure that misunderstandings are mitigated as best as possible since the local people may not always be so accommodating.

A balance of knowing what to expect, without having any false expectations, is another key to moving gracefully into another culture. Knowing what to expect helps one prepare appropriately for the situation, such as bringing food that the local people can recognize and prepare, or bringing only the necessities if you are staying in a place that is poor. False expectations are usually the downfall of an individual and the root of most culture shock. Overall, is it best to investigate all aspects of place and come amply prepared, but leave all assumptions on the airplane? The only expectation that is ever safe to have is that you will encounter something different.

UNM Water Resources students have a great deal to gain from an experience such as the one described in this paper. The WR 573 class trip to Honduras this summer served to consolidate all that we have learned in the WRP, and more specifically, pulled together the two other core courses, WR 571 and WR 572 (*Water Resources II – Models*). This course combined the all the aspects faced by a community when dealing with water issues, such as economics, politics, resources, and technical knowledge. In addition to the academic value of this class, the students were able to experience a completely different culture, allowing a lesson in humanity, as well as in water management.

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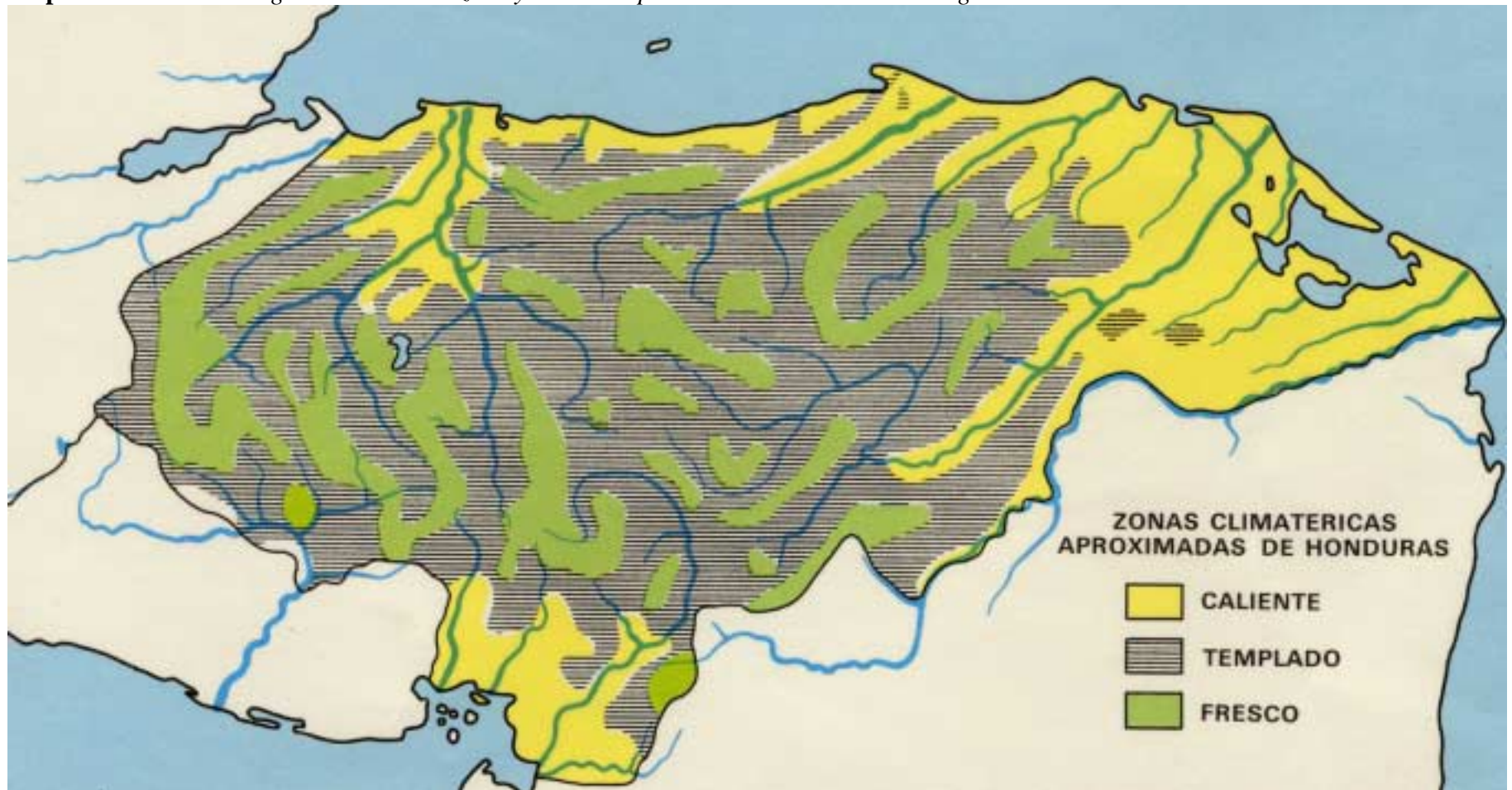
Appendix A

Maps

Map 1. Topography. In the location of our study site there is an average difference of 600 meters between the peaks of the mountains and the adjacent valleys. The majority of the gradients are between 30-45%. The largest gradients exceed 45%.



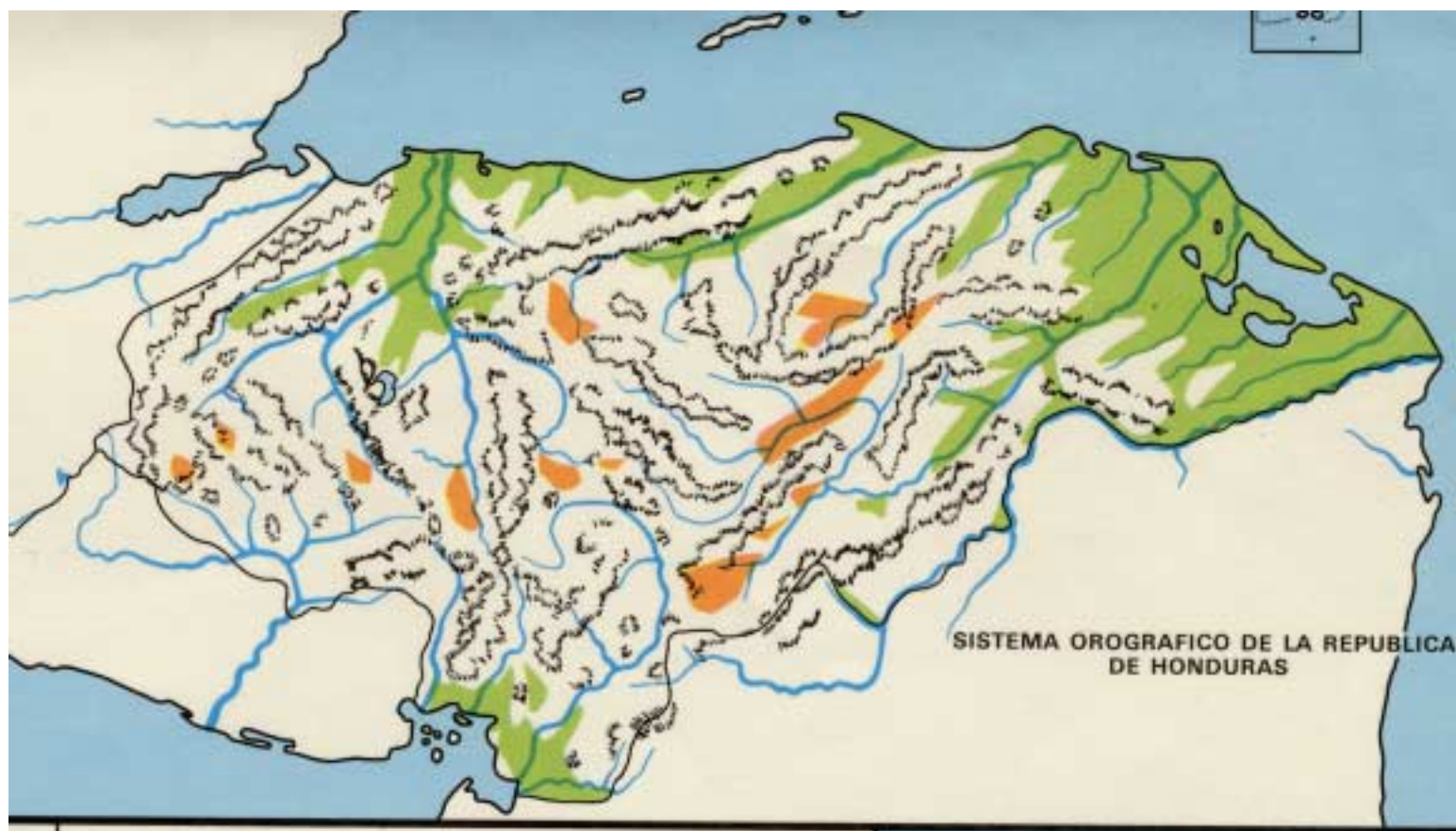
Map. 2. *Climate. This region is characterized by hot to temperate climates with increasing altitude.*



Map 3. Precipitation. Tropical rains (May-September) with a regular/temporal distribution of rainstorms. The absence of rain gauges in this region makes it difficult to assess actual rainfall.



Map 4. *Water resources. The Miramar region is dominated by the presence of springs and seeps that provide citizens with access to fresh water for human and animal consumption and household needs. There is a delivery system in place, however it needs to be expanded to further provide access to potable water.*



Map 5. Land Use/Vegetation. *Miramar and the surrounding localities are comprised of dense woodland, primarily continuous areas of dense broadleaf evergreen forest. Agriculture exists on hillslopes and in the fertile valley of this region. The current levels of agriculture are sufficient to meet the demands of the population, however, with an increasing population, the land will not be able to support current agricultural practices.*



Appendix B

Social Sustainability

Social Sustainability

The community's ability to sustain itself socially is divided into formal and informal structures. Miramar presently sustains both of these structures. Miramar is approximately 60 years old, and has continued to have a sustainable population growth over the years. The village's remoteness requires a strong work ethic by the villagers in order to survive without modern conveniences and to make the village sustainable.

The formal community within Miramar includes churches, a school, the Women's Club, and the water advisory board. Two churches are within the village: one Protestant and one Catholic. The village does not have its own pastors/priests so a lay person from the village performs services on a regular basis. The priest serves several villages in the area and visits Miramar once a month. The churches have a mid-week service and a service on the weekend. Each church holds approximately fifty people; each has its own building.

The village's children are educated in a two-room schoolhouse that was built in the late 1990s. Prior to this, school was taught in a smaller building. Children begin school at the kindergarten level, and continue through the sixth grade. If they wish to continue their education beyond the sixth grade, they must leave the village. Schooling outside of the village is costly, because it requires paying room and board. Therefore, further education is often too expensive and difficult to achieve, and the educational level of most villagers is at a sixth grade level. Approximately 60 to 70 children attend the village school. The Honduran government pays for the two teachers' salaries. School uniforms are desired; however, many of the children can not afford them.

The community is strongly supported by the Women's Club, which maintains a cooperative of small coffee producers and acts as a rural bank.

The towns and cities in Honduras experience frequent theft. There are military checkpoints on major roadways, which help to improve the safety of the citizens. However, Miramar maintains a zero crime rate. Crime is not even an issue, because of the remote location of the village, and the ability to recognize outsiders immediately. The villagers are quite happy and content with their daily life. The villagers appreciated American students' desire to improve their water supply. The Honduran government has not participated in any of the water improvements, except to provide some materials.

Miramar grants land to new inhabitants of the village. When land is given to a new villager, they are expected to make improvements, including a house and some form of farming.

Medical care is limited within the village, as a result of its remote location. Villagers medicate minor wounds with indigenous plants and iodine patches. There is also a house with first aid supplies. The supplies include a first aid kit, pain medicine, crutches, splints, and stretchers. In the case of childbirth, some women will travel outside of Miramar to Omoa to deliver. Otherwise, they have a home birth. Unfortunately, Honduras does not have adequate medical care; therefore, even traveling to the city does

not promise adequate medical care.

A recent formal structure that developed within the community is the water advisory board, created because of the water supply project. Each dwelling hooked up to the water supply network requires the family members to donate a certain number of days to build and maintain the project (similar to Habitat for Humanity). The board keeps track of the days that individuals work on the project. The board also collects each family's share of the project's money. The board helps to keep the members informed of the project and what work needs to be done.

Miramar's informal structures are a result of the environment: location, weather, population, and livelihood. These informal structures are represented in their way of life. Traveling within the community is by foot, horse or mule. Houses are closely spaced, and children play freely with their neighbors. The community's livelihood is dependent upon its ability to raise crops. The villagers are subsistence farmers. The community is very homogenous. Everyone lives and works there. With the above-mentioned formal and informal structures, Miramar is capable of being socially self-sustaining.

Miramar is approximately sixty years old and prior to this time was an uninhabited forest. The village has continued to grow, and Alex's plan is based on a 4.5% annual population growth. Based on this population growth, the village appears to be sustainable. The villagers are able to maintain a simple modest way of life. They are able to provide food and housing for their families, and they are able to sell a small portion of their crops to communities along the ocean.

The implementation of the water delivery system will help to improve the sustainability of the village. Improving the water quality and actual delivery of water to the households will help raise the standard of living.

The fact that the community is self-sustaining does not exclude their need for improvements. Some of the villagers expressed their desire for an improved road to the ocean. The current path is dirt and rather steep and one can only travel it via horse or mule or on foot. The trail is approximately seven kilometers from the beachside community of Masca. However with an improvement in the road system, there could be an increase in population and other problems, which could result in limiting the sustainability of the village. It is possible that people from outside communities could move to Miramar for safety and farming.

With any new project, there will be pros and cons. The water project has thoroughly considered possible ramifications of improving the village's water supply, which were discussed in the contract submitted to the villagers. The water advisory board was required to sign the actual document and promise that they would uphold these rules and regulations within the village. An example of one item the contract addressed was the use of the water: it is to be used only for household purposes. The water is not to be used for crops or in the harvesting of coffee beans.

The goal of the water project is to supply clean water to the households, with the assumption of a population growth rate of 4.5% per annum. This system was constructed to have minimal changes on the villagers' way of life, and to improve their quality of life without detracting from their social structures.

In conclusion, the social sustainability of Miramar is maintained by formal and informal structures. These social structures of education, religion, the Women's Club, the water advisory board, and the cooperation between families and neighbors, are imperative to the sustainability of the community.

Appendix C

Personal Insights

Jessica Bentley

We arrived in San Pedro Sula on the afternoon of June 14. Clearing customs, we emerged into a hot, muggy, crowded, and chaotic scene. Soon enough however, Rolando López (the trip coordinator from the Honduran side) and his son Guillermo are able to locate us, which I am sure was not difficult as we all look like the ultimate tourists with our trendy American sports gear, not to mention many of us are taller and paler than your average Honduran.

Immediately, we are separated from our luggage and herded into two vehicles, one driven by Rolando, and the other driven by Alex Uriel del Cid Vásquez. I am fortunate to share the front seat of the minivan, driven by Alex, with a young woman, Doris, from the village of Miramar who is continuing her education in the larger town of Omoa. Because we don't speak each other's languages, we mostly just smiled a lot and communicated via lots of hand waving. You can communicate quite a bit that way. The first stop is PriceSmart for groceries.

I think that the general feeling among the group was slight disappointment as we were all anxious to experience every aspect of the Honduran culture and PriceSmart wasn't exactly what we had in mind as it's like any superstore in the States, with the exception of the heavily armed guards. Nevertheless, we loaded up with what turned out to be a ridiculous amount of food, especially cereal, which I had nothing to do with (oh, except those three boxes of "Fitness Flakes"). We checked out and packed-up in the vehicles.

The minivan is plenty comfortable and quite an entertaining vehicle to ride in as most of my other classmates are with me, and I am, after all, in the front seat with a window. We stop for gas, which always seems to be a given on any auto ride in Honduras. The next stop for our group is the municipal building of Omoa, a town near Masca. We are not quite sure what we are doing here, although we think this is where we are to meet the other truck carrying our professors and two other classmates. While we wait, we hang with some of the locals, get a 0.5 liter Mirinda orange drink from the Pepsi stand near the road, and (the best part) we get to meet the mayor of Omoa! He thanked us for being there and for helping the local community. The truck carrying our luggage, but not our cohorts, shows up and informs us that we have been waiting in the wrong place. Now, we are really off to Masca.

Many people and their mules greet us at the road to Miramar. We are each assigned a mule and are lead up the trail, into the jungle. Pedro, an older member of the Miramar, is the owner of my mule. I asked him what the mule's name was and he just laughed and exclaimed "Caballo!" Oh, of course. The trip to Miramar is breathtaking. Completely tropical with huge trees and hanging vines, ferns, flowers of many type including bright orange and red bird-of-paradise, and countless other organisms. Once in while, we would reach a bit of a clearing and look down over the ocean and the beach butting up to jungle. My mind was brimming with excitement and a little nervousness. Four hours later, we arrived in Miramar.

A dinner of beans, rice, eggs, yogurt, and corn tortillas are served to us. Delicious! Being completely beat, we are all eager to settle down for the evening. Our luggage arrived shortly after we did, mine, however did not make it up that night. No matter. All I needed was a flat space to crash. The four women in the group are taken to the teachers' house, Gloria Fuentes. Gloria and her daughter Nancy are both teachers in the village. Mario, Gloria's husband and Maudy, the youngest daughter, also live in the house. We were overcome with appreciativeness to see that they had a private room with two beds for us. The next thing I remembered was a holler from the family rooster at five in the morning and the smell of corn tortillas on the grill. It was time to see Miramar and the treacherous hike to the dam site. That's a whole other story....

Barak Bruerd

I have always loved the third world having spent most of my life overseas. The benefits of a third world experience such as our recent visit to Honduras are numerous and priceless. Each time I go overseas I learn new things and find myself expanding. And while they are sometime hard to describe, there are several things that I think are most important.

Understanding the 'real' world – the chance to go to the third world gives students an understanding of what most of the world faces every single day. America is unique in the world, along with a handful of other first world nations, in that its population as a whole is protected from the harsh realities of life. Most of the world lives a hand-to-mouth existence, children owning only one pair of shoes, if any, no clean water, no health services, a staple diet with little variety, and so on. It teaches students how much we can do without, a fact which Americans, consumers of over 50% of the world's resources, would do well to remember when it complains about conservation laws, or regulations on such commodities as water.

Cross-cultural awareness – Lets face it, America, for the most part, is a unilingual race with very little exposure to other cultures. In an ever-shrinking world, dealing with people from other cultures is becoming almost commonplace. Being able to identify with other mindsets, worldviews, value systems, and logic, as well as tolerate those cultures that seem almost contrary to our own, are skills that are in increasing demand. And while America may be viewed as either a positive or negative role model by a nation, there is no dispute that the planet is slowly becoming an English-speaking, franchised world. Experiencing the beauty of diversity that other nations have to offer is a step towards preserving their uniqueness.

Character building – We live the land of instant gratification and mass consumerism. A land where rules, rights, and the second hand on the watch reign supreme. Growing up with these values often makes it difficult to transition to a country where time has little meaning, there is only one brand on the shelf, and it's usually backordered three months (and arrives infested with cockroaches). A third world experience often goes a long way towards developing patience and flexibility. At the same time, seeing the mass poverty which so many people live in day in and day out instills a much greater sense of compassion that can never be created by a commercial or TV documentary. To further then experience the hospitality and generosity of those impoverished people and realize what kindness really means... that can be life changing, not to mention the revelation of just how much we in America are blessed with.

Hands-on experience – There is no substitute for engaging in a real life project with real life problems and solutions. Most of the classes that hydrology students take work with formulas, theories, and hypothetical situations. They can be manipulated or changed to fit the desires of the students or eliminate the presence of a problem. But more than that, they hide many of the true obstacles in a project – the problems of implementation or the importance of relationships, professional and personal. The project at Miramar

demonstrated the high priority of long-term planning and relationship building. It showed that problems can arise that are not anticipated, and that solutions are not always as simple as they appear. Giving hands and feet to a real project also instills a great sense of satisfaction, especially when it helps someone who desperately needs it.

Michael Gabora

The field problems course and the associated trip to Honduras was a fantastic opportunity to gain “hands on” experience in the field. I gained a great deal of appreciation for the difficulty in actually implementing a water resources project. Throughout my career at the University of New Mexico I have learned about how to evaluate problems, model them and then design some type of solution. The Honduras trip illustrated to me the magnitude that planning and community relations play in making such projects a reality.

It was very clear that Alex had spent many months working with the community, selling the idea, encouraging residents to participate, and organizing the local work force. This is in addition to the time spent coordinating funding and material acquisition etc. It seemed as though the technical aspects of the project were actually the least time consuming portion. It was very clear that motivating the community and developing a relationship with them was the most difficult aspect of the project.

Perhaps the second most valuable aspect of the course trip was realizing just how much work remains to be done. While the village of Miramar may have a reliable source of clean water in place, it still has many other water resource and environmental challenges. For example, there exists a clear need to develop and share knowledge regarding sustainable agricultural methods. The extremely high erosion rates resulting from poor agricultural techniques have serious ramifications on water quality and the longevity of the productive life of the land. Any land use hydrology class illustrates that watershed planning should be employed in order to minimize the risk deteriorating water supplies for the down stream users. While it is easy to learn about how to plan such things, the experience in Honduras illustrated to me how difficult it would be to implement it Miramar. When one experiences what the day to day difficulties for these people are, it puts into perspective how much effort is necessary to implement solutions to their water and environmental problems.

Beyond the water related aspects of trip was the chance to experience such an exceptional group of people in the village. They showed us incredible kindness and hospitality, and their friendship was the most rewarding aspect of the trip.

Steve Kolk

My expectation of Honduras, the people, the work we would do, and what I would gain from it were quite vague. I knew that the culture would be foreign, and that the work would be basic, and I had hoped that the experience would be rewarding, but I didn't count on it opening up my eyes in another way. Instead of feeling sorry for people who had less than I did and desiring to help them live a more "civilized" life, I noticed myself appreciating how simple their life was, and took back with me a more critical outlook on what is often described as the excesses of America.

The contrast was stark from the moment we touched down in San Pedro Sula. Suddenly we were immersed in a world where we looked different, talked different, and felt fairly helpless. I'm sure this was obvious to the locals, who were either helpful or paid us no mind, but that didn't diminish the discomfort of being a stranger in a strange land. We came to trust our hosts quite rapidly. We had to, because in no time our luggage was all tossed into a truck, and drove away. Then the bulk of us crammed into a minivan with our driver and project coordinator Alex (although I don't think most of us realized his role in the whole process at the time) and drove somewhere, we weren't sure where, with someone we couldn't communicate with.

Although our first stop was a disappointment (we had hoped we had left the commercial trappings of places like PriceSmart back in the States), as we headed toward the trail that would take us to Miramar there wasn't one among us who wasn't wondering what in the hell were we getting in to. Soon enough, we found out. After taking mules way up into the coastal mountains (and those of us with an apparent aversion to equines walked), we came upon a collection of rustic dwellings that would serve as home for the next week. It was dark when we arrived, but dinner was awaiting us. When we finished the meal that was to be a staple for the next several days, we retired to the schoolhouse where the majority of the gringos would sleep. It was a long way to have come in one day, and although I'd traveled greater distances in a 24 hour period, in reality I'd never traveled farther.

Now, if that introduction doesn't sound too cheery, rest assured that the remainder of our trip was nothing short of the most incredible experience of my life. Being a rather adventurous type myself, and deeply involved in water issues, as evidenced by my participation in this program and my employment with the U.S. Bureau of Reclamation, it was incredible to be able to participate in the type of project that one would be hard pressed to find at home. We helped Alex and the village in siting and excavating the location for a tank, we saw and help prepare the dam site and traced the path of the pipe that would carry water from it, we met the future recipients of the water from this project, and we helped cut and thread various types and sizes of pipes for the individual services. Although we were there merely to plug in as labor, it was impressive to see how the project had been brought together. Sometimes, in this country, we tend to feel bogged down by bureaucracy and red tape. Well, at least somewhere in that mess is an infrastructure that enables public works projects to happen. But in the case of Miramar,

there was no governmental leadership or funding, just the determination and efforts of one individual with incredible vision. It truly left a lasting impression on us.

As I alluded to in the first paragraph, our experience in Miramar gave us an appreciation for a simpler way of life, and made us think about issues that hold true importance. Our farewell meeting with several of the villagers we had come to know only reinforced that point. They expressed their gratitude for all of our assistance, when it was really us who needed to say thanks. As we left our friends and headed down the mountain, I was pretty sure that this wouldn't be the last time that I would find myself working in such surroundings. And I know that my experiences there will influence the way I go about business here at home, as well impact my daily life.

Eric Riebsomer

The first thing that came to mind when I learned the class was going to Honduras was, “what a great idea for a capstone field course.” I wasn’t sure what to expect, so I did a little research and learned several things, the first thing was that during the time we would be there, it is very hot and humid. I learned that Honduras is one of the poorest countries in the world. With that in mind I did expect to see lots of poverty, small rundown homes, people with no homes, and people begging or even stealing money from the americanos. Because of the climate being hot and humid, I did expect to sweat a lot and have to fight off many big bugs (also something that I learned while reading my Honduras book). As far the village where we were going to work at was concerned, I had no expectations. All we knew was that it was a small village up in the mountains and that they had a water project they needed help with and we were going to help them in whatever way they needed.

When we arrived in San Pedro Sula, the first thing I noticed was the landscape around us. It was very beautiful, lots of deciduous trees and lots of green vegetation. The city is one of the larger cities in Honduras so there were quite a few people and vehicles everywhere. The airport was small, crowded and very chaotic. Once we were all able to get our luggage, which took a while, we met with the people we would grow to trust and rely on while we were there. From the airport we began the first part of the journey, which was a ride in an old cramped Toyota Previa van (which held 8 of us, the others were another vehicle behind us) to what is analogous to a Sam’s Club. This was very surprising to all of us because we did not expect to buy groceries in such a modern place. It had everything you could buy in the U.S. Here we stocked up on food that we would give to the villagers who would do the cooking for us while we were there. Once we were done buying our food, we began an approximately 1-hour journey to the location where we would travel up to the village. On the way there, we saw a lot of poverty, we saw military personnel armed very well and in the midst of it all we saw a very beautiful country. When we arrived to the location where we would begin the next stage of the long trip we noticed many burros with guides. Apparently they were for us. The villagers were afraid the trip up to the village would be too difficult for us. So we mounted up on the animals and began the trip up. The trip to the village is approximately 4 miles with a vertical ascent of 1000 meters. If you think about it, that is incredibly steep. As some of us would find out after giving up our ride! It was very humid and very hot! As the three-hour trip wore on, we finally arrived at the village after dark. The first thing we encountered was food. They were kind enough to have dinner for us: scrambled eggs, refried beans, and homemade corn tortillas. It was very good and we were very grateful for it. After dinner the men made camp in the old school building for the rest of our stay at the village. From that time on, we became not only the villagers guests, but part of their community.

It was the second day that we really began to develop a sense of what was going to go on for the next several days, and what the project entailed. Basically the project was to build a small dam that would capture spring water. From there it would be piped to a 5000 gallon holding tank, and then piped to the individual houses (approximately 45). At this

point only some of the material had arrived, which left us to help with preparation of the dam site, tank site and many other initial tasks that needed to be completed. Once we learned of what we were going to be involved with, we took a hike to the dam site. Everything was either straight up or straight down, so the hiking was fairly difficult. As we hiked to the dam and followed the route the piping would follow, we began to realize how difficult the project was and all the work that would be necessary to complete the project. Our class would only be a small part of the whole. When we got back to the village we realized there wasn't much to do, the material was slowly filtering up and much of the work we could do would come later. So we waited. When the material did arrive, we broke up into two groups, one day one group would go up to the dam and prepare the dam site footings, i.e. digging, placing rebar, and doing other tasks such as that. The other group would stay at the village and thread and glue the pipe that would eventually carry the water. Then the next day we would switch. For the short time we were there, we did help as much as we could, and I believe the villagers appreciated our help very much.

What did I learn on this trip? I learned a lot. As far as the work goes, I learned about the needs of another country. I learned about working in a different climate, one that is more harsh in many ways than where I am from. As for the work, well some of the techniques are probably old compared to what we are accustomed to, but for them they were very appropriate and necessary. It was the people that I learned the most from. The villagers that we were able to interact with through translators, and the times we were able to just sit around and watch the children play soccer or be at school recess. These are the real learning moments. The people in the village of Miramar were very gracious, very hard working, and very community oriented. Many of the good qualities that you miss in many of the Americanized communities you see around us. This whole project's success was dependent on the participation of the villagers. And to see the community pull together to make it happen was nice. I know it was not easy to get the support, and I know they were still trying to rally even more support, but I believe they will succeed. I learned how fortunate we, as Americans are when it comes to basic needs such as sanitation and clean water to drink. These people do not have that luxury, although they will have something better than what they have now when this project is finished. I learned about true determination and survival, and that as a community they will make it. I believe this trip will compel me to do these types of projects in the future, not just for a class credit, but as someone simply to help others.

In closing, I would just like to say that the trip to Honduras, to be apart of this project and help the people of Miramar, was one of the best things about the Water Resource Program. I hope and encourage anybody in the future classes to be apart of whatever projects may come in the future, wherever they may be. It will be very rewarding. As far as anybody involved in supporting programs such as this goes, I encourage you to offer whatever help you can to enable future students to be impacted in such a beneficial way like I have.

Rick Shean

My first impressions of Honduras were formulated after we had landed and found ourselves packed in a small van headed to the trailhead where our group was to meet with the mules and their guides, who would be carrying and leading us, respectively, up to Miramar. We passed several soldiers posted along the highway between San Pedro Sula and Omoa, which later was explained to us, was a result of federal government measures against increased robberies on the highways by local gangs. It was apparent after the first few hours on the road that there was an economic disparity between rural and urban populations.

Living within the village was a priceless experience. Eating native food, hiking through dense, tropical vegetation, and a mule ride up to the village were highlights of my time in Miramar. Communicating with the villagers in broken English and Spanish, although difficult, was rewarding once the message was understood. After the first full day of moving around the village I was in awe of the excellent physical strength the villagers had, travelling up and down the road everyday to get to the fields or to the coast. The workers had very defined muscles and proved to be very strong in field. Although strong, villagers also appeared malnourished. Children looked four to five years younger than they were, and adults grew to only about five and half feet tall at most. Observing the villagers grow, harvest and eat their food made me appreciate every meal I was served, and wonder if I was taking nourishment from anyone of them. I tried to eat everything put in front of me.

My anticipation for our course work in Miramar, Honduras was that whatever we plans our group made for fieldwork would change drastically once we had arrived to the site. I was right. Miscommunication between Michael Campana, Rolando López (our unofficial sponsor) and Alex Uriel del Cid Vásquez (our field boss) created a different work schedule than we had designed for ourselves in Albuquerque. Our class had originally planned to spend 3 days working side-by-side with the villagers, building their water supply systems, that consisted of a small dam, pipeline, storage tank and distributions network. Instead, we did manual labor for the extent of our stay.

The labor was rewarding and hopefully useful to the villagers, but I was unsure as to how our experience could be used for the course. The most grueling day of field work was the day Eric, Andrew, Michael G., Barak and I went to the dam location to help build the rebar supports for the concrete foundation. It took us about 1 and a half hours to reach the site (twice as much time as it took the locals) without the midmorning clouds rolling on our ridge, that we had grown accustom to being relieved by during our long hikes.

Nightfall came quick and shortly after dinner, we would all go to bed. It was dark by 8:00 pm and not much to do, except take sponge baths, hang up wet clothes, and play a short game of cards using a “Star Trek” commemorative deck. I fell asleep seconds after hitting my pad. No real excitement during the night, other than Mark’s “sleep yelling.”

The community of Miramar apparently was having problems with getting labor help from the households that wanted water service. The laborers that we worked with were eager to get the project finished and didn't appear to have a moral problem. However, during the last community meeting Alex's speech hinted at an existing struggle to get all of the community members that wanted water distributed to their house, to work. This was a requirement of the program and obviously was hindering the progress of this project. During the first meeting with Alex, he mentioned that financial support for the project had been pulled by the funding agency. He was unable to pay labor for their help. During the last meeting, Michael Campana gave the community a substantial amount of cash for their project, which added to the amount of money he gave to Alex earlier in the week. I hope it was enough to continue the project through its completion.

The water project did appear well planned and it was hard for us to find any problems with the overall scheme. We did, however, find technical problems, such as the location of the supply tank and the threading and burying of the PVC portions of the 1 ½ mile pipeline. Using PVC was okay, but Alex planned to bury the PVC portions along the pathway's course to keep it from being burned by farmers clearing their land. This creates obvious maintenance problems, especially if the PVC is threaded. Water system planning accounts for population growth due to normal birthrates, however, the introduction of incoming residents attracted by the new water supply didn't appear to be accounted for. The sustainability of this system is questionable, therefore further research and planning for this should be done before any more large investments are planned for Miramar.

I would recommend to future students that may come back to Miramar or another village to assist with a similar project the following: Allow work schedules to be flexible, but make sure you are able to meet the objectives that were planned for in the research project. Enjoy the "down time" and be prepared to "hurry up and wait." Before going, make sure you build your stamina and be prepared for a lot of hiking and physical work, and common courtesy goes a long way.

Mark Van Eeckhout

Expectations For Honduran WR 573 Trip

Before our class left for Miramar, we were asked to draft up a paragraph or two discussing what we expected from the trip to Honduras. Even though I did not write the assignment until I was in the village, I gave a great deal of thought to the question. I did not want to set myself up for a failure so I had prepared myself for a number of different outcomes. In the past I had traveled to third world countries including Guatemala and Peru, but never on a trip such as this one. We were going to be spending a good deal of time in this small village and trying to help them prepare for their future. This was a lofty goal that I wasn't exactly sure where we fit. I thought to myself that the most helpful we could be was in helping Alex with the design of the water delivery system. I was not sure that we would be able to provide this village with much labor help. Even though I had these reservations I still figured I could learn a great deal about a different culture and get the opportunity to see a community struggling to meet some of the most basic of human needs.

Impressions From The Honduran Trip

After spending seven days in the village of Miramar, I went back and thought through what went as I had originally expected and what was totally different. Since I had prepared myself for a large number of outcomes there were no really earth shaking surprises. I learned that my classmates were tougher than I had originally thought.

I believe that although we as a class did do a good deal of manual labor on the project, that our presence there was one of the most beneficial aspects for the community. By just showing up and spending seven days in a village that was far from anything we would have stayed in the states, we showed the individuals in the community how important it is to pitch in to support the community effort. This seems to have been somewhat of a driving force for some of the labor in the village.

In addition, there were a few changes to the overall plan of the project that needed to be questioned. Alex for the most part had covered most of the basis from a technical aspect, but I think it was helpful for him to be checked and reassured of his design process. As it turns out we did end up moving the tank sight on him and questioned him about other aspects of the project, which he chose not to change.

There were a few observations that I made of somewhat of a personal level that I can also share. The village seemed better off to me than other villages I had seen in third world countries. Although the village was very poor, they had good access to food and as far as we could tell through our studies access to "clean" water. The families within the village also seemed to be intact and there was a real sense of community. This is very important and in the larger cities in these developing countries this does not seem to be the case. Overall, I believe their quality of life is better than poor people trying to survive in the larger cities.

The ability to see a tropical environment that was surviving off of subsistence farming was fascinating for me. Most of my travels in the past have taken me to places that were out of the tropics and usually at a much higher elevation. This trip gave me the ability to see an environment that I had never been exposed to in the past. This is one of the best reasons I can think of to give my support towards the WR573 class making return trips to locals such as this. The students take a life experience out of a class, which rewards both the students as well as the staff.

Sherry Weber

The Water Resources 573 trip to Honduras provided me with practical experience. I learned how to develop a water supply system in a third world country, that included the designing of the water system, and the managing of the community.

I realized that this project could only be successful with the support of the community. Miramar was fully cooperative and involved in this project. An example, of their cooperation was their labor to bring all the supplies to the village. It required them to carry supplies seven kilometers by mule or their own backs. They were also involved in the actual hand labor of building the water system.

I was impressed with the contract made with the villagers. The contract has specific clauses in regard to the appropriate uses for the water. For example, irrigation of crops is not allowed, and how future water users can be connected to the system.

It was also very personally rewarding to be able to live in a small, beautiful village and view another culture close-up. It made me realize how lucky I was to live in the United States, and enjoy the financial and educational opportunities here. I also saw the benefits of living in a small village. Some of these benefits include the advantages of having a close-knit family and community. The villagers value their family and their modest environment.

This trip was beneficial in providing the practical experience of a developing community, and the implementing of a community project. I learned to appreciate all the preparations involved in developing a water system of this magnitude.

Rosemarie Chora

My trip to Honduras was quite an adventure. Before leaving the States I was mostly preoccupied with the weather, bugs and not getting sick. Looking back, these were issues that would turn out to be the most superficial of concerns. My experiences in Honduras were not like the hardship I had imagined.

Once we arrived in Honduras I began to realize how similar Honduras was to the United States. The supermarket, billboards and American products all reminded me of home. People in our group commented on how different Honduras was. Coming from an immigrant community, I felt a strong sense of familiarity.

At first I felt uncomfortable that there were armed guards in the city of San Pedro Sula. It implied danger to me. After awhile I became used to the “extra security”. It actually made me think of safety in the United States. I wasn’t sure where I was safer.

As our time in Honduras passed I started to notice how different I was within the group. I knew before leaving the States that I was the only Latina on this trip. I thought there would be issues around this, but I didn’t realize what they would be.

When we first arrived in Miramar, the local people looked at me with confusion. I looked like them, but I wasn’t one of them. I remember being conscientious of how I was dressed. I was self-conscious of my hiking boots, sunglasses and bottled water. My Dad would have laughed if he could see me arriving to Miramar on a mule. He has always thought that I am too Americanized: an outrageous anomaly of my culture. Early in my trip I was very aware of how right he is.

As we settled in and began to meet the locals, I found that people were trying to figure me out. “Why don’t you speak Spanish?” “Why *won’t* you speak Spanish?” “What about your parents?” I knew people were trying to find out what went wrong with me and whose fault it was. This didn’t surprise me since it happens in the U.S. all the time.

The surprise came from my classmates. People began asking me to translate for them. I did my best to help, but my Spanish was sorely lacking. At first, I tried very hard to get the correct translation. I struggled to get just the right words out. Most people realized my limitations and were respectful. They did their best to be independent and help themselves. Others expected (and almost demanded) that I translate. I wasn’t a professional. I didn’t even have a dictionary. At a certain point I stopped trying as hard. It took too much energy from me and I could only do so much. It was nice to talk with Julissa (Rolando López’s daughter) about these issues. She was someone throughout the week who not only understood me, but also shared the same feelings. We spent a lot of time exchanging ideas on translations and talking about the difficulties of translating.

As the week progressed, I got to meet and know some of the local people. We began to connect on levels deeper than language. There was culture, family, stories and shared experiences. I found that we had a lot in common. It was amazing.

It felt odd when I was allowed to know what the locals really thought of the “Americans”. I was shocked at first because I was one of those “Americans”. Somewhere along the line they came to see me differently. I think it was the way I looked or some of the conversations we had in Spanish. I felt torn when I was able to understand the perception of Americans through the eyes of others. There are some parts of American culture that I don’t want to associate with....but it’s still part of my American experience and part of me.

For the most part, I think my trip to Honduras was a chance to step back into a part of my life that I have been distant from. It helped me to remember what it’s like to be poor and to work hard. Being in Honduras reminded me how little I need and how much I have. What a great trip and a great life!!