HUAMANZAÑA, PERU:
Phase II Assessment and Plan for Future Projects

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Trip dates:
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with

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Dedicated to the people of Huamanzaña, Peru, who never cease to inspire us.

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Acknowledgments

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Renzo Ventura has been invaluable in his services to EWB–Princeton, and he deserves much recognition for the integral role he plays in the success of any project.

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How to Use this Report

This report is a catchall document intended for various audiences, and it serves as a repository for the many minute details and facts we have collected during our work with Engineers Without Borders–Princeton University. With that in mind, we have constructed this report in a highly sectionalized manner to facilitate ease of use. Few readers will read from cover to cover; rather, this document is designed to allow the user to skip to sections of interest with relative ease.

Nonetheless, the many subdivisions also mean that some information relevant to a technical section may also be discussed in a non-technical or community section. When this is the case, we have tried to cross-reference so that the reader is aware of the additional relevant material.

Details on logistics, hotels, and travel arrangements are included for the benefit for future EWB–Princeton trip participants and the University; they are not intended as an endorsement of the safety or quality of any of these firms.

1. Executive Summary

In December 2006 and January 2007, EWB–Princeton returned to Huamanzaña, La Libertad, Peru to conduct an assessment trip with four sets of objectives:

1. Evaluating the solar energy system at the primary school
2. Constructing and testing an efficient wood-burning stove
3. Conducting water quality testing and performing an overall site assessment
4. Fostering increased community involvement in the projects

This report discusse the findings in each of these areas, as well as gives a thorough account of the preparation, execution, and follow-up for the trip. Additionally, this document describes the logistics of travel to Huamanzaña and includes a final budget. Finally, it concludes with recommendations for how EWB–Princeton should move forward with its work in Huamanzaña, Peru.

2. Partnership with Huamanzaña

In summer 2004, Princeton undergraduate Sean McGowan ’06 visited Huamanzaña while working with the EWB–University of Colorado, Boulder team in Santa Rita. Upon returning to campus, he founded an EWB chapter at Princeton University with Sebastien Douville ’06 and other students, and a team returned to the community in June 2005 to assess the possibilities for a sanitation system upgrade. The sanitation system was upgraded in August 2005, during which time the team simultaneously conducted an assessment trip for a summer 2006 project dealing with solar lighting and a battery charging station. This second project was implemented in August 2006. In accordance with EWB–USA’s model of a five-year commitment to the community, we anticipate working with Huamanzaña at least through summer 2009.

Our partnership with Huamanzaña is based upon our complete immersion into town life as we work, eat, and live with community members. In addition to dealing in an official capacity with the town leader (currently Santos Moreno) and other adult leaders, we constantly interact with the elders, women, and children.

3. Assessment Trip Objectives

In preparation for this assessment trip, we identified four areas of investigation. For each of these areas, we developed specific objectives to guide us in our assessment and evaluate our progress.

3.1 Solar Energy Project Objectives

Background: In August 2006, EWB-Princeton installed a solar energy project in the primary school in Huamanzaña. The system consists of four panels located on the school roof, interior lighting in the school and adjacent community areas, and a battery charging station where townspeople can charge batteries for rechargeable LED lanterns introduced as part of the project. In fall 2006 we received reports from Renzo Ventura that there were some adjustments and clarifications that need to be made in order for the system to operate at its maximum potential.

Objective 1: *Bring promised instructional materials to Huamanzaña*. These materials include a troubleshooting manual and translated safety information and will be left in the care of the technical team that oversees the solar installation (Jaime, Jesus, Eduard). Use the maintenance checklist prepared by Rebecca and Elena; go through these steps with the technical team so that they are comfortable with the tasks involved.

Objective 2: *Determine what is wrong with the problematic "foco" and fix or replace it*. Determine which either bulb or lantern is not working properly and deciding what can be done to rectify the problem.

Objective 3: *Collect data on the Powerizer batteries*. Investigate how long batteries are lasting between charges and how long it takes to charge batteries at the charging station. Determine whether the low voltage disconnect is being engaged, and whether that could account for the amount of time it takes batteries to charge.

Objective 4: *Reconnect the television and DVD*, and test whether it is working within the limits of the system.

Objective 5: *Check system for any damage*. Evaluate how clean the panels and battery chargers with respect to system performance. Completely inspect the wires between the solar panels (noting in particular the condition of the insulation), as well as check to make sure that the holes around the black boxes on the back of the solar panels are well sealed with electrical tape. Find out whether distilled water has been added to the batteries.

Objective 6: *Gauge community reaction to the project*. Through interviews and conversations, discover how much villagers use their lanterns and the lights in the school, whether this source of light has complemented or replaced kerosene and candles, and whether it is worth the fee they are paying.

Objective 7: *Evaluate the appliance socket in the locale*, and determine whether it is sufficiently safe or whether it should be covered.

Objective 8: *Consider the need and feasibility of project expansion*. Determine whether the community needs and wants the system to be expanded, which might include solar panels for other uses (such as refrigeration) and the installation of an inverter so that other appliances might be used. Consider the possibility of applying for the Ashden Awards for Sustainable Energy, a prize for which we would be eligible after the system has been running for one year.

Primary solar team contact: Forrest R Bradbury (bradbury@Princeton.EDU)[1]

3.2 Wood-Burning Stove Objectives

Background: Currently, cooking in Huamanzaña is done on open fires in enclosed homes. This leads to considerable pollution inside the homes, resulting in smoke-related illnesses. We are performing a complete assessment of the use of wood-fueled cooking in Huamanzaña, to enable the design of alternative stoves, which use a sustainable fuel source and remove pollutants from homes.

Objective 1: *Wood Fuel Assessment*. Determine the annual demand for fuel wood by the community and compare this to the available sources of wood. Determine the current depletion levels of local trees. Survey the land availability to support a sustainable fuel source from wood. Estimate the cost and labor involved with managing an arboretum.

Objective 2: *Alternative Fuel Assessment*. Assess the availability of alternative fuels from nearby towns. Determine the annual cost for a family to cook with an alternative fuel such as LPG or Propane: materials, fuel and transport

Objective 3: *Material Availability Survey*. Identify the locations to purchase necessary materials for wood burning stoves: bricks, mortar, rebar, ceramic. Estimate the cost of implementing a wood burning stove: materials, fuel wood, and transport.

Objective 4: *Materials Testing*. Test bricks for heat/flame compatibility. Test suitability of ceramic for insulation. Assess fire hazards and heat sensitive materials in buildings.

Objective 5: *Establishment of Baseline*. Observe current food preparation habits: duration, quantity of food, boiling vs. simmering, etc. Survey current fire management methods: size of wood, size of fire, frequency of replenishment, etc. Perform

[1] Forrest, a Princeton graduate student in electrical engineering, was one of the technical leads for the August 2006 project.

Water Boiling Tests on current stoves. Test current emissions levels. Talk to community members about their cooking habits, fuel use, use of fire as a heat source, and any other comments.

Objective 6: *Model Stove*. Build a model stove to show our current design to the local community. Engage community members in discussion about the stove and allow them to make comments. Give community members time to try out the stove with their own fuel burning and cooking methods.

3.3 Water Testing and Site Evaluation Objectives

Background: Currently, we have little to no information regarding the water collection and distribution systems serving Huamanzaña. We are performing this assessment as a part of a larger assessment to help the community determine what projects (if any) should be undertaken by them individually or in collaboration with others.

Objective 1: Talk with members of the community about the quality and quantity of water that they receive. Find out if individuals are getting sick from the water. Determine whether or not they see improving their system as necessary. Determine population served by (a) piped water supply source, and (b) other sources.

Objective 2: Locate source of piped water and make general observations concerning the site (e.g., protected or unprotected source). Explore the area around the source, especially upstream (agriculture, animal husbandry, mining, etc.) if the source is surface water, for possible sources of contamination.

Objective 3: Locate alternative/additional water sources for the future. Perform exploration described in Objective 2 at these additional sites.

Objective 4: Determine general condition of the supply and distribution systems. Walk the entire line, noting the size, material and degradation of the pipes as well as leaks in the system. Examine water tanks.

Objective 5: Determine the approximate quantity of water used (for the season we're visiting) per individual. Observe how water is used in the community to see if water consumption can be reduced. Also, note how water is transported from the taps to the house to determine if contamination may be occurring during the transportation.

Objective 6: Examine how and where the water is being chlorinated. Determine how the money for chlorine is raised, where the chlorine is being purchased, and who is dosing the system. Perform chlorine residual tests at the fourteen taps in the community. Ask members of the community whether the water tastes funny at certain times of day/year.

Objective 7: Perform very basic water quality tests: pH, turbidity, dissolved oxygen, salinity, and possibly nitrates, iron, total dissolved solids, and presence of coliforms (total).

Objective 8: Visit nearby communities, including San León, the community where CU Boulder is working (approximately 10 kilometers away), to determine size of communities served, see what projects have been implemented, and evaluate the impact that those projects have had.

Water projects are expensive endeavors and for a community the size of Huamanzaña, this cost has to be carefully considered. Before undertaking a water-related project, a clear need (more water, improved water quality, or both) should exist and appropriate solutions must be researched and discussed with the community before implementation.

3.4 Community Interaction and Participation Objectives

Background: This will be EWB–Princeton's fourth trip to Huamanzaña since 2005. We intend to strengthen existing community relationships so that the people of Huamanzaña can be more involved in the design and implementation processes.

Objective 1: *Foster broader community involvement and stakeholder participation.* Drawing on the Our People, Our Resources technique and logic models, promote greater community participation in the projects. Huamanzaña needs to evaluate what its needs are and how it prioritizes these needs. Increase dialogue between EWB–Princeton and Huamanzaña as to the feasibility of different projects. Rather than discuss ideas we have for projects, give citizens more opportunities to bring their concerns and ideas for solutions to us so that we can work together in this process. Achieve this via in town meetings, smaller group meetings, and individual conversations.

Objective 2: *Increase informal interaction within the community.* Although EWB–Princeton already has established a high level of informal interaction with the people of Huamanzaña, there are still many invaluable opportunities to learn about our Peruvian partners.

- WATER EXPLORATION AND SITE ASSESSMENT. During this phase, ask several community members to walk with us to the storage tank. Interview Martín Mendoza and discuss how he chlorinates Huamanzaña's water (if he does). Walk the lines of water leading into the town with the company of knowledgeable community members. (Rulfino, Norberto, Moreno, etc.)
- STOVES, FUELS, AND COOKING TECHNIQUES. Visit houses and help with the preparation of meals. Talk to women about their cooking needs and observe the current techniques for stoking fires and preparing meals. (Alicia, Elena, Asunciona, etc.)

- MEALTIMES. Because all members of the team speak Spanish to some extent, converse over meals in Spanish and encourage families to join us at the table. Get to know less outgoing members of the community better.

Objective 3: *Evaluate how the stove project can best be implemented.* On previous trips we have always implemented community projects, and have therefore never dealt with a project that involves the introduction of technology in individual households. Determine our model for supporting family-initiated and -installed projects—i.e., what families will contribute and what our role will be. Work with the community to consider how they can share the technology with other towns in the area, or whether EWB might consider sending a few students and community members to nearby villages to spearhead similar efforts. Determine how many students the community can support, as well as how long we will need to be there.

Objective 4: *Consider educational campaigns related to future projects* after observing and interviewing townspeople so we may begin to prepare for the educational components of future projects.

Objective 5: *Locate other organizations working in the area.* Find out what the engineers currently living in the school are doing with the irrigation canal, as well as find out about other organizations that are working in the area. Visit a Peruvian developmental NGO called Coprodeli and learn about their efforts in more urban areas.

Objective 6: *Set up regular community contact with Huamanzaña.* Renzo Ventura is a very valuable asset to us, but it is also important that Huamanzaña can contact us directly (and vice versa) because Renzo is not always available to make the lengthy and costly trip to the town. Identify one or two people who might email us when they are in Chao. (This will be based on who would like to serve in this capacity.) Consider making a trip with these people to set up an email account.

4. Background on Huamanzaña, Peru

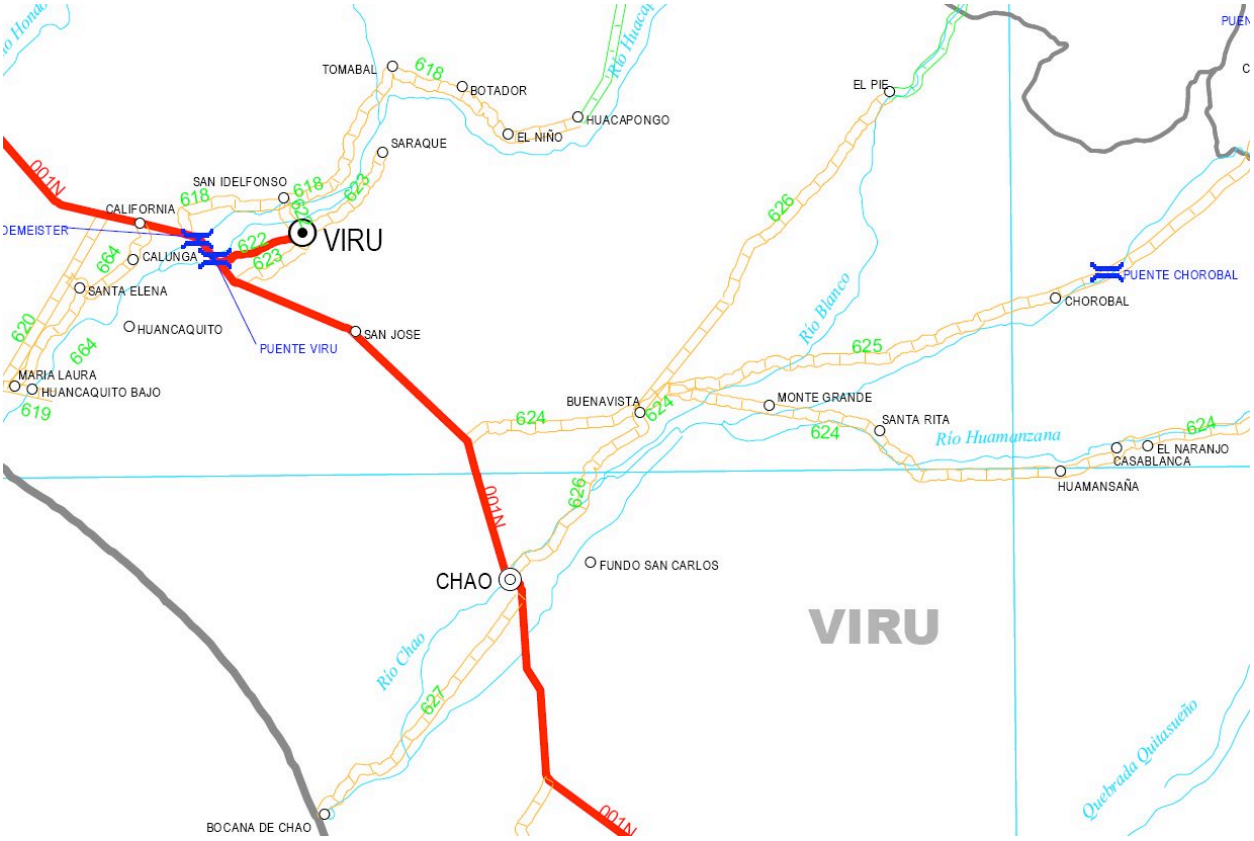
4.1 History

The Chao valley was originally populated by indigenous peoples and boasts a vibrant agricultural economy and rich cultural traditions. Since defeat to the Spanish Conquistadores, the area has been characterized by extreme poverty, misuse of natural resources, and abandonment by the central government in far away Lima. Recently globalized markets have helped spur development and migration to nearby Chao (on the Pan-American Highway). However, they have also allowed the entrance of agricultural moguls from Colombia, and encouraged the move away from subsistence farming and toward cash crops suited for trade and export. These two phenomena have increased Huamanzaña's relative poverty and decreased its self-sufficiency. Huamanzaña's health situation reflects these difficult conditions. The loss of traditional healing practices has ushered in a new dependence on expensive western medicines which can only be attained from foreign aid or from a national government whose presence in

Huamanzaña is practically nonexistent, save during election time when the residents' walls are used as propaganda battlefields by competing political parties.

4.2 Location

Huamanzaña, Peru is located in the northern highlands of Peru, approximately 500 kilometers north of Lima. From Lima, one can either take an eight-hour cross-country bus ride north along the Pan-American Highway or a one-hour flight to Trujillo. From Trujillo, Huamanzaña is about one hour south along the Pan-American Highway, then 1.5 hours east along unpaved local roads.



Huamanzaña (Huamansana) is located in the district of Viru in La Libertad. A map of La Libertad may be downloaded from EWB–Princeton's

The town is isolated from most governmental services and markets; the closest town that has more comprehensive health, education, family services, and active commerce is Chao. Chao is located an hour south of Trujillo along the Pan-American Highway. Although we do not have exact population figures for Chao, our estimates put it between 2,000 and 5,000 people. Both Huamanzaña and Chao lie in the district of Viru; there is also a town called Viru or Puente Viru, which has a population around 40,000, and is located slightly north of Chao on the Pan-American Highway. The population of Viru has ballooned in recent years as a result of large agricultural enterprises that have sparked an asparagus boom in the region.

Huamanzaña and other neighboring communities are served by *combis*, which are private vans that transport paying customers between Chao and their homes. These other communities are generally of comparable population, with Santa Rita slightly larger (roughly 400) and Montegrande and Buena Vista around 600 persons.

Huamanzaña is situated in the arid and hilly Chao valley at an elevation of approximately 650 meters. The town comprises roughly 35 houses, some 20 of which are clustered around the town center, while the remaining homes are scattered in outlying areas. Also in town is the primary school, a Catholic church (which is locked and priest-less), a solar-powered public telephone, and an unused *comedor* (kitchen) that was built several years ago by an NGO.

There are about 20 homes that make up Huamanzaña proper, with several more scattered outside the village.

4.3 Climate

Huamanzaña experiences both a dry season and a rainy season. Members of the community have said that the rainy season occurs primarily in February and March and that during the dry season, the community experiences little precipitation. They've also mentioned that December and January are typically the warmest months. The nearest weather station is located at the airport in Trujillo. For Trujillo the average high temperature, 78° F (26° C), occurs in February and March. August and September are the coolest months with an average high temperature 68°

F (14° C). The temperature in Huamanzaña is probably comparable to these values. Trujillo records very little rainfall, which is not representative of what Huamanzaña experiences.[2]

4.4 Demographics

Some 135 people live in Huamanzaña as part of 35 household units; EWB–Princeton University conducted a census in August 2006. Nearly all families are related to one another in some way, often through extended kinship networks. Racially, the community is fairly heterogeneous and reflects an indigenous ancestry. Although the church is rarely used, the majority of families are Catholic. Few couples are married; the majority of adults have cohabited with their partners for many years, though several adults also have children from previous relationships. Recently, a wave of Evangelism has reached Huamanzaña, with at least three families converting to the religion. These families have married, and their religion prevents them from eating *cuy* (guinea pigs—a staple food source), singing, and dancing. There is some friction between the Catholics and Evangelists, though since everyone is family, overt hostility seems rare, particularly during our visits.

The primary school served 21 students in the 2006 school year; the next academic year begins in March 2007 and runs through December. The schoolhouse has two rooms, one of which serves as the classroom and the other accommodates the teacher (Magda) and her two-year-old daughter during the school year. Magda lives in Trujillo and travels to Huamanzaña each week to teach the six grades offered at the school, as well as deal with administrative issues and lead the parents' association. Classes are held five days a week at the following hours:

Monday: 1:00 PM-5:00 PM
Tuesday through Friday: 7:45 AM-12:45 PM

Each morning the primary school children gather to sing the Peruvian national anthem.

The teacher can also hold and cancel classes at her prerogative, adjusting the schedule to both the town's and her own needs. Only a fraction of the students who finish primary school continue on to secondary school; because the nearest secondary school is in Buena Vista, continued schooling requires either a significant investment in unreliable and expensive daily transportation or a family member living in a nearby city willing to host the child for the duration of his schooling.

[2] *Monthly Averages for Trujillo*, Peru. 2007. The Weather Channel Interactive. 22 Feb. 2007 <http://www.weather.com/outlook/travel/businesstraveler/wxclimatology/monthly/graph/PEXX0022?from=search>

Many citizens of Huamanzaña have family members living in nearby Viru (working for the agricultural enterprises) or Chao; a few have relatives in Spain and the United States. Mobility to visit Viru and Chao depends on family resources.

4.5 Economy

Agriculture is the primary and often only source of income. On average, the families use about 0.25-2 acres of the 8-16 acres they own due to water shortages. The main crops are corn, chili peppers, beans, and sweet potatoes and other root vegetables. When their crops are growing regularly, farmers can expect to make around 10 soles ($3) per day. Some men travel to neighboring plantations to work as day laborers on farms with better access to water (natural springs and irrigation channels). A few families sell a limited amount of livestock (chickens, guinea pigs, goats, ducks), but most raise the animals for their own consumption only. Most livestock are free to roam the town and have frequent contact with all villagers. Cages are kept for prized roosters, pigeons, and some goats. Guinea pigs are usually confined to the kitchen area. There is one person who knows a traditional (and potentially lucrative) weaving technique.

There is also an established store that offers basic items for sale, as well as a smaller vendor co-owned and managed by a father and his 13-year-old daughter; this second vendor mainly sells bread, candy, soda pop, and crackers. The storeowners have a large truck that they sometimes use to transport crops and other townspeople; other than that, there are no motorized vehicles within the town. Burros for transportation are common, and a few families have horses or bicycles. *Combis* are the most common means of transportation for distances greater than 10 kilometers, though each Friday, four large trucks pass through Huamanzaña on their way to sell items in a market deeper in the mountains.

Geography also limits Huamanzaña's economic possibilities because the town is isolated for approximately two months of the year. During the rains of February and March, the River Huamanzaña floods near Aguas Calientes (just outside of Santa Rita). The road becomes impassable, and people who need to leave Huamanzaña must wade or swim through rushing water ranging from 1-2 meters in depth. After crossing, *combis* can take them the remaining distance to Chao. However, because there is no vehicle to transport people and goods from Aguas Calientes to Huamanzaña, the possibilities for trade and commerce are severely limited.

4.6 Health Care

The nearest health post is in Santa Rita, 20 minutes by car. It is infrequently staffed by one nurse whose expertise is questionable. Although it was wired for electricity when it was built, Santa Rita is not connected to the grid. The post has fallen into disrepair, and the walls are buckling. Select medications are available, but costs can be prohibitive. The primary illnesses are diarrheal (cholera, dysentery, etc), respiratory (pneumonia, bronchitis), dermatological (rashes), and kidney malfunction in older people.

Diarrhea is a result of poor sanitation and waste disposal. Hand washing is not very common; hand washing with soap even less so. Most families insist they have some sort of outhouses, though fewer than 10 have pit latrines of a more sanitary design. Many people defecate out in

the open in the dried-up streambed (which is not dry during the rainy season) or in their fields. Before implementation of the 2005 sanitation project, there were three pit latrines on the school property for use by students. Since then we have installed four flush toilets and a shower near the school. None of the latrines in Huamanzaña has a lid.

Respiratory problems are due to the close living quarters of the families and to their cooking practices. Many households have only one or two beds, with several family members sharing. Viruses spread quickly. Because everyone uses poorly ventilated wood-burning stoves, smoke accumulates in the homes, as evidenced by the blackened walls. The skin problems are due to contact with livestock, contact with contaminated water (pesticides and other), and the bites of various tropical insects. Kidney problems are attributed to the physically-demanding farming work, to foods high in salt and fat, and chronic dehydration.

For more detailed health information, please see the Summer 2006 implementation report.

4.7 Previous EWB–Princeton Efforts in Huamanzaña

EWB–Princeton University began working in Huamanzaña after Sean McGowan ’06 met with members of the community while working with EWB–University of Colorado, Boulder on a community bathroom project in nearby Santa Rita.

4.7.1 Assessment Trip: June 2005

Peter Anderson, a professional engineer, joined Princeton undergraduates Sean McGowan, Elena Olivi, and Anshuman Sahoo on the first EWB-Princeton Assessment trip to Huamanzaña, Peru, in preparation for the Sanitation System Upgrade Project. The week spent there in June 2005 was devoted to evaluating the impact of Santa Rita's EWB project, surveying the site of the Huamanzaña project, and holding town meetings and one-on-one interviews in order to gain a clearer understanding of Huamanzaña needs and wants.

EWB–Princeton students outside the bathrooms.

4.7.2 Implementation Trip: August 2005

The first project undertaken by EWB–Princeton University was the Sanitation System Upgrade and Water Storage Facility. The implementation trip, carried out in August 2005, had two primary objectives: building the sanitation system and establishing a health committee through a hygiene campaign. Both these tasks were completed during that trip, which also served as an assessment for the August 2006 visit. In total, seven Princeton undergraduates and a

professional engineer participated on that trip.

4.7.3 Implementation Trip: August 2006

The Solar Electricity and Lighting Project in Huamanzaña, La Libertad, Peru was EWB–Princeton's second project in the area. The implementation trip, carried out in August, 2006, achieved three goals: installation of the solar-powered electricity station and lighting, education and training for the correct use of the system, and distribution of rechargeable lanterns.
The Solar Electricity and Lighting Project consisted of 5 major components:

1. Solar panels
2. Lead acid batteries
3. Battery recharge station
4. Wiring, low voltage disconnect and charge controller
5. Compact fluorescent lighting for 3 common buildings

The training and education campaign consisted of 3 major components:

1. Safety training for the general community
2. Technical training for the elected system caretakers
3. Education for the community and the children on solar electricity

Also during this trip, we conducted the health assessment for Huamanzaña. In total, seven undergraduate and two graduate students participated in this endeavor.

5. Phase II Assessment Trip: 27 December through 10 January

5.1 The Travel Team

The travel team consisted of two undergraduate students, one graduate student, and one professional engineer. Once in Peru, we partnered with H. Renzo Ventura Ayasta, a Peruvian archeologist.

Shannon M. Brink '09 is the project manager for the Huamanzaña projects, and she served as group leader for the trip. She traveled to Huamanzaña in August 2006 with that implementation team, during which time she primarily served as a translator and conducted the community assessment survey. In addition to coordinating the travel logistics and overseeing the direction of the project, Shannon led the community meetings, conducted individual interviews, and served as Health Point Person for the group.

Christopher D. Pritchard '07 is a mechanical engineer from Oxford University participating this year in an exchange at Princeton University. Chris had previously worked with Engineers Without Borders–United Kingdom on a project in Guatemala. For this trip, he led the technical team charged with designing the stove project. In Huamanzaña, Chris oversaw the purchase of materials, taught the community basic principles of how it functioned, and built a prototype with community members.

Edward (Ted) M. Segal GS '08 is pursuing his Master's of Science in mechanics, materials, and structures after receiving a degree in civil and environmental engineering from Cornell in 2006. He also lived in Honduras for four months while working on a water treatment project with Engineers for a Sustainable World. On this assessment trip, Ted worked with the professional engineer to plan and execute the water testing and general site assessment. He also worked closely with Shannon to conduct individual interviews with women in the community.

Peter Templer is a senior project engineer at Malcolm Pirnie who boasts 32 years of engineering experience. He has worked for both the World Bank and USAID on numerous projects in Africa (Kenya, Ethiopia, the Gambia, Somalia, Benin, Morocco, Ivory Coast), Latin America (Puerto Rico, Jamaica, Costa Rica), Europe (United Kingdom, Cyprus), the Middle East (Qatar, Yemen), and Asia (Bangladesh, Indonesia). Peter specializes in water and environmental engineering and is fluent in Spanish and French.

H. Renzo Ventura Ayasta is a freelance Peruvian archeologist who began working with Engineers Without Borders–University of Colorado, Boulder in 2004 while employed by the now defunct NGO P.E.R.U. Since then, he has been a member of every EWB–Princeton travel team. Renzo primarily works as a translator and community liaison; in the months between our visits, he travels to Huamanzaña to communicate information about our project while gathering input from the village. On trips, he is also instrumental in leading community meetings and securing materials. Renzo also provides input on cultural issues.

5.2 Trip Timeline

Events (including most informal interactions with the town) that are mentioned in this section are fully described in subsequent parts of this report.

27 December 2006 — Shannon and Ted met around 9:00 AM to finish packing and making last minute trip preparations. At approximately 11:30 AM, they left Princeton's train station for Newark International Airport. Their 2:50 PM flight arrived in Lima around 11:00 PM. After clearing customs, they met Renzo's friend Jose Luiz Latorre Gonzáles in the airport, and he drove them to their accommodations at the Inka Lodge in the Miraflores section of Lima. Shannon and Ted arrived at Inka Lodge around 1 AM.

28 December 2006 — After rising shortly after 7 AM, Shannon and Ted ate breakfast and checked email. At 9 AM, Carlos Enrique Ormeño Grados, an engineer with the NGO Coprodeli Peru met them at the hostel. From the hostel, Mr. Ormeño, Shannon, and Ted took a taxi to Coprodeli's offices in Callao. There, they met with Coprodeli's founder Padre Miguel Ranera as well as Mr. Ormeño and other Corpodeli staff. After lunch at an area restaurant, the group visited Pachacutec, a nascent shantytown outside Lima where 100,000 squatters have settled. They toured one of Coprodeli's compounds including the school, church, and buildings under construction.

After meeting with Coprodeli, Shannon and Ted returned to Jorge Chavez International Airport for their evening flight to Trujillo. Upon arrival, they took a taxi to Hostal Colonial.

29 December 2006 Shannon and Ted met with Renzo early Friday morning, and together the three traveled to the Santa Cruz bus station to secure transportation to Chao. After the 1-hour ride to Chao, they purchased materials for the project as well as food and other supplies for the trip. Around 2:30 PM, they met with García, who provides all EWB–Princeton's transportation to and from Huamanzaña with his *combi* service "El Rápido." The *combi* departed shortly after three, and the group arrived in Huamanzaña around 5 PM. After unpacking, we dined at Don Rulfino's house, and then socialized with community members after dinner.

30 December 2006 After breakfast, Shannon, Ted, and Renzo walked to Don Martín Mendoza's property to discuss water-related issues with him and visit Puquio Shaque. That afternoon, Jesus, one of the members of the solar project technical team, joined them to review the system according to guidelines prepared by the technical team at Princeton. Later that afternoon, Renzo departed by *combi* for Trujillo to meet Chris and Peter. Ted and Shannon reviewed notes, and then dined at the house of Rosa Navaez, where they discussed the lanterns with Eduard and Don Rulfino. After dinner, they socialized with townspeople.

31 December 2006 Sunday morning, Ted and Shannon breakfasted at the home of Don Norberto and Doña Ubalda, and then they toured their garden to learn about the plants grown there. After returning to Huamanzaña mid-morning, they helped catch some stray goats, and then aided Don Leoncio and his family in building their new house. In the afternoon, Ted and Shannon ate lunch prepared by Doña Elena. She was making bread with Don Rulfino and Eduard (their family makes more than 100 pieces each week to sell within the town), so Shannon and Ted learned how to mix the dough and then shape it into the proper size for baking.

Shannon and Don Rulfino make bread.

Later that afternoon, Shannon and Ted visited Reservoir 1982, where water is stored for irrigation purposes, as well as the Puquio Reprisa. They also climbed one of the low *cerros* (mountains), which provided an aerial view of Huamanzaña. Shortly before 6 PM, Renzo, Chris, and Peter arrived in Huamanzaña. That evening, we dined at the home of Santos Ibañez Ferrar, where we had a lively discussion in Spanish over dinner. Around 9 PM, we left their

home to ring in the New Year with other community members. The celebration included burning of *viejos* (effigies) and drinking hot chocolate.

1 January 2007 — With Eduard as guide, the group of five first visited the Puquio Reprisa, and then continued to the Puquio Shaque so that all group members had toured the water sites. We spent the morning working on these water issues. Materials for the stove construction were also delivered on Monday. In the afternoon, we prepared for the community meeting, which was held shortly after 5 PM. After the meeting, we returned to Don Martín's home for dinner and to discuss the water sources in more detail.

2 January 2007 — Because not all stove construction materials had been available in Chao when Ted and Shannon made initial purchases, Chris, Peter, and Renzo returned to Chao on Tuesday morning to locate and buy these additional materials. Ted and Shannon conducted interviews with Doña Alicia and Doña Estela. After lunch, the pair debriefed and then visited Don Martín to follow up on a few water-related questions. Later that afternoon, Ted and Shannon visited the field of Mario Ramos, where he was working with Don Alfonso's family to harvest corn. Shannon interviewed Doña Celinda while Ted talked with Don Alfonso and Don Mario. Upon returning to Huamanzaña, Shannon and Ted attended a birthday party at Don Walter's home and then dinner at Don Miguel's.

Around 8 PM, Shannon and Ted learned of Peter's accident from a text message on Shannon's phone, and they got in touch with Chris shortly thereafter.

3 January 2007 — Ted and Shannon worked on water testing while waiting for news from Chris in Trujillo. They also packed Peter's belongings, as well as Ted's (in case he would have to accompany Peter on the evacuation). The pair also followed up on the interview with Doña Celinda and helped cook lunch. Shortly after noon, the combi arrived to transport the two back to Chao, where they took a bus to Trujillo and met the rest of the group at Hostal Colonial. That afternoon and evening were spent purchasing crutches, arranging the evacuation, and communicating with the EWB–Princeton team and family members in the US.

4 January 2007 — Renzo arrived at Hostal Colonial shortly after 6 AM to accompany Peter to the Trujillo airport. He then returned to his apartment to conduct personal business while Shannon, Ted, and Chris went to Huamanzaña. Upon arriving, we met with Don Norberto and Doña Ubalda, with whom we were supposed to meet the previous day before we learned of Peter's accident. Renzo joined us in Huamanzaña later that afternoon, and we had another community meeting. After dinner, we joined a large group of

community members who were watching a DVD in the *locale* (one of the community buildings lit during the August 2006 project).

5 January 2007 — Stove construction began Friday morning with Chris teaming with Don Norberto and other community members. Shannon also conducted several interviews. At lunch at Rosa Navaez's home, the three conducted smoke testing using a filter to collect fine particles from the *tusa* and other combustibles. Later that day, water testing and stove construction continued, followed by a *fútbol* game with the local players. That evening, like most, was spent relaxing and chatting with community members.

6 January 2007 — On Saturday morning, Shannon continued with interviews while Ted worked on water testing. Then the entire group headed down to San León to visit with the EWB–University of Colorado, Boulder team. We toured their project and then returned to Huamanzaña early in the afternoon. After lunch, stove construction continued, followed by another game of *fútbol*.

7 January 2007 — After breakfast, Shannon interviewed Doña Elena, Doña Asunciona, Lejdi, and Don Leoncio while Chris, Ted, and Renzo continued stove construction. In the afternoon, Shannon, Ted, and Renzo worked on taking GPS measurements for each house in town and drawing a map; in the meantime, Chris continued working with Don Norberto and other community members on the stove. Around 5 PM, stove testing began. Following stove testing, there was a lively photo shoot with most of the small children in town (everyone adores photos). After dinner, we spent our last night chatting with community members.

8 January 2007 — Before breakfast, Santos Moreno met briefly with Shannon and asked to schedule a town meeting prior to our departure that afternoon. The rest of the morning was devoted to packing, cleaning, and other preparations for our departure. The meeting began shortly after 1 PM and was cut short by the arrival of our combi, which left around 1:45 PM. The group arrived in Trujillo around 5 PM, dined, and then Chris, Ted, and Shannon took a flight back to Lima. They arrived at the Inka Lodge around midnight.

9 January 2007 — On Tuesday morning, Shannon, Ted, and Chris debriefed over breakfast and then explored Lima. They left for the airport around 7 PM, and their flight departed shortly before midnight.

10 January 2007 — The team arrived at Newark International Airport before 8 AM, cleared customs without problems, and proceeded to Princeton University on NJ Transit, arriving on campus around 10:30 AM.

5.3 Peter Templer's Evacuation

On Tuesday, 2 January 2007, Chris, Peter, and Renzo returned to Chao to locate and buy additional materials for the stoves. Chao did not have the necessary materials so the three continued on to Trujillo. In Trujillo they entered a poorly lit workshop. Peter entering first continued straight ahead and did not see the large opening in the floor (used for changing the oil in a car), and he fell partially into the opening, injuring his knee. Chris and Renzo assisted Peter in getting out of the hole and then accompanied him to a clinic in Trujillo where Peter was told he had torn ligaments in his knee. The doctors applied a plaster cast. Because Peter was unable to continue to work, arrangements were made through Peter's insurance provider to prepare for his evacuation on Star Peru Airlines and Continental Airlines. Peter left Trujillo on the morning of 4 January 2007 and arrived at Newark International Airport the following morning.

Peter Templer models his plaster cast.

6. Solar Electricity System Evaluation

6.1 System Condition

In August 2006, EWB-Princeton installed a solar energy project in the primary school in Huamanzaña. The system consists of four panels located on the school roof, interior lighting in the school and adjacent community areas, and a battery charging station where townspeople can charge batteries for rechargeable LED lanterns introduced as part of the project. Members of the community technical team are maintaining the system, and the solar panels, wiring, connections, lights, and deep cycle batteries are in good condition. The community has experienced some problems with the battery chargers and rechargeable batteries.

6.2 Objectives and Execution

6.2.1 Objective 1: Transferring Instructional Materials

Objective: *Bring promised instructional materials to Huamanzaña*. These materials include a troubleshooting manual and translated safety information and will be left in the care of the technical team that oversees the solar installation (Jaime, Jesus, Eduard). Use the maintenance checklist prepared by Rebecca and Elena; go through these steps with the technical team so that they are comfortable with the tasks involved.

The necessary instructional materials were not prepared in time for the trip, but should be ready in time for the summer 2007 trip. We are also planning to send additional materials to Jesus via Renzo this spring.

6.2.2 Objective 2: Troubleshooting Problematic *foco*

Objective: *Determine what is wrong with the problematic "foco" and fix or replace it.* Determine which either bulb or lantern is not working properly and deciding what can be done to rectify the problem.

Jesus resolved the problem with one of the exterior lights; he discovered that it was improperly connected to the rest of the system. All lights are now working well.

6.2.3 Objective 3: Batteries

Objective: *Collect data on the Powerizer batteries.* Investigate how long batteries are lasting between charges and how long it takes to charge batteries at the charging station. Determine whether the low voltage disconnect is being engaged, and whether that could account for the amount of time it takes batteries to charge.

When we arrived in Huamanzaña, we discovered several issues with the batteries and battery chargers. Although nearly all families had non-Powerizer brand batteries replaced by Powerizer batteries in November when Renzo brought a shipment from EWB–Princeton, there are still some problems with the batteries themselves. The majority of the batteries are taking around 12 hours to charge (up from the 6 hours that EWB–Princeton had anticipated during the summer), and some need as many as 24 or 36 hours to receive a full charge. This differential is controversial because some people find it unfair that a family whose batteries need longer to charge pay the same fee as others and take up charging space. However, the community is committed to resolving the question of the fee structure among themselves.

The duration of the batteries seems to be comparable to EWB–Princeton's revised estimates from August 2006.[3] However, the instructions we had given the community in August were that they should wait until the batteries were completely depleted before they recharged them. Some preliminary lab tests conducted in Princeton by Forrest Bradbury (electrical engineering graduate student and one of the mentors for the August 2006 project) indicated that the batteries charge faster if recharging begins immediately after the light begins to dim. We explained these different instructions to the community at two meetings, and we will follow up to see whether it rectifies the charging time differentials.

[3] EWB–Princeton's initial estimated that the Powerizer batteries would last 400 hours between charges; this was the life advertised by manufacturers. After testing the batteries in Huamanzaña, we discovered that this was a very misleading estimate—in reality they last only about 25 to 40 hours between charges. Depending on how long families use their lanterns each night, they last anywhere from about 3 to 8 days (assuming daily use).

6.2.4 Objective 4: Television and DVD

Objective: *Reconnect the television and DVD*, and test whether it is working within the limits of the system.

Individuals have successfully connecting the television and the DVD player to the system with few problems. Once or twice a week members of the community gather to watch a movie in the school or *locale*. There was one occasion late in the assessment trip that an attempt to hook up the appliances did not work. This issue was not raised until it was too late to look into the problem, but it did not seem to arise from the low-voltage disconnect engaging.[4]

The townspeople gather several times a week to watch movies using the electricity from the system. The television, DVD player, and speakers are all AC appliances attached to an inverter. Don Miguel Tiburcio owns the inverter and media equipment.

6.2.5 Objective 5: Check system for any damage.

Objective: *Check system for any damage*. Evaluate how clean the panels and battery chargers with respect to system performance. Completely inspect the wires between the solar panels (noting in particular the condition of the insulation), as well as check to make sure that the holes around the black boxes on the back of the solar panels are well sealed with electrical tape. Find out whether distilled water has been added to the batteries.

The system has experienced no damage and the components are clean. A general review of the system found no short circuits, ground faults, damage to conduit or wire insulation, or damaged or loose wiring connections. The charge controller is clean and the ambient temperature is in the appropriate range. The

The solar panels were in good condition. Ted also cleaned them.

[4] The low-voltage disconnect engages when the system is overloaded.

deep cycle batteries are seeing the correct size and type of loads. Battery connections are secure, clean and corrosion-free and the caps secure. Distilled water has not been added to the batteries, but the current levels are adequate. Battery tops are clean and dry. The enclosure and interior shelving is clean and in good condition. The ventilation path is clear. The panels are clean and not broken. The mounting hardware is secure and in good condition. The conduit and connections are secure and in good condition.

6.2.6 Objective 6: Community Feedback

Objective: *Gauge community reaction to the project*. Through interviews and conversations, discover how much villagers use their lanterns and the lights in the school, whether this source of light has complemented or replaced kerosene and candles, and whether it is worth the fee they are paying.

Community reaction to the project is best disguised as mixed. The permanent lighting and electricity in the school and *locale* are extremely popular—so much so that individuals desire permanent lighting and electricity within their homes. This sentiment may be compounded by the problems with the lantern *pilas* and the reality that the lantern light is not comparable to a 12-W fluorescent bulb. This objective was best addressed in community meetings and individual interviews. Please see section 9.9.2 for a complete discussion.

6.2.7 Objective 7: Appliance Socket

Objective: *Evaluate the appliance socket in the locale*, and determine whether it is sufficiently safe or whether it should be covered.

The appliance socket in the school is located approximately 6 feet above the ground and there are exposed wires. For safety, when individuals are not connecting appliances this should be covered. However, because the DVD and television are being operated frequently using an inverter that connects with the system, development of a safer, more permanent connection for the inverter is a consideration.

6.2.8 Objective 8: Project Expansion

Objective: *Consider the need and feasibility of project expansion*. Determine whether the community needs and wants the system to be expanded, which might include solar panels for other uses (such as refrigeration) and the installation of an inverter so that other appliances might be used. Consider the possibility of applying for the Ashden Awards for Sustainable Energy, a prize for which we would be eligible after the system has been running for one year.

Clearly there is a great desire for project expansion; the ultimate question is to whether it is within EWB–Princeton's mission to expand the system to provide light and electricity in each home. In spring 2007, our team will be working to address the technical and cultural issues involved. We also plan to reevaluate whether the existing system can be modified to improve accessibility to all citizens, not just the teacher, schoolchildren, and those who watch movies in the *locale*. Additionally, because many women mentioned that they would like to have access to

a blender to make fruit juices to sell, we are considering ways that this appliance could be added for communal use. After we have evaluated all these possibilities, we will reconsider applying for the Ashden Awards for Sustainable Energy, which have a November 2007 deadline. For a complete discussion of the issues surrounding the solar electricity station, please see sections 9.9.2, 13.1.1, and 13.1.2.

7. Efficient Wood-Burning Stoves

7.1 Summary (Project Choice)

The aim of redesigning stoves in Huamanzaña is to reduce the environmental and health problems resulting from current cooking methods. Currently, near-open fires are used to cook inside homes in Huamanzaña, resulting in significant indoor air pollution and inefficient fuel use. Additionally, the main fuel currently used in Huamanzaña is wood, which is not only scarce, but also leads to local deforestation.

The associated health problems described to EWB-Princeton University during the summer 2006 trip included respiratory problems such as bronchitis, pneumonia and increased frequency and severity of colds. In addition, villagers complained of black smoke particles in their saliva and eye problems due to smoke exposure. The primary groups affected were women and children.

As a result there are three technological aims to redesigning stoves in Huamanzaña. First, the indoor air pollution needs to be reduced by improving completion of fuel combustion and minimizing the amount of exhaust gas entering the homes. Second, maximizing heat transfer to cooking pots, will increase stove efficiency resulting in a reduced demand for fuel. Third, the stoves should reduce the amount of time women must spend cooking each day.

In order to ensure sustainability of the new stoves, a number of constraints must be met. The stoves must be applicable to the fuels available in Huamanzaña. The stoves must cook the food in a way that is convenient, acceptable and sensitive to the demands of the community. The stoves must be durable over a reasonable lifetime and must be able to be constructed using locally available materials, tools and labor. Consequently, they must incorporate the mental and physical input of the local community in design and construction.

We are trying to approach the problems associated with cooking in a holistic manner, considering practical, technical, and economic limitations. As a result, the solution is not straightforward, but will hopefully be a compromise between functionality, efficiency, and cost.

7.2 Preparation and Designs

The combustion of wood to produce energy is already very efficient in open fires. Therefore, the main advantage of improving combustion efficiency is to reduce smoke and harmful emissions. Improvement of heat transfer from the fire to the pots presents the largest opportunity for reduced fuel use. The design principles for both aims are summarized briefly below.

7.2.1 Combustion

For complete combustion, excess air is required; however, this air should be preheated to facilitate oxidation reactions. Insulating the area around the fire helps it burn at a higher temperature, reducing smoke production and facilitating more complete combustion. A chimney above the fire increases draft through the fire. It also gives exhaust gases a place to further react, thus reducing harmful emissions.

7.2.2 Fuel Efficiency

Increasing temperature and speed of gases in contact with pots will increase fuel efficiency. This can be done by insulating the hot gas pathway, except where it contacts the pots. Maximizing contact area between pots and hot gases will also improve efficiency.

In order to propose an example of an efficient, clean-burning stove to the community of Huamanzaña in January, EWB-Princeton built a stove based upon the "rocket-elbow" or "Inkawasi" design. The Inkawasi design was chosen because it has proven to be a successful implementation of the design principles outlined above. Nonetheless, after constructing the stove in the community, we realized that there are drawbacks to this model. The final design must improve efficiency and reduce emissions in a way that complements villagers' needs, rather than solely driving the stove design from a technocratic point of view.

7.3 Current Stoves

Current stoves have no chimneys for exhaust gases. However, they are nearly open fires, which can often be more efficient than a more complex stove if the latter is poorly insulated with massive materials close to the fire. Therefore, removal of exhaust gases through redesigned stoves must not compromise the efficiency of heat transfer or fuel use. In fact, a good design will improve on all of these aspects.

Right: Doña Cristina poses with her stove.

Below: Billowing smoke from current stoves cause vision and respiratory problems for women and their families.

7.4 New Stove Design

The following three schematics depict the proposed stoves, which are based on an elbow shaped combustion chamber that preheats the air. The exhaust passage passes by the pots, transferring this heat to them. The cross-sectional area of the gas pathway is kept constant to ensure continuous flow through to the chimney. The stove is hottest closest to the combustion chamber. Water boils fastest for this pot; however there will be sufficient heat to the other pots for reheating and simmering pots of food.

Figure 7.1: EWB–Princeton's Inkawasi Stove, Round 1 (General Schematic)

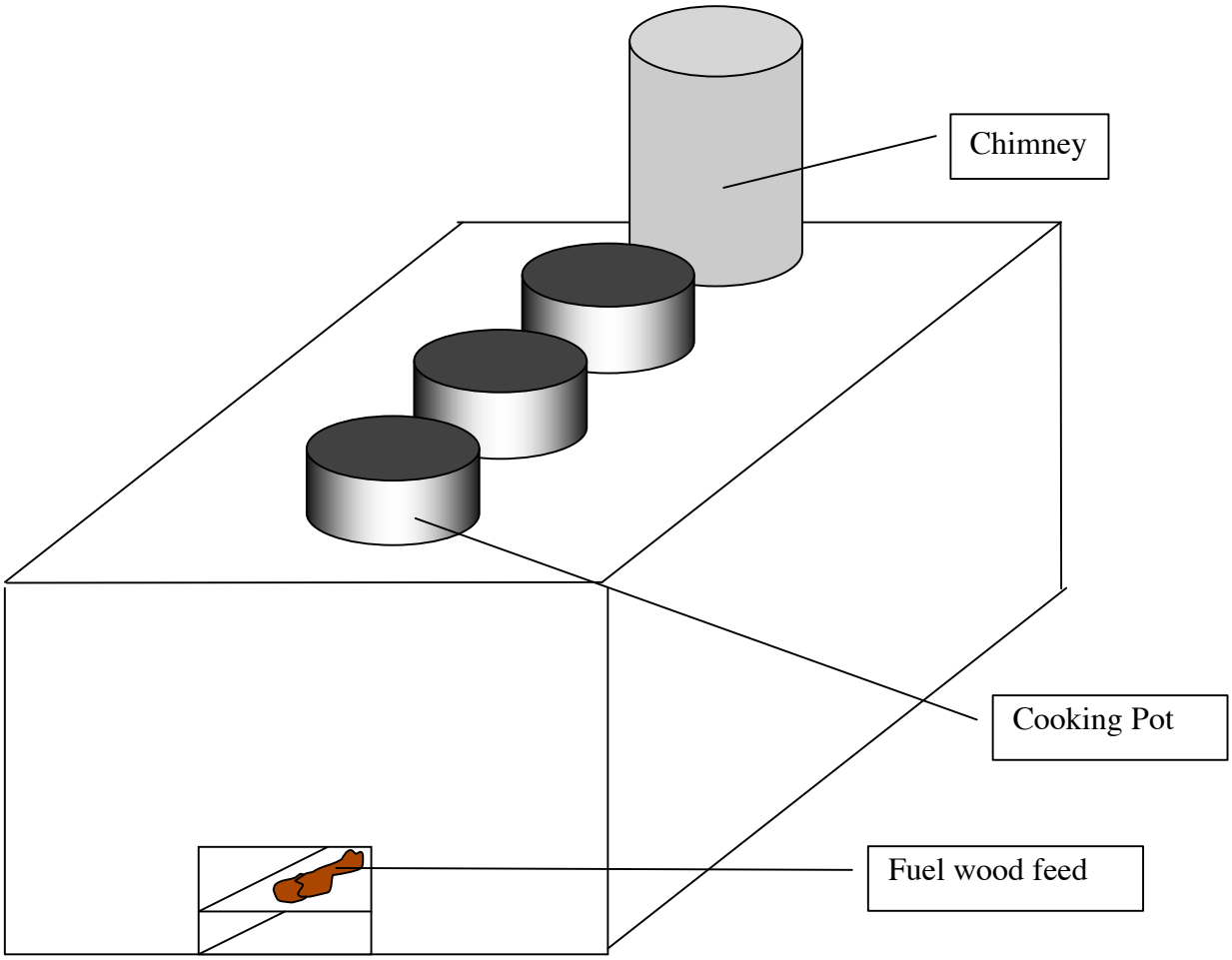


Figure 7.2: EWB–Princeton's Inkawasi Stove, Round 1 (Airflow Schematic)

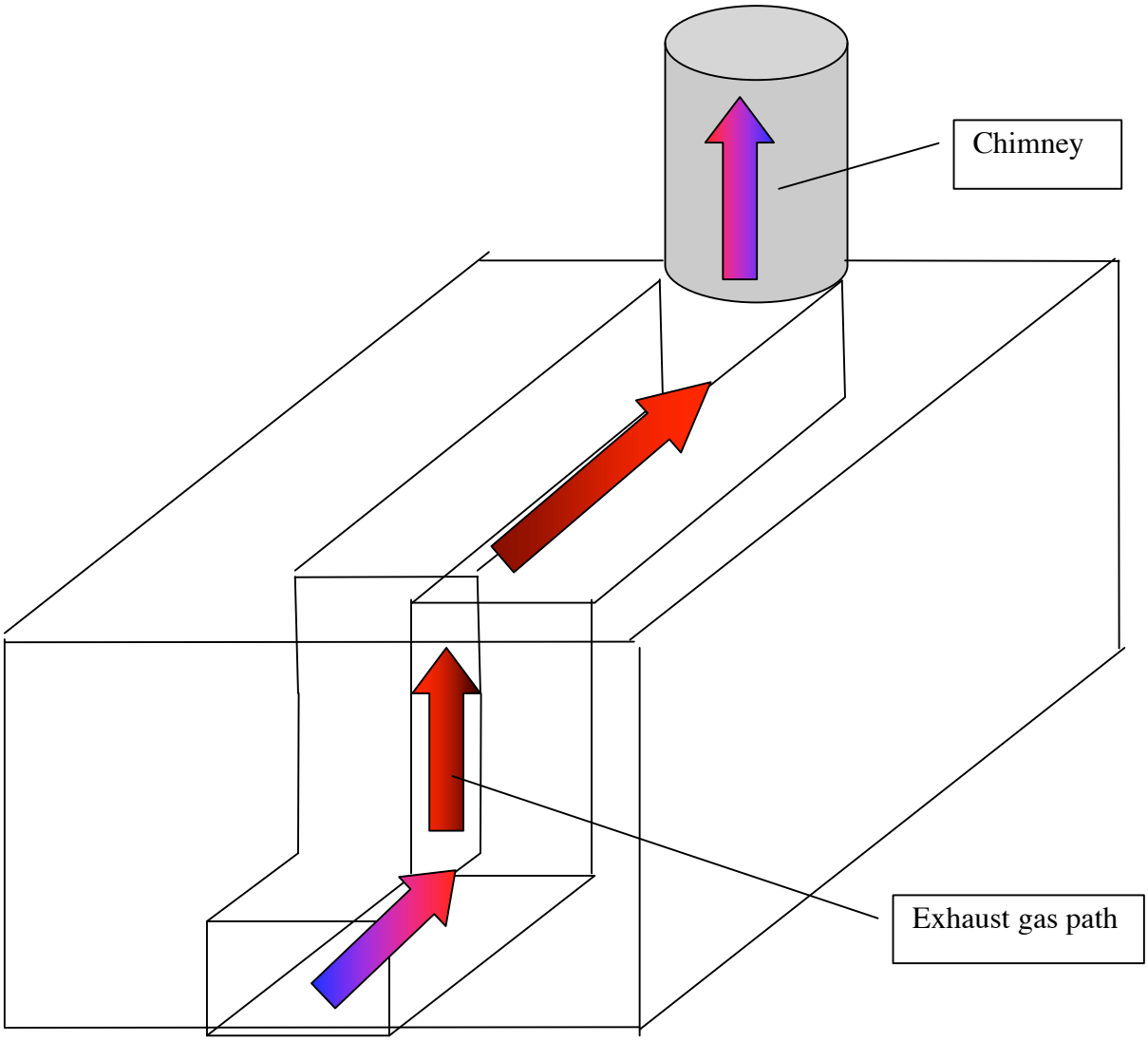
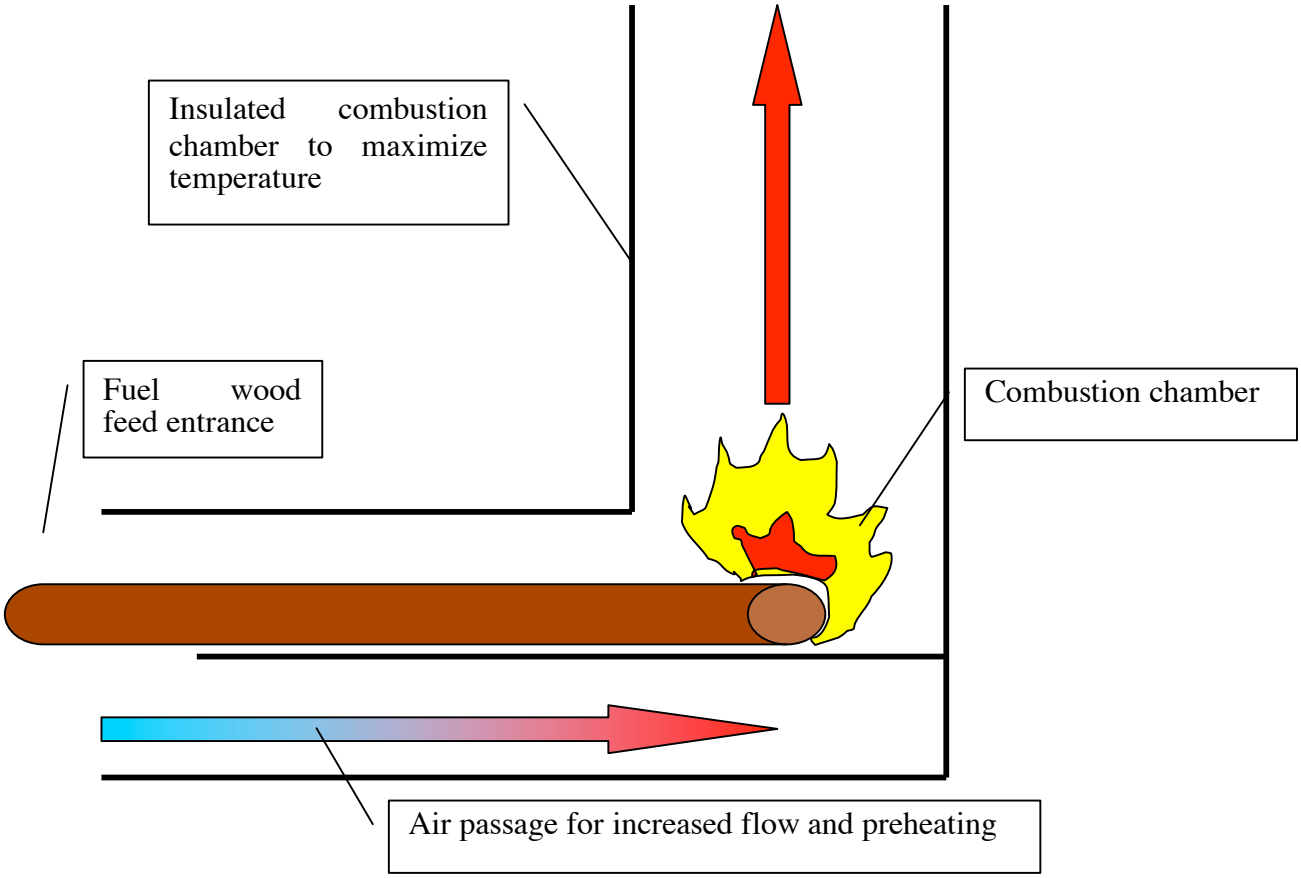


Figure 7.3: EWB–Princeton's Inkawasi Stove, Round 1 (Detail: Combustion Elbow)



7.5 Testing

7.5.1 Campus Testing

In November 2006, EWB–Princeton team members built a prototype stove in the Engineering Quadrangle, approximating local materials with American versions available at Home Depot. Construction took several days and was overseen by Chris Pritchard and Dobromir Parushev. Stove testing consisted of the Water Boiling test and was conducted in a single evening, though in retrospect, this was not enough time to truly evaluate the stove's efficiency.

Left: Campus testing included measuring the temperature of the water in the pot and temperature of the smoke leaving the chimney.

Below: Rebecca Legett '08 inspects the combustion chamber on the campus test stove.

7.5.2 Efficiency Testing

The success of the stoves to deliver heat to the cooking pots was to be measured by a standardized test procedure (1995 VITA International Standard Water Boiling Test) consisting of three parts:

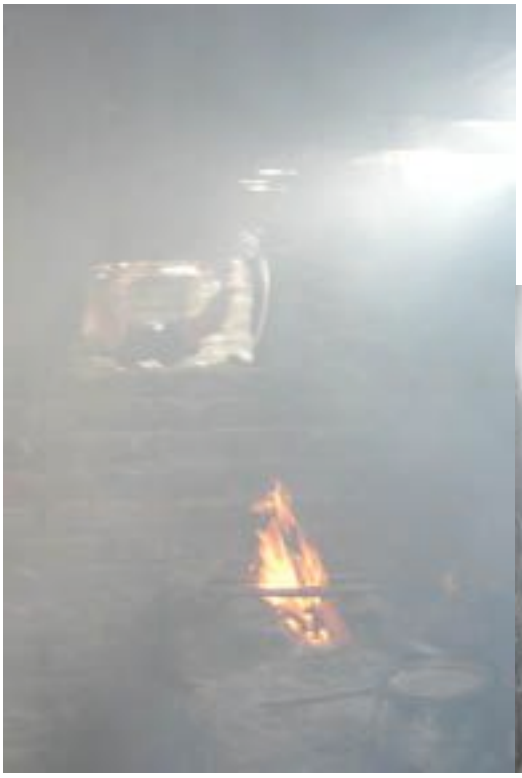
- *High Power Test (Cold Start).* This test measures the time and fuel required to boil a pot of water on a freshly ignited stove.
- *High Power Test (Hot Start).* This test measures the time and fuel required to boil a pot of water on a hot stove.
- *Low Power Test.* This test measures the fuel required to maintain water at simmering temperatures.

The majority of cooking occurs at simmering temperatures. Therefore the most fuel savings can be obtained by ensuring the stoves do not produce excessive amounts of steam during this phase. Our plan was for villagers to be invited to prepare common meals on the stoves so we could

evaluate their efficacy for daily cooking purposes, but because of time constraints relating to Peter Templer's evacuation, there was not enough time for this during the visit. We plan to follow up by phone to see how the stove is working.

7.5.3 Exhaust Testing

Testing of the exhaust gases should include measuring the exhaust gas temperature. This can ensure the stove is transferring sufficient energy to the pots whilst ensuring the exhaust gases have significant energy to react completely. Also, an analysis of exhaust gas components was collected by taking samples using pump filters that trap particles and trace elements. These were analyzed upon return to Princeton.



Left: In an attempt to spare himself from the smoke, Chris uses the hand pump through a window as he collects exhaust samples.

Below: While helping Chris with the exhaust testing, Ted is overcome by the acrid smoke from *tusa*.

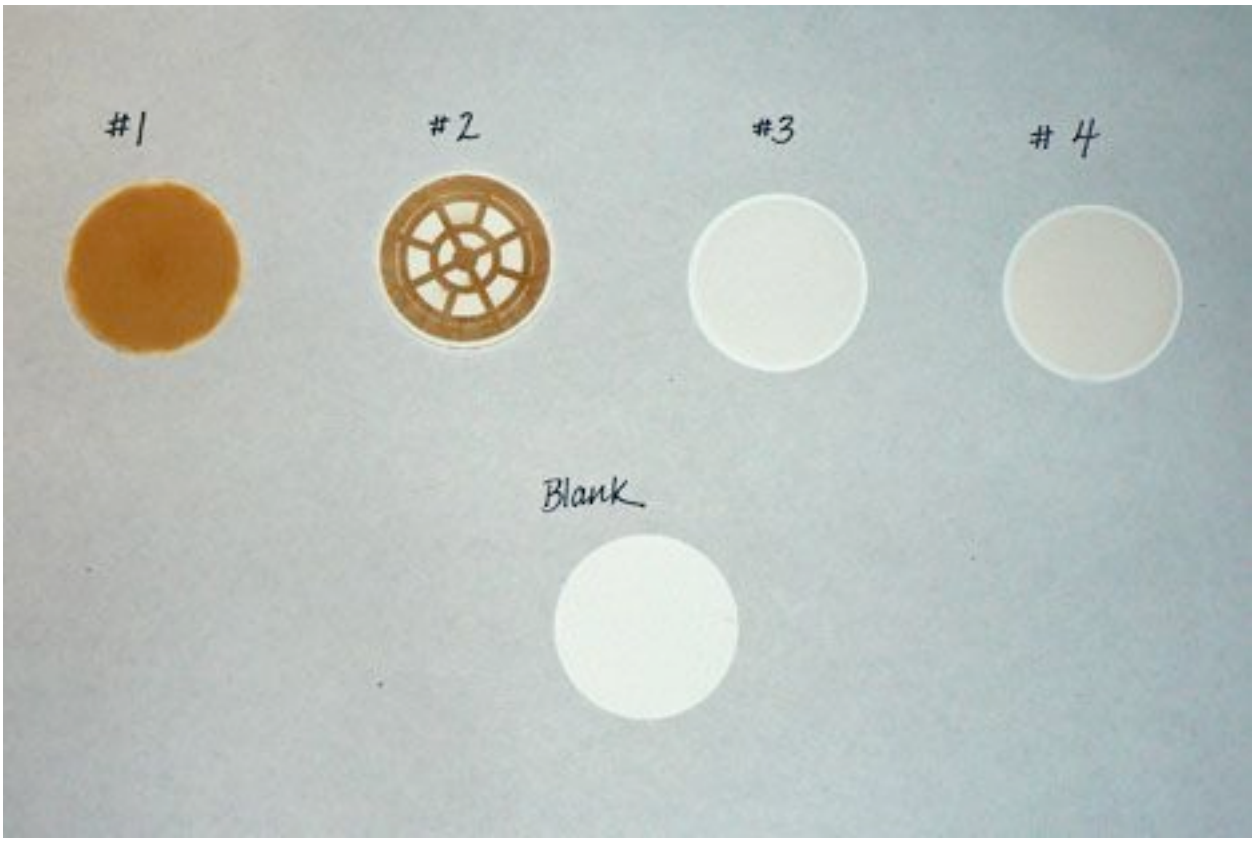
EWB–Princeton conducted two sets of tests, one set in the home of Doña Rosa Navaez while she used *tusa* as fuel, and another in the home of Doña Asunciona Rojas while she used *algorrobo*. The *tusa* test was particularly difficult on the parts of Chris and Ted who had to use a hand pump for 3 minutes to collect the particulates from the smoke; the fumes were acrid and burned their eyes, leading them to cough and pull their shirts over their mouths for protection against the smoke. This test was not truly indicative of the general conditions under which women cook because some leave the room while the *tusa* ignites the other fuels, and moreover, Doña Rosa added *tusa* to ensure that the smoke continued for the full three minutes. Although one of the two tests conducted during this set failed because the filter was inserted incorrectly, from both filters, it is obvious that the *tusa* produces a thick, brown cloud of particulates that the cook ingests.

Shannon conducted the second test in the home of Doña Asunciona with the help of her granddaughter and fellow cook Lejdi Diana Ibañez Polonio. This test with *algorrobo*, a common type of firewood,[5] and the particulates captured were much cleaner. Shannon also reported that it was significantly easier to breathe during the *algorrobo* test.

Definite quantitative conclusions are difficult to reach with the data from the hand pump, but EWB–Princeton did weigh the filters to provide a rough comparison of the mass of particulates per pump. If we extrapolate that one pump might be roughly equivalent to one breath, the data suggests that the effects of *tusa* are 16 times those of *algorrobo*.

Right: Chris displays the filter from the *tusa* exhaust testing.

Below: Filters from exhaust testing. #1 and #2: *Tusa* at Rosa Navaez's home. (On test #2, the filter was inserted incorrectly, but it is clear that a comparable amount of particulate matter accumulated.) #3 and #4: *Algorrobo* at Asunciona Roja's homes. A blank filter has been included for comparison.



[5] See Appendix 15.2 for more information about species of woods used.

Test	Fuel	Minutes	Pumps	Particulate Mass	Mass/Pump
1	*Tusa*	3:00	~180	28 mg	$0.1\overline{5}$ mg/pump
2[6]	*Tusa*	3:00	~180	—	—
3	*Algorrobo*	3:00	~210	2 mg	0.0095 mg/pump
4	*Algorrobo*	3:00	~200	Negligible	~0

7.6 Fuel Assessment[7]

The main fuels available in Huamanzaña are *leña* (wood) and *tusa* (corncobs). The amount of time families spend collecting fuel wood varies depending on the availability of firewood on their *chacras* (plots). They collect branches that have fallen to the ground, and they often climb into the trees and cut branches down with machetes. The corn is grown locally, and once the kernels are stripped from the cobs, the cobs are collected and used as fuel.

The major disadvantages of corncobs are that they burn very quickly, do not produce as much heat as wood, and produce tremendous amounts of smoke. However, due to the scarcity of trees in the area, they constitute a major source of fuel for the community, particularly after the harvest, when wood is scarce, or during the rainy season when wood is constantly damp.

Alternative fuels, such as propane or kerosene were available, but considered too expensive for usual cooking. A small canister of kerosene cost around $10 USD. Only a few houses in the community had kerosene canisters, in case they ran out of wood or corncobs. The cost of liquid or gas fuels was clearly prohibitive and not a viable option compared to perhaps more labor intensive, less efficient but cheaper solid biomass fuels.

7.7 Materials and Their Availability

The materials used were:

- Bricks
- Mortar
- Steel pipe for chimney
- Rebar for supporting pots and to provide a grate for fuel wood.
- Ceramic tiles (called *ladrillos pasteleros*)

All of the necessary materials were found within three hours of Huamanzaña, either in Chao or Trujillo. It was possible to have heavy items, such as brick and mortar delivered to the village, though this takes several days and can be expensive.

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[6] The second test failed because the filter was inserted incorrectly. However, we can observe that the amount of *tusa* particulate matter seems comparable to the amount collected during the first test, suggesting that the first test was no anomaly.

[7] For further discussion of fuel uses as reported by women during the interviews, please see section 9.6.1.

7.8 Prototype Site Selection

The prototype stove was built in the school's new *comedor* (dining hall), currently still under construction.[8] We designed the stove to accommodate the large 35-centimeter pots used for cooking for the school children's lunchtime meals.

7.9 Stove Construction

The stove was constructed on a *tendal*, or table, which is customary in the area.[9] Locals did all of the construction. Don Norberto was appointed as the project leader to direct the construction. We worked with him to explain the concepts behind the design and the necessary dimensions. Following that, he directed a group of men to construct the stove. This facilitated not only community involvement, but also community leadership and responsibility.

Chris works with Don Norberto and Omar to build the stove in the primary school's *comedor*.

Don Rulfino and Don Norberto put the finishing touches on the prototype stove.

[8] The community decided on the site for the prototype stove during the second meeting. See section 9.4 for a complete discussion of what went on during that meeting.

[9] Many families have *tendales* made from iron or other metals; the metal serves as a counter over a table supported by concrete. (Some families have space underneath their *tendales* while others have solid block *tendales*. The *tendal* built for the new *comedor* was made from adobe bricks.

7.10 Community Feedback[10]

We received significant feedback from the community on the prototype stove. The major concerns were:

• ***Cost:*** The stove cost around $70 dollars to construct, which was far too expensive. The community asked us to look into ways of using fewer bricks and a cheaper option for the chimney.

• ***Use of corncobs:*** The stove was unsuitable for corncobs due to the small access to the combustion chamber. Corncobs would clog the combustion chamber and inhibit the flow of air into the stove. However, because corncobs are such a significant source of fuel, the design needs to accommodate this fuel source.

• ***Variable pot sizes:*** The current stove design requires that each household choose three pot sizes to which the stove be fitted. However, this does not provide sufficient flexibility for cooking. A modification needs to be created to allow people to vary which pots they use in each opening.

• ***Boiling more than one pot simultaneously:*** The current design only produces enough heat for boiling in the first opening. However, often women in Huamanzaña boil different foods in more than one pot at the same time.

• ***Using fewer than three pots simultaneously:*** The current design only works if all three openings are filled. Therefore, without covers, it is not possibly to use fewer than three pots simultaneously.

7.11 Design Revisions and Future Plans

After the assessment trip we have met for a number of brainstorming sessions to try and resolve the issues with the stove design we built in Huamanzaña. This enabled us to step back and reassess our goals for the project: *a*) to improve health standards in Huamanzaña; *b*) to lessen pressures on fuel supply; and *c*) to reduce the amount of time women need to spend cooking each day, thus freeing them to participate in other productive activities.

Currently, we are rethinking the approach in two ways:

- ***Reassessing the viability of solar cooking.*** The capacity for solar cooking in Huamanzaña needs to be assessed. This could determine to what extent solar cooking could be a substitute for conventional cooking, such as pasteurizing water, or heating food to a certain temperature and then finishing off the cooking on an efficient wood-burning stove.
- ***Redesigning the efficient stoves to allow more flexibility and the use of corncobs.***

[10] For a complete discussion of community feedback, see reports of interviews and town meetings in section 9.

8. Water and General Site Assessment

8.1 Summary

EWB–Princeton collected basic information regarding the potable water sources, the collection and distribution infrastructure, the water quality, and general water practices. Information pertaining to the irrigation system was gathered and GPS coordinates for points of interest in the town were recorded. Also, we logged information found on discarded pesticide containers.

8.2 Objectives and Execution

8.2.1 Objective 1: Community Feedback

Objective: Talk with members of the community about the quality and quantity of water that they receive. Determine population served by (a) piped water supply source and (b) other sources. Find out if individuals are getting sick from the water (and whether this is seasonal) or have chronic medical conditions. See if medical records exist for Huamanzaña and/or the greater area. Determine whether or not members of the community see improving their system as necessary.

The majority of the town is connected to the piped water supply. The pipes comprising the system are connected to fourteen communal taps located throughout the community; these same pipes also serve the community bathrooms at the primary school. Individuals above the main part of town connect to the distribution line directly instead of using a communal tap. People who live just below the main part of town also connect directly to the system. Those located further down either walk back to town and collect water from a tap or depend on alternative sources of water, such as hand dug wells.

The community members are not experiencing sicknesses, such as dysentery, that are often associated with water quality issues. There is no indication that community members suffer from terminal conditions related to drinking of contaminated water. Medical records are not available in Huamanzaña, but may be available in Santa Rita (located 20 minutes away by *combi*). Individuals are happy with the quality of the water that they are receiving, and they report no difference in quality from the rainy to dry seasons. People would like more irrigation and potable water, but this was not as high of a priority as more light and improved stoves.

8.2.2 Objective 2: Water Sources

Objective: Locate source of piped water and make general observations concerning the site (e.g., protected or unprotected source). Explore the area around the source, especially upstream if the source is surface water for possible sources of contamination (agriculture, animal husbandry, mining, etc.).

8.2.2.1 Puquio Shaque

Puquio Shaque is both the primary potable water source and an irrigation source for the community. The source, a natural spring, is located a few kilometers above the center of town. Surrounding vegetation protects the source from sediment runoff in the rainy months. There are some leaves and other debris in the spring due to the vegetation located directly overhead; however, this overhead vegetation also protects the source from additional debris. Members of the community noted no difference in the clarity of the water in the rainy and dry seasons. This system of potable water was constructed in 2001 and has been used continuously since that date.

Vegetation protects *Puquio Shaque*.

Water in *Puquio Shaque* is clear despite some debris from surrounding vegetation.

8.2.2.2 Puquio Reprisa

Puquio Reprisa is primarily used for irrigation. This natural spring is located closer to town than Puquio Shaque. Irrigation canals run from the spring to a reservoir (Reservoir 1982) that is filled every morning, and from there, the water is then distributed to the fields that are scheduled for irrigation. This source was the potable water source before being replaced by Puquio Shaque. Individuals

Reservoir 1982 was built by the pueblo in that year; it stores water for irrigation use.

in the community said that occasionally when they need more water, they go to this source to fill up buckets and bags. Nonetheless, this does not seem to happen often. Several people were seen washing near the reservoir.

***Puquio Reprisa* is primary used for irrigation, but it served as Huamanzaña's primary water source until the potable water system was built in 2001.**

8.2.3 Objective 3: Alternative Sources

Objective: Locate alternative/additional water sources for the future. Perform same exploration at these additional sites as were performed in Objective 2.

There is no surface water during the dry season, and without performing an assessment during the rainy season, it is impossible to determine whether this could serve as a potential addition to the system. Because much of the water in the area is from spring sources, it is possible that borings could be made to tap the aquifer; in fact, Don Norberto's family had its own spring well of this type until about ten years ago when El Niño interrupted the water flow in some way.

8.2.4 Objective 4: Water Collection and Distribution Infrastructure

Objective: Determine general condition of the supply and distribution systems. Walk the entire line, noting the size, material and degradation of the pipes as well as leaks in the system. Examine water tanks.

Don Martín Mendoza maintains Huamanzaña's water tank.

Engineers from outside the community are responsible for the original infrastructure of the potable water system, and since 2004, Don Martín has maintained the system. The potable water leaves the spring in one 1-inch diameter PVC pipe and one 2-inch diameter PVC pipe. These pipes then run below ground (approximately 0.5 meters below the surface) for most of the stretch to the distribution tank. In a particularly rocky stretch, rather than burying the pipe, the pipe has been elevated and suspended from a cable running between two concrete columns. Prior to the transition above ground, the two pipes are connected and reduced to a single pipe. The pipe that is elevated is 1.5-inch diameter flexible PVC tubing; we observed no leaks in the above ground portions of the line. The distribution tank is located near Don Martín's house; he cleans it every two to three months. The distribution lines are located underground, and we did not observe the size or quality of these pipes.

8.2.5 Objective 5: Water Usage

Objective: Determine the approximate quantity of water used (for the season we're visiting) per individual. Observe how water is used in the community to see if and where more water is needed and where it is being wasted. Also, note how water is transported from the taps to the house to determine if contamination may be occurring during the transportation.

Don Martín opens the distribution lines to the town for an hour each day. Community members fill large buckets and tanks at the communal taps. Once these containers are full, some families cover their buckets while others choose not to. There is also variation in the frequency with which these buckets are cleaned, but in general, EWB–Princeton observed clean buckets; contamination during the short walk from the tap to the house is unlikely. Every four days Don Martín opens an irrigation channel that runs through town for four hours so that individuals can do laundry. Most people do not use this water for other purposes.

Per capita water usage is approximately 21.3 L per day, though this is a rough estimate because some families gave their potable water usage only for cooking and drinking, whereas other families also use this water for cleaning and other purposes. Some people also use potable water to bathe.

Individuals in the community do not waste a lot of water; however during the hour in the morning when there is water available in the town, the taps run continuously leaving unattended buckets to overflow. Also, some people allow the water to flow into the shallow basin below the tap and then scoop the water into buckets, rather than allowing the buckets to fill up from the taps directly; some water is inevitably lost in the process.

8.2.6 Objective 6: Water Chlorination

Objective: Examine how and where the water is being chlorinated. Determine how the money for chlorine is raised, where the chlorine is being purchased and who is dosing the system. Perform chlorine residual tests (free and total chlorine) at the fourteen taps in the community. Ask members of the community whether the water tastes funny at certain times of the day/year.

Previously, Don Martín was chlorinating the water with bleach prior to distribution, but he discontinued the practice because the community did not like the taste of the water. He had been fully funding the venture.

8.2.7 Objective 7: Water Testing (Water Quality)

Objective: Perform very basic water quality tests. Measure the following: pH, nitrates, nitrites, total hardness, total alkalinity, turbidity, conductivity (and from that calculate total dissolved solids), lead, and presence of waterborne and fecal coliforms.

The condensed results of the water testing are presented in the sections below, 8.2.7.1 to 8.2.7.11. See Appendix A for the complete set of results.

8.2.7.1 pH

We measured pH using Eco-Check™ 5in1 Test Strips. For both Puquio Shaque and Puquio Reprisa, the pH was 8.5. Eco-Check™ lists this value as being high.[11] The Environmental Protection Agency (EPA) considers pH to be a secondary standard and lists a range of 6.5 to 8.5 as being acceptable.[12]

8.2.7.2 Nitrate

Nitrate was measured using Eco-Check™ 5in1 Test Strips. Puquio Shaque contained a range of 0-20 ppm of nitrate present while Puquio Reprisa did not have any nitrate present. Eco-Check™

[11] Eco-Check™ 5in1Test Strips correlates the numerical range with a written a description.
[12] *Drinking Water Contaminants*. 28 Nov. 2006. U.S. Environmental Protection Agency. 5 Mar. 2007. <http://www.epa.gov/safewater/contaminants/index.html>.

lists these values as being "safe." The EPA lists 10 ppm as the Maximum Contaminant Level (MCL). The MCL is the highest level of contamination allowed in potable water.[13]

8.2.7.3 Nitrite

Nitrite was measured using Eco-Check™ 5in1 Test Strips. Both Puquio Shaque and Puquio Reprisa did not have any nitrite present. The EPA lists 1 ppm as the MCL.[14]

8.2.7.4 Total Hardness

Total hardness was measured using Eco-Check™ 5in1 Test Strips. Both Puquio Shaque and Puquio Reprisa had a total hardness of 300 ppm. Eco-Check™ states that this corresponds to water that is "very hard." The EPA does not list a limit for hardness because it not a property that is important with regards to potable water quality. The EPA states that "water hardness is caused by the polyvalent metallic ions dissolved in water" and is the cause of scaling in pipes.[15]

8.2.7.5 Total Alkalinity

Total Alkalinity was measured using Eco-Check™ 5in1 Test Strips. Puquio Shaque had a total alkalinity of 300 ppm while Puquio Reprisa had a total alkalinity between 180 and 300 ppm. Eco-Check™ states that 180 ppm is "ideal" while 300 ppm is "high." The EPA does not list a limit for total alkalinity because it's not a property that is important with regards to potable water quality. The EPA defines alkalinity as "a measure of the capacity of water to neutralize acids."[16]

8.2.7.6 Turbidity

Turbidity was not measured as the clarity of the water was high and the test apparatus did not have the capability to record values in the necessary range.

8.2.7.7 Conductivity

Conductivity was measured using a conductivity probe. Puquio Shaque had a conductivity of 669 μS. Puquio Reprisa had a conductivity of 594 μS. According to Dr. Eileen Zerba, Director of the Undergraduate Lab and Lecturer in Ecology and Evolutionary Biology (Princeton Environmental Institute), fresh water is in the range of 200 μS while salt water has conductivity approximately 200 times that or 40 mS.[17]

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[13] Ibid.
[14] *Drinking Water Contaminants.*
[15] *Quality Criteria for Water 1986.* 1 May 1986. U.S. Environmental Protection Agency. 5 Mar. 2007. <http://www.epa.gov/waterscience/criteria/goldbook.pdf>, 146-147.
[16] *5.10 Total Alkalinity.* 30 Nov. 2006. U.S. Environmental Protection Agency. 5 Mar. 2007. <http://www.epa.gov/volunteer/stream/vms510.html>.
[17] Zerba, Eileen. Personal Interview. Dec. 2006.

8.2.6.8 Total Dissolved Solids

The conductivity probe uses the value of conductivity measured to determine the total dissolved solids present in the water. Puquio Shaque had 469 ppm of total dissolved solids while Puquio Reprisa had 417 ppm. The EPA considers total dissolved solids to be a secondary standard and states that 500 ppm or less is acceptable.[18]

8.2.7.9 Lead

Lead was measured using a PurTest® Lead Test. The test involves a test strip that changes color to indicate whether the sample is positive or negative for lead. Samples taken from Puquio Shaque and Puquio Reprisa were negative.[19] The EPA lists 0.015 ppm as the MCL.[20]

8.2.7.10 Waterborne and Fecal Coliforms

Counts of waterborne and fecal coliforms were made with Micrology Laboratories Coliscan® Easygel®. For Puquio Shaque counts of 187 fecal coliform colonies and 2,620 coliform colonies per 100 mL were found. For Puquio Reprisa counts of 154 fecal coliform colonies and 2,800 coliform colonies per 100 mL were found.

There were a number of factors that cold have affected the test results. It was not possible to regulate the temperature in the room in which the tests were performed. Micrology Laboratories states that there is the possibility of more variation from sample to sample when the temperature is not kept constant. Also, the counts included all purple (fecal coliforms) and pink (other coliforms) colonies, regardless of size. The guidelines did not state whether the colonies had to be of a particular size to be counted, but it's possible that a grouping of individual dots counted could actually comprise a single colony. Regardless, presence of Fecal and other coliform colonies alone provides some insight.[21]

According to the EPA, presence of coliform colonies is not a direct threat to human health, but rather an indicator that fecal coliform colonies may be present. Fecal coliforms arise from the presence of human and/or animal feces.[22] Fecal coliforms were found to be present in both water sources.

8.2.7.11 Copper

Copper was measured using a PurTest® Copper Test. The test involves a test strip that changes color to indicate the approximate level of the parameter. The range of the test strips was 0 ppm

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[18] *Drinking Water Contaminants.*
[19] PurTest® is manufactured by American Water Service in Matthew, NC 28104. Their website is www.purtest.com.
[20] *Drinking Water Contaminants.*
[21] Micrology Laboratories, LLC, provided instructions and background information regarding the tests performed. The name of the document is *Detection of Waterborne Coliforms and Fecal Coliforms with Coliscan® Easygel®.*
[22] *Drinking Water Contaminants.*

to 3 ppm. Two test strips were used for each of the two samples (Puquio Reprisa and Puquio Shaque). Both tests for Puquio Shaque indicated a level between 1.3 ppm and 3 ppm (closer to 1.3 ppm). Both tests for Puquio Reprisa indicated a level of approximately 1.3 ppm. The EPA lists 1.3 ppm as the MCL.[23]

8.2.8 Objective 8: Visiting Water Projects Occurring in Nearby Communities

Objective: Visit nearby communities, including San León, the community where CU Boulder is working (approximately 10 kilometers away), to determine size of communities served, see what projects have been implemented, and evaluate the impact that those projects have had.

EWB–CU Boulder is currently working in San Leon, which is located 30 minutes away from Huamanzaña by car. San Leon does not have any surface water sources or natural springs; villages currently use hand-dug wells as their source of water. CU Boulder's project in the community is to replace these wells with a communal well and piped distribution system. The well is more than 12 meters deep and was dug last summer. Plans call for water to be brought to the surface with a solar-powered pump that has not yet been installed. Water will be stored on site in two 2500-gallon plastic tanks, and from there it will then be distributed to members of the community. For more information, see section 11.2.

8.4 Irrigation Infrastructure

The irrigation system fed by Puquio Shaque alternates between a canal and PVC pipes. The canals are concrete and have Styrofoam expansion joints approximately every 10 feet; the pipes are 4 inches in diameter. Most connections between segments are clean suggesting that an adhesive like PVC glue was used. At some of the connections there is a black rubbery material wrapped around the pipe; this material is also used to repair leaks. The tube is above ground at all times and consequently completely exposed. There is very little shade; it is unlikely that the pipes have UV resistance, and UV degradation could become an issue. The tubing sometimes rests directly on the ground, but other times it is supported approximately 2 feet above the ground on criss-crossing sticks. These supports are located closely enough that sagging of the tubes is not an issue. If there were a large enough storm, some of the supports could be washed away, leaving the tube to sag and/or break. At a few of the supports the tube is pinched, suggesting that

Local engineers are supervising the construction of new irrigation lines.

[23] Ibid.

the tube is of a low grade and with thin walls.

The irrigation system fed by Puquio Reprisa is also concrete. Currently this system is being expanded by members of the community under supervision by an engineer named Carlos with the NGO Promach.

On some parts of the potable water distribution line, the PVC pipes are exposed to the sun.

8.5 Community Map

Shannon and Ted took GPS coordinates for all the houses, communal water taps, and main buildings in the central part of town, as well as coordinates for Puquio Reprisa and Reservoir 1982. These points will be plotted to create a map of the community, which we will use for future projects and provide to Huamanzaña as a communal resource. Because of its digital nature, we will be able to add additional items such as water distribution and power lines as we continue our work in Huamanzaña.

8.6 Pesticides

Discarded pesticide containers were found in the fields above town, and we copied the following information from the labels:

Container 1: *Gramoxone Super – Herbicida no selectivo de contacto; ingrediente activo - paraquat* 200g/L

Container 2: *Regen – Insecticida de contacto; ingrediente activo – Fipronil* 200 g/L

Container 3: *Alkalary poly ethoxy etanol – acideficante indicador de pH*

Container 4: *Carboxy-a – Acido Trihydoxiglufánico, Fertilizer, Skemata insecticida Agricola, Composición: Methamidophos* 600 g/L, *Dietilenglico y humectantes* 570 g/L

Since primary pesticide use by Huamanzañans occurs below Puquio Shaque, pesticides should not be a source of contamination for the potable water system. However, if communities located above the town are using similar pesticides, this could be a possible source of contamination.

8.7 Future Recommendations

The water quality of the two sources was approximately the same. While some of the water quality parameter checked were above the standards set by the EPA and fecal coliforms were present, members of the community are not experiencing sicknesses such as dysentery, nor are

they suffering from terminal conditions often associated with water quality issues. The EPA recommends that water contaminated with fecal coliforms be treated before consumption. The most viable options for the community are chlorinating the water or boiling the water prior to drinking.[24] As individuals in the community are not getting sick it is likely that the strains of fecal coliforms present in the water are not harmful or that individuals have developed a resistance to the strains present. Individuals seem happy with the quality of the water that they are receiving, and they say that there is no difference in the quality from the rainy to the dry season. While no explicit turbidity test was conducted, the clarity of the water was high. Based on community feedback and the tests that were performed, it does not seem necessary to pursue a project that involves improving the water quality. However, if in the future the community voices issues about the water quality or begins to experience sickness associated with waterborne disease, tests should be performed based on the complaints and/or symptoms of members of the community. While the community discontinued chlorination of the potable water because of the taste, it is possible that the dose was too high. Alternative methods of chlorination should be researched. One concern with introducing chlorination is that if members of the community move to a community where the water is not being chlorinated they may not have the resistance to the contaminants that may be present.

People would like more irrigation and potable water. Because much of the water in the area is from spring sources (the rivers run only during the rainy season), it is possible to bore into the aquifer. However, this would require a hydrological survey and could prove to be expensive. Currently, water quality and quantity does not seem to be a large enough issue to warrant this action. Individuals in the community do not waste a lot of water, but there are small improvements that could be made. Filling buckets up directly from the taps and monitoring them to make sure that they do not overflow would be a simple step to conserve water.

9. Community Interaction

9.1 Summary

EWB–Princeton University has a strong tradition of community involvement, interaction, and participation, and this trip heightened our contact with individual community members. The result was that we are now more attuned to the needs and priorities of the community as they see them. It also exposed us to how our existing projects should be improved to result in greater access for all Huamanzañans. The outcome of our community interaction is that we can now refocus and redefine our implementation of the technical sides of projects so that they will better serve human needs.

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[24] *Basic Information about* **E. coli** *0157:H7 in Drinking Water*. 28 Nov. 2006. U.S. Environmental Protection Agency. 5 Mar. 2007. <http://www.epa.gov/safewater/contaminants/ecoli.html>

9.2 Objectives and Their Execution

Objective 1: *Foster broader community involvement and stakeholder participation.* Drawing on the Our People, Our Resources technique and logic models, promote greater community participation in the projects. Huamanzaña needs to evaluate what its needs are and how it prioritizes these needs. Increase dialogue between EWB–Princeton and Huamanzaña as to the feasibility of different projects. Rather than discuss ideas we have for projects, give citizens more opportunities to bring their concerns and ideas for solutions to us so that we can work together in this process. Achieve this via in town meetings, smaller group meetings, and individual conversations.

With Our People, Our Resources[25] as a basis, we sought to achieve these objectives through increased dialogue during community meetings. However, Our People, Our Resources provides guidelines for community efforts that are of broader scope and to be executed over a longer timeframe than is possible in the EWB development model. Therefore, some efforts had to be adapted to the shorter timeframe and limited manpower of the EWB–Princeton team.

Community meetings were increasingly focused on discussing projects that would solve specific needs, and EWB–Princeton was honest about the feasibility of our organization being able to meet them. This exchange of information was beneficial to the Huamanzaña project as a whole, but also underscores the need for heightened debate about the philosophy of choosing projects. For a complete discussion of community meetings, please refer to the below section summarizing each meeting.

Objective 2: *Increase informal interaction within the community.* Although EWB–Princeton already has established a high level of informal interaction with the people of Huamanzaña, there are still many invaluable opportunities to learn about our Peruvian partners.

- WATER EXPLORATION AND SITE ASSESSMENT. During this phase, ask several community members to walk with us to the storage tank. Interview Martín Mendoza and discuss how he chlorinates Huamanzaña's water (if he does). Walk the lines of water leading into the town with the company of knowledgeable community members. (Rulfino, Norberto, Moreno, etc.)

This objective was fully achieved. Over three separate visits, we spent several hours talking to Martín Mendoza, visiting the water sources on his property, and assessing the quality of that water. We also toured Puquio Shaque and the other water source, Puquio Reprisa, with Eduard to get another perspective, in addition to conversing with Don Norberto and other community members about the issue on separate occasions.

[25] T.Barton, G. Borrini-Feyerabend, A. de Sherbinin, and P. Warren, *Our People, Our Resources*, Switzerland and Cambridge (UK): IUCN, Gland, (1997).

- STOVES, FUELS, AND COOKING TECHNIQUES. Visit houses and help with the preparation of meals. Talk to women about their cooking needs and observe the current techniques for stoking fires and preparing meals. (Alicia, Elena, Asunciona, etc.)

We visited the majority of the homes in Huamanzaña and conducted more than twelve individual and small group interviews. These interviews also afforded us the opportunity to talk specifically to women about their goals and priorities for the town. Although we only cooked twice, we did observe cooking techniques, learn about combustibles, and photograph each stove.

Doña Alicia and her family pose with their stove.

- MEALTIMES. Because all members of the team speak Spanish to some extent, converse over meals in Spanish and encourage families to join us at the table. Get to know less outgoing members of the community better.

This was one of the most important ways we interacted informally with the community, and it proved to be an invaluable technique for getting to know other Huamanzañans better, as well as providing a venue in which they could voice their concerns. At nearly every meal, the man of the house ate with us, and at several homes, women and children did so as well.

Objective 3: *Evaluate how the stove project can best be implemented.* On previous trips we have always implemented community projects, and have therefore never dealt with a project that involves the introduction of technology in individual households. Determine our model for supporting family-initiated and -installed projects—i.e., what families will contribute and what our role will be. Work with the community to consider how they can share the technology with other towns in the area, or whether EWB might consider sending a few students and community members to nearby villages to spearhead similar efforts. Determine how many students the community can support, as well as how long we will need to be there.

This objective was more difficult to achieve because stove construction had to be postponed until later in the trip due to Peter's evacuation. Nonetheless, we do have much better information on the necessary materials and the amount of labor necessary to complete the stoves, so we will devote this spring to determining how families will be expected to contribute. In light of the work that needs to be done on other projects, we will probably postpone branching out to other towns in the immediate future, with the exception of the small settlement of Casablanca, which has expressed their desire for stoves via family members in Huamanzaña. Additionally, this trip underscored the value of a smaller group when considering community relations. These observations will help us this spring as we determine how to best implement the coming projects.

Objective 4: *Consider educational campaigns related to future projects* after observing and interviewing townspeople so we may begin to prepare for the educational components of future projects.

Through personal interviews and general observations, we have concluded that in addition to any educational campaign accompanying the stove project, we should also recap the previous educational campaigns associated with earlier implementation trips. Although some people have adopted habits like hand-washing, the majority have not, and reiterating these points will be important as we reconsider existing projects and the best ways in which we can improve upon their efficacy.

Objective 5: *Locate other organizations working in the area*. Find out what the engineers currently living in the school are doing with the irrigation canal, as well as find out about other organizations that are working in the area. Visit a Peruvian developmental NGO called Coprodeli and learn about their efforts in more urban areas.

The meeting with Coprodeli was very productive, and news of the organization's recent expansion to Viru opens the possibility of collaboration between Coprodeli and EWB–Princeton in the future. However, because our visit came during the New Year's holiday, it was difficult to identify other local NGOs with which we should work. This is an area in which we anticipate increasing our efforts this coming spring.

Objective 6: *Set up regular community contact with Huamanzaña*. Renzo Ventura is a very valuable asset to us, but it is also important that Huamanzaña can contact us directly (and vice versa) because Renzo is not always available to make the lengthy and costly trip to the town. Identify one or two people who might email us when they are in Chao. (This will be based on who would like to serve in this capacity.) Consider making a trip with these people to set up an email account.

This was a difficult objective to complete because we realized how difficult it would be to choose a person (or several) to serve in this capacity, and then leave them with the resources necessary to pay for internet access in Chao. Instead, we offered our contact information to the community as a whole, and some people who have relatives with email accounts provided us with their contact information. So far, we have had limited contact, but Doña Alicia has been in touch via email and phone. We also learned how to phone Huamanzaña's rural telephone, so we will be trying this as a method for communicating with the village in the future.

9.3 Meeting Summary: 1 January 2007

The first official meeting of the trip was held shortly after 5:00 PM on 1 January 2007, several days into the trip. We chose this date because we wanted all group members to be present, and we were also mindful of the New Year's holiday. Even so, several families were not in Huamanzaña that day, including that of the de facto mayor Santos Moreno.

We began the meeting by greeting people, introducing ourselves, thanking the community for its hospitality, and giving a brief explanation of why we were in Huamanzaña in the summer (Southern hemisphere) rather than in August, as is typical. We also presented the town with a card from the EWB–Princeton team, which had a photo of group members and messages to the town. In general, Renzo and Shannon ran the meeting with help from Don Alfonso and Peter. The meeting was held outside the school, and chairs from the school were provided to all attendees. These chairs were arranged in a crescent shape facing the school building, where EWB–Princeton team members had hung posters with stove designs and space for note taking.

We were already aware that the primary problem with the solar panel system was the *pilas* (D batteries that are used in the lanterns) and the amount of time required for them to receive a full charge. Forrest Bradbury (from the technical team for the solar energy project) had conducted tests in the Princeton labs, and he had determined that the *pilas* were taking a long time to charge because people were waiting until they were fully discharged before they recharged; these were the instructions we had given the villagers in August. Forrest's tests led him to conclude that it would be better to charge the batteries as soon as the light began to fade.

Over breakfast on Saturday, Renzo and Shannon had discussed this with Don Alfonso, the elected president of the solar energy committee. Because he was already familiar with the problem and Forrest's proposed solution, he helped us run the town meeting and explain the situation.

Our team had purchased and brought 25 D batteries to augment the town's supply and ensure that all families had batteries of equal quality and size. Of these 25 batteries, four were made by Radio Shack (*los verdes*); several batteries of this brand had been in the lanterns presented to families in August. The Radio Shack batteries had been problematic and were of different voltage; these batteries had already been replaced in November when Renzo brought Powerizer batteries that had been shipped to him by Forrest. Because we had already established that the Radio Shack batteries were problematic, we removed them from the set of new batteries that could be added to the town's supplies.

The question then became how to distribute the remaining 21 batteries.[26] We brought this dilemma up during the meeting, and there was some discussion over how best to distribute a limited quantity of batteries when most people are having problems with their batteries. The ultimate verdict was that people who had batteries of different voltages that had not been replaced previously would have first access to the new Powerizer batteries; the rest would be distributed by the solar committee on a case-by-case basis depending on the problems with the batteries. At this point, we turned the batteries entirely over to the solar committee, and they will resolve any further questions regarding the matter. We also brought up the fee system briefly, but few people raised concerns on the matter, and the solar committee said that they would handle any adjustments to it.

The general consensus on the light was that people were moderately happy with the lanterns and had no problems with the light and electricity in the public buildings. We congratulated the

[26] Each lantern uses four D batteries.

technical team for the solar energy project on their success in hooking up a color television and DVD using an inverter.

We then discussed the two main stove designs that the technical team had prepared—the Inkawasi stove and a more traditional rocket stove. Prior to the meeting, Chris had shown his drawing plans to Don Norberto, who had arrived early. The two had discussed the schematics, and Don Norberto had good ideas for improving them. During the meeting, Chris encouraged other townspeople to give similar feedback. He also asked Don Norberto, one of two townspeople who is considered an expert bricklayer, to help oversee the technical side of the stove project with him. Huamanzañans were interested in participating with the construction of the stove, but because Chris still lacked some materials setting fixed dates for construction was postponed until the next day. Due to Peter's accident, the rest of the stove discussion ended up occurring at the following meeting, which we scheduled for Thursday, 4 January 2007.

At the first meeting, villagers brainstormed many ideas for future projects.

Next we discussed possible projects for the future so that we could begin the planning process and prepare to assess more on our next trip to Huamanzaña. In the past, EWB–Princeton often came to Huamanzaña with their ideas for projects that would address town needs. However, we wanted to the townspeople to voice their concerns and priorities, and then together work with them to come up with project ideas. Although we explained this new approach to the townspeople, they were slow to begin voicing their ideas during the meeting. But with the help of Don Alfonso and Peter, we began brainstorming possible projects that would address issues facing Huamanzañans. As ideas were generated, we added them to a poster taped to the wall of the school building so everyone could see them. The list of project ideas is as follows:

Project	**Concern(s) Addressed**
Stoves	• Indoor smoke that damages vision and causes lung problems • Difficulty of finding wood fuel[27]
Bridge at Aguas Calientes	• During February and March (the rainy months) the Río Huamanzaña run so high and forcefully that combis cannot reach Huamanzaña, thus limiting access to medical facilities and food
Highway improvement project	• Slow, pitted road
Light (possibly generated by wind)	• Difficulty to cook and do other tasks at night
Showers for each home	• Health

[27] For some people, it is very difficult to find wood for their stoves, whereas others have no problems with the task. Nonetheless, the primary priority for EWB–Princeton is to address the health concerns related to the current stoves; solid fuel reduction will be secondary. For further discussion of the current fuel wood demand, see section 9.6.

	• Lack of access to current shower built by EWB–Princeton
Health post[28]	• Low quality care in Santa Rita • Distance one must travel for medical care
Irrigation improvement	• Lack of water for the *chacras* (fields)
Roof improvement	• Leakage during the rainy season
In-home potable water access	• Uncovered buckets of water[29]

Following the conclusion of the formal part of the meeting, Shannon gave people pictures taken during the previous visit to Huamanzaña. Also, because we had asked to see the television in action, Don Miguel Tiburcio and his family brought the inverter, television, and DVD player to the school to demonstrate. The inverter converts from DC to AC power; it can be attached to the system via the connection that Forrest installed. This connection consists of two wires (positive and negative) attached to a board hung at a level of about 5 feet above the ground in the classroom; electricity to the circuit is controlled with a switch in the school as well as a separate switch in the circuit breaker. The inverter's plug has been removed, and the power cord now consists of positive and negative wires that can be wrapped around the connection.[30] The DVD and television can then be plugged into one of the three sockets in the inverter; though the inverter says these sockets are for different amperages, they all seem to work equally because three appliances have been run successfully simultaneously.[31]

The movie showing after the meeting kept the large crowd at the school for several more hours.

After the connections for the television were made, most meeting attendees (as well as all the children in the vicinity) filed into the school for a showing of *Platoon.* Although Peter mentioned to adults that the movie contained adult themes and content, no one seemed concerned.

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[28] The government (or a recently elected politician) has promised a post of the Ministry of Salud in Huamanzaña. The location has not yet been chosen, nor does there seem to be a timeframe by which this post is expected to be completed.

[29] Huamanzañans did not cite uncovered water buckets as a potential health problem, but team members observed that many households did not cover their buckets. The clarity of the standing water inside the buckets varied.

[30] This connection is equivalent to the one in the *locale* (community building).

[31] Don Miguel's oldest son Dandy has a cellular telephone that he sometimes charges while the movie is playing.

EWB–Princeton members had to leave the group in the school watching the movie in order to keep a dinner appointment at Don Martín Mendoza's home, but the community was very respectful of our belongings in the school. Don Rulfino and Don Alfonso oversaw the clean up after the conclusion of the film, and we returned to find everything in place.

9.4 Meeting Summary: 4 January 2007

The second meeting was also held outside the school shortly after 5:30 PM. Because we had just returned that afternoon from Trujillo (due to Peter's evacuation), some people had forgotten about the meeting, and we hadn't had enough time to remind everyone. Nonetheless, we still had a fairly good attendance.

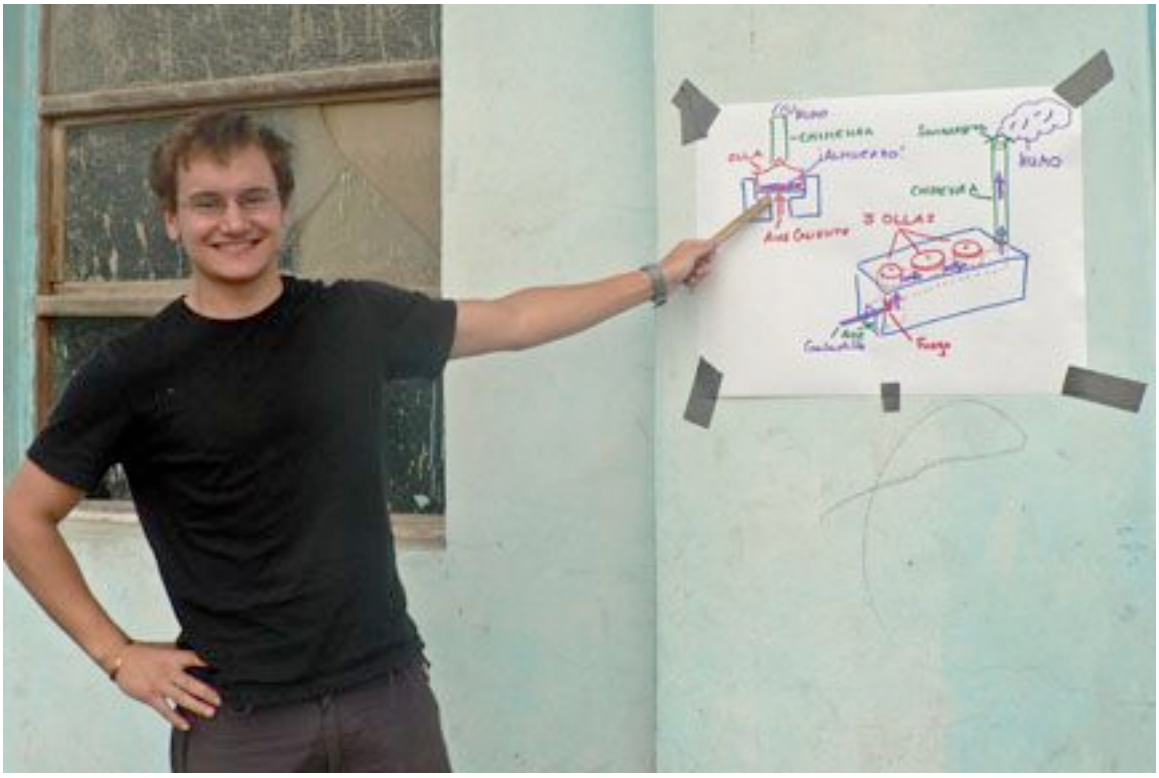
We began by explaining our absence and bringing news of Peter's condition. (Most townspeople were already aware of the accident after hearing about it from Shannon and Ted on Tuesday night or Wednesday morning.) Huamanzañans were concerned for Peter's wellbeing and expressed their sadness that he had to leave early.

Stove plans were on the agenda at the second town meeting. Chris, Renzo, Don Norberto, and Don Alfonso explain a schematic to the crowd.

Next Chris explained the Inkawasi stove plans in greater detail and showed townspeople the materials purchased in Trujillo: the welded steel chimney and a special type of brick (*ladrillos pasteleros*). Shannon also brought up some observations that she and Ted had made, namely, that the stoves needed to be a certain height with openings for kindling that would be out of the reach of small children. With the community's help, we generated a list of their concerns with the project. A copy of the list (which was posted outside the school) follows:

Potential Problem	**Why**	**Proposed Solution**
Stove height	• Stoves slightly above waist level are most comfortable so that women don't have to bend over them • All current stoves are built on *tendales*, iron tables that are about waist level (78 cm)	• Engineers must make sure that stoves can be built on existing *tendales*, taking into consideration height and the weight these tables can support (they seem very strong)
Pot sizes	• Women use different size pots depending on the meal and the number of people for whom they are cooking	• The standard stove model will have accommodate one large pot and two medium pots with a graduating mechanism for smaller pots

Location of the model	• The old school *comedor* (communal kitchen) is in disrepair and the new *comedor* has not been completed	• The model was built in the new *comedor*
Type of chimney tube and durability	• Cost (100 /s is too expensive) • Concern with the durability of the steel	• Evaluate how this chimney holds up with use on the model stove in the new *comedor* • Look for alternative chimney materials, including possibly using dryer vent hose



Chris explains the science behind the Inkawasi stoves to the attendees at the town meeting.

In conjunction with the stove discussion, we briefly discussed health problems. This is a difficult topic to discuss because most townspeople do not like to talk about their problems, especially publicly. Therefore, we did not press this issue very much. Nonetheless, Huamanzañans did identify smoke in the kitchen as a problem, especially when they cook with *tusa* and *sapote*.[32]

[32] *Tusa* is dried corn husks that are commonly used to ignite fires, but also can be used as a general fuel. *Sapote* (*zapote*) is a type of *leña* (firewood). For more information about the plants of Huamanzaña, see Appendix 15.2.

We continued the meeting by revisiting the list of ideas for future projects that had been generated the previous Monday. Townspeople were asked to prioritize these projects. Through a combination of voting and individuals voicing their opinions, the community collectively identified three projects: stoves, a bridge for Aguas Calientes, and more light. At this meeting, the consensus was also to continue with the stove project in the immediate future.

Finally, we also recapped some of the information about batteries and solar panels from the previous meeting for those people who had not been in attendance. After the meeting, we met with Andre de la Cruz and Doña Pancha regarding their batteries, whose plastic cases were splitting due to the heat from the charger or displayed wear from rubbing within the chargers. Neither of these minor superficial flaws should affect battery performance.

The plastic cases of Andre de la Cruz's batteries (above left) show splitting because of heat in the chargers, while Doña Pancha's battery shows some wear (above right). Neither of these minor flaws should affect battery performance.

This was the final scheduled meeting of the trip.

9.5 Meeting Summary: 8 January 2007

On Monday morning, the final day that the EWB–Princeton team was in Huamanzaña, Don Moreno came to the school at 7 AM. Shannon was the only person awake, so she talked with him about his concerns. Don Moreno wished to hold a town meeting prior to our departure at 1 PM in the afternoon. Later that morning, while talking with Don Rulfino, Renzo learned that the purpose of this meeting was for the town to express their desires for more light instead of stoves.

This town meeting was the low-point of the trip, first in that it was very rushed; our *combi*, which had been scheduled to arrive at 2:30 PM, arrived at 1 PM and was eager to leave. Although we convinced the drivers to wait 45 minutes, the meeting was highly rushed and impeded other last-minute activities like final packing and goodbyes.

During the meeting, which only about 15 people attended, Don Moreno voiced the opinion that light rather than stoves should be EWB–Princeton's next project because that is where the town's priorities lie. We explained what we had reiterated during previous meetings and interviews, which was that we do not know whether it is possible and within the scope of EWB–Princeton's work to expand the current lighting system. We explained again the technical difficulties of doing so. The final consensus was that EWB–Princeton would continue the stove project for implementation in August 2007 and revisit the possibilities for increased lighting.

Shannon also provided her email address and contact information to Don Moreno and Don Alfonso so that they can contact her with further information and concerns as they arise.

One thing that was disconcerting about this meeting was that the priorities expressed (more light) did not always agree with what people had said during personal interviews. Although there were several women at this last-minute meeting, many of the people who had expressed their desires for stoves in a smaller setting were not represented.

9.6 Formal Interviews

Shannon and Ted, with help at times from Renzo, conducted interviews with more than twelve different families over the course of the visit. They visited the majority of the families in the center of town, as well as several living outside the town. Also, many families were traveling during all or part of the trip due to the New Years holiday, and therefore, we were unable to interview them.

9.6.1 Talking with Women About Their Stoves and Cooking Techniques

Stove interviews were structured around investigating thirteen primary questions in order to collect comparable data from each household. Questions were as follows:

1. What type of combustible do you use in your current stove (firewood, *tusa*, kerosene, gas, etc.)?
2. What type of firewood do you use (*algorrobo, sapote, espino,* etc.)?
3. At what times of the day do you generally cook?
4. How much time do you spend cooking each meal?
5. What meals do you cook frequently?
6. Do you boil your water before drinking it?
7. What effects does the smoke from the stove have upon you and your family?
8. How much firewood do you use?
9. How much time does it take you to collect firewood?
10. How many pots do you need to cook and of what size?
11. How many buckets or barrels of water do you fill each day?
12. Do you use chlorine or bleach to treat the water?
13. Of the priorities that the townspeople have generated for future EWB–Princeton projects, which are most important to you and your family? Why?

Interviews were not strictly limited to the topics addressed by the questions, and we let the interviewees steer the conversation. This worked well because women often provided other

relevant information, such as news that the government is planning to build a health post in Huamanzaña or information about how people collect water from the Puquio Reprisa or Reservoir 1982 when there is not enough water in the taps. Also, as we conducted more interviews, we saw some trends in the responses. Nearly all townspeople use the same types of firewood, though they do so in varying quantities. No one treats their water with chlorine or bleach, though many do use the chemicals to clean the buckets in which they store their water for the day. Moreover, women admitted that when Don Martín had chlorinated the water that ran to the taps in town, people disliked the flavor.

Doña Stela laughs while preparing a meal during an interview with Ted and Shannon.

The interviews also show many personal variations in the cooking times, fuel use, and difficulty of finding firewood within the different families. These results are summarized in Appendix B. Though the variations will prove challenging to designing a stove that supports various cooking styles and techniques, it also highlights the important role that education can play in modifying these habits. In particular, it underscores the need for EWB–Princeton to develop an educational component for the stove implementation trip that deals with the proper amount of wood necessary to stoke the new stoves.

Visiting homes and talking to women on a one-on-one basis or with other women also afforded us the opportunity to observe another side of Huamanzaña life. We noticed that there is significant variation in how families store their water for the day: after filling their buckets or barrels at the various taps throughout the town, some people leave the water buckets uncovered, whereas others are careful to put lids on each bucket. Within the subset of families who leave their buckets uncovered, there is also variability in the cleanliness of the containers and the water itself. Nonetheless, because water-borne illnesses do not seem to be a significant health issue in Huamanzaña, these results may serve only as anecdotes.

Shannon and Ted conducted the majority of the interviews with women as a pair, though the latter interviews were conducted solely by Shannon. As the only female member of our team, we thought it was important that she lead the interviews because women might be more comfortable talking with someone of the same gender.

We tried to conduct the interviews during mid-morning and mid-afternoon, two times of the day when women are less burdened by the tasks of cooking and would have more time to chat with us. Often the interviews took place in the kitchens themselves, with some occurring elsewhere in the home or outside on the stoop. Sometimes we participated in the cooking, learning how to defeather pigeons for lunch and cooking bread to be sold to other townspeople. In nearly all

cases, we asked the women to pose for a photograph with their stoves so that we have a record of variation within the types of stoves in Huamanzaña. Furthermore, because photographs are highly prized, by having Shannon ask to photograph a woman with her stove is seen as a form of flattery.

Shannon conducts a literal field interview during a break from harvesting corn.

Ted and Shannon learn to pluck feathers from pigeons during an interview with Doña Celinda.

9.7 Discussions Regarding Future Projects

In both formal and informal settings, we frequently talked to townspeople about their priorities and needs for future EWB–Princeton project. This was a key component of the interview with women about their stoves, and it did illuminate a slight bias among women toward projects relating to health, such as the stoves, latrines, and a health post. Sentiments in favor of latrines were particularly stronger among women in a small-scale setting rather than in the group meetings. Also, we noticed a slight bias toward health-oriented projects among wealthier and seemingly more educated community members. Nonetheless, these families often live in the outlying areas of Huamanzaña on larger properties; due to their distance from the center of town, they will be more likely to benefit from in-home projects such as stoves and personal showers rather than electricity or communal bathrooms located within the town.

Even so, the overwhelming sentiment in Huamanzaña is that light and electricity in every home is the greatest priority for townspeople.

9.8 Informal Interactions

Central to EWB–Princeton's approach to working with Huamanzaña is maintaining a large informal presence in the community during our visits. This is one of the most rewarding aspects of the trip because it allows us to get to know townspeople of all ages on a more personal level.

The small size of the travel team for this assessment trip was helpful because it promoted our assimilation into the community. Because all team members speak some Spanish, nearly all our conversations over meals were in Spanish, thus making it easier for the hosts to join in the

discussion. Moreover, we had more families join us at the table to eat the meals, which allowed us to get to know the wives and children rather than just the heads of households.

After a day of work, the young men of Huamanzaña enjoy playing *fútbol*, and we sometimes joined them on the pitch. Each night after dinner, we socialized with community members, sharing jokes, riddles, and stories. Plus, during any free time, we'd often find ourselves surrounded by children eagerly probing us with questions about our families and friends back home. The friendships formed during these informal interactions help the community get to know us better and feel more comfortable addressing us with their concerns.

After dinner, we socialized with townspeople. Here Chris and Ted posed with Doña Elena and Leidi Diana.

Photographs are always popular with the kids. Here Shannon is surrounded by posing children.

9.9 Recommendations for Existing Projects

9.9.1 Community Bathroom and Sanitation Facility

Since its construction by EWB–Princeton in August 2005, the community bathroom facility has worked well, with the only minor problem of note being a few leaky taps that are easily fixed by community members. Nonetheless, the bathrooms are located in the uppermost section of the central Huamanzaña town, well away from the road. Due to community concerns about vandalism and the responsibility of cleaning the facility, the bathrooms are generally locked except during school hours. During the school day, the primary school teacher (who has been entrusted with the keys) unlocks the facility for use by the children during recesses; the bathrooms often remain open until nightfall,[33] provided the teacher is around and can monitor them to some extent. Even so, the teacher's primary residence is in Trujillo, where she returns each weekend. That means that the much of the time Huamanzaña's bathrooms are locked and unavailable for use by the majority of the community.

EWB–Princeton's assessment trip fell in the first weeks of the summer vacation. Because two engineers from an NGO called Promach were working to upgrade the irrigation ditch running from Don Martín's property to below the town, the bathrooms were unlocked as a courtesy for

[33] The teacher and her family unlock the bathrooms for personal use at night.

the engineers' personal use. Though the facility was never locked during the ten days we were visiting, we observed only one person from Huamanzaña use the toilets, and a few others used the sink to wash their hands without prompting. Moreover, in interviews with townspeople, it became apparent that virtually no one except the teacher uses the shower, in part due to the long walk for people who live in the lower sections. Most families also use their own latrines or those of their neighbors rather than use the community facility. These latrines vary in their quality and safety from health and environmental standpoints.[34]

Don Walter's newly dug latrine is stalled by his lack of materials to finish the job.

Nonetheless, two families have begun building their own latrine and shower facilities based loosely around EWB–Princeton's example. Walter Paredes Ibañez has already dug a pit for his latrine and prepared two cubicles—one for the shower and one for the latrine—but he lacks the cement to continue the project. He plans to use a 100-L elevated tank coming off the main potable water line to feed his shower. Santos Moreno has similar plans.

The personal initiative demonstrated by these two families is excellent in that it exemplifies the manner in which technologies introduced by EWB–Princeton are adapted by the community to become their own. Nevertheless, the water to feed these showers will be diverted from the main potable water line, reducing the quantity of water available for families living in the lower section of the town. Both Don Walter and Don Moreno's families are somewhat better off than the majority of Huamanzañans; Don Walter owns a horse, stereo, and refrigerator (though the later no longer works) and Don Moreno serves as the informal mayor of the village. The added luxury of a shower and higher-quality personal latrine at the expense of the water consumption for families in the lower section could prove problematic.

In light of these two developments—locked bathrooms with limited village use and personal projects—EWB–Princeton is considering revisiting the community bathroom project. Among our current plans include evaluating policy changes that could be suggested to the town to promote bathroom use, as well as the possibilities of building another bathroom facility to serve the lower section of town or providing more extensive materials and engineering support for families who wish to construct their own personal latrines.

[34] EWB–Princeton left some materials for individual families to use to build personal latrines according to a design they brought during the August 2005 trip. An estimate from Elena Olivi, a member of the first three travel teams, is that roughly nine families ended up building these latrines. However, most latrines are behind houses and out of sight, so it is hard to evaluate how many were built and of what quality.

As a simple solution to the problem of cleanliness of the existing facility, we are also considering attaching backs to the toilets. Doña Ubalda, whose family already has a toilet with a back and a personal shower, recommends the upgrade because it will keep the toilet bowls cleaner, thus reducing the burden on the schoolchildren who currently are responsible for keeping them maintained. Although it may use slightly more water, it should also help the toilets flush completely, thus reducing the problem of incomplete flushes when young children or the uninitiated flush them with a large pitcher.

In considering these possibilities, we also must anticipate that the community may want to designate some stalls according to gender. In the bathrooms at the primary school, stalls have been specified as to who may use them: boys in the first stall, girls in the second and third stalls, and the teacher in the fourth stall. According to Elena Olivi, an anthropology major who traveled on the first three trips to Huamanzaña, this may be due in part to the belief that a man's urine can impregnate a woman.[35] Whether this taboo is rooted too deeply to be overcome by education remains to be seen, but it would have ramifications for another bathroom facility in the lower section of the town.

Doña Ubalda's grandson Elias poses in their shower.

Finally, the bathroom project was introduced with an extensive educational campaign to promote hand washing and good sanitation practices that reduce the risk of cholera, diarrhea, and other dysentery ailments. Though many people still remember the hand washing song, we observed only one person wash his hands without prompting. Furthermore, many people (men especially) continue to urinate and defecate in their fields. A refresher course on the importance of hygiene may also help rekindle interest in these issues.

9.9.2 Solar Energy System

Among Huamanzañans, there is an overwhelming preference for light (and electricity) in every home over any other project—including the wood burning stoves. In the final meeting with the town on 8 January 2007, we established that EWB–Princeton would implement the stoves project in summer 2007 but continue exploring the option of expanding the solar energy system (or exploring renewable methods to generate electricity) in order to bring light into each home.

EWB–Princeton is very hesitant to commit to this endeavor, not only from a technical standpoint, but also because of the repercussions it may have for the culture and way of life in this tiny town. Currently, after dinner entertainment is stories and jokes told in the darkness

[35] Even so, we observed that men within a family seem to use the same personal latrines as their daughters and sisters.

under the starry Milky Way skies. The introduction of electricity in the *locale*, school, and other primary buildings has enabled townspeople to watch television. This is currently a communal event that brings many people together, but if there were electricity in each home, families might be more likely to remain in their houses rather than continuing this rich oral tradition after dinners.

Nonetheless, there are undoubtedly benefits to light and electricity in houses. In interviews, several women expressed their interest in being able to run *licuadoras* (blenders) in order to make juices to sell up the mountain in nearby Huaraday, where truckloads of sellers journey each Friday morning. Furthermore, stronger light than the lanterns would be more likely to facilitate reading among townspeople of all ages, but particularly children. Finally, some older residents seem to have vision problems, and light would help them better navigate their dark adobe homes and remain independent.

Even so, there are equally compelling arguments to not install electricity in individual homes. Several EWB–Princeton students hypothesize that the prestige associated with light may be outweighing more practical and pressing considerations such as health. Additionally, wood burning stoves are something that is closer to being within the means of a typical family, whereas solar panels and the digital equipment that accompany them are novel and well beyond anything these families could afford. And, were we to effectively create an electrical grid in Huamanzaña, it might lead families to spend precious earnings on equipment such as televisions and DVD players rather than make investments in their families and farms. Finally, light in town could prove divisive considering that a number of people live outside the central grouping of houses and would be outside the reaches of an electrification project.

Renzo Ventura also makes several comments on the possibility of an expanded lighting project. We have translated his opinion into English, but the original text appears in Appendix 18.

> *For the people of Huamanzaña to have electric light in each home is a priority. However, the objectives stated by EWB–Princeton contemplate nothing more than action to improve small communities with engineering projects. Without understanding the social context and cultural peculiarities where these projects evolve (which in the case of Huamanzaña specifically include a lack of adequate educational programs, a significant number of adults and elders who are illiterate, and a majority of children who complete only primary school), it would be very complex and, moreover, risky to implement a project of this type without first evaluating the possible impact and consequences that this project could bring to the social behavior of this community where certain native elements of the culture still exist.*
>
> *A possible solution would be to improve and optimize the system that has already been implemented without elevating the capacity that it already has. Another possibility would be to begin to find new mechanisms of interaction with the community that focus on education. This second suggestion is sufficiently difficult to undertake, seeing as in many ways our efforts would be competing with those of the Peruvian state.*[36]

[36] By this, I think Renzo is suggesting that our educational efforts would be made more difficult by the poor quality of Peruvian public education in the rural areas, especially considering that

> *Nevertheless, the people of Huamanzaña are very grateful with all types of assistance and support that EWB–Princeton can offer.*
>
> *My judgment depends a lot on the success of the new project to renew the confidence of the town in EWB–Princeton. Thus, as I have already commented, the light system has left a desire for more thorough electrification, as we have encountered among the townspeople.*

Of course, this is a tough topic to tackle. Our group agrees that paternalistic sentiments should not govern whether or not we undertake any given project; instead we must consider our own dual mission as a University chapter—that is, to educate ourselves as engineers, policy makers, anthropologists, and world citizens and simultaneously to promote sustainable development through appropriate technologies. These considerations have already played a role in the philosophical debates we have had since the assessment trip, and we anticipate that they will continue to influence the direction of this and all other EWB–Princeton endeavors.

9.9.3 School Library

As a component of the solar energy project, EWB–Princeton also provided fiction and nonfiction books to start a lending library based at the school. Though our assessment trip took place over the summer vacations, there was no evidence that the books had been touched since August. Moreover, few people in town seem to be reading, in part due to a lack of up-to-date reading material of any kind. For the summer 2007 trip, we will be considering ways to improve library access and book circulation, perhaps by moving it out of the primary school building and into the *locale*, to which the community has greater access when the teacher is away. Furthermore, by placing the books in the locale, it makes good use of the light installed in that location, and might also serve as competition with the movies that are screened in the same spot.

10. Community Health Assessment

A thorough community health assessment was conducted in conjunction with the August 2006 solar energy project.[37] We did garner some additional relevant information from the personal interviews with women, and that information has been summarized below.[38]

10.1 Indoor Air Pollution

Several—though not all—women interviewed noted that their current stoves cause smoke and indoor air pollution that damages their vision and causes respiratory problems. One of the most

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there is currently no science curriculum. Therefore, the base education level of many people within Huamanzaña may be unprepared for the rigors and complexity of lessons based on the scientific method. [SMB]

[37] A Solar Energy Project for Huamanzaña, Peru. Ron Weissbard, ed. EWB–Princeton, 2006.

[38] Original notes are available from Shannon M. Brink in Spanish and English. For further information, contact her directly.

harmful fuels is *tusa*, the corncob remnants from livestock feed that are used to ignite a fire. *Tusa* creates a particularly acrid and burning smoke that makes eyes water and breathing difficult. In one case, the smoke was so bad and the hole in the roof through which it should have escaped was so ineffective that the woman had moved her stove to each corner of the room in an attempt to find some location where the draft removed the heavy smoke. Nevertheless, women informed us that they often leave the room after adding *tusa*, and they keep their children out of the kitchen while cooking. The veracity of the latter statement may depend on the amount of smoke; we often observed children in the kitchen—for they help their mothers with the cooking—and some parents reported spending money on expensive eye drops to treat the vision problems arising from the smoke.

10.2 Water Consumption

During the individual interviews with women about their stoves, we also inquired about the quantity of potable water they reserve each day for cooking and drinking. Although these figures are approximate at best (given in the number of buckets and varying depending whether the family also uses potable water for cleaning), it does give us a rough estimate of the water consumption at 21.3 L of potable water per person per day for the families surveyed. Furthermore, during the interviews, we could observe how people store the water for the day and how frequently they clean their buckets. Some families use bleach, chlorine, or boiling water to clean their buckets daily, whereas others only need to do so a few times a week. Some families cover their buckets, while others leave them uncovered all day; the water in the uncovered buckets sometimes collects dirt and grime. Also, at least one family fills up a large tank that lasts for two or three days. In general, the water consumption is higher among smaller families because these families may fill their buckets at the taps for a comparable amount of time as the larger families.

10.3 Healthcare Accessibility and Preferences

In keeping with our findings from the August 2006 health survey, we discovered that the majority of the townspeople in Huamanzaña seek health care in Chao or Viru instead of the Ministerio de Salud health post in Santa Rita, which is staffed only by a nurse. A few families report visiting the health post for minor ailments, but for more serious afflictions, nearly all choose to travel the greater distance for the better care. Several people in Huamanzaña are reporting that the Ministerio de Salud has promised a health post for Huamanzaña, and people are excited about the prospect of healthcare within the town. Though a tentative location has been suggested near the *fútbol* field and old school *comedor* building, there does not seem to be a start date for this project.

11. Greater Community Interaction

Among EWB–Princeton's objectives for this trip were increased interaction and engagement with NGOs and similar organizations working in the country. Some efforts to set up these encounters were hindered by our timing, which coincided with the Christmas and New Years

holidays. Nonetheless, we did have two very successful meetings with other groups working in the area.

11.1 Coprodeli

Coprodeli is a Peruvian based NGO founded by Padre Miguel Ranera Sanchez-Pardo that has been working since 1989 to promote economic and social development in the Lima's slums. Coprodeli's development model relies on community-based methods to promote job creation, education, health, and improved infrastructure for impoverished Peruvian families; its operating budget is several million dollars each year, and it sometimes works using government grants or as a contractor. For more information on the background and history of Coprodeli, please visit http://www.coprodeli.org or http://www.coprodeliusa.org (the American branch of the organization).

We first learned of Coprodeli through a contact of Ted's who works for the National Rural Water Association. Via email, we arranged a meeting with Padre Miguel and a Coprodeli engineer, Carlos Enrique Ormeño Grados. Mr. Ormeño met us at our hostel, brought us to Coprodeli's headquarters in Callao, and gave us a tour of the offices. Though modest, Coprodeli's offices boast separate sections devoted to each aspect of their development promotion, and there are also several community businesses (primarily technology-based) that operate within the facility. Most employees were on holiday, but those who were there were very friendly and helpful. Mr. Ormeño briefed us more in Coprodeli's work, particularly from an engineering standpoint, until Padre Miguel arrived.

Padre Miguel, a native of Spain, has been living and working in Lima for the past 25 years. Although he came to the country as a Catholic missionary and continues his work as a Father, from our conversations, we could discern no prerequisite or requirement that families benefiting from Coprodeli's work profess the faith. Coprodeli's schools do have religious icons on the walls, but it is unclear whether the education has a religious component.

Perched on sand at the edge of the ocean, Pachacutec is a haven for 100,000 Peruvians who cannot afford to live in Lima.

Padre Miguel told us about Coprodeli's work in Pachacutec, a city of 100,000 squatters that sprung up on the sandy hills well outside of Callao because real estate prices were too high in the city. Pachacutec had no water source, and in 2002, Coprodeli began working there to construct reservoirs using funds from the Peruvian government's *Agua Para Todos* (Water for All) program. Since then, Coprodeli has built three compounds in Pachacutec, each with education, healthcare, job training, and worship facilities. They have also built a number of houses.

Coprodeli's development model deals with fulfilling all components of human services in the area including education, healthcare, job creation, and infrastructure (houses, water, sanitation). In terms of education, their *colegios* (schools) house 500 students in grades 1-12. The teachers' salaries are paid by the government, but the salaries for all other staff members are funded by the organization. Class sizes are about 40 students per class, and parents pay only about 5 soles per month so that the students can eat in the school facilities. Fathers are also expected to volunteer in the school for a total of five hours each year. In the case of Coprodeli's health clinics, care is provided principally by doctors paid by the NGO. Visits to the clinic cost 4 soles (versus 3 for Ministerio de Salud health posts), but specialty services such as x-rays are less expensive than their Ministerio de Salud counterparts.

The Coprodeli compound in Pachacutec includes a health center (above left) and a school serving grades 1-12 (above right).

Coprodeli is continuing to expand its work, and is now considering projects in Ica and Viru.[39] Ted and Shannon were particularly interested in the Viru efforts due to the proximity of Viru to Huamanzaña, as well as the fact that many people in Huamanzaña have relatives living in Viru.

Viru is experiencing an asparagus boom that has led to an influx of 40,000 workers into the region, some 20,000 of whom seem to work in a single plant. In total, Padre Miguel reports that there are seven large *agrícola* (agricultural) enterprises.[40] The majority of the workers in these plants are between 18 and 24 years of age, and Corprodeli's aim is to avert problems in the nascent city by introducing sustainable methods of development. Viru benefits from a bank in the city where workers in the *agrícolas* who have held their job for three years become eligible for credit. Although Coprodeli does seem to offer some microcredit at an interest rate of about 17%, there are few other opportunities for affordable credit in Peru. The organization initially became involved in Viru when they were asked to build schools in the city by a large *agrícola* enterprise that had worked with them in Callao. Because Coprodeli's development model

[39] Viru is both a distict in La Libertad and a town, which is also known as Puente Viru. In this case, we refer to the town.

[40] I believe the largest of these enterprises is Camposol SA, which also works in Chao: http://www.camposol.com.pe. [SMB]

addresses all aspects of human development, their plans for Viru are similar to those for Pachacutec.

After talking for several hours at Coprodeli's offices, Padre Miguel graciously invited us to visit Pachacutec to tour a Coprodeli compound there. Because of the summer vacation, few people were on the site, but thosre who were present were very kind and all seemed to know Padre Miguel—a testament to his personal involvement on all levels of the organization. We toured the school's kitchen, the newly constructed library, classroom construction site, and the chapel.

EWB–Princeton hopes to continue this relationship with Coprodeli, and is considering the possibility of working with the organization in their new efforts in Viru.

11.2 Visit With EWB–CU Boulder in San León

On 6 January 2007, EWB–Princeton traveled to San León to meet with the EWB team from the University of Colorado at Boulder. (Renzo and Shannon had met one of the students, Kevin, on their visit to the site in August 2006; during this visit, David Dani, the leader of the Peru group at CU Boulder, was in Trujillo working to collect solar panels that had been shipped there from the United States.)

Upon arriving in San León, we walked to the location where EWB–CU Boulder has dug a well (more than 12 meters deep) that will serve the community of roughly 100 persons. The community has prepared a fenced facility that will hold two 2500-gallon storage tanks for the water, which will then be distributed to individual homes once the distribution line is constructed.

We spent about 45 minutes at the site discussing the technology the team is using, particularly their photovoltaic pump, sharing stories of the trials and challenges that we'd encountered thus far, and discussing our plans for the future. Afterwards, we walked back to San León and continued these discussions before returning to Huamanzaña.

EWB–Princeton enjoyed meeting with the four members of the EWB–CU Boulder group who were in San León during the visit, and it was interesting to observe the different ways in which EWB groups interact with the community. For example, the CU Boulder team cooks their own meals in a building lent to them by the community, and thus does not impose on families to provide food. Yet because EWB–Princeton eats meals with community members, we find we get to know these families better because of this interaction. In preparation for our future projects, we should consider again the advantages and drawbacks of how our taking meals in village homes, which may pose a high cost for families that opt not to use the ingredients we offer them.[41] Nonetheless, deep involvement in the Huamanzaña community is intrinsic to EWB–Princeton's work, and this tradition will continue.

[41] For more information on how EWB–Princeton handles meals in Huamanzaña, see section 12.4.

12. Logistics

12.1 Group Selection

The travel team for the assessment trip was chosen from applications submitted by members of the EWB–Princeton Peru group. Andrew J. Lapetina, the chapter president at the time of the selection, and Shannon M. Brink, the project manager, chose the students based on the qualifications and experience for a short, intensive assessment trip. The selection of Peter Templer as the mentor was based on his résumé and a personal interview in Princeton; he learned of our need for a mentor though the New York City branch of the non-profit Water for People.

12.2 Transportation

12.2.1 Within Lima and Trujillo

Within Lima and Trujillo, we travel on foot or via registered taxi. In the Miraflores district, which has a reputation for being the safest part of Lima, we generally walked. Similarly, Trujillo is a small, safe city with a police presence, and we also walked most of the time. Short rides in Lima generally run 8 to 12 soles compared to 2 to 4 soles in Trujillo.

12.2.2 Between Lima and Trujillo

In an effort to maximize our time in Huamanzaña and reduce the safety risks associated with long-distance bus travel, we flew to Trujillo via LAN airlines. This reduced our Lima-Trujillo travel time from nine hours to one hour. LAN is an international airline that is a member of the One World Alliance (which includes British Airways and American Airlines). The US Federal Aviation Administration has stated that Peru is in compliance with ICAO international safety standards for oversight of Peru's air carrier operations. Furthermore, during his evacuation, Peter Templer flew StarPeru, the other airline flying between Lima and Trujillo; he reported that the equipment was new and the experience was excellent. In the future, we recommend that EWB–Princeton opt to fly to Trujillo because it saves a lot of time and the price (we paid $68 roundtrip per person) is reasonable, even in comparison to the bus services.

12.2.3 Between Trujillo and Chao

Between Trujillo and Chao we take a bus that travels along the Pan-American Highway. These buses all depart from the central Santa Cruz station in Trujillo; all companies seem to be comparable. When departing from Chao, these buses are parked along the shoulder of the Pan-American Highway and pick up passengers there.

12.2.4 Between Chao and Huamanzaña

For the distance between Chao and Huamanzaña, we take *combis*, which are Nissan and Toyota buses that have been retrofitted with bench seats. They are a popular form of transportation throughout Latin America. The *combis* we take are provided by García ("El Rápido")—the same company that has provided transportation for EWB-Princeton on prior trips; we are familiar with

these drivers (generally Augosto, Manuel, or García himself). There have been a few isolated incidents of armed robberies on the one-lane dirt road between Huamanzaña and Chao (including one involving EWB–CU Boulder), however, we take safety measures by not advertising our departure times for Huamanzaña, by traveling at different times of day, and by using the same reputable company. We also are careful to distribute our money and valuables in various locations on our bodies and in our luggage, and we try to limit the equipment that we transport unnecessarily.

12.3 Lodging

12.3.1 Lima: Inka Lodge

Inka Lodge Hostel
Elias Aguirre 278, Miraflores
Telephone: 51-1-242-6989.

This was the first time that EWB–Princeton stayed at the Inka Lodge, a small, quiet hostel in the upscale Miraflores district of Lima. We were pleased with the accommodations; for about $12 per person, we had private rooms (with shared bathrooms) and complimentary breakfast and internet access. The management also offers secure storage facilities for luggage. The rooms were new and clean, and the other lodgers were friendly. There were also several stores and restaurants within easy walking distance. We recommend staying there again. For further information, visit http://www.inkalodge.com.

12.3.2 Trujillo: Hostal Colonial

Hostal Colonial
Jr. Independencia 618
Telephone: 51-044-258-261

We have stayed at the Hostal Colonial, recommended by Frommers and Lonely Planet guides, on previous EWB–Princeton trips. Though prices are relatively high, they do offer an International Student Identity Card student discount on doubles (65 PEN per night for a double with private bath). The Hostal Colonial is conveniently located in a safe and central part of Trujillo, close to the Plaza de Armas, many shops, and the large banks. We recommend staying there again. Their email address is hostcolonialtruji@hotmail.com, though they do a poor job responding to email reservations.

12.3.3 Huamanzaña: Primary School Facilities

In contrast to previous trips to Huamanzaña in which we stayed in the old primary school building, during this winter assessment trip we lived in the classroom part of the new primary school building. (Engineers from the NGO Promach were living where we generally stay, and because the teacher had returned to Trujillo for the summer vacation, it was easiest for us to stay in the new primary school.) The building is concrete and has a heavy door; it is safe and comfortable. It also has electricity and is close to the community bathrooms.

12.4 Food

While we are in Huamanzaña, families host us for meals on a rotating schedule that they devise; on this trip, we had a tendency to eat at the same few homes several times. This is probably a result of the smaller group size (in comparison to previous visits), and the fact that some homes only host once (which they see as a duty), whereas others are more eager to have us join them.[42]

EWB–Princeton always eats with the people of Huamanzaña, including special occasions like this birthday party.

Meals generally consist of some combination of rice, *caldo* (made from vegetable and hen stock), fried eggs, beans, *menestra* (vegetable stew that sometimes has meat), *yuca* (family *Liliaceae*), *camote* (tuber; family *Convolvulaceae*), potatoes, and noodles. Meat is generally hen or pigeon, though we are occasionally served lamb, guinea pig, or canned tuna. We also try some fruits, but we are carefully to eat them only in moderation and consider the recommendations of the Princeton University Health Services with respect to uncooked fruits and vegetables. We purchase basic ingredients (vegetables, rice, eggs, noodles) in Chao and inform all townspeople at meetings that they are welcome to come for ingredients at any time. Some people use our ingredients, but the majority do not. This policy is something we should consider with the summer project so that a larger group is not a burden on already scarce family resources.

In the case of most restaurant meals, we ate typical Peruvian fare, generally from establishments recommended by guidebooks or locals. We also try to keep our meal costs very low (to keep overall budgetary costs down), and EWB–Princeton will be refining and streamlining this policy more in the coming months.

12.5 Security

We were always cautious and aware of our surrounding, and we experienced no problems with security. We follow US State Department warnings closely, and avoid areas that appear on those lists. EWB–Princeton makes a point of traveling with the reputable *combi* service with whom we have worked on past trips. Students are careful to always travel in pairs, and we are careful to hide our money and valuables in various locations on our person to avoid theft. For those that

[42] Although we provide ingredients for women to use when cooking for our group, families often end up using some of their personal resources to feed us. This might account for why we eat at some homes only once each trip. Families that are more involved in the project or socialize with us in the afternoons also host us more frequently.

carry cameras (an essential tool for documenting the trip), memory cards and other digital storage devices are often carried separately to preserve the data in the event that the device is stolen. There are inevitably risks associated with living and working in a region that has some crime (generally robberies but also rapes and occasional murders), but EWB–Princeton travelers are instructed to cooperate and turn over values in a dangerous situation.

Within Huamanzaña, townspeople watch for any suspicious activity that might threaten our work. We lock our belongings in the sleeping area when we are out of sight of the door, but no doors can be secured from the inside. On this assessment trip, we left townspeople in our sleeping area with our belongings (they were watching a movie) while we went to dinner, and no articles went missing.

12.6 Money

As with previous trips, students traveled with a cash advance. This money goes into their personal accounts, and they are responsible for withdrawing appropriate amounts throughout the course of the trip. We had a combination of soles (bills and coins) and dollars, though nearly all transactions were in cash soles. We made withdrawals from ATMs in Trujillo and Lima; these machines dispense both soles and dollars. EWB–Princeton expects students to keep detailed records of how much they spend for each transaction, especially if the seller does not provide a receipt. The travelers on this trip did a fairly good job of keeping track of their money, and we did not overspend the cash advance of $2,000 (total).

12.7 Communications

12.7.1 Phone Services

Public pay phones (generally operated by the company Telefónica) are the best ways to call within the country, whereas *locutorios* (shops that generally offer telephone and computer services) often have the best rates to the United States (as low as 0.40 soles per minute). In Huamanzaña there is a solar-powered telephone, but this phone operates only using *Habla Fácil* phone cards (distributed by Telefónica). These cards are difficult to find, rates are mediocre (1 sole per minute to the United States), and come in small denominations (often 3 or 5 soles). EWB–Princeton constantly searches for these cards to purchase in large quantities, but we often end up buying out the supply in Huamanzaña and Chao. This can be problematic for other people in the town if they need to make phone calls, so we have resold these cards to townspeople who need to make calls. Nonetheless, during Peter's evacuation, we were left without a phone card.

However, Huamanzaña now has spotty cell phone service at the top of the town near the school. Shannon succeeded in getting both Claro and TIM Peru signals through her domestic carrier T-Mobile; Dandy Tiburcio, a teenager in town, also has a cell phone that gets a Moviestar signal. Though cell phone rates are very expensive, text messaging was relatively affordable and helpful during the evacuation.

12.7.2 Internet and Printing Services

EWB–Princeton did not use the internet services in Chao, but we did go to internet cafés in Trujillo and Lima; these cafés are easy to find and generally have affordable rates of about 1 sole

per hour. Although the connections are slow in Trujillo, there is no problem checking email and American websites. Both hostels where we stayed had internet services, and the Hostal Colonial in Trujillo also offered printing.

13. Recommendations and Plan for Action

13.1 Recommendations for Future Projects

As EWB–Princeton decided with the people of Huamanzaña prior to departing in January, we will continue with the wood-burning stoves project for implementation in summer 2007. The next steps for that project involve both reconsideration of the general type of stove design as well as revision of the physical Inkawasi stove design to accommodate design challenges raised during the trip.[43] Our group will also be working on the educational component of the stoves project, which will address the health and environmental motivations for adopting a safer stove design and the science behind combustion. Since Shannon, Ted, and Chris' return, the larger Peru team has divided into subteams to work on the technical and educational stove-related issues. But our group is also responding to the other findings from the assessment trip.

13.1.1 The Potential for Light

The technical team from the August 2006 solar energy project has reconvened to look at the potential for reconfiguring the current electricity system to meet Huamanzaña's desires or expanding the electrical capacity with additional photovoltaic panels or other renewable sources of energy, such as wind power. Preliminary calculations show that the existing systems would allow for additional bulbs in individual homes were it reconfigured, but there would be a tremendous loss of energy due to the efficiency loss with distance. Because this would necessitate removing the light from the school and the capacity to use electrical appliances such as the television, it does not seem to be a viable option for Huamanzaña. Therefore, the best options for permanent electrical light in Huamanzaña would involve additional electrical capacity with photovoltaic cells or other sources. Nonetheless, light in homes provides additional challenges because of the physical infrastructure in which electricity would be installed. The majority of the homes in Huamanzaña are adobe with tin or woven fiber roofs that are anchored with large stones. In such a setting where the buildings are not designed for installation of electricity, the safety of such an endeavor would be another important factor to consider.

13.1.2 The Ethics of Light

Apart from the technical challenges of expanding the electricity potential in Huamanzaña, EWB–Princeton still is committed to addressing what the villagers now see as their primary priority: light. This dilemma has already generated lively philosophical debates among our team, and we recognize that we will need to address it on future trips. A subteam has been created to look into the effects of battery charging stations and lantern distributions on other rural communities in the

[43] For a complete discussion of how the stove designs will be improved, see sections 7.10-7.11, 9.4, 9.6.1, and 9.7.

developing world and whether their installation has generated a similar demand for additional electricity within the home.

We are also looking into the ways in which the existing lighting and electricity in the school, *locale*, and other community buildings can be better utilized by the community as a whole. A few ideas have included designing a more effective book-lending system for the library EWB–Princeton created in August 2006 and organizing secondary school classes to be held in these buildings after dark. There remains the challenge of not encroaching on the teacher's personal space (since she lives in half of the school), but we hope that our summer trip might help us identify individuals within the community who have more advanced training in certain areas and might be willing to share their knowledge.[44] Additionally, we are rethinking our interaction with the community for the summer trip. In the past, we have spent a lot of time after dinner socializing with various families. Now we are hoping to design a diverse curriculum of short after dinner courses targeting people who have completed a primary school education. We are also planning to have a reading hour for the children to promote a tradition of literacy that may continue after we have departed. By using the existing light in ways besides watching television or DVDs, we hope to give community members new ideas for how to use their new technology.

Finally, we are researching microenterprises that might be viable in Huamanzaña in the hopes that increased knowledge would give budding entrepreneurs the power to start their own businesses. In the short term, this may involve simple classes in how to run a business, basic economics or finances, and sources for micro-credit or rotating credit associations in the area; these classes would be designed and taught by EWB–Princeton students during the implementation trip. In the long term, this could lead to women starting a weaving cooperative that would work after dinner utilizing the light and perhaps the electricity to run a radio with the favorite *huayno* music in the background.[45] On this trip, many women mentioned in interviews that they would be like to run blenders so they can make juice to sell in Huaraday; perhaps the electricity

This summer, EWB–Princeton hopes to work with Huamanzañans to find new ways to use the electricity from the solar panels in economically productive ways. That may eventually lead to businesses that make juice or yogurt with existing resources (like these goats) and electrical appliances.

[44] We are aware of some families that have children living in other parts of Peru who have professional training as chemists, engineers, economists, teachers, and nurses. There are also some people in Huamanzaña who have attended schools elsewhere and might be interested in sharing their knowledge if they had the resources to do so.

[45] A relatively successful weaving cooperative has been started in nearby Santa Rita, and we plan to learn more about this effort from Renzo Ventura, who is also involved with that endeavor.

could be used for this purpose.[46] Finally, because one of EWB–Princeton's missions is to promote wider scale development, we are looking into other ways to provide microenterprise support that might not involve electricity, including a flavored yogurt cooperative that would link the family with a herd of goats to other families that grow fruits.

For additional discussion of the ethical considerations with respect to in-house electricity, see section 9.9.2.

13.1.3 Community Bathrooms and Sanitation

We have also formed a subteam that will be looking into increasing the accessibility to the existing community bathrooms and considering the expansion of sanitation projects on a community and household level. EWB–Princeton also is preparing another educational campaign to reinforce the program that was developed for the installation of the community bathroom project in August 2005. For a complete discussion of the potential to reevaluate the community bathroom project, please see section 9.9.1.

13.1.4 River Crossing at Aguas Calientes

13.1.4.1 Problem

During two months of the year—in February and March—vehicles are unable to access Huamanzaña; at the point where the road crosses the riverbed near Aguas Calientes, there are at least 2 meters of water near the center of the riverbed. Individuals in Huamanzaña still need to access areas below the community for food, supplies, and medical attention; consequently, they must cross the river on foot. The crossing requires villagers to wade across the river and can be dangerous as the water can be high and visibility of the river bottom difficult (footings are unsure). Many people in the community do not attempt the crossing, and members of the community would like to have vehicular access year round.

13.1.4.2 Site

The current roadway is 4 meters wide and curved in plan. The distance along this curve from bank to bank is approximately 75 meters. Consequently, the straight span from bank to bank is less than 75 meters.

13.1.4.3 Alternatives

One solution for a shallow river crossing is to construct concrete ramps from the banks into the riverbed. However, with a water depth of at least 2 meters, this option is not feasible.

[46] EWB–Princeton is also considering designing a blender that doesn't require electricity and might instead use another form of renewable energy, such as a bicycle.

The Río Huamanzaña floods the highway near Aguas Calientes in February and March of each year.

The idea proposed by Eduard and Don Martín was to cover the bottom of the riverbed with large rocks and then to pour concrete across the top. The rocks would allow water to pass through while the concrete would serve as a level-wearing surface for vehicles to drive over. This solution would require locally available materials and in smaller quantities than required for the construction of a bridge. However, if water is able to pass through, it is possible that the rocks could shift causing the concrete above to crack or collapse of the structure. Another concern is that if the rocks don't allow the water to pass through, the structure will act a dam, in which case the water level will eventually rise, and water will pass over the structure.

An alternative solution would be to construct a bridge at the site. The most likely location for the crossing is where the current road is situated; from use, the approaches and banks along the roadway are more compact than surrounding areas. (When Ted tried to climb the bank at an alternate location, the soil broke off from the bank.) With time, the banks will continue to erode. Eduard reported that the widening of the river has not widened substantially over the years, but he did not quantify this statement. For the primary location, Eduard thinks that we may only need to span the middle 30 meters because the water level in the regions outside this band are not high during the rainy season. Without seeing the river during the rainy season, it is difficult to predict whether a crossing in the middle of the riverbed will be sufficient. This location has a high spot near the center of the riverbed that could serve as a location for a pier.

All locations other than where the road currently passes are private property, but Eduard doesn't think it would be difficult to negotiate with the individual who owns the property. However, if an alternative location were chosen, larger approaches would be needed to ensure that the foundation was on solid ground. These larger approaches may make it more difficult to negotiate with the individual who owns the property. One alternative location has a span bank to bank of approximately 55 m. This location has a high spot near the center of the riverbed that could serve as a location for a pier.

13.1.4.4 Future Recommendations

Until structures similar to those described by Eduard and Don Martín are studied, a vehicular bridge appears to be the better long-term option for providing vehicular access to Huamanzaña year round. However, construction of a bridge this size is an expensive endeavor. While a concrete bridge could be constructed largely of local materials, costs for formwork could be

expensive. Transportation of laborers from Huamanzaña to the site is another concern. Currently, it's unclear what the regulations are for constructing a bridge in the area. Community members and Renzo also report that it may involve significant paperwork and take a long time to secure administrative approval within Peru to clear the project. Construction of a pedestrian or donkey bridge is another option. While this bridge would not provide for vehicular traffic, it would provide for a safer crossing option in the rainy season.

Further assessment including a site survey performed during the rainy season and collection of information pertaining to construction regulations in the area should be performed before committing to this project. A project of this magnitude would require substantial outside professional assistance in review of the design and overseeing of construction.

13.2 Timeline for Summer Implementation

EWB–Princeton has developed the following timeline for the spring 2007 semester as we prepare for the summer 2007 implementation project. Team meetings are held each Thursday night in Wilcox Seminar Room 204 B.

1 March 2007: Application deadline for the Class of 1939/Fred Fox Fund
6 March 2007: Applications for summer travel distributed to team members
7 March 2007: EWB–USA conference call with other Peru teams
8 March 2007: Deadline for first round of revised stove designs
13 March 2007: Deadline for the applications for summer travel
15 March 2007: Deadline for applications to the Class of 1984 Memorial Fund
16 March 2007: Decisions of summer travel team will be announced
31 March 2007: Deadline for applications to the Class of 1991 Fund
4 April 2007: Deadline for applications to the Class of 1995 Fund
12-14 April 2007: EWB–USA National Conference
22 April 2007: Deadline to submit implementation proposal to EWB–USA
10 May 2007: East Coast TAC meeting
25 May 2007: Target date for airline ticket purchases
10 June 2007: Circulation of educational curriculum among all group members
1 July 2007: Final circulation of all plans, educational curriculums, and supporting materials
16 July 2007: Tentative departure date for Huamanzaña base team[47]
8 August 2007: Tentative departure date for implementation team
28-30 August 2007: Conference on sustainable energy in Piura, Peru[48]
1 September 2007: Tentative return to the United States

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[47] Our team is planning to complete the implementation with two groups of travelers, one (the base team) that will go down in mid-July to make all necessary arrangements, begin educational campaigns, and cultivate relationships with NGOs, and another team (the implementation team) that will arrive in early August for the actual implementation. As a prerequisite for being part of the base team, students must be fluent or near fluent in Spanish.

[48] Helio Mogollón Saavedra, a Peruvian engineer who works with solar energy and helped advise the EWB-Princeton solar energy team in preparation for the August 2006 trip, has invited us to speak at this conference in Piura.

All travel dates are subject to change depending on student schedules and airfare availability.

13.3 Compliance with Princeton University's New Travel Requirements

In response to the cancellation of the winter 2006 EWB–Princeton trip to Arsi Negelle, Ethiopia, Princeton University is developing new protocol for student groups traveling to the developing world and other high-risk areas. In addition to new paperwork for student groups, there will be a panel comprising Princeton faculty as well as reliable in-country sources at universities, NGOs, and in the government who can apprise us of the situation on the ground in the event of an emergency. We are currently planning to work through faculty connections at local universities and EWB–CU Boulder's connections within the Peruvian government to comply with these new regulations.

14. Final Budget

This budget will also be available for download in Microsoft Excel format from our website.
Abbreviations: SMB=Shannon M. Brink; EMS=Edward Segal; CDP=Christopher Pritchard; PT=Peter Templer; HRVA=H. Renzo Ventura Ayasta.

14.1 Expenses Summary

Shannon M. Brink	1279.02
Edward Segal	1005.12
Christopher Pritchard	1370.92
Peter Templer	1381.21
$2,000 Advance	2000
Total	7036.27

EWB–Princeton had budgeted $7,500 for the assessment trip, so we were under budget by $463.73.

14.2 Shannon M. Brink Expenses

Date (MM/DD/YYYY)	Receipt	Company/Seller	Items	Cost (PEN)	Cost (USD)
10/30/06	Yes	Home Depot	Bricks and stove-building materials		84.6
11/28/06	Yes	Continental Airlines	Plane ticket, SMB		1247
12/10/06	Yes	LAN	Plane tickets, SMB & EMS		180.96
12/18/06	Yes	Nasco	Water testing equipment		23.57
12/19/06	Yes	BatterySpace.com	Batteries		130.48

12/26/06	Yes	Gema	Phone card for Renzo	10	
12/27/06	Yes	NJ Transit	Transportation from Princeton to EWR, SMB & EMS (2 @ $14.50)		29
12/27/06	Yes/No	Inka Lodge, Lima	Accommodations, SMB & EMS		24
12/27/06	No	José Luis Latorre Gonzalez	Transportation from airport to Inka Lodge	60	
28-Dec	No	Taxi	Transportation returning from Coprodeli	10	
12/28/06	Yes	Airport Tax	Airport tax, SMB & EMS (2 @ $6.05)		12.1
12/28/06	No	Taxi	Transportation from airport to Hostal Colonial	15	
12/28/06	No	Hostal Colonial	Accommodations, SMB & EMS	65	
12/29/06	No	Paneria near Central Market	Breakfast, SMB & EMS	2	
12/29/06	No	Taxi	Trujillo taxi to train station (estación Santa Cruz)	2	
12/29/06	No	Empresa de Transportes	Bus from Trujillo to Chao (3 @ 3.5 /s)	10.5	
12/29/06	No	Local vendor, Chao	Food, toilet paper	30	
29-Dec	Yes	Novedades "Reyes"	Poster paper, markers, electrical socket	21	
12/29/06	Yes	Comercial "Cruz Marcos" De: Cruz marcos Paulino Rogelio	Soccer ball (for community)	36	
12/29/06	No	García's "El Rápido" (Agosto)	Combi to Huamanzaña (for three)	20	
12/29/06	Yes	Vidriería y Ferretería Palacios	Metal sheet, rebar, electrical socket	133.3	
12/30/06	No	Freddy and Erasmo	Phone cards for Huamanzaña's phone	15	
12/30/06	No	García's "El Rápido" (Agosto)	Combi from Huamanzaña to Chao (for Renzo)	5	
12/30/06	No	Local bus company	Chao to Trujillo (for Renzo)	3.5	

12/30/06	No	Taxi	Taxi to Renzo's house	3	
12/30/06	No	Taxi	Taxi to and from the airport to pick up CDP, PT	30	
12/30/06	No	Telefónica	Call to Pancho to arrange materials transportation	2.5	
12/31/06	No	Local bus company	Trujillo to Chao	4.5	
12/31/06	No	Telefónica	Phone cards for Huamanzaña's phone	8	
12/31/06	No	Local vendor, Chao	internet	1	
12/31/06	No	Francsico Chilon Urcia (Pancho)	Materials	20	
12/31/06	No	García's "El Rápido" (Agosto)	Combi to Huamanzaña (for three)	15	
1/1/07	Yes	Francisco Chilon Urcia (Pancho)	Transportation of sand, 3 bags of cement, 120 bricks	234.2	
1/1/07	Yes	Francisco Chilon Urcia (Pancho)	Materials: 2 m3 sand, 3 bags of cement, 120 bricks	185.8	
1/1/07	Yes	V&B De: Barros Calderón Richard Manuel	Water	20	
1/2/07	Yes	Indumeb De: Bohuytrón Gonzáles Victor W.	Metal tube	100	
1/2/07	Yes	ALCA E.I.R.L.	Stove bricks	5.7	
1/2/07	No	García's "El Rápido" (Agosto)	Santa Rita to Chao (CDP, HRVA, PT)	10.5	
1/2/07	No	Local bus company	Chao to Trujillo (CDP, HRVA, PT)	10.5	
1/2/07	No	Taxi	Taxi to the bank	3	
1/2/07	No	Taxi	Taxi to central Trujillo	3	
1/2/07	No	Taxi	Taxi back to the bank and back to central Trujillo	3	
1/2/07	No	Taxi	Taxi to restaurant	2.5	
1/2/07	No	Taxi	Taxi	2.5	
1/2/07	No	Taxi	Taxi to the hospital	3	
1/2/07	No	Taxi	Taxi from the hospital to the hotel	2.5	
1/3/07	No	Taxi	Taxi to pick up the	6	

			metal tube (to and from)		
1/3/07	No	Taxi	Taxi to Renzo's house	2.5	
1/3/07	No	Taxi	Taxi to central Trujillo	10	
1/3/07	No	Taxi	Taxi from Hostal Colonial to the airport	12	
1/3/07	No	Taxi	Taxi to pick up medical certificate for Peter	6	
1/3/07	No	Taxi	Taxi from house to bus station	2.5	
1/3/07	No	García's "El Rápido" (Manuel)	Combi from Huamanzaña to Chao, SMB & EMS	12	
1/3/07	No	Local bus company	Chao to Trujillo, SMB & EMS	7	
1/3/07	No	Taxi	Estación Santa Cruz to Hostal Colonial, SMB & EMS	3	
1/3/07	No	Hostal Colonial	Printing and internet	6	
1/4/07	No	Hostal Colonial	Two rooms (1 night @ 65 /s each): CDP & PT, SMB & EMS	130	
1/4/07	No	Taxi	Hostal Colonial to Estación Santa Cruz	3	
1/4/07	No	Local bus company	Trujillo to Chao, SMB, EMS, CDP	10.5	
1/6/07	No	García's "El Rápido" (Agosto)	Combi to San León and back	18	
1/8/07	No	García's "El Rápido" (Manuel)	Combi to Chao for all	24	
1/8/07	No	Local bus company	Bus to Trujillo for four	14	
1/8/07	No	Taxi	Taxi to Renzo's house	4	
1/8/07	No	Taxi	Taxi to restaurant	5	
1/8/07	No	Taxi	Taxi to Renzo's house, airport	16	
1/8/07	Yes	Airport Tax	Airport tax, SMB (1@ $3.47)		3.47
1/8/07	Yes	H. Renzo Ventura Ayasta	Services	600	
1/8/07	No	Carlos	Transportation from airport to Inka Lodge	30	
1/9/07	No	Carlos	Transportation from	30	

			Inka Lodge to airport		
1/9/07	Yes	Airport Tax	Airport tax, SMB (1@ $30.25)		30.25
		Subtotal by currency		2060	1765.43
		Conversion	Exchange rate 3.1932	645.12 08819	1765.43
		SHANNON M. BRINK TOTAL EXPENSES			2410.55
Dec-06		$1,000 Advance from Steve Tavares			-1,000
Jan-07		100 /s transfer from Edward Segal	Converstion to USD		-31
Jan-07		320 /s transfer from Chris Pritchard	Converstion to USD		-100
		Outstanding Reimbursement			1,279.02

14.3 Edward Segal Expenses

Date (MM/DD/ YYYY)	Receipt	Company/Seller	Items	Cost (PEN)	Cost (USD)
11/12/06	Yes	Home Depot	Bag of Mortar Mix and Rebar		17.54
11/28/06	Yes	Continental Airlines	Plane ticket, EMS		1247
12/26/07	Yes	Target	Energizer 2032 and Energizer 357BP3 Batteries for Water Testing		12.50
12/28/06	No	Taxi	Transportation from Inka Lodge to airport	45	
12/29/06	Yes	V&B De: Barros Calderón Richard Manuel	Water, food	40	
1/2/07	No	Transfer to Shannon M. Brink	Money for Renzo for Materials	100	
1/3/07	Yes	Micrology Laboratories	Water Testing		31.94
1/4/07	No	García's "El Rápido" (Agosto)	Combi to Huamanzaña (for three)	18	

1/4/07	No	García's "El Rápido" (Agosto)	Combi to Huamanzaña (for Renzo and Materials)	20	
1/6/07	No	García's "El Rápido" (Agosto)	Combi to Santa Rita	6	
1/8/07	No		Dinner in Trujillo (Renzo, SMB, CRP, & EMS)	55	
1/8/07	No	Taxi	Taxi from restaurant to Renzo's apartment and then to airport	14	
1/8/07	No		Payment to Renzo	5	
1/9/07	Yes	Inka Lodge	Accomodations, SMB, CDP, & EMS		36
1/9/07	Yes	Inka Lodge	Locker Charge		6
1/9/07	Yes	Lima Airport	Airport Tax		30.25
1/10/07	Yes	NJ Transit	Transportation from EWR to Princeton, SMB & EMS (2 @ $14.50)		29
		Subtotal by currency		303	1410.23
		Conversion	Exchange rate 3.1932	94.889 13942	1410.23
		EDWARD SEGAL TOTAL EXPENSES			1505.11
Dec-06		$500 Advance from Steve			-500.00
		Outstanding Reimbursement			1005.12

14.4 Christopher Pritchard Expenses

Date (MM/DD/ YYYY)	Receipt	Company/Seller	Items	Cost (PEN)	Cost (USD)
12/29/06	Yes	NJ Transit	Transportation to EWR		14.5
12/30/06	Yes	Inka Lodge	Lodging for CDP and PT	84	
12/30/06	Yes	"Gestion Car", Pedro Espichan Salguero	Transportation from hostel to airport	40	

12/30/06	Yes	Unknown	Lunch, CDP and PT	40	
12/30/06	Yes	Airport	Airport Tax		6.05
12/31/06	Yes	America Express	Bus fare	5	
1/2/07	Yes	Hostal Colonial	Lodging for CDP and PT	75	
1/2/07	Yes	Restaurant Romano	Dinner	33.5	
1/2/07	Yes	Mar Picante	Lunch	38.5	
1/2/07	No	Unknown	Chimney	100	
1/2/07	No	Transfer to Shannon M. Brink	for materials from Francisco Chilon Urcia	300	
1/3/07	No	Unknown	Breakfast	20	
1/3/07	No	Unknown	Dinner	50.5	
1/3/07	No	Transfer to Shannon M. Brink	—	20	
1/10/07	Yes	NJ Transit	Transportation to Princeton		14.5
		Subtotal by currency		806.5	35.05
		Conversion	Exchange rate 3.1932	252.56 79569	70.1
		CHRISTOPHER PRITCHARD TOTAL EXPENSES			322.667 9569
Dec-06		$500 Advance from Steve			($500)
		Outstanding Reimbursement			($177.33)

14.5 Peter Templer Expenses

Date	**Description**	**Amount Soles**	**Amount USD**
12/29/06			
12/29/06	Train (White Plains - Grand Central)		$11.00
12/29/06	Bus (Grand Central - Newark Airport)		$14.00
12/29/06	Lunch (airport)		$11.00
12/29/06	Taxi (Lima Airport - Hotel)	S/. 50.00	
12/30/06	Taxi (Hotel - Lima Airport)	S/. 25.00	
12/30/06	Airport Tax (Lima)		$6.05
12/30/06	Dinner (Trujillo)	S/. 25.00	
12/31/06	Hotel (Trujillo)	S/. 75.00	

12/31/06	Breakfast (Trujillo)	S/. 18.00	
12/31/06	Bus (Trujillo - Linda)	S/. 14.00	
12/31/06	Bus (Linda - Chao)	S/. 10.00	
12/31/06	Lunch (Chao)	S/. 24.00	
1/2/07	Lunch (Trujillo)	S/. 50.50	
1/4/07	Airport Tax (Trujillo)		$3.47
1/4/07	Lunch (Lima airport)	S/. 20.50	
1/4/07	Airport Tax (Lima)	S/. 3.00	$30.25
	P. Templer Expenses Subtotal:	***S/. 315.00***	***$75.77***
	@ $1.00 =	S/. 3.20	
		$98.44	***$98.44***
1/5/07	**P. TEMPLER TRIP TOTAL:**		**$174.21**
12/5/06	**P.TEMPLER AIRFARE NEWARK/LIMA:**		**$1,207.00**
	P. TEMPLER EXPENSE TOTAL:		**$1,381.21**

15. References

Additional references not cited in text include:

Aprovecho Research Center, 2006. *Design Principles for Wood Burning Cook Stoves*. Oregon: Aprovecho.

Lillywhite, M., 1984. *Improved Cookstoves: A Training Manual*. Denver: Domestic Technology International, Inc.

Schlecht, Neil E. Frommer's Peru. Hoboken [NJ]: Wiley Publishing, Inc., 2006.

16. Appendix A: Water Testing

We used Eco-Check™ 5in1 Test Strips to measure pH, nitrate, nitrite, total hardness, and total alkalinity. The test strips change color to indicate the approximate level of a parameter. A sample of water was taken from one of the communal taps fed by Puquio Shaque and a sample of water was taken directly from Puquiou Reprisa. Five test strips were used on the sample from Puquio Shaque and three test strips were used on the sample from Puquio Reprisa. The repetition of testing was to verify that the test strips were giving the same result. Tables 16.1 and 16.2 show the results.

Table 16.1: Puquio Shaque: Results from the 5-in-1 Test Strips

Strip #	pH	Nitrate (ppm)	Nitrite (ppm)	Total Hardness (ppm)	Total Alkalinity (ppm)
1	8.5	Between 0 and 20	Closer to 0 than 20	Closer to 300 than 1,000	Closer to 720 than 300
2	8.5	Closer to 20 than 0	Closer to 0 than 20	Closer to 300 than 1,000	Closer to 300 than 720
3	8.5	Between 0 and 20	Closer to 0 than 20	Closer to 300 than 1,000	Closer to 300 than 720
4	8.5	Between 0 and 20	Closer to 0 than 20	Closer to 300 than 1,000	Closer to 300 than 720
5	8.5	Between 0 and 20	Closer to 0 than 20	Between 300 and 1,000	Closer to 300 than 720
Average	8.5	0-20	0	300	300

Table 16.2: Puquio Reprisa: Results from the 5-in-1 Test Strips

Strip #	pH	Nitrate (ppm)	Nitrite (ppm)	Total Hardness (ppm)	Total Alkalinity (ppm)
1	8.5	Closer to 0 than 20	Closer to 0 than 20	Between 150 and 300	Closer to 180 than 300
2	8.5	Closer to 0 than 20	Closer to 0 than 20	Between 300 and 1,000	Closer to 300 than 180
3	8.5	Closer to 0 than 20	Closer to 0 than 20	Between 150 and 300	Closer to 180 than 300
Average	8.5	0	0	300	180-300

Eco-Check ™ correlates the numerical range with a written a description. These descriptions are presented in Tables 16.3 to 16.7.

Table 16.3: pH Range

Value	Translation
5.5	Low
6.5	Acceptable
7.0	Ideal
7.5	Ideal
8.0	Acceptable
8.5	High
9.5	High

Table 16.4: Nitrate NO_3^-

Value (ppm)	Translation
0	Safe
20	Safe
40	
80	Harmful
160	Harmful
200	Harmful

Table 16.5: Nitrite NO_2^-

Value (ppm)	Translation
0	Safe
0.5	Caution
1	
3	Stress
5	
10	Danger
20	Danger

Table 16.6: Total Hardness Range

Value (ppm)	Translation
0	Very Soft
25	Very Soft
75	Soft
150	Hard
300	Very Hard
1,000	Very Hard

Table 16.7: Total Alkalinity Range

Value (ppm)	Translation
0	Low
40	Low
80	Moderate
120	
180	Ideal
300	High
720	High

Counts of waterborne and fecal coliforms were made with Micrology Laboratories Coliscan® Easygel®. Three samples were prepared from each of the two sources. Each sample consisted of 5 mL of water taken from the source mixed with a bottle of Coliscan Easygel. The mixture was then poured into a petri dish. The directions provided indicated that the samples should sit at a temperature of 95° F for 24 hours or at room temperature, 68-74° F for 48 hours. As it was not possible to elevate the temperature in the room in which the tests were performed Micrology Laboratories' procedure for testing at room temperature was followed. The guidelines stated that the samples should be observed every 10 to 12 hours until pink or purple colonies are then after another 24 to 30 hours a final count of these colonies should be made.

Table 16.8: Puquio Shaque: Results from Coliscan® Easygel®

Sample #	Sample Volume (mL)	# of Fecal Coliform Colonies	# of Coliform Colonies
1	5	11	130
2	5	5	125
3	5	12	137
Average	5	9.33	131

For Puquio Shaque the average number of fecal coliform colonies found was 9.33 per 5 mL. For a 100 mL sample there would be 187 colonies. The average number of coliform colonies found was 131 per 5mL. For a 100 mL sample there would be 2,620 colonies.

Table 16.9: Puquio Reprisa: Results from Coliscan® Easygel®

Sample #	Sample Volume (mL)	# of Fecal Coliform Colonies	# of Coliform Colonies
1	5	9	151
2	5	4	154
3	5	10	114
Average	5	7.67	140

For Puquio Reprisa the average number of fecal coliform colonies found was 7.67 per 5mL. For a 100 mL sample there would be 154 colonies. The average number of coliform colonies found was 140 per 5 mL. For a 100 mL sample there would be 2,800 colonies.

17. Appendix B: Summarized Results from Stove Interviews

Interviewee	Fuel	Type of Wood	Hours	Boil water?	# of buckets	Amount of wood	# of pots	Pot size
Alicia	leña, tusa	algarrobo, espino	2	always	3 x 18 L	4 sticks	2 small or 1 large	8-10 in; 14" large
Estela	leña, tusa	sapote, espino	1-1.5	At times	8; largest is 18 L	5 sticks		
Celinda	leña, tusa	algarrobo, espino, sapote	2-Jan	When ill	5 x 18 L	8 thin sticks	2	
Ubalda	leña, tusa	algarrobo, espino, sapote	0.5-1	At times	3 x 18 L	2-3 thin sticks	3-Feb	
Cristina	leña, tusa	algarrobo, espino	1-1.5	At times	4		2	24, 18, 15 cm
Antonia	leña, tusa	algarrobo, sapote	1		4			
Marisol	leña	algarrobo, espino	0.5-1	no	5 x 18 L	15 thin sticks; 5-6 sticks	3	small
Elena	leña, tusa	algarrobo, espino, sapote	1		tank	6 sticks	3	13-26 cm
Pancha	leña (less tusa)	Molle, algarrobo, espino	1.5		tank	4-5 thin sticks	3	12 cm
Sara	leña (tusa when no leña)	algarrobo, espino	0.5	When it is hot	tanks (2 x 40 L)	4-5 thin sticks	3	12 in.
Lejdi	leña (less tusa)	algarrobo, espino, sapote	0.5-1		8 x 18	5 sticks	2	large: 12 in.

18. Appendix C: Original Text from Renzo Ventura

Below is Renzo Ventura's original text regarding his concerns for expanding the solar energy system. The translated version is in section 9.2.2.

> Para la gente de Huamanzaña tener luz eléctrica en cada casa es una prioridad, sin embargo ya que los objetivos de EWB no contemplan nada mas que la accíon de mejorar con obras de ingenieria las pequeñas comunidades sin entender el contexto social donde se desenvuelven estos proyectos y sus particularidades culturales, (específicamente en el caso de Huamanzaña donde faltan programas de educación adecuados y existe una significativo número de ancianos y adultos analfabetos y niños con unicamente escuela primaria) sería bastante complejo por no decir arriesgado el implementar un proyecto de este tipo sin antes evaluar el psobile impacto y consecuencias que esto traería consigo al comportamiento social de esta comunidad donde perviven algunos elementos de cultura autoctona.
>
> Una posible soloucion sería mejorar el sistema ya implementado (optimizar) sin elevar la capacidad que ya tiene. O empezar a buscar nuevos mecanismos de interacción con la comunidad que contemplen educación. Esto ultimo es bastante dificil ya que es una tarea que en gran parte le compete al estado peruano.
>
> La gente de Huamanzaña, sin embargo, esta bastante agradecida con todo tipo de ayuda que se le pueda brindar.
>
> A mi criterio depende mucho en el éxtio de este nuevo proyecto el que la confianza del pueblo, en EWB-Princeton se renueve. Pues como ya habíamos comentado el proyecto del sistema de luz ha dejado un sentimiento encontrado en algunas personas de la comunidad.

Dated 9 January 2007.

19. Further Information

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