Oregon State University
Engineers without Borders

Site Assessment #3
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Project Background

The Spring 2007 site assessment visit was carried out in continuation of the water treatment and distribution project in El Naranjito and Las Mercedes, El Salvador, in which EWB-OSU has been involved for the past year. The previous trip to these communities occurred in September 2006. The main task of the second assessment team was to survey the area and conduct water quality tests in preparation for a phased implementation of pumps and storage tanks. During that visit, it became clear that the project's scale would be larger than anticipated. In response to the community families' reported water requirements, the team would have to supply water and build storage space to expanded specifications. The team came up with many ideas of how the system could be designed, and a rainwater catchment and storage system seemed to be a popular option. Collecting rainwater is an attractive option because of the abundance of rain in winter; additionally, it is economically efficient to avoid maintenance and electricity costs associated with pumps. However, collecting rainwater still creates engineering challenges. When the team returned to Oregon more system design ideas continued to arise. Following advice from professionals who had worked in similar projects, the team decided that pumps were not impossible to implement after all. Relatively small pumps could be used. Maintaining a steady flow of water from pumps, rather than storing a winter's worth of water at a time, meant that smaller tanks could be used.

The team knew that the design of the pump, piping, supports, structures, etc. would take some time. Therefore, EWB-OSU decided that another pre-implementation trip would be necessary in order to start helping the community and obtain other data needed to make the final design. A group of four students and one professional were selected to take on this task. One of the main missions of the trip would be to provide the clay filters identified in the second assessment trip. These would be bought in San Salvador at Potters for Peace and distributed in the village. The cost of each filter to the families would consist of only U.S. $5.00 each with an $8.00 replacement every two years. EWB-OSU would pay the remaining cost.

Another part of the project consisted of investigating the potential water sources noted by the previous teams, including precise flow measurements since spring is the driest season of the year. Once these sites were located, survey (or topography) data would be taken to obtain precise altitudes that the water would have to be pumped in order to design the pumps and develop an idea of how much piping would be needed. Other small but important tasks were also to be completed, such as meeting the new water board members and explain their importance in the implementation of this project. They will be in charge of obtaining clearance from different owners to be able to use their property to build the tanks and lay the pipes, amongst other tasks.

Another simple but important mission would be to collect the monthly installments for the new water filter replacements. The OSU-EWB team would also make some family interviews to note patterns potentially related to water-borne illnesses.

A few weeks before the team traveled to El Salvador meetings were conducted to ensure all members knew the importance of the project and that all understood the tasks at hand. The team was fortunate to receive training from Jim Kiser, an Oregon State University faculty member in the Forest Engineering department. Mr. Kiser trained the team in appropriate data collection methods with the surveying equipment and data collection simulations with the total station were conducted at the MacDonald-Dunn Research Forest.

Goals

This site visit brought EWB-OSU closer to achieving its goals of reducing the distance between clean water sources and the communities of El Naranjito and Las Mercedes. With regard to treatment, a method of water purification was made available to the villagers; with regard to distribution, further data was collected in preparation for future placement of pumps and construction of tanks and rainwater catchment. This site assessment had three major objectives: to distribute water filters, to maintain relationships with the community members, and to collect further data necessary for project implementation.

A. Water Filter Distribution

Through previous health assessments, it was apparent that the community members were concerned about the quality of their drinking water. They believed that their water sources were responsible for causing illness. Several methods of water purification were considered, and after a series of taste tests, the community chose a system of colloidal silver-infused ceramics pots provided by the non-governmental organization Potters for Peace. Prior to this third site visit, forty-two families signed up to purchase a filter to use in their homes. Filters are worth $30 each; community members agreed to pay five dollars per filter, and the Oregon State University chapter of Engineers without Borders supplemented the remainder. Funding for the subsidy was gathered principally through a drive conducted by students at Linus Pauling Middle School, as well as through individual donations. One of the main purposes for this trip was to deliver these filters to the villagers.

The filters have a simple design of a ceramic pot permeated with colloidal silver contained inside a five-gallon plastic bucket. As the water passes through the pot, the ceramic removes solid contaminants and the silver disinfects; through this process 99.88 percent of most water born diseases agents are removed from the water, according to Potters for Peace. The water that drips into the plastic bucket can then be used for drinking without fear of contamination. Thus, the filters are effective as well as easy to use.

During the site assessment, the local water board oversaw the filter distribution, collecting the community contributions and explaining pot maintenance. In addition to the filters that went to private homes, two filters apiece went to the elementary schools in El Naranjito and Las Mercedes so that students would have clean water to drink. The contributions that the water board collected were directed to a bank account in Tacuba, to be used to subsidize a further demand for filters.

B. Establishment of the Local Water Board

Partnership with the communities has been progressively building over the course of the site visits. EWB OSU requested the formation of the water board between the second site assessment and this one to ensure a reliable body in the community to act as a point of contact and task force. In continuation of this cooperation, the visiting team met with the water board to discuss allocation of roles and responsibilities. Roughly a dozen community members attended the meeting; and four of them were chosen as officers (President, Vice President, Treasurer, Secretary), and several others (including two women) as public liasons. The visiting team requested that the water board be in charge of making sure the water sources are kept clean, monitoring the health of the community, and helping more members of the community get filters.

The team also met the new Peace Corps volunteer, Aaron Oppelt, who agreed to continue acting as a community contact.

C. Data Collection

The final objective of this trip was to gather dry-season flow rate data for potential water sources and topographic data to assist with piping design. Because rainfall varies so dramatically depending on the season, it was necessary to have stream discharge data from the time of lowest annual flow as a boundary condition for sustainable pumping volumes. The traveling team discovered that there is less water to in the potential sources during the dry season than previously thought, and that upstream limits of substantial aboveground flow are located further down valley than previously thought.

In addition, detailed topographic information was needed for the hillslopes which may potentially support piping of pumped stream water. Topographical data was collected using a total station and surveying equipment. EWB-OSU already had some topographical GIS data obtained during earlier trips, but detailed data on specific hillslopes was necessary to better estimate the amount of piping needed and the gradient to be overcome if pumps were used. These proved to be remarkably difficult to do because the hillsides of the community are overgrown with vegetation, and clear shots to the equipment were difficult to find or create. Despite difficulties, one hill site in El Naranjito was successfully surveyed.

Salvadoran surveyors may need to provide follow-up measurements for additional slopes.

Data Collection

In past project reports possible sources of water have been discussed for the communities of Las Mercedes, La Cumbre and El Naranjito, including 1) creating a reservoir by impounding a stream, 2) pumping water from stream valleys up to the ridgetop communities and 3) rainwater catchment tanks. At the time of this site assessment trip, the project team was leaning heavily towards the pumping option after undertaking a thorough analysis of the positive and negative attributes of the possible source options. In order to determine the feasibility of the pumping option, it was necessary to confirm that the streams contain sufficient water to sustain environmental low flows during the dry season in order to preserve ecological function downstream. The streams located to the east and west of El Naranjito both flow to a Salvadoran national park, Parque Nacional El Impossible. It was reported, unofficially, that villagers once tried to impound water from these streams and were told by a state official that they must remove their dams. It is evident that to fulfill the project goals of ecological and system sustainability, we must not withdraw quantities of water that will impact the ecological function of downstream areas.

In order to determine the suitability for pumping of each streams approximate to the three population centers, it was necessary to accurately measure the discharge of water in each stream during the time of lowest annual flow. The traveling team originally planned to measure flow in four locations pre-determined by the project team (Figure One, page 11, orange points). The traveling team visited each of these locations and found that the locations specified were either dry or did not contain enough water to collect accurate discharge data. The traveling team decided to collect data from the specified sources, but chose sampling locations that were further downstream than the original locations specified (Figure One, black points).

Discharge was measured in four locations during the week of March 25, 2007 using a salt slug tracer test. A solution of a known mass of table salt (NaCl) was dissolved in a volume of stream water and the salt solution was added to the stream in one slug. The salt solution pulse moved downstream, mixing as it traveled to a point where we had placed a YSI 556M conductivity probe (50-100 feet downstream of the salt injection point). At this point, specific conductivity of the stream water was recorded by the YSI at an interval of every 2 to 3 seconds. The probe was left in the stream until the entire mass of salt had been flushed through our measured reach and the specific conductivity had returned to background levels. A background sample of water was taken and background specific conductivity was recorded before the salt was injected.

The background sample of water taken from each stream was used to create a calibration curve by adding known aliquots of a pre-mixed NaCl stock solution (1mgNaCl/1ml de-ionized water) with a pipetter and measuring specific conductivity until a concentration of NaCl with a specific conductivity peak higher than the peak recorded during the slug test had been reached. Concentration of NaCl was plotted against specific conductivity and a best-fit linear curve was fit to the data in order to form a calibration curve for each stream. Specific conductance values recorded by the YSI during the slug test were transformed to concentration of NaCl using the parameters from the calibration curve generated from each stream. Concentration of NaCl was plotted against time for each stream and the area under the curve was integrated. Stream discharge in L/s was calculated with the following equation:

$$\text{Discharge (L / sec)} = \frac{\text{Mass of NaCl injected (mg)}}{\text{integral under curve (mg / L)} \times \text{ data collection time step (sec)}}$$

Mercedes-Cumbre Source- Sunday, March 25, 2007

The first stream tested was named Mercedes-Cumbre Source because this stream drains the valley between the Las Mercedes finca and La Cumbre (Figure One, page 11). The wetted stream width at this time ranged from <1 to 3 meters, although the active channel appears to be much wider (3-6 meters). The active channel was scoured to bedrock, as was a small tributary channel that contributed to the stream directly downstream of our YSI monitoring location. The active channel obviously sustains high peak flows during the wet season. There was little sediment in the channel substrate however, there was a bit of organic material in the stream that had accumulated during the dry season. The wetted channel at this time was comprised of riffle/cascade and pool sequences and the stream velocity appeared sluggish. The measured reach had over 90% canopy closure.

The salt slug was injected at 10:10am on Sunday, March 25, 2007 and the YSI probe pulled out at approximately 6:15am on Monday, March 26. The final discharge measurement came to 1.3 L/s.

Cumbre-Naranjito Source- Monday, March 26, 2007

The second stream measured was named Cumbre-Naranjito Source because it is located in the valley midway between La Cumbre and El Naranjito (Figure One, page 11). This stream channel is also scoured to bedrock and has a riffle/cascade and pool sequence. The active channel was approximately 1 to 3 meters wide; however the wetted channel was less than one meter wide at most riffle sections. We also observed hill slope water seeping out of sheer walls adjacent to this stream.

Despite attempts to measure flow with a salt tracer at this stream, the flow was too low and would not cover the YSI probe. Therefore, there is not a discharge measurement for Cumbre-Naranjito Source.

El Naranjito Source- Monday, March 26, 2007

The third stream measured was named El Naranjito Source it is located in the valley to the east of El Naranjito (Figure One, page 11). This stream is a source of water for many people in El Naranjito. Used packets of cleaning materials were observed near the stream and women were washing clothes in the channel. To the river right a small seep of hillslope water draining to the channel had been impounded and covered and it was from this place that people collected drinking water. They realize that the hillslope water is cleaner than water in the channel and use the seep for drinking and the stream water for washing.

The wetted stream channel ranged from 1 to 2 meters wide and the active channel was between 3 to 5 meters wide. The geomorphology was characterized by riffle-pool sequences and the substrate was comprised of bedrock, boulders and cobble. The reach that was surveyed had greater than 90% canopy closure. Fish were observed in this stream whereas only amphibians were seen at the other streams we visited. It can be concluded that this source contains flowing water throughout the year.

The salt slug was injected at 1pm on Monday, March 26, 2007 and the probe was pulled out at approximately 5:30pm. While data was being recorded a man came to the stream for water leading a mule. The mule drank from the stream and may have caused irregularities observed in the data. Additionally, the probe had to be removed before the conductivity reached background levels. During analysis of El Naranjito Source data, the slope of the recorded trajectory was simply extended until background conductivity values were reached. The final discharge measurement came to 1.2 L/s.

Las Mercedes Source- Wednesday, March 28, 2007

The final stream measured was named Las Mercedes Source because it is located in the valley to the east of Las Mercedes (Figure One, page 11). The active channel of Las Mercedes Source was 1 to 2 meters wide and the wetted channel was less than a meter wide. The substrate was comprised of bedrock, boulders and coarse sand. The reach that was measured had canopy closure greater than 90%. We did not observe people collecting water from this source; however, there was a bamboo trough that collected hill slope water and it is likely that this water is used as a current source.

Two tracer tests were run at this source because the peak specific conductivity from the first test appeared too high and there was concern that too much stream water was used to flush the salt through. The second slug was injected at 6:55am on Thursday, March 29, 2007. The final discharge measurement at Las Mercedes Source came to 0.6 L/s.

Surveying

The hill slope was measured between where the flow rate was taken for El Naranjito Source and the road in El Naranjito using a total station. The final profile is shown below (Figure Two, page 12).

Conclusion and Recommendations

Through a more detailed analysis of the area, a comprehensive plan can be developed to achieve the long-term sustainable goals of this project. It is important that EWB-OSU continue to evaluate all possible water sources in order to address issues of ecological and design sustainability in our water delivery system for these communities.

The information gathered during this most recent site assessment indicates that *quantities of flow in potential water sources are lower during the dry season than previously thought and that the upstream limits of aboveground flow during the dry season are located farther downstream than indicated in previous site assessment trips*. This information influences the water delivery design in two ways. First, upstream limits of aboveground stream flow will to some extent dictate placement of collection tanks if a pumping system is to be used. Secondly, the low quantities of flow will influence the amount of water that we can expect to extract from these sources during the dry season.

It is the recommendation of the traveling team that water demand in the dry season should not be met by pumping alone, but rather that we should diversify our design to include water storage during the rainy months. With the abundance of rainfall during the wet months, water collected and stored during the rainy season can be exploited by the communities for use during the dry season.

A. Design Recommendations

While low pumping rates (e.g. 0.1 L/s) during the dry season would not supply full water demands, low pumping rates could supplement stored water, reducing the size and number of catchment tanks that would need to be built. Furthermore, these low volumes could potentially be feasibly attained using ram pumps. It may be worth looking into the possibility of building smaller tanks for single family use in some areas and allowing each to be responsible for water storage.

The traveling group felt that community members were open to the idea of rainwater catchment. First, the group conducted informal interviews with community members, who were receptive to the idea. Second, the group noticed a newly-constructed rainwater catchment and storage tank at the school at La Cumbre. It was reported that ADIC installed this tank, but that it wasn’t large enough to sustain the school for long dry periods of the year.

Larger holding tanks may be necessary in order to supply a sufficient amount to last through the driest months of the year while being supplemented by low volumes of pumped water. According to community members, the longest period in which they need to store water is approximately three months. This is usually through March, April, and May, just before the rains start up again toward the end of May. Volumes for tanks have been approximated based on estimates of daily water usage per household. One objective on this trip was to identify feasible tank locations. While there seem to be a couple of options for flat, elevated locations, there are still other issues and questions of legal nature that must be answered before materials are purchased and tanks constructed.

B. Legal Concerns

The possibility of building large centralized tanks in addition to small private ones will is largely dependent on legal accessibility. First, there is the matter of land ownership. Over the course of the site visits, several sites have been identified. The land ownership is known for a majority of the areas around Las Mercedes and La Cumbre. The coffee plantation owner, “Don” Tom Hawk, is known to own this land. Through conversation with Ruben Flores (the engineer who works for Mr. Hawk), it was established that those sites under consideration are indeed available for project use. As for the third area, El Naranjito, the vice president of the water board claims to know the land owner and to have been granted permission to use it for a tank. In both of these cases, the land owner has not been contacted directly by the group. Direct follow-up with the land owners is necessary to legally establish availability.

In addition to determining land ownership, further research on El Salvador’s regulations and the water rights for areas that may be affected by these communities pumping water from the streams. Communication must take place with the proper authorities and agencies regarding the potential pumping of water from the streams in these three communities. By removing water upstream in a watershed, there may be a negative impact downstream on plants, wildlife, and other communities which rely on those rivers for survival. It must be kept in mind that the land is upstream from one of the most important national parks in El Salvador: El Imposible. El Imposible provides habitat for plants and animals and generates much-needed tourism for the region.

C. Follow-Up on Water Purification Systems

In addition to the water distribution plans, it is also important to sustain the water purification efforts which have thus far been achieved. To this end, it is important that the water board stay committed and organized. In establishing the water board’s role in this project, it was asked that they act as a liaison between Potters for Peace and families who wish to purchase a filter. The community-participation money ($5 per filter) was left behind for the water board to open a bank account in nearby Tacuba. These funds are intended as future subsidy for filter-purchasers. The water board’s second main role is to collect monthly maintenance payments from the families who have purchased the pots.

We have asked the new Peace Corps volunteer, Aaron Oppelt, to help with maintained communication with the water board. The expectation is that the water board take full command of the filter pot project. The role of EWB will be to continue fundraising so that the initial cost of the pot is feasible for every family who wishes to purchase one.

Finally, the water board is also expected to educate the public regarding preserving the cleanliness of water sources. It was evident during this assessment that community members prefer to obtain their drinking water from sources other than directly from the stream channels. Several areas of impounded hill slope water were observed and it is from these sources that community members preferentially draw drinking water. They use the stream channels for washing clothes and bathing. Particularly if pumped stream water is to be used as a water source, we should take steps to ensure that all community members know to keep harmful substances, such as bleach or phosphates from cleaning solutions out of water that may be used for consumption downstream. The need for this type of public education should also be communicated to Mr. Oppelt.

Along with organizational follow-up to the purification element of this project, there must also be follow-up to determine the efficacy of the filters. Prior to the next site visit, a (preferably) quantitative health assessment should be designed. It is important to understand the degree to which the filters are helping. If no changes are noted, different solutions should be pursued.

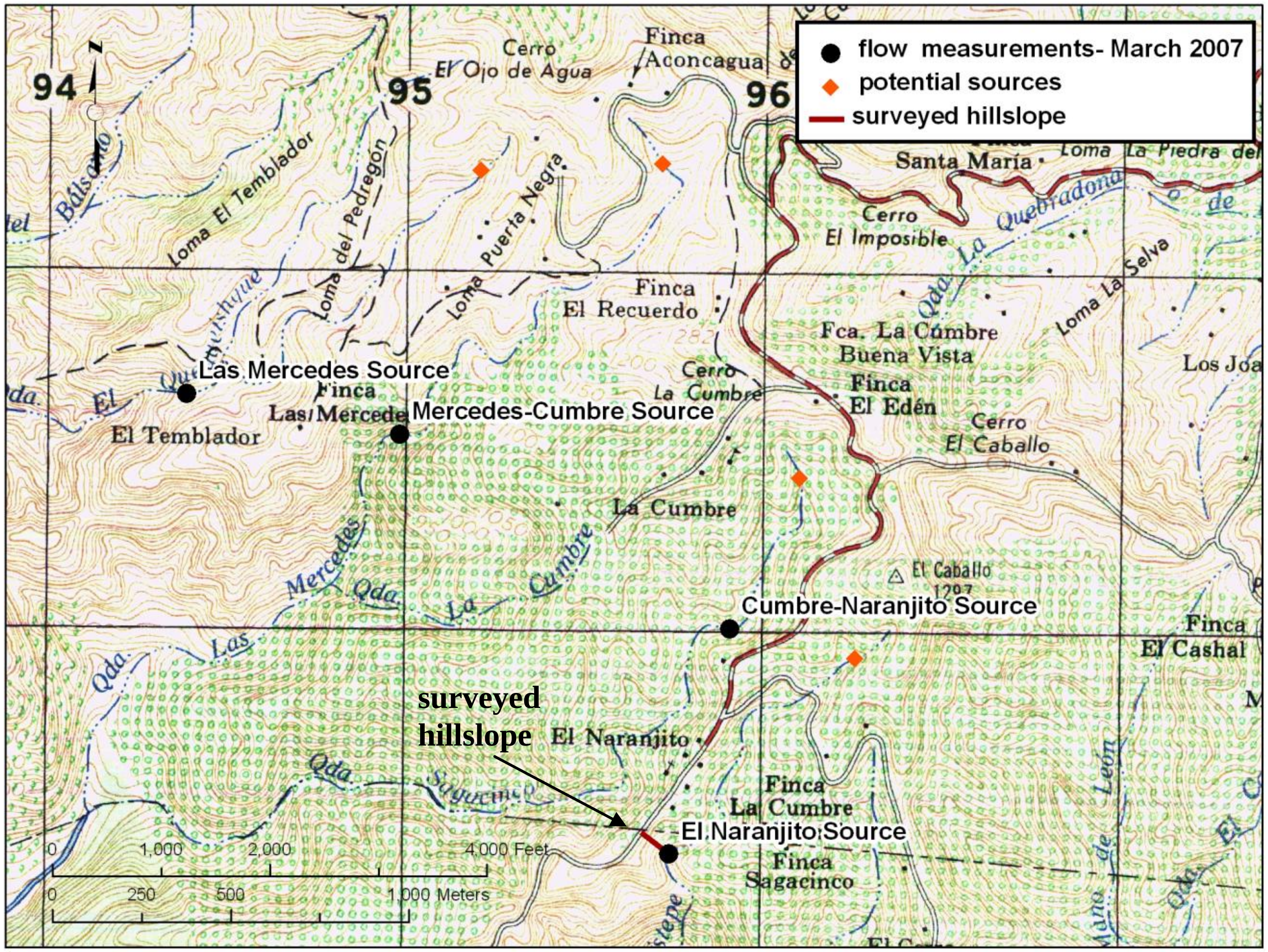

Figure One: Project vicinity map with locations of planned discharge measurements, locations of actual discharge measurements and surveyed hillslope.

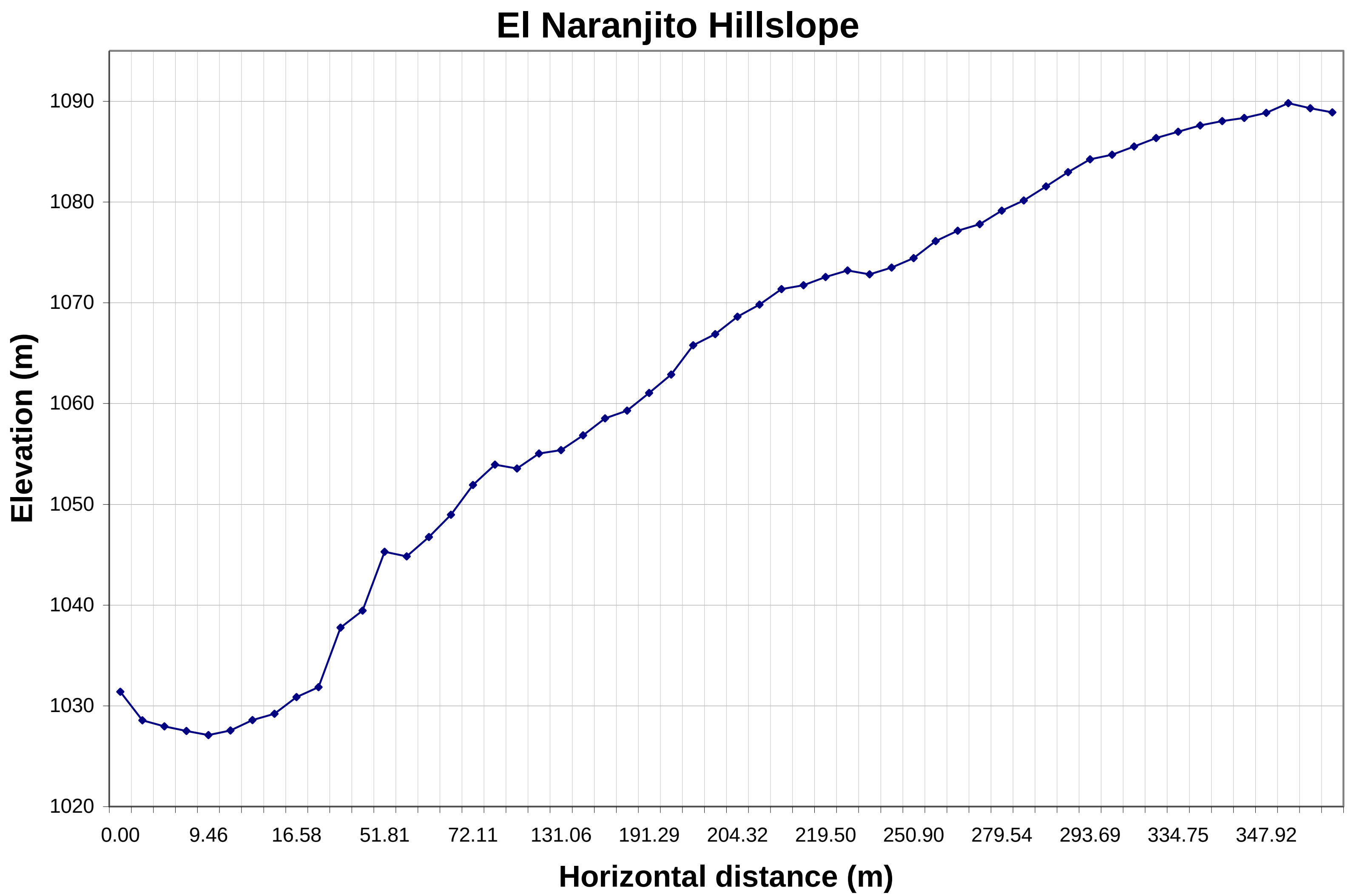

Figure Two: Profile of surveyed hillslope