Illinois Institute of Technology

Final Report

IPRO 327

Advisors: Prof. Kurzydlo

Sustainable Water Distribution System for Pignon, Haiti

Section 1.0

INTRODUCTION

The IPRO 327 group sought to create a complete set of drawings and specifications of a water distribution system for Pignon, Haiti that can be easily built and used by the town. This is a continuation of a spring 2007 IPRO, which completed mapping of the town. This semester, the group designed the physical water distribution system, which included selecting a pump, designing a water storage tank, mapping out the pipe network, and designing water kiosks from which the water can be drawn. Research was also conducted to determine the proper materials to be used in each section and an efficient erosion protection system was designed. Through our work, we hope to create a system that can be implemented by Pignon to provide a clean and reliable water source for its citizens.

Section 2.0

BACKGROUND

Pignon is a town of about 10,000 citizens sitting in the mountains of north-central Haiti. The country has long been one of the poorest and undeveloped nations in the western hemisphere but has recently seen an upswing in its economy under new governmental leadership. Aid from numerous volunteer organizations from around the world is also helping to stabilize the nation and provide a better quality of living for its citizens. Pignon has received a great deal of help from different organizations to improve the small town, receiving their first electrical streetlights in 2005, and now, through our group at IIT and Haiti Outreach, a new water distribution system. Haiti Outreach, the project's sponsor, is a non-profit, non-governmental organization that works with different communities in Haiti on water distribution systems and other community development projects. Haiti Outreach projects are based on ideas of both grassroots community participation and community ownership, with the goal of bringing about a realization in the community of what can be accomplished when everyone works together.

In November 2006, a student chapter of Haiti Outreach was formed at IIT to address the numerous problems facing the nation and the town of Pignon. From this group, two large projects were started that numerous students and IPRO groups have worked on, including our current project of designing a water distribution system. Working on a project that is in a different country presents many problems for task completion. Gathering needed information is difficult and working with the local government of Pignon has proved a challenge. Working in a developing nation is even more complex, with different standards to follow and a way of life very different from our own.

The current water distribution system in Pignon is in desperate need of repair. The maintenance of the system has been meager and water is only available to 20 percent of the population from two to five hours a day, only every five to fifteen days. This forces much of the population to walk several miles to reach alternate sources of water, such as rivers, springs, or wells that are often contaminated. The IIT Haiti Outreach Group and this IPRO have worked on creating a water distribution system that is both safe and reliable. To do this, we had to find a water source that was able to provide the needed amount of water and use different technologies to distribute it throughout the town as needed. This was extremely difficult to do. Much of the information and data needed could only be collected firsthand. Being thousands of miles away from our project created limitations on information gathering, which was needed to complete certain aspects of the design. For instance, when designing the water storage tank, the soil type at its location was unknown, making it extremely difficult to design the tank efficiently. The tank was designed conservatively, but this may not have been the most cost effective manor.

Surveying of the town had already been completed and GPS data collected but mapping using AutoCAD or a similar computer aided drafting program still had to be finished. The size of the piping was to be determined through computer programs and then plotted on AutoCAD. Once all aspects of the project were finished, a complete set of design specifications were to be printed out and made into a book for the town's implementation.

It is through Haiti Outreach that our project will go from an idea to a reality. They are not only sponsoring the IPRO project but will help with the building costs in the town of Pignon. IIT students have already made two trips to Pignon, with half of the costs covered by Haiti Outreach and another trip is being planned for early January. (The remaining costs for the trip have been fundraised.) The rest of the work will be up to the town, though. The cost of the project is still to be fully determined. It proved a major challenge to determine the cost of the materials (let alone what materials are available on the island) or the cost of labor for this project. This is unfortunate, as a project turned over to the town that proves to be very expensive would be of little help or relief. The job of the IPRO was to come up with a set of design specifications and drawings that can be given to the town for implementation. However, those in charge on the Pignon side will be able to decide what parts of the plan they will follow and any changes they want to make. The mayors of Pignon have already made clear that changes may be made that could cause the project to fall below our design standards. The IIT team has refused to compromise the project's integrity, though. We will sign off on a design that we believe is safe and up to standards and would not approve of any changes that could negatively impact the system.

Section 3.0

PURPOSE

The main objective of the IPRO 327 group was to create a complete set of drawings and specifications for a water distribution system, tailored for the town of Pignon, Haiti. With mapping of the town completed in the spring by the previous IPRO group, the fall IPRO group sought to design the actual physical system and its major components. Several factors significant to the success of this system were identified and groups were formed based on each major section of the project. These major components included finding a water source that could provide a continuous and adequate flow of water, design of a pump and the power source to run it, design of water kiosks and

faucets, and design of the piping network with erosion protection. User fees were also to be determined for both public and private water lines.

The first major objective was to design a pump and power source for the water distribution system. The pump selection was based on information found from different pump manufacturers and the type of pump that would work best within the system. The pump had to be adequate in providing the pipe network with the needed volume of water throughout the day. As there are peak periods throughout the span of the day, it was also decided that the best design would include a storage tank from which the pump would draw water. During low use times, the water level in the tank would be allowed to fill and during peak times, water could be drawn from the storage tank; this would decrease the likelihood that the system would run dry, as had been such a problem with previous systems. Both the pump and the power source were worked on by Group 1. However, the IIT student chapter of Haiti Outreach ended up absorbing the power source research and also found a pump most suitable for our system. The storage tank design was completed by two members of the IPRO group. This was challenging in the fact that the soil type of the area where the tank would be located was unknown. Therefore, the worst case scenario was designed for to ensure the sustainability of the product.

The next objective for the semester was designing water kiosks. These kiosks would be located throughout the city and would allow the townspeople to purchase the water for a set fee. The materials used in the kiosk designed had to be readily available and inexpensive, and the overall design could not be very large. The goal was to make the design small and efficient so that several could be constructed throughout the town, allowing for easy access for the citizens of Pignon. Shipping containers were considered for a time, but the cost of transportation and the large size made them infeasible.

The pipe network also had to be designed. The topographic map of the town had been competed in the first semester of this IPRO. On the second trip made to Haiti, survey data was collected on the expected water usage throughout the town. After water needs and the topographic features were considered, the pipe network design was underway. Erosion protection was also to be considered. Past systems literally fell apart as the roads that covered the pipe network eroded with the rain. Several methods of

erosion protection were to be looked into to ensure that such problems would not affect our design.

The final objective was to take all of the information and the final design and develop a complete set of specifications and drawings to be handed over to the town. Also, the cost for the completion of the project was to be determined as well as an appropriate price for water based on the design. These design specifications and drawings would then be handed over to Haiti Outreach and the town of Pignon for implementation.

Section 4.0

Research Methodology

The problem that was been presented to this IPRO group was to create a set of operational manuals with drawings and specifications for the design of a water distribution system for the town of Pignon, Haiti. The water distribution system was to consist of public water kiosks that could be patrolled and paid as per person use as well as private faucets to those who requested them. The system also required a pump that could provide the needed volumes of water, a power source, and erosion protection to ensure sustainability of the system. Finally, taking into account all aspects of the water distribution system, the cost of building it and the price to use the system were to be determined.

In order to solve these problems, the IPRO group worked together with the IIT student chapter of Haiti Outreach. Several main objectives were identified that were necessary for the success of the system and five groups were created and given specific assignments based on the major project phases. As this was a continuation of a spring 2007 IPRO, some aspects of the project had been completed; however, most of the design still lay untouched. Last semester, a digital map of Pignon was created to show the locations of the existing water pumps and which ones were in operation. A major step in designing the water distribution system was to take the map, study the current system, and design the new pipe network based on the locations of the roads, buildings, and major topographic features of the town.

During the first week of the semester one of the students continuing into this IPRO traveled to Haiti and conducted a survey on the citizens of Pignon. The survey data then had to be translated to English and put into a computer database. From these surveys, information was gathered on the population of the town, the average daily amount of water consumed in a single home as well as by the town as a whole, and the interest in having private lines available to single homes. This data was used by the team designing the layout of the water distribution system in helping to determine how much water should be moved through the pipe system to different parts of the town. This aided in the calculation of the correct size of the piping needed and, with the aid of the completed map, where these pipes should be placed within the system.

These calculations for the pipe sizing were done with the help of a program called EPANET. EPANET is a software program that models the hydraulic and water quality behavior of a water distribution piping system. EPANET tracks the flow of water in each pipe, the pressure at each node, the height of water in each tank, and the concentration of a chemical species throughout the network during a simulation period. The EPANET model was an important tool used by the pipe network design team. Once the details of the water system were designed and tested, feasibility research on various pipe materials was conducted. Two members looked into various erosion protection methods best suited for the town but no specific method has been chosen at this time. This is currently where the work on the pipe network has stopped, due to the time constraints of this project. At this stage of work, the design still needs to be approved by a professional in the field and AutoCad plans and profile plans of the system for construction must be created. Water purification methods have been looked into, but this is a very important aspect that will be left in the hands of Haiti Outreach.

One group was assigned the task of finding a pump best suited for our specific water distribution system as well as the best way to power the pump. Early on, the power research portion of the assigned tasks was taken over by the Haiti Outreach group. Pump research continued and several manufacturers were contacted to try to find information about different kinds of pumps, where they work best, and the amount of water they could supply. During this research, it was determined that the best way to ensure that enough water was always available for this system, a water storage tank should be

constructed. Two members of the pipe network group were assigned this task and began research on construction materials, the needed size of the tank, and the best location for it. Pump research continued until the Haiti Outreach group notified our IPRO team that a pump had been selected.

Another group focused on the design of the water kiosks, where the water would be distributed to and paid for by its users. A water kiosk was to include a water connection, a water meter and main valve with three to five distribution pipes with valves located inside the kiosk. The team looked into several different alternatives for this task. One idea was to use large shipping containers. These containers are readily available on the island and could be easily adjusted for our purposes. However, it was decided that the price of moving these containers from a port to the mountain town would not be cost effective. The shipping containers were also deemed to be too large to be placed in numerous locations throughout Pignon. Therefore, a cinderblock method was decided upon. A previous IPRO group that had designed an extension for the high school in Pignon had developed a mold for a cinderblock and gave our group all of the needed dimensions. This way, the kiosk could be made not only out of readily made materials, the cost would also be minimal. An AutoCad plan of this design was completed and the kiosk is small enough that it can easily be built in several locations throughout the town without taking up a great amount of space.

The final group was formed to complete the IPRO deliverables portion of the project. One member in this group was responsible for taking meeting minutes and sending out emails to the IPRO team. This group facilitated communication between groups and made sure that needed information was being passed between the groups. If one group's tasks was dependent on information being researched by a separate group, the two members on the deliverables team made sure that deadlines were set so that all groups could complete their assignment by the needed date. Also, this team gathered all needed information from groups for each deliverable and put it in the acceptable format. If additional assistance was needed for a deliverable (e.g. an Architect to help design the poster) this group explained what the deliverable required and received extra assistance. After peer editing and team discussion had been completed, the final product of the deliverable was produced and the information submitted to the IPRO department.

Section 5.0

ASSIGNMENTS

At the beginning of the semester the IPRO team was divided into five different subteams. These divisions are seen below.

Group 1: Selection of Pump

Tom Lis

Peter Smauger

Ermin Skrebo

Group 2: Water Kiosks Design

Gustavo Mendoza

Ivan Nockov

Ivan Rahjic

Fuzel Shethwala

Joanna Szwajnos

Group 3: Pipe Size and Erosion Protection

Mudassir Hussaini

Ashfaq Mohammed

Enis Omeralovic

Ionut Parv

Mark Rokita

Kinjal Tailor

Nastasja Terry

Group 4: IPRO Deliverables

Nicole Dennis

Meredith Stella

Group 5: Specifications/Feasibility

Jonathan Kohler

Eric Radloff

Each group was assigned specific tasks; the semester progress of the groups is detailed in the table below. As it can be seen not all assignments were completed, such large components were the specifications and construction/operations manual. Since these components were not completed it will be up to the Haiti Outreach program to complete this from the research and calculations completed by this IPRO.

Results to Date:

Task:	**Completion:**
Group 1	
Analysis required volume	Completed
Pump research	Completed
Pump manufacture research	Completed

Final pump selection	Completed
Elevation and pipe network	Completed
Water purification	Incomplete
Cistern design	Completed
Group 2	
Storage tank foundation	Completed
Storage tank design	Completed
Construction Research	Completed
Tank material research	Completed
Water kiosk preliminary design	Completed
Alternative materials research	Completed
Final Design water kiosk	In-Progress
3D View of water kiosk	Completed
La Tanya Research	In-progress
Group 3	
Survey data	Completed
Pipe material research	Completed
Pipe Design	Completed
Pipe Drawings	Incomplete
Erosion protection research	Complete
Update EPANET model	Completed
Maps of Pignon	Incomplete
Fundraising coordination	Incomplete
Group 4	
Project Plan	Completed
Ethics Code	Completed

Meeting Minutes	Completed
Mid-Term Report	Completed
Mid-Term Presentation	Completed
Final Report	Completed
IPRO Day Presentation prep	Completed
Poster	Completed
Group 5	
Currency research	Completed
Population growth research	Completed
Survey data analysis	Completed
Budget	Completed
Feasibility research	Completed
Specifications	Incomplete
Construction/Operations Manual	Incomplete

Section 6.0

OBSTACLES

There are many obstacles that are faced in starting any design project; these obstacles are often increased when the design requirements are unfamiliar to the engineer and/or when the client comes from a different culture. One of the obstacles our IPRO has encountered is the group's lack of experience in designing water systems. There is a lot of knowledge in engineering that is developed through time and experience from working on different design projects. This is one of the major reasons why engineers have to have five years of experience in the field before they can test for their professional engineering license. This experience, of course, is extremely limited in our group so tasks took more time than expected and more research was conducted than originally anticipated.

Another obstacle the group encountered was the language and culture barriers. The native language of Haiti is a mix of Creole and French, making translation of

documents extremely difficult. Within Pignon there has been an ongoing dispute for the controlling authority of the town. At one point the town had two different mayors. Right now it is still not clear who is the controlling governing body; however, all contact to the local authority is achieved through the Haiti Outreach group.

There is also the barrier working with the Haiti Outreach group to accomplish this project. In the United States, every construction project is designed and built to a certain set of standards. In many cases, Haiti does not have clearly defined standards, if any at all. We are faced with the obstacle of designing and planning the safe construction of a water distribution system for this underdeveloped country. The Haiti Outreach group has accomplished various projects in Haiti and the IPRO team needed to rely on their experience to develop an understanding of the available resources and common procedures.

The various tasks of this project were evenly divided between the five sub teams. Members that were specifically working on the design elements of the project such as the water pumps or the piping system were often found consulting professors. These encounters were an absolute must since none of the members on the IPRO team have designed a water distribution system before and are not licensed engineers.

Our IPRO had a fairly difficult time overcoming the cultural barriers when planning the cost estimates. Since there isn't a set unit price for materials or labor in Haiti, it was difficult to estimate the prices for the project. Since we have not completed a project in Haiti before, our lack of knowledge proved to be a huge setback since the cost estimate is not as detailed as we had anticipated. The cost estimating group started to get more involved with the Haiti Outreach group to gather more information to aid in completing the necessary cost estimates for the project. They also worked with members from a past IPRO who had just completed the design and construction of an addition to the high school in Pignon.

An unexpected obstacle that our IPRO has encountered is having to print the IPRO Day poster without the assistance of the IPRO office. Due to a lack of communication, the team members designing the poster did not receive the needed

information from other group members in a timely manner. Thus, they were unable to complete the poster by the deadline. The poster will now have to be printed through other means. The IPRO team will either split the cost of having the poster printed at a Kinkos or it will be printed using members' IIT printing accounts in Crown Hall.

Since this IPRO will not be continued next semester, a future obstacle will be for the Haiti Outreach group to complete this project. During this semester, the team members did everything to the best of their ability to ensure the completion of the project. However, we fell short. The IPRO did achieve the completion of a final design for most of the system except for the water kiosks; the specifications were not written, either. Also, since the design was not finalized, it could not be checked by a licensed engineer. Thus, all of the research, calculations, and designs completed by the IPRO will be turned over to the Haiti Outreach group, who will be in charge of finishing the project.

Section 7.0

RESULTS

The accomplishments in this IPRO have been immense. The water distribution system has come together with the completion of the pipe network design, pump selection, water kiosk and water storage tank design. A map of the town of Pignon has also been completed and will be given as a gift to the mayor of Pignon with the final design.

Using the EPANET Model program the pipe network system was designed. The EPANET software program is used to model the hydraulic and water quality behavior of a water distribution piping system. The program is able to analyze the system for a certain number of years, which provided important information to us as to whether our system design will last for the required twenty years. Once the details of the water system were designed and tested in the EPANET program the pipes were sized to handle the peak flow, limit the head loss, and allow the descent velocity in the pipe for twenty years. Since the pipes won't actually be replaced within twenty years it was necessary to design

the system for a longer period of time. Feasibility research on various pipe materials was conducted. From this research, PVC pipe was selected for the design of this system. There was not enough time to use AutoCad to complete a set of drawings for the piping system so the only documentation we have is the EPANET model. This will be a task that will be left to the Haiti Outreach group to finish.

The pump selection process proved to be very interesting. A great amount of time was spent doing research on the pump design, but the group doing this work was later informed by a member of the Haiti Outreach group of a specific pump that was to be used. Even though some time was wasted on unnecessary research, the assistance of the Haiti Outreach group was appreciated. The pump that was selected for this water distribution system was a Fybroc division 1530 Series Group 1 pump. An outline drawing with base plate can be seen included in the calculations.

Water from a spring flows through the ram pump at a rate of 85 gpm into the water storage tank. When the electric pump pumps water, there needs to be enough water in the water storage tank to accommodate the water being pumped out of it. The purpose of the water tank is to fill up while the electric pump is not running, store the water, and to have an efficient amount of water to pump out during the few hours the electric pump will run. The water storage tank is a reinforced concrete tank designed to store 15,000 gallons of water, which is equal to a volume of 56.78 cubic meters. The general measurements of the tank are a 10 inch thick bottom slab, 5 inch thick top slab, 8 inch thick walls and a 2 foot deep foundation. The design can be seen in the completed AutoCad drawings.

The erosion protection system was not designed even though a lot of research on erosion protection was completed. The erosion protection was unable to be designed since the piping network design was not completed in time for construction and erosion protection to be considered. The type of erosion protection needed depends on location and type of piping network designed.

The water kiosk has been designed as a concrete structure, since concrete is a construction material that can be mixed fairly easily. The original idea was to make the

water kiosk out of the shipping containers left in the city of Pignon. However, after some research it proved to be more expensive to move the shipping containers to the designated stations than to mix concrete for concrete blocks. Labor is fairly inexpensive in Pignon so having more laborers to mix the concrete for the concrete blocks is more cost efficient. The water kiosk design has not been finalized so this will be one of the aspects that Haiti Outreach will be finishing.

Part of the responsibility of this IPRO was to create a map of Pignon since there is no map on record. In actuality, multiple variations of the map of Pignon were created. The purpose of the maps was to show the water kiosk locations in relation to the rest of the town and to give an accurate topographical representation of the area. This map was also designed as a gift for the authority of Pignon to assist in future construction projects

Section 8.0

RECOMMENDATIONS

The design will be handed over to Haiti Outreach for the IIT chapter to assist in finalizing the design. The water purification will need to be looked at extensively and decided upon, and the water kiosk design will need to be finalized. After a final design is completed, tests should be conducted on simulations to test the accuracy of the design. The design should also be reviewed by professionals to deterimine its feasibility in Haiti. Haiti Outreach will also need to work with the governing authority in the town to see through with the proper implementation of the design and to assist in the building process.

Section 9.0

REFERENCES

American Concrete Institute (ACI). (2005) *Building Code Requirements for Strucural Concrete (ACI 318-05) and Commentary.* Farmington Hills, MI : Second Printing.

Crowe, Clayton T., Elger, Donald F., and Roberson, John A. (2005) *Engineering Fluid Mechanics.* Hoboken, NJ: John Wiley & Sons

Munshi, Javeed A. (1998) Rectangular Concrete Tanks. Skokie, IL: Publication Skokie.

Section 10.0

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- Haiti Outreach Group – Assisted throughout the semester in the design process, and is assisting in planning another research trip to Pignon in January.
- IIT IPRO Office – Provided seminars to assist in various deliverables, set guidelines for the deliverables.
- David Baker – Assistance in fundraising and trip planning.