

WEFTA Trip Report

Project: San Cayetano, Colombia
Participants: Andrew Robertson, P.E. and Tory Tadano, EIT
Date of Trip: February 25, 2012 to March 8, 2012

Trip Summary:

Executive Summary

During this trip, field work for the topographic survey was completed and completed soils testing was reviewed in the field with the geotechnical engineer. In addition, WEFTA, Lutheran World Relief (LWR) and the Corporation for Solidarity Development (CDS) reached a tentative agreement by which LWR will pay for the remainder of the engineering feasibility study for the gravity-fed water supply alternative and a comparative study between the gravity-fed and pump-fed alternatives (app. US\$50,000), on the condition that the local Alcalde commits to accepting the recommendations of the study. LWR currently has funds available to cover this work. The community, the local engineer, CDS and WEFTA met with the Alcalde to propose this comparative study and ask for the Alcalde to commit to supporting its recommendations, whatever they may turn out to be. Political work with the Alcalde is still ongoing.

History and Background

The town of San Cayetano, population 9,000, is located in the low mountains southeast of Cartagena, Bolivar, Colombia, about 35 miles from the Caribbean coast at an elevation of app. 300 ft above sea level. Despite its size, the town does not have running water. Instead, residents rely on hauled water, untreated river water (not available during the dry season), and other sources.

In the late 1990s, the Colombian government constructed a \$1+ million water system to pump water from the Canal del Dique (near sea level) through 23 km of pipeline to a surface water treatment plant and re-pump to a tank on a hillside above the plant. However, after more than 15 years, this existing system still has not delivered water to the town. In 2008, WEFTA inspected this system and catalogued a large number of design and construction defects which prevent its proper operation. The Colombian government also recognizes that this system was improperly designed and constructed, and has budgeted app. US\$750,000 for re-construction of a re-designed system (funding for the re-design itself has not been identified by the government).

Given the magnitude and cost of the effort to rehabilitate this failed system, the community has asked WEFTA to look at other alternatives that might be more economical and sustainable. One of the fundamental problems with the existing system is the high cost of electricity for pumping from sea level to 300 ft MSL through a long pipe with high head loss. Other O&M problems include maintenance of 23 km of pipe in an area where transportation is difficult and expensive, the risk of water theft from such a long and vulnerable pipeline (it would run along a major highway), and the cost to treat highly turbid water from the Canal del Dique.



The first alternative considered by the community, CDS, WEFTA and LWR was drilling a well. Other communities in the area have drilled wells, with good results. Unfortunately, while San Cayetano has abundant rainfall, the soils are primarily impermeable clay and rock, so there is no aquifer to speak of. CDS and LWR funded a geophysical investigation of the area (attached), which determined that drilling a well is unlikely to produce adequate quantity or quality of water, and is therefore unfeasible.

The next alternative considered was to construct a small earthen dam at the mouth of a canyon known as 'The Tunnel' above the town, to collect rainwater falling in the upstream watershed and convey it by gravity to the town. During the summer dry season (December to April), the reservoir created by the dam would store enough water to sustain the town. A surface water treatment plant and treated-water storage tank would be located between the dam and the town, allowing the entire system to work by gravity, with no need for electricity or moving parts.

Project Parties

Parties active in the San Cayetano water project include:

- Community – The 1,500+ families currently living in San Cayetano.
- Aqueduct Association – A group of community residents volunteering to implement the water project.
- Corporation for Solidarity Development (CDS) – A Colombian NGO based in Cartagena that supports Aqueduct Associations in San Cayetano and nine neighboring communities, as well as other social and economic-development work.
- Lutheran World Relief (LWR) – An international aid organization that provides funding and management assistance to local NGO. LWR has its own funding stream, as well as the capacity to apply to other foundations on behalf of NGOs and communities.
- Alcaldía de San Juan Nepomuceno – Roughly the equivalent of a county government in the USA. The elected leader of the Alcaldía is the Alcalde (mayor), who presides over an area (municipalidad) that includes several towns and villages.
- Water Engineers for the Americas (WEFTA) – A USA-based NGO that provides 100% volunteer engineering support for water and wastewater projects throughout Central and South America.
- HidroConsultores – A Colombian consulting engineering firm based in Cartagena that has been recommended by numerous entities and has given a proposal for engineering work on the gravity-fed water supply alternative.

Focus of Current WEFTA Trip

The trip focused on three areas to move the gravity-fed alternative to feasibility level:

1. Technical (topographic surveying, soils testing and hydrology)
2. Funding (from Lutheran World Relief)
3. Government support (focused on the Alcaldía de San Juan Nepomuceno)

Each of these project components is discussed in detail below.

Technical



The gravity-flow alternative is currently in the feasibility-level of analysis, meaning that basic engineering studies are in the process of being conducted to determine whether this alternative is technically feasible, how safe it would be, and how much it would cost. The feasibility analysis consists of the following major components:

1. Topographic surveying: The topographic survey of the dam site itself will be incorporated into the preliminary engineering report to determine the amount of earthmoving required during construction, which has a direct bearing on project construction cost. Surveying the area to be flooded by the proposed reservoir upstream of the dam will be used to determine how tall the dam needs to be to provide adequate volume of water storage to last through the dry season; dam height is a major factor in determining project safety, as well as cost, and will be one of the main deciding factors whether the project will proceed. Finally, surveying the terrain downstream of the dam is necessary both for dam design and erosion protection, as well as design of the gravity-fed water transmission line.

In October 2010, a survey crew composed of WEFTA engineers and local community members surveyed the dam site, the canyon downstream of the dam site, and the first 1-2 km of water transmission line. During the February 2012 trip, the survey crew returned to survey the reservoir “take area” upstream of the dam. **All topographic surveying field work for the feasibility analysis has been completed.** WEFTA is currently in the process of analyzing this new data to determine the required height of the dam.

2. Soils Analysis: Another major factor affecting dam safety and cost is the quality of the soils underneath it (foundation) and in the canyon walls on each side of it (abutments). In May 2011, a local geotechnical engineering firm drilled five 60 ft deep test holes in the foundation, as well as shallow (10 ft) deep holes in the abutments to determine the soils are adequate to support the dam. At this feasibility level, the soil test results seem to indicate that the site will support a dam with approximately 10 feet of overexcavation (i.e. dig up the top 10 feet of soil and re-compact it). The foundation is predominantly impermeable clay, which will prevent water from seeping under and undermining the dam. Test results from the abutments are still pending. However, a significant amount of rock was observed in the right abutment, which may benefit construction.

Feasibility-level soils analysis has been completed, although additional funding is needed to pay the balance of the geotechnical engineering fee (from LWR, see below). Test results from shallow holes drilled on the left abutment are still pending from the engineer. **Additional deep test holes will need to be drilled prior to final design of the dam**, particularly on both abutments and downstream of the dam foundation.

3. Preliminary Engineering Report: This report has not yet been performed, although certain components of it have been started. See discussion below regarding funding for this report. The Preliminary Engineer Report will include:



- a. Hydrology – Analysis of rainfall volume within the watershed that will be captured by the reservoir. This will determine the adequacy of the project to supply the town’s water demand, required reservoir volume to last through the dry season, and estimation of average and peak flows which will be used to design the dam’s spillway and ensure the dam will not be overtopped during severe storms.

A very rudimentary calculation based on average annual rainfall indicates that the Tunel produces approximately 14 times more water each year than the town’s annual water demand (see attached). Thus, it is apparent that this site has more enough water to supply the town, provided other factors of cost, safety and summer storage can be addressed.

- b. Geomorphology – This analysis will look at the competence of the damsite to support the dam and the risk of earth slides in the reservoir site (the resulting splash-waves can cause overtopping of the dam if adequate freeboard is not provided). This analysis will also make preliminary recommendations regarding location of dam spillway, waterline alignment, etc.
- c. Hydraulic Study – This analysis will determine approximate dimensions of the dam, reservoir volume, area and depth, and spillway sizing. Such determinations will take into account community water demand, population growth, evaporation, sediment accumulation, etc.
- d. Basic Water Quality – Basic water quality parameters, such as TDS, metals, anions and cations, will be analyzed. It is noted that WEFTA personnel and community members performed a “taste test” on the water during this past trip. The verdict was that the water is delicious.
- e. Preliminary Design of Hydraulic Structures– A preliminary design of major hydraulic structures, including the dam, water transmission line, treatment plant, tank and distribution, will be performed to develop a preliminary construction cost estimate.
- f. Construction Cost Estimate – Based on the foregoing analyses and preliminary design, a preliminary Construction Cost Estimate will be developed.

In addition to the construction cost estimate, comparative operation and maintenance (O&M) estimates will also be refined. A rudimentary O&M cost comparison between the pumped and gravity-fed alternatives has been developed by WEFTA, which indicates **the pumped system may cost up to 3 times as much to maintain as the gravity-fed alternative.** See attached calculations. The primary driver is the high cost of electricity



for the pumped system, although the longer pipeline and poorer source water quality also contribute to higher treatment and maintenance costs.

4. Environmental Document: An Environmental Document will be prepared in accordance with Colombian legal requirements. It is noted that the San Cayetano Acueduct Association has proposed creating a wilderness preserve upstream of the dam to protect water quality, as well as to meet the municipality's Federally-mandated conservation goals. This proposal is currently being negotiated with the Alcalde de San Juan Nepomuceno.

The Environmental Document has not yet been started; see discussing below regarding funding for this study.

Funding

WEFTA met with LWR and CDS to discuss possible project funding. LWR's country director stated that **LWR currently has US\$80,000 available for water projects in the region, of which approximately \$50,000 could be set aside for San Cayetano.** This amount would cover all of the remaining feasibility-level studies (detailed above) needed to advance the project to final design.

LWR stated they were willing to commit these funds to the project, on one condition: LWR needs a commitment from the Alcalde that he will cooperate with LWR on a comparative study between the old (pumping) and new (gravity-fed) water supply alternatives. This comparative study would consist of an evaluation of the existing system and costs to rehabilitate it, plus the feasibility-level studies of the gravity-fed alternative described above, with a brief quantitative comparison of the relative merits and costs of the two alternatives. The Alcalde already has funds set aside to study the rehabilitation of the existing system. LWR is not requiring that the Alcalde contribute any matching funds; rather, the Alcalde will pay for the evaluation of the existing system and LWR will pay for the feasibility study of the new alternative. The key points to such collaboration are that both studies must use the same design criteria, unit costs and assumptions to ensure "apples-to-apples" comparison, and the Alcalde must commit to honoring the results of the comparison.

LWR and WEFTA agreed that HidroConsultores (the local engineering firm currently involved on the project) would be the most logical choice to complete the comparative study in coordination with the Alcalde. WEFTA would review all of their work as LWR's and the Aqueduct Association's technical representative.

In addition to their own funding, LWR is currently working on a grant proposal to a Spanish foundation for a grant to implement a large regional water and sanitation program that would encompass multiple towns and community aqueducts. According to LWR, this grant, if approved, would be on the order of US\$1 -2 million. As part of the proposal process, LWR is contemplating hiring HidroConsultores to perform a baseline study of numerous community water systems, upon which the proposal will be based. If LWR succeeds in securing this grant, it would likely cover final design costs, and possibly part of construction costs, for the San Cayetano project.



Finally, the community itself needs to contribute funding to demonstrate their grass-roots support of the project. The community has set a goal of Col\$10.000.000 (US\$5,500), which translates to \$5.000 (US\$2.75) per family. **To date, the Association has raised approximately Col\$1.000.000 (US\$550), or 10% of their goal.** The Aqueduct Association is continuing to work on community outreach and door-to-door fundraising. We expect this effort will get a boost after the community forum with the Alcalde later this year, as discussed below.

Government Support

After the LWR meeting, the Aqueduct Association, CDS, HidroConsultores and WEFTA met with the Alcalde to present the gravity-fed system as a lower-cost alternative to the existing, but non-functional, pump-based system. Key points of the presentation included the dramatically lower O&M cost of the gravity system, the superior water quality of the Tunel (sample bottles of both Tunel and Canal del Dique water were presented – see attached photo), and the preliminary hydrological calculation that indicates the Tunel will be more than adequate to supply the town’s water demand.

CDS also pointed out that LWR has funding available to complete the feasibility study of the gravity alternative and a comparative study between the two alternatives, if the Alcalde is willing to support it. The Alcalde would fund his own study of the cost to rehabilitate the existing system, while LWR would fund the feasibility study of the gravity system and the comparison between the two. We asked the Alcalde to commit to participating in this comparative study, which would require the use of common design criteria and assumptions for both parts of the study. We also asked the Alcalde to commit to supporting whichever alternative comes out most favorably in this objective comparison. The Aqueduct Association committed to support whichever alternative is most favorable, even if it turns out to be the pumped system.

The Alcalde stated that he was open to the idea of a gravity system and would consider the comparative study. However, he stated that he needed to consult with his legal counsel to see if he could legally consider a new water system with an existing system already in the ground. It appeared to the project team that the legal issue was a pretext to avoid committing to the new project on the spur of the moment. CDS, HidroConsultores and the Association agreed that it is highly uncommon for a Colombian elected official to commit to a new project in public. Typically, such decisions are made privately, in meetings of 2 or 3 people, that do not include constituents. Therefore, CDS and HidroConsultores will follow up with the Alcalde in small, private meetings to discuss the Association’s proposal in more detail.

Part of the original agenda for this trip was to hold a public forum in the community to present the different alternatives, and to explain to the community why they need to contribute money (and eventually labor) to complete the water project. Apart from educating the community and raising community funds, one side benefit of such a meeting was to gauge public support for the gravity-fed alternative. However, the Aqueduct Association decided it was important to have the Alcalde’s support before presenting different alternatives to the community, so both the Alcalde and the Association could present the comparative study together. WEFTA and CDS agreed that this was a prudent decision,



because going to the community directly without involving the Alcalde would inevitably lead to a political backlash and make it much more difficult to secure the Alcalde's support later on. This public forum will be re-scheduled after the Alcalde's is brought fully on-board.

Next steps

The next steps to move the project forward are as follows:

1. CDS and HidroConsultores continue working with Alcalde to educate him about the different alternatives. They will seek his participation in the comparative analysis and support for whichever alternative emerges from this comparison as most advantageous for the community.
2. Upon securing the Alcalde's support, hold the public forum with the entire community. Ideally, the Aqueduct Association and the Alcalde would present the project to the community as a united front.
3. Aqueduct Association will continue door-to-door outreach to community residents to inform them about the project alternatives and raise funds for the project at the grassroots level.
4. Upon receiving the support of the Alcalde (Step #1) and concurrent with Steps #2&3, LWR will execute grant agreements with CDS to complete the feasibility studies of the gravity-fed alternative. HidroConsultores will complete the feasibility studies and the comparison between the gravity and pumped alternatives.
5. Upon completion of the comparative study, the Association and the Alcalde, with input from CDS and WEFTA, will need to make a final decision which alternative to pursue.
6. All parties move forward with final design, land acquisition, legal requirements and other requirements to start construction.
7. Concurrent with Step #6, all parties work with the State government of Bolivar to implement funding and procurement for construction.
8. Construction.

Attachments

- Photos
- Topographic images of both alternatives
 - Gravity alternative showing dam, reservoir, watershed boundary and transmission line
 - Pump based alternative showing transmission line
- Precipitation map – Bolivar State
- Preliminary hydrological calculations
- Preliminary O&M cost comparison between alternatives
- HidroConsultores cost proposal for feasibility-level engineering studies
- Preliminary geotechnical report on dam site
- Geophysical report on proposed groundwater well

